Department of Management Science,
University of Strathclyde

Thesis title: “How do value chain (VC) decisions in bread production contribute to quality characteristics related to human health?”

Author: Victoria Hill
Submitted in 2013 for degree of PhD

Declaration of Authenticity and Author's Rights

This thesis is the result of the author’s original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.

Signed:

Date:

Abstract

Abstract for thesis titled, “How do value chain (VC) decisions in bread production contribute to quality characteristics related to human health?”

This thesis compares the bread VC in two OECD countries (France and the United States) in terms of the impact of government policy and industry strategy upon certain heath characteristics (i.e. protein qualities that influence glycaemic index levels) in the end product (bread). Using kaizen quality management tools, the thesis examines the influence of each VC-entity (baker, miller, wheat grower), as well as consumer behaviour, on beneficial and detrimental health characteristics of the end product. The wheat grower was found to be the most frequently associated contributor to changes in protein quality characteristics. Kaizen models are used to show how these changes to protein quality characteristics are the result of management decisions made by the wheat grower, but formulated in response to government policy and industry strategy. Combining the models with product design tools shows that even some of the most quality-oriented wheat producers could still make further strategic product improvements. The research also shows that kaizen tools could be applied to inexpensively monitor crop development and to compare management practices at stages critical to production of good protein quality characteristics. In addition, due to the similarity of kaizen methodology and the Codex Alimentarius Commission (Codex) recommendations for food quality management--including Hazard Analysis Critical Control Point (HACCP) food safety system--agribusiness producers who employ kaizen would not only achieve general business benefits, but improved food safety and quality, as well.

Acknowledgements

There are a number of people who patiently and generously helped me with various stages of the thesis research:

Hervé Le Stum, AGPB, France

Dr. Lajos Bóna and colleagues at the Cereal Research Institute, Hungary

Dr. Richard Dempster and Mr. Tom Lehmann of AIB Online, U.S.A.

Stjepan Tanic, Food and Agriculture Organization of the U.N., Europe and Central Asia

Tomás Landazuri, INBP, France

Dr. Maarten Stapper, formerly with CSIRO Plant Industry, Australia

Dr. Andrew Fieldsend, Research Institute of Agricultural Economics, Hungary

Dr.Walter Lopez, LimaGrain, France

Mr. James Bair, NAMA, U.S.A.

Dr. Robert van der Meer and Dr. Tim Bedford, my very patient and supportive Thesis advisors at University of Strathclyde, U.K.

A very special acknowledgement, though, should go to Stan Cauvain, BakeTran, U.K. who continually and graciously provided answers to my many questions about the bread value chain and cereal science. Stan's thorough explanations provided the background needed for a novice to the bread value chain to carry out the necessary research.

Acronyms used in this thesis

Afssa = *Agence française de sécurité sanitaire des aliments*

AGPB = *Association Générale Producteurs des Blé et autres cereals*

AIB = American Independent Bakers

ANMF = *Association Nationale de la Meunerie Française*

ARVALIS = *ARVALIS Institut du végétal*

BN = Burlington-Northern Railroad; later BNSF (Burlington Northern Santa Fe Railroad)

CP = Common Agricultural Policy

CCP and CP = Critical Control Point (for HACCP) and Control point (for non-HACCP)

CDC = Centers for Disease Control

CFTC = Commodities Futures Trading Commission

CI = Continuous improvement

Codex = Codex Alimentarius Commission (also CAC)

CRNH = French National Institute of Human Nutrition

EC = European Commission

EFSA = European Food Safety Agency

EU = European Union

FAO = The Food and Agriculture Organization of the United Nations

FBD = foodborne disease

FDA = U.S. Food and Drug Administration

FEBPF = *Fédération des enterprises de boulangerie-pâtisserie françaises*

FGIS = U.S. Federal Grain Inspection Service

FTE/FTEs = fulltime equivalent/equivalents (a fulltime worker)

GAO = U.S. Government Accounting Office

GAPs = Good agricultural practices

GATT = General Agreement on Tariffs and Trade (forerunner of WTO)

GHPs = Good hygienic practices

GMPs = Good manufacturing practices

GI = Glycaemic Index

GL = Glycaemic Load

GMPs = Good management practices

GNI = Gross national income

GNIS = *Groupement National Interprofessionnel des Semences et Plants*

Ha = hectare (equal to 10,000 square metres or 2.471 acres)

HACCP = Hazard Analysis Critical Control Point (food safety system and food safety plan)

HSPH = Harvard School of Public Health

ICC = U.S. Interstate Commerce Commission; also International Chamber of Commerce

IDF = International Diabetes Federation

INBP = *Institut National de La Boulangerie Pâtisserie*

INRA = French National Institute of Agricultural Research

INSERM = French National Institute of Nutrition and Food Science

IOM = U.S. Institute of Medicine

IP = identity preservation

ITCF = *Institut Technique des Céréales et des Fourrages*

KSU = Kansas State University

MT/MTs = metric tonne/tonnes; also metric ton/tons (equal to 1,000 kilograms or 2,205 pounds)

NAMA = North American Millers Association

NIH = U.S. National Institutes of Health

NDSU = North Dakota State University

OECD = Organisation for Economic Cooperation and Development

ONIC = forerunner of ONIGC

ONIGC = *Office National Interprofessionnel des Grandes Cultures*

OSU = Oklahoma State University

PRP/PRPs = Prerequisite programme/programmes

QFD = Quality function deployment

QMS = Quality management system

RS = resistant starch

SPS (Agreement) = Agreement on the Application of Sanitary and Phytosanitary Measures

TBT (Agreement) = Agreement on Technical Barriers to Trade

TQM = Total Quality Management

UNIGRAINS = a financial institution owned by AGPB for funding grain processing

URAA = Uruguay Round Agreement on Agriculture

USDA = U.S. Department of Agriculture

USDA/ARS = USDA's Advanced Research Service

USDA/ERS = USDA's Economic Research Service

USDA/FAS = USDA's/Foreign Agricultural Service

USDA/FSIS = USDA's Food Safety and Inspection Service

USDA/GIPSA = USDA's Grain Inspection, Packers and Stockyards Administration's Grain Inspection Service

VC = Value chain

VS = Value stream

VSM = Value stream model

WHO = The World Health Organization of the United Nations

WI/WIs = work instruction/instructions

WTO = World Trade Organization

Table of contents

List of figures and tables

Chapter 0

Introduction to the thesis

Chapter 0

Introduction to the thesis

0.1 Chapter overview

This chapter is an overview of the thesis. Section 0.2 provides a synopsis of the thesis. Section 0.3 describes a logical overview of the thesis. Section 0.4 discusses the gaps found in the literature. Section 0.5 describes the contribution of each chapter toward the main thesis argument.

0.2 Thesis synopsis

0.2.1 Main research question

The main research question was:

“How do value chain (VC) decisions in bread production contribute to quality characteristics related to human health?”

Three subordinate questions, derived from investigating the main research question, were addressed, as well:

- “What effects have changes since 1994 in government policy and industry strategies had on VC decisions by primary producers that contribute to quality characteristics related to human health?”
- “How do differences in national food safety programmes in the U.S. and France affect VC decisions by primary producers that contribute to quality characteristics related to human health?”
- “Could national food safety programmes provide benefits to primary producers beyond food safety?”

The thesis uses ‘protein quality characteristics’ of wheat, bread’s chief ingredient, as quality characteristics that impact human health (i.e. links to glycaemic index levels in bread). The research investigates whether or not management decisions made in an 'upstream' VC-entity could result in quality characteristics in the end product that could impact consumer health. In order to develop a better understanding of how this might happen and whether the situation could be managed differently, the research compared food safety regulation and VC management practices for bread, flour and wheat production in two countries: France and the U.S. Research was limited to the period of time beginning with 1994 and ending mid-2009.

The 1994/1995 timeframe was extremely important in terms of international food safety and consumer protection. During 1994 the Uruguay Round of Multilateral Trade Negotiations resulted in formation of the World Trade Organization (WTO). Related agreements were negotiated and included:

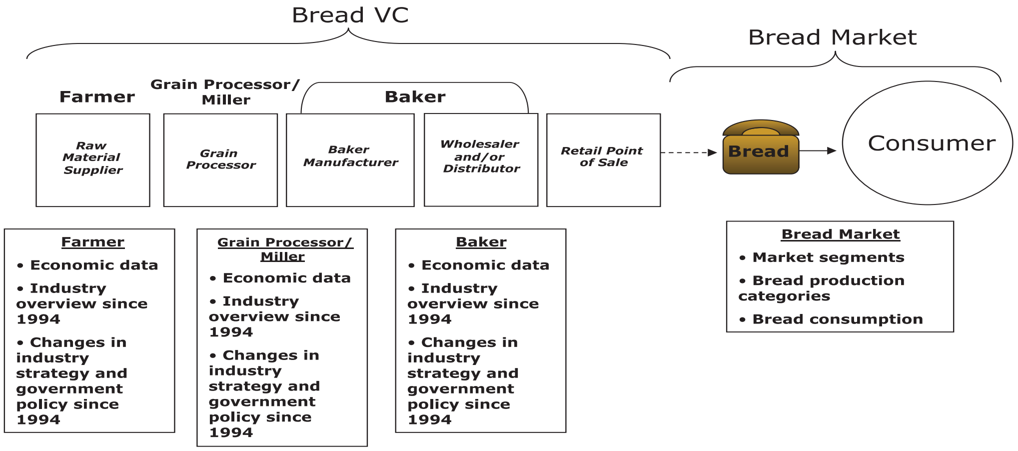
- Removal of agricultural subsidies in the wealthier (formerly GATT) countries;
- A lowering of potential trade barriers that permitted poorer countries access to broader agrifood markets;
- Revision of the recommendations from the U.N.'s World Health Organization (WHO) and Food and Agriculture Organization (FAO) via the WHO/FAO's Codex Alimentarius Commission (Codex) for national food safety and consumer protection programmes.
- Binding commitments by each WTO member (including France and the U.S.) to use the Codex recommendations on food safety and consumer protection as a reference point, or benchmark, in national food safety and consumer protection programmes.

All of these changes contributed to an improved environment for food safety and consumer protection throughout the world while enhancing international agricultural trade.

0.2.2 The premise of the thesis

A starting point for literature review was to compare: 1) the bread VCs in France and the U.S.; 2) the bread market and consumption patterns in both countries (Figure 0.1).

Figure 0.1
Overview of the bread VC for a single country



Source: Based on author's own research.

Differences in consumption patterns were heavily influenced by consumer attitudes toward low-carbohydrate diets and by differences in national public health policies in each country. Despite these differences, the main issue from an operations management perspective was whether or not the quality characteristics related to human health could actually appear in the bread, and if so, where and how might this happen in the bread VC. For example, if protein quality characteristics can impact human health, is this only a result of the baker's management practices? Or, is it possible that management practices upstream (in the grain processor's facility and/or on the wheat farm) could be involved? In terms of regulation and food safety precautions that might prevent this, it was also important to examine the regulatory environment and the national food safety programmes of both France and the U.S. The Codex strongly advises, but does not require, that food safety risks primarily be addressed by adoption of good management practices (GMPs), good agricultural practices

(GAPs) and/or good hygienic practices (GHPs). The use of Hazard Analysis Critical Control Point (HACCP) plans (or HACCP-like plans) is meant to prevent any risks that might not have been prevented through use of the GMPs/GAPs/GHPs. This raises questions about: how closely the national food safety programmes in France and the U.S. adhere to the Codex recommendations; how these national programmes might affect VC decisions (particularly management decisions of primary producers); and how these decisions might affect quality characteristics that are related to human health. In addition, there are characteristics of the Codex recommendations (i.e. the use of GMPs/GAPs/GHPs and adoption of HACCP) that resemble a very basic quality management system (QMS). This leads to an additional question of whether national food safety programmes (applying the Codex recommendations) might provide benefits to primary producers beyond food safety?

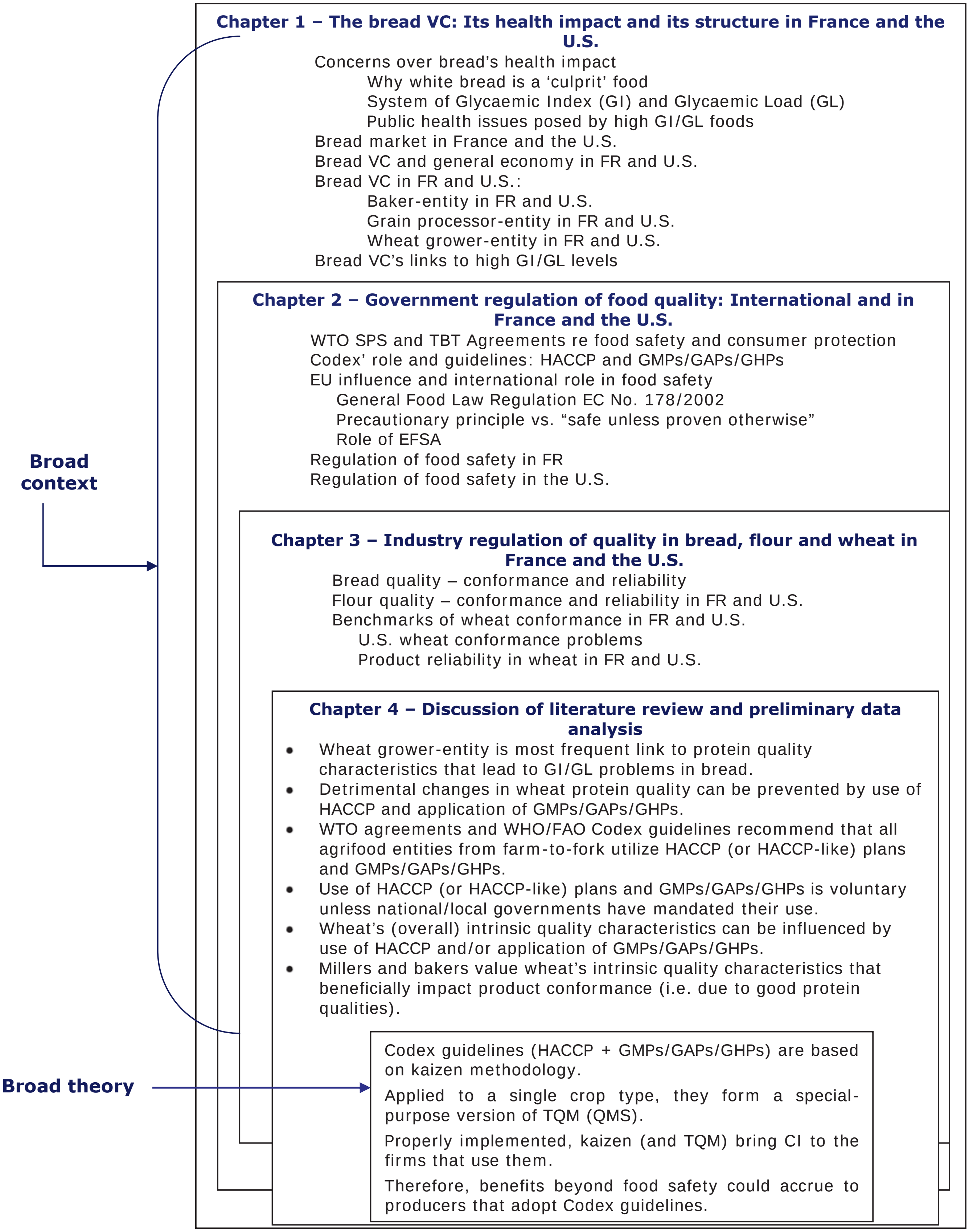
0.3 The thesis argument

Figure 0.2 provides an overview of the thesis argument.

0.3.1 Logical overview of thesis

As Figure 0.2 shows, the Broad context of the thesis argument comes from the first three chapters of literature review drawn from three main spheres: 1) the bread VC, (including the bread market and links between the bread VC and GI/GL levels; 2) government regulation of food safety (i.e. reliability); 3) industry regulation of quality (i.e. conformance and reliability) in bread, flour and wheat. Chapter four discusses preliminary findings showing: the primary producer as the most frequent link to protein quality characteristics associated with GI/GL problems in bread; that GI/GL problems in bread are not directly regulated—although WHO/FAO’s Codex guidelines, if applied, would reduce/prevent the problems—and that flour and bread conformance benefit from good protein qualities, as well.

Figure 0.2
Structure of thesis argument



Chapter 1 – The bread VC: Its health impact and its structure in France and the U.S.

- Concerns over bread's health impact
  - Why white bread is a 'culprit' food
  - System of Glycaemic Index (GI) and Glycaemic Load (GL)
  - Public health issues posed by high GI/GL foods
- Bread market in France and the U.S.
- Bread VC and general economy in FR and U.S.
- Bread VC in FR and U.S.:
  - Baker-entity in FR and U.S.
  - Grain processor-entity in FR and U.S.
  - Wheat grower-entity in FR and U.S.
- Bread VC's links to high GI/GL levels

Chapter 2 – Government regulation of food quality: International and in France and the U.S.

- WTO SPS and TBT Agreements re food safety and consumer protection
- Codex' role and guidelines: HACCP and GMPs/GAPs/GHPs
- EU influence and international role in food safety
  - General Food Law Regulation EC No. 178/2002
  - Precautionary principle vs. "safe unless proven otherwise"
  - Role of EFSA
- Regulation of food safety in FR
- Regulation of food safety in the U.S.

Chapter 3 – Industry regulation of quality in bread, flour and wheat in France and the U.S.

- Bread quality – conformance and reliability
- Flour quality – conformance and reliability in FR and U.S.
- Benchmarks of wheat conformance in FR and U.S.
  - U.S. wheat conformance problems
  - Product reliability in wheat in FR and U.S.

Chapter 4 – Discussion of literature review and preliminary data analysis

- Wheat grower-entity is most frequent link to protein quality characteristics that lead to GI/GL problems in bread.
- Detrimental changes in wheat protein quality can be prevented by use of HACCP and application of GMPs/GAPs/GHPs.
- WTO agreements and WHO/FAO Codex guidelines recommend that all agrifood entities from farm-to-fork utilize HACCP (or HACCP-like) plans and GMPs/GAPs/GHPs.
- Use of HACCP (or HACCP-like) plans and GMPs/GAPs/GHPs is voluntary unless national/local governments have mandated their use.
- Wheat's (overall) intrinsic quality characteristics can be influenced by use of HACCP and/or application of GMPs/GAPs/GHPs.
- Millers and bakers value wheat's intrinsic quality characteristics that beneficially impact product conformance (i.e. due to good protein qualities).

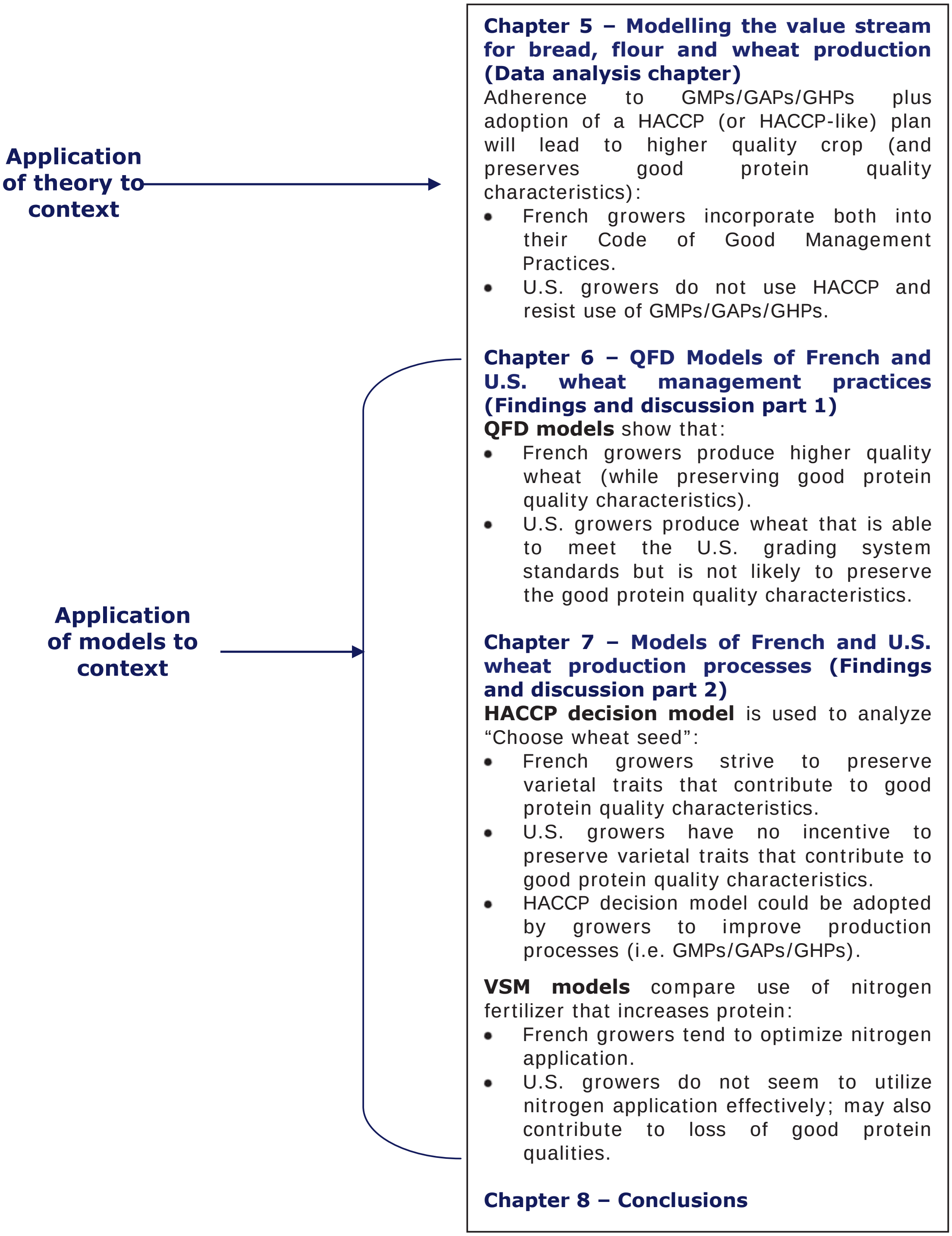
Codex guidelines (HACCP + GMPs/GAPs/GHPs) are based on kaizen methodology.

Applied to a single crop type, they form a special-purpose version of TQM (QMS).

Properly implemented, kaizen (and TQM) bring CI to the firms that use them.

Therefore, benefits beyond food safety could accrue to producers that adopt Codex guidelines.

Continuation of Figure 0.2



Application of theory to context

Chapter 5 – Modelling the value stream for bread, flour and wheat production (Data analysis chapter)

Adherence to GMPs/GAPs/GHPs plus adoption of a HACCP (or HACCP-like) plan will lead to higher quality crop (and preserves good protein quality characteristics):

- French growers incorporate both into their Code of Good Management Practices.
- U.S. growers do not use HACCP and resist use of GMPs/GAPs/GHPs.

Application of models to context

Chapter 6 – QFD Models of French and U.S. wheat management practices (Findings and discussion part 1)

QFD models show that:

- French growers produce higher quality wheat (while preserving good protein quality characteristics).
- U.S. growers produce wheat that is able to meet the U.S. grading system standards but is not likely to preserve the good protein quality characteristics.

Chapter 7 – Models of French and U.S. wheat production processes (Findings and discussion part 2)

HACCP decision model is used to analyze "Choose wheat seed":

- French growers strive to preserve varietal traits that contribute to good protein quality characteristics.
- U.S. growers have no incentive to preserve varietal traits that contribute to good protein quality characteristics.
- HACCP decision model could be adopted by growers to improve production processes (i.e. GMPs/GAPs/GHPs).

VSM models compare use of nitrogen fertilizer that increases protein:

- French growers tend to optimize nitrogen application.
- U.S. growers do not seem to utilize nitrogen application effectively; may also contribute to loss of good protein qualities.

Chapter 8 – Conclusions

Source: Model structure Grigg, N.P. 2004;analysis based on author's own research.

The preliminary data analysis in Chapter four also leads to a Broad theory that Codex guidelines are in fact based on kaizen methodology, which when properly implemented leads to continuous improvement of quality. Therefore, a possibility exists that not only could primary producers offer a higher quality and safer product by implementing the Codex recommendations, but also the firms themselves could begin to accrue operational benefits.

Chapter five describes how Broad theory can be applied to Context using a variety of kaizen models (QFD, HACCP and VSM). The models first examine how desirable product characteristics are collected initially from the End consumer, then working upstream, are consolidated with the characteristics desired by retailers, bakers, millers. (Desirability of protein quality characteristics is also tracked throughout the process). Finally the "Miller's list", representing all of the characteristics that all the downstream customers desire, is presented to the Wheat grower (via QFD models). QFD matrices are used to show how the Wheat grower might formally design a (wheat) product to meet customer demands (i.e. the Miller's list). Chapter five also describes how specific wheat growing processes (that are necessary for meeting customer demands) can be developed using HACCP and VSM.

Chapters six and seven provide the opportunity to apply the kaizen models to Context. Chapter six uses QFD models to compare the wheat product found in 'open' production in France and the U.S. Particular attention is paid to how protein quality characteristics are managed in both systems. Chapter seven uses a HACCP decision process-tool to compare a wheat management activity in France and the U.S. The VSM models are used to depict wheat plant growth as well as to make comparisons of wheat production practices. All of these models (HACCP and both types of VSM) are used to identify how VC decisions contribute to quality characteristics related to human health in France and in the U.S.

Chapter eight contains the findings, recommendations and conclusions.

0.4 Methodology

0.4.1 Methodological considerations

0.4.1.1 Research methodology

The thesis is a comparative case study of the bread value chain/value stream in France and the U.S. It is based primarily on literature and documents with some data analysis and expert validation.

0.4.1.2 Choice of white bread as the food product for study

White bread was selected as the food product for several reasons. It is widely consumed in both France and the U.S. The ingredients used are nearly the same and preparation methods are very similar in both countries. In white bread's simplest form, only four ingredients are used. This would make it easier to conduct future investigations of the upstream VC of each ingredient. In addition, white bread's basic ingredients appear in many other products (such as buns/rolls, pasta, noodles, tortillas, quiche, pie shells) so the same basic research can be extended to those similar products. White bread itself is a primary component in complex food combinations (such as pizza), so any future investigations downstream of 'white bread dough' would be facilitated. Comparisons of the bread VC in France and the U.S. were also facilitated by certain similarities that emerged: marketers in both countries segment bread into comparable products; bakers receive similar basic training; and baking plants and mills use similar production methodologies.

0.4.1.3 Selection of a set of quality characteristics to investigate

'Protein quality' represents a group of wheat characteristics that may have either a beneficial or detrimental effect on human health. These characteristics include: changes in protein-to-starch ratio of wheat; changes in amylose-to-amylopectin ratio; changes in level of resistant starch and/or fibre. These types of changes influence the glycaemic index/glycaemic load (GI/GL) level in wheat-based foods. Therefore, changes in protein quality were chosen as the set of quality characteristics to be examined more closely in each entity of the VC.

0.4.1.4 Choice of value stream methodology

VC methodology is rooted in marketing and financial management; its underlying goal is to maximize the price the firm gets for its product/service. VC methodology does not consider impacts on the consumer; rather it focuses on price obtained in the marketplace. As a result, VC methodology proved to be insufficient for analysis of quality management practices or impact of the bread VC on health characteristics that might involve consumers.

A methodology that addresses production quality management issues (such as Six sigma, ISO, value stream and/or kaizen) needed to be selected. Value stream (VS) methodology starts with the end product and looks at how the decisions and practices upstream contribute to the customer's perception of the product's overall quality (i.e. 'value' as viewed by the consumer). The VS/kaizen approach represents the (Japanese) philosophy of continuous improvement as well as being the foundation behind several quality management systems (e.g. ISO 9001, Six sigma, Total Quality Management, Japanese CWQC). The focus on the Customer (rather than product price in the market) along with its foundations in quality management made VS/kaizen a better choice of methodology.

0.4.1.5 Agronomic benchmarks

Measurable benchmarks of wheat production were needed to serve as key performance indicators (KPIs) in evaluating process performance. Despite the fact that wheat has been grown for many centuries with only two methods of cultivation (dryland or irrigated), there is very little literature that addresses KPIs in wheat production. Dr Maarten Stapper and Dr Tony Fischer developed a system of wheat plant/crop growth benchmarks mapped to Dr Jan Zadoks' Decimal Growth Scale of Cereals to support best management practices in wheat farming. The Stapper/Fischer system is applicable across geographies, not just limited to Australia. E.g. the FAO's International Maize and Wheat Improvement Center (CIMMYT) teaches low-income farmers, lacking financial and other resources, how to use the system to monitor/measure development of their wheat crops. With the advice of the Industry thesis advisor (S. Cauvain) Stapper and Fischer's system has been adopted to represent KPIs in the VSM models developed in this thesis. S. Cauvain and L. Bona validated the resulting VSM models (seen in Chapter seven).

0.4.1.6 Selected kaizen concepts

There are several kaizen concepts that were employed in development and analysis of the QFD, HACCP and VSM models. Key concepts applied were: Next process is the customer; Primary focus on Quality, Cost and Delivery (QCD); Elimination of Waste (*muda*); Deming's SDCA-PDCA cycle; *Takt* time; KJ method of creating affinity diagrams; and *Hoshin Kanri*. For the interested reader wanting more details, two of the more comprehensive single sources are: 1) Imai, M. 1997. *Gemba Kaizen: A Commonsense, Low-Cost Approach to Management*. McGraw-Hill. New York; 2) Deming, W. 2000. *Out of the Crisis*. Cambridge, Massachusetts. MIT Press.

0.5 Gaps in the literature

During the literature search, certain gaps were found that also influenced the development of the thesis. Overall there were four main gaps found:

1) There is a mismatch in the management literature between the concepts of VC and VS; throughout the literature they are treated as nearly analogous.

2) There was little attempt to connect farming to the manufacture of a food product or to treat farming as a manufacturing entity – particularly in U.S. literature. In general, though, farming is treated as if it were exempt from the domain of production and operations management.

3) Gap two leads to a potentially more serious gap. Although some literature discussed *a posteriori* prevention of mycotoxins, no (U.S.) literature was found regarding *a priori* quality management of processes on the wheat farm to prevent food quality or HACCP issues in the finished product.

4) There is a partial gap in the literature concerning links between wheat quality characteristics and human health. Existing literature describes the nutritional aspects of wheat-based foods but ignores raw wheat quality characteristics. Only veterinary literature seemed to link wheat quality characteristics with wheat production management practices.

0.6 Overview of the chapters

The following sections describe how each chapter is used to support the thesis argument and to answer the main research question.

0.6.1 Chapter one: *The bread VC: Its health impact and its structure in France and the U.S.*

This chapter begins with a discussion of the concerns of U.S. consumers regarding bread, carbohydrates and obesity. Although French consumers haven't developed the same concerns about bread as U.S. consumers, French public health officials have undertaken a national campaign based on the GI/GL system to persuade consumers to forego white baguette in favour of breads with lower GI/GL levels to reduce risk of obesity and other serious health conditions. While U.S. public health officials have largely ignored consumers' health concerns associated with bread, bread producers have responded with a multitude of low-carbohydrate (or low GI/GL) products.

These differences between consumer attitudes, public health strategies and bread producer response are discussed.

Chapter one compares the bread market and the three main bread VC-industry segments—bakers, millers/grain processors and primary producers—in both countries. Although bakers in both countries receive the same training and use nearly the same ingredients in the same bread varieties, the differences in business management are stark. Likewise, millers/grain processors use similar processes in both countries but business structure is quite different. Wheat grower behaviour in the two countries showed the greatest differences; therefore, these characteristics are discussed in more detail.

The last part of this chapter examines: 1) the ingredients used in bread that may result in a beneficial or detrimental GI/GL value; 2) the production practices used by the baker, miller or wheat grower that could cause changes to protein quality characteristics (that in turn affect GI/GL levels; and 3) consumer behaviour related to bread consumption that could result in a high (i.e. detrimental) GI/GL value.

0.6.2 Chapter two: *Government regulation of food quality: International and in France and the U.S.*

The regulatory framework for national food safety programmes is based on the international framework of the Joint FAO/WHO Food Standards Programme. The first part of this chapter describes the Programme, the development of the Codex Alimentarius Commission (Codex). The Codex is an intergovernmental body with more than 150 Member Governments, under the auspices of the FAO. Codex guidelines for food safety have been developed by the scientific community and are relevant to world trade in agricultural products and food safety in all member countries of the World Trade Organization (WTO). However, Codex guidelines are merely recommendations and enforcement depends on national implementations of the Food Standards Programme. National food safety programmes in France and the U.S. are compared in terms of alignment to the Joint FAO/WHO Food Standards Programme.

The Principles of Good Hygiene developed by the Codex encompass good management practices (GMPs), good agricultural practices (GAPs) and good hygienic practices (GHPs) are intended for food producers from 'farm-to-fork' as a means of preventing any food safety risk or event. As an additional safeguard, the Codex also developed the Hazard Analysis Critical Control Point (HACCP) system for food safety control against three main categories of contaminants (i.e. biological, physical objects and chemical). HACCP is part of the Codex guidelines, but like GMPs/GAPs/GHPs, the adoption of a HACCP plan is only recommended.[1] [

The chapter also examines two sets of international regulations regarding food quality and consumer protection (i.e. the Sanitary and Phytosanitary Standards (SPS) Agreement that regulates food safety and the Technical Barriers to Trade (TBT) Agreement for consumer protection) that have been signed by all member countries of the WTO. Comparisons are made of the interpretation of these agreements in France and the U.S. Additionally, the European Union has established regulatory authority not only over food products manufactured or sold within the EU, but even those that transit its territories. The impact on U.S. producers (especially wheat growers) is discussed, as well.

---

[1] For readers unfamiliar with the Codex GMPs/GAPs/GHPs and/or HACCP plans, it should be understood that none of these are written standards or procedures to be followed. They are more like 'open' frameworks for how best to develop/tailor processes to a user-specific environment. This may be more clearly seen in the HACCP decision process model (Figure 2.6).

0.6.3 Chapter three: *Industry regulation of quality in bread, flour and wheat in France and the U.S.*

Chapter three discusses industry regulation of the dual aspects of food quality (i.e. product conformance and reliability) in each bread-VC entity. Product conformance standards and test procedures are nearly identical (based on bread variety) for bakers in France and the U.S. Bakers are usually required by local laws to utilize HACCP and bakers, in turn, generally require millers/grain processors who supply to them to do the same. But across the VC, adoption of GMPs/GAPs/GHPs is voluntary. In general, millers/grain processors utilize the same basic procedures for processing grain, however variety exists regarding required test results with the final product being a combination of baker demands and available wheat characteristics. This is particularly true in France where the grain processors compete with one another to attract bakers based on quality characteristics that are customized (often at no additional cost) for the baker.

Wheat growers' practices appear similar in both countries, but a more careful examination shows how very differently the growers in each country manage processes and benchmarks. For example, farmers in both countries use approximately 50 percent saved seeds from the previous crop. But French growers utilize scientific assessments to verify that genetic traits have not been lost and that seeds are clean and healthy. U.S. farmers tend to clean the seeds themselves, although independent agencies do offer seed-cleaning services. Although wheat-growing practices were examined in open production in both countries, in the U.S. system of open production and commingling, there is little benefit in checking/preserving genetic traits.

Some of the more important differences in management approach in the two countries relate to prevention of adverse health characteristics, particularly changes in protein qualities that contribute to increased GI/GL levels. Wheat with 'good protein' qualities is appreciated by millers/bakers in both countries. I.e. good protein qualities improve both bread conformance and reliability; growers in France are encouraged throughout the VC to produce highest possible quality. In the U.S., even though millers and bakers also value good protein qualities, USDA contends that protein quality characteristics represent a commercial issue between buyer and seller and not suitable as a requirement for the U.S. grain grading standard—in contrast to France having introduced intrinsic characteristics to its grain grading system in 1998. USDA also contends that farm-to-fork food safety means starting at the farmgate, thereby leaving responsibility for food safety to a one-to-three-minute organoleptic test of incoming loads of wheat at the elevator. Meanwhile, the Commerce Department contends that wheat growing is an ‘extractive activity’ like oil production; that, in a sense, makes it somehow understandable that food safety might begin with the miller and move downstream, thereby excluding the primary producer.

It’s possible to attribute the dramatic differences in attitude of primary producers toward food safety in France and the U.S. as ‘over concern’ on the part of the French and ‘no real problem’ in the U.S. But as a comparison of foodborne disease (FBD) incidence rates in France and the U.S. showed (Section 2.4.2), the U.S. rate is more than six times greater than that of France. The U.S. rate is also one of the highest in the OECD; thus, it appears that food quality issues in the U.S. are probably not confined to wheat.

0.6.4 Chapter four: *Discussion of literature review and preliminary data analysis*

Chapter four discusses the literature review found in Chapters one, two and three. The discussion of the initial three chapters was aimed at laying out the Broad context of the thesis argument. Matching key points from the discussion against data elements needed to support the Broad context of the thesis argument (Figure 0.2) produced the preliminary findings. The literature review supported the Broad context of the thesis argument, but as Figure 0.2) showed, the Application of theory to context is addressed in Chapter five and the Application of models to context appears in Chapters six and seven. A validation research project to show that millers and bakers in both France and the U.S. desire good protein quality characteristics was also discussed.

0.6.5 Chapter five: *Modelling the value stream for bread, flour and wheat production*

The primary goal of Chapter five was describe generic elements of models seen in Chapters six and seven. This chapter also described how customer requirements for each element of the wheat, flour and bread VS can be developed and consolidated to represent a generic model of the customer's 'needs' and 'desires' for each VS-entity (i.e. End customer; Retailer; Baker; and Miller). Section 5.5 described the analysis that was done to translate the Miller's requirements into the wheat production processes. Section 5.6 described how the generic models of wheat production practices were developed, including generic wheat farm activity areas and the processes that are part of these activities (Figures 5.24 through 5.33). VS/kaizen models (QFD, HACCP and VSM) were introduced that will be used in Chapters six and seven to compare protein quality characteristics of French and U.S. wheat.

0.6.6 Chapter six: *QFD models of French and U.S. wheat management practices*

This chapter compares the wheat product offered in open production in France and the U.S using QFD models (introduced in Chapter five). Wheat product design is modelled and described. The models showed that use of GMPs/GAPs/GHPs could prevent poor protein quality characteristics and consistent with Codex guidelines; i.e. all types of non-HACCP food safety defects should be prevented through adoption of GMPs/GAPs/GHPs.

0.6.7 Chapter seven: *HACCP and VSM models of French and U.S. wheat production processes*

This chapter compares two wheat production processes that can influence protein quality characteristics. The processes selected come from two different production activities: Seed selection (Fig. 5.27)) and the Growing phase (Fig. 5.29). "Choose wheat seed" is modelled using the HACCP decision model (Fig. 2.6). This model not only compares the French and U.S. approaches to seed selection, but it illustrates that GMPs/GAPs/GHPs can be tested--and improved--using the HACCP decision model.

There are too many processes in the Growing phase that influence protein quality characteristics to consider the impacts of each one. Therefore, a decision was made with the assistance of the Industry thesis advisor (S. Cauvain) to look more closely at nitrogen fertilizer topdressing because it is significantly connected to protein in wheat. A variety of nitrogen fertilizer applications were compared using VSM models. Also with assistance from the Industry thesis advisor, the decision was made to utilize Australian wheat growers' system of measurements and benchmarks developed by Dr. Maarten Stapper as an example of successful and measurable processes. VSM models depicted wheat plant growth and the system of benchmarks applied to the tillering stage.

0.6.8 Chapter eight: *Findings, recommendations and conclusion*

The main conclusion was that the Codex guidelines (i.e. use of GMPs/GAPs/GHPs and adherence to HACCP plans) should be adopted by each VC-entity involved in food production—from "the farm to the fork". However, as the thesis showed, not all producers at each stage of the VC have voluntarily adopted the Codex guidelines; primary producers being the main exception. Nor have all governments adopted and implemented policies, including sufficient oversight, to adequately protect consumers. Products coming from the bread VC in France are much more likely to represent 'good protein' quality characteristics than those from the U.S. In both countries, though, the wheat growers share greatest likelihood of responsibility for the final product's impact on GI/GL levels.

This raises the possibility of alternative supply chains for secondary producers who want to be sure that their own wheat-based products will not be impacted by poor quality management of upstream suppliers in the U.S. However, there are few alternatives for U.S. wheat growers: e.g. partially become a contract producer; shift a portion of wheat crop to higher quality; form cooperatives with neighbours. The advantages and risks of the various alternatives are discussed. At the same time it becomes the responsibility of the consumer to only purchase products known to comply with safety standards and codes of good management practices.

0.7 Chapter summary

The intent of this chapter was to provide a roadmap for the reader. While the thesis addresses food safety in terms of bread and other wheat-based foods, many of the same issues apply to other types of foods, especially to grain commodities. Hopefully the models used in this thesis can be utilized for examining other non-wheat food products.

Chapter 1

The bread VC: Its health impact and VC structure in France and the U.S.

Chapter 1

The bread VC: Its health impact and structure in France and the U.S.

1.1 Concerns over bread's health impacts

1.1.1 Why white bread is a 'culprit' food

A mixture of errors and omissions occurred in the calorie counting system for carbohydrates (Kienzele 2002; Schulze and Hu 2004). These flaws led to false conclusions about the influence of various breads on weight gain. In particular, the effect of dietary "fibre was not taken into account" (Kienzle 2002). Carbohydrate calories are usually lower if they come from natural (i.e. not processed) fibre-rich foods (HSPH 2004). Until recently, the calorie content of breads made with wholegrain flour (that includes wheat's dietary fibre) was considered roughly equivalent to white breads. In France, INRA undertook a national initiative in 2002 to persuade consumers to substitute wholegrain bread for white baguette (INRA 2007). By 2004 the U.S. medical community also recognized the importance of how much fibre a food contained (Schulze and Hu 2004).

1.1.2 The Glycaemic Index (GI) and Glycaemic Load (GL) system

Misunderstandings concerning carbohydrate quality persisted until the late 1980s when researchers at the University of Toronto began to question connections between carbohydrate quality and glycaemic response.[2] Their work became codified as the GI/GL system (Jenkins and Wolever 1987).

"The **Glycaemic Index** … measures how rapidly and how high blood sugar rises after a food is eaten that contains carbohydrates. Low GI foods are those with a value of *55 or less*, Medium GI = *56 – 69* and High GI = *70 or more*" (University of Sydney 2002). White bread or white table sugar

---

[2] Glycaemic response refers to. the effects on blood glucose and lipid metabolism (Jenkins 1987).

is used as the reference value for a 'High GI'. "Carbohydrates that break down quickly during digestion have the highest glycaemic indexes, while those that break down slowly have low glycaemic indexes" (University of Sydney 2002).

Glycaemic Load reflects a refinement to the GI system. GL indicates the GI value multiplied by the total grams of net available carbohydrate[3], i.e. GL = GI/100 x net carbohydrate content. The GL ranges are defined as: Low GL = *10 or less*; Medium GL = *11- 19*; and High GL = *20 or more*. Table 1.1 shows examples of GI and GL values.

Table 1.1
Comparison of GI and GL values for various foods

Carbohydrate	Portion size	GI value	GL value
White bread – U.S.	30 gram	70	10
Potatoes – boiled	150 gram	101 ±15	17
Soft drink (cola)	250 ml	63	16
Fresh carrot juice	250 ml	43 ±3	10
Carrots – raw	80 gram	8	1

Source: Foster-Powell *et al*. 2002.

Using GI and GL values

In 1997 the FAO endorsed the GI method for classifying carbohydrate-rich foods and recommended its use in guiding food choices (Foster-Powell *et al*. 2002). Despite strong consumer interest in GI diets, there is (at least) one caveat when attempting to use the GI/GL system to characterize a specific food as 'healthy' or 'unhealthy': An index, by its nature, is only indicative and doesn't represent a specific numeric value assignable to a specific food even if the specific food is used as a reference point in the GI system, even if the specific food is used as a reference point in the GI system (Wolever 2005).

Another issue in using the GI system has to do with the underlying knowledge it requires for successful use. An example of misunderstandings that might arise over what is 'healthy' or

---

[3] Net available carbohydrate refers to total carbohydrate content less dietary fibre.

‘unhealthy’ is shown in Table 2.3. The consumer could choose one slice of plain white baguette; eaten alone this would produce a high-GI response of 95 (Item 1). Eating two slices of baguette with a sizeable portion of chocolate spread (Item 2) actually produces a lower GI response than the single slice of plain bread. When a comparison is made with a doubled portion of white baguette served with a topping of butter and strawberry jam (Item 3), the GI value goes even lower. Fats in the chocolate spread and butter and fruit fibre in the strawberry jam contribute to a lower GI response.

Table 1.2
GI values for three choices of bread in France

Item Nº	Bread type and toppings	GI	Serving size (g)
1	Baguette, white, plain (France)	95	30
2	French baguette (60 g) with chocolate spread (20 g) (France)	72	60
3	French baguette (60 g) with butter (10 g) and strawberry jam (20 g) (France)	62	60

Source: Bornet *et al.* 1987.

1.1.3 Public health issues posed by overeating high GI/GL foods

Progression to serious disease

Obesity, metabolic syndrome, diabetes and cardiovascular disease are some to the disease conditions associated with over-consumption of high GI/GL foods (Schwarzbein 2002; University of Sydney 2008; IDF 2006). Researchers at Columbia University Medical Center found a correlation to memory decline; related studies showed increased risk of dementia (NY Times 2009). Other studies found consumption of high GI/GL food to be “…a universal mechanism for disease progression” (University of Sydney 2008). From 1992 the French government required all public health research to consider any nutritional aspect (Dupin, H. *et al*. 1992; INSEE 2006).

Impact on public healthcare systems and government response

Cost of health care services for the obese are 36 percent higher and the cost of medications 77 percent higher than for people of normal weight" (Sturm 2002). Health spending for the obese costs five to seven percent of total U.S. health spending (Thompson and Wolf 2001).

In 2003, French rates of obesity were 11 percent versus 31 percent in the U.S.--the highest rate in the OECD (OECD 2005). Between 2003 and 2005, the French health authorities focused on convincing consumers that wholegrain breads were less likely to cause high GI/GL levels, excess weight and metabolic syndrome than the popular white baguette (INRA 2007). Despite the U.S. having such a high rate of obesity, there was no national prevention programme aimed at obesity, metabolic syndrome or diabetes. There was, however, a U.S. diet and weight-loss industry worth $46 billion per year (Marketdata Enterprises 2005).

1.2 The bread market in France and the U.S.

1.2.1 Similar bread production methods

Baker training in France and the U.S. is similar. The focus is on preparation of three basic dough types: white pan bread (or sandwich loaf), hearth-baked loaves (e.g. baguette) and laminated pastry doughs (used for croissants and sweet pastries). Bread production categories are split into three groups in both countries: industrial, semi-industrial and artisan:

Industrial – a bread plant with one or more automated production lines.

Semi-industrial – an industrial plant that has produced dough to be baked into artisan-appearing loaves; the plant either freezes the dough, a par-baked loaf or the fully baked loaf of bread, then ships the product for the retailer or customer to finish the process.

Artisan – each loaf is prepared manually; baker adjusts each batch for differences in raw materials, daily temperature/humidity, etc. (INBP 2005; Le Cordon Bleu 2005; Cauvain 1998).

1.2.2 Similar market segments for bread

Every type of product can be split into one of four categories based on how commodity-like or unique the product is, and whether the target market of customers is large or small (Porter 1985). Food products can also be split into similar groupings—"Economy, Value, Premium and Super Premium, based on net price" (Taylor 2003).

Bread market segmentation is more sensitive to consumer preferences than to production technology. Although production methods are similar in both the U.S. and France, market segments are slightly different (Figures 1.1a and 1.1b). Discount priced 'soft' white bread is the mainstream (Economy) product in the U.S. while Discount priced baguette is the mainstream (Economy) product in France.

Figure 1.1a
U.S. Bread market product categories

	Lower Cost	*Differentiation*
Broad Target	**ECONOMY:** Discount priced 'soft' white	**PREMIUM:** Commercially produced artisan-appearing
Narrow Target	**VALUE:** Branded 'soft' white	**SUPER PREMIUM:** Artisan

Figure 1.1b
French bread market product categories

	Lower Cost	*Differentiation*
Broad Target	**ECONOMY:** Discount priced baguette	**PREMIUM:** Commercially produced artisan-appearing
Narrow Target	**VALUE:** Branded baguette	**SUPER PREMIUM:** Artisan

Source: compiled from author's own research from discussions with S. Cauvain (2007).

1.2.3 Differences in consumption between France and the U.S.

Table 1.3 shows daily bread consumption in France from 1950 through 2004.

Table 1.3
French bread consumption
(Shown as per person per day in grams)

1950	1960	1970	1980	1990	1995	2000	2002	2003	2004
325	265	200	175	160	160	160	155	160	160

Source: FEBPF 2005.

In 2002: 1) Health Ministry campaign to forego white baguette in favour of whole grain might have led to lower overall consumption; 2) Bakers began offering more variety (wholemeal loaves, breadsticks, longer life sliced bread and “exotic” breads from the French regions and world at large), increasing retail competition (Bakers Federation UK 2005). This may have led to increased consumption in 2003-2004.

White bread consumption in the U.S. decreased throughout the 1970s, but increased in the 1980s due to popularity of in-store bakeries (Harwood *et al.* 1989). In order to compare U.S. and French consumption, some adjustments needed to be made as USDA statistics not only include flour consumed as bread, but consumed in other ways (such as filler in packaged foods). Assuming bread in France is some 97 to 99 percent flour, then a daily consumption of 100 grams of bread should result in some 98 grams of wheat flour consumed. Using this logic, French flour consumption from 1950 through 2000 was estimated and compared to U.S. consumption rates. Thus, French consumption in the 1950s was slightly more than twice that of the U.S., but by 2000, French consumption was only 86 percent of the U.S. (Table 1.4). Despite the U.S. adoption of low-carbohydrate diets and a downward consumption pattern from 1950s to 1970s, the U.S. cumulative change for 1950 to 2000 showed an increase of 17.1 percent versus a 64.1 percent decrease in France.

Table 1.4
U.S. and France wheat flour consumption
(Shown as per person per day in grams

Years	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000
U.S. quantity[1]	156.5	142.5	141.5	152.9	176.2	182.2
Rate of change in the U.S.	--	-9.8%	-0.7%	7.5%	13.2%	3.3%
France quantity[2]	318.5	259.7	196	171.5	156.8	156.8
French share of U.S. consumption	203.5%	182.2%	138.5%	112.2%	89.0%	86.1%

Source: Compiled from author's own research based on [1]USDA ERS Agricultural Fact Book 2001-2002; [2]FEBPF 2005 data recast as flour.

The most recent version of the USDA's Food Guide Pyramid recommends 6 to 11 daily servings from the bread/grain food group. Public health experts have argued that the Food Guide Pyramid is unhealthy and that it was produced with the influence of food industry lobbyists (Willett 2001). Confusion over USDA's dietary recommendations may have led to increased consumption of bread/wheat flour.

1.2.4 Influence of low-carbohydrate diets and GI/GL diets

Although low-carbohydrate diets became popular in the 1980s, the Atkins diet is attributed with having introduced the low-carbohydrate trend according to a market study by *Packaged Facts* in 2005. "By 2003-2004, some 30 million Americans were following the diet. In a 2003 poll of shoppers by the Food Marketing Institute, 20 percent said they had started buying specific products because they were low-carbohydrate; food manufacturers that same year introduced more than 3,000 new low-carbohydrate products" (Wharton Marketing News 2005). Despite the popularity of low-carbohydrate diets, 25 percent of consumers report purchasing more bread in 2005 than they did in 2004. Of that group, 44 percent attributed the increase to stores offering more variety and nearly half of that group believed product quality had improved (Bakingbusiness.com 2005).

1.2.5 Producer interest in low-carbohydrate and GI/GL diets

Whether or not low-carbohydrate diets are a fad or a trend, market data places low-carbohydrate products clearly in the lucrative super-premium food category. E.g. in 2003, growth of U.S market value (at 235 percent) far outpaced growth rate of the actual number of low-carbohydrate products (at 3.8 percent) introduced to the market (Euromonitor International 2004). For bread producers facing a nearly saturated market with flat growth, the low-carbohydrate diet may represent an unexpected marketing opportunity.

Although Atkins and other low-carbohydrate diets seemed to catch bread producers unprepared, some producers have responded to the GI/GL system more proactively. E.g.: "Warburtons developed … [its All in One] bread with a low glycaemic index as both consumers and producers have become more aware of the benefits GI can have in controlling diabetes, obesity and energy levels. … [Warburtons] used added fibre and a special ingredients formula to develop the white bread with the goodness of wholemeal and a low position on the glycaemic index. … Warburtons' spokesperson, Claire Simpson, said that, 'After Atkins and low-carb diets, there's been a lot more coming into the press about GI and complex carbohydrates and the role that they have, particularly for children' " (BakeryAndSnacks.com 2/18/2005).

1.2.6 Comparison of bread market issues

Marketers look at the bread market similarly in France and the U.S.; production methods are the same. Although strong interest in low-carb and GI/GL diets/foods, Americans consume 16 percent more flour per day than do French who show little interest in low-carb and GI/GL diets but stronger interest in wholegrain breads (Table 1.5).

Table 1.5
Comparison of France and U.S. bread markets

Characteristic	France	U.S.
Same 4 product segments	Yes	Yes
Same production methods	Yes	Yes
Per capita flour consumption	157 grams/day	182 grams/day
Impact of low-carb, low GI/GL diets	Little direct effect; stronger influence on wholegrain breads	Strong effect on demand

Source: Compiled from author's own research.

1.3 The bread VC in France and the U.S.

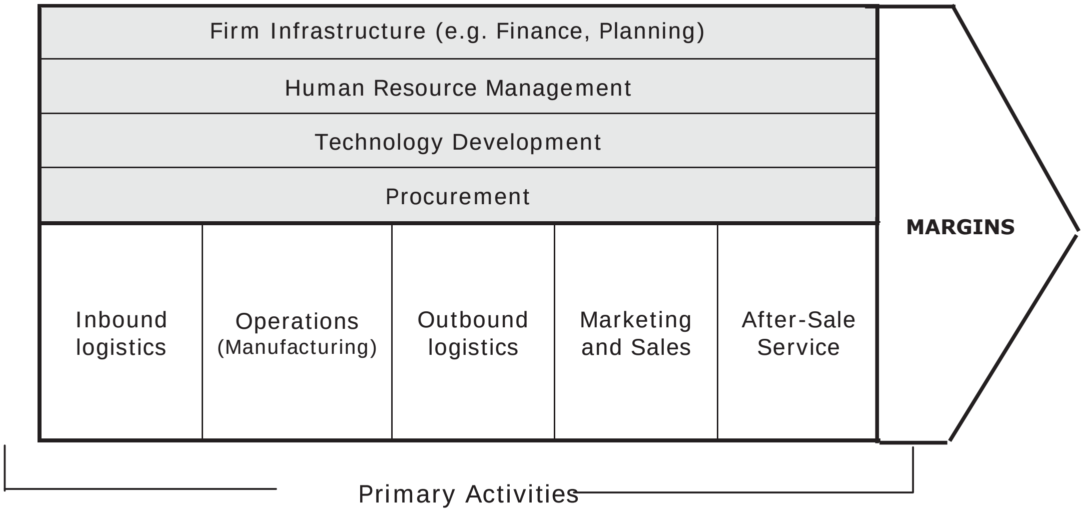
1.3.1 The VC for bread

"Every product has a value chain that has been defined as the set of linked activities required to transform raw materials into products for end consumers" (Shank and Govindarajan 1993). Each link in the VC (Figure 1.2) adds economic value to the finished product and, this in turn, helps to create competitive advantage (Porter 1985). Individual firms also have an internal VC (Figure 1.3).

Figure 1.2
Classical Value Chain

Source: Porter 1985

Figure 1.3
Porter's view of a firm within the VC

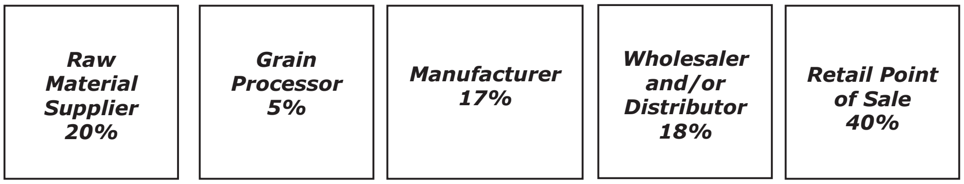


Source: Porter 1985

Porter splits this ‘internal VC’ into primary activities (i.e. “ongoing production, marketing, delivery and servicing of the product”) and support activities (i.e. all functions needed to support the primary activities, e.g. purchasing, information technology, human resources); every primary activity draws on the support activities (Porter 1985). Raison d'être for the internal VC is increased margins.

Figure 1.4 depicts a composite of the typical VC for bread and bakery products based on interviews with large international bread manufacturers. Ranges shown indicate the amount of processing involved in manufacture (Akdeniz *et al.* 2003).

Figure 1.4
Bread VC for large commercial bakeries



Source: Compiled from author’s own research based on Akdeniz *et al.* 2003.

1.3.2 Economic comparison of the bakery-VC in France and the U.S.

Table 1.6 summarizes key economic data for the bakery-VC in France and the U.S.

Table 1.6
Summary of general economy and the bakery-VC in France and the U.S.

	France	**U.S.**
General economy	“Good”	“Better”
GNI per capita	Lower GNI	Higher GNI
Unemployment	9.7%	5.3%
GDP (in 2005)	$1 897.8 billion	$12 455.1 billion
Retail bakery sales (in 2005)	$7.45 billion	$19.43 billion
Bakery share of GDP (in 2005)	.39% (more than twice the U.S. share)	.16%
Bakery industry employment (in 2005)	35 thousand	280 thousand
Bakery share of employment (in 2005)	.140%	.198%
Price of bread	$2.07	$2.25
Share of flour to bread	97 to 99 %	50%
Price adjusted for flour content	$2.07	$4.26

Baker worker productivity:		
Sales per worker	Higher (3 to 4 times more than U.S.)	Lower
Bread volume per worker	Higher (4 to 5 times more than U.S.)	Lower

Source: Compiled from author's own research based on Euromonitor International 2007; FAOSTAT 2006; FEBPF 2007; France in Figures 2007; OECD 2006; U.S. Bureau of Labor Statistics 2005, 2006, 2007; U.S. Economic Census of Manufactures 1997, 2002 and 2003; World Bank 2006.

Although U.S. general economic data is more favourable than French, the contribution of the bakery industry to GDP is more than twice as great in France as in the U.S. U.S. bakers tended to get slightly more than twice the retail price of French bakers per kilo of flour used, while productivity per bakery worker in France was three to five times higher than in the U.S. It appears that the U.S. bakery industry pursued a VC-strategy of increased margins while the French did not.[4]

1.3.3 The U.S. bakery industry

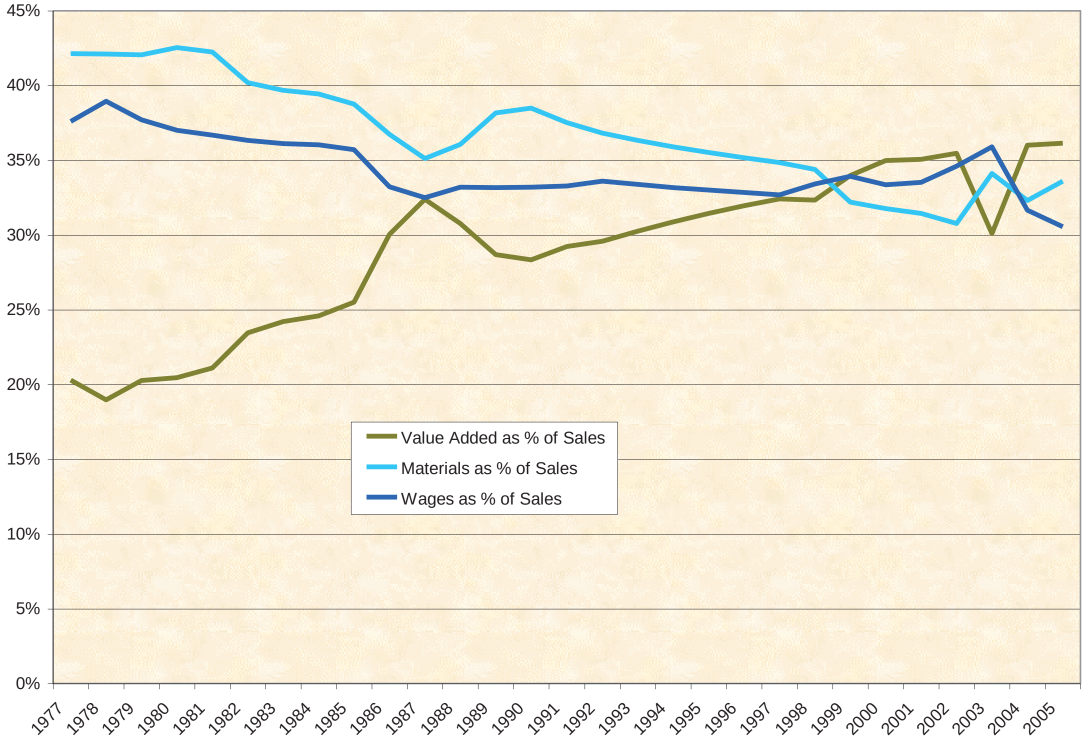
Focus on increased margins

As value added is what remains from retail sales after subtracting the cost of wages and materials, examining changes in wages and materials helps to understand whether U.S. bakers employed a strategy directly aimed at increasing margins. Between 1977 and 2005, wages as a share of retail sales decreased steadily from 37.6 percent to 30.6 percent (Figure 1.5). Cost of materials as a share of sales declined from 42.1 percent to 33.6 percent in the same period. Value of retail sales quadrupled (a gain of 365 percent), yet wages and cost of materials only increased 297 percent and 292 percent, respectively, while value added saw an increase of 651 percent. Therefore, it seems extremely likely the U.S. bakery industry followed a strategy of 'increased margins' between 1977 and 2005.

---

[4] Appendix 1.A describes these data in more detail.

Figure 1.5
Value added, materials and wages as share of sales



Source: Compiled from author's own research based on U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006.

Greater emphasis on financial than operational performance

The U.S. bakery industry pursued a labour policy that also suggests industry strategy focused more on financial performance than on production management concerns:

1) Increase of non-baker FTEs combined with an already low number of bakers. Bakers comprised only 16 percent of the workforce in 2002 (U.S. Census Bureau 2004a; U.S. Census Bureau 2004b);

2) Production volumes per worker were just one-quarter to one-fifth of French production volumes per worker yet retail price per kilo of bread was nearly the same (Euromonitor International 2007). Such low productivity in the U.S. bakeries should have led to uncompetitively high wages. Also, the reduced quantity of flour used in the U.S. permitted a near doubling of sales income (U.S. Economic Census of Manufactures 1997, 2002, 2003). This suggests the industry adopted a

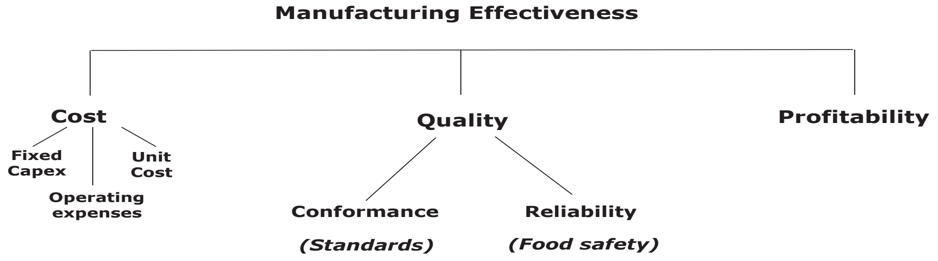
financial solution rather than a focus on improving productivity. Such high margins may also have masked any operational weaknesses.

Consolidations to improve efficiencies

"A consolidation of large bakeries with diversified agricultural firms … introduced financial, managerial, and marketing resources previously not available to the bakery industry" (Harwood *et al.* 1989). Given the large geographic size of the U.S., consolidation across the flour milling and bakery industries doesn't seem to represent optimization of logistics or supply chain; e.g. transportation distances for raw materials would have increased. Therefore, it seems more likely that consolidations might have been driven by a strategy to make Porter's 'support activities' more efficient.

A strategy to increase efficiencies driven predominantly by increased profitability is not representative of an operations management perspective (Figure 1.6). "Profitability is only one aspect of manufacturing effectiveness; cost and quality are equally important" (Noori and Radford 1995). For food products (such as bread), quality characteristics of conformance to product standards and product reliability (i.e. food safety) cannot easily be separated from discussions of effectiveness. A consolidation of bakery plants and mills, that leads to increased transport distances for heavy raw materials (wheat) and for food products subject to staling (bread) seems to ignore the quality aspects of conformance and reliability in favour of profitability. As Porter himself explains, "The ultimate value a firm creates is measured by the amount buyers are willing to pay for its product or service" (Porter 1985). This purely financial perspective of 'value' doesn't appear to consider qualitative product characteristics.

Figure 1.6
Measuring manufacturing effectiveness



Source: Noori and Radford 1995

1.3.4 The French bakery industry

Increased efficiencies via improved processes

While the U.S. emphasized increased margins, the French bakers made product changes that focused on increased efficiencies in production processes. “Traditionally, baguette breads are associated with the artisan baker” (Le Cordon Bleu 2005). French law governs preparation of fresh baguette dough (INBP 2005; Le Cordon Bleu 2005). The majority of bakers[5] in France are artisans, but the share of fresh dough used for baguettes dropped by 71 percentage points between 1985 and 2005. While the use of frozen dough and pre-baked loaves increased by 1100 percent and 800 percent, respectively, the volume of bread produced by artisans declined by only 22 percent (FEBPF 2007). This indicates that artisans also adopted the use of frozen and pre-baked techniques. As artisans employed the new techniques, they began to expand their businesses to the international market. As of 2006, they exported 15 percent of their annual production volume, with 70 percent of that going to North America, Asia and the Middle East (FEBPF 2007).

---

[5] Roughly 66 percent in 2005 were artisans (FEBPF 2007).

Other factors contributing to operational improvements

Personal choice may have also played a role in operational improvements. "The artisan's job has long been considered the most dangerous of all of the French culinary specialties" (Le Cordon Bleu 2005). Due to the risks of lung disease associated with flour particles, making a larger batch and freezing dough could reduce the frequency of exposure.

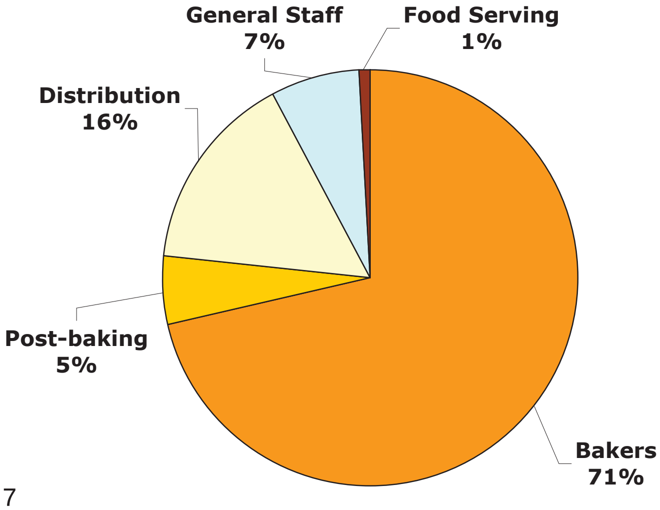
In addition, "French laws require that traditional baguette dough be allowed to rise for a minimum of 12 hours and preferably longer, up to 16 hours, to allow enough time for the yeast activity to fully end" (Le Cordon Bleu 2005). Thus time needed for the second dough rise when added to baking time requires the baker to arrive at work between 4:00 and 5:00 a.m. in order to provide freshly baked bread for customers at 7:00 or 8:00 a.m. Baking a frozen dough or finishing the baking of a pre-baked loaf would allow the baker to start work approximately an hour before the first customers appeared. Some artisans may have preferred the improvement in working hours or those who employed other baking staff might have seen shorter hours leading to cost savings.

Bakery workers allocated according to production processes

The impact of the artisans on the overall scale of worker productivity shouldn't be overlooked. While the U.S. employed bakers at a rate of only 16 percent, in France 71 percent were trained artisan bakers. The remaining 29 percent non-artisan workforce were categorized as the "after the baking stage". As Figure 1.7 shows, even the sub-division of this group was described in production terms: most were involved in distribution activities and only seven percent were dedicated to general staff. To allocate only seven percent of employees to general staff and to label workers according to their role in a production process, is very different from the U.S. practice of categorizing workers according to their cost impact—i.e. employee versus hourly worker. The

French approach suggests a deeper involvement in process management than with increasing margins.

Figure 1.7
Distribution of French bakery workforce by type



Source: FEBPF 2007

Artisans' "pull" approach to retail sales

In kaizen theory, a "pull" system is one in which only as many products are produced as customers will consume; in a "push" system, as many products as possible are produced, whether there is a customer or not (Imai 1997). It is up to Porter's "primary activity" of Marketing/sales to "push" the products onto the market. "Baguettes are perishable by the end of the day they're baked. Bakers only produce for the number of customers they expect in a day" (Le Cordon Bleu 2005). This is a "pull" system; it might indicate that French bakers pursue a strategy of quality management/continuous improvement.

1.3.5 Summary comparison of the bakery-VC in France and the U.S.

There are many similarities between bread products and production methodologies in France and the U.S. but there are also important differences. It appears likely that the considerably higher number of employees and the lower rates of worker productivity in the U.S. would have had a strong negative influence on value added; but that wasn't the case. In 2005, the U.S. bakery industry achieved a value added of 36 percent; possibly due to the higher price per kilo of bread (based on flour content) and by applying downward pressure on wages (Table 1.7).

Table 1.7
Summary of bakery VC strategies in France and the U.S.

Characteristic	**France**	**U.S.**
Industry strategy	Process management and improvement	Financial management and VC optimisation
Main characteristic	Product quality	Increased margins
Primary driver of the strategy	Conformance to baking standards	Added value as share of sales
Strategy benchmark	Best matched production of fresh-baked bread to customers	Getting the highest price the customer will pay
Primary goal of non-baker workforce	Assisting the baker	Selling the product
Primary goal for bakers	Conformance to standards and customer expectations	Exert pressure on cost of materials and wages
Primary goals for government	Sufficient and healthy source of food at an acceptable (economic) price	High employment; contribution to tax revenue; from 1994-onward: as little government regulation as possible

Source: Compiled from author's own research based on FEBPF 2007; U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006.

The French bakery industry is more concerned with the product itself than with financial strategies for the firm. This is clear from the emphasis placed on product conformance and meeting customer expectations. Certainly there are large French producers of baked goods who are more oriented toward financial objectives than the composite data would indicate. At the same time, there are many small artisan bakers in the U.S. whose operational goals are likely to be closer to the French baking industry than to the composite data that described U.S. bakeries. The key issue that emerges from this comparison of the French and U.S. bakery industries is how different their main strategic orientations are. It appears the French bakery industry behaved more like manufacturing companies while the U.S. bakery industry behaved more like large corporate entities, with layers of support staff.

1.3.6 The grain processor-VC in the U.S. and France

The next VC-entity upstream from the bakery is grain processors, including both grain storage elevators and flourmills. The milling industry production processes are similar in the U.S. and France but the elevator operations are not, and the elevator ownership structure is considerably different in each country.

1.3.7 Grain processors in the U.S.

"Dynamic structural changes in the flour milling industry have resulted in fewer and larger firms, larger plants, and increased concentration" (Wilson 1995). "Concentration in flour milling increased substantially, with the top 12 firms controlling almost 84 percent of capacity in 1987, up from 68 percent in 1973" (Harwood *et al.* 1989). The U.S. mills were mostly privately owned and operated until two decades ago when most ownership shifted from small private businesses to large multi-national grain processors (Titus and Dooley 1996). By 2007, "three companies [Cargill, Archer Daniels Midland and ConAgra] accounted for nearly all of the industry's $10.9 billion revenue" (IBISWorld 2008). "Barge operations are largely owned by only four leading grain firms: ADM, ConAgra, Cargill and Bunge[6]" (FAO 2006). Simultaneously as mill ownership changed, deregulation of the U.S. grain industry and ownership changes in the railroads took place. Ownership change in grain elevators began to include the large grain processors and the railroads themselves as co-owners of the elevators. One force behind this consolidation was the pressure to optimise costs (Wilson and Dahl 1999).

The ownership changes introduced by the large grain processors and the railroads began to alter the structure of the bread VC. Some activities that were previously performed by the farmers and/or grain elevators (i.e. Porter's Outbound Logistics and Retail Point of Sale) were shifted to the new

---

[6] "For a more detailed analysis of [the] domestic transportation system in the United States see *Grain Transportation and Marketing Channels*, FAPRI-UMC Briefing Paper No. 4, June 2004" (FAO/Abbassian 2006).

owners. This may have caused the value added for the U.S. grain processors to be higher than would have been possible in the former VC structure. Certainly transport costs of farmers were converted to revenue for the grain processors/railroads or grain processors/barge operators. In addition, a more complex financial transfer would likely be possible due to the grain processors/transport carriers having physical possession/ownership of greatly increased shares of wheat earlier in the process than under the former VC structure. Just as in oil trading, physical possession of large quantities of wheat would be likely to carry financial benefits to grain processors involved in commodities trading.[7] The wheat could be used to leverage a better price, larger margins or other more favourable conditions on purchases of futures and/or options (Battley 1995).

1.3.8 Grain processors in France

Despite pressures to optimise costs, there was little change in the grain processor-VC in France. In an interview with the author on December 10, 2007, Mr. Hervé Le Stum, Executive Director of AGPB described the structure of the bread VC in France: The traditional linkages between wheat growers, grain elevators and millers have remained very strong. Most elevators are owned by cooperatives of farmers and most elevators serve a select clientele of millers who in turn have their own set of baker customers. Although millers may have a preferred grain supplier, the elevators compete very strongly with one another to gain new business. As a result, most millers also have a secondary supplier, and this gives the miller some leverage over both price and product qualities. For example, most elevators employ a specialist (wheat) blender who knows the particular needs of each miller, who in turn has preferences based on the miller's regular set of baker customers. The skill of the blender is one of the important competitive advantages of one grain elevator over another (Le Stum 2007). This has enabled each of the actors in France's bread VC to work closely

---

[7] All four of the leading grain processors are involved in commodities trading, either directly or via subsidiary companies.

with one another. At the same time, benefits accrue to the overall bread VC rather than only to specific elements.

In the U.S., some cooperatively owned grain storage elevators do exist, but in France this is the norm. The French grain storage cooperatives (owned by the farmers) have endured for centuries and refined their operations—and competitive skills—over time. As one personal communication from an agribusiness officer at FAO put it, "The strengths of the French, and other Western European, cooperatives are legendary. There are no similar structures elsewhere" (Tanic 2008).

1.3.9 Summary comparison of the grain processors-VC

As in the discussion of the U.S. bakery industry, the emphasis on increased margins along with the high number of employees suggests that the U.S. grain processing industry was following a VC strategy. Meanwhile, the French grain processing industry (owned by the farmer cooperatives) was focused on competition based on differentiation of product quality characteristics and customer satisfaction. Table 1.8 summarizes some of the main differences between grain processors in the two countries.[8]

Table 1.8
Summary comparison of grain processors

Characteristic	France	U.S.
Primary goal	Meeting customer requirements	Increased margins
Marketing strategy	Differentiation of product quality characteristics for customer satisfaction	Leverage commodity in grain markets
Benchmarks for strategic success	Tight links to millers (with tight links to bakers)	Value of wheat in the commodities market
Gross sales (in 2000)	$13,754.1 million	$6,612.1 million
Sales per mill (in 2000)	$10.2 million	$18.4 million
Sales per worker (in 2000)	$403,442	$297,521
Workers per mill (in 2000)	25	62

---

[8] Detailed comparisons of retail sales and labour productivity can be seen in Appendix 1.C.

Organizational structure	'Lean'	Possibly 'Top heavy'
Elevator ownership	Mostly the farmers	Mostly grain processors and 2 railroads
Mill ownership	Private	Mostly 3 or 4 largest grain processors

Source: Compiled from author's own research. Compiled from author's own research based on [1] INSEE 2007; [2] *U.S. 2002 Economic Census*, U.S. Census Bureau 2005; [3] *Statistics for Industry Groups and Industries: 2003*, Annual Survey of Manufactures, Dept. of Commerce 2005. Note: [4] Data showed 15,987 employees with another 12,128 equivalent full-time employees (FTEs) based on 25.266 million hours worked by "production workers". *U.S. 2002 Economic Census*, Dept. of Commerce 2005

1.3.10 Some differences between wheat grower-VC in the U.S. and France

"Wheat is grown on more than 240 million ha, larger than for any other crop, and world trade is greater than for all other crops combined" (FAO/Curtis 2000). The world's six highest wheat producers in 2005 included both France (fifth highest) and the U.S. (third). However, in terms of yield per ha, France is the most productive (7 MT/ha) of the six countries; the U.S. (2.9 MT/ha) is less than half as productive (FAOSTAT 2007). While favourable climate and good growing seasons affect productivity per ha, irrigated wheat produces a much higher yield[9] than dryland wheat. However, irrigation use was higher in the U.S. (12.66 percent) than in France (11.44 percent) in 1999 (FAOSTAT 2000).

As the world market price for wheat is more or less uniform, 'retail price' comparisons are meaningless but comparisons of production costs are useful in determining value added. Table 1.9 compares French and U.S. wheat farm data for 2004/2005. In 2005, world market price was $155.98 per MT; French farmers netted $51 versus $37 for the U.S. leading to net revenue per ha of $357 versus $107 for France and the U.S., respectively. France provided work for some four percent more wheat farmers than the U.S. Yet, productivity per worker was 2.33 MT per ha in France compared with 1.45 MT per ha in the U.S.

---

[9] A minimum of five MT/ha is the initial benchmark of a successful irrigation programme. Eight MT/ha is considered the highest practical goal (Rawson and Gómez Macpherson 2000).

Table 1.9
Comparison of French and U.S. wheat farms

	2005 France	2004 France	2005 U.S.	2004 U.S.
Number of ha with wheat	5,280,000	5,220,000	20,240,000	21 million
MT produced	36,922,000	39,704,760	57,105,550	58,737,800
MT per ha	6.99	7.61	2.90	2.80
Wheat value in USD (000s)	$5,759,093	$6,193,149	$8,907,323	$9,161,922
Wheat value per MT	$155.98	$155.98	$155.98	$155.98
Production costs per MT	$105.00	--	$119.00	--
Revenue per MT	$ 50.98	--	$ 36.98	--
Number of wheat farms	112,700	??	166,800	??
Average farm size	46.85 ha	--	121.34 ha	--
Employment	346,200	??	est. 333,600	??
Workers per farm	3	--	2	-
Productivity per worker	2.33 MT/ha	--	1.45 MT/ha	--

Note: Data reflects total wheat and not only bread wheat; U.S. employment based on two persons per farm.

Source: Compiled from author's own research based on FAOSTAT 2006, 2007; AGPB-AGPM 2007; USDA 2007.

The wheat market in France is considerably more focused than in the U.S.: 1) France limits wheat varieties to a group of 60 to 80, split into three categories[10]; more than that would not be financially sustainable (Le Stum 2007). 2) The U.S. has more than 30 000 varieties, split into six categories. Bread and pasta categories are similar to the French; wheat that is too soft for bread or pasta is used for noodles, cakes, cookies and filler for packaged food products.

France predominantly grows spring wheat that is planted and harvested in the same calendar year with costs and revenue also occurring during the same calendar year. The majority of U.S. wheat is winter wheat with planting in one calendar year and harvesting the next year.

---

[10] I.e. bread, pasta and animal feed.

The U.S. reports its data as bushels while France uses MTs. Because a bushel represents a mass volume, rather than weight of its contents, every year's data varies because moisture and protein content cause the average weight to vary with each crop.[11]

The U.S. Government views harvesting wheat—and other grains and cotton—as 'extractive economic activities' like mining or crude oil production. As a result, official economic data is not easily compared with other countries that consider wheat production as a type of manufacturing. To see the significance of this, Table 1.10 recasts U.S. farm data to match the reporting format the U.S. Government uses for manufacturing enterprises.

Table 1.10
Value added for U.S. wheat farmers in 1998
(Calculation shown in billions of USD)

Characteristics of 1998 U.S. wheat production:	Value Added calculation:
Revenue	***$7,090***
Total 65.8 million planted acres	
Produced 2.55 billion bushels; up 2.8% from 1997 (or 69.4 million tonnes)	
Average value of $2.78 per bushel (or $102 per tonne)	
Less Purchased inputs	***$10,098***
Input costs of $166 per acre or $3.96 per bushel	
Calculated at per acre rate: $10,923	
OR per bushel rate: $10,098 (or $145 per tonne)	
Value added	***- $3,010***
Value added as share of sales	***- 42.4 percent***

Source: Compiled from author's own research based on *U.S. 2002 Economic Census*, Dept. of Commerce 2005

The original government data described farm earnings in positive terms (Department of Commerce 2005). However, as Table 1.10 shows, farmers—even before paying themselves or their employees—incurred expenses that were nearly one-and-one-half times the market price for wheat. This occurred despite a market price unchanged for four years and a record surge in output (of 28

---

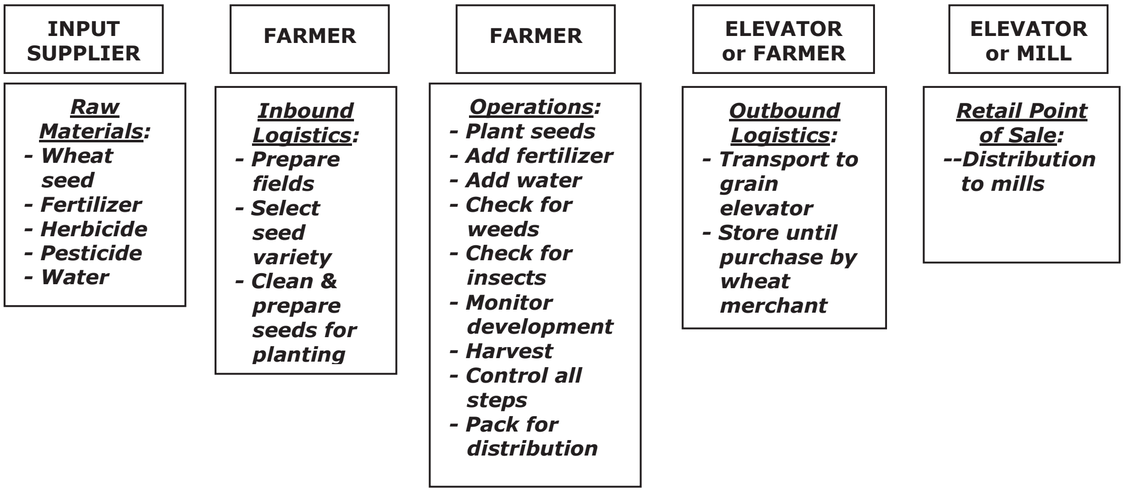
[11] Based on a comparison of U.S. data for 2000 through 2005 bushels ranged from 36.67 to 36.86 per MT with 36.74 bushels being the most frequent figure (FAO 2005; OECD 2005). Therefore, 36.74 bushels per MT was used in this thesis.

percent). From a business perspective, the U.S. wheat farmers did not 'add value' but rather lost 42.4 percent of their revenue.

1.3.11 Framework for a generic wheat farm-VC

Although baking plants and flourmills are relatively easy to imagine as manufacturing entities, a literature search found a gap in describing the wheat farm-VC in operations management terms. Therefore Figure 1.8 depicts an operations management perspective of the wheat farm based on narrative descriptions found in the literature (Rawson and Gómez Macpherson 2000; KSU 1997; Anderson and Impiglia 2002; NDSU 1997; OSU 1995; Maier 2002; Herrman 2002; Stapper 2006, 2007; ARVALIS and IRTAC 2000). S. Cauvain (Thesis industry advisor) and L. Bona (Wheat developer at the Hungarian National Wheat Research Institute) validated the data in the diagram.

Figure 1.8
Generic VC for wheat production

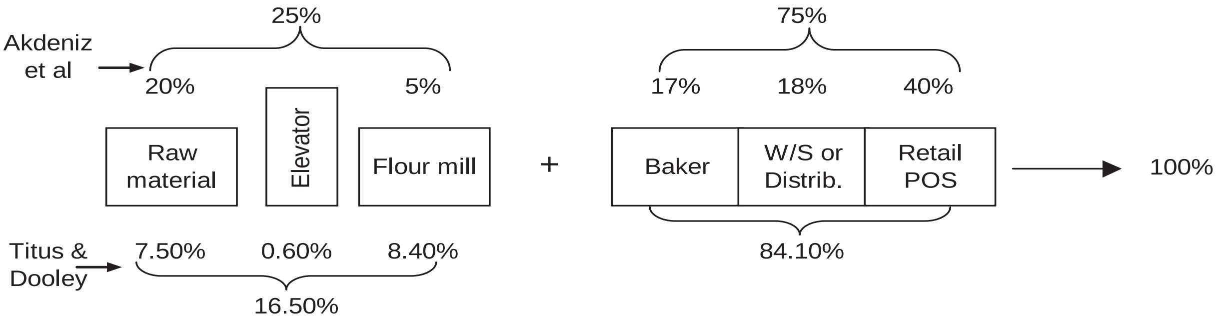


Source: Compiled from author's own research.

1.3.12 The wheat farm-VC in the U.S.

Figure 1.9 compares value added from Akdeniz *et al.*'s study (Figure 1.4) of international companies with a study by NDSU, a major U.S. wheat-growing state. NDSU analysed VC costs associated with white bread produced and sold by small independent bakers in four states in the North Central U.S. (Titus and Dooley 1996).

Figure 1.9
Value added by commercial and independent bakers



Source: Compiled from author's own research based on Akdeniz *et al*.2003 and Titus and Dooley 1996.

Several points suggest U.S. value added was different from the international companies. This may have resulted from the strategies employed by the three largest grain processors and their railroad partners:

- Titus and Dooley assigned only 7.5% value added to the wheat farmer; a negligible 0.6% to the grain elevator, altogether roughly 8.1%. Thus, the farmer's share of 7.5% is considerably smaller than the 20% in Akdeniz *et al*.

- The flourmill and elevator in Akdeniz *et al.* received 5% but only 9% from Titus and Dooley. This likely reflects the grain processors/railroads recouped the value of transportation (some 2%). Also, Titus and Dooley studied farmers in the large, sparsely populated states of North and South Dakota, Montana and Minnesota where distances between farms, elevators and mills are much greater than other regions.

- From 1997 through 2002, value added for all U.S. grain processors ranged from 23.7% to 32%. The equivalent figure in the Titus and Dooley study was likely 7%.[12] Although this is much

---

[12] After adjusting for the extraordinary transport revenue.

closer to Akdeniz *et al.*'s international grain processors (i.e. 5%), it was far less than in later years in the U.S.

- During 1997, value added for U.S. grain processors was 23.7% and bakers saw a positive 32.4%; yet wheat farmers lost value at a rate of 42.4%.

It is not clear whether a 'free market' existed for U.S. wheat sales. Some restructuring and ownership changes in the railroads changed network routes and tariffs (Wilson and Wilson 1999). Some changes had already begun when Titus and Dooley studied the bread VC. By 2007, nearly all U.S. grain elevators were co-owned by the four largest grain processors/their railroad partners. Although sales of wheat would have been based on world market price, if a farmer didn't like terms offered by the local elevator company there would be few alternatives. As for transportation, the farmer would have no alternative to the railroad's rates and conditions. All of this suggests that a type of oligopsony developed; the effects can be seen on wheat farmers' earnings.

In 1994, just 38 percent of wheat farmers earned less than U.S. GNI. In 1996 the Federal Agriculture Improvement and Reform Act was passed and intended to prepare for a free agricultural market. But after the law passed, "wheat farmers got 50 times more in subsidies for their 1996 crop than before" (Bovard 1999). Despite the dramatic rise in subsidies, wheat farm earnings continued to decline and by 1998, a majority (59 percent) of wheat farmers were earning less than 60 percent of GNI (USDA 2002). Despite revenue from wheat sales combined with the largest government payments in the OECD[13], a majority of wheat farmers were on welfare (USDA/ERS 2002). By 2005, more than 80 percent of wheat farmers required welfare payments to compensate for their very low incomes—despite also receiving direct government payments that were so large they outweighed revenue from wheat sales (USDA 2007). "Without government

---

[13] Producer Support Estimate per farmer from 1998-2000 in the U.S. was $20,803 vs. OECD average of $11,334 (OECD 2001).

payments, fewer than 20 percent of the specialized wheat farms [i.e. those primarily growing wheat] would have had farm revenue greater than economic costs" (USDA/ERS 2006). 'Economic costs' are "cash costs plus an allowance for depreciation plus imputed returns to management, land, and unpaid labor of the operator and family" (USDA/ERS 2006). Already more than 80 percent of wheat farmers could not cover their business expenses, let alone pay themselves a wage.

Not only was the number of farmers who needed help climbing rapidly, their farm earnings had dropped by 40 percent in five years (USDA/ERS 2006). Although there is a world market price for wheat, governments do intervene to influence the price. As the USDA explains, government practice was to support farm prices by withdrawing wheat from the market and placing it in government stocks, while private stockholding was aimed at profiting by withholding wheat from the market when prices are low and selling later when prices rise (USDA 2000). So, why didn't the U.S. government withhold more wheat from the market to raise wheat farm income? The issue is because it couldn't. In the early 1990s commercially held wheat stocks accounted for a relatively small share of total U.S. stockholdings. But by 2000, wheat held by the commercial sector made up a predominant share of U.S.-held stocks (USDA 2000). In other words, the grain processors and the railroads controlled the majority of wheat stocks—and indirectly farm income. It appears the bread VC had been restructured causing a very detrimental effect on wheat farm incomes.

U.S. Government policy

Given the dire situation of U.S. wheat farmers, one might expect them to abandon wheat growing in favour of more profitable crops. However, federal law prohibits farmers from attempting to grow other crops (even trees or perennial plants) on land that has been designated for wheat, other grains or cotton. According to USDA, the passage of the "Federal Agriculture Improvement and Reform Act of 1996 severed the connection between program payments and market prices and gave flexibility in making cropping decisions to farm operators, landowners and managers"

(USDA/ERS 2000). This new ‘flexibility’ seems to have been non-existent in practice as any farmers who attempted to grow fruits/vegetables on land designated for ‘commodity crops’ received financial and administrative punishments from the USDA (NY Times/Hedin 2008).

The federal law passed May 22, 2008[14] guarantees three types of payments to wheat farmers from 2008 through 2012 whose acreage exceeds ten acres (approximately 4.1 ha): 1) direct payments for each bushel produced; 2) “counter-cyclical” payments to guarantee a fixed minimum market price per bushel; 3) crop acreage payments for every acre planted with wheat. The payments are available to all categories of wheat producers (owners, operators, landlords, tenants, or sharecroppers) and wheat seed growers. Although the payments scheme is based on harvested crops, payments can also be accessed prior to harvest by forfeiting 20 to 30 percent of the projected payment, effectively treating the advance payments as an ‘unsecured loan’ with interest rates similar to credit card debt (U.S. Public Law 110—234 2008).

According to Public Law 110–234, it appears the farmer has two legal exits from the USDA programme: 1) to permanently reduce the number of designated acres (and thereby, permanently opt out of the payments programme); 2) to redevelop the land as multiple residential housing units (or other non-farm use) and in such a manner that “the size of the tracts and the density of the subdivision is such that the land is unlikely to return to the previous agricultural use.”

The USDA described the farmers’ economic problems as resulting from several factors:

- “Stagnant … demand for wheat” (USDA/ERS 2005). U.S. share of world wheat sales dropped from 28.48 percent in 2000 to 23.03 percent in 2006 (USDA/FAS 2006).

---

[14] Also officially known as the ‘‘Food, Conservation, and Energy Act of 2008.’’

- Increased international competition. The exported share of U.S. wheat steadily declined from 75 percent in 1987 to 41 percent in 1998 (USDA/FAS 2007).
- Stronger emphasis on wheat's quality characteristics. "Several important importing countries … liberalized import purchasing regimes. As a result, large grain companies expanded their role in the international wheat trade making it more 'market oriented,' resulting in more care being paid to quality considerations" (USDA/ERS 2005).

Two other (rather specious) explanations were: new flexibility in cropping decisions; and continued subsidies from the EU countries (USDA/ERS 2005). As the discussion of Public Law 110-234 showed (above), there is very little flexibility in cropping decisions for U.S. wheat farmers. As for EU subsidies, the U.S. has paid the highest subsidies in the entire OECD since approximately 1996 (OECD 2001). Despite blaming continued EU subsidies, USDA seems aware that the subsidies would've had little impact on U.S. competitiveness: "Although the EU-25 continues to subsidize exports, the subsidies in recent years have been relatively small and often nothing" (USDA/ERS 2005).

Despite much literature that criticises the U.S. grading system and relates its use to questions of wheat quality (Hill 1990; Johnson and Wilson 1992; Marlenee 1987; Pick *et al*. 1992; Wilson and Preszler 1992), the USDA rejected any changes for the last two decades. It is difficult to understand the USDA resistance to making changes that might enable U.S. wheat growers to be more competitive. But the history and development of the grading system are equally difficult to appreciate.

Grain traders, substituting for government employees in 1916, developed the grain grading system guidelines that are still in use today (Chicago Historical Society 2005). Throughout the past 150 years, there was no notion of considering wheat as a food. Nor was there any indication in the literature that food scientists, health authorities or others with knowledge of human (or animal) health participated in revising the system. A related issue is the economic role of wheat as a financial commodity traded on the open exchange rather than as a raw ingredient to be used in foods.

On 24 June 2009, a yearlong U.S. Congressional investigation on "Excessive Speculation in the Wheat Market" found that six traders held as much as 60 percent of the wheat futures contracts. Although CFTC regulations permitted the six traders to hold about 39,000 wheat futures contracts, in actuality they held nearly 130,000. Most of the excessive speculation began in 2005/2006, but by July 2008, traders holding futures contracts called for delivery of more than one billion bushels of wheat, while U.S. farmers, grain elevators, grain merchants and other commercial sellers had only some 800 million bushels of wheat. The 'shortfall' pushed wheat prices higher, from just over $3 per bushel in mid-2006 to more than $11 per bushel at the end of 2008. Despite the high prices, by April 2008, the Federal Reserve Bank of Kansas City reported that more than 40 percent of all grain elevators had only enough cash available to "just manage current margin calls." The cash flow problems of the elevators began to affect farmers as the elevators reduced their cash purchases, cut back on forward contracts offered to the farmers, lowered cash prices offered for crops and began to require that farmers pre-pay for seed and fertilizer. Those farmers who were directly participating in the futures market also found themselves subject to rising margin calls (Levin and Coburn 2009).

1.3.13 The wheat farm-VC in France

Structure and strategies of the French wheat growers

In contrast to the weak political position of the U.S. farmers, the French wheat growers are very unusual. France is the most export-oriented country in Europe and agriculture plays an important role in exports. Agriculture is considered strategic to the French national economy. In turn, the wheat growers are the most powerful agricultural producer in France and have used this power to leverage their unique perspective on reform of the CAP (OECD 2001).

The French wheat growers are more formally organized than their U.S. counterparts. AGPB is an industry association funded by the French wheat growers; each producer is a member. AGPB owns ITCF and UNIGRAINS. ITCF is an extension service focused on improving grain producers' production. UNIGRAINS is a bank that finances processing of cereal and animal feed products but does not loan funds to producers. The wheat board, ONIC, is another important organization that represents the farmers; membership is based on a tax assessed against acreage.

French agricultural policy is defined in law[15] and takes a multidimensional view of agriculture including economic, social and environmental aspects. All three areas must be rewarded in order to prevent exclusive support for production. The growers' strategy focuses on increased international competitiveness for both raw and intermediate products (e.g. wheat, flour) as well as improved efficiencies to obtain competitive advantage of export food products. The wheat farmers petitioned the government to make this strategy a national priority (ARVALIS and ONIC 2000).

With the strategy in place as a national priority, the farmers began to develop goals and implement policies to support the strategy; e.g.: 1) developed a new wheat grading system based on intrinsic testing; 2) After much consultation with the millers and bakers, and based on 1999 harvest's intrinsic results, the physical grading criteria were discontinued; similar intrinsic criteria were adopted for wheat used for animal feed. 3) The farmers' main operational goal was to shift as much production as possible from lower grades into the two highest grades – both for breadmaking and for animal feed (ARVALIS and ONIC 2000). Clearly the French growers were behaving as a competitive industry intent on improving their product.

---

[15] Defined in the *Loi d'Orientation Agricole*

Downstream strategies driven from the wheat farm-VC

Although it appears that U.S. grain processors may have shifted revenue from farmers to themselves, this situation wouldn't exist in France. The farmers *are* the grain processors—they own the grain elevator cooperatives and perform some strategic pre-milling processes. The specialist blender that each cooperative hires has exceptional skills in preparing wheat blends for specific millers. Not only is this a service for the miller, but depending on how well the blender knows the miller's needs and how qualified the blender is, the end product can help to make the miller more valuable to each baker the miller serves (Le Stum 2007). Another example is small leaflets prepared by the wheat growers describing the special attributes of certain wheat varieties. The miller gives the leaflets to the baker, who gives them to each customer who purchases the bread made from the special varieties (Cauvain 2007a). These examples show the strong influence of the wheat farmers along the entire VC and their active interest in downstream customers at all levels.

Financial decisions on the farm and at the grain processor cooperatives

Revenue from the wheat farm-VC remains under each farmer's control and revenues from the grain processor-VC are also (largely) under the wheat farmers' direction. The farmers own shares in the cooperatives and participate in decision-making. However, the cooperatives hire business management professionals to carry out specialized tasks needed by the cooperative. Finance managers in the cooperatives perform financial planning and optimisation of investment strategy. Unlike in the U.S., farmers, per se, do not purchase futures contracts. The business managers hired by the French wheat cooperatives may invest in futures, but French farmers have no interest in direct participation in financial markets (Le Stum 2007).

Role of subsidies in France

There is criticism that all former GATT countries still maintain some form of subsidy despite the URAA that agreed to eliminate subsidies. The OECD describes the direct government payments in the U.S. as a particular violation because of the magnitude of the payments and the fact that they hadn't previously existed (OECD 2001). Although the OECD literature doesn't separate French payments to farmers from other EU nations, the French government figures show decreasing percentages for each year after 1995 and display a complete absence of subsidies by year 2000 (INSEE 2007). But, the U.S. data shows a similar absence of subsidies (USDA/ERS 2002).

Other forms of assistance to farmers exist in both countries. In the U.S., welfare assistance and special income tax deductions are offered in addition to direct government payments. In France, INRA assists the farmers in selection, cleaning and other scientific advice on the use of farmer-saved seed. While the funding for INRA comes from the national budget and could be interpreted as government assistance, INRA's primary goal is to preserve the varietal traits of the wheat plants in support of food safety (Le Stum 2007).

1.3.14 Comparison of wheat production costs in France and the U.S.

In 1990 UNIGRAINS initiated research comparing production costs on French wheat farms with the U.S. UNIGRAINS researchers collected data from 3,000 farms in 16 regions in the northern plains, representing more than half of all French wheat production from 1982 through 1989 (Le Stum and Camaret 1990). USDA methodology was adopted and all costs were expressed on a 'per hectare' basis.[16]

---

[16] A detailed description of the comparison appears in Appendix 1.D.

Adjustments[17] were made to the UNIGRAINS data by the author to include factors (e.g. interest expense related to spring versus winter wheat) that were not part of the original analysis. After these adjustments, production costs of French growers were some 25 percent higher than those of the U.S. (i.e. $1,471/ha versus the adjusted U.S. rate of $1,191/ha); yet French growers' costs per MT were only half as much as the U.S. growers (i.e. $235 compared with $451). There could be several reasons for the higher rates of effectiveness of the French growers:

1) More irrigation was in use in France and this led to a higher yield per ha.

2) The U.S. growers are motivated by the USDA's wheat acreage payments scheme to plant as many wheat acres as possible, rather than to produce as many bushels as possible.

3) Both sets of growers are motivated to keep costs as low as possible, but perhaps there is some sort of 'minimum effective expenditure' per ha. If so, the difference in French and U.S. expenses might suggest that U.S. growers spent too little while the French were more focused on obtaining a certain level of quality.

4) Another possibility is there might be an optimal range of 'MT per ha' in terms of production costs balanced against yield. Literature suggests an optimal range for irrigated wheat between five and eight MT per ha (Rawson and Gómez Macpherson 2000).

Additionally, it should be noted that the wheat markets in both France and the U.S. weren't subject to (URAA) reform until 1995. Therefore, financial behaviour of farmers in 1989 would have been strongly influenced by government policy and existing subsidies. It isn't precisely clear how farmer expenses would compare today, as no more recent literature was found than the work of Le Stum and Camaret in 1990.

---

[17] Details are seen in Appendix 1.D.

1.3.15 Comparing productivity of French and U.S. wheat farms

A comparison of wheat farm productivity in 1989 and 2005 (Table 1.11) leads to the following observations:

1) In 1989, French farms were considerably less productive than those in the U.S.; planted ha per U.S. farm were ten times higher than in France and U.S. farmers produced four times more MT of wheat;

2) The changes that took place in French agriculture from 1989 to 2005 were dramatic: planted ha per farm increased nearly fivefold; MT of wheat increased more than fivefold;

3) Comparison of U.S. data from 1989 to 2005 showed less change; planted ha grew by 16 percent and MT produced increased by 25 percent.

Table 1.11
Productivity per farm

1989	**France**	**U.S.**
Farms per wheat-planted hectares	1:10	1:104
Farms per tonnes produced	1:63	1:274
2005	**France**	**U.S.**
Farms per wheat-planted hectares	1:47	1:121
Farms per tonnes produced	1:328	1:342

Sources: Compiled from author’s own research based on Le Stum and Camaret 1990 and detail from Table 1.9. Additional description can be found in Appendix 1.D.

4) By 2005, French wheat farms were producing nearly the same MT-per-farm as the U.S., but using roughly a quarter as much land. Yet, the majority of U.S. wheat farmers were on welfare (despite government supplements that more than doubled their wheat revenues) while the French wheat farmers were profitable and receiving little in the way of subsidies.

5) The dramatic productivity improvements by the French farmers might have partially been due to improvements in methods and technology, but were also likely to have been influenced by a high exit rate from wheat farming between 1989 and 2005--more than 70 percent of French farms versus

slightly less than 40 percent in the U.S.[18] The French farmers who chose to exit wheat farming were enjoying much more favourable financial circumstances than their U.S. counterparts; more U.S. farmers might have preferred to exit if U.S. government policies had not discouraged them from doing so.

1.3.16 Summary comparison of French and U.S. wheat farms

Table 1.12 compares wheat farm issues in France with the U.S. Clearly the French wheat farmers are considerably better off than their counterparts in the U.S.: Income is higher; farm size is smaller; political power is greater. In addition, French wheat production strategy is aimed at highest possible quality rather than lowest possible cost of production.

Table 1.12
Summary comparison of wheat farm-VCs in France and U.S.

Characteristic:	France	U.S.
Economic situation of wheat farmers	Stable	Majority in need of public assistance
Political position of farmers	One of the country's strongest lobbies	Little power
Primary product strategy	Highest possible quality	Lowest possible cost of production
Number of wheat farmers	112,700	166,751
Average farm size:		
Small farms	60 to 150 ha	490 ha
Large farms	150 ha or more	525 ha
Yield per hectare	7.5 MT	3.0 MT
Average farmer net income (2003):		
Small farms (no government payments)	€17,000	$11,000
Large farms	€30,000	$41,000 goes to less than ten percent of farmers

Source: Compiled from author's own research.

---

[18] Compiled from data in Le Stum and Camaret 1990 and detail from Table 1.9.

1.4 Bread VC's links to GI/GL levels

A survey of French and U.S. literature described a variety of causes for high GI levels in bread[19] as well as beneficial/detrimental links between the bread VC and GI/GL levels: ingredients used (Section 1.4.1); processes employed by any of the VC-entities (Section 1.4.2); and intrinsic quality characteristics of the wheat used (Sections 1.4.3, 1.4.4 and 1.4.5).

Section 1.4.6 summarizes the various literature reviews (Table 1.16).

1.4.1 Ingredients used in breadmaking

Table 1.13 shows a list of more than one hundred ingredients typically used in bread production and the operational purpose of each ingredient. Items 1 through 4 are the minimum ingredients that might be found in a loaf of bread; they are the primary ingredients used in artisan-type bread, while ingredients 1 through 12 are typical for industrial-type bread. The ingredients in Item 13 are being added by producers to respond to consumer concerns about possible health risks (i.e. weight gain and high GI/GL values) associated with eating white bread. Several of the ingredients (i.e. 13.1, 13.2, 13.3 and 13.5) are known to result in a lower GI/GL value (McKeown, *et al*. 2004; Willett, *et al*. 2002; Liu 2003; Wolever 1994). Nutraceuticals (Item 13.6) are a recent addition to breads and often take the form of vitamins, antioxidants or other nutritional supplements. Item 10.3 (potassium bromate) is the only item not used in both countries. While legal in the U.S., potassium bromate is not permitted in France. In both countries flour is bread's chief ingredient.

Table 1.13
Typical ingredients used in bread

Item nr	Ingredient name	Production purpose in bread
0	**Formulation ingredients**	**Used in Mixing Stage**
1	**Flour**	Chief ingredient
2	**Yeast**	Leavening
3	**Salt**	Controlling yeast
4	**Water**	Dough consistency
5	**Sugar and sweeteners**	
5.1	Sugar	Yeast activation; flavour
5.2	Other sweetener	Flavour

---

[19] Appendix 1.E shows a detailed summary (Table 1.E-1) of literature linking bread to high GI levels.

Continuation of Table 1.13

6	**Liquid brew**	Flavour
7	**Fats**	
7.1	Soft fats	Softening agent; increase shelf life
7.2	Solid fats	Stabilize dough; increase shelf life
8	**Milk solids**	
8.1	Skimmed milk powders	Crust colour; flavour
8.2	Other milk solids	Crust colour; flavour
9	**Emulsifiers:**	
9.1	DATA Esters (E472e)	Stabilize dough
9.2	Sodium stearoyl-2-lactate (SSL, E482)	Enhances gas retention
9.3	Distilled monoglyceride (E471)	Extends crumb softness
9.4	Lecithins (E322)	Enhances gas retention; extends crust crispiness
10	**Improvers and/or flour treatments:**	
10.1	Ascorbic acid (E300, vitamin C)	Stabilizes gluten network
10.2	L-cysteine (920)	Improves dough flow
10.3	Potassium bromate (U.S. only; illegal in EU)	Stabilizes gluten network
11	**Enzymes:**	
11.1	Fungal alpha-amylase	Slows crumb firming
11.2	Bacterial alpha-amylase	Slows crumb firming
11.3	Cereal alpha-amylase	Slows crumb firming
11.4	Enzyme-active malt flour	Gas production; gas retention; crust colour
11.5	Enzyme-active soy flour	Crumb whiteness
12	**Preservatives:**	
12.1	Calcium propionate	Mould prevention
12.2	Ethyl alcohol	Mould prevention
12.3	Potassium sorbate	Mould prevention
13	**New additions:**	Added health benefits
13.1	Wheat germ	Lower GI level
13.2	Wholegrain	Lower GI level
13.3	Resistant starch	Lower GI level
13.4	Fruit	Add antioxidant
13.5	Nuts	Add antioxidant; lower GI level
13.6	Nutraceuticals	Various (and uncertain benefits)

Source: Cauvain 1998 and 2006; BakeryAndSnacks.com December 2, 2004.

1.4.2 Bread VC processes linked to GI/GL levels

The main properties of wheat that concern health characteristics are protein, starch and the mineral content (or micronutrients[20]). The proportions, and quality of each, are highly dependent on the particular wheat variety, climate and even the soil geology, especially with regard to mineral content (Cauvain 2007). However, processes employed in the bread VC can modify grains, affecting GI/GL levels in the final product. The effects of: processing and refining grains; starch

---

[20] Also known as trace elements.

gelatinisation; particle size and fibre represent processes that might influence wheat's impact on GI/GL levels.[21] Table 1.16 (Section 1.4.6) summarizes these effects.

1.4.3 Composition of the wheat grain

A description of the wheat grain and role of protein and starch in the grain helps to better understand the influence of wheat quality characteristics on human health. "Cereals not only provide carbohydrates but also fibre, plant protein, minerals and micronutrients. The two factors that mainly determine the level of minerals and micronutrients in bread are the flour milling method and the type of wheat used. Minerals and vitamins in the wheat grain are concentrated in the outer envelope (the bran) and the germ, which are removed in the milling process. The use of enriched or wholemeal flour improves the nutritional density of the bread (i.e. the content of major minerals such as magnesium, trace elements and micronutrients is increased) and also makes the bread a useful source of dietary fibre" (INRA 2002).

The wheat kernel

The wheat kernel endosperm is the internal part of the grain that is ground into flour. It represents 82 to 85 percent of the total composition of the grain and includes both protein and starch. The outer layer of the grain (bran) is primarily composed of fibre, and represents 15 percent of the grain. The balance is the wheat germ—rich in vitamin B, minerals and protein; it represents some 2-3 percent of the wheat grain (Cauvain 2009; ANMF 2007).

Starch in wheat

The French baking literature describes starch as being present at a rate of some 70 percent (in every type of grain). Starch behaves as a slow-release carbohydrate and is considered to be a member of the family of nutrients that the human body slowly converts to sugar during digestion (Vantal

---

[21] Appendix 1.E describes these effects in more detail and summarizes relevant literature (Table 1.E-2).

2001). The fact that wheat starch is a "slow-release carbohydrate" and that protein (and other micronutrients) form the balance of the nutritional composition of wheat, should cause food products made from wheat to be low GI/GL. But that hasn't been the case. The fundamental reasons behind this have to do with what makes for 'good protein'.

'Good protein' quality characteristics

Good protein quality in wheat is largely a factor of two characteristics:

1) <u>The wheat kernel's protein-to-starch ratio</u>;

An increase in starch found in the wheat kernel will automatically result in a decrease in protein, leading to a less favourable wheat for many baking processes. At the same time, wheat with higher levels of protein (and lower levels of starch) is more likely to result in lower GI/GL values (Cauvain 2007).

2) <u>The wheat kernel's amylose-to-amylopectin ratio</u>;

The starch found in the wheat kernel is of two types (amylose and amylopectin), and a higher proportion of one type will automatically lower the other. Higher proportions of amylose (and therefore, lower levels of amylopectin) have a more beneficial effect on GI/GL levels. Considered altogether, these factors (protein-to-starch ratio and amylose-to-amylopectin ratio) in wheat flour can be described as contributing 'good protein' (Cauvain 2007).

1.4.4 Amylose-to-amylopectin ratio

After milling the wheat, starch remains the main component of flour, representing about 65 percent of the material (at 14 percent moisture). It is also a very necessary component to breadmaking in that it contributes to the bread's structure and impacts how quickly the bread stales. "Wheat starch comprises about 23 percent amylose and 73 percent amylopectin, although the two represent about 15 percent and 50 percent of the flour weight, respectively" (Stauffer 1998). "The starch polymer consists of two structurally distinct polysaccharides: amylose and amylopectin. Amylose is an essentially linear polymer, apparently amorphous, containing approximately 4000 glucose units. Amylopectin, the partially crystalline component, is a multi-branched polysaccharide composed of approximately 100,000 glucose units" (Schoch 1945).

Although starch (in general) is beneficial to human health, the impact on GI/GL levels in the end product from amylose and amylopectin are not the same. In a literature search it was found that increasing the proportion of amylose resulted in lowered GI levels; an increase in the proportion of amylopectin increased GI levels. However, the increased proportion of amylopectin improved the bread's ability to retard staling. Table 1.14 shows a summary of the related literature search:

- Items 1 through 3 are summaries of various nutritional studies that showed when amylose was increased to 50 percent or more of flour volume, there was a reduced glycaemic and insulin response (Behall *et al*. 1989; Behall and Howe 1995; Behall and Hallfrisch 2000 and 2002; Hoebler *et al*. 1999). In other words, the increase in amylose was very favourable for human health.
- Item 4 describes a study conducted by cereal scientists; the study is frequently quoted in the bread technology literature (Ghiasi *et al*. 1984). The purpose of the study was to validate the contribution of amylopectin to retardation of bread staling. Starting with a mix of 25 percent amylose and 75 percent amylopectin, the proportion of amylopectin was increased until the bread collapsed. The beginning proportions were shown to be optimal for firm bread structure and greatest delay in staling. Unfortunately (as seen in the first three studies), lowered amylose would seem to be less beneficial for humans.
- Item 5 describes a study that was done to look at both breadmaking and GI response. Amylose was added to the dough as maize starch at varying proportions (but consistent with levels

described in studies 1, 2 and 3). While the effect on human health was beneficial (i.e. decreased GI response), the bread could not be baked properly.

It would seem that the optimal balance between lower GI/GL levels and producing properly baked bread might lie with the initial proportions of amylose-to-amylopectin (i.e. 25 percent amylose and 75 percent amylopectin) used in the first Ghiasi *et al*. trial (Item 4 in Table 1.14). However, this bread would presumably stale rapidly.

1.4.5 Health characteristics connected to the wheat farm

Literature gap

There is a partial gap in the literature concerning links between wheat quality characteristics and human health. Considerable literature does exist that describes the nutritional aspects of wheat as a food, but most of the literature linking wheat to human health begins at the stage that some processing or refining is done. Some literature was found that discussed certain components of wheat and human health (i.e. the 'good protein' characteristics that were discussed in Section 1.4.3). Studies by physicians, dieticians and other nutrition experts described other beneficial characteristics of wheat (e.g. fibre or resistant starch), but didn't discuss how the characteristics were derived/influenced on the farm (e.g. through choice of wheat variety, growing conditions). The only studies found directly connecting wheat quality characteristics to health were from veterinary schools or pertained to cultivation of wheat for animal feed. However, the veterinary studies could be correlated to other research done by plant physiologists, agronomists and biology experts interested in wheat and human health.

Table 1.14
Literature summary regarding amylose–to-amylopectin ratio

Item	Researchers	Entity	Purpose	Study year	Conclusions
1	Behall *et al* (nutritionists)	Beltsville Human Nutrition Research Center (now USDA)	Affect lipid profile -- 70% amylose and 30% amylopectin -- 30% amylose and 70% amylopectin	1989	70% amylose combination lowered TGs* and lowered overall cholesterol
2	Behall & Howe (nutritionists)	USDA	Affect lipid profile in both normal subjects and those with hyperinsulinemia -- 70% amylose and 30% amylopectin	1995	Lowered TGs* for both groups Normalized insulin response for those with hyperinsulinemia
3	Behall and Hallfrisch (nutritionists)	USDA	Effects of varying levels of amylose on GI -- increased from 30% up to 70% amylose	2002	Levels of 50% or more amylose lowered levels of blood glucose and reduced insulin response
4	Ghiasi *et al* (cereal chemists)	Unknown	Effects of increasing amylopectin on bread staling (firming) -- 25% amylose and 75% amylopectin --16.6% amylose and 83.4% amylopectin -- 0% amylose and 100% barley amylopectin	1984	Amylose gives firm structure but amylopectin slows staling, maximum of 3-5 days Lack of amylose causes bread to collapse during baking
5	Hoebler *et al* (nutritionists)	CRNH (Centre de Recherche en Nutrition Humaine	Effects on GI and insulin --70% maize amylose and 30% wheat amylopectin bread Also measured: -- degree of starch crystallinity and resistant starch	1999	Bread with high amylose starch showed a lower GI response; High amylose content in bread lowered starch degradation Starch resistance from high amylose increased to 14% of dry matter; Bread incompletely gelatinised during baking due to melting temperature 105C attributable to high native and added amylose maize starch

*TGs = triglycerides

Source: Compiled from author's own research.

Literature survey

The veterinary studies used their own set of terms that were not consistent with studies concerning human health. Using the veterinary studies required an additional step of checking the conclusions against the research done by plant physiologists, agronomists and other biology experts to make certain that the different terminology hadn't been misunderstood. Appendix 1.F describes the process used to review the veterinary and animal feed literature and map terminology.

By comparing the terms used in the veterinary/animal feed literature review with the terminology in the human health literature, it was possible to find literature (Table 1.15) that describes wheat characteristics related to management processes on the wheat farm. The veterinary/animal feed studies were generally concerned with what would lead to problems with fibre or starch in wheat (e.g. varietal choice, inadequate precipitation or irrigation, choice of growing season). Two articles, though, were concerned with how faults in producing RS might disrupt its human health benefits (IFIST 2007). Another was concerned with general quality management issues: "The quality properties of a grain are affected by its genetic traits, the growing period, timing of harvest, grain harvesting and handling equipment, drying system, storage management practices, and transportation procedures" (Maier 1995). These three articles were the only literature found that directly links production decisions to health characteristics; all are summarized at the end of Table 1.15.

In addition, there is more literature that connects wheat quality characteristics to conditions and/or processes in the grain elevator. These were purposely not investigated because it is an area already known to be well-researched (Cauvain 2006) and additional citations related to the elevator VC weren't directly useful to this thesis.

Table 1.15
Summary of veterinary/animal feed literature

Faulty or no management decision-category	Beneficial	Detrimental
Impacts of wheat variety choice:		
Wheat is predominantly IDF; therefore, the wheat variety strongly affects its carbohydrate components:	Depends on choice of variety	
-- Includes fast digestible starch (FDS);		X
-- Includes acid detergent fibre (ADF);	X	
-- Includes total and insoluble non-starch polysaccharides (NSP).	Less able to improve insulin sensitivity	
Wheat variety strongly affects resistance to insects, weeds and disease (all of which may adversely impact protein content).	Depends on choice of variety	
Wheat variety strongly affects protein content (and protein content is a measure of quality and a link to health characteristics).	Depends on choice of variety	
Growing season (spring vs. winter wheat):		
Influences bushel weight;	High bushel weight is better for health and for farm revenue	
May decrease crude protein (CP);		X
Influences amylose and amylopectin;	Depends on choice (more amylose is better for health; more amylopectin is better for baking	
Faulty or no management decision-category	**Beneficial**	**Detrimental**
Growing season (spring vs. winter wheat):		
May decrease acid detergent fibre (ADF);		X
May decrease soluble NSP;		X
May increase free sugars;		X
May decrease lignin.		X
Too little precipitation and/or irrigation:	**Beneficial**	**Detrimental**
Correlates to bushel weight;	High bushel weight is better for health and for farm revenue	
May decrease protein content;		X
Too little precipitation and/or irrigation:	**Beneficial**	**Detrimental**
Correlates to carbohydrate composition that may:	Depends on composition	
-- Influence starch;	Increase is detrimental	
-- May decrease soluble NSP;		X
-- May increase free sugars;		X
-- May decrease lignin.		X
Poor quality control category:	**Beneficial**	**Detrimental**
Grain storage under unfavourable conditions may lead to:		
Increased free sugar content;		X
Decreased acid detergent fibre (ADF);		X
Decreased soluble NSP;		X
Decreased lignin.		X
Destruction of wheat protein from heat:		X
-- Can occur with artificial drying or from storage;	Depends on quality control	
-- Can result from insects, disease or weeds.	Depends on quality control	

Poor quality control category:	**Beneficial**	**Detrimental**
Production faults in RS due to improper handling: destruction of fibre; disruption of native starch		**X**
General quality management faults		**X**

Source: Compiled from author's own research based on Choct and Anniston 1992; Maier 1995; Choct *et al*. 1999; Rowe *et al*. 1999; Kim *et al*. 2005a, 2005b, 2004; Kim 2006; Zijlstra 2006; IFIST 2007; Hoffman 2009.

1.4.6 Summary of the literature linking bread VC and GI/GL levels

Table 1.16 is a consolidated view of health characteristics found in the literature reviews discussed in Sections 1.4.1 through 1.4.5. Table 1.16 separates 'detrimental' from 'beneficial' linkages; then the health characteristic categories are split by those related to: processing or refining; characteristics of the wheat itself or of bread formulation; literature that is only connected to wheat characteristics; only connected to bread formulation; and consumer behaviour. There is no attempt to assign weights or prioritise topics in Table 1.16; an "X" indicates that literature was found pertaining to a specific health characteristic topic.

Table 1.16
Consolidated view of literature linking bread VC to impact on GI/GL levels

Characteristic	**Col. 2 Bread and GI**	**Col. 3 Proc.'s**	**Col. 4 Vet.**
Detrimental links:			
Literature connected to processing or refining			
Cooking and preparation methods:			
a) Higher temperature heat; level of gelatinisation	**X**	**X**	
b) Longer cooking times	**X**	**X**	
c) Use of thermal treatments	**X**	**X**	
d) Processes that allow more softening and swelling	**X**	**X**	
e) More processing or refining	**X**		
f) Force applied in production	**X**	**X**	
g) Breadmaking method used	**X**		
h) Processes that disrupt structure of native starch		**X**	**X**
i) Processed under heat prior to milling or rolling		**X**	
Physical grain particles:			
j) Finer particles	**X**	**X**	
k) Increased level of refining and/or milling		**X**	
l) Grains that have been cut or flaked		**X**	
m) Flakes that have been cut too thin		**X**	
Acid content:			
n) Less acids (phytic, others)	**X**	**X**	
o) Types of fermentation	**X**		
p) Fermentation process	**X**	**X**	

Characteristic	Col. 2 Bread and GI	Col. 3 Proc.'s	Col. 4 Vet.
Literature connected to wheat or to formulation			
Fibre content:			
q) Fibre not intact to shield starch	X		
r) Less soluble fibre	X	X	X
s) Overall decrease in fibre		X	X
t) No wholly intact grains	X	X	
u) Addition of heated/boiled grains		X	
v) Resistant starch heated too high destroys fibre			X
w) Lack of resistant starch		X	
x) Addition of wholegrain		X	
y) Added grain high in beta glucans (oats, rye, barley)		X	X
Literature connected to wheat			
Type of starch:			
z) Less amylose/more amylopectin	X	X	X
A1) Ease of conversion to sugar	X		X
Protein content:			
A2) Less protein	X		X
Choice of wheat variety:			
A3) Impacts 'good protein' (protein-to-starch and amylose-to-amylopectin ratios)		X	X
A4) Choice of growing season			X
A5) Resistance to insects, weeds, disease			X
Wheat production practices:			
A6) Too little irrigation			X
A7) Influence on protein content and carbohydrate composition (i.e. aspects of 'good protein')			X
Wheat storage conditions:			
A8) More free sugars, less fibre, less protein			X
Literature connected to formulation			
A9) Less fructose	X		
A10) Use of High Fructose Corn Syrup (HFCS)	X	X	
A11) Less fat	X	X	
A12) Saturated fats and damaged fats	X		
A13) Chemical additives, preservatives, enzymes		X	
Literature connected to consumer			
GI or GL value:			
A14) Level of net available carbohydrate	X	X	
A15) Consumed at breakfast		X	
A16) Consumed without other food		X	
A17) Consumed without healthy fat/fibre		X	
A18) Consumes too great a quantity		X	
Beneficial Links:			
Literature connected to formulation			
A19) Addition of magnesium (via sea salt, wholegrains)		X	
A20) Addition of other micronutrients		X	
A21) Addition of intact fibre (found in wholegrain)		X	
A22) Addition of intact grain (with little heat treatment)		X	

Source: Compiled from author's own research based on the following literature:

Column 2 Bread and high GI -- Australian Nutrition Foundation Inc. 2002; Canadian Diabetes Association Nutrition Guidelines 2008; Department of Biochemistry at Hospital Hotel-Dieu Paris 2006; HSPH 2004; INRA/CRNH 2006; INSERM 2006; Utah State University Extension Service 2004.

Column 3 Ingredients, processes in the bread VC -- ANMF 2007; BakeryAndSnacks.com/2004; Behall *et al*. 1989; Behall and Howe 1995; Behall and Hallfrisch 2000 and 2002; Björck 1996; Brittanysalt.com/2007; Cauvain 1998 and 2006; Cauvain 2007: Cauvain 2009; CRNH 1999; Eisenberg 1992; Englyst *et al*. 1995; Garzon and Eisenberg 1998; Ghiasi *et al*. 1984; Golay *et al*. 1992; Goodlad and Englyst 2001; Granfeldt *et al*. 1994; Granfeldt *et al*. 1995; Granfeldt *et al*. 2000; Guerrero-Romero *et al*. 2002; Hallfrisch and Behall 2000;

Hoebler *et al*. 1999; Holm *et al*. 1988; HSPH 2005; INRA 2002; Jenkins *et al*. 1982; Jenkins *et al*. 1988; Krauss *et al*. 1996; Le Cordon Bleu 2005; Liljeberg *et al*. 1992; Liljeberg *et al*. 1999; Liu 2003; Ma *et al*. 1995; Marquart *et al*. 2002; McKeown, *et al*. 2004; Meyer *et al*. 2000; National Institute of Medicine, Food and Nutrition Board 1999; NIH 2005; O'Dea *et al*. 1980; Saris *et al*. 2000; Schoch 1945; Snow and O'Dea 1981; Stauffer 1998; Stevens *et al*. 2002; Tovar *et al*. 1992; USDA 2000; Willett, *et al*. 2002; Wirfält *et al*. 2001; Wolever 1994; Yasunaga *et al*. 1968.
Column 4 Veterinary and animal feed -- Choct and Anniston 1992; Choct *et al*. 1999; Hoffman 2009; IFIST 2007; Jankiewicz and Michniewicz 1987; Kim 2006; Kim and D'Appolonia 1977; Kim *et al*. 2005a, 2005b, 2004; Maier 1995; Rowe *et al*. 1999; Zijlstra 2006.

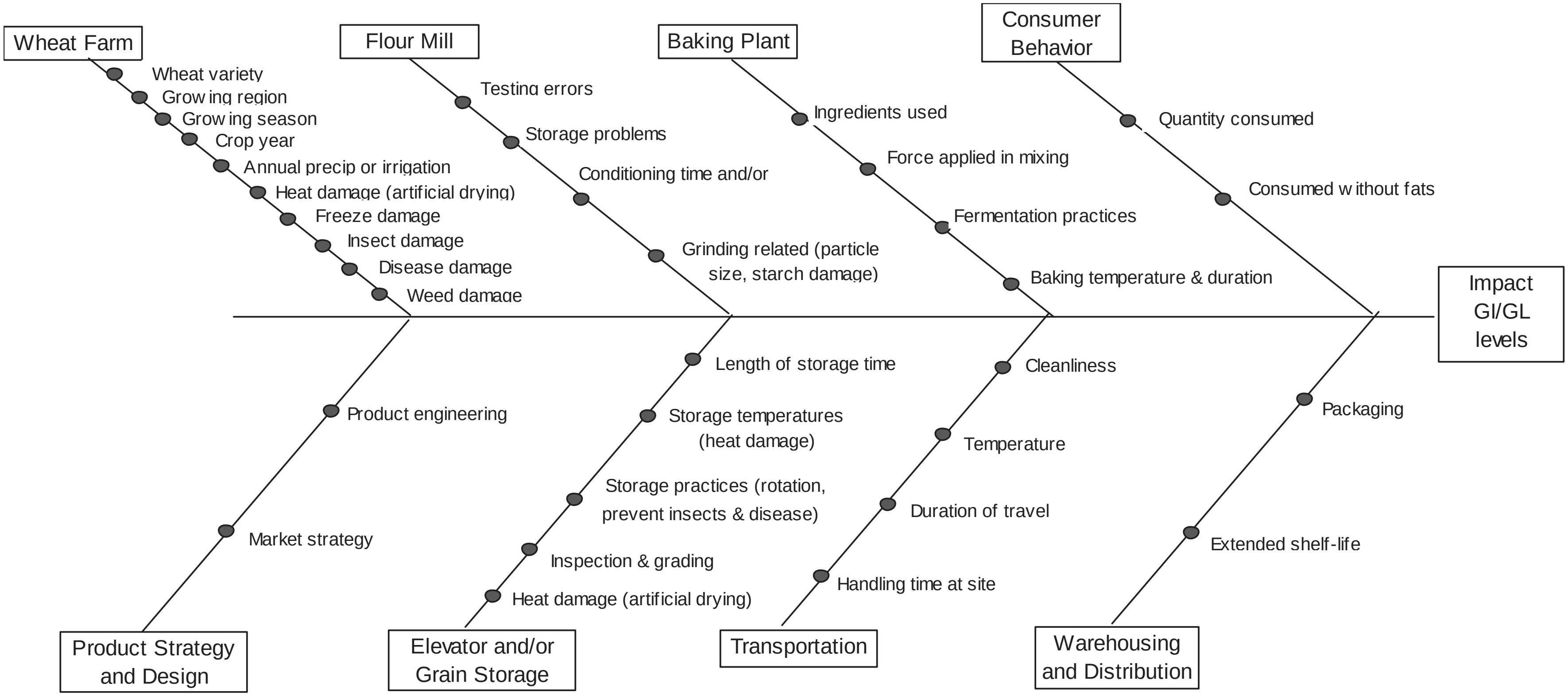
GI/GL links and the bread-VC processes

Each of the items shown in Table 1.16 represents a detrimental or beneficial quality characteristic connected to bread's impact on health. A majority of the items are directly related to protein quality. To understand better how these characteristics relate to the bread VC, they must be compared to the ingredients and production processes used in each VC-entity and with consumer behaviour (Figure 1.10) [22]. The wheat farm is more frequently associated with the health characteristics than are the other VC-entities or the consumer.

---

[22] Appendix 1.G shows the detailed analyses used to convert the data from Table 1.16 to Figure 1.10.

Figure 1.10
Value chain links between white bread and health characteristics



Source: Compiled from author's own research

1.5 Chapter summary

This chapter described the impact on health characteristics from the bread VC. Government policy, industry strategy and consumer behaviour all play a role. By the time the GI/GL system began to attract worldwide interest, the French had already developed a broad public health policy aimed at managing the effects of high GI foods/diets in the general population. U.S. studies (particularly those from HSPH) made recommendations directly to consumers and to policymakers.

The bread market itself is where the greatest similarities exist between France and the U.S. Bakers in both countries receive the same training; production methods are similar for each main category of bread. Although French consumers predominantly prefer baguette to 'soft' white bread, and U.S. consumers take the opposite position, the same basic bread categories are available in both countries. Market segmentation and product positioning are approached in a similar manner in both countries.

As the chapter discussed, there are a number of beneficial alterations that can be made that could be less likely to result in a bread with a 'high GI' value. But, there are also a number of management decisions (e.g. changes in methods of bread production, product formulation and raw ingredients used) that could adversely impact GI/GL levels.

From the viewpoint of a government policymaker, it might seem that the bread VC in the U.S. is working well. Across the bread VC, the U.S. bakery and grain processing industries provide more jobs per unit volume produced than the respective industries in France. But at an industry (VC-entity) level, the bread VC in France is outperforming the U.S. For example, the bread VC is more tightly integrated in France.

Wheat growers are also the owners of the grain cooperatives; they compete with one another to get more (miller) customers but also assist the millers to better meet needs of their (baker) customers. The driving force behind this attention to customer needs is the goal of quality. The strategy of the wheat growers, and adopted by the government as a national priority, was to make France the highest quality wheat producer in the international market. Year on year as the growers have strived to meet this goal, French wheat quality has measurably improved.

The situation in the U.S. is very different than in France. There are strong links between bakers and grain processors, sometimes formed through consolidation of their businesses. Although U.S. bakers and grain processors enjoy greater profitability than in France, they appear to be considerably less efficient. In addition, the wheat-farming element of the bread VC is nearly 'decoupled' from the rest of the VC. Although wheat is the chief ingredient in bread, wheat farms seem to be operating with little 'connectedness' to the bread marketplace. (Farmers do, however, stay involved in the financial markets to manage their futures contracts). Although three separate companies hold more than 90 percent of the grain processing market, they (and their joint venture railroad partners) are geographically dispersed. A farmer in one locale has very limited opportunity to sell and/or transport wheat to another buyer; effectively, it appears a type of oligopsony exists. Wheat-only farmers (in open production) in the U.S. are generally not profitable and more than 80 percent of them require public assistance. Opportunities for growing more lucrative crops are restricted by federal law, and probably also indirectly influenced by the potential loss of direct government payments (subsidies) that are greater than revenue from wheat sales.

Chapter 2

Government regulation of food quality: International and in France and the U.S.

Chapter 2

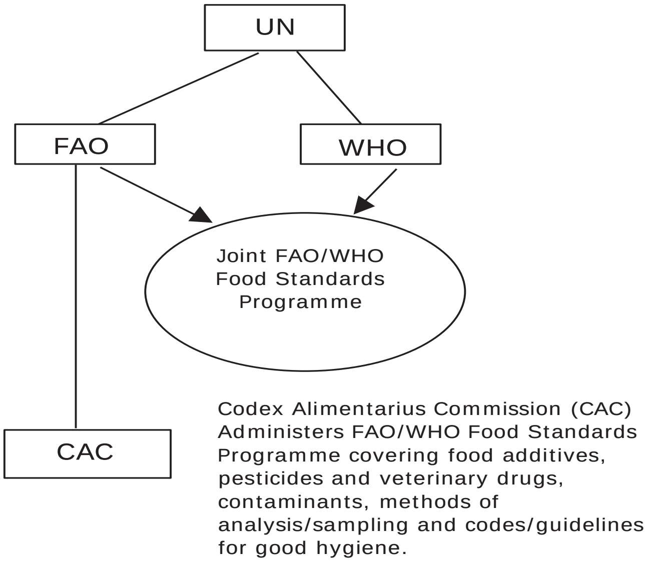
Government regulation of food quality: International and in France and the U.S.

2.1 International framework for food safety

2.1.1 Role of the Codex Alimentarius Commission

Two United Nations organizations, the FAO and the WHO, established the Codex Alimentarius Commission (CAC or Codex) in 1961. "CAC is responsible for implementing the Joint FAO/WHO Food Standards Programme, whose primary aims are to protect the health of consumers and to ensure fair and safe practices in the international food trade [Figure 2.1]. CAC is an intergovernmental body, with 158 Member Governments as of 31 August 1997" (FAO 2005). The FAO/WHO Food Standards Programme addresses food safety related to a wide variety of issues. The Codex Commission has developed numerous food standards, codes of practice and other recommendations relating to food quality composition and safety (FAO 2006).

Figure 2.1
Overall structure of the Codex



Codex Alimentarius Commission (CAC) Administers FAO/WHO Food Standards Programme covering food additives, pesticides and veterinary drugs, contaminants, methods of analysis/sampling and codes/guidelines for good hygiene.

Source: Compiled from author's own research based on FAO 2005 and 2006.

The Codex is particularly active in the prevention of chemical contaminants (such as residual pesticides) and in the development of standards and frameworks for food safety (Figure 2.2).

Figure 2.2
Codex scorecard of accomplishments

The Codex scorecard as of 1 July 2005

- Commodity standards – 202
- Commodity-related guidelines and codes of practice – 38
- General standards and guidelines on food labelling – 7
- General codes and guidelines on food hygiene – 5
- Guidelines on food safety risk assessment – 5
- Standards, codes and guidelines on contaminants in foods – 14
- Standards, guidelines and other recommendations on sampling, analysis, inspection and certification procedures – 22
- Maximum limits for pesticide residues – 2 579, covering 213 pesticides
- Food additives provisions – 683, covering 222 food additives
- Maximum limits for veterinary drugs in foods – 377, covering 44 veterinary drugs (FAO 2006).

Source: FAO 2006

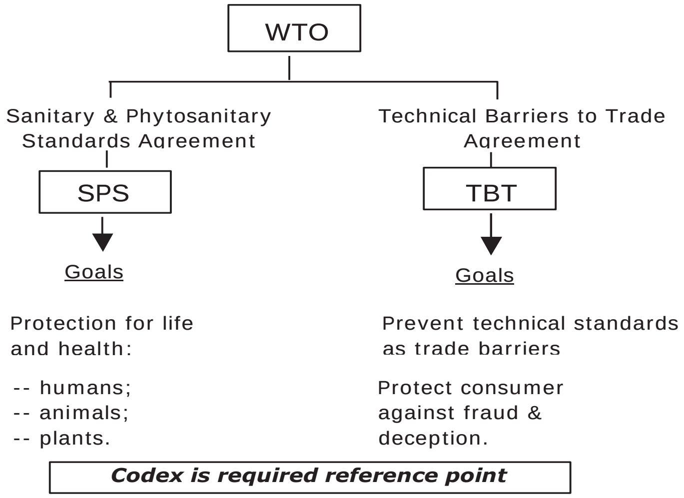
2.1.2 Uruguay Round Agreement on Agriculture (URAA)

Signed in April 1994, the URAA liberalized agricultural trade by bringing it under the rules of GATT. “One of the main achievements of the URAA was the development and implementation of a framework to address barriers and distortions to trade in three major policy domains: market access; domestic support; export subsidies” (OECD 2001). The URAA also included two binding agreements: the SPS Agreement and the TBT Agreement (FAO 2005). The purpose of the agreements and their relationship to the Codex is depicted in Figure 2.3.

2.1.3 SPS Agreement

"The SPS Agreement confirms the right of WTO member countries to apply measures necessary to protect human, animal and plant life and health. This right was included in the original 1947 GATT as a general exclusion to prevent 'disguised restrictions on international trade' " (FAO 2006). Despite the original intent, "national sanitary and phytosanitary measures had become effective trade barriers….The SPS Agreement therefore set new rules to require that WTO members base their national food safety programmes on international standards, guidelines and other recommendations adopted by the Codex" (FAO 2006).

Figure 2.3
Codex in relation to world agricultural trade



Source: Compiled from the author's own research.

2.1.4 TBT Agreement

The TBT Agreement is a revision of an earlier GATT agreement of the same name negotiated in the 1970s. The "objective of the agreement is to prevent the use of national or regional technical requirements, or standards in general, as unjustified technical barriers to trade. The agreement covers standards relating to all types of products including industrial and agricultural products, with the exception of aspects of food standards related to sanitary and phytosanitary measures. It includes numerous measures designed to protect consumers against deception and economic fraud. Examples of food standards covered by the TBT Agreement are those related to quality and labelling" (FAO 2006).

2.1.5 Different interpretations of SPS and TBT

The U.S. interpretation of the SPS and TBT Agreements varies considerably with that of France, and the rest of Europe (Table 2.1). The European perspective is consistent with the Codex view (i.e. Figure 2.3). The U.S. tends to see both agreements as more representative of standards in trade than of food safety.

Table 2.1
Differing perspectives on SPS and TBT Agreements

	European/French view	U.S. view
SPS Agreement	• Protects rights of plants, animals, humans; element of environmental protection and animal welfare involved • Basic intent is food safety.	• Protects intellectual property rights of plant breeders; • Focus of food safety regulation on end-use product--not the processes used • 'End-use product' may imply that primary production (e.g. wheat vs. bread) is somehow exempt from food safety regulation.
TBT Agreement	• Basis for consumer protection from deceptive practices; • The main agreement to prevent agricultural trade barriers between countries.	• Goal is to provide government and private sector with tools to protect domestic industry from unfair foreign competition; • Sees Codex as an international standards body under WTO.

Compiled from the author's own research based on FAO 2006; University of Florida/Evans 2004; FAO/WHO 2003; USDA, Venable LLP[23] and Bryson 2007

2.1.6 Codex standards, guidelines and recommendations

The Codex Committee on Food Hygiene, hosted by the U.S. Government and founded in 1963, originally "adopted the *Recommended International Code of Practice - General Principles of Food Hygiene* in 1969. The most recent revision (CAC/RCP 1-1969, Rev. 3) was adopted in 1997. The General Principles use 'food safety' to mean a food does not cause

---

[23] Venable LLP is a law firm representing USDA.

illness or injury to consumers; "…'suitability for consumption' is meant to distinguish if a food is spoiled or otherwise not suitable for normal human consumption" (FAO 2006). In terms of international trade, Codex intends that food hygiene should be controlled in the exporting country. This is consistent with the key principle that food hygiene is best regulated at each processing stage during production (Figure 2.4).

Figure 2.4
Key principles for good food hygiene

> **Key principles to ensure good food hygiene**
>
> -- Controls are best administered at production and processing stages;
>
> -- Codes of hygiene should be preventive rather than based on end product control (FAO 2006).

Source: FAO 2006.

As a result, "the committee's main outputs have been codes of hygienic practice rather than end product microbiological standards". The emphasis is on preventive rather than excessive control of the end product (FAO 2006). As Table 2.1 showed, the U.S. focus is on control of the end product rather than the production processes; the French perspective matches the FAO description.

2.1.7 The 'good manufacturing/agricultural/hygienic practices' (GMPs/GAPs/GHPs)

Adoption of the Codex GMPs/GAPs/GHPs, contained within "*The General Principles of Food Hygiene*, allow the producer to operate within environmental conditions favourable to the production of safe food" (FAO 2006).

GMPs

In *The General Principles of Food Hygiene* (2003, third edition) only a few excerpts are related to GMPs. The rationale given was that a preventive approach such as HACCP "offers more control … because the effectiveness of microbiological examination to assess the safety of foods is limited" (FAO 2003).

GAPs

The GAPs are "codes, standards and regulations that have been developed by the food industry, producers' organizations, governments and NGOs aimed at codifying agricultural practices at the farm level. Their purpose varies from fulfilment of trade and government regulatory requirements (in particular with regard to food safety and quality) to more specific requirements of specialty or niche markets" (FAO 2007). The GAPs "are practices that address environmental, economic and social sustainability for on-farm processes, and result in safe and quality food and non-food agricultural products" (FAO COAG 2003).

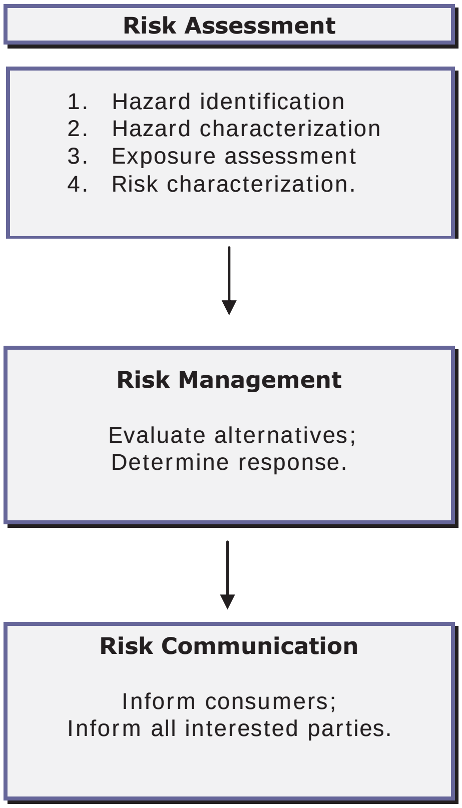
GHPs

The General Principles of Food Hygiene refers to prevention of food contamination caused by "microbial pathogens, chemicals, foreign bodies, spoilage agents, objectionable taints and unwanted or diseased matter, e.g. sawdust or decomposed material" (FAO 2006).

2.1.8 The HACCP system

The Codex "adopted the *Guidelines for the application of the Hazard Analysis Critical Control Point* (*HACCP*) *system* through its Committee on Food Hygiene in 1993, and revised it in 1997. HACCP is recognized as a tool to assess hazards and establish control systems that focus on preventive measures instead of relying primarily on end product testing. The HACCP guidelines define a hazard as "a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect." HACCP guidelines are intended to follow the food chain from primary production through to the final consumer, highlighting the key controls at each stage" (FAO 2005). The Codex doesn't insist producers adopt HACCP, but only a HACCP-type of preventive approach. The HACCP-based approach has become the de facto international standard for food safety and suitability (FAO 2005). HACCP includes a risk analysis process that comprises risk assessment, risk management and risk communication (Figure 2.5).

Figure 2.5
HACCP risk analysis process

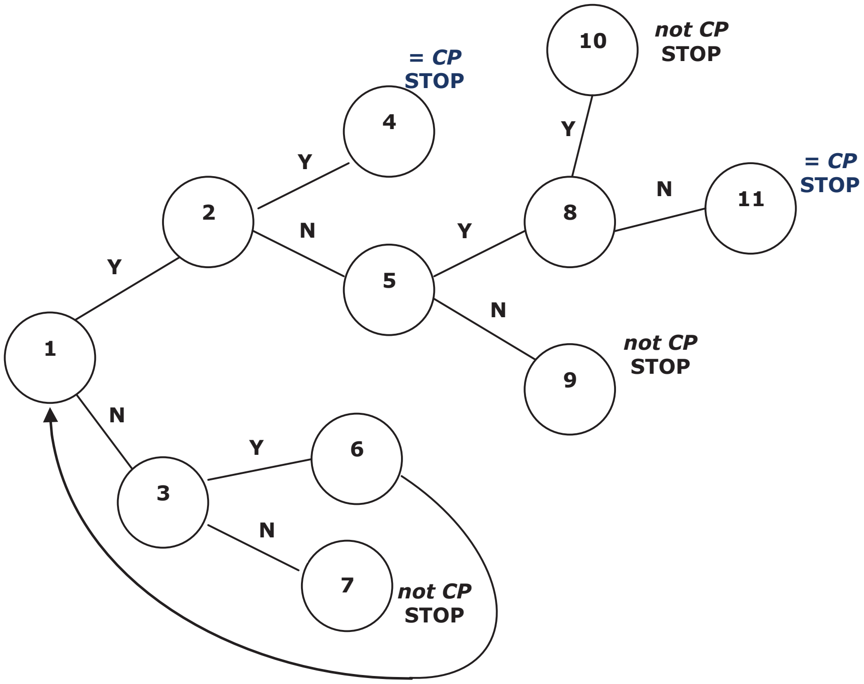


Source: Compiled from author's own research.

The relationship of HACCP to kaizen and continuous improvement (CI)

HACCP has an influence on process management, control and improvement in food manufacture (FAO 2005). Pillsbury Company (along with Natick Laboratories of the U.S. Army) developed the HACCP system for NASA astronauts in the 1950s, basing the design on the work of W. Edwards Deming (kaizen and quality management) in 1950s Japan (Linton, Purdue University 2001). A basic rule in both HACCP and kaizen is that no Critical Control Point (CCP), in HACCP, or control point (CP) in kaizen, should be introduced if the condition it controls can be eliminated through the application of GMPs/GAPs/GHPs. There is a HACCP decision process for determining when a CCP should be established for hazard prevention. When this process is reconfigured as a network diagram, it becomes clear that HACCP is a form of CI rather than a methodology for end product control and testing (Figure 2.6).

Figure 2.6
HACCP decision process for CCPs seen as a network diagram



Source: Compiled from author's own research based on Codex 1997.

The HACCP decision process is comprised of four questions:

1 "Do control preventive measure(s) exist?" (Codex 1997). [Begins at node 1]
  1.1 "Is control at this step necessary for safety?" (Codex 1997). [Begins at node 3]
    1.1.1 "If step is necessary for safety, modify step, process or product" (Codex 1997). [Iterative process that begins at node 6]

  Note: The treatment of this question is an example of focus on managing the process through its improvement. The introduction of a CCP (which equates with some form of output testing) should only take place when every realistic alternative to process improvement proves insufficient.

2 "Is the step specifically designed to eliminate or reduce the likely occurrence of a hazard to an acceptable level?" (Codex 1997). [Begins at node 2]
3 "Could contamination with identified hazard(s) occur in excess of acceptable level(s) or could these increase to unacceptable levels?" (Codex 1997). [Begins at node 5]
4 "Will a subsequent step eliminate identified hazard(s) or reduce likely occurrence to an acceptable level?" (Codex 1997). [Begins at node 8].

The process operates as a type of 'pruning' algorithm. Each link carries a value of Y (yes) or N (no). As each link is 'traversed' (i.e. considered), it is either cut (pruned) or generates a new traversal. This continues until one of the endpoints (that are assigned as STOP points] is reached. Only link 6-1 is an exception because it is an iterative process that begins at Q1 and must be run until no more modifications can be identified. When the iterative process ends, it either leads to node 7 and the process stops, OR it prunes link 3-7 and (by inference) link 1-3 and generates a traversal on link 1-2 and starts Q2. At Q2, either the process stops at node 4, OR link 2-4 is cut and a traversal on link 2-5 generates Q3, etc. Whenever the algorithm finally stops, two things will have been accomplished: process improvements will have been planned to the extent possible; and an unnecessary CCP will have been prevented from being established or a needed CCP will have been identified.

2.1.8.1 Coverage gap(s) in HACCP

The original HACCP system only included GMPs/GHPs and a HACCP plan; the Codex added GAPs later to differentiate agricultural practices from GMPs in manufacturing. GMPs/GAPs/GHPs comprised the backbone of the food safety system. The HACCP plan was a type of 'fail-safe' backstop against the three (HACCP) contaminants (biological, physical, chemical) that could be present in a zero gravity space capsule.[24] Primary intent was to prevent the contaminants '*a priori*' via the GMPs/GAPs/GHPs; in case they somehow got through, then the HACCP plan should kick-in. Pillsbury turned their work over to NASA in 1959 and first publicly described their HACCP development in a conference in 1971; documentation was published in 1973. However, between 1971 and 1973, a number of large well-known food companies already began to adopt HACCP plans—without GMPs/GAPs/GHPs. It seems these companies thought that the HACCP plan *was* the entire food safety system. This perspective still seems pervasive in the U.S. (Table 2.2). The table compares the PRPs against kaizen rules coming from Deming's work. But, as can be seen, critical kaizen elements that ensure food safety *a priori* are missing. Additional details of the U.S. perspective can be seen in Appendix 2.A.

---

[24] Other contaminants (e.g. zoonoses) were never considered because they wouldn't exist in a space capsule.

Table 2.2
Status of prerequisite programmes (PRPs) in U.S. HACCP systems

Item Nr.	Characteristic	Status of prerequisite programmes (PRPs) in U.S. HACCP systems
1	Work instructions (WIs) exist for all key production processes	Documented instructions are only used for some WIs (related to sanitation and to HACCP); GAPs and GMPs are not included.
2	Contents of WI body text	Kaizen WIs must have measurable, objective benchmarks for performance. SOPs are general and contain corrective actions; i.e. they expect to detect a flaw *a posteriori*. The goal is not on helping to perfect performance of the WI (standardized).
3	PDCA vs. SDCA cycle and standards	Performance of WIs in the PDCA cycle are tracked until benchmarks are consistently achieved or exceeded. For the most part, the SOPs have no measurable benchmarks. Even if they had objective benchmarks, the *a posteriori* approach to flaws indicates that SOPs are only randomly likely to become part of the SDCA cycle.
4	General QA/QC and GMPs/GAPs/GHPs	Processes that can result in conformance defects should be flagged. Control points (CPs) are inserted to prevent a conformance defect *a priori*. A CP is used in a PRP only when it is associated with a defined HACCP risk.
5	HACCP plan	Processes that can result in HACCP defects are reworked to (preferably) remove the risk or insert a Critical control point (CCP); written records are kept of the use of the HACCP system.
6	Connected to Quality Management System (QMS)	WIs in PRPs and HACCP are single purpose and may be completely disconnected from any QMS, if one exists.

Source: Compiled from author's own research based on Codex 1997; Cornell Univ. 2002; Univ. of Maryland) 2007; USDA FSIS 2007; Univ. of Florida 2010.

2.1.9 The influence of the European Union (EU) on international food safety

2.1.9.1 General Food Law Regulation EC No. 178/2002

In 2002, EC No. 178/2002 came into effect addressing a variety of food safety issues. Two key aspects include: establishment of an independent and scientifically-based EFSA; and greater transparency across the food production chain with farm-to-fork traceability of all foodstuffs produced in, imported to or transiting the EU (European Commission 2000).

2.1.9.2 The precautionary principle and 'safe unless proven otherwise'

Although EC No. 178/2002 closely follows the Codex, it also treats food safety according to the *Communication on the Precautionary Principle* (Van der haegen 2003). "Where, following an assessment of available scientific information, there are reasonable grounds for concern for the possibility of adverse effects but scientific uncertainty persists, provisional risk management measures … priority will be given to human health … pending further scientific information for a more comprehensive risk assessment, without having to wait until the reality and seriousness of those adverse effects become fully apparent" (Fisher *et al*. 2006).

At a 2007 Codex meeting, the precautionary principle was specifically *not* adopted for guidelines regarding risk analysis[25] as a result of strong lobbying from both governmental and non-governmental U.S. organisations. "Scientific evaluations are carried out when there are justified doubts about the safety of a food product and therefore there are systems in place to protect the health of the consumers. However, the use of the precautionary principle is often abusive in cases where there is no scientific proof of the unsafety [*sic*] of a food product" (Pineda 2007). This statement points up the fundamental difference in U.S. and European philosophies concerning the role of government in protecting the consumer. In general, 'safe unless proven otherwise' applies to the sale of food products in the U.S. as: "Foods are presumed to be safe unless the FDA determines that a particular food is injurious to health" (CSPInet.org 2010).

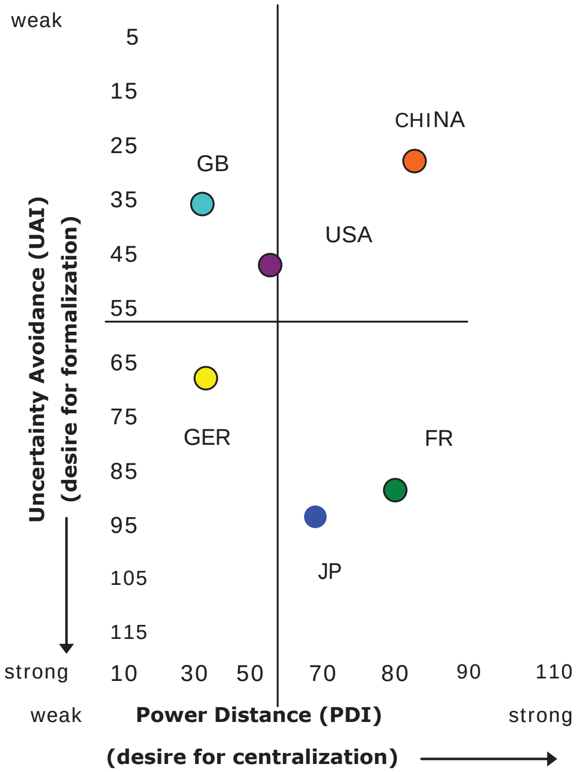
---

[25] *Working Principles for Risk Analysis for Food Safety for Application by Governments*.

2.1.9.3 A reflection of cultural preferences?

A preference for ‘safe unless proven otherwise’ versus the precautionary principle might be based on cultural differences that Hofstede describes as ‘uncertainty avoidance.’ Some cultures are comfortable with ambiguity and uncertainty while others regard that as stressful and risky. Out of some 74 countries surveyed, the U.S. respondents were one of the most comfortable with uncertainty while most Europeans were extremely uncomfortable with it.

Figure 2.7
Hofstede’s UAI and PDI mapping



	UAI	PDI
China	30	80
France	86	68
Germany	65	35
Great Britain	35	35
Japan	92	54
USA	46	40

Source: Compiled from author’s own research based on Hofstede 2001, 2005.

Scores ranged from 112 to 8 with a high score representing extreme discomfort with uncertainty; the U.S. score was 46 and the French score was 86 (Hofstede and Hofstede 2005). Hofstede’s cultural studies measure ‘power distance’ to represent desirability of centralization, which also reflects preferred organizational structure. Using Henry Mintzberg’s work on basic organizational types, Hofstede was able to show that cultures preferring high degrees of power distance also prefer standardization of work processes. The reverse of that, cultures preferring low power distance also prefer standardization of skills. Those cultures in the middle prefer standardization of outputs. Probably not surprising, France prefers high power distance while the U.S. prefers a middle level of power distance (Figure 2.7).

2.1.10 The role of the European Food Safety Authority (EFSA)

Established January 2002, “EFSA’s remit covers food and feed safety, nutrition, animal health and welfare, plant protection and plant health. In all these fields, EFSA’s most critical commitment is to provide objective and independent science-based advice” (http://www.efsa.europa.eu; Accessed 31 March 2011).

2.1.11 The Caswell and Henson view of food safety across the OECD

Caswell and Henson summarized most OECD countries’ approach toward food safety as “increasingly:

- Organized into one agency that focuses on food safety;
- Using risk analysis to design regulation;
- Stressing a farm-to-table approach in addressing food safety hazards;
- Adopting the HACCP system as a basis for new regulation of microbial pathogens in food;
- Adopting more stringent standards for many food safety hazards;
- Adding new and more extensive regulation to handle newly identified hazards;
- Improving market performance in food safety through provision of information” (Caswell and Henson 1997).

EFSA's structure and approach to food safety regulation provides a good example of what Caswell and Henson described. (Section 2.4.1 compares the national food safety programmes of France and the U.S. to the Caswell and Henson model).

2.1.12 Comparing EFSA's approach with the U.S.

EFSA depicts food safety regulation that is very much in conformance with Codex guidelines. Consumers look to EFSA for professional opinions about a range of food safety issues. This is very different than the U.S. approach of "scientific evaluations are carried out when there are justified doubts about the safety of a food product" (Pineda 2007). While the U.S. approach of conducting scientific evaluations only when justified might seem more streamlined, it should be remembered that the U.S. position does not support the Codex principle of *a priori* risk avoidance. Therefore, waiting for 'justified doubts' might, as a practical matter, lead to conducting evaluations of *a posteriori* safety events.

Despite EFSA's primary purpose of food safety, its influence on agrifood trade should not be overlooked. Although the EU represents only one group of nations, it has the ability to create regulations that impact the majority of other WTO nations (e.g. EC 178/2002). The application of the precautionary principle may well be an expected regulatory response by EU consumers; not including it in legislation might be unacceptable to the populace. Adopting it into U.S. legislation (e.g. via Codex guidelines on risk analysis) might be equally unacceptable to a U.S. population that prefers 'safe unless proven otherwise'.

2.2 Food safety regulation in France

2.2.1 Role of Afssa

Afssa, the French food safety agency, is a scientific body with legal "responsibility for evaluating the health and nutritional risks that could affect food intended for humans and animals, including possible risks from water" (FAO 2002). Afssa's powers range "from production of raw materials (animal and plant products) to distribution to the end consumer. … Afssa [is supervised by] three ministries (agriculture and fishery; economy, finances and industry; and solidarity and employment), [but] it issues independent scientific opinions. …. [With] 13 national specialized laboratories, Afssa is a centre for research and technical support to French risk managers working in food safety. …. [Its] opinions and recommendations are published … [but it] has no powers of inspection" (FAO 2002). The underlying principles are drawn from the French interpretation of "farm to table": "All aspects of the food production chain must be considered, from primary production (including animal protection and health aspects) and the production of animal feed, to the distribution of foodstuffs to the end consumer. Each component may have an impact on food safety" (FAO 2002). The following components are particularly relevant: changes in production methods, sales formats and consumption of agricultural products; an increase in intensive methods of stockbreeding, crops and the manufacture of animal feed; the appearance of new diseases (e.g. BSE); better consumer information … as well as the change in lifestyle ([e.g.] increased consumption of prepared meals); … increased … trade in foodstuffs, … [but also] the path taken by products from their place of production to the end consumer" (FAO 2002).

2.2.1.1 French approach to risk management

French risk management includes: risk analysis; risk evaluation and risk communication. In particular, Afssa employs a formal approach to risk evaluation as "a scientific process consisting of stages of identifying and characterizing dangers, then evaluating exposure to these dangers in order to characterize the risk, i.e. probability of the danger in real terms" (FAO 2002). This is nearly identical to HACCP risk management described in Section 2.1.8.

An unusual aspect of the French approach is strong reliance on participation of companies and manufacturers that have considerable resources set aside for managing risk. A basic tenet is food safety professionals from the purely professional (national associations for agrifood industries, trade unions, health defence groups) to the multi-disciplinary (National Food Council and National Consumers Council) should hear one another's opinions before regulatory texts are drafted (FAO 2002).

2.2.1.2 Tools for food safety professionals

The following tools available to food safety regulators and professionals are intended to meet consumer concerns and expectations: 1) Companies can use an external laboratory or their own accredited laboratory. 2) HACCP-based guides to GHPs, produced by professional organizations and validated by relevant authorities, define methods for monitoring specific risks. 3) Voluntary certification of a company's QMS by an independent organization (e.g. French Association for Quality Assurance (AFAQ); more than 1 000 agrifood sites are already ISO 9000-certified. Consumer interest in protecting the environment to safeguard health of the general public has recently led companies to begin implementing an EMS (e.g. ISO 14001). 4) Product standardization voluntarily established by many companies via "technical reference systems that describe the characteristics of their products, the manufacturing process or analytical and control methods. This practice is well established in France and the French Standardization Agency (AFNOR) coordinates drafting of the standards" (FAO 2002). 5) Written procedures of product information or product/batch identification are established and kept up-to-date "in order to trace the origin and determine the production and distribution conditions of products/batches. French agrifood companies see traceability as an essential component of product certification or quality assurance certification" (FAO 2002). 6) Distribution processes are monitored via QMSs used at the distribution stage (FAO 2002).

2.2.2 Role of French National Institute of Agricultural Research (INRA)

In 2003, INRA's senior management--with advice from the French National Food Council (CNA), Afssa and some consumer groups--established a working group focused on food research for the coming 10-15 years. The aims of the working group included recalibrating INRA's work against three priorities (i.e. sustainable agriculture, environment and food) while taking into consideration the continuously changing context of relationships between food and health, demographics, globalization and tools and methods (CNA 2004). Today INRA is the largest agricultural research institute in Europe and its research goals are oriented toward agriculture, food and the environment (INRA 2011).

2.3 Food safety regulation in the U.S.

2.3.1 Overview

Regulation in the U.S. is very different from that of France. While France emphasizes coordination and consensus, the U.S. emphasizes independence, states' rights and minimal interference from the federal government. Although state food safety laws already existed, in 1906 the U.S. Congress established the Food and Drug Administration and the Agriculture Department's meat inspection programme. Presently more than "a dozen federal agencies share jurisdiction over [various] food safety roles (e.g. education, enforcement, inspection, monitoring, outbreak management, research and surveillance)" (GAO 1998). The main federal agencies and their food safety roles are seen in Table 2.3.

Table 2.3
Overview of national food safety entities in U.S.

REPORTING RESPONSIBILITY	AGENCY NAME	FOOD SAFETY ROLE	FOODS INVOLVED
Cabinet-level:			
Secy. of Agriculture (USDA)	Food Safety and Inspection Service (FSIS)	Regulatory (monitor imports, survey safety of foreign production, sanitation audits of foreign production facilities)	Meat and poultry; shares responsibility with FDA for eggs.
Secy. of Health & Human Services (HHS)	Food and Drug Administration (FDA)		Oversees all domestic/import inspections; testing for pesticide residues, sanitary violations; shares responsibility with FSIS for eggs; responsible for regulation of seafood safety.
Environmental Protection Agency (EPA)			Environmental issues
USDA	Grain Inspection, Packers and Stockyard Administration (GIPSA)	Regulates trade and market practices.	Grains, livestock and poultry.
Secy. of Commerce (DOC)	National Marine Fisheries Service (NMFS)	Inspection of vessels, seafood products and processing plants	Inspection of seafood products, but FDA is responsible for seafood regulation.
HHS	Centers for Disease Control and Prevention (CDC)	Food safety remit within its research, prevention, surveillance and outbreak response activities.	General food safety, especially risk management and communication.
HHS	National Institutes of Health (NIH)	27 Institutes & centres provide direction and financial support to researchers "to protect and improve health".	Broad health issues that also include food safety.
Agency-level:			
FSIS	Office of Food Defense & Emergency Response (OFDER)	Manages all homeland security activities in FSIS, coordinates with USDA Homeland Security, the Department of Homeland Security (DHS), FDA, other federal/state agencies with food-related responsibilities as well as with industry.	
FSIS	Office of Program Evaluation, Enforcement and Review (OPEER)	Supports food safety, public health and food security requirements through development and implementation of information systems.	
FSIS	Public Affairs, Education and Outreach (OPAED)	Ensures all segments of farm-to-table chain get food safety information.	
FSIS	Policy, Program and Employee Development (OPPED)	Assesses and develops all domestic policy.	
FSIS	Office of Management (OM)	General administrative activities; primarily budget and civil rights.	
FSIS	Office of Field Operations (OFS)	Manages inspection and enforcement of domestic products.	Meat, poultry and eggs.
FSIS	Public Health Science (OPHS)	Provides impartial scientific advice, including responsibility for FERN.	
FSIS' OPHS	Food Emergency Response Network (FERN)	More than ninety federal, state and local laboratories that identify biological, chemical and radiological agents in food.	
FSIS	Office of International Affairs (OIA)	"Re-inspects meat, poultry and eggs imported into the U.S., provides export information to U.S. producers and coordinates responses to issues before the Codex" (FSIS 2006).	

Continuation of Table 2.3

REPORTING RESPONSIBILITY	AGENCY NAME	FOOD SAFETY ROLE	FOODS INVOLVED
Other:			
National Academy of Sciences	Institute of Medicine (IOM)	Non-profit organization devoted to science-based advice from biomedical science, medicine and health. IOM works outside government to ensure scientifically informed analysis and independent guidance. Mission is "to serve as adviser to the nation to improve health" (IOM 2007). Includes food safety, nutrition and diet.	
Private sector companies		"Private sector pioneers food safety advances. Firms…have developed food safety assurances standards beyond mandated ones" (USDEC 2001). Firms can increase market share with safer products; sales can be targeted to large supermarket chains with particular food standards" (USDA/ERS 2001).	
FDA and The Federal Trade Commission (FTC)		The 2 agencies share responsibility for consumer protection from false advertising: 1) FDA is responsible for product labelling and promotional materials at point-of-sale. 2) FTC monitors advertising in print, broadcast (including 'infomercials'), catalogues and direct marketing (FTC 2001).	

Source: Compiled from author's own research based on GAO 1998, 2004, 2008; IOM 1998, 2007; FTC 2001; USDA/ERS 2001; FSIS 2006; NIH 2007; National Agricultural Law Center, University of Arkansas 2011.

2.3.2 Roles of food safety agencies

Despite the involvement of four different cabinet secretaries and a number of national agencies in U.S. food safety, their remits are similar and rather narrow (Table 2.3):

- Food product safety focuses on meat, poultry, seafood and eggs; grains are addressed as a by-product of livestock production.
- Regulation, end-product inspections and facilitation of trade seem to be the main activities.
- Even though FDA's work is mostly comprised of end-product inspections, FDA activities seem to be most similar to what Codex recommends for national food safety programmes.
- The only mention of 'farm-to-table' is part of a food safety awareness programme rather than food safety inspections or other direct actions as a priority for all elements of the food chain (including primary producers such as wheat growers).
- It appears that USDA may see private sector companies as more effective than federal agencies in protecting food safety.

Table 2.3 suggests there is some confusion (particularly at FSIS) regarding Codex, national food safety programmes and use of HACCP. This can also be seen in statements from FSIS:

"HACCP clarifies the respective roles of government and industry. Industry is accountable for producing safe food. Government is responsible for setting appropriate food safety standards, maintaining vigorous inspection oversight to ensure those standards are met, and maintaining a strong enforcement program to deal with plants that do not meet regulatory standards" (FSIS 2006). FSIS' point concerning respective roles for government and industry is correct in terms of national food safety programmes, but this assignment of roles and responsibilities comes from national laws concerning food safety programmes-not from HACCP. Since 1963 the U.S. has hosted the Codex Committee on Food Hygiene within physical facilities provided by FSIS. But FSIS describes the work of the Codex as: "…the major international mechanism for encouraging fair international trade in food while promoting the health and economic interest of consumers" (FSIS 2007).

Some governmental actors in the U.S., though, do agree with the goals of the Codex. GAO has consistently recommended since 1992 that the U.S. establish a single, independent, risk-based food safety agency (i.e. similar to Afssa and EFSA's implementations and in keeping with Codex recommendations concerning the Joint FAO/WHO Food Standards Programme). However, despite more than 30 reports and testimonies from GAO over the years, the U.S. system (as seen in Table 2.3) remains fragmented and complex (GAO 2004).

2.3.3 FDA HACCP study

As FDA seems to be most representative of Codex national food safety programmes (Table 2.3), it's useful to look more closely at one of FDA's key activities: HACCP audits. The

FDA initiated a three-year project in 1994 to determine the ease with which HACCP could be implemented in participating firms and to assess whether HACCP should be expanded (beyond seafood) as a food safety regulatory programme. FDA described one of its goals for the study "to provide FDA with additional experience in working with the audit type inspection necessary for verifying a HACCP program" (FDA 1997). One of the surprising results of the study was that use of a HACCP system brought benefits beyond food safety to the participant firms. Seven firms participated in the study (Table 2.4); including bread and flour producers, with four of the six firms using wheat as a raw material

Table 2.4
Overview of FDA participant companies

Companies [1]	**Product (in study) [1]**	**Annual Sales**
Alto Dairy	Hard cheese	Unknown
Campbell Soup Company	Salad dressing	\$7.2 billion [3] 1995
ConAgra	Flour	\$5.6 billion [4] 2001
EarthGrains (was Campbell-Taggart, Inc. at outset of pilot)	Bread (30% of product is Premium category bread segment [2])	\$2.8 billion [2] 2001
Pillsbury (owned by General Mills and acquired by Diageo)	Frozen dough	Estimated \$10.4 billion
Ralston Foods	Breakfast cereal	Unknown

Sources: Compiled from author's own research based on [1] FDA 1997; [2] Gale Group 2001; [3] Prepared Foods 1996; [4] Food Engineering, BNET Business Network 2001.

The number of hazards controlled in the HACCP programmes ranged from one to seven per participant firm. During the study, the FDA evaluated the adequacy of the participants' HACCP plans and verification of proper implementation. Over a ten-month period, the FDA teams helped the participants to develop and/or refine their HACCP plans, eliminating as many CCPs as possible. One firm began with 80 CCPs; working with the FDA team, the firm initially reduced the number of CCPs to two, and then finally to just one (FDA 1997). After the study, the firms themselves took responsibility for evaluating and updating their own HACCP plans.

2.3.4 Benefits of FDA audits

The benefits to the firms were greater than what was expected at the outset of the pilot: "The principal benefits from HACCP reported by the firms are (1) more effective and efficient operations; (2) a higher level of confidence in the safety of the product; and (3) greater customer satisfaction" (FDA 1997). "Improvement in employee performance was perhaps the most significant benefit from HACCP expressed to FDA by the firms. One firm reported that 'due to increased HACCP awareness, employees have been instrumental in designing new processes/procedures for monitoring and control' " (FDA 1997). As another firm pointed out, "The benefits strongly outweigh the costs" (FDA 1997). As the FDA described: "Properly applied verification audit procedures provide built-in safeguards that can be effectively substituted for routine end-product sampling. That is, frequent reviews of the HACCP plan, CCP monitoring records and corrective action records ensures that the final product is safe, rather than relying upon end-product sampling results" (FDA 1997).

2.3.5 Role and capabilities of FDA

In 2006 testimony before Congress, William K. Hubbard, former FDA Associate Commissioner (and 33-year FDA veteran), supplied testimony that gives a good overview of changes at FDA: "In 1972, FDA's food program constituted approximately one-half of the FDA's efforts, in terms of the agency's resource allocation. Today, it is about one-quarter, even though FDA has little more staff than it had in the 1970s. Likewise, 34 years ago, FDA conducted 35,000 inspections of food manufacturing facilities. This year, they will do perhaps 5,000. The volume of food imports from overseas is approaching 10 million per year, and the number that FDA inspectors physically examine is in the single digit thousands—making it virtually certain that any given food shipment will enter the United States with no FDA inspection" (Hubbard 2006).[26]

In January 2007, GAO issued a special report designating "federal oversight of food safety as a high-risk area needing urgent attention and transformation" (GAO 2007). A key reason for that designation was "FDA was just one of 15 agencies that collectively administered at least 30 laws related to food safety" (GAO 2008). Although FDA shares food safety responsibility with so many other agencies, it oversees "roughly 80 percent of the U.S. food supply, including $417 billion worth of domestic food and $49 billion in imported food annually" (GAO 2008). As a practical matter, in 2007 FDA was responsible for inspecting 65,500 domestic firms. Due to manpower constraints, the number of FDA domestic inspections actually completed ranged from 14,721 (in 2001) to 14,566 (in 2007). Financial limits were also apparent in FDA budget requests: $42 and $48 million for 2008 and 2009, respectively, with no increase in the number of annual inspections. FDA's annual budget in 2008 was $620 million, of which the $42 million increase was intended for strategic actions described in its *Food Protection Plan* (GAO 2008). However, the subtitle for the GAO auditors' report, *FDA Has Provided Few Details on the Resources and Strategies Needed to Implement its Food Protection Plan*, sums up part of the problem. FDA showed little inclination to disclose operational aspects of its proposed new strategy.

According to further GAO testimony, Congress expressed considerable interest in enhancing FDA's oversight of food safety, and the House considered a draft bill contained provisions allowing FDA to leverage resources using outside organizations, such as third-party inspectors (GAO 2008).

---

[26] Taken from "Senate Committee on Health, Education, Labor and Pensions" meeting on July 27, 2006.

On June 12, 2008, GAO testimony to Congress expressed concern that of 34 recommendations GAO had proposed to FDA since 2004 to better manage its projects or to leverage financial resources, only seven of those recommendations were implemented. FDA commissioner, Andrew von Eschenbach, raised additional concerns about the severity of constraints saying the FDA needed to do a better job of tracking products and admitted that the use of paper records instead of electronic made it hard for the agency to do its job effectively (ABC News 2008). I.e. in 2008, the FDA still used paper records to track food products worth $466 billion (GAO 2008). But it is also difficult to understand the dramatic difference between the FDA of 1997 (Sections 2.3.3 and 2.3.4) and the FDA of 2006 through 2008--changes that had taken place in just a decade.

2.4 How similar are the food safety systems in both countries?

2.4.1 Comparison of French and U.S. systems

The Caswell and Henson model for food safety systems (Section 2.1.11) provides a useful framework for comparison of the French and U.S. systems. Several versions of U.S. data were required. The first version compared the French and U.S. systems based on 2007 data (Table 2.5). Due to the fact that the U.S. food safety system was substantially altered between 2001-2008 (during the George W. Bush Administration), U.S. data from March 2000 needed to be compared with March 2007. Documentation from 2000 and 2001 describe a robust system with all of the main Codex principles of food safety included (CFSCAN 2000, 2001; FSIS 2000). By 2007 the U.S. food safety programme had become more fragmented, begun to rely on less objective/scientific data in risk analysis and clearly excluded certain primary producers (e.g. grain producers) from farm-to-table initiatives (Table 2.6).

Table 2.5
Comparison of French and U.S. food safety systems based on 2007 data

Characteristic	France	U.S.
Organized into one agency that focuses on food safety	1	15+
Uses risk analysis to design regulation	Yes	Unclear (at FSIS)
Stresses a farm-to-table approach re food safety hazards	Yes	Begins after farm; fruits & vegetables are exception
HACCP system is basis for new regulation of microbial pathogens	Yes	Yes
Adopting more stringent standards for many food safety hazards	Yes	Unclear (not an 'early adopter')
Adding new and more extensive regulation for newly identified hazards	Yes (e.g. GMO)	Yes (e.g. terrorism)
Improving market performance in food safety through provision of information	Yes	Yes

Source: Compiled from author's own research.

Table 2.6
The U.S. food safety system in 2000 and 2007

Characteristic	U.S. (Mach 2000)	U.S. (March 2007)
Organized into one agency that focuses on food safety	4	15+
Uses risk analysis to design regulation	Yes	Unclear (at FSIS)
Stresses a farm-to-table approach re food safety hazards	Yes	Begins after farm; fruits & vegetables are exception
HACCP system is basis for new regulation of microbial pathogens	Yes	Yes
Adopting more stringent standards for many food safety hazards	Yes	Unclear (not an 'early adopter')
Adding new and more extensive regulation for newly identified hazards	Yes (e.g. GMO)	Yes (e.g. terrorism)
Improving market performance in food safety through provision of information	Yes	Yes

Source: Compiled from author's own research based on CFSCAN 2000, 2001; FSIS 2000.

The precise rationale behind the policy shift from 2000 to 2007 wasn't clear. The documents from 2000 described regulatory authority consistent with responsibilities defined in the U.S. Constitution. The FSIS website, though, refers to several presidential directives that gave extraordinary authority to President George W. Bush to make the proposed changes in the agencies. The FSIS website also indicates in its self-history[27] that 'good actions' taken by past U.S. Presidents were only from those in the Republican party by showing an "R" after their names (although President Eisenhower seems to have been overlooked). The FSIS document from 2000 is a description of a programme that was begun by the U.S. Presidency in 1997 – that would mean the programme was actually developed during the Administration of President Clinton, a Democrat. It is not possible to determine how much of the FSIS website is factual versus political posturing. But this level of politicisation is in stark contrast to the Afssa policy of employing non-partisan specialists.

An excerpt from FSIS describing food safety policy in 2000 offers some insights as to how responsibilities are split in the U.S. between national/state governmental entities and the private sector. At the same time, this policy seemed nearly compliant with Codex principles for national food safety programmes; the exceptions are emphasis on end product rather than processes and lack of thoroughness in farm safety: "In achieving the nation's farm-to-table food safety objective, the federal government is only one part of the equation. Federal agencies collaborate with state and local agencies and other stakeholders to encourage food safety practices and to offer assistance to industry and consumers on practices that promote food safety. Establishments are responsible for producing food products that meet regulatory requirements for safety. The government's role is to set appropriate standards and do what is necessary to verify that the industry is meeting those standards and other food safety requirements. Consistent with modernization of inspection systems and the farm-to-table initiatives, federal agencies use their resources as efficiently and effectively as possible to protect the public from foodborne illness. As an extension of HACCP, the U.S. is testing

---

[27] From http://www.fsis.usda.gov/About_FSIS/Agency_History/index.asp. Accessed April 27, 2007.

new meat and poultry inspection models to determine whether or not additional protections can be provided consumers through redeployment of some in-plant resources to the distribution segment of the farm-to-table chain, which includes transportation, storage, and retail sale of products" (FSIS 2000). As the excerpt notes, protecting the public from foodborne disease (FBD) is a primary goal; therefore, incidence rates of FBD become another benchmark for policy effectiveness. Section 2.4.2 compares French and U.S. incidence rates of FBD.

2.4.2 Comparing the impact of FBD

2.4.2.1 U.S. incidence rates of FBD

In 1996 the CDC began tracking the incidence of FBD each month in ten U.S. states. "An estimated 76 million cases of foodborne disease occur each year in the United States. … CDC estimates that there are 325,000 hospitalizations and 5,000 deaths related to foodborne diseases each year" (CDC 2005). CDC estimated that the 2004 figures were repeated each successive year as data collection of actual instances ended between 2001 and 2004 (CDC 2008). "The estimated economic cost of FBD (in terms of reduced productivity and medical expenses) is substantial, in the range of $10-83 billion each year" (FDA 2004). A former FDA economist suggests the actual economic cost is some $152 billion per annum, while the U.S. Government spends $1 billion and state governments spend $300 million on food safety programmes (Scharff 2010).

In 1994, the U.S. reported a range of 6.5 million to 33 million cases, or an incidence rate of 25 to 130 cases per 1,000 inhabitants. By 1999, the number of cases was reported at 73 to 76 million, or an incidence rate of 255 to 278 cases per 1,000 inhabitants. The rate of FBD had more than doubled (and possibly increased by as much as ten-fold) in the five intervening years (Table 2.7).

Table 2.7
Rates of U.S. FBD between 1994 and 1999

	1994	1999	Degree of increase
Cases of foodborne illness	6.5 to 33 million	73 to 76 million	Two to twelve-fold
Incidence rate per 1,000	25 to 130	255 to 278	Two to ten-fold
New secondary cases	130 to 990 thousand	1.5 to 2.3 million	One-and-a-half to eighteen times

Source: Compiled from author's own research based on CDC 2008.

2.4.2.2 French incidence rates of FBD

In 1990, total cases of FBD were between 735,590 and 769,615; thus an incidence rate of 13 cases per 1,000 inhabitants (Table 2.8). That rate climbed to 44 cases per 1,000 inhabitants by 1999. Although French incidence rates tripled between 1990 and 1999, the incidence rate of 44 is comparable to other Western European OECD countries during the same timeframe (WHO 2003). The considerable increase over the nine-year period was most likely due to underreporting in 1990 (Goulet *et al.* 2001).

Table 2.8
Rates of FBD in France between 1990 and 1999

	1990	1998/1999	Degree of increase
Cases of foodborne illness	736 to 770 thousand	2.6 million	More than triple
Incidence rate per 1,000	13	44	More than triple
New secondary cases	15 to 23 thousand	52 to 78 thousand	More than triple

Source: Compiled from author's own research based on INSERM and Afssa 1990; WHO 2003.

2.4.2.3 Comparing French and U.S. incidence rates

The high rates of FBD in the U.S. have not gone unnoticed by food safety researchers: "A substantial percentage of U.S. cases are of unknown aetiology and seem to be associated with the large number of new foodborne pathogens that have emerged in recent years" (Mead *et al.* 1999). These unknown agents account for approximately 78-81% of foodborne illnesses, for 50% of hospitalisations and 64% of deaths in the U.S. (Mead *et al.* 1999; Mounts *et al.* 1999). "Most of the new pathogens have an animal reservoir and often do not cause illness in the infected animal [such as *Salmonella* in chickens or Norwalk viruses in oysters]. Therefore, the new foodborne hazards often escape traditional food inspection systems, which often rely on visual signs of disease" (WHO 2003).

In addition, WHO points out emerging constraints on the national reporting systems. "Raw data from surveillance do not allow estimation of the percentage of cases that are directly caused by [finished] food products and, more specifically, the number of cases that can be attributed to specific food commodities [possibly including wheat]. This information is crucial for food safety risk management because of additional transmission routes for most foodborne pathogens (waterborne, animal contact, farm environment...) and because of specific pathogen-food commodity associations. However, very limited data are available" (WHO 2003). The increased likelihood of FBD cases attributable to food commodities would require a policy adjustment in the U.S. away from categorizing them as 'extractive commodities' rather than food with concomitant food safety regulation.

2.5 Chapter summary

This chapter presented the international framework for food safety regulation and an overview of how it is applied in France and the U.S. The Codex guidelines for national food safety programmes and the HACCP food safety system are recommendations only—force of law is dependent on individual governments. The French food regulations were found to be more representative of the Codex guidelines than those of the U.S. The focus of the French system is broad with strong orientation toward addressing nutritional health characteristics as well as food safety problems coming from HACCP-type contaminations. The U.S. system is on one hand robust, but on the other very uneven. Emphasis on specific food products (such as eggs, poultry, meat and seafood) may have left others less protected. The sheer number of governmental entities also raises questions about overall effectiveness of the U.S system. The rates of FBD experienced by the U.S. population are considerably greater than those of France (and other Western European countries). This fact alone suggests that the U.S. national food safety programme is not performing as well as it should. Congressional testimony from a former FDA Commissioner and more than 30 reports and testimonials from the GAO also suggest that a variety of problems—including inertia on the part of the national government--render food safety regulation less effective than it should be.

Chapter 3

Industry regulation of quality in bread, flour and wheat in France and the U.S.

Chapter 3

Industry regulation of quality in bread, flour and wheat in France and the U.S.

3.1 Benchmarks of bread quality

3.1.1 Product conformance in bread

Product conformance is one of the two aspects of a product's quality, reliability being the other. Techniques for measuring bread quality usually fit into three broad categories: External and internal characteristics and texture, including flavour (Cauvain 1998). Despite the wide variety of breads that exist, there is essentially just one set of product standards used and adapted to the various bread types (Table 3.1).

Table 3.1
Generic quality standards for all varieties of white bread

Characteristic	Testing[1]	Subj/Obj[2]
1. External characteristics		
a) Dimensions (L, H, W)	At-line OR off-line	O
b) Volume (H and W) Note: for pan breads	At-line OR off-line	O
c) Appearance c.1) General c.2) Oven spring c.2.1) Good for baguette c.2.2) Bad for pan bread	 Off-line At-line	 S O
d) Colour	At-line OR off-line	S/O
e) Crust formation	Off-line	S
2. Internal characteristics		
a) Crumb grain a.1) Size, number, distribution of cells in crumb a.2) Optional: Cell wall thickness Note: No standard; based on variety	At-line OR off-line	O
b) Crumb colour	At-line OR off-line	S/O
3. Bread texture		
Note: indicates firmness & resiliency of crumb		
a) Main test: Squeeze test	Off-line	S
a.1) Resistance to deformation a.2) Degrees of softness/hardness a.3) Springiness		
b) Alternate tests with instruments b.1) Compression test (hardness)	At-line OR off-line	O
b.2) Compression test (recovery, resiliency)	At-line OR off-line	O
4. Eating quality		
a) Taste tests a.1) Panel a.2) Individual a.3) Against set of descriptors	Off-line	S
b) Optional: Electromyography assessments to replicate human sensory perception	Off-line	O

Continuation of Table 3.1

Characteristic	**Testing**[1]	**Subj/Obj**[2]
c) Texture profile analysis (TPA) Note: Combines subjective & objective assessments	Off-line	S/O
c.1) Set of 7 basic descriptors of eating quality	Off-line	S
c.2) Alternate: All 7 include instrument tests	Off-line	O
5. Flavour		
a) Panel b) Individual c) Crust and crumb Note: Can assess together or separately	Off-line	S

[1]At-line means the test is done without removing the product from the production line. Off-line means the test is performed away from the moving production line. [2]Indicates if the criteria are subjectively or objectively assessed. Source: Cauvain 1998.

A particular bread variety dictates variations in the quality benchmarks. For example: "Different bread types have different flavour profiles. A French baguette requires a much higher proportion of crust-to-crumb than a white sandwich bread" (Cauvain 1998).

Although a baker may be producing many different varieties of bread, one set of standards is used to evaluate product conformance. Likewise, bakers in France and the U.S. employ similar standards of product conformance.

3.1.2 Product reliability in bread

"Bread remains fresh for only a few hours after leaving the oven" (Pateras 1998). Therefore, loss of freshness due to staling (i.e. the physical changes that cause firming) and (microbial) spoilage are the most important reliability issues for bread. Prevention relies on the application of GHPs and the adherence to a HACCP (or HACCP-like) plan. However, whether or not HACCP use is required is left up to the regulator in each producer's country.

Some aspects of food safety in bread are controlled less by specific laws than by the economic relationship between the baker and the consumer. "Consumers will avoid purchasing bread that is visibly mouldy and many will avoid purchasing stale bread, as well"

(Legan 1993). For the artisan baker staling is avoided by discarding unsold loaves after a certain time period, generally end of the business day (Le Cordon Bleu 2005).

3.1.3 Summary re conformance and reliability in bread

This section described the standards for product conformance and the main reliability issues in bread. Bakers in both France and the U.S. are likely to encounter the same sets of risks and to respond similarly. It should be noted, though, that in both countries there is minimal regulation; the producer is expected to voluntarily employ safe practices. Despite the food safety risks associated with bread, there appears to be no direct linkage between those risks and GI level of the finished product. Table 1.16 showed literature that connected ingredients and production processes with characteristics that lead to high GI/GL values. Except for use of certain ingredients (e.g. sugar), some cooking and preparation methods and HACCP-type failures, there is little to suggest that increased GI/GL levels originate in bakeries.

3.2 Benchmarks of flour quality

3.2.1 General product conformance and reliability

In a very real sense the miller is the link between the baker and the farmer. There are other actors (e.g. grain merchants, elevator operators and transport companies), but product conformance in flour represents the miller's understanding and interpretation of the baker's requirements. To some degree the baker can influence product conformance and reliability by controlling and/or refining processes in the bakery. The miller, though, has considerably fewer options. Product conformance in flour is strongly determined by the wheat. Controls for reliability and food safety exist, but there are limited options. The miller is more dependent on the overall quality of each lot of wheat.

3.2.2 Wheat characteristics and end use

The two wheat species

Although wheat has existed since 3000 to 4000 B.C., most modern wheat can be split into two species:

- Bread wheat (*Triticum aestivum* L.) accounting for 90 to 95 percent of all wheat and referred to as 'hard' or 'soft' depending on grain hardness;
- Durum wheat (*T. turgidum* L. var. *durum*) used to produce pasta.

The two species "are different from one another in genomic make-up, in grain composition and in food end-use quality attributes" (FAO/Peña 2000).

Many cultivars in each species

Each species is comprised of many different cultivars. Cultivar differences in grain composition and processing quality quite large even within a species. Thus, one cultivar may be suitable for one food but unsuitable for another. It is common to find that the value of a wheat crop in the market is generally determined by grain attributes associated with its processing quality (FAO/Peña 2000).

Grain characteristics

Wheat can be segregated by grain quality characteristics: grain hardness, protein level and gluten strength. Table 3.2 shows the correlation between these grain quality characteristics and their final product use (FAO 2000). Both the type of bread and the breadmaking process determine flour (or dough) strength requirements. In general, an industrial breadmaking process using high-speed mixing requires stronger wheat flour than does a manual one.

Table 3.2
Grain quality characteristics and end-use product types

Type	Grain hardness	Grain protein (%)	Gluten (dough) strength type
Leavened breads			
Pan-type, buns	Hard	>13	Strong-extensible
Hearth, French	Hard/Medium	11-14	Medium-extensible
Steamed	Hard/Soft	11-13	Medium/Weak
Unleavened (flat) breads			
Arabic	Hard/Medium	12-14	Medium-extensible
Chapatis, tortillas	Medium	11-13	Medium-extensible
Crackers	Medium/Soft	11-13	Medium
Noodles			
Yellow alkaline	Medium	11-13	Medium/Strong
White	Medium/Soft	10-12	Medium
Cookies, cakes, pastries	Soft/Very soft	8-10	Weak/Weak-extensible

Source: FAO/ Peña 2000

Hard to medium-hard wheat, which yields strong flour dough, is more suitable for the industrial production of leavened breads, such as pan bread (Faridi and Faubion 1995; Wrigley 1991). "Hard to medium-hard grain is preferred for the manufacture of leavened breads because the levels of damaged starch produced from these wheat classes are appropriate to achieve the high dough water absorption desired by the baker. High water absorption means high flour yield per unit of bread" (FAO/Peña 2000). Those flours yielding medium-strong doughs are more suitable for the (generally manual) production of French-type (yeast-fermented, hearth-baked) breads (Qarooni 1996; Singh and Kulshrestha 1996).

For purposes of this thesis, and with the kind assistance of the thesis industry advisor (S. Cauvain), desirable 'protein quality characteristics' are limited to hard-grained wheat with high protein levels and moderately strong to strong extensibility.

3.2.3 Flour conformance from the baker's perspective

Characteristics that are important to most bakers are protein level, moisture content, ash content, gluten content and ratio of amylose-to-amylopectin starch. Some of these characteristics are clearly specified by the baker (such as protein level, moisture content and ash content); others are more implicitly agreed characteristics (such as the amylose-to-amylopectin ratio). The implicitly agreed characteristics tend to be more representative of the wheat that has been used (Cauvain 2008).

3.2.4 Wheat trading characteristics that influence flour

For trading purposes, wheat (conformance) is classified into "…distinct categories of grain hardness (soft, medium-hard and hard) and colour (red, white and amber). It may be further subdivided into subclasses based on growing habit (spring or winter). Each wheat subclass may also be grouped into grades, which are generally used to adjust the basic price of a wheat stock by applying premiums or penalties. Wheat grades are indicators of the purity of a wheat class or subclass, the effects of external factors on grain soundness (rain, heat, frost, insect and mould damage) and the cleanliness (dockage and foreign material) of the wheat lot. Grain protein content and *alpha*-amylase activity (enzymatic activity associated with the germination of the grain) are frequently considered as grading factors in wheat trading. These two factors, which are important in determining the end-use properties of wheat, can be tested rapidly when the wheat arrives at the mill. High *alpha*-amylase activity has a large negative effect on the properties of baking doughs, as it excessively hydrolyses the flour's starch. Grain lots having very high levels of amylase activity may be totally rejected as a food item and accepted in the market only as feed grain" (FAO/Peña 2000).

*Alpha*-amylase activity

Hagberg Falling Number (FN) tests measure the "cereal *alpha*-amylase in wheat, a critical parameter for large-scale bakeries" (Catterall 1998). A higher number indicates a lower presence of *alpha*-amylase. The theoretically "lowest possible FN is 60 seconds and the highest reliable figure would be 350 seconds" (Catterall 1998).

It is important that the Hagberg FN "is controlled at the wheat stage because the milling process can't adjust it. The FN can be lowered by the addition of malt flours but no technique has been found to actually reduce the amylase and thereby increase the Hagberg number" (Catterall 1998).

Ash content

Flour grade colour is closely linked with ash content and considered a measure of flour purity. However, grade colour isn't a measure of the visual appearance of the flour: "Two samples that look completely different may give the same colour grade value" (Catterall 1998). Ash content (or flour colour) "can affect flour performance in baking; the whiter the flour, the better the breadmaking properties" (Cauvain *et al*. 1983, 1985).

3.2.5 Product reliability in flour

As can be seen from the preceding discussion of wheat characteristics and flour grades, reliability and conformance in flour are not easily separated. However, Catterall does provide some guidelines about reliability and food safety in flour milling. He advises the application of HACCP plans to prevent introduction of foreign bodies and chemical or biological contaminants (Catterall 1998).

3.2.6 Flour conformance in France and the U.S.

3.2.6.1 Flour conformance in France

The French system categorizes flour by three main types, but the categories refer to the quantity of minerals and micronutrients[28], in the flour. When wheat is milled in France, the resulting grades of flour provide bakers and end consumers with information about their mineral and micronutrient content (INRA 2002). The "two factors that mainly determine the level of minerals and micronutrients in bread are the flour milling method and the type of wheat used. Minerals and vitamins in the wheat grain are concentrated in the outer envelope (the bran) and the germ, which are removed in the milling process" (INRA 2002).

The different particle size fractions are separated into three main categories:

- "*White flour* is the finest fraction. Under the French classification system, white flour contains 0.55 g of minerals per 100 g flour and is known as type 55.
- *Farine bise* is obtained by mixing an intermediate fraction derived from the germ and bran back into the white flour; *farine bise* flours are types 80 to 110 in the French system.
- *Wholemeal flour* is obtained by incorporating all fractions, including the coarsest elements" (INRA 2002).

Traditionally French bakers have used flour type 55 for 'daily bread,' or standard white baguette (INRA 2002).

French legislation contains very detailed specifications regarding the name used for each flour category. A chemical analysis of each flour is performed to precisely identify moisture

---

[28] Sometimes referred to as trace elements.

level and content of fats, proteins and other materials. But the classification only reports two specific criteria: extraction rate and ash content (Vantal 2001). Flour category, mineral (ash) content and extraction rate are shown in Table 3.3; "the higher the ash content, the higher the extraction rate. In short, ash content is broadly a measure of extraction rate" (Cauvain 2008).

Table 3.3
French flour grades

Category	Mineral (ash) content	Extraction rate
45	Less than 0.5%	70%
55	0.5 – 0.6%	75%
80	0.75 – 0.90%	85%

Source: Vantal 2001

3.2.6.2 Flour conformance in the U.S.

Flour categories

Flour grades in the U.S. contain information about whether or not most wheat bran and germ were removed during the milling process, type of wheat milled and the purpose of end use (Figoni 2003). Table 3.4 shows the U.S. flour grades; only straight flour is equivalent to French breadmaking flour. Each of the U.S. flour categories implicitly refers to extraction rate while the French system directly states extraction rate. The U.S. baking industry expects extraction rates of: straight flours 76 to 78 percent; brown flours (blends of straight flour and bran) roughly 90 percent; and wholemeal or whole wheat flours 100 percent.

Table 3.4
Overview of U.S. flour grades

Category	Description
Straight flour*	Wheat is milled from the entire endosperm (rather than only the inner starchy part); bran and germ are removed. Straight flour is used to produce patent, clear and low-grade flours.
Patent flour	Whitest flour and highest quality; contains mostly the white, starchy innermost part of the endosperm and very little bran or germ; used for breads or cakes; comes from blending the first parts of the streams of flour at the mill; has 5 sub-categories based on which milling streams are blended
	Made from soft wheat; used for cakes:
Fancy Patent flour	(Also known as Extra Short flour); highest quality of all U.S. flours; contains40 to 60% straight flour
First Patent flour	Contains 60 to 70% straight flour
	Made from hard wheat; used for breadmaking:
Short Patent flour	Contains 70 to 80% straight flour;
Medium Patent flour	Contains 80 to 90% straight flour;
Long Patent flour	Contains 90 to 95% straight flour;

Continuation of Table 3.4

Clear flour	Made from what remains from straight flour after the patent grades have been removed from sieves; despite name is darker than other flours because of high ash content; desirable taste in rye breads.
Fancy Clear	Used for pastries
First Clear	Made from hard wheat and blended with lower gluten flours; often added to whole wheat, rye or other dark breads where colour isn't seen
Second Clear	Very dark; generally used in animal feed (such as dry foods for dogs and cats)
Low-grade	Made from straight flour; very dark; used for animal feed (such as dry foods for dogs and cats)
Stuffed straight	Straight flour with some clear flour added

** Not used by bakers in North America but is the main bread flour in France.*

Source: www.practicallyedible.com and Figoni 2003

Millers require test weight per bushel of incoming wheat as a surrogate test for extraction rate. Additionally, the extraction rate not only tells about the flour content, but also indicates mill efficiency (Catterall 1998). Although there is no legislation to require disclosure of extraction rate or ash content, it seems likely that millers and bakers could require one or both as contract specifications. Nevertheless, there is no linkage between the grades (Table 3.4) and nutritional characteristics, common in France and described by INRA (Section 3.2.6.1).

Quality problems

"Millers in the export market have shown a growing preference for Canadian and Australian wheat over U.S. wheat since the 1980s, primarily because Canada and Australia offer more consistent quality. Overseas millers do not feel that the U.S. Federal Grain Inspection Service (FGIS) wheat grades and standards are an appropriate indicator of end-use quality. They want more information on dough and flour properties and are concerned about the variability in quality both within and among lots of wheat" (Wilson and Dahl 2000). In February 2011, NAMA requested that USDA/GIPSA revise wheat-grading standards to improve flour quality and increase U.S. competitiveness. Their main objectives were to identify: "Flour yield; insect damaged kernels; live insect infestation; protein quality vs. quantity; mycotoxins; and alpha amylase enzyme activity" (NAMA 2011). Over the years the USDA has consistently refused to make the standards more stringent and regards higher quality requirements as a contractual issue between buyer and seller. This stance is again clear in USDA comments regarding reduction of live insects: “The market deals effectively through contract specifications with live insects, and accordingly, [GIPSA] will not propose revising the wheat standards regarding the live insect tolerance” (Federal Register 2012). Thus, quality problems or inconsistencies in wheat lead to questionable flour properties for both domestic and international buyers.

3.3 Benchmarks of wheat quality

All countries that grow wheat have a grading system for the product. So, in a sense, product conformance is determined on a country-by-country basis. As discussed regarding flour, reliability (food safety) criteria cannot easily be separated from product conformance in wheat.

3.3.1 Wheat conformance in France

The French wheat grading system (as of 2007) appears in Table 3.5. In 1998, the French grain industry, represented through ITCF working in concert with ONIC, ANMF and GNIS, devised a new grading system and introduced it as a pilot in 1999. The changes were designed to better meet “the needs of buyers on European and worldwide markets that are increasingly segmented. [The experimental grading system is] designed to facilitate trading; it is an objective reference for operators depending on the intended use: breadmaking, biscuit making, starch industry, animal feed, etc. … The grading system will be used as a reference in the disposition of the INCO[29]-GRAINS contract, among others. By providing this

---

[29] “INCO terms are internationally agreed conditions and terminology for export contracts, letters of credit and other internationally negotiable documents” (International Chamber of Commerce 2010).

classification of French wheats, we hope to facilitate the customer's assessment of the full range of wheats on offer in order to better target their procurement needs" (joint statement of ONIC and ITCF 1999).

Table 3.5
French grading system for soft (bread) wheat

Class	Protein content	(W) force of the baker	Hagberg FN
E	≥ 12%	≥ 250	≥ 220
1	11 – 12.5%	160 - 250	≥ 220
2	10.5 – 11.5%	Depends on specific contract	≥ 180
3	< 10.5%	Not specified	Not specified

Source: *ARVALIS* 2007

Table 3.6 shows the experimental wheat grading system that was introduced in 1999. The Physical criteria column represents 'specific weight/maximum moisture content/broken kernels/sprouted kernels/impurities'. This causes the entries for the classes E, 1 and 2 to be interpreted as:

- Specific weight should be at least 76 kg/hl;
- Moisture content should not exceed 15%;
- Broken kernels should not exceed 4 in a sample of 100 grams;
- Sprouted kernels should not exceed 2 in a sample of 100 grams;
- Impurities should not exceed 2 in a sample of 100 grams (ITCF 1999).

Table 3.6
French grading system for soft (bread) wheat in 1999

Class	Protein content	(W) force of the baker	Hagberg FN	Physical criteria
E	≥ 12%	≥ 250	≥ 220	76/15/4/2/2
1	11 – 12.5%	160 - 250	≥ 220	76/15/4/2/2
2	10.5 – 11.5%	Depends on specific contract	≥ 180	76/15/4/2/2
3a **3b**	< 10.5%	Not specified	Not specified	**a**: PS≥74/15/4/2/2 **b**: PS≤74/15/4/2/2

Source: ITCF 1999.

The experimental system contained both physical criteria and intrinsic characteristics. By year 2000, the French grading system no longer included physical criteria. A comparison of the intrinsic characteristics of 1999 with the French wheat grading system of 2007 showed that the benchmark values for the intrinsic characteristics were the same in both years. However, the test methods changed toward more internationally recognized testing standards (Table 3.7); further proof of the French growers' focus on successfully competing in the international marketplace.

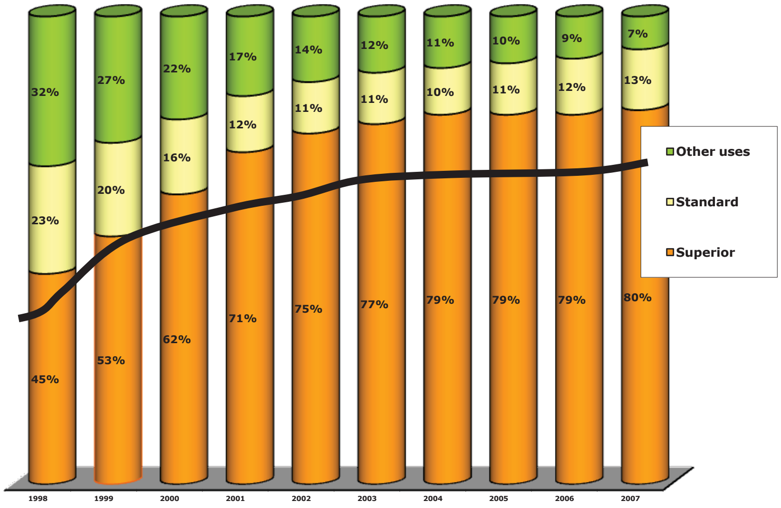
Table 3.7
Comparison of French grading system from 1999 with 2007

Criteria category	Test basis	Test std. 1999	Test std. 2007
Protein content	*Nitrogen x 5.7% dry matter*	**NF V03-750 (a French national test standard)**	**Dumas measurement method using Kjeldhal infrared reference ISO 20483**
(W) force of the baker	*Alveograph with W is 10^{-4} joules per gram*	**Chopin method, NF ISO 5530.4**	**Chopin method, XP V03-170**
Hagberg FN	*Amylase activity; ideal is 180-250 sec.*	**NF V03-703**	**NF EN ISO 3093**
Criteria category	**Test basis**	**Test std. 1999**	**Test std. 2007**
Physical criteria	*Test weight, moisture content and defects/dockage*	**NF V03-719, NF ISO 712, and visual tests**	**Eliminated prior to 2003**

Source: Compiled by author's own research of data from *ARVALIS* 2007, 2006, 2005, 2004, 2003,1999

Changes in wheat grading have not only facilitated export trade, but also served to focus producers on a steady improvement in quality; this shows in the changes in characteristics of breadmaking wheats from 1998 through 2007. The change in grading system began to affect production very shortly after introduction (Figure 3.1).

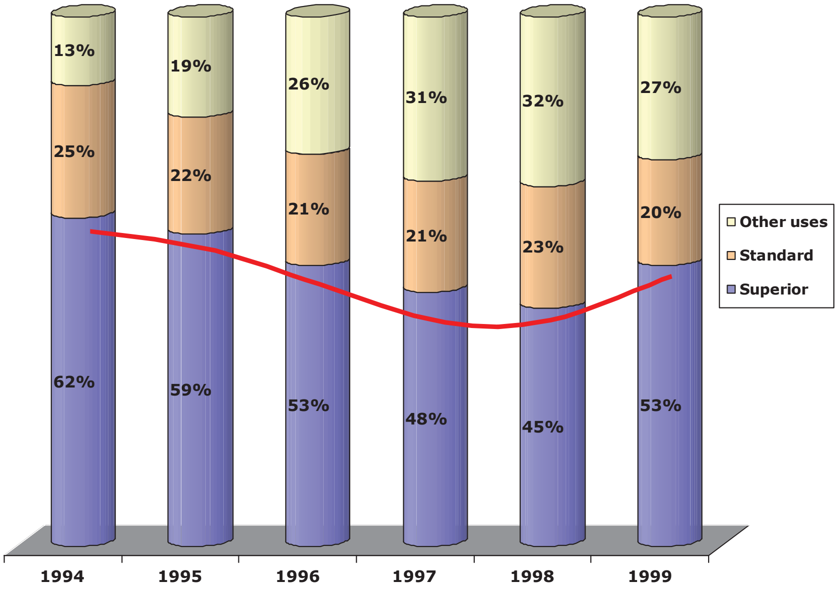
Figure 3.1
Trend for superior breadmaking wheats



Source: ARVALIS and ONIC 2007

Within a few years, the share of wheat in the highest ('superior') breadmaking category grew rapidly as the share of moderate-level ('standard') breadmaking wheats decreased; around 2002 the superior category began to erode the lowest ('wheat for other uses') category, as well. A more thorough analysis of the specific types of changes in ONIC test results, and the related production qualities, shows that one prominent factor was an increase in protein content. As an example, in tests of more than 60 wheat samples collected from 88 percent of the total area sown with breadmaking wheat in France, only seven samples' test results in the 1999 harvest showed protein content less than 10 percent. Considering that French bread varieties are best suited for soft wheats of slightly less than 10 percent protein[30], it seems likely that the majority of growers began competing more actively for the export market. This was further corroborated by the AGPB: "The export market drives wheat quality in France" (Le Stum 2007). To understand better the mindset of the French wheat growers, it helps to look at the trend for superior breadmaking wheats prior to the decision to change the grading system (Figure 3.2).

Figure 3.2
Pre-1999 trend for superior breadmaking wheats



Source: ARVALIS and ONIC 1999.

---

[30] "Ideally, protein content of soft wheats for French breads are approximately 9.5% ± 0.7%" (Cauvain 2007).

The red line (from 1994 through 1998, and including the introduction of the new grading system in 1999) shows the steady decline in superior quality breadmaking wheats from 1994 to 1998, with an upturn in 1999.

While the discussion here has been about the impact of the grading system, that raises a question about whether or not quality truly improved or the changes were only cosmetic. True quality improvements would be seen in the intrinsic (chemical laboratory) tests. Intrinsic tests showed measurable improvements between 1998 and 1999 harvests as follows:

- Protein content – "Consolidated protein content was an average of 11.1% which is a 0.2 percent increase over last year. The distribution of the French wheat supply around this average makes it possible to offer a range of batches suitable for all the segments of the market" (ARVALIS and ONIC 1999);
- Baking strength – "Among the wheats that have a protein content of at least 11%, 2/3 have a baking strength (W) greater than 160, and 1/6 show a baking strength between 200 and 250 inclusive. These results guarantee that extremely large quantities of French wheats can easily be used for breadmaking" (ARVALIS and ONIC 1999).
- Hagberg FN – "The 1999 harvest showed no signs of a problem with sprouting. Over 99% of the wheats had a Hagberg FN greater than 220 seconds and almost 2/3 were about 300 seconds. The average of 300 seconds is in comparison to 263 seconds for the 1998 harvest" (ARVALIS and ONIC 1999).

3.3.2 Wheat conformance in the U.S.

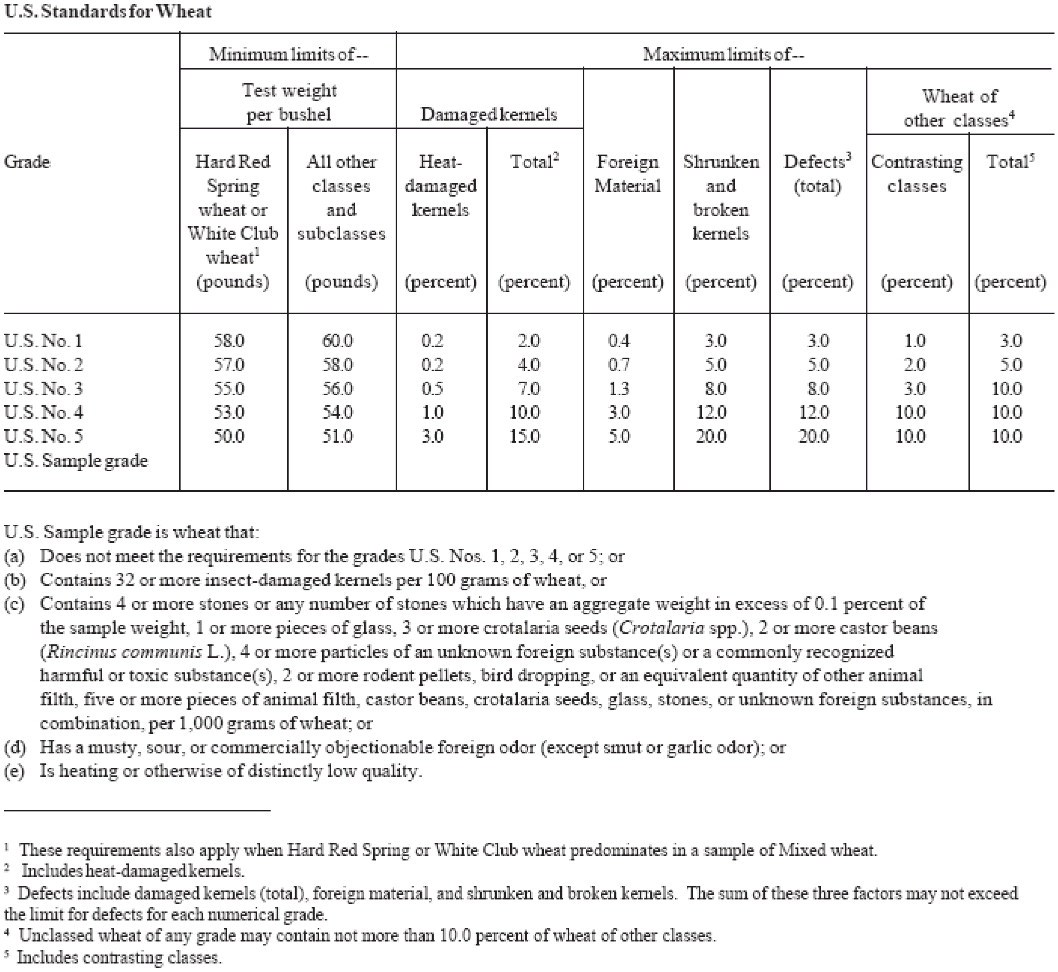
The U.S. wheat grading system appears more complex than that of the French, but it reports only one set of criteria: physical characteristics. The grading system is discussed in more detail in Appendix 3.A, but key elements of the official grading system are reproduced in Figure 3.3. Test weight is the only criterion from Figure 3.3 that can be directly compared with the physical criteria of the French grading system of 1999.

- Test weight for hard wheat grade no. should be approximately 79 kg/hl. Test weight for soft wheat should be at least 76 kg/hl for grade no. 1 and at least 66 kg/hl for grade 5. (The comparable test weight in the French criteria was 76 kg/hl for grades E, 1 and 2 and at least 74 kg/hl for grade 3 – considerably higher than the U.S. grades).

- Moisture content and protein content are reported in the U.S. but not included in the formal grading system.

Although Figure 3.3 contains a number of data elements, the practical value to a miller or baker is limited to three items: test weight, grade number and wheat class; test weight providing surrogate data about flour extraction rate and grade number actually incorporating data about cleanliness. But, as the changes to the French grading system showed, buyers need more information (such as protein content, alveograph and Hagberg test results) to determine how a wheat would perform in the buyer's own production environment.

Figure 3.3
Official U.S. wheat grading system



U.S. Standards for Wheat

Grade	Minimum limits of--		Maximum limits of--						
	Test weight per bushel		Damaged kernels					Wheat of other classes[4]	
	Hard Red Spring wheat or White Club wheat[1] (pounds)	All other classes and subclasses (pounds)	Heat-damaged kernels (percent)	Total[2] (percent)	Foreign Material (percent)	Shrunken and broken kernels (percent)	Defects[3] (total) (percent)	Contrasting classes (percent)	Total[5] (percent)
U.S. No. 1	58.0	60.0	0.2	2.0	0.4	3.0	3.0	1.0	3.0
U.S. No. 2	57.0	58.0	0.2	4.0	0.7	5.0	5.0	2.0	5.0
U.S. No. 3	55.0	56.0	0.5	7.0	1.3	8.0	8.0	3.0	10.0
U.S. No. 4	53.0	54.0	1.0	10.0	3.0	12.0	12.0	10.0	10.0
U.S. No. 5	50.0	51.0	3.0	15.0	5.0	20.0	20.0	10.0	10.0
U.S. Sample grade									

U.S. Sample grade is wheat that:
(a) Does not meet the requirements for the grades U.S. Nos. 1, 2, 3, 4, or 5; or
(b) Contains 32 or more insect-damaged kernels per 100 grams of wheat, or
(c) Contains 4 or more stones or any number of stones which have an aggregate weight in excess of 0.1 percent of the sample weight, 1 or more pieces of glass, 3 or more crotalaria seeds (*Crotalaria* spp.), 2 or more castor beans (*Rincinus communis* L.), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), 2 or more rodent pellets, bird dropping, or an equivalent quantity of other animal filth, five or more pieces of animal filth, castor beans, crotalaria seeds, glass, stones, or unknown foreign substances, in combination, per 1,000 grams of wheat; or
(d) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or
(e) Is heating or otherwise of distinctly low quality.

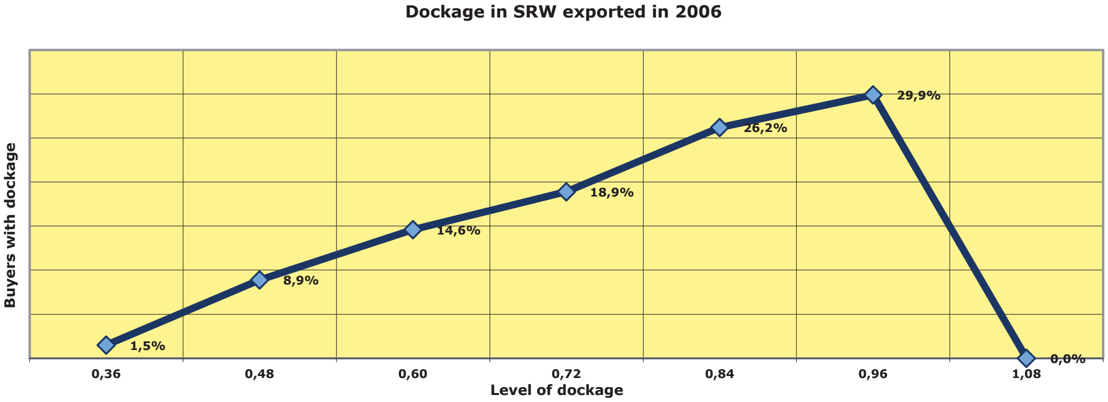
---

[1] These requirements also apply when Hard Red Spring or White Club wheat predominates in a sample of Mixed wheat.
[2] Includes heat-damaged kernels.
[3] Defects include damaged kernels (total), foreign material, and shrunken and broken kernels. The sum of these three factors may not exceed the limit for defects for each numerical grade.
[4] Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.
[5] Includes contrasting classes.

Source: GIPSA/USDA Effective May 2006.

As a practical matter, nearly all exports in 2004 through 2006 were grade numbers 1 and 2. It would seem that the other grades were of little interest to the export market. GIPSA reported the dockage in 2006 for exported soft red winter wheat (the most similar wheat variety to that of France) to have been less than one percent of each lot shipped. While the one percent-figure seems small, the GIPSA data showed *every* lot to have some level of dockage (distribution as shown in Figure 3.4). Also, the fact that the rate of dockage increases consistently with the increased number of MTs, then suddenly drops to zero, might indicate that the inspectors stopped counting at a certain point.

Figure 3.4
Dockage in U.S. spring red wheat in 2006



Source: USDA/GIPSA 2007

Dockage must be removed before the wheat can be milled due to issues of food safety, protection of the milling equipment and safety of the mill workers. The technology for removing dockage consists of two or three layers of electrically powered vibrating screens of differing screen sizes. Screening is done “with multiple screens for more efficacy. If one screen cannot get it all clean the second or the third one will. A single stack of screens can process as much as five to ten tonnes per hour of input material, and in large operations, multiple stacks of screening stations could be configured” (Schmidt 2011). So it seems unlikely that the American storage terminals didn’t have time to remove dockage before shipping. It is more likely they didn’t want to invest in equipment and -- lacking a feedback loop from end customers -- believed that their product was clean and competitive. This same missing feedback loop from the market plays a role in other conformance and reliability issues (discussed in balance of this section).

The conformance and reliability problems are not new

Although deregulation occurred in 1996, there is little sign of competitive behaviour in open production. It seems unclear whether growers are motivated to grow wheat as a food crop or simply to produce the maximum planted acreage to optimize payments of direct subsidies. The industry remains disconnected from both bakers and millers, while possibly more strongly influenced by commodities trading. The overall impression is that the industry is a large, rapidly moving manufacturing line with “no time to waste” analysing the current business environment. The U.S. situation is complicated further by the possible oligopsony situation formed by the three large grain processors and their railroad partners.

The problems associated with U.S. wheat quality began to attract U.S. government attention as early as 1989. The U.S. Congressional Office of Technology Assessment (OTA) performed a study that year of buyers’ preferences for wheat from five of the world’s dominant exporters (Canada, Australia, U.S., EU and Argentina). It concluded that, when price plus transport costs were similar, U.S. wheat was nearly always the least preferred of the group. The reasons given were: wheat class wasn’t a good indicator of end-use quality; lack of information on dough-handling properties; insufficient information (concerning protein quality, pesticide residue, both hidden and dead insects and mycotoxins) for ranking the wheat; and an apparent increase in lack of uniformity in end-use quality (OTA 1989).

Some of the factors that may contribute to the U.S. reluctance to keep pace in a competitive market could be related to the following:

-- Insufficient time for thorough testing (Section 3.3.2.1);
-- Mass manufacturing mentality (Section 3.3.2.2);
-- U.S. grain standards that were developed nearly a century ago (Section 3.3.2.3);
-- Farmers have little motivation to produce based on consistency of quality (Section 3.3.2.4);
-- U.S. Government policy doesn’t encourage competitive practices (Section 3.3.2.5);

-- A belief that 'downstream' actors can blend out differences to offer a consistent quality (Section 3.3.2.6);
-- Little interaction with end customers (Section 3.3.2.7);
-- Attitude toward dockage and other quality attributes (Section 3.3.2.8).

3.3.2.1 Insufficient time for thorough testing

Grain receipt at country elevators is the first collection point from the farm harvests. A study in these elevators showed that the total time allotted for collecting and evaluating a grain sample from each truck varies at individual elevators, but the total time taken ranges from one minute to more than three minutes (Herrman *et al*. 2001). Table 3.8 shows time for each type of testing activity based on elevator size.

Table 3.8
Test time per truckload at country elevators (shown in seconds)

Tasks	Small	Medium	Large
Collect sample	42	36	42
Check moisture level	72	66	38
Check for dockage	23	33	33
Check test weight	32	27	28
Total time	***169***	***162***	***141***

Source: Herrman *et al* 2001.

A key requirement of testing is that it should occur before the truck deposits its load on the tipping floor. The constraint at the elevator is the number of drive-on weighing scales available. The small elevators are described as typically having one scale and large operations may have two. However, during peak periods trucks arrive at the rate of 50 per hour – or an average of one truck every 72 seconds. This raises the possibility that not all tests are performed during peak periods.

It might also be possible that trucks tip their load, even though immediate testing isn't available; this would necessitate each load being held in a segregated bin until tests could be performed. However, elevators store a variety of grain, not only wheat. Considering that a truckload of wheat ranges from 11 to 20.5 tons (depending on the size of the trailer) that would mean the temporary storage required for just one hour would range from 550 to 1,025 tons, or some 2 to 4 percent of total grain storage capacity in the large elevators. In addition, this scenario would need to include adequate time to clean each bin between deposits – all in that same hour. Perhaps the elevator operators know their suppliers well and are aware of whose deposits require more careful inspection. It seems likely though, that at least during peak periods, there simply isn't adequate time to carry out sufficient testing.

Incoming receipt of wheat and testing at the mill. Tests are conducted on incoming wheat to determine quality against the buyer's specifications. Sampling must be efficient so as to collect a sample representative of the entire load. Two methods exist: one uses a manual spear that requires the test person to stand on top of the load, making the test unsuitable for food products but easier for spotting contamination; another uses a pneumatic sampling spear that is vertically driven down into the load allowing samples to be taken at all depths and multiple locations (Catterall 1998).

Based on the type of mill and the flour produced, the tests will generally include the following tests:

1) Test of appearance or presence of off-odours and taints;
2) Screening for impurities;
3) Wheat density test (or bushel/hectolitre weight);
4) Gluten content;
5) Hagberg FN;
6) Moisture content;
7) Protein content;
8) Grain hardness test;

9) Increasingly more often, an electrophoresis test to verify authenticity of wheat variety (Catterall 1998).

In the Herrman *et al*. study, only four of Catterall's nine tests were performed at the elevators (Table 3.9). Assuming that somehow the time allotted for the four tests was sufficient (which seems unlikely), there are still five tests not performed. These five are most representative of baking qualities.

Table 3.9
Overview of intake tests at flourmill

Test	Description/purpose	Correlation to U.S. tests
Appearance, odours, taints	Visual test. Trained lab staff looks for unusual odours, dampness or musty, mouldy wheat, or contamination from truck, previous load or fuel used in truck.	Part of the 36 to 42 seconds for sample collection
Screening out impurities	Series of vibrating screens are used to separate two types of impurities: foreign matter such as string, paper, nails, stones, infestation from insects or mice; shrivelled or diseased grain, weeds, straw, ergot (a fungus that is toxic to humans and livestock). Composite weight from fine and coarse impurities as a percentage of original wheat sample, represent a contract specification that can cause wheat to be rejected.	23 to 33 seconds are allotted for checking for dockage
Wheat density (or bushel/hectolitre weight)	A cylinder of known volume is filled and weighed; result is converted to kg per hectolitre (kg/hl). Two purposes: 1) Breadmaking wheats need more than 80 kg/hl; softer biscuits need approx. 70 kg/hl. 2) Extraction rate = optimum amount of flour from a wheat; is determined by hl weight. Low hl weight: gives low extraction rate; can cause 'specky' and unacceptable flour; relates to low FN, as well.	27 to 32 seconds are allotted for test weight
End of initial tests	**Wheat that passes the 3 initial tests (*above*) goes to second stage of tests based on a sample ground in the lab and further tests (*below*).**	
Gluten content	Sample of ground wheat is mixed into dough and kneaded; a salt solution is used to keep gluten intact while the starch is washed away. Smooth dough (gluten) with a light grey colour is goal; wheat that was dried incorrectly may have damaged protein that causes gluten to break up into gritty pieces; in extreme cases it might not even form a gluten.	
Hagberg Falling Number (FN)	FN tests measure *alpha*-amylase level in ground wheat and are critical in large bakeries. Test duration is 60 to 350 seconds.	
Moisture content	Important to farmer & miller; wheat may be stored to 12 months; to prevent spoilage moisture shouldn't exceed 15%. Near-infrared (NIR) testing often used.	38 to 72 seconds
Protein content	Protein content and quality are vitally important to miller; they are the basis for wheat trading; As protein varies widely from one truckload to the next, accurate measurement is needed to be able to segregate wheat and blend properly. NIR testing is used with results in 25 seconds; test value is based on nitrogen x 5.7.	

Continuation of Table 3.9

Test	Description/purpose	Correlation to U.S. tests
Grain hardness	Measures wheat endosperm texture; endosperm contributes to grain hardness. Breadmaking requires hard wheat, but some 'hard' wheats are too soft and should be used in cookies/cakes; others are too hard and should be used for feed. NIR can be used which reduces number of overall tests as well as time needed.	
Electrophoresis test	Used for identity verification. Test splits protein into individual amino acids and stores them as unique pattern that becomes benchmark for comparing unknown pattern samples.	

Source: Catterall 1998.

The primary argument in the U.S. government literature against use of more sophisticated testing is one of cost (Uri and Hyberg 1996). This was previously described, but the line of thought is that the seller shouldn't be burdened with having to invest in expensive equipment without compensation in the form of income for performing the tests – although the buyer does need the results of these tests. The Uri and Hyberg study was performed in the same year that deregulation took place. Here again the attitude is more reflective of monopolist thinking than of a seller in a competitive market. A secondary argument, put forth by the grain industry, is that additional testing would be too time consuming (Herrman 2002). But differences in attitudes toward management of quality control are described in the next section; a preference for 'safe unless proven otherwise' versus 'the precautionary principle' (Section 2.1.9.2) may also play a role in determining attitudes toward grain testing.

Differences in attitudes toward management of quality control

Some quality control decisions can be considered a shared responsibility, partially decided by farmers and partially by regulators. The task of cleaning equipment after its use and cleaning it again before the next use, serves to illustrate the differences of opinion between the U.S. and French farmers and regulators. The French "Charter of Good Production Practices" views cleaning of equipment as one of the good manufacturing practices/good agricultural practices/good hygienic practices (GMPs/GAPs/GHPs) to prevent possible contamination from a pathogen overlooked in the previous lot. The EC recommends it to avoid accidental commingling when farmers grow both GMO and non-GMO grain (EC 2003).

The U.S. Farm Foundation and the USDA view the task as an unnecessary cost overhead introduced by EU requirements for traceability (Wilson *et al.* 2005). On one hand it could be argued that a farmer who has consistently applied GMPs/GAPs/GHPs to every other process that contains a related critical control point (CCP) will not have introduced pathogens or commingled GMO and non-GMO wheat. But the absence of quality management systems and HACCP plans – not only in U.S. farming but in storage elevators, as well – would indicate that there is no formal quality control of production management practices. It also seems that U.S. growers and regulators see no potential danger in omitting cleaning of equipment.

3.3.2.2 Mass manufacturing mentality

Receipt of grain at the country elevator is only the first stage into a huge, rapidly moving system for grain handling across the U.S. and overseas. Grain may arrive at the country elevator directly from the harvest or it may be coming from on-farm storage facilities. In 2002, total U.S. off-farm storage represented capacity for more than 10 billion MTs, while on-farm storage was less than 300 million MTs and declining each year (U.S. National Agricultural Statistics Service 2007). Product intended for export passes from the country elevators to inland sub-terminals to export terminals and finally onto vessels for overseas transport. All export terminals have capacity greater than 25,500 MTs (U.S. National Agricultural Statistics Service 2007). Grain destined for export is loaded onto vessels with capacity ranging from 20,000 MT to 50,000 MT—more than the capacity of most individual off-farm storage facilities. Trainloads arriving at the export terminals are likely to be 100 cars or more in length (Herrman 2002).

Influence of rail carriers

Possibly the rail carrier system provides the best example of the mass manufacturing nature of wheat production in the U.S. Deregulation of railroads took place in 1980 and was mostly centred on allowing carriers to introduce various pricing and car allocation strategies. Prior to deregulation, tariffs were posted and cars were allocated on a first-come-first-served basis. From the shippers' perspective, the system was characterized as exhibiting little innovation or motivation for timely car placement. From the carriers' point of view, the system was inefficient and operationally expensive. For example, there were no penalties for order cancellations. Shippers wanting to be certain of car availability generated many 'phantom orders' (i.e., excess orders to increase odds that cars would be available when needed); those not used would be cancelled prior to shipping (Wilson and Dahl 2005). Although not mentioned in the literature, it appears phantom orders were the shippers' response to erratic service from the carriers.

Following deregulation, the rail carriers were faced with increased uncertainty in making operating and capacity decisions. The carriers responded by offering service level guarantees in confidential contracts. In 1988 Burlington Northern (BN) became the first railroad to attempt innovative pricing. The program allowed shippers to bid for guaranteed railcar placement by offering to pay a premium over the shipping cost. However, that led to what Wilson characterized as "an industry where notions of equitable distribution and common carriage were somewhat nebulous" and the policies being challenged by shippers via the Interstate Commerce Commission (ICC). Ultimately, the ICC decided in favour of BN, indicating “allocation by price is efficient because service is provided to those who value it most” and that the program should “enhance long-run efficiency by giving incentives to maintain an optimally sized grain car fleet.” Following the ICC decision, most other carriers introduced similar pricing mechanisms (Wilson and Dahl 2005).

It should be noted from the ICC ruling that BN’s service was primarily intended for grain shippers (farmers). It also seems from the ICC ruling that BN’s service levels and capacity planning improved following deregulation. Now the railroad was able to eliminate phantom orders and shift the burden of car availability to those shippers who could afford to pay more. Initially separate auctions were held for highly specific geographic/grain ‘corridors’ (e.g., Northern wheat west, corn south). Over time these were aggregated into fewer corridors due to sparse number of bidders in some corridors. Aggregating corridors served to increase the number of independent bidders in each auction. (It seems aggregation would have also optimized the railroads’ costs: Increased bidders per route and longer trains with fewer routes travelled). Presently bidding occurs weekly, highest bid is accepted and the winning shipper is issued a transferable certificate. The transferability of the certificates allows numerous subsidiary-trading mechanisms, including fairly active secondary markets for the instruments. The shippers and cash grain brokers operate these markets internally by bundling the instruments as part of most grain procurement strategies (Wilson and Dahl 2005).

Car placement was guaranteed within a 15-day window with penalties for cancellations. If shippers cancelled their order, they would forfeit their prepayment ($300 per car). The carriers guarantee car placements to be within the 15-day window and will pay a penalty of $400 per car for default; the order then rolls forward into the next 15-day slot (Wilson and Dahl 2005). But this penalty still leaves most shippers at a disadvantage. If shippers do not receive cars on the requested date, the shipper will incur additional storage and interest costs. In addition, on export sales, the shipper will incur demurrage costs. There are no alternative modes of transportation available to the shipper, and as contracted grain is already destined for a specific customer, no alternative market. Thus, if cars are not received on time, the carrier default penalty of $400 per car is unlikely to fully compensate the shipper. There are also likely to be quality impacts to the wheat. For example, harvest occurs in summer and some of the largest wheat-growing areas in the U.S. (e.g., Kansas and the northern plains) have daily temperatures well in excess of 35ºC – the temperature at which damage to breadmaking quality occurs. It takes more than four hours to fill just one train car (Herrman 2002). This makes It is hard to imagine that such large volumes of wheat would be off-loaded and held in cool, ventilated conditions while the shipper prepares for the revised car arrival.

As for the rail carriers, several mergers have occurred. Burlington Northern Santa Fe's (BNSF) consolidated routes strengthened its position as a shuttle service for grain elevators throughout the central and northwestern U.S. Union Pacific and Southern Pacific also merged to focus on the grain handling business (Herrman 2002).

No indication of HACCP use

Throughout the literature regarding grain elevators and the shipping industry – whether by truck, rail or barge – there was nothing that indicated the existence of specialized treatment or planning to support food safety nor did descriptions of testing deal with the topic. Although the Codex recommends the use of HACCP, or a similar plan, for *every* entity in the food chain, there is no indication that any sort of food safety plan is used by wheat growers, storage points or transport services. References to use of HACCP in U.S. agricultural literature was primarily concerned with animal safety in the feed industry and the potential for using HACCP as a system to comply with traceability (Herrman 2002). It seems reasonably clear that HACCP plans are rarely used in the transport services, elevators or on the wheat farm.

A related topic is reluctance to comply with traceability regulations (such as EC 178/2002). There is much discussion in the literature regarding the impact of compliance. Most of the literature pertains to the separation of GMO from non-GMO grain and the related costs and logistics (Berruto and Maier 1999, 2001; Herrman 2000, 2002; Wisner 2003; Wilson, Janzen and Dahl 2003). Some literature is beginning to appear that relates segregation to the issues of handling specialty grains as well as meeting the needs of bespoke buyers, such as Frito-Lay and General Mills (Herrman 2002; Taylor, Brester and Boland 2005).

Consolidation of elevators and mills

Another issue related to the mass manufacturing mentality is the consolidation of elevators and mills into fewer and larger entities -- which also has an impact on product conformance. Storage times in the elevators may have increased and this, as well as increased transport distances (and costs), could affect wheat quality. Consolidation of mills seems to have been driven by pricing practices in the rail industry. In addition to increasing travel distances, the railroads changed practices so that wheat could not be milled at stopover points along the journey but brought intact to the end point first (Titus and Dooley 1992). This would also contribute to longer journeys increasing potential degradation of wheat quality. Maintaining wheat in its unprocessed condition may be an influence from commodities trading.

Large multi-purpose agribusiness firms (Cargill, ADM and ConAgra) with interests in milling, prepared foods, restaurant holdings, grain merchandising, feed manufacturing and other activities are buying up many of the previously family-owned mills. In 1974, the top four firms controlled 34 percent of the industry; by 1992 that figure was 70 percent (Wilson 1995). The agricultural economists at the NDSU extension service saw no clear business reason for the acquisitions in the milling industry because milling traditionally hadn't been profitable (Titus and Dooley 1992). Harwood, *et al.* noted the profitability issue in earlier literature: "The milling operations of several agribusiness firms have been sold because of high risk and low profits (Harwood, *et al.* 1989). While the acquisitions could support vertical integration for the agribusiness firms, it might be that milling is merely an additional line of business to support other more lucrative business activities (e.g. large-scale futures trading). Regardless, it also raises a question about the impact on quality.

3.3.2.3 Little motivation to grow based on consistency of quality

Farmers have little motivation to match varietal characteristics to consistency of quality. There are several reasons behind this. One is the goal to merely achieve U.S. Grade 1 or 2. As can be seen in the grain standards (Figure 3.3), these are fairly broad categories and entirely based on external characteristics. Varietal characteristics would be more discernible with intrinsic testing.

An additional (theoretical) quality concern is raised in literature. Kennett suggests that if an open market system were to have no grades, all wheat would be "sold at the same market price regardless of quality level. Since farmers would not be financially rewarded for producing higher quality wheat, they would exert the minimum level of effort" (Kennett 1998). This would lead to "maximum quality variability." In an open market system with grading, farmer effort increases proportionally as a greater percentage of wheat moves into the highest quality category (Kennett 1998). But this raises a question as to whether or not the very slight price differential between Grades 1 and 2 is really sufficient to insure that "maximum quality variability" is not the consequence.

A third reason that likely causes less weight to be given to varietal characteristics has to do with the strong influence of futures trading. KSU Department of Agricultural Economics conducted three related studies between 1987 and 2004 based on data collected from some 1000 Kansas farms. All three studies were concerned with a comparison of profits coming from futures trading with profits related to several benchmarks for good production practices. The research covers data collected from some 1000 Kansas farms during three overlapping time periods ranging from 1987 to 2004.

While the studies seem business management-oriented, some of the meanings are unique within the grain industry—possibly even unique to the U.S. For example, although "good management" is defined as "economic success" the authors question this definition: "For agricultural producers, what defines economic success? Does it have to do with obtaining higher yields, lower costs, or higher prices? Knowing when to adopt new technologies? …. As a producer, is it easier to lower your cost, or to increase your yield? Will profit be more affected by changing technology or by 'picking' good prices[31]?" (Nivens and Kastens 1999; Kastens, Dhuyvetter and Nivens 2001; Kastens and Dhuyvetter 2005). Appendix 3.B provides more detail of the three KSU studies.

How to 'pick' good prices for wheat

---

[31] 'Picking' good prices refers to choosing, or guessing, a price at planting time of the likely price of the crop on the commodities exchange at harvest time.

The KSU Extension Service published *Grain Marketing Plan for Farmers 2000* (excerpted in Appendix 3.C) as a sort of how-to manual for farmers' participation in the futures markets. In addition to describing the various investment instruments available to the farmer, it also helps a farmer develop multiple strategies to choose the best wheat price. The publication also recommends applying the same investment strategies to the farmer's purchase of inputs. The dissimilarity with conventional business management goals is striking; farmers are encouraged to leverage the markets to get the best price from buyers.

3.3.2.4 U.S. Government policy

Vast subsidies and farmers on welfare

Professor Daryll Ray,[32] testifying in February 2000 before the Democratic Policy Committee was very critical of the 1996 Freedom to Farm bill. (Highlights of his testimony can be found in Appendix 3.D). Professor Ray criticized the 1996 legislation for having introduced vast subsidies for wheat farmers under the assumption that they would be transitional, although continuing until at least 2012. Other aspects of his testimony underlined the terrible deficits that increasing numbers of wheat farmers were incurring while the strenuous restrictions on cropping decisions and the strong financial incentives tied to planting as many acres as possible continued in force.

A very different perspective on the 1996 Freedom to Farm bill is seen in the December 2002 comments from the Future of Freedom Foundation, a special interest group: The "1996 farm act gave subsidized farmers more than three times as much in cash handouts in 1996 and 1997 as they would have received under the previous five-year farm bill. Wheat farmers got

---

[32] Chairholder of the Blasingame Chair of Excellence in Agricultural Policy and Director of the Agricultural Policy Analysis Center at the University of Tennessee.

50 times more in subsidies for their 1996 crop than they would have got if Congress had merely extended existing farm programs" (Bovard 2002). In the same time frame, Senator Richard Lugar (R-Indiana) warned that the lavish new subsidies--some $200 billion about to be enacted in 2002--would result "almost inevitably" in "vast oversupply and lower prices" as well as demands for even more subsidies (Bovard 2002).

In fact, 'vast oversupply and lower prices' in the wheat market did not result (Section 1.3.12). Despite the 'lavish new subsidies' that were enacted, wheat farmers did not demand even more subsidies. Their income level continued to erode; more than 80 percent of the wheat farmers were on welfare by 2005 (Section 1.3.12).

Outmoded grain grading system

Grain grading standards rely on visual and external tests that were developed nearly a century ago in 1916 by commodities traders. At the time, the number of wheat varieties was small and more easily typified. Despite onerous resource requirements (10 to 12 years of laboratory work plus field tests at a cost of some $500,000 per variety) before a new seed wheat can be released for production, today there are more than 30,000 varieties available in the U.S. (NAMA 2006). With a smaller number of varieties, it might have been possible to associate intrinsic qualities with varietal characteristics using visual identification; but that would be impossible today.

Ongoing regulation of wheat farming

Section 3.3.2 introduced the Official U.S. wheat grading system standards. The Standards are contained in the Federal Register and each time the law is updated, the Federal Register publishes the modification. While the Federal Register is the legal source, it is not the easiest version to comprehend. Therefore Appendix 3.A provides an excerpt from the grading standards taken from Subpart M – United States Standards (May 2006). The last part of Appendix 3.A is a more detailed description of wheat testing in the U.S. (Herrman and Reed 2000). Unlike the French system, the wheat growers do not define the standards, lobby for qualities the standards should represent or become involved in drafting the law. Also unlike the French, and as Professor Ray's testimony pointed out, the U.S. growers have little freedom over cropping decisions on their own land and are motivated through the USDA regulations to plant as many acres as possible with little regard for quality.

In November 2009 in a periodic review, GIPSA/USDA invited comments regarding suggested changes to the wheat grading system. In April 2012 USDA announced in the Federal Register only a slight change to the grading standards (reducing shrunken and broken kernels by one percent for Categories 1 and 2). A comment from a large trade association representing 70 percent of all grain processors, feedlot owners and oilseed handlers requested no "major changes to the wheat standards that would adversely impact the marketing system or current priorities and operations of GIPSA"; this seemed to have been the basis for GIPSA/USDA's decision to make little change (Sosland 2012).

3.3.2.5 Belief that downstream actors can blend out inconsistent quality

There seems to be a belief that downstream actors can blend out differences to offer a consistent quality. This is characterized in multiple ways.

When the Grain Standards Act was first promulgated in 1916 it provided a legal framework to facilitate grain trading. Today "arbitrage opportunities exist during years where low quality grain can be purchased at a discount and blended to meet minimum or maximum grade and contract specifications" (Herrman 2002). This suggests a belief that grain merchants and millers can compensate for any deficiencies.

Catterall describes some of the limits on blending that the miller (or other blender) encounters. The miller has two options for 'custom-mixing: 1) wheat may be blended as a grist relying on the expertise of the miller; 2) or the flour may be blended after milling. Both techniques require specialised skills (Catterall 1998).

An additional issue has to do with the inability to use blending to improve the Hagberg Falling FN of a poor quality wheat. Large-scale bakeries are especially sensitive to *alpha*-amylase activity. The FN test is used to determine the level of *alpha*-amylase in a flour (Section 3.2.4). A flour with a low FN has high *alpha*-amylase content that cannot be blended out (Catterall 1998).

The "blending of flours with different FNs can be problematic because a simple arithmetic mean will not give a satisfactory approximation. Instead, the values must first be converted to a liquefaction number" (Catterall 1998). Attempts at blending two flours with different FNs will tend to significantly bias the final blend toward the level of the flour with the less suitable FN (Catterall 1998). If a miller wanted to blend two flours in equal proportions and Flour 1 had an FN of 100 (i.e., poor quality) and Flour 2 had an FN of 300 (high quality), the FN of the blended flour would not be 200, but only 189 (Catterall 1998); as in Table 3.10.

Table 3.10
Calculation of Hagberg FN of blended flours

Liquefaction number (LN) = 6000/(FN + 50); can be converted to Hagberg FN = 6000 + 50/LN.

If a miller wanted to blend two flours in equal proportions and Flour 1 had a FN of 100 (i.e., of poor quality) and Flour 2 had a FN of 300 (high quality), the equations would be:

Flour 1 LN = 6000/(100 + 50) = 6000/150 = 40

Flour 2 LN = 6000/(300 + 50) = 6000/350 = 17

The liquefaction number of the blended flour will be:

LN (blended flour) = (40 x 50)/100 + (17 x 50)/100 = 20 + 8.5 = 28.5

The Hagberg FN of the blended flour would be 189:

FN = (6000/28.5) + 28.5 = 239 - 50 = 189

Note: The Hagberg FN would *NOT* be 200 (the average of 300 and 100).

Source: Catterall 1998

Despite the practical problems associated with blending, it appears to be an accepted practice that elevators in the Great Plains states blend the wheat to meet “particular quality attributes” upon arrival. This may be an explanation for literature that showed farmers choosing to grow varieties that cannot be used except if blended. As explained in a personal communication from Dr. Timothy Herrman, “Growers select wheat based on economic incentives, primarily of which is yield. … It is important to note that in some areas of Kansas and southern plains states (e.g. Oklahoma and Texas), the farmers graze their wheat with cattle prior to letting it produce a wheat crop (essentially obtaining two crops in some years)” (Herrman 2007). The farmers were predominantly growing two types of cultivars – those with such high protein levels they couldn’t be used alone and those that were so low as to be unusable for breadmaking but very useful for cattle grazing.

3.3.2.6 Little interaction with end customers

The agricultural extension services of the state universities in the areas where wheat is grown have prepared considerable literature on dough and breadmaking properties. For example, KSU produced a booklet on milling and bread making qualities of hard winter wheat varieties. The booklet was a summary of other literature from USDA, the Wheat Quality

Council and KSU's Grain Science Department. The data was summarized to the level of just offering lists of suggested wheat varieties based on those that had been popular with millers or bakers (Bennett, Chung and Herrman 2002). The simplicity of the booklet makes it not only easy to read and remember, but a document that could be digested very quickly. But there is almost no detailed information that connects varietal characteristics to the specific requirements of bakers and millers.

In addition, some states, such as Kansas, have made large investments in establishing test laboratories to simulate commercial breadmaking plants. But no literature was found that indicated close cooperation between the state extension services and the bakery industry. There seems to be considerable interest on the part of the extension services to better understand the needs of the baker. Today the extension services fill the role of keeping the farmer informed of the customer's needs and offering advice on how to meet those needs within the local growing environment. The literature from the extension services shows them to be very dedicated to helping the farmer as much as possible. The difficulty seems to be that the extension services aren't fully aware of what the baker requires, or why the baker requires it.

OSU Agricultural Extension Service put together a study that compares wheat characteristics with desirable flour and dough characteristics. However, no direct linkage was made to wheat variety (OSU 2004). According to USDA, it would be impossible to accurately test the intrinsic characteristics of a majority of U.S. wheat because more than fifty percent of the seed used is farmer-saved seed (USDA-ERS 2002). Even if the farmer used certified seed (that has been graded and sold to represent a specific variety) in one crop year, saving the seed from that crop to use in successive crops doesn't insure that the same traits will be exhibited. Successive crops may or may not properly develop the expected varietal characteristics (USDA-ERS 2002). When saved seed is used; the subsequent plants may differ in height and appearance from the original type. In addition, seed contamination with other varieties can occur and cause off-type plants (KSU 1997). However, it should be noted that French farmers use some 50 percent saved seed, but INRA tests the seed for them to verify that varietal traits remain (Section 1.3.13).

While the OSU work accurately interprets general characteristics that bakers and millers require, it shows the same wheat industry perspective as previously discussed–that someone 'downstream' could solve all these issues. There is a gap in knowledge of what the baker really needs and just how much blending and improvement a miller can provide. In particular is the lack of appreciation for consistency, possibly the most important requirement for millers and bakers.

3.3.2.7 Attitude toward dockage and other quality attributes

Title XX of the Food, Agriculture, Conservation and Trade Act of 1990 (Public Law 101-624) mandated the USDA's Federal Grain Inspection Service (FGIS) "to study the benefits and costs of providing cleaner grain to the export market. The purpose of the legislation was to better understand the economic impacts that might occur in response to any changes in the grades and standards in place since 1916. The concern was that the information conveyed by the grades and standards were outdated and responsible for complaints about U.S. grain quality by foreign buyers. The study focused on whether the grain quality factors used by the FGIS (including test weight, dockage, moisture content, percentage of foreign material, percentage of shrunken and broken kernels and protein content) influenced the price of wheat for export to 63 countries. The conclusion was that only test weight and the protein content were characteristics consistently valued by the market" (Uri and Hyberg 1996).

"Dockage is one of many quality attributes that affects U.S. wheat competitiveness in international trade. While other countries regulate the dockage level in their wheat exports, the United States does not. Dockage is a non-grade-determining factor in the U.S. system, meaning that its level in export shipments is a negotiable contract term" (Johnson and Wilson 1995). In 1996 when the U.S. wheat market was deregulated, the USDA-ERS conducted comprehensive research of issues related to wheat quality. A major part of the study included interviews with buyers in major wheat-importing countries. The results showed that five topics influenced choice of supplier: role of quality factors in the buyer's country; ability to detail preferences in purchase contract specifications; level of dockage; sensitivity of purchases to cleanliness; and willingness to pay a premium for a cleaner wheat from the U.S. One effect of the study was the decision by FGIS that the cost of tests to determine particular intrinsic characteristics should be borne by those importers who requested them because other buyers didn't (Uri and Hyberg 1996).

Several points made by Wilson and Dahl *et al*. seem reminiscent of all former monopolies who find themselves unprepared for a competitive market with 'demanding' customers: "The U.S. grading system typically only measures physical (not chemical) [i.e. intrinsic] characteristics, and this is the mechanism upon which quality…relies" (Wilson and Dahl *et al*. 2000); privatization of grain imports increases communications between buyers and sellers, resulting in a more sophisticated buyer (Wilson and Dahl 2000); the U.S. has not performed as well in those markets in which purchases are made by private buyers (Mercier

1993); and, private buyers tend to use a more stringent, comprehensive set of specifications in their purchase contracts to reduce quality variability (Wilson 1995).

3.3.2.8 Summary

Possibly the conformance problems from the growers' perspective could best be summed up as there's not a lot of incentive to invest extra effort or expense under the current system. "The U.S. wheat growers are not unique is this aspect. Growers in the U.K. are becoming reluctant to grow Grade 1 wheat unless they are assured of a premium price" (Cauvain 2007). But, as the French production figures for class E showed, prior to the grading system change the French farmers were producing very little of the top class. In fact, in 1999, class E represented only two percent (720 000 MTs) of the total harvest (ARVALIS 1999). They had already made a *de facto* choice to ignore class E. But when the new grading system was developed, rather than "lower the bar" so that the criteria for class 1 became the criteria for class E or even eliminate class E altogether, the French growers made the strategic decision to perform the extra effort and to become stronger competitors. By 2007, class E had climbed to 13.3 percent, or four million MTs (ARVALIS 2007).

3.3.3 Product reliability in wheat in general

As Catterall describes, the agricultural industries in some countries have been slower than others to adopt food safety guidelines:

"The consumer's requirement for increasing confidence in safety and wholesomeness of the food that they eat has over the years worked its way through the supply chain from the multiple supermarkets, through to the food manufacturer, and then to the primary ingredient suppliers. The growers are now also understanding that they have a role to play in food safety, and the dialogue between the miller and farmer, which at one time was only about price, is now becoming more intense on more serious food safety issues" (Catterall 1998).

"Millers have had to change their culture from being an extension of the agricultural industry to being a food factory that allays customer concerns about food safety by applying HACCP principles" (Catterall 1998).

3.3.3.1 Amylose and amylopectin

As with bread and flour, reliability refers to the ability of the product to perform as expected without any food safety issues. While much of the discussion in the previous sections focused on the needs of the miller, the baker's primary needs are based on protein quality and amylose-to-amylopectin starch ratio. Wheat protein was discussed in previous sections. Amylose and amylopectin can both affect a bread and there are some differences between each of these types of starch.

"The amylose portion of starch is linear and made up of thousands of glucose units, while the amylopectin portion is branched and made up of a million or more glucose units… Starch in wheat flour generally contains some 25 percent amylose and 75 percent amylopectin. Although amylose and amylopectin are both made up of the same D-glucose building block, they have different chemical and physical properties that affect their behaviour during baking" (Lallemand Baking Update 1997).

"At 60ºC/140ºF, amylose easily diffuses out of starch granules when they absorb water and swell (gelatinise). Amylose re-crystallizes (retrogrades) rapidly when it cools after gelatinisation. In contrast, amylopectin does not easily diffuse out of starch granules when they gelatinise. … Amylopectin retrogrades slowly upon cooling after gelatinisation. The goal is to break down enough amylopectin to inhibit staling, but not so much that crumb becomes sticky or difficult to slice" (Lallemand Baking Update 1997). "The amylose molecules are responsible for a bread's structure. Once set in a solid state, the amylose molecules do not contribute to product staling whereas the amylopectin begins to stale immediately after baking" (Pateras 1998).

"French bakers regard the amylose-to-amylopectin ratio to be linked to wheat variety and, as a result, out of their control. Therefore it is not an item to be specified in flour purchase contracts or tested in the baking plant" (Landazuri 2005). However, as described above, baking experimentation to adjust amylose-to-amylopectin ratio in bread formulation through additions from other flour grains does occur in France. It has mostly been carried out by researchers at INRA and driven by interest in impact on human nutrition (INRA 2002). Other studies in France and in the U.S. showed the beneficial GI/GL effects of increased amylose and reduced amylopectin (Table 1.14).

Detrimental alterations to amylose-to-amylopectin ratio present a reliability issue. "The alterations can come from production practices on the farm (ranging from poor choice of seed to improper care of the growing wheat plants) but environmental factors also have a role that the farmer may not be able to control" (Cauvain 2008). However, solving this issue of a reliability problem for bread production also solves the issue for food safety.

3.3.3.2 Sprout damaged kernels

"The main properties of wheat that concern reliability and food safety are protein, starch and mineral content (or micronutrients). The proportions, and quality of each, are highly dependent on the particular wheat variety, climate and even the soil geology, especially with regard to mineral content" (Cauvain 2007). However, even a very high quality wheat sown in the best possible soil and subjected to ideal climatic conditions can have reliability problems that arise from production practices. One of the more common is sprouted kernel damage, which can also harm a bread product.

There are potential differences in the way damaged wheat kernels are regarded. For instance, in the U.K. literature, sprouted grain accounts for low bushel or hectolitre weight in wheat density tests (Cauvain and Catterall 1998). The U.S. literature indicates a variety of quality problems associated with sprout damage. Some of the problems appear downstream in the mill and in the baking plant: "Sprouting lowers test weight and flour yield, lowering the grade and value to the miller. The impact on baking quality is observed by lower absorption (water added in baking, which reduces bread yield), reduced mixing strength and tolerance, and sticky dough. It can also affect loaf volume, crust strength and crumb texture, whereas a wet and gummy crumb causes problems with slicing and shelf life. The level and impact of sprout damage is not fully realized until it is processed into bread. It was for this reason that the FN test was developed" (University of Minnesota 2004). FN tests are used to measure "changes in the physical properties of the starch portion of the wheat kernel" (NDSU 2004).

Tests from NDSU showed how strongly contamination from sprouting affected FN tests. Two kernels of visibly sprouted wheat were added to 200 grams of sound wheat (i.e. the two kernels represented .03 percent quantity). Even this very small addition reduced the FN by 100 seconds. In another test, sprouted flour (FN = 66) was blended with sound wheat flour at a rate of 1.6 percent; FN was lowered by 34 seconds. From a practical perspective, it is nearly impossible to "blend out" sprout damage (NDSU 2004).

3.3.3.3 Product reliability in the U.S.

There is no FN testing in the inspection and grading processes of GIPSA. This suggests the U.S. system might not be able to detect sprout damage. Despite the lack of a GIPSA standard, overseas buyers do tend to write minimum tolerances for FN into their purchase contracts. Local elevators in the U.S. will steeply discount sprouted wheat, both the visibly sprouted kernels as well as those with 'incipient sprouting' (i.e., moisture levels, temperature and time were adequate to produce sprouting prior to threshing). When the detrimental conditions are stopped, the subsequent sprouting stops prior to visible signs of sprouted kernels (University of Minnesota 2004). Considering that GIPSA uses organoleptic testing and no test for FN, this raises questions as to whether U.S. wheat may routinely contain levels of sprouting that are detrimental to bread production and are also a food safety risk. Table 3.11a shows how USDA interprets production requirements, quality assurance schemes, and marketing channels associated with four trait-specific grain products. As the table shows, moving from left to right, each category represents a significantly more differentiated product. The four trait-specific products fit neatly into USDA's framework but don't reflect how customers view trait-specific grains.

Table 3.11a
USDA overview of IP and trait-specific grain markets

	Output specific traits	Absence of specific traits (GM)	Certified organic	Pharmaceutical and federally regulated industrial
Product Example	High-oil corn	Non-GM corn	Organic soybean	"Cystic fibrosis" corn
Production protocol	Specific variety	IP production controls Inspections	Certified organic seed Multi-step inspections	IP protocols/Isolation Dedicated equipment Field inspections
Quality assurance	Testing (Near reflectance)	Non-GM testing Auditing Certification	Non-GM testing Auditing; Certification (National Organic Program)	3rd-party audits Certification Record-keeping; Source verification
Marketing channels	Segregation within bulk	Segregation within bulk	Certification	Closed loop/ containment

Source: USDA-ERS 2007

The quality requirements of Warburtons (a U.K. bread producer) were described in Section 1.2.5. If Warburtons contract standards were compared to USDA's perspective (Table 3.11a), they would appear as the shaded areas of Table 3.11b.

Table 3.11b
USDA overview – revised to include Warburtons

	Output specific traits	**Absence of specific traits (GM)**	**Certified organic**	**Pharmaceutical and federally regulated industrial**
Product Example	Wheat for Warburtons	Non-GM corn	Organic soybean	"Cystic fibrosis" corn
Production protocol	3 specific varieties	IP production controls Inspections	Certified ~~organic~~ seed Multi-step inspections	IP protocols/Isolation Dedicated equipment Field inspections
Quality assurance	Testing (Near reflectance)	Non-GM testing Auditing Certification	Non-GM testing Auditing Certification (National Organic Program)	~~3rd-party audits~~ Certification Record-keeping Source verification
Marketing channels	Segregation within bulk	Segregation within bulk	Certification	Closed loop/ containment

Source: Compiled from author's own research (based on USDA-ERS 2007)

Essentially, the Warburtons production system is most closely fitted to USDA's view of production for pharmaceutical products; Warburtons has already incorporated nearly all aspects of U.S. pharmaceutical production programs based on IP grains. Only third-party audits are missing, but Warburtons supplies its own audits point-to-point throughout the production and supply chain (e.g. grain is tested prior to being loaded for transport to the U.K. and tested again upon arrival in the U.K.) Other aspects of Warburtons' needs for trait-specific production and quality assurance are also out of step with USDA's perspective (as seen in the two middle columns of Table 3.11b).

The USDA researchers make it clear that they are aware of Warburtons interest in trait-specific wheat, but seem not to understand the very strict quality levels that Warburtons demands:

"Food processors' demand for trait-specific crops is derived from the need to improve production and processing efficiency, reduce costs, or enhance product value. General Mills, for example, now procures variety-specific wheat and oats, relying on contracts with a network of producers and cooperatives in several States. Warburtons, in the UK, has established contracts with Canadian wheat producers to deliver variety-specific wheat" (USDA-ERS 2007).

It is not clear whether the USDA's view is representative of the U.S. grain industry or not. But it does show that the executive branch of government meant to represent farmers and assist the grain industry is not that familiar with customer expectations.

3.3.3.4 Product reliability concerns in France

Wheat production in France is firmly rooted as part of food production. There may be historical and cultural reasons for this, but the practical issue is how much more closely the public health authorities (and the wheat industry) seem to recognize consumer health concerns. This is seen in a press release from INRA:

> "In 2002, several INRA units (the Metabolic Diseases and Micronutrients Unit, the Plant Breeding Unit and the Cereals Technology Unit) began an extensive study of wheat varieties from the standpoint of their mineral and micronutrient content and to improve their nutritional value. The work was supported by the Industry Ministry and conducted in partnership with the Limagrain Group. The research was aimed at raising nutritional density of wheat by studying every stage that affects this parameter: variety choice, cultivation method, fractionation process [milling] and breadmaking process.
>
> Systematically breeding wheat for yield and technological qualities seems to have resulted in the loss of useful nutritional characteristics in the grain. Researchers have showed that the mineral content of current French varieties is 30 to 40 percent below that of older

> varieties. Studies of bioavailability and metabolic impact in humans at the Human Nutrition Research Centre (CRNH) in Auvergne showed how the nutritional value of cereal products could be improved. The CRNH scientists showed the effects of the flour fractionation process [milling] and fermentation type on the bioavailability of the minerals in the flour" (INRA 2002).

In addition to the research in human nutrition and disease, INRA also operates the national stations for plant breeding and experimental wheat growing. This also reinforces the notion that French authorities see wheat, food and human health as inter-related. In 2010, INRA changed its name from the National Institute for Food Research to the National Institute for Agricultural Research to better reflect its broad role.

3.3.3.5 Summary

Reliability issues in wheat affect both production and food safety, yet from the U.S. regulatory perspective, reliability is mainly left unaddressed. In the instances where food safety is regulated (usually with voluntary compliance), the focus is confined to the same three HACCP areas of concern for product conformance: contamination from biological pathogens; chemical pathogens; and physical agents. This is in sharp contrast to the level of quality needed by producers, such as Warburtons or General Mills. It is also in sharp contrast to the French approach of linking governmental authorities, research institutes and universities, health authorities and producers with one another to achieve broad objectives that benefit both the consumer and the producer.

3.4 Chapter summary

This chapter discussed bread, flour and wheat quality in France and the U.S. in terms of conformance and reliability:

Bread product conformance standards are essentially the same for all types of white bread in both France and the U.S. In addition, bakers in both countries receive similar training, so it is not likely that breadmaking differences would be dramatic. Prevention and control of bread staling and spoilage are very similar in both countries. Bakers are encouraged to use HACCP plans in both France and the U.S., but this is not a mandatory regulation in the national food safety laws, although local ordinances may require it. In France, for bakers wishing to call their establishment a *boulangerie*, the law is very strict that only the traditional four ingredients (flour, yeast, salt and water) may be used. One variation between bread in the two countries is the practice of adding as much water as possible to some U.S. breads (since price is based on finished loaf weight) while in France, bread is sold by dry solids weight.

Flour conformance is slightly different than bread conformance because much of the flour's quality characteristics directly reflect the quality characteristics of the wheat that was used. In fact, discussions of flour conformance and reliability cannot easily be separated, and are very much dependent on wheat quality characteristics. HACCP plans are not usually required, but most millers adopt them anyway as bakers frequently demand them. As with bread, wheat with 'good protein qualities' is less likely to contribute to high GI/GL levels and is also more likely to produce a higher quality flour resulting in a higher quality loaf of bread.

Wheat quality:

Conformance in wheat varies considerably between France and the U.S. A driving force behind this seems to be the change in 'business climate' created by the Uruguay Round of

WTO negotiations. The difference in response from the French growers compared with the U.S. is best seen when considered in terms of the rapid adoption by the French of a wheat grading system based on intrinsic tests in 1998 and continual improvements to the system between 1999 and 2009 to refine the specifications, making them increasingly more difficult to achieve. The French national association of wheat growers worked together with the national associations of millers and bakers to determine the wheat quality characteristics that were most meaningful to the millers and bakers.

In the U.S., the system of physical grades defined by commodity traders in 1916 remained in place. It is difficult to assess the actual impact on quality of U.S. wheat (between 1998 through 2009) due to the unchanged physical grading system. As early as the 1980s, international millers had begun to decrease purchases of U.S. wheat due to quality problems. It seems likely that the overall quality of U.S. wheat declined based on the concerns about increased levels of dockage, the resistance of GIPSA to meet demands of international customers for cleaner wheat and especially the rapid deterioration in wheat farmer profitability. This would suggest farm businesses operating at the bare subsistence level rather than ones actively pursuing quality improvements and adopting GMPs/GAPs/GHPs and HACCP plans.

<u>Reliability</u> in French wheat increases year on year. This is not only seen in the ever more demanding standards for wheat destined for human consumption but similarly more demanding intrinsic standards for wheat for animal feed. U.S. wheat growers are also often cattle growers and do base planting decisions on wheat varieties that are better suited for cattle (more foliage) or better for bread (higher levels of grain protein). But there was no literature to suggest that U.S. growers (in open production) are implementing

GMPs/GAPs/GHPs and adopting HACCP plans. In direct contrast, the French wheat growers selected what they believed to be the most important GMPs/GAPs/GHPs and incorporated them into a “Charter of Good Management Practices”. The Charter also contains what could be considered a ‘HACCP-like plan’ for food safety. The U.S. wheat growers seemed more strongly influenced by the commodities markets and U.S. government schemes that pay subsidies based on total number of acres planted, rather than on benchmarks of wheat quality. At the same time, though, U.S. growers are not participants in the design of wheat quality standards.

Chapter 4

Discussion of literature review and preliminary data analysis

Chapter 4

Discussion of literature review and preliminary data analysis

4.1 Bread's impact on human health

Chapter one pointed out that white bread is a high GI/GL food and over-consumption of high GI/GL foods leads to obesity, metabolic syndrome, diabetes and cardiovascular disease. The cost of treating disease outcomes of over-consumption of high GI/GL foods is disproportionately higher than other disease conditions (Section 1.1.3).

By 2003, the U.S. had the greatest number of obese individuals in the OECD, but no national prevention programme aimed at obesity, metabolic syndrome or diabetes (Section 1.1.3). Two years earlier, public health experts from HSPH argued that the USDA's Food Guide Pyramid publication (that recommended *increased* daily consumption of refined grains) was unhealthy and had been produced under lobbyist influence (Section 1.2.3). By 2003-2004, ten percent of Americans were pursing a low carbohydrate or GI/GL diet (Section 1.2.4).

Meanwhile, French consumers were not very interested in low carbohydrate or GI/GL diets—or in cutting back on white baguette. In 2002 French public health authorities, worried about the over-consumption of high GI/GL bread and its subsequent disease outcomes, launched a national campaign with the bakery industry to persuade consumers to eat more wholemeal breads (Sections 1.2.3 and 1.4.6).

These two different sets of responses to the same public health issue show some underlying contrasts between the two countries:

a) French public health authorities were much more proactive than their U.S. counterparts. Not only was there a lack of response on the part of U.S. public health authorities, but also consumers—at their own initiative—cut back on consumption of high GI/GL products.

b) French public health authorities and the bakery industry probably had similar perspectives about high GI/GL bread and a shared interest in public health, as there was no 'market demand' from consumers for lower GI/GL breads.

c) In roughly the same timeframe that French health authorities and bakers were striving to persuade consumers to cut back on white bread consumption, the USDA was encouraging just the opposite. HSPH warned the public of the dangers of over-consumption of refined grains and/or following USDA's (likely lobbyist-influenced) advice.

Points a) and b) are probably more reflective of cultural differences between the two countries than of differences in their bread VCs. The European preference for the Precautionary principle and the U.S. belief in 'safe unless proven otherwise' could explain the differences in policy response by public health authorities in France and the U.S. But point c) seems very odd.

HSPH isn't concerned that the advice is coming from USDA (i.e. the 'agricultural ministry')—just that the advice is not accurate and consumers would seem to be likely to follow the advice of USDA. Put into the context of Codex recommendations and the Joint FAO/WHO Food Standards Programme, it would appear that USDA had the authority to act as an equivalent of 'health ministry' in relation to grains; and that USDA's authority extended back beyond the introduction of the URAA, and throughout administrations of either Republicans or Democrats. This would require that the various actors believed there were no public health issues associated with refined grains. While HSPH does believe there is a public health issue involved, they seem to limit their concerns to ‘refined’, rather than health impacts from ‘grain quality characteristics’. Therefore, this example appears to reflect a cultural/historical belief that wheat is not a food until it reaches the first processing point and that U.S. wheat grading standards established in 1916 (by commodities traders) are still suitable (i.e. ‘safe’). This cultural/historical belief would also provide more of a context for the U.S. Commerce Department’s position that wheat growing is an ‘extractive activity’ (like oil production).

Despite these stark differences in attitude toward wheat, basic operations in the bakery- and grain processing-entities in France and the U.S. were much more similar, although the French were considerably more efficient than their American counterparts in both industries. Bakers receive the same training in both countries, similar ingredients are used in similar bread varieties, the same basic bread preparation methods are used across both countries and bread markets are segmented similarly in both countries (Sections 1.2.1 and 1.2.2). However, the difference in approach by farmers toward the significance of wheat quality characteristics—especially good protein qualities—strongly affects practices and competitiveness of millers/grain processors and bakers, as well.

4.2 Bread VC in France and the U.S.

4.2.1 Bakery-entity in France and the U.S.

U.S. bakers are focused more on financial than operational goals; an indication the industry pursues a VC strategy of increased margins. Consolidations are used to improve production efficiencies; a disproportionately large number of non-bakers exist to perform VC ‘support activities'; hiring of baker-labour is optimised against financial goals rather than operational performance; product emphasis is on financial value (e.g. U.S. bakers tended to earn more than twice as much per kilo of flour used as the French) rather than product's qualitative value. Despite these differences, the French bakery industry contributed more than twice as much to GDP as did the U.S. (Sections 1.3.2, 1.3. 3 and 1.3.5).

The French bakery industry focuses more strongly on production and operations while following a 'lean' organizational structure; indications of employing a VS/kaizen strategy. This can be seen in the increased productivity per worker (four to five times more per unit volume produced than in the U.S.), the adoption of more efficient processes (e.g. use of frozen dough and pre-baked loaves), the artisans' "pull" approach to retail sales and that bakery employees primarily perform production and operations activities (Sections 1.3.2 and 1.3.4).

From the viewpoint of a government policymaker, it might seem that the bread VC in the U.S. is working well. The U.S. bakery industry provides more jobs per unit volume produced than the bakery industry in France; contribution to employment is .198% while that of France is .140%. Yet, French contribution to GDP is more than twice the U.S. rate (.39% and.16%, respectively) and share of flour required is some 80 percent of U.S. bakers' consumption, thus providing a much (proportionately) larger market for wheat farmers than in the U.S. (Section 1.3.2). At the bakery-VC level, it appears the bread VC in France outperforms the U.S. in terms of overall support for the broader economy.

Differences in bakery industry strategies could have a potential impact on quality/food safety. The differences in focus of industry strategies (process management and improvement in

France versus financial management and VC optimisation in the U.S.) suggest that quality is, at least, a secondary priority in the U.S. The main benchmarks for success with the French and U.S. bakery strategies are “Best matched production of fresh-baked bread to customers” and “Getting the highest price the customer will pay”, respectively. In support of these broader strategies, the primary goals for bakers become “Conformance to standards and customer expectations” in France and “Exert pressure on cost of materials and wages” in the U.S. Conformance to standards and provision for reliability (i.e. food safety) are the characteristics that represent quality in food products. While costs and profitability are other characteristics of manufacturing effectiveness (Figure 1.6), quality is, at least, equally important (Sections 1.3.3 and 1.3.5).

4.2.2 Grain processor-entity in FR and U.S.

Milling production processes are comparable in the U.S. and France but elevator operations are not; elevator ownership structure is considerably different. Wheat growers are also the owners of the grain cooperatives in France; they compete with one another to get more (miller) customers but also assist the millers to better meet needs of their (baker) customers. The driving force behind this attention to customer needs is the goal of quality (Section 1.3.8). In the U.S. there are strong links between large commercial bakers and grain processors, sometimes formed through consolidation of their businesses. The stated goal of the consolidations, both within the milling industry and between milling and baking, has been to optimise costs (Section 1.3.7).

U.S. grain processors—like U.S. bakers—enjoy greater profitability than in France; but also like bakers, the U.S. grain processors seem to be considerably less efficient than the French. The French milling industry produced double the revenue of the U.S. in 2000, but sales per mill were only 55 percent of the average U.S. mill. However, this was done with only 40 percent of the staff employed on average in U.S. mills. The 'lean' French staffing produced sales per worker that were 36 percent greater than in the U.S. The U.S. mills were considerably larger and fewer than in France and more staff would have been needed in the U.S. for the 'support activities' (in pursuit of a VC strategy). For each U.S. mill, the French grain processors operated 3.76 mills (Section 1.3.9). This would not only require replication of capital investment in land and buildings but replication of milling equipment—all at a unit rate of nearly 4:1 compared to the U.S. milling industry. Considering that raw materials in both countries are based on a comparable (world) market price, one would expect a very poor financial outcome for the French grain processors—yet their revenue was double that of the U.S. This suggests that the U.S. grain processors (and their railroad partners) are less interested in financial optimisation of milling and elevator operations than in capturing grain transport revenue, reducing competitive transport/elevator options for farmers and maximizing grain stocks for increased leverage of commodities trades (Section 1.3.7). This also suggests that wheat flour quality (conformance and reliability) is not a primary concern in the U.S.

It is also plausible that the French grain processors are more efficient than their U.S. counterparts because they follow a VS/kaizen rather than a VC strategy. Although literature review did not suggest that French grain processors (and bakers) purposely follow a VS/kaizen strategy, it seems by definition they might. Some of the characteristics of a VS/kaizen approach include primary focus on quality, 'lean' organizational structure, attention to process management and improvement, 'pull' rather than 'push' in sales, avoidance of automation using conveyors[33], *et al*. The topography of the U.S. grain-processing network is akin to 'automation with conveyors'; railroad links become substitutes for conveyors with elevators, mills and shipping terminals substituting for automated processing nodes (Section 3.3.2.2). By not optimising capital expenditures via consolidation of elevators, mills and other processing centres, the French grain processors would be required to utilize more (rather than faster) facilities. Operating a greater number of smaller, more efficient facilities would be an indication of a VS/kaizen strategy.

Following a VS/kaizen rather than a VC strategy could potentially have a more favourable impact on quality/food safety. Theoretically, a strategy focused on product quality might be expected to result in measurably fewer product defects and food safety incidents than a strategy that primarily optimises costs. It seems, though, that even when adjustments are made to improve production quality/food safety within firms that follow a VC strategy, quality improvements occur, as was demonstrated by the multi-year FDA study in the U.S. (Sections 2.3.3 and 2.3.4).

Wheat quality characteristics strongly contribute to bread quality. The literature concerning wheat-trading characteristics gives an indication of the tremendous importance certain quality characteristics (e.g. protein content, *alpha*-amylase activity and ash content) play in bread quality. The baker has very few options that can compensate for deficiencies in these three broad areas; the miller has few options, either (Section 3.2.4).

French laws relate flour grades to the nutritional values while the U.S. system relates the grades to wheat type. Regardless of end purpose of a flour, in France the baker or consumer

---

[33] Referred to as *muda* of transport (Imai 1997).

can expect certain nutritional characteristics to be present (Section 3.2.6.1). Wheat types assigned in the U.S. system relate to sub-grades that indicate suitability for breads, cakes, and animal feed or industrial feedstock. Both systems, though, function similarly for bakers. The larger difference has to do with quality problems in the U.S.: lack of information concerning end-use quality; lack of information on dough and flour properties; and variability in quality between and within lots (Section 3.2.6.2). Nearly all of these problems originate with wheat quality.

4.2.3 Wheat grower-entity in France and U.S.

4.2.3.1 Political power

The French wheat farmers are one of the strongest lobbies in France; the U.S. farmers have little political power. The French wheat growers used the introduction of the URAA to improve their competitiveness. The strategy of the wheat growers, and adopted by the government as a national priority, was to make France the highest quality producer of wheat and wheat-based products in the international market. Year on year as the growers strived to meet this goal, French wheat quality measurably improved (Sections 1.3.13, 1.3.16 and 3.3.1).

The U.S. growers have shown little interest in customers while the French growers continually try to find ways to make their own customers more competitive and to satisfy the end consumer, as well. Influence of the French wheat farmers on the rest of the bread VC (as well as the other VCs that use wheat flour) represents a completely different dynamic than that in the U.S.; the French wheat growers are driving quality (and indirectly change) in multiple industries. There is no equivalent in the U.S. (Section 1.3.16).

4.2.3.2 Striving for quality and efficicency

As was the case with bakers and grain processors, wheat growers in France are much more efficient than their American counterparts. French growers recoup 37 percent greater net revenue per MT than U.S. growers, despite a comparable (world) wheat price; and French growers produce 60 percent greater volume per worker than in the U.S.—even though the average French wheat farm employs three people compared to only two in the U.S. Overall, employment in French wheat production exceeds the U.S. by four percent while requiring only one-quarter of the land mass used by U.S. wheat farmers (Sections 1.3.10 and 1.3.15).

Not only are the French wheat growers more efficient and more profitable than their U.S. counterparts, they are also more oriented toward wheat quality. Certainly the fact that the farmers are the owners of the grain cooperatives, and therefore their own customers, has contributed to the quality of wheat turned over to the grain processors. But introduction of the URAA led to the French wheat growers' strategy of aiming for highest quality in the international marketplace as well as inclusion of higher quality for the wheat-based products of all downstream customers. Interaction with bakers and scientific institutions (e.g. INRA and ARVALIS) has also influenced growers' attitudes toward continuously striving to improve quality (Section 1.3.13).

The French wheat growers themselves drove the changes to the grading system:

- The grain industry decided independently that a new grading system was needed; it wasn't mandated or funded by a French governmental authority.

- *ARVALIS Institut du végétal* (formerly ITCF[34]) is owned (indirectly) by the wheat farmers. All wheat growers are required to be members of the *Association Générale des Producteurs de Blé et Autres Céréales* (AGPB), which owns ARVALIS and UNIGRAINS, a financial institution for funding grain processing.
- Facilitating trade was one of the key goals of changing the grading system. The French wheat growers saw the potential advantage of using standardized contract terms and EDI[35] to reduce their own costs proactively meeting their customers' needs. The strong interest in 'customer care' may be the result of having worked with the ANMF to develop grading criteria that met millers' needs.
- Revision of the grading system was begun in 1998 with the goal of being ready in time for the 1999 crop of spring wheat; that date was met. The sheer level of work required to keep three national organizations focused on a deadline—completion of an experimental set of grades and in time for the farmers to plant the 1999 crop—and all within the space of less than one year shows a serious commitment to the goal (Section 3.3.1).
- Changing the grading system required work to be carried out by multiple stakeholders across the bread VC; millers, cereal-science professionals and other members of the scientific community shared actualisation of the goal (Section 3.3.1). The project to create an improved grading system is a good example of concurrent engineering in the style of kaizen. One of the more surprising facts, though, is the rapidity and frequency (several times in the past decade) with which the French grading system has been revised and updated.

---

[34] *Institut Technique des Céréales et des Fourrages*

[35] Definitions of INCO terms that are more precise eliminate contract disputes and also lead to easier use of electronic data interchange (ICC 2010).

While change to the French grading system was strongly driven by competitive demands of the export market, little has changed in the U.S. system since 1916 when the system was first introduced. It could be argued that the French growers and millers have had centuries of experience through the system of craft guilds to enhance their abilities to cooperate with one another (Section 1.3.8). However, it also seems likely that they are simply more motivated to look after customer requirements than their American counterparts. .

4.2.3.3 U.S. farmers' income reversals

Introduction of the URAA (1995) seems to have been the catalyst in reversing income trends for the U.S. wheat growers. In 1994 only 38 percent of U.S. wheat farmers earned less than the GNI. In 1996, Titus and Dooley calculated that wheat farmers' share of value added was 7.5 percent. But by 1997, value added distributions in the U.S. bread VC shifted dramatically with bakers gaining 32.4 percent, grain processors gaining 23.7 percent and wheat farmers losing value at a rate of 42.4 percent. By 1998—and despite a dramatic rise in subsidies—59 percent of wheat farmers were earning less than 60 percent of GNI; and by 2005, more than 80 percent of wheat farmers required welfare payments even with subsidies that outweighed revenue from wheat sales (Section 1.3.12).

U.S. wheat growers have very limited sources of additional revenue. Wheat farm revenue could arise from purchase of futures contracts, planting as many acres as possible to secure maximum USDA payment, and planting wheat varieties that can also be used as forage for cattle. While the revenue from these sources varies depending on individual farmer's circumstances, most of these revenue streams are likely to be small as only individuals with low earnings qualify for public assistance (Section 1.3.10).

French grain processors produce a highly competitive product, are profitable and are mostly owned by the wheat farmers; this desirable business extension is essentially closed to U.S. wheat farmers. When the French growers developed their strategy of highest possible quality wheat, a key component of their success was their ability to determine what French grading standards should be. U.S. farmers have never had this right; since 1916, commodities traders and the USDA have controlled grading standards. More recently (April 11, 2012), following a multi-year open solicitation period and despite recommendations from NAMA to test for protein quality and other wheat quality attributes important to bakers, USDA ruled in favour of no significant change to the standards (Section 3.3.2.4).

4.2.3.4 Regulatory behaviour in a 'deregulated' market

Agriculture, including wheat, was 'deregulated' with introduction of the URAA; yet USDA has remained actively involved in the market, both as a regulatory authority and as a provider of fee-based inspection services. Wheat grading standards were last revised in 1993, prior to the URAA (Section 3.3.2). As early as 1989 there were complaints about cleanliness and other problems with U.S. wheat (Section 3.2.6.2). Despite changes in U.S. Presidents and their appointments of USDA Secretaries, USDA/GIPSA has consistently refused to make the standards more stringent. USDA/GIPSA's 2012 decision to support a trade association representing one of GIPSA's largest blocks of inspection service customers, rather than the needs of millers (and indirectly bakers) to be more competitive, might be considered a conflict of interest (Section 3.3.2.4). It would seem that U.S. wheat production is still a regulated market where the 'regulatory authority' (USDA) determines quality characteristics of wheat-based products while millers and bakers take financial and operational responsibility for both conformance and reliability.

Although millers and bakers have been penalized by the lack of competitiveness in U.S. grading standards and incur added costs due to the resulting lower quality wheat, the U.S. wheat growers seem to have borne the brunt of ongoing U.S. regulation of the wheat market. As with millers and bakers, the outmoded grading system has made U.S. wheat less competitive in the international marketplace. In the past the U.S. government was able to withhold wheat from the marketplace until a higher price could be obtained. But with wheat stocks mostly held by private firms, this option is unavailable. Despite U.S. government announcements about increased flexibility in cropping decisions, wheat farmers have very limited options over their own land; the greatest flexibility is limited to planting other designated commodities (i.e. grains or cotton). Additionally, there is no simple and equitable way to exit wheat farming (Section 1.3.12).

It appears that millers and bakers might not be the primary market for U.S. wheat. With an emphasis on production of minimal quality characteristics and minimal test results coupled with maximum acres planted, it is as though USDA's main goal is an annual harvest that produces a predictable quantity of wheat in proportion to the number of acres available for planting. There is little about this that suggests wheat quality characteristics related to human health are a primary concern. This is further reinforced by the notion that wheat is not a food until it reaches the secondary producer (i.e. the grain processor). Most striking, though, is USDA's continued refusal to adjust the wheat grading system to better reflect wheat's performance characteristics when milled and baked (Section 3.3.2.4).

4.2.3.5 U.S. growers' conundrum

U.S. wheat farmers are in a powerless political position and are nearly 'decoupled' from the rest of the bread VC. The following two items exemplify the relatively powerless political position of the U.S. wheat farmer. This ‘powerless position’ possibly underscores the main difference between the U.S. and French growers:

US cropping decisions

Continued USDA regulation of cropping decisions is one example of a powerless position. Continuance of the OECD’s largest direct government payments is another. While the subsidies are certainly helpful to the farmers, the purpose of continued government control over what the farmer may produce on private land seems unclear. The increase in subsidies to 50 times their previous rate might have been needed to keep wheat farmers growing wheat at a relatively predictable level, thus assuring the grain processors (and their commodities trading subsidiaries) of a large domestic source of raw material (Section 3.3.2.4).

Leaving the USDA wheat farm payments scheme

Permanently leaving the USDA programme means forfeiting a nearly ‘guaranteed’ income (direct government payment, food stamps, health insurance and revenue from wheat sales) for the risk of insufficient income via production of other non-commodity crops. Illegally planting a more profitable crop is possible, but if caught all the revenue must be turned over to the government plus a fine paid comparable to the lost wheat revenue. If the farmer sells the lands, the commodity designation is applied to the new owner, as well. Therefore, the new owner would already be a wheat grower faced with the same set of financial problems. Real estate development remains an option, but considering that farmers aren’t likely to have experience in this area and that most of the wheat growing takes place on large agricultural lands far from the nearest town, it doesn’t seem likely that a farmer could leave the USDA programme and become a successful real estate developer (Sections 1.3.12 and 3.3.2.4).

4.2.3.6 Importance of intrinsic tests

One of the most crucial differences between the U.S. and French wheat grading systems is the use of intrinsic testing in France versus the use of organoleptic testing against physical criteria in the U.S. Intrinsic testing allows the French to offer more differentiated and competitive services. For example, grain processors in France employ a specialist blender who is able to match wheat varietal traits to miller requirements. The better the skills of the blender, the more competitive the grain processor. The French farmers and grain processors utilize IP and varietal segregation, thus allowing the blender to mix varieties with more certainty of outcome than in the U.S. The U.S. commingles wheat based on protein content; with each lot of wheat being somewhat different from others. Both systems, though, are considered ‘open production’ as opposed to ‘closed production’ (i.e. growing to bespoke conditions) and market prices are roughly the same (Section 3.3.1).

Intrinsic testing combined with the French attempts to grow best quality wheat, results in ever-greater proportions of the highest quality grades of wheat. The use of intrinsic testing extends to animal feed, as well. The French wheat growers have also used the results from intrinsic testing to help target deficiencies and improve each year’s crop. Intrinsic tests are such an important tool in grain production in the French system, that even animal feed is subjected to intrinsic tests that are nearly identical[36] to those of wheat destined for human consumption. Animal feed is treated as part of a food chain that eventually becomes human food and at the same time, aims to preserve animal welfare to the extent possible (Sections 3.3.1 and 3.4).

---

[36] Only the proportion of nitrogen in animal feed varies from wheat for human consumption.

The situation of the French wheat farmers is nearly opposite to that of the U.S. farmers. In France, farmers' financial decisions are limited to operating a farm business and participating in operation of grain processor cooperatives; in the U.S. the farmer's financial skills are split between farm operation and speculation in the commodities markets. The U.S. wheat farmer receives the highest subsidies in the OECD while the French farmer receives little if any subsidy and privately contributes to the costs of AGPB, which includes the costs of owning ARVALIS and UNIGRAINS. French wheat farmers are also assessed a tax against acreage to pay for the costs of the wheat board, ONIC (Section 1.3.13). Yet, the French wheat grower is profitable and the U.S. growers are predominantly not.

4.3 Bread VC's links to high GI/GL levels

Ingredients used in breadmaking are similar in both France and the U.S. Although both countries use nearly the same ingredients in the three classes of breadmaking (artisan, semi-industrial and industrial), 66 percent of French breads contain only the four basic ingredients (flour, water, yeast, salt) while just 25 percent[37] of U.S. breads do. This suggests that U.S. consumers have a greater exposure to added ingredients, either beneficial or detrimental (Section 1.4.1). However, as Table 1.16 shows, the added ingredients most likely to be linked to high GI are sugars, fats and chemicals—none of which are included in French baguette. Yet, French health authorities have actively campaigned to persuade the population to reduce consumption of white baguette (Section 1.4.6). This indicates that one or more of the four basic ingredients must be associated with high GI levels. While all four were discussed in the literature, only wheat flour was linked to detrimental influences on GI.

---

[37] If the 40 percent unfulfilled U.S. market demand for artisan bread were added to artisan output, then both countries would reflect similar consumer behaviour (Uptown Bakers 2005; Cauvain 2007).

Of bread VC processes with links to high GI/GL levels, only wheat/wheat flour is involved. Cooking and preparation methods, as well as grain particle size, are linked to high GI/GL levels (Section 1.4.2).

Composition of the wheat grain has a strong influence on GI/GL levels. The various elements of the wheat kernel itself; starch in wheat; 'good protein' quality characteristics (e.g. wheat kernel's protein-to-starch ratio; wheat kernel's amylose-to-amylopectin ratio) are all closely associated with GI/GL levels (Section 1.4.3).

'Good protein' quality characteristics are particularly significant for GI/GL levels. Nutritionists and cereal scientists have researched the influence on GI/GL levels from amylose-to-amylopectin and protein-to-starch ratios (Section 1.4.4). However, only veterinary specialists have researched the influence of farm management practices on 'good protein' qualities (Section 1.4.5).

The wheat farm is the VC-entity most frequently associated in literature linking the bread VC and GI/GL levels. The wheat farm is the bread VC-entity most often linked to (either detrimental or beneficial) health quality characteristics. As seen in Figure 1.10, a majority of the wheat farm links are directly related to protein quality (Section 1.4.6).

4.4 Government regulation of food quality: International and in France and the U.S.

4.4.1 International framework for food safety

4.4.1.1 URAA and the SPS and TBT Agreements

The URAA liberalized agricultural trade and included key agreements on food safety (SPS) and consumer protection (TBT). The SPS Agreement addresses food safety through the protection of life and health of humans, animals and plants. The TBT Agreement addresses prevention of technical standards' use as trade barriers and consumer protection against fraud and deceptive practices (Sections 2.1.2 and 2.1.3).

Different interpretations of SPS and TBT Agreements exist in France (i.e. Codex view) and the U.S. (i.e. trading standards). French interpretation matches Codex perspective; U.S. view relates more to trading standards rather than standards for food safety (Section 2.1.5). Wheat quality characteristics are also impacted by differences in interpretation of SPS and TBT Agreements. For example, U.S. view that SPS pertains to the end-use product may imply that wheat is exempted from some food safety regulations while bread is not. SPS protection of life and health of plants has been interpreted in the U.S. as protection for the intellectual property rights of wheat breeders (Section 2.1.5).

4.4.1.2 The Codex

Codex' role is to implement the Joint FAO/WHO Food Standards Programme. The Programme addresses food safety including food standards, codes of practice and recommendations relating to food quality composition/safety (Section 2.1.1).

Codex' "General Principles of Food Hygiene" are only recommendations for use of GMPs/GAPs/GHPs and adoption of HACCP from farm-to-fork to produce safe food.

Although following Codex recommendations is only voluntary, they were designed for and directed toward every element in the food chain, including primary producers (Section 2.1.7). The Codex system of GMPs/GAPs/GHPs and HACCP is based on the work of Deming related to kaizen and quality management in 1950s Japan (Section 2.1.8).

Codex' intent is use of GMPs/GAPs/GHPs to avoid any food safety risk and HACCP will be a 'last defence' should GMPs/GAPs/GHPs fail. The Codex guidelines result in the production of safe food using an *a priori* preventive approach based on continuous improvement of the processes (i.e. the GMPs/GAPs/GHPs) rather than reliance on end product testing (Section 2.1.8). However, over time or through misunderstandings, coverage gaps remained in HACCP implementations. E.g. HACCP was treated as equivalent to a food safety system; zoonoses were not addressed; PRPs used in U.S. implementations disregard *a priori* prevention of food safety risks (Section 2.1.8).

4.4.1.3 EU regulatory influence

The European Food Safety Agency (EFSA) is an independent science-based agency. EFSA is comprised of experts in food and feed safety, nutrition, animal health and welfare, plant protection and plant health. EFSA decisions are politically independent from the EC as well as from the EU Member States (Section 2.1.10).

EU regulations not only influence food safety policy in France but also outside the EU. EC No. 178/2002 established the EFSA and required farm-to-fork traceability of all foodstuffs produced in, imported to or transiting the EU (Section 2.1.9). EU (and French) regulation is based on the precautionary principle while U.S. relies on 'safe unless proven otherwise'. Under the precautionary principle, if there are reasonable grounds for concern of possible adverse effects but scientific uncertainty persists, provisional priority is given to human health. In the U.S., foods are presumed to be safe unless scientific evaluations determine that a particular food is injurious to health (Section 2.1.9).

The U.S. practice of conducting scientific evaluations only when justified might be an example of *'a posteriori'* evaluations of safety events. In general, the U.S. position does not support the Codex principle of *a priori* risk avoidance. Therefore, waiting for 'justified doubts' to be proven conclusive might be a natural extension of applying an *a posteriori* approach to quality management (Section 2.1.12). Cultural preferences might account for the differing perspectives in France and the U.S. toward food safety. A preference for 'safe unless proven otherwise' versus the precautionary principle might be based on cultural differences that Hofstede describes as 'uncertainty avoidance.' Hofstede's research showed the U.S. population was considerably more comfortable with uncertainty than were the French (Section 2.1.9).

4.4.2 Regulation of food safety in France

Afssa's role, structure and approach to risk management is very similar to EFSA. Afssa represents a very streamlined approach to national food safety. It's the main scientific body responsible for evaluating health and nutritional risks that could affect human/animal food. Risk management includes the participation of companies. A number of formal tools, guides, standards for quality management, risk reduction and safety in food production are made available to producers and practitioners. Assistance is offered to small producers for establishing QMSs (Section 2.2.1). Afssa's work is assisted by INRA. INRA plays a major role in supporting food safety as well as agricultural, environmental and human sustainability. INRA is also the largest agricultural research institute in Europe (Section 2.2.2).

INRA researches wheat grain and wheat production; concentrates on farm-to-table food safety. INRA's work is especially significant for the bread VC. Its research into nutritional and metabolic consequences of human diet (Section 3.3.2) as well as production processes in both wheat production (e.g. tests on farmer-saved seed, Section 1.3.13) and flour milling (e.g. quantities of minerals and micronutrients, Section 3.2.6) are two examples of INRA's multi-disciplinary approach to food/agricultural research.

4.4.3 Regulation of food safety in the U.S.

A multiplicity of food safety agencies is just one of a number of issues that could negatively impact food safety in the U.S. The multiplicity of food safety agencies is not only unwieldy, but contributes to the lack of a single overall vision (Table 2.3). The strong degree of politicization toward the governmental agencies responsible for food safety (e.g. FSIS' website denoting only Republican presidents as having introduced good policies) is starkly different than Afssa's political independence in France or the Codex guidelines for national food safety programmes (Sections 2.3.2, 2.3.5 and 2.4.1). There is also a limited perspective of international food safety regulation (e.g. FSIS' misunderstandings of the role of Codex). Regulation is minimal (e.g. mostly limited to meat, poultry, seafood, eggs and dairy products) exists and 'from farm-to-fork' safety seems to mean 'from the farm-gate' rather than processes performed on the farm. A particular concern for the bread VC is the U.S. government position that wheat is an "extracted commodity" and not a food (Section 2.3.1).

Despite issues with the overall policy approach in the U.S., FDA has been an example of good food safety regulation. In particular, FDA's HACCP audits and support programmes have not only been of value to consumers, but audited firms found (measurable) benefits beyond food safety (Sections 2.3.3 and 2.3.4). FDA's HACCP audits are kaizen-based. FDA's HACCP audits are focused on *a priori* prevention of food safety risks and continuous improvement. Adherence to kaizen may account for some of the success of FDA's HACCP audits (Section 2.3.4).

4.4.4 Differences between food safety regulation in France and the U.S.

One measure of effective food safety regulation is close alignment to the Caswell and Henson model for national food safety programmes. In 2000, both the French and U.S. food safety programmes were well-aligned with the Caswell and Henson model. By 2007, the French programme was still well-aligned but the U.S. had begun to dismantle some of its national food safety programme (Section 2.4.1)

One measure of food safety success can be seen in national incidence rates for foodborne disease (FBD). U.S. incidence rates of FBD are six times greater than in France: in 1999, U.S. incidence rates of FBD were between 255 and 278 cases-per-1000; incidence rates in France were 44 cases-per-1000 (Section 2.4.2).

4.5 Industry regulation of quality in bread, flour and wheat in France and the U.S.

4.5.1 Benchmarks of bread quality–conformance and reliability

Conformance is one aspect of product quality—reliability being the other. Bread product conformance standards are very similar in France and the U.S. Bread is categorized bys external and internal characteristics and texture, including flavour. There is just one set of product standards used and adapted to all the various bread types (Section 3.1.1).

Bread product reliability is very similar in both countries. Staling and spoilage are the most important reliability issues for bread. Prevention relies on the application of GHPs and adherence to a HACCP (or HACCP-like) plan. Required HACCP use is left up to the health authorities in each producer's country (Section 3.1.2). Staling and spoilage are influenced more by the economic relationship between the baker and the consumer than by specific laws. I.e. consumers avoid purchasing bread that is visibly mouldy or stale.

Some ingredients used in bread, some cooking/preparation methods and HACCP-type failures are the main links between bakeries and high GI/GL levels. If the baker controls these risks, there is little to suggest that increased GI/GL levels would originate in bakeries (Section 3.1.3).

Staling and spoilage in bread (both reliability issues) are influenced more by the economic relationship between the baker and the consumer than by specific laws. Consumers avoid purchasing bread that is visibly mouldy or stale (Section 3.1.2). The French artisan baker avoids staling by discarding unsold loaves at end of each business day (Section 3.1.2); this practice can be an example of kaizen. The kaizen approach to inventory managemnt relies on a “pull” system in which only as many products are produced as customers will consume; in a “push” system, as many products as possible are produced, whether there is a customer or not (Section 1.3.4).

4.5.2 Benchmarks of flour quality—conformance and reliability: France and the U.S.

The baker views the miller as responsible for flour conformance, but the wheat used largely determines conformance. Flour conformance reflects the miller's understanding and interpretation of the baker's requirements, however the miller is dependent on characteristics in each separate lot of wheat (Section 3.2.1)

Important characteristics for bakers are protein level, moisture content, ash content, gluten content and good 'protein qualities'. The baker specifies protein level, moisture content, ash content and gluten content. 'Good protein' characteristics such as protein-to-starch and amylose-to-amylopectin ratios are implicitly agreed between baker and miller and are more representative of the wheat used (Sections 1.4.3, 1.4.4 and 3.2.3).

Flour reliability and conformance are not easily separated, as flour with HACCP contaminants (i.e. chemical, biological or foreign objects) cannot easily produce bread loaves that exhibit good product conformance. Thus, even disregarding the issue of reliability, flour with HACCP problems is likely to produce loaves that are unsaleable from a conformance perspective. As a result, most bakers require that millers use HACCP plans (Section 3.2.5).

4.5.3 Differences in flour conformance and reliability in France and the U.S.

Flour milled in France provides bakers and end consumers with information about its mineral and micronutrient content. The flour milling method and the type of wheat used is mostly responsible for the level of minerals and micronutrients in bread (Section 3.2.6). U.S. flour grades provide information about whether or not most wheat bran and germ were removed during the milling process, type of wheat milled and the purpose of end use. Although no information is offered regarding mineral/micronutrient content, the presence of wheat bran and/or germ could be a possible indication of the flour's ability to limit GI level in the end product (Section 3.2.6).

The larger issue with flour quality problems in the U.S. has to do with wheat quality characteristics, particularly protein quality characteristics. There is a lack of information concerning end-use quality, lack of information on dough and flour properties and variability in quality within and between lots. Nearly all of these problems originate with wheat quality (Sections 1.4.3, 1.4.4 and 3.3). Without intrinsic testing of wheat, it is not possible to predict the effect of the flour on GI levels.

The ratio of amylose-to-amylopectin starch in wheat (is just one quality characteristic that) has an effect on product conformance of bread and also on GI levels in the bread. Although French wheat undergoes intrinsic testing, amylose-to-amylopectin ratio is not reported. Nevertheless, it can be surmised from the wheat's variety. French wheat is segregated by genotype and identity is preserved. In the U.S. wheat is commingled and no intrinsic testing takes place (Sections 3.3.3).

4.5.4 Benchmarks of wheat quality—conformance and reliability: France and the U.S.

Good 'protein quality' and wheat quality in general

Good 'protein quality' in wheat is largely a factor of the wheat kernel's protein-to-starch and amylose-to-amylopectin ratios. Good protein quality is significant for bread product conformance and also plays a significant role in reducing GI/GL levels in the bread (Sections 1.4.3 and 1.4.4). Detrimental alterations to amylose-to-amylopectin ratio are a reliability issue. If the wheat grower applies GMPs/GAPs/GHPs and adopts a HAACP plan, it might be possible to avoid some of the product defects/food safety risks posed by altered levels of amylose-to-amylopectin both in bread production and as a health characteristic (Section 3.3.3.1).

Conformance and reliability in France

French wheat growers have used conformance as the key element in a strategy to increase international competitiveness. The key element of highest possible wheat quality in the international marketplace encompasses all downstream actors, as well (Section 1.3.13). Wheat conformance in France is driven by continuous improvement to quality. Superior wheat's share of the annual harvest has increased from 45 percent in 1998 to 80 percent in 2007. Prior to adoption of the new grading system, Superior wheat as a share of national French harvest was steadily declining. From 1994 through 1998, Superior wheat decreased from 62 percent to only 45 percent in 1998. Introduction of the more stringent benchmarks of the 1999 grading system saw an increase in Superior wheat of eight percent in its first year of operation (Section 3.3.1).

Reliability in French wheat is assured through intrinsic testing, both in wheat destined for humans and that destined for animals. Grading standards are nearly the same for wheat for humans and for animals. Only the benchmark for protein (i.e. level of nitrogen needed) varies. In the French system, care is taken that animal health and welfare is respected; this is a condition of the SPS Agreement but also to avoid introducing any disease conditions in animals that could be passed on to humans (Section 3.3.1).

Some direct comparisons between France and the U.S.

Oversight of wheat production practices (for reliability concerns) is voluntary in France but non-existent in the U.S. Afssa establishes broad health/food safety regulations in France.

French growers participate with INRA, ARVALIS and ONIC to make certain that food safety issues are avoided. There is no oversight of on-the-farm wheat production practices in the U.S. open production system (Sections 2.2.1, 2.3.1, and 2.3.2).

The French wheat growers incorporated their most important GMPs/GAPs/GHPs and a 'HACCP-like plan' for food safety into their "Charter of Good Management Practices". There was no literature to suggest that U.S. growers (in open production) are implementing GMPs/GAPs/GHPs and/or adopting HACCP plans (Section 3.4). Growers in France and the U.S. both tend to use approximately 50 percent farmer-saved seed. Farmer-saved seed is susceptible to loss of varietal/quality characteristics that could lead to conformance and reliability problems. In France, INRA verifies the seeds that are safe for re-use. In the U.S., seed certification laws vary from state to state with some states not requiring certification at all (Section 3.3.2.6). This suggests that (at worst) 50 percent of the resulting harvest may contain altered quality characteristics; without intrinsic testing, most of the altered characteristics would remain undetected.

USDA policy drives U.S. wheat grower decisions

U.S. wheat growers' de facto strategy has been to plant as many acres as possible, aim for harvest in Category 1 or 2 and purchase as much in futures contracts as affordable. U.S. wheat growers appear to be driven more by U.S. government policy than any collective strategy of their own (Sections 3.3.2.3 and 3.3.2.4). U.S. government policy toward the wheat grading system, as executed by USDA, has been to minimize grain processors/feedlots/grain handlers' expenses and to resist change to the grading system. This has meant that needs of typical wheat customers (i.e. millers and bakers; the export market) have been disregarded. E.g. the U.S. government has made no attempt to replace grain trader-characteristics in the wheat grading system (from 1916) with criteria from the scientific community (i.e. agronomists, public health officials or other wheat specialists). Both conformance and reliability have been affected (Section 3.3.2.4).

Both conformance and reliability are difficult to assess in U.S. wheat. Organoleptic tests of physical grading criteria provide little useful performance data for millers and bakers. While intrinsic testing provides more information about performance as well as reliability, intrinsic tests are only useful when performed on a single variety. Therefore, the U.S. would first need to discontinue commingling, segregate wheat by variety and establish procedures for identity preservation (IP) throughout the entire production cycle (Section 3.3.2).

Wheat quality problems in the U.S. have been ongoing since the late 1980s, as seen in the following items:

1) Insufficient time for thorough testing -- Test time required per truckload of wheat arriving at country elevators ranges from 141 to 169 seconds (Section 3.3.2.1).

2) Mass manufacturing mentality -- Grain harvest is treated as a sort of huge, rapidly moving system for grain handling across the U.S. and overseas. E.g. Grain destined for export is loaded onto vessels with capacity ranging from 20,000 MT to 50,000 MT—more than the capacity of most individual off-farm storage facilities. Trainloads arriving at the export terminals are likely to be 100 cars or more in length. Deregulation of the railroads occurred in 1980; by 1992, joint ventures had been formed with the largest grain processors and the new partnerships exerted considerable influence (likely functioning as an oligopsony) over farmers' decisions concerning wheat sales/transport (Section 3.3.2.2).

3) Little motivation to grow based on consistency of quality -- Two contributing causes for the low level of motivation are likely to be: Without intrinsic testing, varietal characteristics that reflect quality characteristics are not discernible; the very slight price differential between Grades 1 and 2 may lead to “maximum quality variability” (Section 3.3.2.3).

4) Belief that downstream actors can blend out inconsistent quality -- Partially there is an attitude that ‘someone else’ will handle any downstream problems. But, there also seems to be a general misunderstanding of just how much blending and improvement millers can provide (Section 3.3.2.5 and 3.3.2.6).

5) Little interaction with end customers -- This has likely led to the total lack of appreciation of the quality characteristic that millers/bakers need most--consistency. (3.3.2.6).

*6) Attitude toward dockage and other quality attribute*s -- Since the late 1980s export customers have complained about excessive amounts of dockage in U.S. wheat. Despite studies that have supported the complaints of the export customers, USDA/FGIS has resisted improvements mostly on the basis that buyers have become too demanding (Section 3.3.2.7).

4.6 Preliminary data analysis: Support for the Broad context of the thesis argument

Key elements from the literature review can be mapped against the ‘Six points of Broad context’ taken from Structure of the thesis argument (Figure 0.2). These mappings are shown in Table 4.1. (Section numbers in Table 4.1 refer to Chapters one through three).

Table 4.1
Broad context mapped to key elements from discussion of literature review

Item	Six points of Broad context	Key elements from literature review
1	Wheat grower-entity is most frequent link to protein quality characteristics that lead to GI/GL problems in bread.	1A) Of bread VC processes linked to high GI/GL levels, only wheat/wheat flour is involved (Section 1.4.2). 1B) Composition of the wheat grain has a strong influence on GI/GL levels (Section 1.4.3). 1C) ‘Good protein’ quality characteristics are particularly significant for GI/GL levels (Section 1.4.5). 1D) The wheat farm is the VC-entity most frequently associated in literature linking the bread VC and GI/GL levels (Section 1.4.6).

Continuation of Table 4.1

Item	Six points of Broad context	Key elements from literature review
2	Detrimental changes in wheat protein quality can be prevented by use of HACCP and application of GMPs/GAPs/GHPs.	2A) Good 'protein quality' in wheat is largely a factor of the wheat kernel's protein-to-starch and amylose-to-amylopectin ratios (Sections 1.4.3 and 1.4.4). 2B) The French wheat growers incorporated their most important GMPs/GAPs/GHPs and a 'HACCP-like plan' for food safety into their "Charter of Good Management Practices" (Section 3.4).
3	WTO agreements and FAO/WHO Codex guidelines recommend that all agrifood entities from farm-to-fork utilize HACCP (or HACCP-like) plans and GMPs/GAPs/GHPs.	3A) Codex' "General Principles of Food Hygiene" only recommend use of GMPs/GAPs/GHPs and adoption of HACCP from farm-to-fork to produce safe food (Sections 2.1.7 and 2.1.8). 3B) Codex' intent is use of GMPs/GAPs/GHPs to avoid any food safety risk and HACCP will be a 'last defence' should GMPs/GAPs/GHPs fail (Section 2.1.8).
4	Use of HACCP (or HACCP-like) plans and GMPs/GAPs/GHPs is voluntary unless national/local governments have mandated their use.	4A) Following a VS/kaizen rather than a VC strategy could have a more favourable impact on quality/food safety (Sections 2.3.3 and 2.3.4). 4B) It is plausible that the French grain processors are more efficient than their U.S. counterparts because they follow a VS/kaizen rather than a VC strategy (Section 3.3.2.2). 4C) Despite issues with the overall policy approach in the U.S., FDA has been an example of good food safety regulation (Sections 2.3.3 and 2.3.4). 4D) FDA's HACCP audits are kaizen-based (Section 2.3.4). 4E) Same as Key element 3A. 4F) Oversight of wheat production practices (for reliability concerns) is voluntary in France but non-existent in the U.S. (Sections 2.2.1, 2.3.1 and 2.3.2). 4G) INRA researches wheat grain and wheat production; concentrates on farm-to-table food safety (Sections 3.3.2, 1.3.13 and 3.2.6).
5	Wheat's (overall) intrinsic quality characteristics can be influenced by use of HACCP and/or application of GMPs/GAPs/GHPs.	5A) Wheat conformance in France is driven by continuous improvement to quality (Section 3.3.1). 5B) Reliability in French wheat is assured through intrinsic testing, both in wheat destined for humans and that destined for animals (Section 3.3.1). 5C) Without intrinsic testing of wheat, it is not possible to predict the effect of the flour on GI levels (Section 3.3.3). 5D) One of the most crucial differences between the U.S. and French wheat grading systems is the use of intrinsic testing in France versus the use of organoleptic testing against physical criteria in the U.S. (Section 3.3.1).
6	Millers and bakers value wheat's intrinsic quality characteristics that beneficially impact product conformance (i.e. due to good protein qualities).	6A) Wheat quality characteristics strongly contribute to bread quality (Section 3.2.4). 6B) The baker views the miller as responsible for flour conformance, but the wheat used largely determines conformance (Section 3.2.1). 6C) Important characteristics for bakers are protein level, moisture content, ash content, gluten content and good 'protein qualities' (i.e. ratios of protein-to-starch and amylose-to-amylopectin starch) (Sections 1.4.3, 1.4.4 and 3.2.3).

		6D) Flour reliability and conformance are not easily separated (e.g. HACCP contaminants will also affect conformance) (Section 3.2.5). 6E) The larger issue with flour quality problems in the U.S. has to do with wheat quality characteristics, particularly protein quality characteristics (Sections 1.4.3, 1.4.4 and 3.3).

Source: Compiled from author's own research

Items 1, 3 and 6 (Table 4.1) show direct connections between the literature review and specific points in the Broad context of the thesis argument. Other Items (i.e. 2, 4 and 5) show indirect connections but are addressed in further chapters:

- Item 2 is addressed in the HACCP model and VSM models in Chapter seven.
- Item 4 is directly addressed by Key element 3A and elaborated by Key elements (4F and 4G) that refer to examples of voluntary plans in France and the U.S.
- Item 5 is addressed through discussion in Chapter five regarding the use of VSM modelling to show that adoption of GMPs/GAPs/GHPs plus adherence to a HACCP (or HACCP-like) plan will lead to higher quality crop while preserving good protein quality characteristics.

4.7 Validation of Item 6 (Table 4.1)

Item 6 (*Millers and bakers value wheat's intrinsic quality characteristics that beneficially impact product conformance (i.e. due to good protein qualities*) did not need to be validated concerning French millers and bakers' preferences as documents used in literature review (e.g. intrinsic test scores from annual harvests 1999-2008 by ONIGC, ARVALIS, ANMF and *Groupement National Interprofessionnel des Semences et Plants*) confirmed this; in particular, alveograph scores were helpful. There were no sources of reciprocal data concerning millers and bakers' preferences in the U.S. The Industry thesis advisor provided anecdotal evidence, though, and his remarks and oversight were invaluable concerning millers and bakers' preferences. NAMA also provided supportive commentary in their request to USDA that GIPSA adopt grain standards that would include protein quality characteristics. (USDA/GIPSA rejected the NAMA requests; see Section 3.2.6.2). Details of the validation research project are provided in Appendix 4.A. The project was undertaken with the very generous assistance of Dr. Richard Dempster, Director for Product and Technological Development at AIB International and Adjunct Professor at Kansas State University, along with Mr. Tom Lehmann, Director of Bakery Assistance at AIB International in Manhattan, Kansas who very kindly provided the composite overview of U.S. baker experience (seen in Table 4.A-1). In brief, it could be said that the validation was successful.

4.8 Corollary to validation research project

An unintended outcome of the validation research project began with some very interesting data (Appendix 4.A, Figures 4.A-1 and 4.A-2) provided by Dr. Dempster. Dr. Dempster's research suggests baking performance varies between IP-wheats and using them as blends. This would be consistent with French bakers' preference for IP (due to the influence of varietal traits on baking performance), and the French wheat growers' strategic interest in adopting intrinsic testing. Dr. Dempster's slides (comparing mix time to absorption rate) show that three IP varieties performed consistently in mix tests using near infrared (NIR) testing (Figures 4.A-1 and 4.A-2). However, when the same varieties (with similar protein content levels as would occur in commingled lots) were mixed at a 50 percent ratio, they lost the ability to perform predictably. While this result doesn't support a claim that 'commingled wheat will behave unpredictably', it does show that three wheats that independently performed predictably, and were expected to maintain similar curves when blended, did not. It is not clear whether protein quality characteristics might have been involved, but the tests show that using protein quantity as a measure of expected baking performance is not likely to be an accurate predictor. .

This issue is also seen in French literature. Alveograph testing that measures baking strength is preferred in France, but rarely used in the U.S. Table 4.2 shows four alveograph test results from the 2007 harvest in France. A single variety, Apache[38], was grown in a number of different regions of France. Even though some of the Apache harvest shared the same level of protein, their baking strength (W) varied; likewise, even when various Apache crops shared the same value of (W), their protein content was not the same. This is consistent with NAMA's request to USDA/GIPSA asking that the wheat grading standards be expanded to reflect protein quality, not just protein quantity.

Table 4.2
Comparison of protein and baking strength in four 2007 Apache crops

Growing region	Protein content (%)	Baking strength (W)
Chalons	11.6	187
Nantes	11.6	241
Clermont	11.8	182
Lyon	10.8	182

Source: Author's own research based on ARVALIS (2007)

4.9 Chapter summary

This chapter discussed the literature review in Chapters one through three. Preliminary findings were developed by matching key points from the discussion against data elements needed to support the Broad context of the thesis argument (Figure 0.2), and shown as the mappings in Table 4.1. The literature review supported the Broad context of the thesis argument, but as Figure 0.2 showed, the Application of theory to context is addressed in Chapter five and the Application of models to context appears in Chapters six and seven.

---

[38] Apache is a variety recommended by ANMF for milling for breads (ARVALIS 2007).

Chapter 5

Modelling the value stream for bread, flour and wheat production

Chapter 5

Modelling the value stream for bread, flour and wheat production

5.1 Analysis of the bread VC using VS/kaizen theory

This section initially describes the upstream development of customer requirements from the bread VC using VS/kaizen theory. Following that, VS/kaizen models are discussed (Section 5.2) and elaborated to create generic models that are populated in Chapters six and seven to compare French and U.S. wheat production practices.

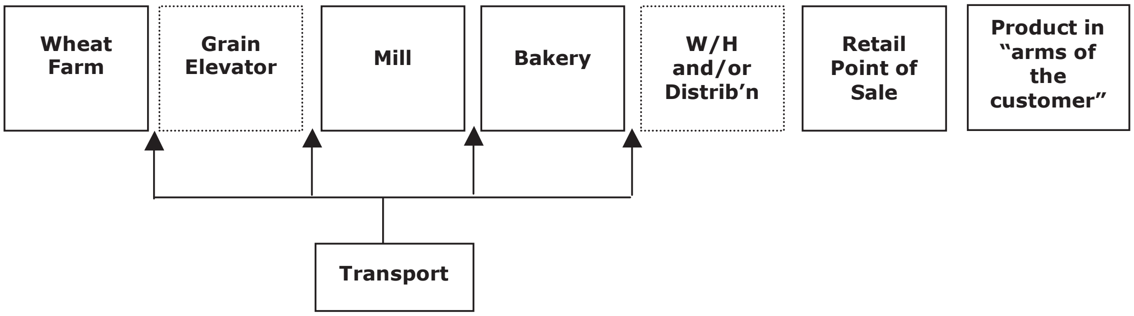
5.1.1 Describing consumer requirements from the bread VC as VS elements

Consumer requirements for a loaf of bread are adapted upstream through the VS, back to the wheat grower. Consumer expectations become the list of Baker wheat requirements that would be necessary to give the consumer what is desired. As a practical matter, the Miller is expected to take responsibility that the Baker gets the proper product; the Miller takes the Baker's list of requirements and reinterprets it to define a specific set of wheat input criteria. The Miller expects growers (and their storage, shipping and other partners) to provide a product that meets or exceeds the Miller's set of tests for incoming wheat. In production practice, each actor in the VS would consider the list of specifications and decide how to meet them (or how to negotiate a revision).

5.1.2 The VS entities

The VS for wheat baked into bread can be conceptualised based on business entities involved (Figure 5.1). The Warehouse and/or distribution function and the Grain elevator are shown in lighter borders because they are optional elements. Transport can contribute to quality characteristics of the final product, but the transport element isn't modelled in the VSM overview because it has little input to *specifying* the quality characteristics of the bread.

Figure 5.1
Business entities-layer view of the VS for wheat baked into bread



Source: Compiled from author's own research.

However, each of Transport's customers expects cleanliness, lack of hazardous treatment (such as fuel fumes, stepping on the wheat, improper moisture levels), price at a suitable level and timely delivery. So quality, cost and delivery (QCD) are also goals for the transport companies but there is no input into other characteristics. In kaizen terms, although it may be a necessity, Transport represents a type of *muda* and is, therefore, directly related to a production decision taken by the VS-entity that uses it. In other words, Transport is not a 'value-adding' entity but part of another entity's processes.

5.1.3 Identifying customer requirements

The first step is to develop a more detailed view of the product in the arms of the customer (i.e. the first element to the right in Figure 5.1). The customer's requirements drive production in VS/kaizen so this is a significant starting point. However, as Porter's VC theory and strategies for competitive advantage described, there are different categories of customers (Porter 1985). Their requirements affect the marketing choices made by the producer as well as the production methodologies selected.

Section 5.1.3.1 describes market segmentation in terms of a quality response in the Baker's operations. Regardless whether the marketing strategy is VS-oriented or VC-oriented; the discussion in the first section fits to the operations department in either type of firm. (Section 5.1.4 describes two further quality-driven strategies).

5.1.3.1 Bread quality as a differentiator in product strategies

As described in Section 1.3.1, Porter's product strategies for competitive advantage can be applied to food products, as well (Porter 1985). Bread products can be segmented across the bread market (Figure 5.2).

Figure 5.2
Porter's market segmentation applied to bread market

	Lower Cost	*Differentiation*
Broad Target	**Discount priced 'soft' white**	**Commercially produced artisan-appearing**
Narrow Target	**Branded 'soft' white**	**Artisan**

Source: Compiled from author's own research.

If the bread market segments were reorganized against a range of 'most differentiated' to 'least differentiated,' then they would appear as seen in Figure 5.3. Bread production categories can be defined as:

Industrial – a bread plant with one or more automated production lines;

Semi-industrial – an industrial plant that has produced dough to be baked into artisan-appearing loaves; the plant either freezes the dough, a par-baked loaf or the fully baked loaf of bread, then ships the product for the retailer or customer to finish the process;

Artisan – each loaf is prepared manually; baker takes into account and adjusts each batch for differences in raw materials, daily temperature/humidity, etc.

Figure 5.3
Differentiated range of bread product categories

Discount priced 'soft' white	Branded 'soft' white	Commercially produced artisan-appearing	Artisan

Degree of Differentiation 1 2 3 4 (Most)

Source: Compiled from author's own research.

The differentiated bread product positions (Figure 5.3) can be correlated to production methodology, as well (Figure 5.4). However, if specialized production behaviour were considered (such as that of Warburtons, Section 1.2.5), it would appear that those bakers are following a strategy of moving from category two ("Lower cost in a narrow market") toward category three ("Differentiated product in a broad market)." A strong element of this strategy's success is dependent on high-quality raw material. In effect, the Warburtons approach splits category three, as seen in Figure 5.5.

Figure 5.4
Bread product categories matched to production methods

Discount priced 'soft' white	Branded 'soft' white	Commercially produced artisan-appearing	Artisan
Industrial	Industrial	Industrial and Semi-industrial	Artisan

Degree of product differentiation
1 2 3 4 (Most)

Source: Compiled from author's own research.

Figure 5.5
Revised Figure 5.4 to include strategy of Warburtons

Discount priced 'soft' white	Branded 'soft' white	Branded 'high quality' white	Commercially produced artisan-appearing	Artisan
Industrial	Industrial	Industrial and Semi-industrial	Industrial and Semi-industrial	Artisan

Degree of product differentiation:
1 2 3 4 (Most)

Source: Compiled from author's own research.

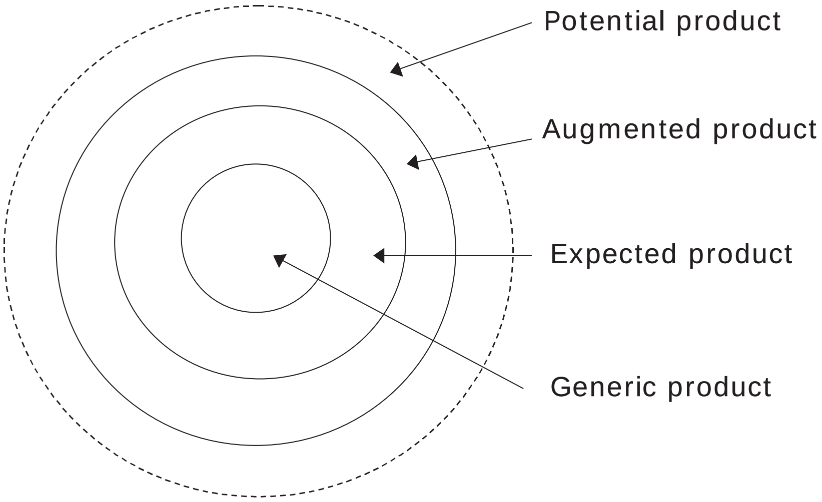
5.1.4 VS development of product requirements for bread

Section 5.1.3.1 described market segmentation as a quality response from the Baker's operations. This section describes two further quality-driven strategies. The first (Levitt's Total product concept) concerns the marketing orientation applied in a quality-driven product concept (Section 5.1.4.1). In other words, how the firm as a whole (both marketing and operations) plans to address quality. The second strategy (Kano *et al*.'s Two dimensions of quality) is an analysis of two dimensions of quality from the customer's perspective (Section 5.1.4.2).

5.1.4.1 Levitt's Total product concept

Theodore Levitt of Harvard Business School developed a Total product concept based on four concentric circles (Figure 5.6).

Figure 5.6
Levitt's Total product concept



Source: Peters 1987

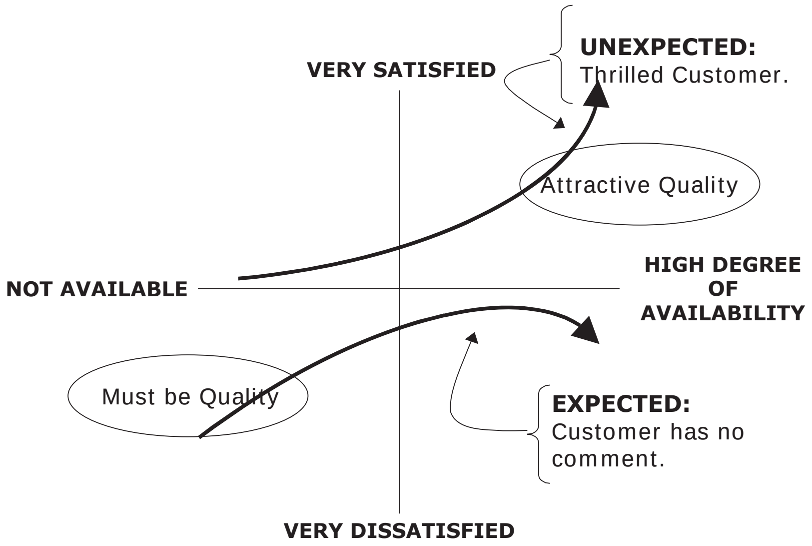
The inner circle represents the Generic product (i.e. features and/or services the firm must offer to at least be a viable competitor). The next layer is the Expected product (i.e. features and/or services that a customer has come to expect from the firm that go beyond the Generic product). The third circle is the Augmented product (i.e. features and/or services that truly set the firm apart, and often cause the firm's prices to be higher than competitors in order to offer the more costly offerings). The outer circle, the Potential product, represents unlimited potential (i.e. all the imaginable extras that a customer will value). But, this set of quality offerings is only made after the firm's competitors have caught up in terms of quality offered. Essentially, in 'Porter VC language', quality becomes the differentiator. Besides the strong emphasis on quality, another difference with competitive advantage theory is that the four circles don't represent an "either or" choice. The firm defines its initial offering and product quality layer, but that choice encompasses all the circles inside the chosen layer. Over time, the firm would eventually be offering the Total product encompassing all four circles – based on competitor behaviour and the firm's internal decisions of when to provide which level of quality.

A similar topic (in Western organizations) relates to what is sometimes referred to as finding "the balance between cost and quality." In kaizen philosophy, there is no 'balance' – quality must be first. The whole idea of quality being first is so important to Japanese CI philosophy that Takoshe Hokake refers to the balance between cost and quality as 'the whispering of Satan' (Soin 1992).

5.1.4.2 Kano et al.'s Two dimensions of quality

A second dimension of quality (i.e. the area of 'attractive quality') may be developed when firms have reached the position that defects and problems are approaching zero (Soin 1992). In kaizen philosophy, customer expectations are closely tied to levels of quality and customer requirements tend to fit to a two-dimensional model of quality (Figure 5.7).

Figure 5.7
The two dimensions of quality



Source: Kano *et al.* 1984

The two dimensions are "must be quality" (i.e. a set of expected features, such as reliable, safe, easy to use) and "attractive quality" (i.e. the unexpected that goes beyond the customer's current needs). "Must be quality" features are the minimum acceptable standard (similar to Levitt's Generic product characteristics). If the customer doesn't receive a "must be quality" feature, there will be extreme dissatisfaction. "Attractive quality" features are those extra features that when offered, thrill or excite a customer; if not offered, the customer has no comment. Over time, "attractive quality" features become "must be" features, and new "attractive quality" features must be found to take their place (Kano *et al.* 1984).

5.1.5 Defining the requirements of the end customer for bread

VS/kaizen methodology begins with the product "in the arms of the customer" and evaluates how well the customer's requirements are met in terms of quality, cost and delivery (QCD). This process is repeated for each entity, moving upstream away from the end customer. Although there are five different categories of possible product offerings (Figure 5.5), in terms of market position, there are still only four basic categories of customer purchase.

Although a hand-made loaf of artisan bread is very different than a discount-priced loaf of soft white sandwich bread, the customer requirements for the end consumer can still be split into the same set of generic criteria (Cauvain 1998; 2008). The generic criteria are seen in Table 5.1.

Table 5.1
End customer requirements

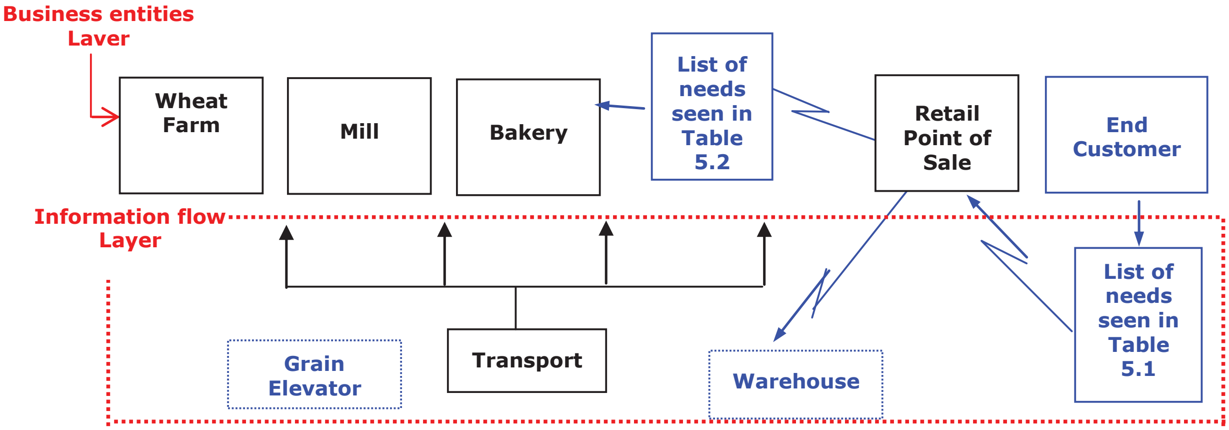
Item Nº.	End customer QUALITY requirement characteristics	Examples
1	External look	Proper shape and size for type; colour; crust formation suited to type
2	Internal look	Crumb grain; "holes" in bread suited to type; crumb colour
3	Bread texture	Springiness; "squeeze test"
4	Eating quality	Taste; sensory perception
5	Flavour	In general, related to crust and crumb
6	Freshness	Not stale
7	Safe to eat	Free from pathogens, GMO, allergens
8	*Optional:* Warmth	Smell and touch of fresh baked
9	*Optional*: Organic	Free from pesticides, herbicides, other chemicals
10	*Optional:* Dietetic	Reduced sugar, salt, fat, other
11	*Optional:* 'Healthy choice'	Added products such as magnesium, nutraceuticals, fruits, nuts, wholegrain, other
Item Nº.	**End customer COST requirement characteristics**	**Examples**
12	Price	Relative to perceived value
Item Nº.	**End customer DELIVERY requirement characteristics**	**Examples**
13	Availability	Store has adequate choice, fresh stock; hours, location, suitability for demographics

Source: Compiled from author's own research.

5.1.6 Analysis of customer requirements

Figure 5.1 showed the bread VS at the 'Business entities' layer and can be redrawn to also show the 'Information flow' layer (Figure 5.8). The blue colouring reflects changes to Figure 5.1; the red distinguishes the layers. The set of End customer requirements (Table 5.1) could be considered as a detailed view of the Product "in the arms of the customer" (from Figure 5.1) or as the 'List of needs seen in Table 5.1' (from Figure 5.8).

Figure 5.8
Layered view of VS: Business entities with start of information flow



Source: Compiled from author's own research.

As Figure 5.8 shows, the End customer's needs are initially collected by the Retailer who in turn transmits that information – along with the Retailer's own set of needs (Table 5.2) – to the Baker and the Warehouse.

Table 5.2
Retailer requirements

Item N°.	Retailer QUALITY requirement characteristics	Examples
1	Product matches market strategy	Bread should represent the Retailer's market strategy; additional options might be warmth, organic, dietetic, or 'healthy choice'.
2	External look	Proper shape and size for type; colour; crust formation suited to type
3	Internal look	Crumb grain; "holes" in bread suited to type; crumb colour
4	Bread texture	Springiness; "squeeze test"
5	Eating quality	Taste; sensory perception
6	Flavour	In general, related to crust and crumb
7	Freshness	Not stale
8	Safe to eat	Free from pathogens, GMO, allergens
Item N°.	**Retailer COST requirement characteristics**	**Examples**
9	Price	Relative to perceived value and fit within plan for cost-of-goods to be sold
Item N°.	**Retailer DELIVERY requirement characteristics**	**Examples**
10	Fit to inventory needs	Deliveries match (JIT) needs; minimal disruption to POS; no mistakes in order or schedule

Source: Compiled from author's own research.

5.1.7 Further analysis of the End customer's needs

If the End customer's requirements (Table 5.1) are reviewed in terms of Kano's Two-dimensional model of quality (Figure 5.7), the list of requirements could be sorted as follows:

<u>"Must be" qualities:</u>	<u>"Attractive" qualities:</u>
Items 1-7, 12 and 13	Items 8, 9, 10, 11

Quality, both in terms of product conformance and reliability, are "must be" characteristics. Product conformance is reflected in items 1-5; reliability (food safety) is shown in items 6 and 7. Items 12 (Price) and 13 (Availability) indirectly affect product conformance (i.e. if the customer doesn't associate the price charged as appropriate for the quality level with availability conditions to match, there will be dissatisfaction). None of these items (i.e. 1 through 7, 12 and 13) could be missing without causing a negative reaction from the customer.

The "attractive" qualities (items 8, 9, 10 and 11) are described as "Optional" from the customer's perspective (Table 5.1). Item 8, warm to the touch with the scent of freshly baked bread, is frequently used by retailers to attract customers to the store (as seen in the many bake-off sites in a variety of retail formats. Items 9, 10 and 11 reflect changes in raw ingredients, formulation or other high-quality raw ingredient inputs.

With considerable and kind assistance from the thesis' Industry advisor (S. Cauvain), the End customer requirements were analysed and described here. The relationship between the End customer requirements and the wheat farm are quite strong. Nearly all requirements are impacted by choice of wheat; only numbers 8 and 13 are not. Numbers 10 and 11 may also be impacted by choice of wheat. Adding fat to bread dough (item 10) causes less variability in the flour made from certain wheat varieties. Therefore, reducing the level of fat, to meet the consumer's request, would place increased importance on choice of wheat. Similar types of variability occur with the addition of health-oriented raw materials (item 11). Therefore, a ‘healthy choice’ bread would also require the use of specific wheat varieties (Cauvain 2007).

5.1.8 The Retailer’s needs

The retail point of sale (POS) is the next element upstream from the end customer. The POS, viewed from the end customer’s perspective, is primarily responsible that end consumer quality requirements are met. Therefore the POS also expects that each of the 11 ‘customer quality requirements’ are fulfilled suitably, based on particular bread variety. But the POS is most concerned that the bread product matches with the retailer’s market strategy (Figures 5.2 and 5.5). There will be some degree of transportation involved to distribute bread to the retail POS. This may or may not entail a warehouse function. Various communications links are shown in Figure 5.8. The links, as well as the data transmitted or collected (from the End customer, for example) are all aspects of the information flow. But the information flow in Figure 5.8 is merely as an example. The specific requirements of the Retailer are shown in Table 5.2. If the Retailer’s needs are split into Kano’s Two dimensions of quality, the categories would be as follows:

“Must be” qualities:	“Attractive” qualities:
Items 1-8, 9 and 10	None

Although the End customer and the Retailer want the same basic quality characteristics from the Baker, they are valued differently. This has (at least) two ramifications, in terms of marketing: 1) the Retailer would seem likely to be “thrilled” by some attractive quality attributes (assuming that all of the listed items are presently provided at a near ‘zero defect’ level); 2) the attractive qualities that would appeal to the End customer have been discovered or enhanced through market research efforts. They are not likely to have been desired without marketing effort. In addition, the same loaf of bread that might exhibit one or more attractive quality attributes to the End customer is only a Generic product to the Retailer. Again, the opportunity for using CI to offer something better to the retail customer exists. Also of interest is that all of the Retailer's quality requirements are connected to the choice of wheat. This begins to show the dramatic impact the wheat grower has on the bread product.

5.1.9 The Baker's needs

The next level upstream is the Baker. The Baker provides the first point where transformation of raw materials occurred. The Baker not only has an interest in meeting the End customer's requirements, but also has a set of its own requirements that are necessary for its suppliers (the mill and the wheat farm) to provide. As described in the End customer's and Retailer's needs analyses, the choice of wheat is a key factor; but the Baker's production skill is also a major factor in achieving both product conformance and reliability. Therefore, the Baker translates the requirements from the Retailer (and sometimes the End customer) into quantifiable supplies for production.

As wheat is the chief raw ingredient – and due to its significant role in final product quality – the requirements could be reduced to reflect only wheat characteristics, rather than the many other ingredients that are sometimes found in bread (Table 1.13). These requirements can be categorized (Table 5.3), and mapped to specific bread production categories (taken from Figure 5.5).

Table 5.3
Baker requirements

Item N$^{o.}$	Baker QUALITY requirement characteristics	Specifics	Production category
1	High protein	Suitably matched to bread type: -- Hard wheat blended to protein content of 12-14% -- Soft wheat blended to protein content of 10-12%	**1, 2, 3** **4**
2	Consistency of product	Little variability between one delivery of flour and the next	**1, 2, 3**

Continuation of Table 5.3

Item N$^{o.}$	**Baker QUALITY requirement characteristics**	**Specifics**	**Production category**
3	Meets regulatory standards	In EU, in US and elsewhere depending on baker's market	**All**
4	Meets existing food safety standards	Non-GMO; no pathogens	**All**
5	Minimal use and documented use of pesticides, fertilizers, herbicides	Written records from mill and farm available for viewing	**2, 3, 4**
Optional quality requirements associated with contract production:			
6	Seed selection agreed or mandated by customer	Includes use of certified seed and identity preservation	**3; possibly 4**
7	Choice of other inputs agreed or mandated by customer	Includes pesticide, fertilizer, herbicide and other chemicals	**3; 4?**
8	Successful intrinsic testing at customer-mandated intervals	Choice of tests mandated by customer	**3; 4?**
9	Satisfactory field scouting	Written reports of field checks	**3; 4?**
10	Farmer documentation of practices	Specific practices agreed with customer	**3; 4?**
11	More frequent shipment intervals	Mapped to production levels	**3; 4?**
12	Less time in storage	Quality improvement; cost savings	**3; 4?**
Item N$^{o.}$	**Baker COST requirement characteristics**	Specifics	**Production category**
13	Suitable price	Price related to flour quality	**All**
Item N$^{o.}$	**Baker DELIVERY requirement characteristics**	Specifics	**Production category**
14	Agreed conditions are met	Timing, quantity, health & safety practices are followed + suitable price	**All**
Production categories: 1 = Discount priced 'soft' white, industrial production; 2 = Branded 'soft' white, industrial production; 3 = either Branded 'high quality' white or Commercially produced artisan-appearing, either industrial and semi-industrial production; 4 = either Volume artisan, industrial production or Artisan bread and artisan production.			

Source: Compiled from author's own research.

If the Baker's requirements were separated into Kano's Two dimensions of quality, the split would be as follows:

"Must be" qualities:	"Attractive" qualities:
Items 1-4, 13 and 14	Items 5-12

Interestingly, the Bakers themselves have sought out the "attractive qualities". It would seem that not only have the wheat producers completely overlooked the opportunity to enhance their Generic product, the lack of attention has forced the most competitive Bakers (those desiring higher quality attributes) to secure their own reliable sources. Further analysis of Baker's requirements can be done using kaizen modelling tools. Section 5.2 describes some of the kaizen modelling tools. Section 5.3 applies the models to the further refinement of the Baker's requirements (Table 5.3).

5.2 Kaizen models in this thesis (VSM, QFD and HACCP)

Modelling requirements can be grouped into two main areas: 1) a comparison of French and U.S. industry strategies and government policies that may impact wheat protein quality; 2) a comparison of French and U.S. wheat grower practices (i.e. processes) that may impact wheat protein quality. Only three kaizen modelling tools were selected: value stream mapping (VSM); quality function deployment (QFD) and HACCP decision-making process were selected.

VSM and QFD: VSM is better at depicting processes and describing the entire VS while QFD is better suited as a planning tool (for a specific product, project, set of actions). VSM can compare how two or more competitors perform a process, but QFD is intended to compare the customer's perception of the various competitors' products.

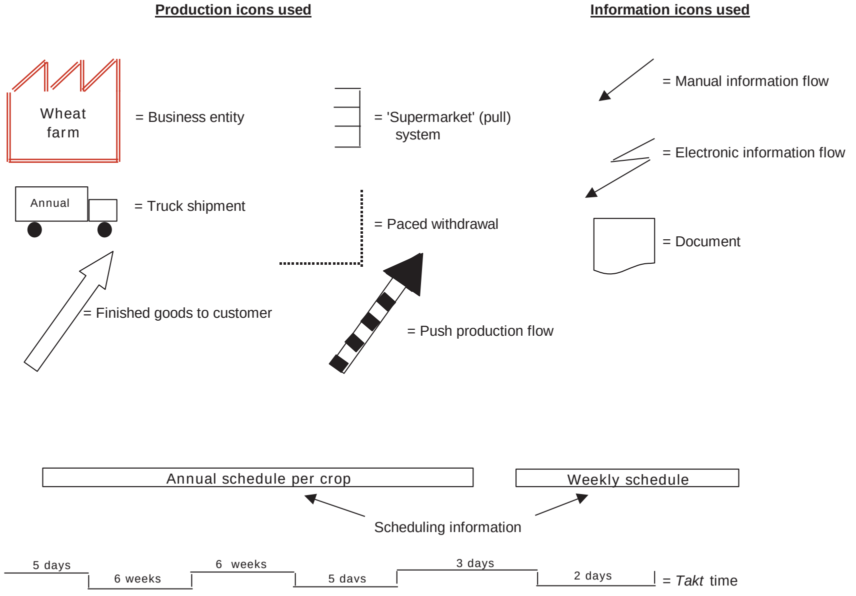
HACCP: Based on Deming's work on quality management in 1950s Japan, HACCP is used to assess food safety hazards and establish control systems (Section 2.1.8). The author contends that the HACCP decision process (Figure 2.6) can also be applied as a tool for assessing process performance in GAPs/GMPs/GHPs and designing *a priori* prevention of process defects. This is examined further in Chapter seven.

Kaizen modelling tools are used extensively to analyse customer requirements (Imai 1997; Soin 1992). Therefore, the starting point for all VS analysis is to identify the customer's requirements. The customer's requirements begin with the end consumer; information and production flows are then developed to support those requirements (Rother and Shook 2003; Imai 1997; Soin 1992; Noori and Radford 1995). As the flows move upstream, other customers are identified and their requirements are collected, as well (Rother and Shook 2003). This thesis is primarily concerned with protein quality characteristics in wheat production, but each set of customer requirements iteratively expands to include additional requirements from each 'upstream' customer (Section 5.1).

5.2.1 VSM tools and icons

VSM is pictographic, relying on icons to describe processes. Icons fall into three categories: those needed to show material **production flow**; those intended for **information flow**; and a more generic group of boxes and labels that either **explain a process or indicate associated process measurements**. Figure 5.9 shows a subset of VSM icons used in this thesis. One of the more significant uses of the icons is to depict whether a system represents a 'push' or 'pull' approach. VS/kaizen advocates the use of 'pull' processes that collectively become a 'pull' system. It is equally important to be able to show any 'push' processes, as well, on the VSM diagram (Figure 5.9).

Figure 5.9
VSM icons



Source: Compiled from author's own research.

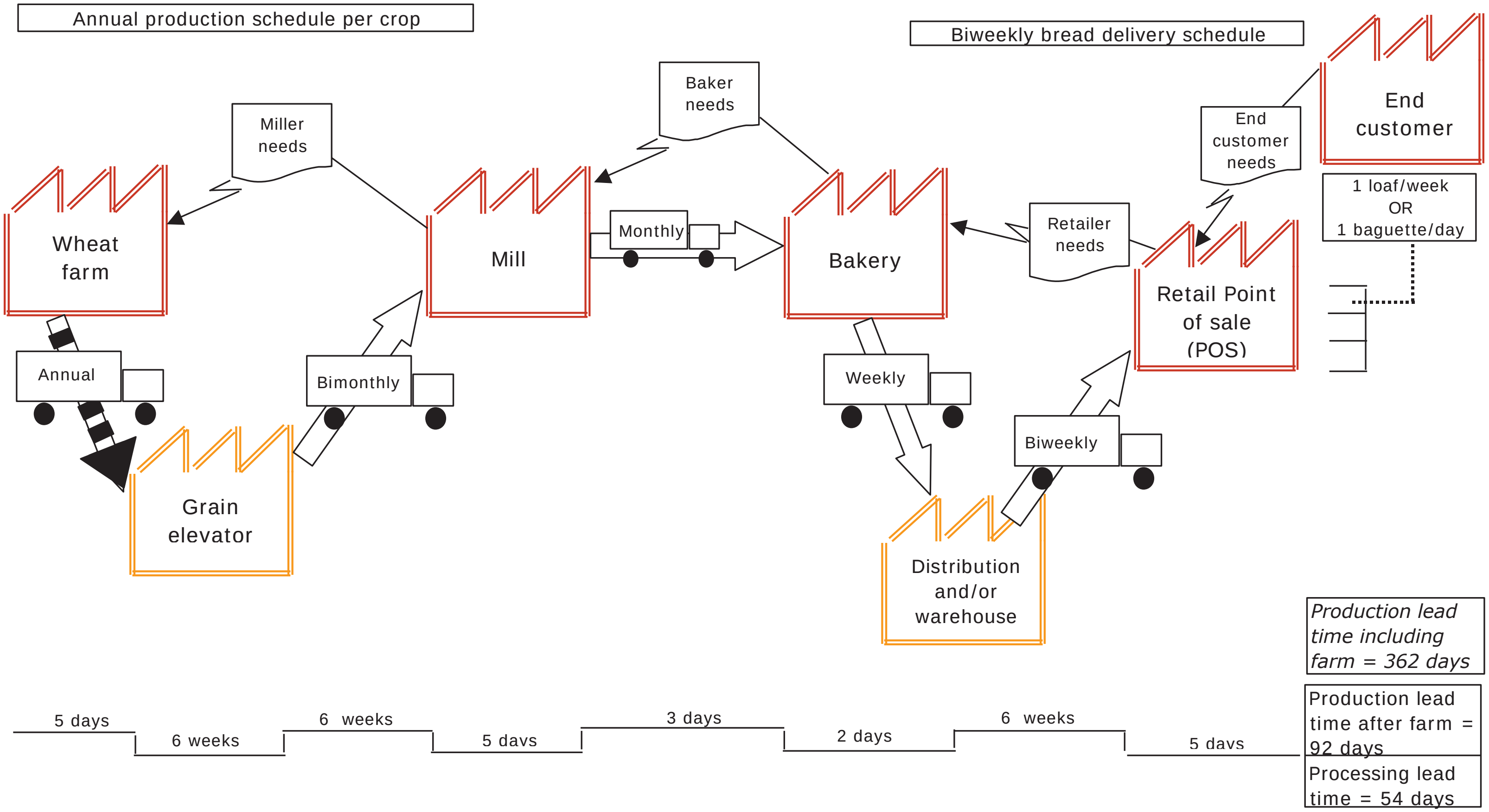
5.2.1.1 VSM Information flow

The upper half of the VSM overview for the bread VC (Figure 5.10) indicates information flow. Starting at the right-hand side of the drawing is the End customer who has a set of expectations, or needs, for bread (Table 5.1). Those needs are transferred to the Retailer at the point of sale (POS). Although much of the information regarding the End customer's preferences might be accumulated manually (e.g. in personal interviews or direct dialogue with the End customer), it is likely the specifics are transferred through some form of electronic transmission (such as bar scan or an RFID device on a wrapper or a field-key used on the cash register receipt). Therefore, an icon for electronic information flow is used. The Retailer's needs (Table 5.2) are consolidated with the End customer's needs and passed on to the Baker. The Baker translates the needs from the Retailer into a working set of manufacturing requirements. As this thesis is primarily concerned with wheat, the Baker's list of needs (Table 5.3) only reflects what's needed from wheat in order to fulfil the Retailer and End customer's needs. The information flow continues toward the left side of the diagram, and the Baker's needs are recast by the Miller to create specific requirements (seen later in Table 5.7) for the Wheat grower.

5.2.1.2 VSM Material production flow

Production flow begins on the left side of the VSM diagram (Figure 5.10) at the Wheat farm. The farmer usually produces one wheat crop per year; planning is done annually. In most cases, wheat is produced in open production systems. As there is no existing buyer or specific set of delivery requirements, the production is part of a 'push' system (i.e. a marketer some where in the VS must push the goods out onto the market) and is shown with the black-and-white production arrow.

Figure 5.10
VSM overview diagram for bread VC



Source: Compiled from author’s own research.

In a contract production system, the production flow icon for delivery of finished goods would be replaced by a white arrow, as seen connected to the other business entities in the diagram (Figure 5.10). At the very bottom of the diagram is *takt* time. This collects two measures of time: the elapsed time and the time required to complete each processing stage. *Takt* time is a key benchmark in VS/kaizen because it represents time needed for cash turnaround as well as time for production flow.

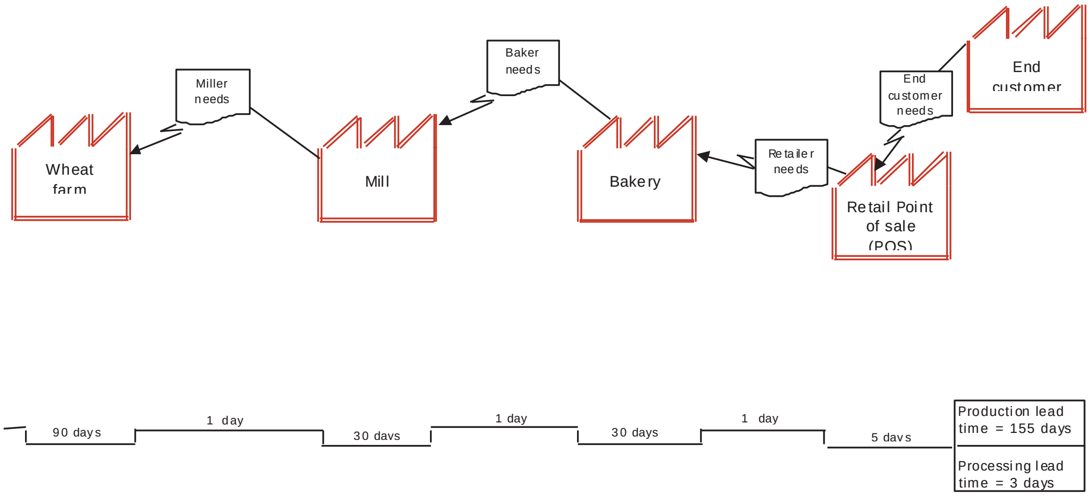
From the grain elevator onward, the diagram shows that product is moved using trucks. But this is merely an illustration; transport could be done via railroad cars, ocean-going ships or river barges. The frequency of transportation is noted on each symbol. Eventually, deliveries of bread take place twice each week at the POS on the far right of the diagram. All of the frequency labels are merely illustrative. In a specific application, actual measurements would be used.

It should also be noted that the POS is shown using a 'supermarket' system to manage incoming deliveries and stock replenishment. This is another component of pull production systems and doesn't necessarily reflect a supermarket or retail POS – it is just the name borrowed from one of the more common inventory management systems used in POS applications. However, the philosophy behind the supermarket system is JIT-based. Only the amount of product needed is in inventory (i.e. on the shelves); as quickly as it is sold, it should be replaced and orders should be optimized against cash flow turnaround. This is also the rationale behind the pull system – maximize customer satisfaction, minimize resource outlay and optimize time – whether the customer is the End customer or the next process. Please note: Figure 5.10 has been validated with S. Cauvain, the thesis' Industry advisor.

5.2.2 Using VSM to "zoom in"

One of the more useful characteristics of VSM is its flexibility to represent more and less detailed views of the same model. VSM literature refers to this as "zooming in" on or "zooming out" of specific sections of the VSM diagram (Rother and Shook 2003). Zooming in on the information flow of Figure 5.10 would appear as Figure 5.11; the main change is the effect on *takt* time.

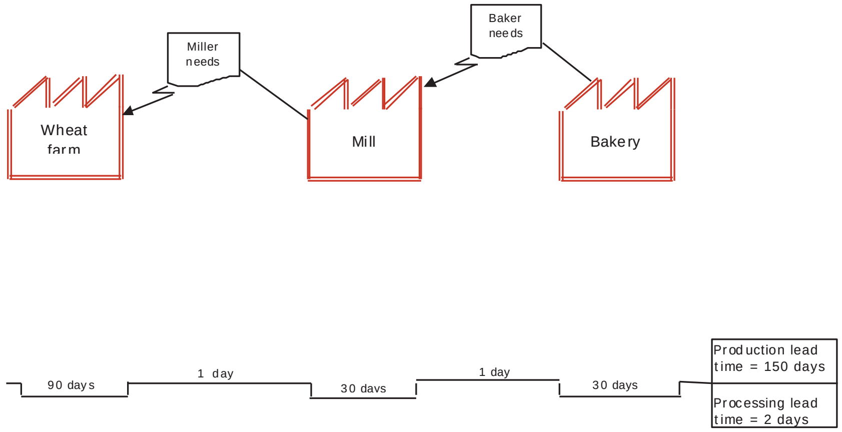
Figure 5.11
Bread VS information flow



Source: Compiled from author's own research.

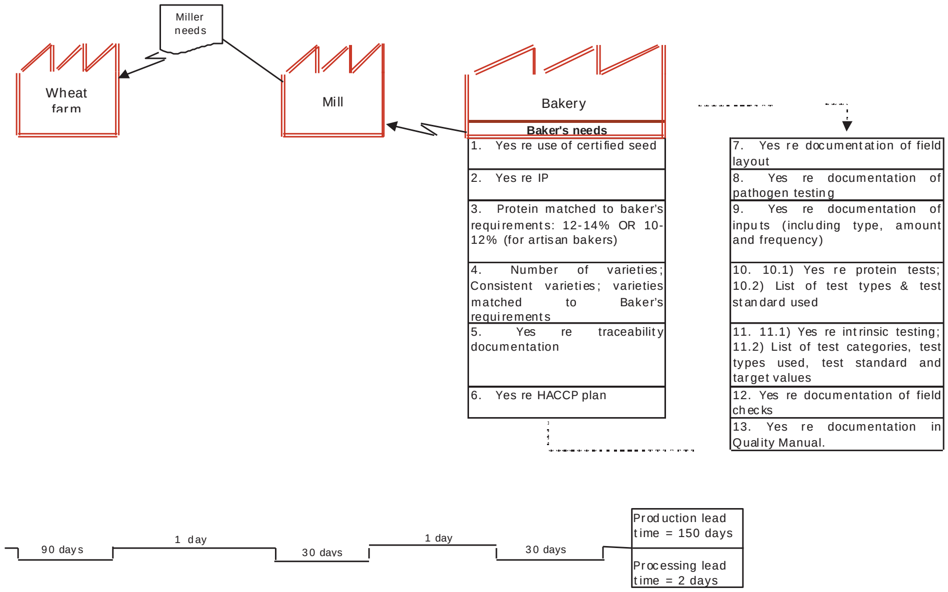
Starting on the left (Figure 5.10), the Farmer who produces winter wheat has approximately three months (maximum) time interval from when the last crop is harvested and sowing should begin for the next crop. So, 90 days was used for processing time, but it is likely to be smaller in practice. For the Miller and the Baker, it was assumed that production planning could be carried out in 30 days. The Retailer shows 5 days, which, depending on the manufacturer's marketing strategy may be excessive or insufficient. The End customer's needs have been incorporated into the processing performed by the Retailer. The End customer's needs might be partially captured in the transaction payments system or possibly accumulated through independent surveys or focus group taste-tests. Therefore, five days is an arbitrary figure. One day was also arbitrarily assigned for the flow of information; this is likely to be excessive in actual practice. But, without mapping the practices of a specific firm, the figure remains arbitrary. A segment of the VSM diagram was extracted showing the portion of the information flow from the Baker's needs back to the Wheat farm (Figure 5.12). If zooming in were repeated on the information flow, it would eventually be possible to depict the detailed view of Baker's needs, with VSM data boxes representing each of the Baker requirements (Figure 5.13).

Figure 5.12
Information flow from Baker to Wheat farmer



Source: Compiled from author's own research.

Figure 5.13
Detailed view of Baker needs



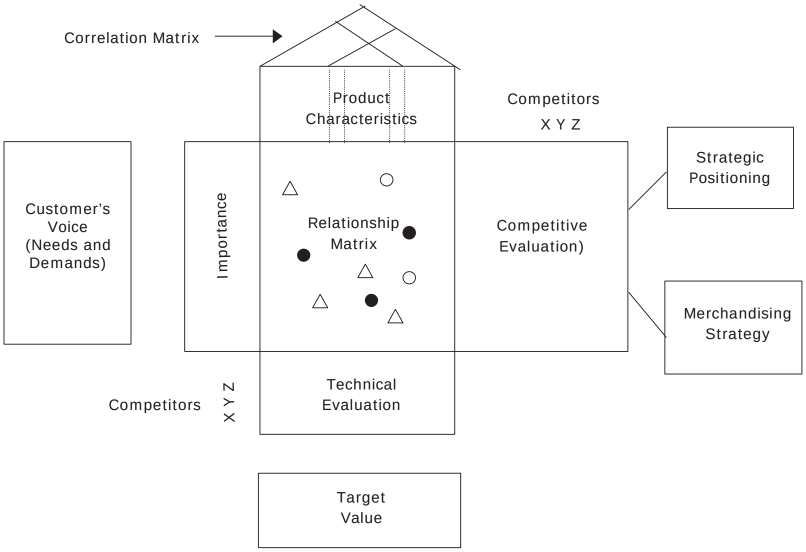
Source: Compiled from author's own research.

VSM is also capable of mapping production flows in service (i.e. intangible products), as well. This feature becomes useful for analysis of the information flow that describes the development of the Miller's needs and the inter-relationship to the Wheat farmer's production design requirements.

5.2.3 The QFD House of Quality

All of the versions of the various customer requirements can be consolidated into a QFD diagram (Figure 5.14). The diagram shows the conceptual logic behind QFD's first phase, "which is known as the house of quality and the matrix of matrices" (Soin 1992). There are multiple versions in the literature, but this one captures the basic elements while showing the relationships between various business functions (Soin 1992).

Figure 5.14
Conceptual diagram of QFD product development



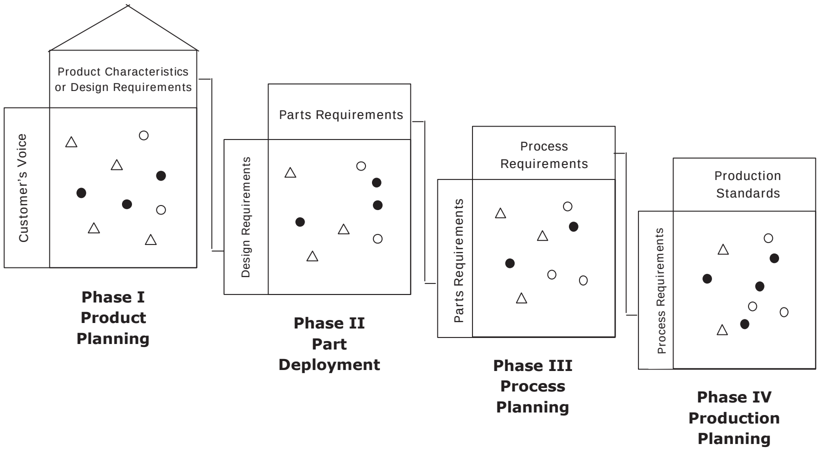
Source: Soin 1992.

Figure 5.14 shows QFD as a system, with Input entering on the left side and Output expanding into multiple activities on the right side. The Customer's Voice is the most important element of all; every other activity is intended to support it. Customer requirements are evaluated and the relationship between each customer desire and how that would translate into a product are assigned a value to represent the importance to the customer. The values (strong, medium and weak) are shown in the Relationship Matrix. Technical Evaluation is an output of the Relationship Matrix that is the operations management view of how to create the product characteristics. Technical Evaluation also considers what the firm's main competitors are producing, related to each product characteristic. Target Value represents benchmarks that the operations department assigns to the specifications that develop in the Technical Evaluation. The Correlation Matrix is a highly detailed view (generally used after production has begun) for identifying any deviations from or areas for possible improvement of delivering what the customer desires. The three elements shown on the right side of the diagram are the kaizen view of Top Management's role in the enterprise. Top Management is expected to continually assess the product's position in the market and take responsibility for the proper strategic and merchandising decisions.

5.2.4 Zooming in on the QFD processes

Many different QFD matrices are used in Japan, but the basic version consists of the four-phase approach (Figure 5.15).

Figure 5.15
Development of the four-phase QFD matrices



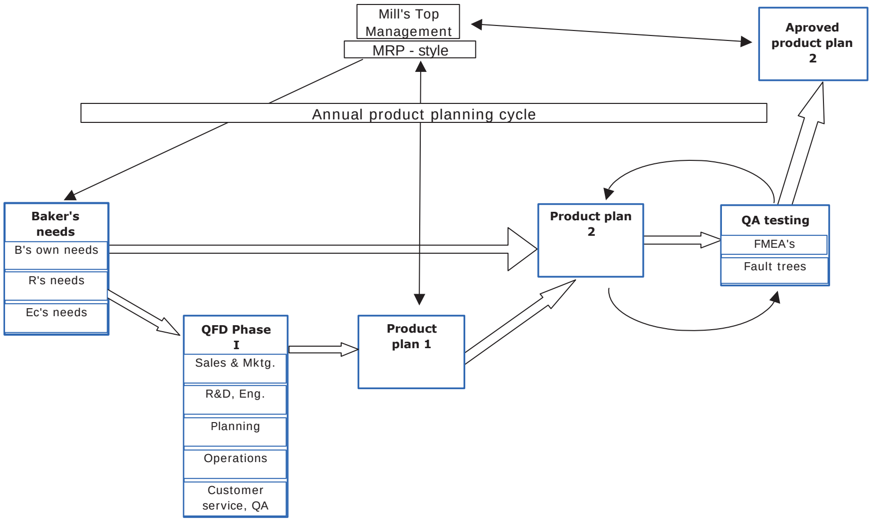
Source: Soin 1992

The customer's requirements become the input to the first version of the product plan (Figure 5.13). The output becomes the design of what the producer sees as the product the customer has defined. The design requirements that develop from the first and second version of the product plan are known as Phase I and become the inputs for Phase II (i.e. the set of parts required) to fulfil the producer's view of the product's design requirements for manufacture. At the end of Phase II, most Japanese companies would test the designs for all conceivable types of reliability issues. The design requirements would be refined, based on the results of the reliability analysis, and the revised design requirements would become the input for Phase III (e.g. to develop the processes needed for manufacture). Phase IV would take process definitions as input and the output would be process standards. To the extent possible, Japanese companies would use existing processes that have been documented and standardized (or performed to the point of near-zero variability when performed); new processes need documentation before they can be performed.

Figure 5.16 shows development of the Miller's needs based on the consolidated needs represented by the Baker (i.e. QFD Phase I). The drawing depicts VSM production flow of planning activities for Product plan 1 and Product plan 2—both part of Phase I—and using the Japanese approach to QFDs (from Soin 1992 and Imai 1997). The boxes in blue are processes that are part of the QFD planning activity. The data boxes (within the processes) indicate various 'metrics' for comparison of these particular processes.

In the process named "QFD Phase I", the various functional departments that participate in product planning have been itemized. In the process named "QA Testing", FMEA and Fault tree analyses are shown in the data boxes. The purpose of the drawing is to show (from a miller's perspective) the minimal processes that should be performed, and still adhere to a kaizen methodology.

Figure 5.16
Miller's QFD Phase I for Product plan 1 and 2



Source: Compiled from author's own research.

5.2.5 Conflicts in literature describing VSM and QFD models

There are differences in the literature concerning methodology and use of VSM and QFD, depending on whether the authors are Japanese (or educated in Japan) versus North American practitioners of kaizen. Some of the differences are discussed in Sections 5.2.5.1 and 5.2.5.2, but more detailed examples are described later in the chapter (Section 5.4).

5.2.5.1 Some comments concerning VSM

Kaizen expects that all upstream and downstream partners (e.g. suppliers and distributors) will have access to VSM models and the models will be easily understood. Section 5.1.6 describes part of the VSM modelling needed in this thesis, and shows an example of a conflict in the literature (Figure 5.8). The North American VS/kaizen literature describes an information flow as separate from the production flow and that both appear on the same overall VSM of a single VS-entity. However, as Figure 5.8 shows, information flow in the VSM that begins in one VS-entity (Retail POS, for example) may introduce process elements of a second VS-entity (such as Warehouse) that are not related to a (manufactured) product but to a service/paper flow—yet may be strategic elements to the second (Mill) and third (Bakery) VS-entities. Therefore, information flow and production flow might not always be two separate streams.

5.2.5.2 Some comments concerning QFD

There are also some differences between North American and Japanese approaches to use of QFD. In western organizations, QFD is a production-planning tool and represents an important design aid for manufacturers (e.g. Xerox, Ford and General Motors) that have adopted total quality management (TQM) approaches (Noori and Radford 1995). Japanese companies use QFD as a planning tool to interpret customer requirements first, and then determine how to produce to meet those requirements. After customer requirements have been identified, then work proceeds back through the stages of design, engineering, production, sales and after-sale service and support of the product (Imai 1997). In North American organizations, possibly because operations and production departments are more isolated from other important areas of the firm, kaizen tools (such as QFD) are not employed at an organizational level but fitted to more narrow production purposes (Noori and Radford 1995). This represents a major difference (possibly cultural) in the way that QFD is used; in Japan QFD drives an integrated company-wide planning process while in North America QFD represents a production design aid.

5.2.5.3 Differences between North American and Japanese versions of QFD

In the following paragraphs, Noori and Radford (1995) represent the perspective of North American operations management textbooks; Imai (1997) represents the more general Japanese company management view.

The first step is to translate customer requirements into appropriate design requirements at each stage of the product development process (Noori and Radford 1995). In Imai's view, QFD "enables management to identify the customer's needs, convert those needs into engineering and designing requirements, and eventually deploy this information to develop components and processes, establish standards, and train workers" (Imai 1997). In Imai's examples of the application of QFD diagrams, each is a type of flow chart (Figure 5.15) that moves from Product planning to Prototype design and testing to Production design to Production preparation and, eventually, to Production followed by Customer service and Audit (Imai 1997). These 'flow charts' pass through the QFD phases (Figure 5.15), relying on Deming's SDCA-PDCA cycle (described in Appendix 0. 1)

The matrices Phases II through IV are 'layers' beneath the (Phase I) House of Quality (Figure 5.14). The Product Plan is designed first. Then the Design Requirements that were generated in the Product Plan matrix are carried over to become the input (or WHATs in the North American version) for developing a required parts list (the HOWs in the North American version of QFD). Parts Requirements become the input into the Process Plan in order to generate the needed set of processes. Process Requirements become the input for Production Standards. In Japan, the output from Phases I and II are frequently tested against an analysis of possible failures using a Failure Modes and Effects Analysis (FMEA).

Noori and Radford state that QFD begins with the Product planning matrix, that it is the best known of the QFD matrices and "frequently the only one developed" (Noori and Radford 1995). Like Imai, they point out that a firm only really addresses the desires of the customer when development of matrices goes beyond creation of the Product planning matrix. However, even those additional phases advocated by Noori and Radford fall short of all the phases expected in the Japanese version. "Yoji Akao of Tamagawa University is the key contributor to QFD development in Japan" (Soin 1992). Akao's approach includes as many as 30 different QFD matrices to fully map all requirements of the customer (Soin 1992). Fukuhara, a QFD expert "…with the Central Japan Quality Control Association …. focuses on the house of quality, namely the product definition aspect" (Soin 1992). The value of QFD hasn't gone unnoticed in the U.S., but adoption has been somewhat more cautious than in Japan. Table 5.4 compares the North American and Japanese approaches.

Table 5.4
Comparison of North American and Japanese approaches to use of QFD

Imai phases	**Noori and Radford:**	
	Phases	**Purposes**
Product planning 1 – to meet customer needs	1) Product planning (Table 5.5a)	Customer expectations are matched to design requirements
Product planning 2 – from standpoint of making product	2) Part deployment (Table 5.5b)	Design requirements are matched to alternative designs; characteristics of each part in final design is studied further; target values for critical parts are set.
Prototype design and testing (includes trial production)	3) Process planning	Critical parts that are sensitive to mfg. and/or environmental variations are analysed against critical parameters for consistency of the process to meet set targets.
Sales preparations		
Production design (includes first receipts of sales orders).		
Production preparations (includes process design, equipment planning, preparation of work standards, education and training; purchasing)	4) Production planning	Selected process parameters that are more difficult to control are evaluated against frequency, severity and ability to detect expected problems. Requirements (such as quality control and training needs) are examined and translated into shop floor instructions.
Production		
Customer service (includes survey of customer satisfaction, claims handling, service and prevention of recurrence of faults)		
Audit (quality review for maintenance and improvement of product quality; standardization)		

Source: Compiled from author's own research based on Imai 1997 and Noori and Radford 1995.

As the table shows, the Japanese perspective is focused much more on the use of concurrent design teams, standards and processes. The North American approach doesn't attempt to link the operations and production teams with other departments in the firm. Unlike the Japanese approach that quickly integrates sales and the customer, the North American version shows little integration with other functions such as Sales and Customer service. When the North American analysis concludes with Product planning, it seems as if management is focused more on ‘action’ and getting started as quickly as possible. But a more careful comparison with the overall approach described by Imai shows that the Japanese not only focus on meeting customer needs, but incorporating production into stable processes, getting samples into the hands of customers as early as possible, and then refining product design and the processes to meet customer and production needs. This approach not only offers the strategic advantage of early market entry, but this ‘pull-based’ methodology utilizes the income from those early sales to subsidize the internal costs of product/process refinement. The North American approach doesn’t address sales at all, which might be a reason that analysis frequently stops after the Product planning phase. Even the systematic consideration of reliability and potential failures doesn’t begin until phase four. At that point, the sample set of potential failures has been reduced twice already with the first round of elimination based on assigning criticality on performance of individual components; this is not the same as an evaluation against every possible point of failure nor evaluation of impact on performance from those components when integrated within an end-to-end system. Regardless of its many different formats and applications, “the ultimate benefit of QFD for any company is its contribution to meeting and exceeding customer needs” (Soin 1992).

5.3 Modelling the Baker’s requirements

The Product planning matrix from the Noori and Radford (1995) text was used to construct the first QFD models and then compared with the Imai descriptions. (The Product planning matrix is Table 5.5a and the Part deployment matrix is Table 5.5b). In Table 5.5a, the WHATs are the customer requirements. In this case, they are the first five quality-related items of the Baker's requirements (Table 5.3). The HOWs represent the design requirements needed for the product itself. Each specific customer requirement is tied to a specific design requirement, as seen in the points where each pair intersects. While it is to be expected that the relationship between a specific WHAT and HOW pair is 'strong' (as shown at the intersections), there are also relationships between other customer and design requirements. Most are positive correlations, but some are negative (such as the link between fertilizer and high protein – too little nitrogen fertilizer will cause protein levels to suffer). Items 5a and 5b (from Table 5.5a) would also raise issues for a producer because they cannot be incorporated into the product design without some form of interface with the customer.

Table 5.5b (i.e. Part deployment matrix) represents the perspective of actually making the product. The initial tasks for the Phase 2 approach to Part deployment described by Noori and Radford are similar to the Imai descriptions. The specific instructions are to shift the HOWs from Table 5.5a to WHATs in the next matrix. (This becomes an iterative task in the North American toolset; each set of HOWs becomes the WHATs in each successive matrix). After that, the two approaches differ: the Imai version attempts to analyse the design requirements to create the new product; the North American version already begins to consider alternative designs and parts that could be critical to production. There is a tacit assumption in the North American version that the HOWs defined in the Product planning matrix (Table 5.5a) correctly interpreted what the customer expects. This might not result in an accurate interpretation of the customer's requirements. For example, in order to construct Table 5.5b, the HOWs from Table 5.5a were moved to WHATs in the Table 5.5b matrix. This resulted in most of the Baker's

Table 5.5a
Product planning

	WHATs	HOWs	Suitable match of protein levels to bread type	Little variability between one delivery of flour and next	Matches baker's market	Non-GMO; free from pathogens	Usage (type, amount, frequency) agreed in advance	Written records from mill and farm; available for viewing
1	High protein		●	●	○	●	△	△
2	Consistency of product		●	●	△	○	○	○
3	Meets regulatory standards		○	○	●	●	●	●
4	Meets food safety standards		△	△	●	●	●	●
5a	Minimal use of pesticides, herbicides and fertilizers		●	○	●	●	●	●
5b	Documented use of pesticides, herbicides and fertilizers		△	△	○	○	○	●
	Preliminary target values:		Cat. 1, 2, 3 = 12 to 14%; cat. 4 = 10 to 12%	Same class in each delivery with same varieties (limited to 3 or 4); use of traceability, segregation and IP mgmt.	Comply with EU and US laws	No use of GMO seed; grow safe distance from GMO crops; pathogen testing as required by regulations and customer	Negotiations with customer to refine specifics	Prepare set of records for customer

Relationship between WHATs and HOWs

● **= Strong**

○ **= Medium**

△ **= Weak**

Source: Compiled from author's own research.

Table 5.5b
Part deployment

		HOWs				
	WHATs	6 Seed selection agreed or mandated by customer; includes use of certified seed and identity preservation	7 Choice of other inputs agreed or mandated by customer; includes pesticide, fertilizer, herbicide and other chemicals	8 Successful intrinsic testing at customer-mandated intervals; choice of tests mandated by customer	9 Satisfactory field scouting; specific practices agreed with customer	10 Farmer documentation of practices; specific practices agreed with customer
1	Suitable match of protein levels to bread type: -- Cat. 1, 2, 3 = 12 to 14%; cat. 4 = 10 to 12%	●	○	●	○	○
2	Little variability between one delivery of flour and next; same class in each delivery with same varieties (limited to 3 or 4); use of traceability, segregation and IP mgmt.	●	●	●	●	○
3	Regulatory standards match baker's market; comply with EU and US laws	●	●	△	△	○
4	Non-GMO; free from pathogens: No use of GMO seed; grow safe distance from GMO crops; pathogen testing as required by regulations and customer	●	●	○	●	○
5a	Use of pesticides, herbicides and fertilizers (type, amount, frequency) agreed in advance with customer	○	●	△	●	●
5b	Documented use of pesticides, herbicides and fertilizers; available for viewing from mill and farm	△	●	△	○	●

Relationship between WHATs and HOWs

● **= Strong**

○ **= Medium**

△ **= Weak**

Source: Compiled from author's own research.

optional quality requirements (i.e. items 6 through 10 in Table 5.3) becoming new HOWs in Table 5.5b. Although some of the WHATs and HOWs in Table 5.5b are directly related to one another (e.g. provision of documentation), the significance of Table 5.5b isn't about the strength of the 'intersections' that were mentioned previously. The HOWs (in Table 5.5a) specifically characterize the design requirements that a Baker expects in the final product. As can be seen by the various relationships, the 'optional quality requirements' are actually product design requirements rather than customer requirements. This issue may also be related to an anomaly in the North American wheat market. If the Porter model of product segmentation (Figure 5.10) were used to reflect U.S. wheat in open production, there should be products in all four quadrants. Instead, the products seem to be clustered in one category (Figure 5.17).

Figure 5.17
U.S. wheat product segments

	Lower Cost	*Differentiation*
Broad Target	**Open production (category 1 and 2 in US system)**	**??**
Narrow Target	**??**	**??**

Source: Compiled from author's own research.

Even if contract production were added to Figure 5.17, it is likely to represent a 'differentiated' product with a 'narrow' range of buyers; thus leaving two typical product categories unserved. Although it might be argued that the two different protein grades of 1 and 2 are both Lower Cost and could be split into Broad Target and Narrow Target, the difference is so slight that grade 1 is not likely to attract a narrower set of buyers than grade 2.

The core issue is that most Bakers' expectations are not being met. This is also consistent with the QFD diagrams. The original split of the Baker's quality requirements made it seem that a Baker that opted for contract production actually had higher quality expectations than other bakers. But that isn’t accurate when the Table 5.5a and Table 5.5b QFD diagrams are compared. The Baker that enters into contract production doesn’t actually want a different product than other bakers; rather, this is an operations management response to the problem that the market doesn’t offer a suitable product. In other words, the baker that opts for contract production has simply made a classical “make vs. buy” decision and partially stepped into a “make” arrangement. Functionally, the arrangement is no different than a manufacturer that is considering producing a particular part in-house but opts for outsourcing while gaining more experience in the production management specifics, effectively postponing the full make vs. buy decision for reconsideration at a later date.

In both views of the QFD diagrams, Baker requirement 1 is sufficient levels of protein. Table 5.5a sets a design criterion that the protein level should match the production category and supplies some target ranges for protein level. But in Table 5.5b, the same requirement is linked to practical actions to achieve the design criterion and the target values. These actions are most strongly linked with: 1) use of certified seed and preservation of varietal identity (and performance characteristics); 2) successful intrinsic testing of protein characteristics. While other inputs (i.e. HOW 7) might influence protein, their use is less significant than certified seed, identity preservation (IP) and intrinsic testing. Although field scouting (i.e. HOW 9) provides useful checkpoints, certified seed, IP and intrinsic testing nearly render field visits unnecessary. However, intrinsic testing is after-the-fact and situations might occur where, for instance, certified seed and IP are agreed and used but perhaps wind blows residue from a neighbour’s GMO crop into the wheat field. Although wheat would be less affected than other grains that are more prone to self-pollination (such as corn), the farmer should document this type of situation and how it was rectified. The point is that situations could occur in which everything doesn’t necessarily work according to previous agreements and plans.

Product consistency, the second customer requirement, is strongly influenced by nearly all of the design requirements (the HOWs) in Table 5.5b. The only area that has less influence is the farmer's documentation of practices. Ideally, that should also be strongly connected to product consistency but the practical perspective is that the four other design requirements will exert adequate control making the documentation nice to have, but not a necessity. In Table 5.5a, product consistency is strongly connected to suitable protein levels and consistent varietal types. But Table 5.5a doesn't show the importance of this particular customer requirement – regulatory compliance and meeting food safety standards appear more significant.

There are two remaining Baker quality requirements that haven't been discussed. These are: 11) More frequent shipment intervals, mapped to production levels; and 12) Less time in storage. Both of these requirements are somewhat more commercial in nature than the others. They might or might not be under the control of the farmer. It would be very difficult to find a suitable resolution without interfacing directly with the farmer, grain elevator and/or mill. So for that reason they've been omitted from the QFD diagrams but accounted for in the VSM model.

5.4 Creating measurable quality for the Baker

The next step in the North American approach to kaizen methodology would be to use the list of HOWs, shown in Table 5.5b of the Part deployment matrix, to develop multiple versions of the product that could be produced. Once a final version is agreed, then work would begin to consider the various elements needed for production and to identify critical components along with their critical values; this would complete the tasks for a North American Part deployment matrix (Noori and Radford 1995).

The Japanese approach would be different. Delegates from multiple departments would have prepared Table 5.5b: Sales department; Product planning group; R&D department; Production planning & production engineering; Production purchasing; and the Inspection, service & QA department. This consensus of perspectives makes the output design the one that will go directly into prototyping, the next stage. During the prototyping phase, tools such as Failure modes and effects analysis (FMEA) and Failure tree analysis (FTA) are used to identify any potential *muda*. Not only does quality receive the highest priority, but cost and delivery are considered, as well. FMEA is applied first to target any potential fault and its impact. (In the North American version, analysis is reserved for those parts considered most likely to be problematic or critical.) Once FMEA has rooted out as many potential points of risk, FTA would be applied, as Imai states, "to analyse and *avoid in advance* any safety and reliability problems" (Imai 1997). Although QCD are the stated goals, it is also clear that an unstated goal is to get production processes into standards as quickly as possible.

In terms of the Baker's requirements as input into the VSM diagram, they need to represent characteristics of production that are measurable. Therefore, the intersected relationships on the QFD Part deployment diagram (Table 5.5b) should be prioritised, first by characteristic (HOW) and strength; then duplications should be eliminated. Finally the list should be trimmed to best reflect the five specific Baker requirements; strongly related intersections appear as in Table 5.6.

Table 5.6
Baker's requirements depicted as characteristics of wheat production

Item	Baker requirement	Measurable value
	Strong relationships:	
A	**Characteristic A:** Seed selection agreed or mandated by customer; includes use of certified seed and identity preservation/ (IP)	Yes/No re use of certified seed; Yes/No re IP
1	Suitable match of protein levels to bread type: Cat. 1, 2, 3 = 12 to 14%; cat. 4 = 10 to 12%	Protein at 12-14% OR 10-12% (for artisan bakers)
2	Little variability between one delivery of flour and next; same class in each delivery with same varieties (limited to 3 or 4); use of traceability, segregation and IP mgmt.	Number of varieties; Yes/No re varieties are same; Yes/No re traceability documentation; Yes/No re IP

Continuation of Table 5.6

Item	Baker requirement	Measurable value
3	Regulatory standards match baker's market; comply with EU and US laws	Yes/No re traceability documentation; Yes/No re HACCP plan
4	Non-GMO; free from pathogens: No use of GMO seed; grow safe distance from GMO crops; pathogen testing as required by regulations and customer	Yes/No re certified seed; Yes/No re IP; Yes/No re documentation of field layout; Yes/No re HACCP plan; Yes/No re documentation of pathogen testing
B	**Characteristic B:** Choice of other inputs agreed or mandated by customer; includes pesticide, fertilizer, herbicide and other chemicals	
5	Little variability between one delivery of flour and next; same class in each delivery with same varieties (limited to 3 or 4); use of traceability, segregation and IP mgmt.	Yes/no re documentation of inputs (including type, amount and frequency)
6	Regulatory standards match baker's market; comply with EU and US laws	Yes/No re traceability documentation; Yes/No re HACCP plan; Yes/No re documentation of inputs
7	Non-GMO; free from pathogens: No use of GMO seed; grow safe distance from GMO crops; pathogen testing as required by regulations and customer	Yes/No re documentation of inputs; Yes/No re traceability documentation; Yes/No re HACCP plan;
8	Use of pesticides, herbicides and fertilizers (type, amount, frequency) agreed in advance with customer	Yes/No re documentation of inputs
9	Documented use of pesticides, herbicides and fertilizers; available for viewing from mill and farm	Yes/No re documentation of inputs
C	**Characteristic C:** Successful intrinsic testing at customer-mandated intervals; choice of tests mandated by customer	
10	Suitable match of protein levels to bread type: -- Cat. 1, 2, 3 = 12 to 14%; cat. 4 = 10 to 12%	Yes/No re protein tests; Test types used
11	Little variability between one delivery of flour and next; same class in each delivery with same varieties (limited to 3 or 4); use of traceability, segregation and IP mgmt.	Yes/No re intrinsic testing; test categories, test types used and target values
D	**Characteristic D:** Satisfactory field scouting; specific practices agreed with customer	
12	Little variability between one delivery of flour and next; same class in each delivery with same varieties (limited to 3 or 4); use of traceability, segregation and IP mgmt.	Yes/No re documentation of field checks
13	Non-GMO; free from pathogens: No use of GMO seed; grow safe distance from GMO crops; pathogen testing as required by regulations and customer	Yes/No re documentation of field checks; Yes/No re documentation of field layout
14	Use of pesticides, herbicides and fertilizers (type, amount, frequency) agreed in advance with customer	Yes/No re documentation of field checks; Yes/No re documentation of inputs
E	**Characteristic E:** Farmer documentation of practices; specific practices agreed with customer	
15	Use of pesticides, herbicides and fertilizers (type, amount, frequency) agreed in advance with customer	Yes/No re documentation of inputs; Yes/No re documentation in Quality Manual
16	Documented use of pesticides, herbicides and fertilizers; available for viewing from mill and farm	Yes/No re documentation of inputs; Yes/No re documentation in Quality Manual

Source: Compiled from author's own research.

The Measurable values of the ‘strong’ relationships can be consolidated into the following set:

1. Yes/No re use of certified seed
2. Yes/No re IP
3. Protein at 12-14% OR 10-12% (for artisan bakers)
4. Number of varieties; Yes/No re varieties are same
5. Yes/No re traceability documentation
6. Yes/No re HACCP plan
7. Yes/No re documentation of field layout
8. Yes/No re documentation of pathogen testing
9. Yes/no re documentation of inputs (including type, amount and frequency)
10. 10.1) Yes/No re protein tests; 10.2) Test types used
11. 11.1) Yes/No re intrinsic testing; 11.2) test categories, test types used and target values
12. Yes/No re documentation of field checks
13. Yes/No re documentation in Quality Manual.

The ‘medium’ and ‘weak’ relationships can be compared to the set of Measurable values to identify any characteristics that might have been overlooked. Three possibilities emerge:

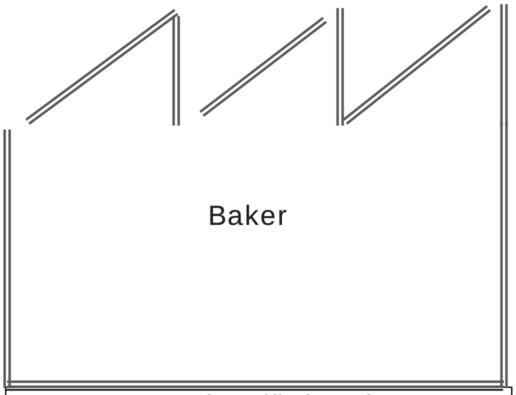
- At intersection 4-8 a possible need for GMO presence should be added to intrinsic testing;
- Intersection 5a/5b-8 raises the issue of whether intrinsic testing could be performed to measure the use of pesticides, herbicides and fertilizers. In theory it seems a good idea, but in reality it would be nearly impossible—and certainly economically undesirable. However, an effective HACCP plan is intended to prevent the most serious hazards; field checks and insistence on documentation of management practices in a Quality Manual might avoid some of the more serious problems.
- Intersection 1-10 goes back to the relationship between protein levels and farm management practices. Some of the issues are covered in points 1 through 12, but the Quality Manual described in point 13 should actually reflect documentation of all farm management practices.

The only change to the set of measurable values would be to revise number 13 as follows:

13. Yes/No re documentation of all farm management practices in a Quality Manual.

This would complete the set of Baker requirements to be added to the VSM diagram. They wouldn’t be shown on the VSM overview, but would appear as a separate sub-diagram, as seen in Figure 5.18.

Figure 5.18
Baker's wheat requirements with measurable values



1. Yes re use of certified seed
2. Yes re IP
3. Protein matched to baker's requirements: 12-14% OR 10-12% (for artisan bakers)
4. Number of varieties; Consistent varieties; varieties matched to Baker's requirements
5. Yes re traceability documentation
6. Yes re HACCP plan
7. Yes re documentation of field layout
8. Yes re documentation of pathogen testing
9. Yes re documentation of inputs (including type, amount and frequency)
10. 10.1) Yes re protein tests; 10.2) List of test types & test standard used
11. 11.1) Yes re intrinsic testing; 11.2) List of test categories, test types used, test standard and target values
12. Yes re documentation of field checks
13. Yes re documentation in Quality Manual.

Source: Compiled from author's own research.

This section developed some quantifiable characteristics for wheat quality characteristics using the VS/kaizen tools. However, as the discussion showed, the choice of tools and how they're applied can cause a difference in outcomes. Since production processes won't be developed for the Baker, or needed for the generic model, the QFD Product planning matrices will be left as they are. But for the balance of the model development, only the Japanese approach will be used to develop the QFD matrices (as shown in Figure 5.15).

5.5 Translating the Miller's requirements into wheat production processes

This section discusses the modifications and additions that the Miller makes to the Baker's list of requirements, before passing those needs on to the wheat grower. The same format used for the End customer, Retailer and Baker represents the Miller's needs (Table 5.7).

Table 5.7
Miller's requirements

Item N$^{o.}$	**Miller QUALITY requirement characteristics**	**Specifics**	**Product category**
1	Each delivery of wheat matched to protein levels needed plus an overhead up to 0.7% to cover (higher) protein in bran layers of endosperm lost during milling	Levels of protein content on an 'as is' basis: -- Soft French wheat of ~9.5% + 0.7% -- Soft wheat of 9-10% +0.7% -- Medium hard wheat of 10-11.0% +0.7% -- Hard wheat of 11.5-12% +0.7% -- Hard wheat of 12.5% and above +0.7%	**4a** **1** **2a, 3a** **3b** **4b**
2	Consistency of product	No variability within a single delivery of wheat; no pre-blending of wheat; commingling only with miller's knowledge and agreement	**All**
3	Meets regulatory standards	In EU, in US and elsewhere depending on miller's market	**All**
4	Meets existing food safety standards	No pathogens or mycotoxins; non-GMO	**All**
5	Minimal use and documented use of pesticides, fertilizers, herbicides	Written records from farm available for viewing	**All**
6	No objectionable odours, taints or other visible signs of contaminants	No unusual odours, dampness or musty, mouldy wheat; no contamination from delivery vehicle (e.g. from previous load or fuel used)	**All**
7	No foreign matter in the wheat	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	**All**
8	Healthy wheat	No diseased or shrivelled grain; no heat-damaged or sprouted grain	**All**
9	Good extraction rate	High test weight: -- 70 kg/hl for soft (and biscuit) wheat; -- 80 kg/hl for bread wheat	**All**
10	Wheat that won't result in specks in flour	Suitable test weight and ash content	**All**
11	Good level of gluten	Passes test with suitable result	**All**
12	No excess of *alpha*-amylase	Hagberg FN test of $\geq$ 250 seconds	**All**
13	Suitable moisture content	Shouldn't exceed 15%	**All**
14	Overall suitability of particular wheats to baked product	Successful flour rheology tests (i.e. Farinograph, Extensograph, Alveograph)	**All**
15	Suitable level of grain hardness	Test results matched to flour strength	**All**
16	Successful intrinsic testing prior to transport to miller	Choice of tests mandated by miller with documented results	**All**
17	Satisfactory field scouting	Written reports of field checks mandated by miller	**All**
18	Farmer documentation of practices	Specific practices agreed with miller	**All**

Continuation of Table 5.7

Item N$^{o.}$	**Miller QUALITY requirement characteristics**	**Specifics**	**Product category**
19	More frequent shipment intervals	Mapped to production levels	**All**
20	Less time in storage	Quality improvement; cost savings	**All**
Optional quality requirements associated with customer-defined grists and blends:			
21	Wheat varieties mandated by customer	Includes use of certified seed and identity preservation	**3, 4; possibly all?**
22	Choice of other inputs agreed or mandated by customer	Includes pesticide, fertilizer, herbicide and other chemicals	**All**
Item N$^{o.}$	**Miller COST requirement characteristics**	**Specifics**	**Product category**
23	Suitable price	Price related to wheat quality characteristics	**All**
Item N$^{o.}$	**Miller DELIVERY requirement characteristics**	**Specifics**	**Product category**
24	Agreed conditions are met	Timing, quantity, health & safety practices are followed + suitable price	**All**

General remark regarding protein content: Traditionally protein values were quoted on a basis of 14% moisture content. However, it has become common practice to quote protein content on a ‘dry matter’ basis that results in a higher protein value. However, bakers use flours as received and therefore, measuring the protein value to include the influence of moisture content better reflects what the baker would expect (Cauvain 2007).

Baker production categories (segmented by bread product category): 1 = Discount priced ‘soft’ white, industrial production; 2 = Branded ‘soft’ white, industrial production; 3 = either Branded ‘high quality’ white or Commercially produced artisan-appearing, either industrial and semi-industrial production; 4 = either Volume artisan, industrial production or Artisan bread and artisan production.

Miller production categories (matching flour product protein category to bread product segments): 1 = Discount priced ‘soft’ white, industrial production (9-10% protein); 2 = Branded ‘soft’ white, industrial production (2a = 10.0-11.0% for ‘no-time’ breads, such as CBP); 3 = either Branded ‘high quality’ white or Commercially produced artisan-appearing, either industrial and semi-industrial production (3a = 10.0-11.0% for ‘no-time’ breads, such as CBP; 3b = 11.5-12% = general purpose baking); 4 = either Volume artisan, industrial production or Artisan bread and artisan production (4a = plus/minus 9.5% using French wheats for artisan baguette; 4b = 12.5% and above for competition and specialty breads) (Items 3 and 4 from Catterall 1998).

Source: Compiled from author’s own research.

If the Miller’s requirements were separated into Kano’s two dimensions of quality, the split would be as follows:

“Must be” qualities:	Unclassified qualities:	“Attractive” qualities:
Items 1, 3, 4, 6, 9-15, 23-24	Items 2, 5, 7 and 8	Items 16-22

The unclassified qualities begin to raise some points. From the Miller’s perspective, items 2, 7 and 8 are “Must be” qualities. Item 5 is also “Must be”, but it is possible to imagine some business agreement in which the grower takes full (and legal) responsibility for all pesticides, fertilizers and herbicides used, and the Miller accepts that as a compromised solution for the

"Must be" characteristics of item 5. The first three items are more controversial and, therefore, more dependent on practices of the particular (national) wheat growing system.

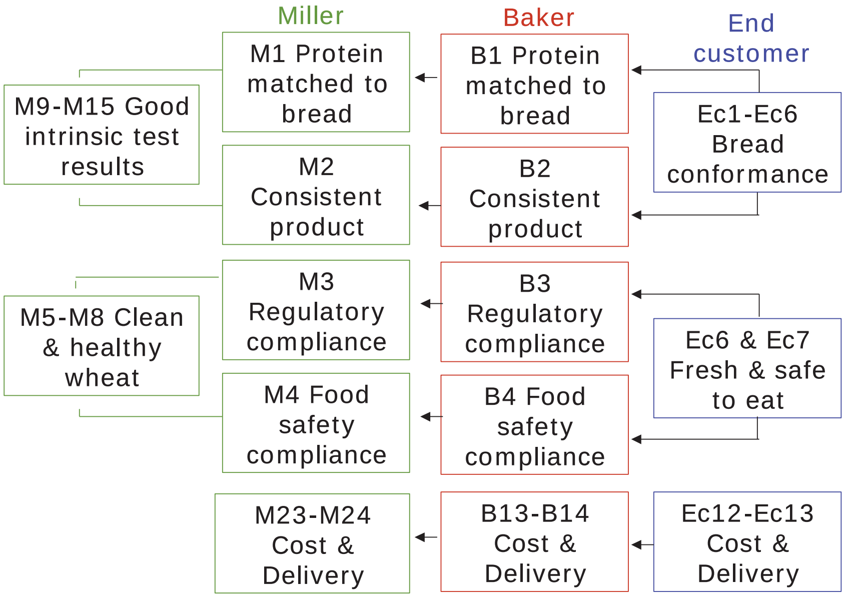
Item 2, Consistency of product, should seem a reasonable request for a "Must be" quality from the buyer of any product, but in order to fulfil that the wheat needs to be the same varieties each time, commingling and pre-blending (without the miller's knowledge) shouldn't occur. In the U.S. system, this isn't possible in open production. Items 7 and 8 are also controversial in the U.S. system discussed in Chapter three concerning dockage. The growers believe that they have made their best effort to prevent excessive foreign matter or excessive numbers of diseased, shrivelled or damaged kernels in the wheat. As Chapter three described, many international buyers do not agree. In addition, all of the Miller's "Must be" quality items numbered 9 through 15 can only be validated through intrinsic quality testing. The U.S. position is that if a buyer needs such tests they should pay extra for them, or perform the tests themselves. So the U.S. behaviour regarding intrinsic testing is very similar to that concerning dockage and damaged kernels. The French position on the other hand, has been to increasingly rely on intrinsic testing as a standard part of the wheat grading system. As described in Chapter three, this strategy has actually caused the French growers to produce wheat of overall higher quality year upon year. All of these points will be addressed further in Chapters six and seven and in the conclusions.

The increasingly sophisticated changes to the French wheat grading system from 2000 onwards eliminated any further reporting of physical characteristics (such as dockage and damaged kernels). At the end of the day, the wheat must be clean before it can be milled. Both dockage and damaged kernels need to be removed first. If the farmers and/or the grain elevators don't perform this work, then the miller must. This would cause items 7 and 8 to actually be "Must be" qualities. The seller that hasn't thoroughly cleaned the wheat or hasn't adequately measured the cleanliness of what will be delivered is risking the loss of a customer.

5.5.1 Consolidating the needs from End customer to Miller

When the Miller's list of needs is transferred to the Wheat grower, that transfer marks the hand off of the End customer's needs, as well. If the Miller's "Must be" list of qualities is compared to that of the Baker, the Retailer and the End customer, it is possible to see how the original needs of the End customer get translated upstream to the Wheat grower (Figure 5.19).

Figure 5.19
Transferring End customer requirements in the VS



Source: Compiled from author's own research.

The End customer's list of 13 requirements can first be separated into "Must be" and "Attractive" qualities, then the nine "Must be" qualities can be further consolidated into three categories: Product conformance; product reliability (food safety); and, commercial characteristics of price and availability. The Baker can expand the three groups of End customer's "Must be" qualities into five groups of "Must be" qualities (Figure 5.19). There are industry standards for product conformance (Table 3.1) that can be used as benchmarks for whether the End customer's needs for product conformance are met. Compliance with regulatory standards and with food safety guidelines and laws are a direct match. Meeting the End customer's expectations regarding price and availability of product are also a near match, but these are more strongly influenced by commercial practices while the other areas are influenced more by bakery industry practices.

At first glance it would seem that there is a direct correlation between Baker and Miller requirements. But in fact, the Miller cannot meet the Baker's needs for specific protein content, flour consistency and other baking characteristics without wheat that passes intrinsic testing successfully. Likewise, the Miller cannot fulfil the Baker's expectations for flour that complies with regulatory standards and food safety guidelines if the wheat the Miller receives isn't clean and healthy. Therefore, putting aside U.S. issues about who should perform these tests and who should pay for them, the tests are necessary in order to meet the End customer's requirements.

5.6 Modelling the wheat farm

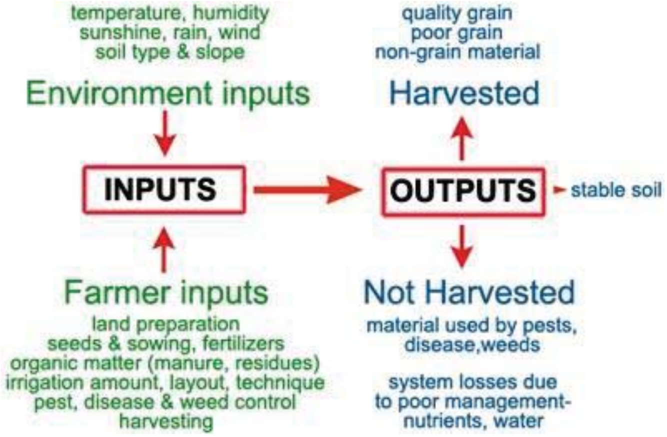
This section aims at defining the activity areas and processes that comprise the production and information flows on the wheat farm. Following that, benchmarks are considered as potentially measurable values for process performance.

5.6.1 Modelling wheat production processes

5.6.1.2 Wheat production as a system

All combinable crops share certain similarities at a systems level. Figure 5.20 is an overview of a system for a combinable crop, such as wheat (Rawson and Gómez Macpherson 2000). Activities (such as Inbound and Outbound logistics and Point of sale) that are customary in a VC model were not included in the combinable crop system view, and are, therefore, added to the VC view.

Figure 5.20
Combinable crop system



Source: Rawson and Gómez Macpherson (FAO 2000).

The combinable crop system view (Figure 5.20) could be reconfigured as a VC, incorporating all of the data from Environmental inputs and Farmer inputs (green text in Figure 5.20) either as Raw materials or Transformation tasks (Figure 5.21).

Figure 5.21
Value chain view of combinable crop system

Raw <u>materials:</u>	***<u>Inbound Logistics</u>:***	***<u>Transformation</u>:***	***<u>Outbound Logistics:</u>***	**Point of <u>Sale:</u>**
Environmental inputs; seeds, nutrients, irrigation	**Suppliers and farmer**	**Land preparation, sowing, mgmt. of nutrients, residue, pests, disease and weed control; harvesting**	***Transport company and farmer***	***Grain elevator***

Source: Compiled from author's own research.

The VC view doesn't make use of the Output data contained in the system view. Neither the production quality characteristics (such as quality grain or poor grain) nor production faults of the farmer (listed in both Harvested and Not harvested categories) are addressed. The overall impact on "asset preservation" (i.e. stable soil) is left out, as well. In effect, the VC approach creates the tacit assumption that 'grain' is the only output from the transformation process and value will be determined by the sales activity.

However, when the wheat production system is reconfigured based on the VS approach, the model more accurately depicts the system described by Rawson and Gómez Macpherson than the VC approach did; this is seen in Figure 5.22. The Output (in Figure 5.20) can then be split into value-adding output and *muda*:

Value adding

Quality grain
Stable soil (sustainable farm)

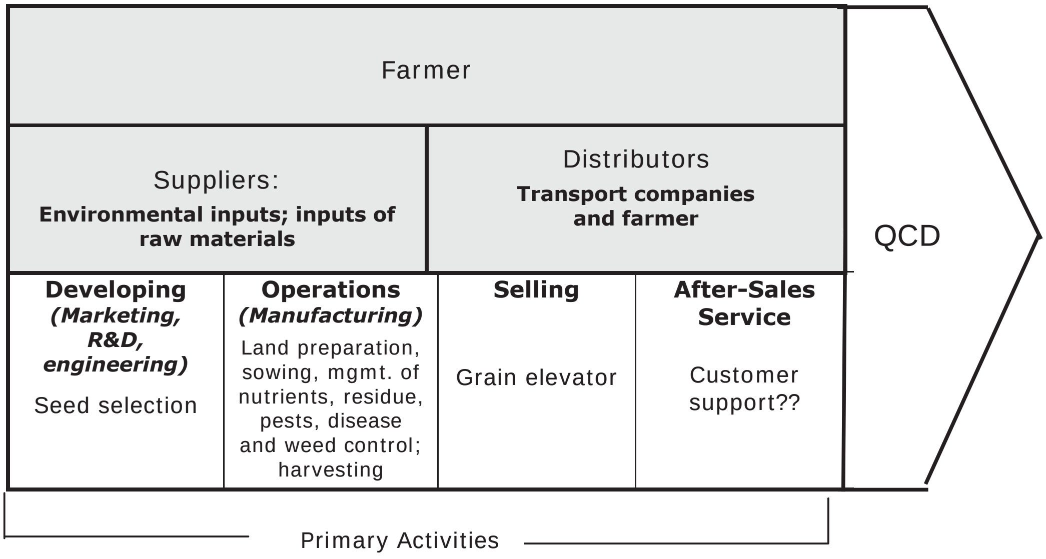
(no further identified)

Muda

Harvested:
Poor quality grain
Non-grain material (dockage)

Not harvested losses:
Plants consumed by pests, disease, and weeds
Losses due to poor management practices.

Figure 5.22
The kaizen value stream adapted for a wheat farm



Source: Compiled from author's own research.

When Output is considered in terms of the goals of Quality, Cost and Delivery (QCD) the following comments can be made:

- Only quality grain can easily be sold; poor quality grain and grain that is not properly cleaned are production defects (*muda*).

- Proper management practices not only lead to higher quality output that enhances the longevity of the farm as a competitive business (through its better reputation), but contribute to a more sustainable operation in terms of the farm land itself.
- Costs associated with *muda* can be split between those losses that occurred after all production expenses had been incurred vs. those that were identified prior to harvesting and sustained at that point rather than after harvesting activities.
- In addition, the 'disconnect' between the farm and its customer(s) is evident in the space allotted for After-Sales Service; there is no 'typical' party identified to carry out this activity. Like *muda*, this will eventually have a negative impact on the farm's business; it is impossible to meet the customer's expectations with no active relationship to the customer. The French wheat farmers fill this through their work with INRA and the associations of millers and bakers (described in Chapters one and three); in the U.S. the extension services try to represent the interests of the growers, but it is not the same as dedicated post-sales service.

Although the information shown in Figure 5.22 is only a simple view of the value stream, it gives an indication of the difference in perspective between VC and VS and the increased information that the VS approach offers for further investigation.

5.6.2 Defining wheat farm activity areas

5.6.2.1 Defining the wheat farm activity areas

The first step to developing either an information flow or production flow is to identify the activity areas to be modelled. A literature search showed that international wheat production practices are categorized as 'dryland wheat production' or 'irrigated wheat production' (Anderson and Impiglia 2002; Rawson and Gómez Macpherson 2000). In terms of specific management practices, there is very little difference. In fact, even the decision to irrigate (which is not always associated with a farm-wide fixed asset), only means ‘added water’ rather than just relying on the moisture available from rain, snow and residual moisture in the soil. Although a farmer might be considered an ‘irrigated wheat grower’, it is a business decision as to if and how the crop is actually irrigated. Likewise, a ‘dryland wheat grower’ might take the business decision to add water to crops in a particularly dry year. In terms of a VSM model, the differences between the two methodologies wouldn’t appear in the upper layer diagram (Figure 5.23) but in views that show details of processes. Therefore, the main generic processes were grouped as activity areas for wheat production:

- Preplanting activities
- Seed selection
- Seeding
- Growing
- Harvesting
- On-farm handling and storage
- Delivery.

In addition, two optional activities are:

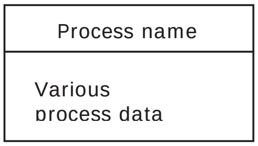
- Livestock grazing
- Summer tillage.

Although the optional activities appear to be isolated from the main production practices of the wheat farm, that really isn’t the case. For example, if a farm chooses to pursue livestock grazing of the wheat crop, considerations such as seed type (one that produces better fodder versus higher quality grain) and nutrient management must also be included (e.g. nitrogen from cattle manure impacts grain protein, the water table and the soil itself).

5.6.2.2 Diagrams of wheat farm activity areas

The VSM diagrams of wheat farm activity areas also ‘zoom in’ to show some detail about the processes. The VSM symbol for a process box shows the name of the process in the upper space and some quantifiable characteristic(s) of the process inside the lower-left portion of the process box (Figure 5.23).

Figure 5.23
Diagram of a VSM process box



Source: Compiled from author’s own research.

All of the activity areas (Section 5.6.2.1) appear as process boxes in each of the VSM diagrams. They are shown as simple rectangles for ease of drawing since no metric was included in the generic models (Figures 5.24 through 5.34). Please note: In March 2009, the Hungarian National Wheat Research Institute[39] validated the various views of wheat production activities seen in Figures 5.24 through 5.33.

In VSM models the symbol for a separate business entity is a rectangle with a jagged upper-edge; this symbol was chosen to differentiate each set of activities from the rectangle symbols that denote processes (Figure 5.24). Also, there is no requirement that the main farming activities must be performed, or owned, by a single legal entity. In fact, in the U.S. farming operations, even the wheat growing activities might be performed by a different legal entity than the farm (e.g. tenant farmer, sharecropper). Different colours are used to indicate each type of generic manufacturing activity represented (Figure 5.24).

---

[39] Dr. Lajos Bona, Chief of Research, wrote a consolidated response on behalf of some 12 to 15 experts at the Institute to confirm that the set of diagrams and activities are accurate.

The upper part of the VSM diagrams (Figures 5.24 through 5.33) shows the information flow. It might be that a farm is using a centralized management system (such as MRP) to schedule activities. But in all likelihood the farmer determines the schedule of activities, either based on procedures defined in a formal quality management system (QMS) or in an ad hoc manner. In any of these cases, the schedule is managed centrally and the frequency of initiating each flow of information is directly related to the crop. Wheat can be either winter wheat or spring wheat, but either crop still carries an annual information flow as the seasons occur only once per annum.

The two optional activities (lower right of Figure 5.24) are also conceptually similar to other categories of manufacturing. If a manufacturing facility has excess capacity – either excess floor space or unused production line(s) – a standard practice is to look for other activities that can be performed to offset the on-going loss from non-utilization of a fixed asset. 'Livestock grazing' is not a completely unrelated activity. Kansas farmers (located in the central Great Plains region) let the cattle graze on the wheat for additional income (KSU 1997). In the southern Great Plains, Oklahoma producers operate dual-purpose facilities and balance the trade-off between increased yield of forage that reduces yield of quality wheat but increases the weight of beef (OSU 1995). In both cases, a manufacturing decision was made to divert a semi-finished good to a different end product. In Kansas, the decision was made after the production process began while in Oklahoma the decision was part of the product design; varieties of wheat with high yields of forage (and lower wheat quality) were preferred. This also has implications related to protein quality characteristics. The decision to divert the semi-finished good to a different end product does show that profitability influences process management more strongly than customer satisfaction does in these instances from the U.S. In fact, in the U.S. open production system, there really isn't a 'customer'; there are only general targets related to quality characteristics.

5.6.3 Mapping wheat production processes

Each activity area in a VSM diagram can be further defined by the processes it contains. Section 5.6.3.1 defines the wheat production processes to be used in the activity areas. Section 5.6.3.2 describes how processes are represented in VSM diagrams.

5.6.3.1 Defining wheat production processes

In literature search there was no single source of wheat production practices found that included the processes related to all activities. As a result, it was necessary to rely on multiple sources (literature review and interviews) in order to create a consolidated view of the processes (Rawson and Gómez Macpherson 2000; KSU 1997; Anderson and Impiglia 2002; NDSU 1997; OSU 1995; Maier 2002; Herrman 2002; Weirsma 2004).[40]

The list of processes were identified as:

- Preplanting activities
  - Land selection
  - Determine target yield
  - Prepare seedbed
  - Pre-fertilizer soil tests
  - Control weeds and volunteer wheat
- Seed selection
  - Identify production requirements
  - Define external requirements

---

[40] The list of wheat production processes was validated by S. Cauvain and L. Bona.

  - Review potential varieties
  - Determine varieties
  - Order and receive seeds

  And/or:

  - Clean and treat seeds
- Seeding
  - Select seed date
  - Determine seed rate
  - Determine sowing depth and spacing
  - Plant seeds
- Growing
  - Production flow processes: Germination (Emergence), Tillering, Stem elongation, Booting, Inflorescence emergence (Heading and flowering), Anthesis (Flowering), Grain milk development, Grain dough development, Ripening
  - Management processes: Weed management, Nutrient management, Disease management, Pest management, Residue management
- Harvesting
  - Prepare combine
  - Harvesting operation processes: Cutting and feeding, Threshing, Separating, Cleaning, Handling
- Storage
  - Receiving
  - Grain placement
  - Grain storage
  - Grain reclaim

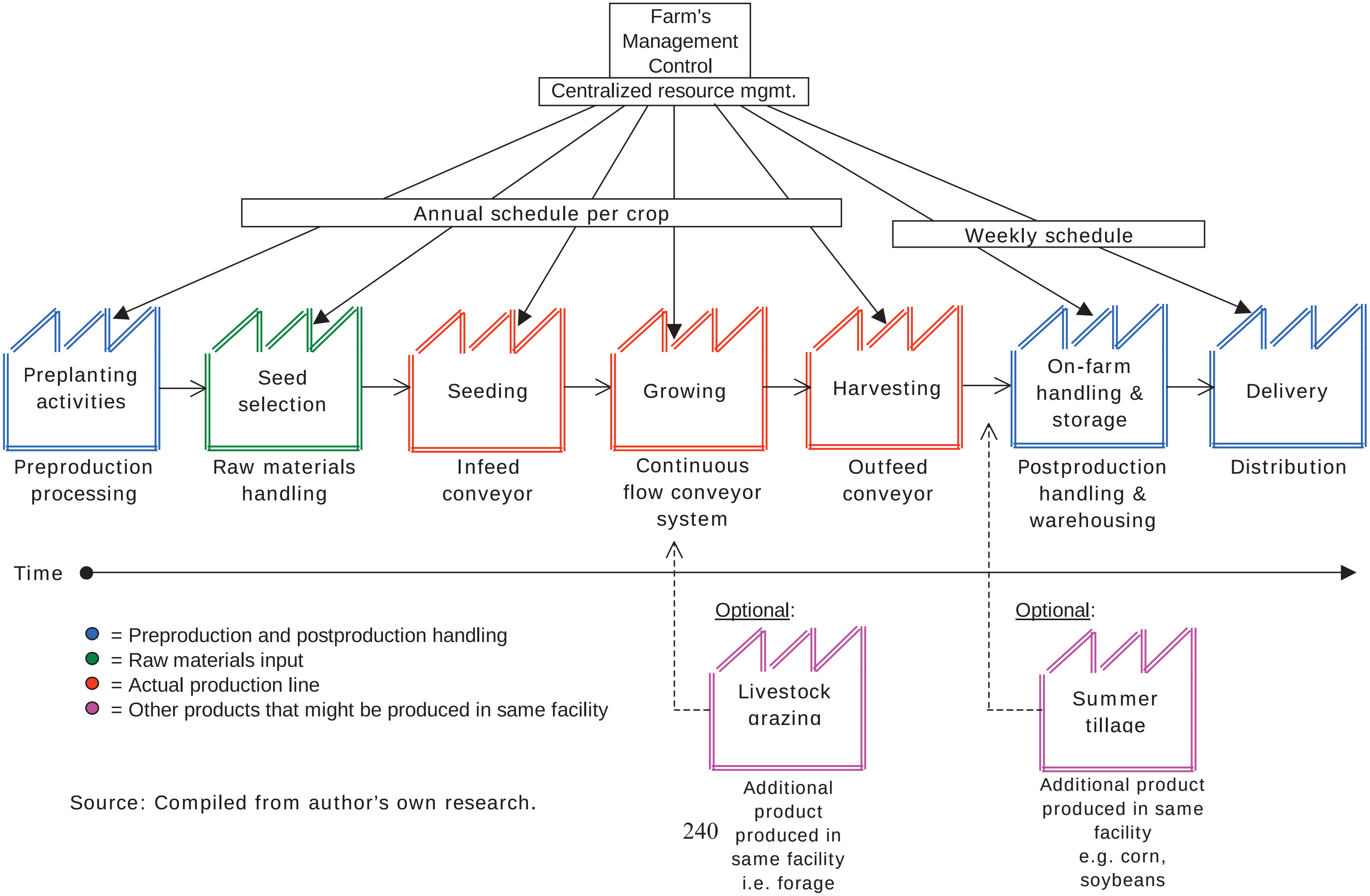
- Delivery
  - Clean trailer, truck bed or wagon
  - Weigh and load goods
  - Transport
  - Unload and check goods
  - Clean trailer, truck bed or wagon

5.6.3.2 Diagramming wheat production processes

For sake of simplicity, VSM usually uses a single process box to indicate multiple processes within one area of material flow that has not been disconnected – in effect, a continuous flow (Rother and Shook 2003). While agriculture can be categorized as a form of continuous flow manufacturing, the only wheat production activity area that strictly meets this definition is the Growing activities (Figure 5.29). The processes are related to ‘uninterrupted material flow’ and based on the growth cycle of the wheat plants that develop (in a continuous flow linear production-style) based on a type of *kanban* information system. Each new process is initiated under the control of the plant’s growing point. The “Management processes” related to Growing activity (Figure 5.30) are controlled by the farmer and need not flow continuously.

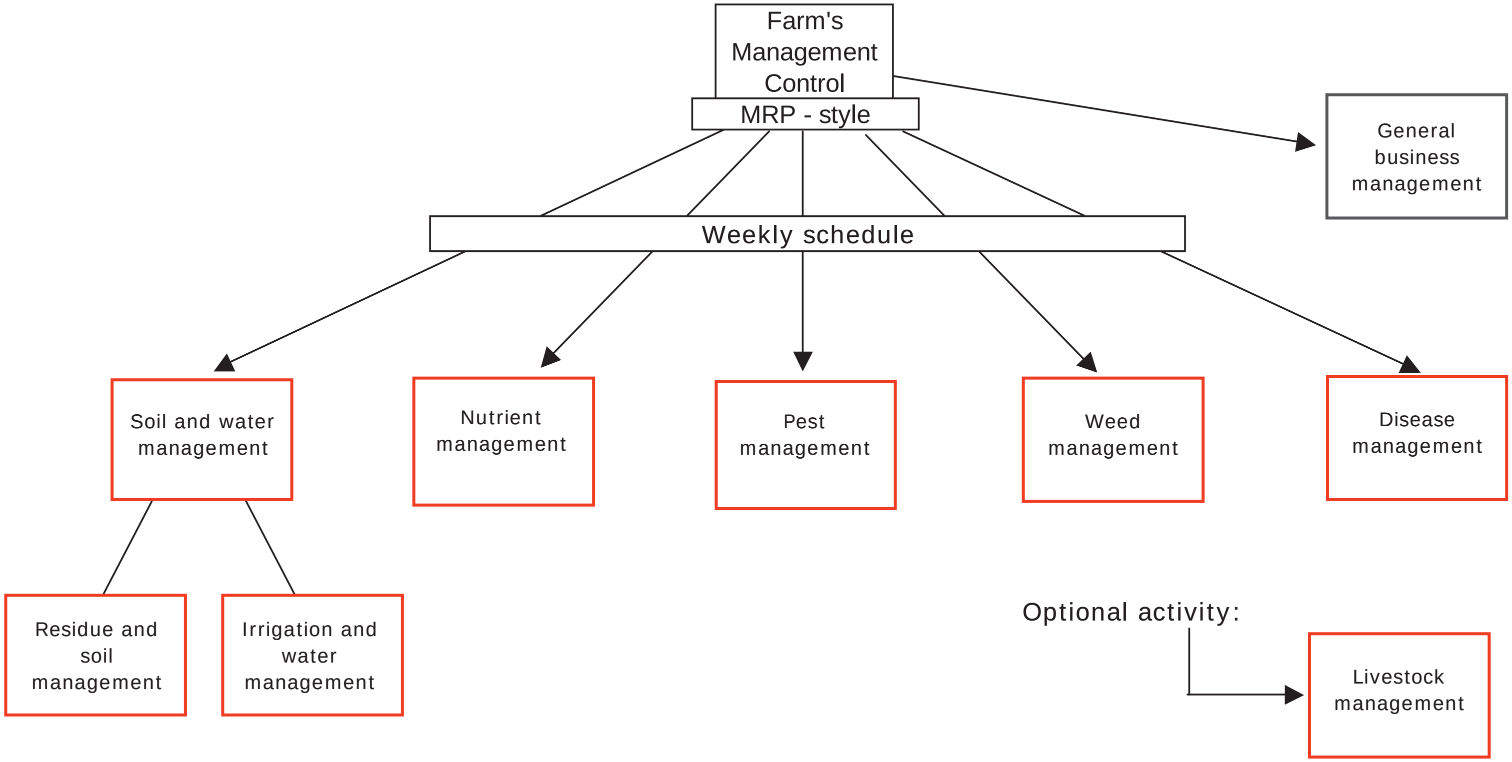
A second area of uninterrupted material flow is in the Harvesting activity. The actual Harvesting operation contains five different processes that (usually) flow continuously from one to another. In sophisticated combines, each of the processes is automated and contained within the one main combine vehicle. However, other kinds of combines might be used, so the individual processes were identified (Figure 5.31).

Figure 5.24
VSM diagram showing overview of wheat production



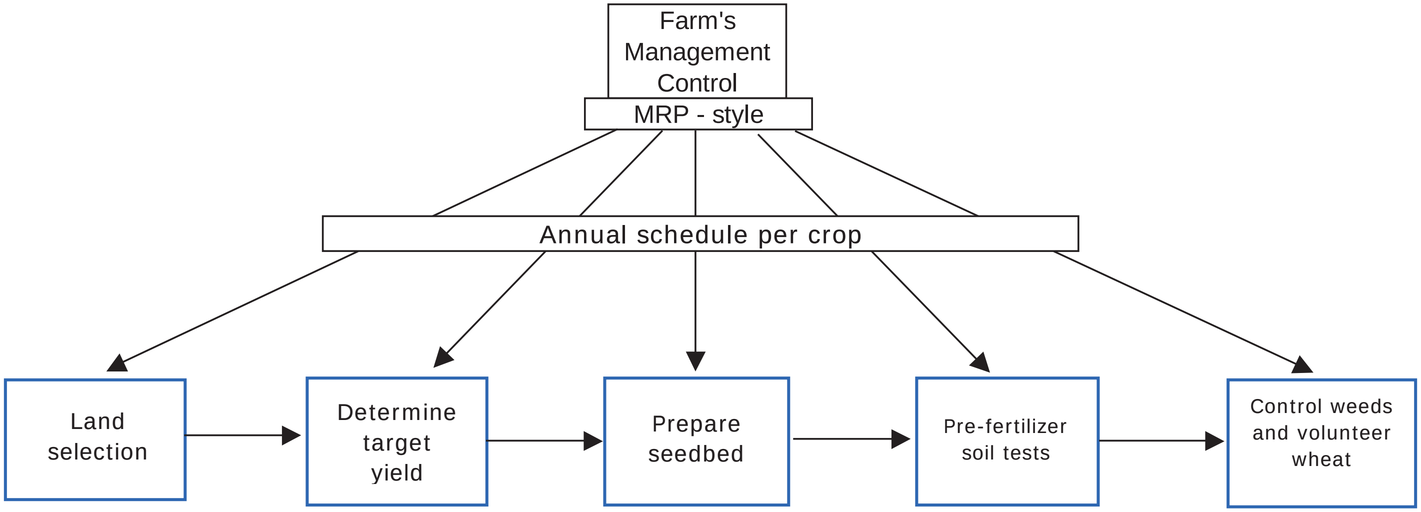
Source: Compiled from author's own research.

Figure 5.25
Overview of the management domains in wheat production



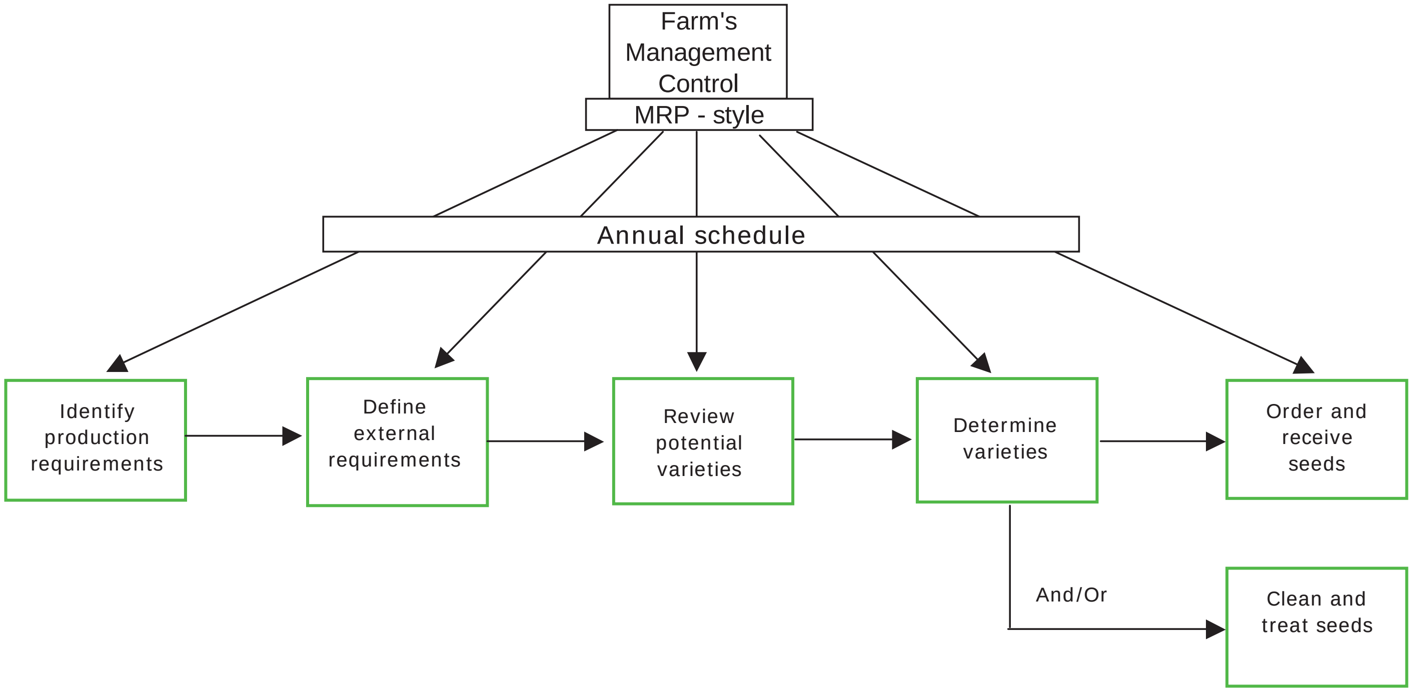
Source: Compiled from author's own research.

Figure 5.26
Preplanting activities



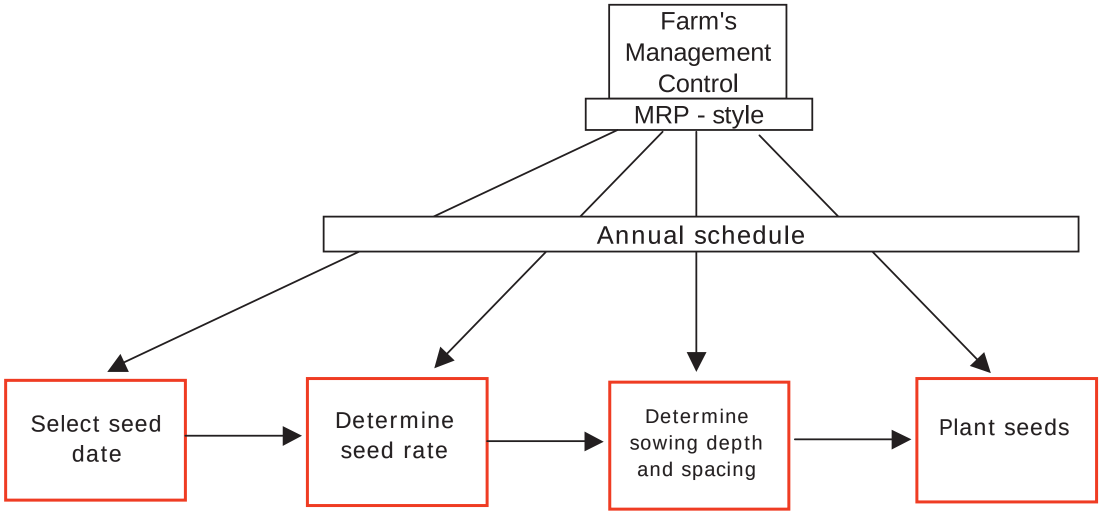
Source: Compiled from author’s own research.

Figure 5.27
Seed selection activities



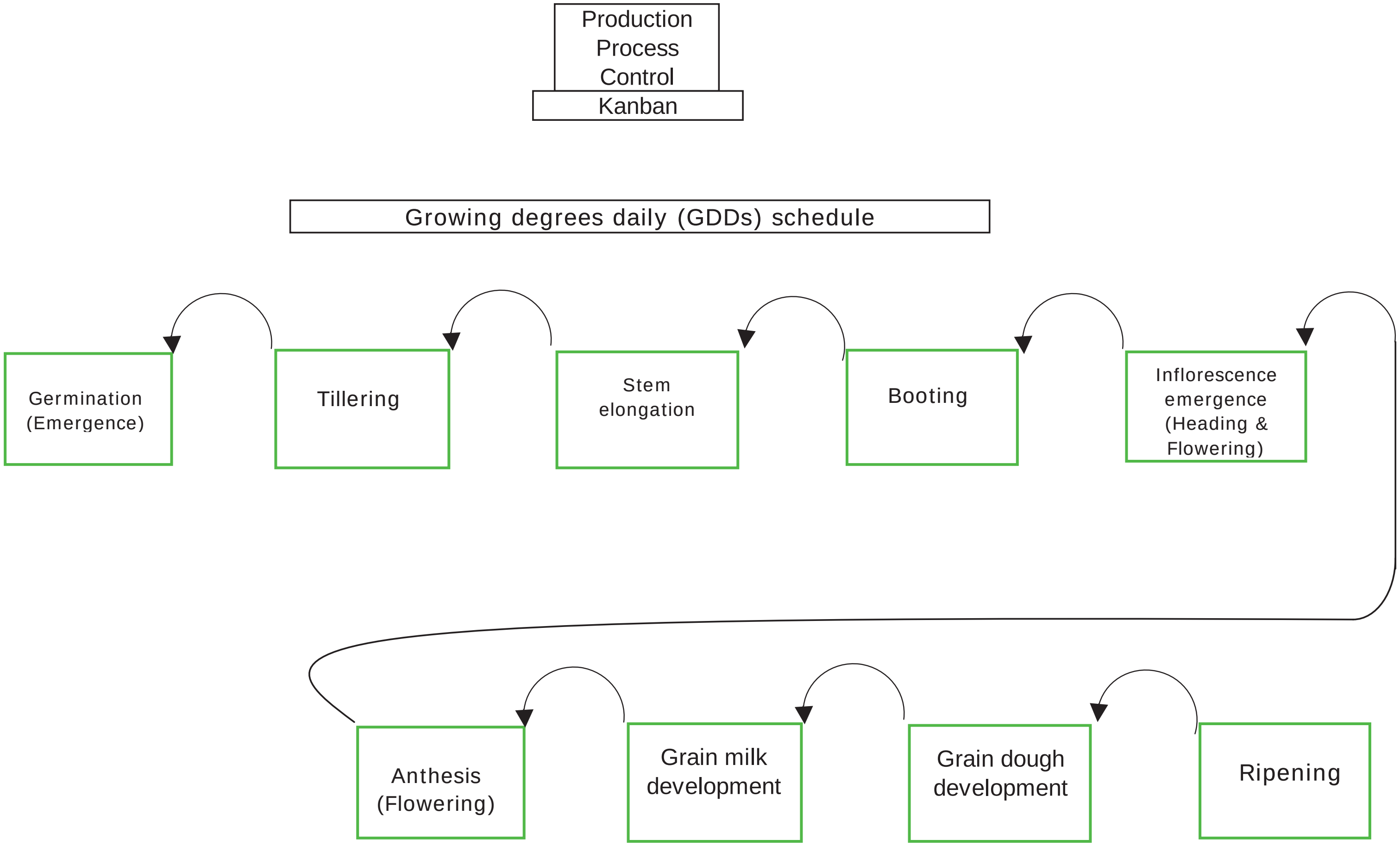
Source: Compiled from author's own research.

Figure 5.28
Seeding activities



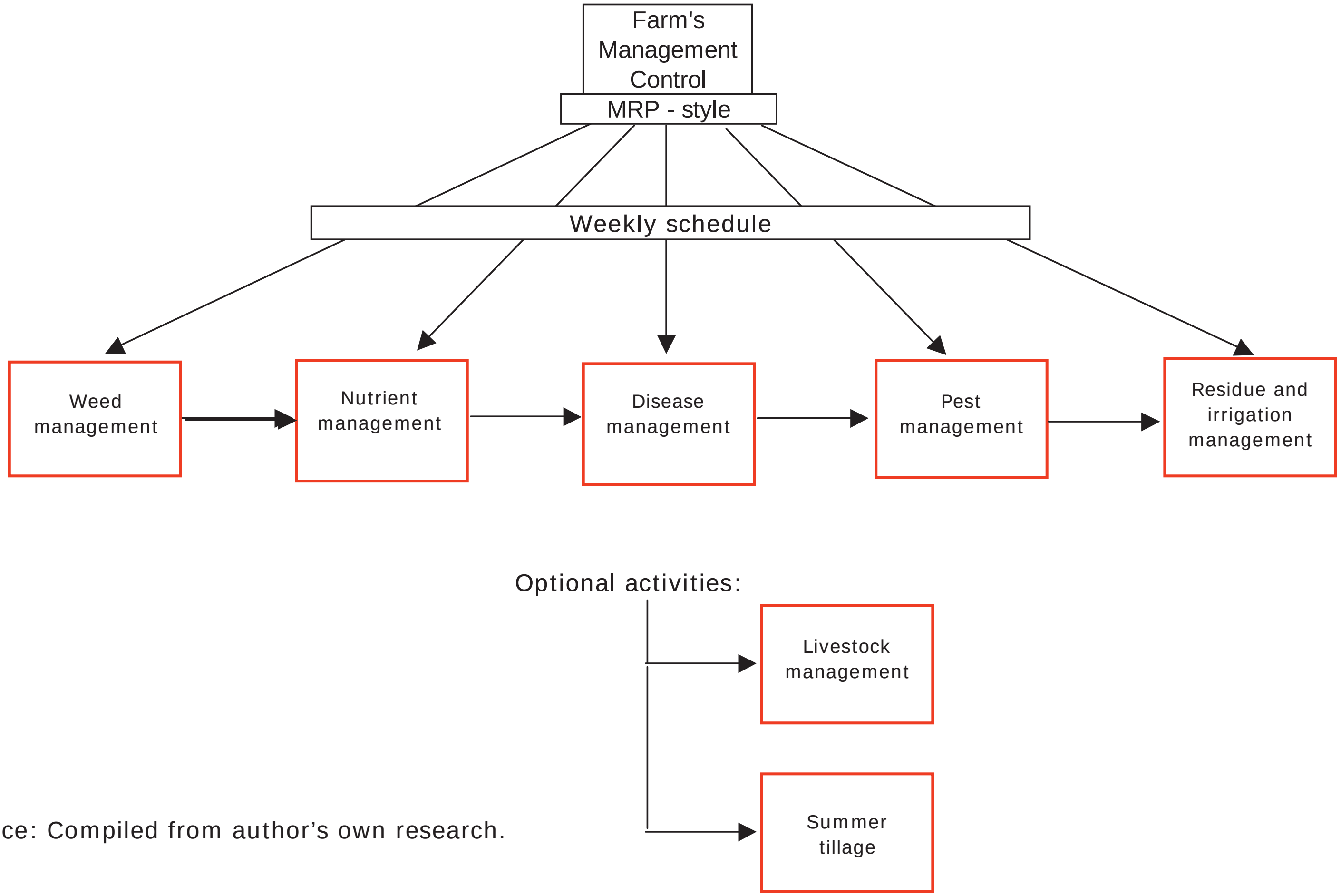
Source: Compiled from author's own research.

Figure 5.29
Growing activities: Wheat plant processes view



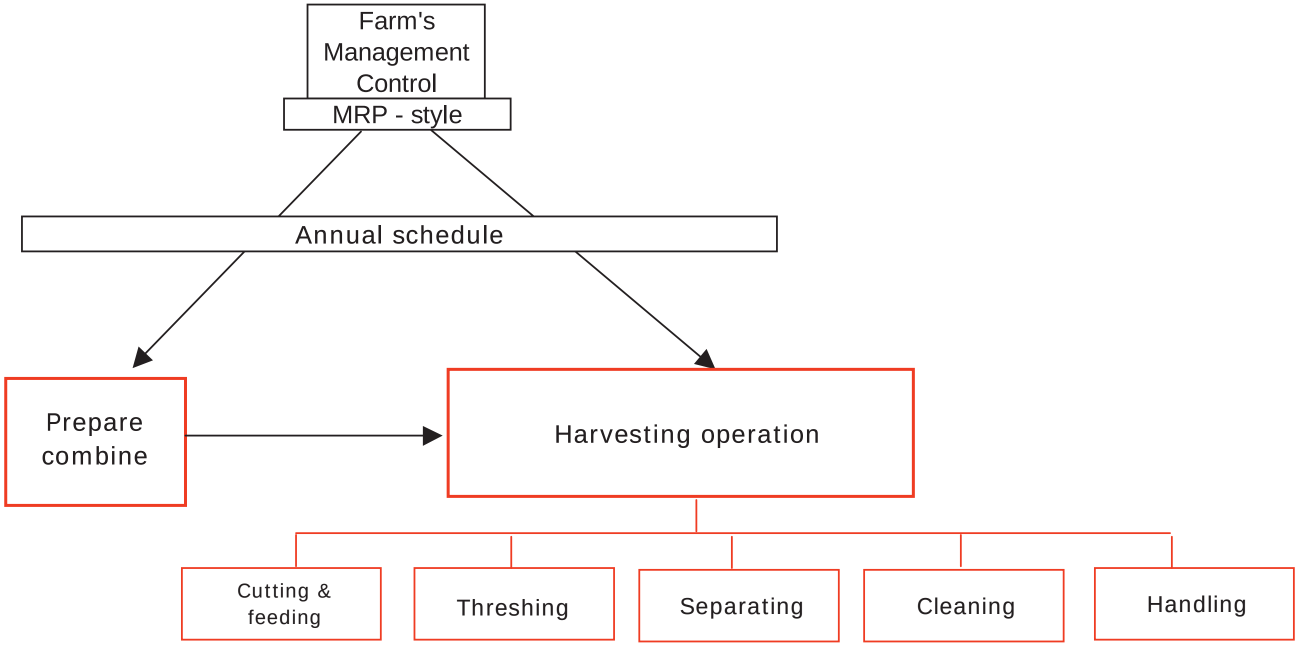
Source: Compiled from author's own research.

Figure 5.30
Growing activities: Wheat grower's management view



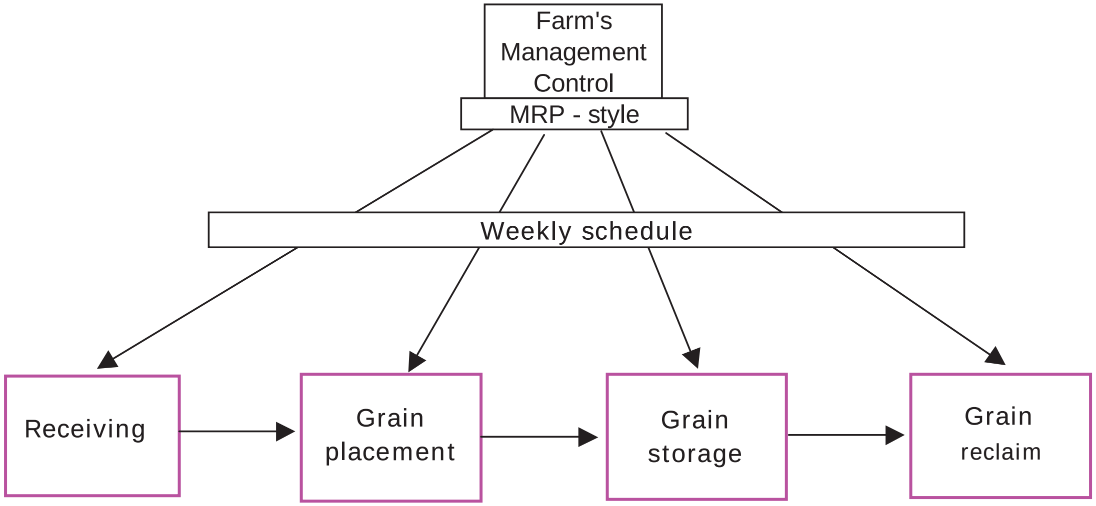
Source: Compiled from author's own research.

Figure 5.31
Harvesting activities



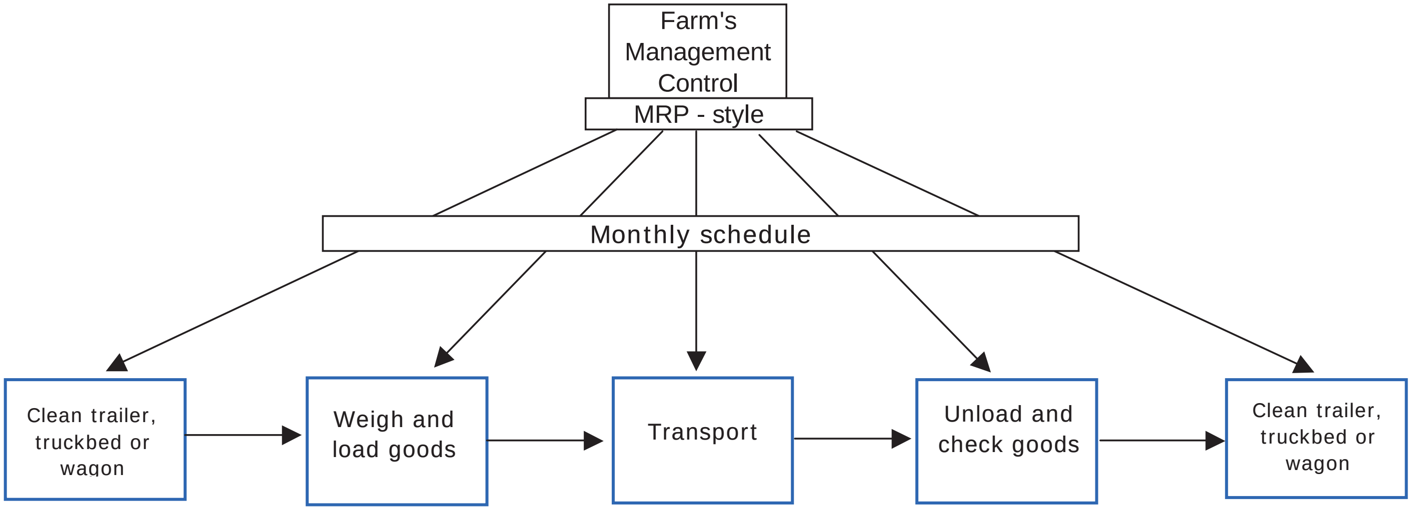
Source: Compiled from author's own research.

Figure 5.32
Storage activities



Source: Compiled from author's own research.

Figure 5.33
Delivery activities



Source: Compiled from author's own research.

5.7 Chapter summary

This chapter described how customer requirements for each element of the wheat, flour and bread VS can be developed and consolidated to represent a generic model of the customer's 'needs' and 'desires'. While representing the entire spectrum of possible white bread product positions (Figure 5.5), other tools were used, i.e. Levitt's Total product concept (Figure 5.6) and Kano's Two dimensions of quality (Figure 5.7), to further analyse the customer requirements for each VS-entity (i.e. End customer; Retailer; Baker; and Miller). Section 5.5 described the analysis that was done to translate the Miller's requirements into the wheat production processes.

Section 5.6 described how the generic models of wheat production practices were developed. Section 5.5.2 described the generic wheat farm activity areas and the processes that are part of these activities (Figures 5.24 through 5.33).

Chapter six builds on the Miller's requirements of the wheat producer and compares open production in France and the U.S. using QFD models. Chapter seven compares two detailed wheat production processes in France and the U.S. VSM models compare the use of nitrogen fertilizer topdressing. HACCP decision process models compare selection of wheat seed. Both of these processes are strongly connected to protein in wheat.

Chapter 6

QFD models of French and U.S. wheat management practices

Chapter 6

QFD models of French and U.S. wheat management practices

6.1 Development of wheat farmer's set of QFD diagrams

One of the main purposes of this chapter is to determine *if* it would be possible for wheat with protein quality defects (e.g. poor protein-to-starch or amylose-to-amylopectin ratios) to enter the VS as a raw ingredient for flour/bread. A further purpose is to determine whether a wheat grower who has made 'best efforts' to produce a quality product and whose management practices are in compliance with food safety guidelines, might still produce an ingredient that has detrimental health characteristics in the final product or whether the system is sufficiently robust to safeguard against such risks. Based on use of Codex guidelines, it should follow that HACCP hazards (such as mycotoxins) have been eliminated, but risks (such as protein quality problems) might not have been. This is shown within the models as a comparison of specific attributes.

This section shows the product offered in France and the U.S. compared with the product defined as the Miller's requirements (Table 5.7). Product plan 1 is developed for using the "Miller's voice" for input. The Grower's view of the product is developed as Product plan 2 and compared to wheat available in the open production systems in France and the U.S. These two product plans complete the Phase I QFD matrices.

6.1.1 Analysis of Miller's needs

The Miller's requirements (Table 5.7) can be simplified. If the Wheat farm actually had market research on hand from the various customers in the VS, the development of the QFDs could be as described throughout this section. In all likelihood, various surrogates perform market research on behalf of the farmer: the grain elevator; state trading authorities; miller; or university extension services. Unfortunately, none of these are a suitable substitute for collecting data in “the customer’s own voice.” So the model building and analysis in this section describe what might happen in a wheat farm following kaizen methodology. Although the tool might seem rather inappropriate for farm product planning, later in this chapter the description of the French system shows some surprising similarities.

Development of Product plan 1 begins with the customer’s own description of what is needed. While both camps of Japanese quality experts agree that this is the first step, the younger group has introduced a new tool to the process. Its name is the KJ method (after Kawakito Jiro, its developer) and it aims at preserving the actual phrases used by a customer rather than allowing industry or company jargon to be substituted.

Initially, the data collected in the customer’s voice is organized into three tiers. Each of the original customer demands is assigned a tertiary label. Phrases are shortened to more easily fit into the QFD format, but the goal is to preserve the speaker’s meaning. The 24 demands of the Miller (Table 5.7) also comprise the demands of the Baker, Retailer and End customer.

6.1.2 Data available from Miller

The Miller’s requirements for Q, C and D characteristics are seen in Table 5.7. The requirements (second column from left) are representative of the type of data returned in customer surveys. Taken alone, the data could be subject to considerable miscommunication. To illustrate the point, the items in column two could be consolidated with the bread product categories from column four to produce the list of Miller demands seen in Table 6.1.

Table 6.1
Simplified list of Miller demands

Quality characteristics:
1. Each delivery matches protein levels by bread type:
   Discount 'soft'; branded 'soft'; branded high quality or artisan-appearing; artisan; competition.
2. Consistent product
3. Meets regulatory standards
4. Meets existing food safety standards
5. Minimal use of pesticides, fertilizers, herbicides
6. No odd odours, taints or contaminants
7. No foreign matter in the wheat
8. Healthy wheat
9. Good extraction rate
10. Wheat that won't result in specks in flour
11. Good level of gluten
12. No excess of *alpha*-amylase
13. Suitable moisture content
14. Overall suitability to baked good
15. Suitable grain hardness
16. Successful intrinsic testing prior to transport to miller
17. Satisfactory field scouting
18. Farmer documentation of practices
19. More frequent shipment intervals
20. Less time in storage

Optional Quality characteristics:

21. Wheat varieties mandated by customer
22. Choice of other inputs agreed or mandated by customer

Cost characteristics:

23. Suitable price

Delivery characteristics:

24. Agreed conditions are met.

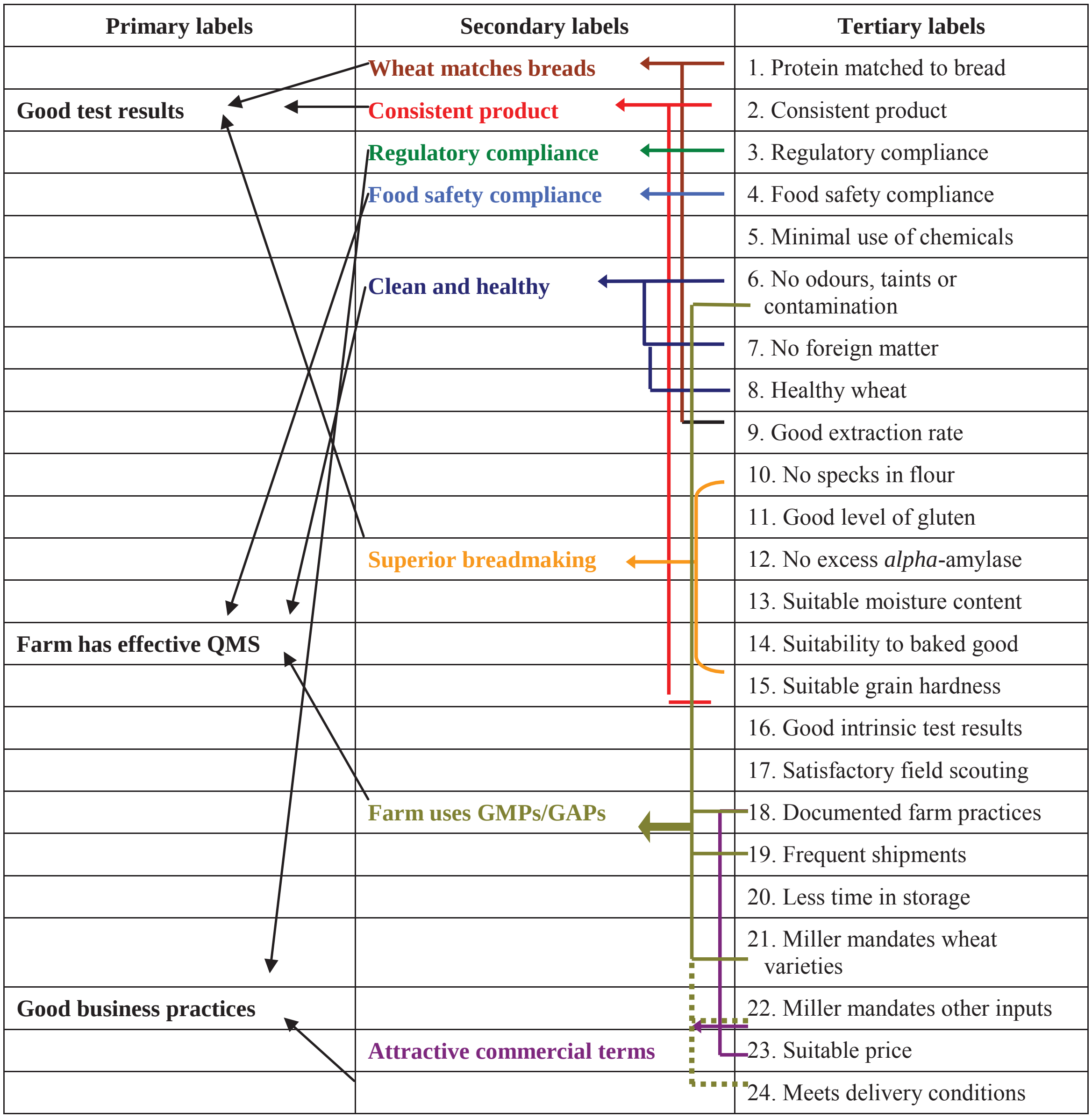
Source: Compiled from author's own research.

Most U.S. wheat farmers reading through the list in Table 6.1 would tend to believe they fulfil nearly all the requirements. (This point can be substantiated from literature that was previously cited). There are a few items, though, that would raise questions; these are items 16, 21 and 22 (highlighted in yellow in Table 6.1 cannot be fulfilled through U.S. system of open production). Item 16 could not easily be fulfilled because intrinsic testing doesn't usually occur, although the USDA position has been to offer it if the customer is willing to pay for the tests (also cited previously). Items 21 and 22 (i.e. customer mandated conditions) would only exist in terms of contract production in the U.S. system. As discussed in Chapter three, the French wheat growers are very sensitive to the performance of wheat varieties and acceptance of the varieties by bakers. While the varieties wouldn't be "mandated" (i.e. Item 21), the growers could probably be expected to react to the demands of the market; thus making Item 21 less of an ‘optional characteristic’ in the French system. Item 22 would be an issue of contract production in France, as in the U.S. Therefore these three items have been left highlighted to indicate that a grower is likely to view them as additional offerings, rather than a basic part of the product design.

If the Product category data (column three) from Table 5.7 were included – which contains measurable targets – a number of demands cannot be met. E.g. the commingling of wheat varieties that occurs in the U.S. grain elevator would prevent the farmer from fulfilling Items 2 and 21. Similar obstacles occur regarding the Miller’s perspective on “Must be” vs. “Attractive” qualities (Section 5.5). The U.S. wheat industry cannot comply with most of the Miller’s demands, except via contract production. Working through Phase I of the QFD diagrams should show more clearly where these inconsistencies occur.

Using the KJ method, each item in Table 6.1 can be considered as a tertiary label. The items are grouped by similarities and a secondary label is assigned that succinctly describes the group. Another grouping occurs, based on the secondary labels, and these are again assigned succinct and descriptive primary labels. In a live design session, the Miller’s needs would likely be written on post-it stickers or flip-chart pages and placed on the walls around the room so that every participant could see the needs. However, the analysis in this thesis only demonstrates how the results of the design session(s) might appear (Table 6.2). As Table 6.2 shows, the 24 original needs are grouped by eight secondary labels, which in turn, are grouped by three primary labels. (The colours used with the secondary labels are merely for ease in tracing the connections to tertiary items).

Table 6.2
KJ view of Miller needs – step 1

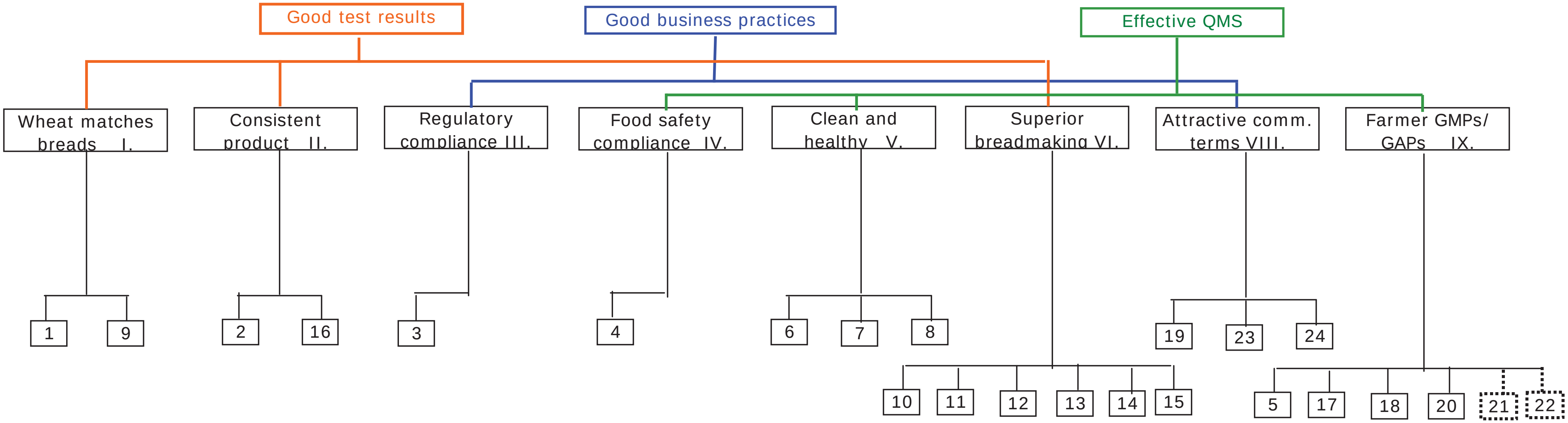


Primary labels	Secondary labels	Tertiary labels
	Wheat matches breads	1. Protein matched to bread
Good test results	Consistent product	2. Consistent product
	Regulatory compliance	3. Regulatory compliance
	Food safety compliance	4. Food safety compliance
		5. Minimal use of chemicals
	Clean and healthy	6. No odours, taints or contamination
		7. No foreign matter
		8. Healthy wheat
		9. Good extraction rate
		10. No specks in flour
		11. Good level of gluten
	Superior breadmaking	12. No excess *alpha*-amylase
		13. Suitable moisture content
Farm has effective QMS		14. Suitability to baked good
		15. Suitable grain hardness
		16. Good intrinsic test results
		17. Satisfactory field scouting
	Farm uses GMPs/GAPs	18. Documented farm practices
		19. Frequent shipments
		20. Less time in storage
		21. Miller mandates wheat varieties
Good business practices		22. Miller mandates other inputs
	Attractive commercial terms	23. Suitable price
		24. Meets delivery conditions

Source: Compiled from author's own research.

The data from Table 6.2 is reformatted in the next step to create a dendogram 'tree' structure. This can be seen in Figure 6.1. The purpose is to check for any customer demands that might have been overlooked. When viewed as a dendogram, the product design intended to meet the Miller's needs shows some areas for further investigation. For example, secondary labels III and IV (Regulatory compliance and Food safety compliance) each have only one "child."

Figure 6.1
KJ view of Miller's needs – step 2



Source: Compiled from author's own research.

The KJ method considers this as an indication that further needs exist and are not represented. Also, secondary labels with a disproportionate number of children (in comparison to the other secondary label- "parents") are re-examined as to whether multiple groups have been consolidated. Separating them might cause single children to appear under a new label, and the issue of overlooked needs would be examined from this perspective, as well.

The process of ferreting out missing desires can be described by looking further at the secondary labels III and IV (Figure 6.1). An initial question is whether or not label III or IV might have been developed as a variation of an existing group (i.e. a duplication) or whether the label was truly germane to the issue the customer expressed. Regulatory compliance (III) and Food safety compliance (IV) are significant topics and unlikely to be "additional features" in one of the other groupings. They are topics that originated in the customer's own voice (not developed through the internal product design process) and therefore, shouldn't be eliminated.

So the next step is to examine what might have been overlooked. In actual practice this step would drive further discussion with the customer or additional market research (such as new surveys or focus groups). For purposes of this thesis, the needs of the other elements (Baker, Retailer, End customer) in the VS could be re-examined. Since the Baker's list was a consolidation of Retailer and End customer, it would be representative of all three elements.

Figure 5.13 showed the Baker's needs. In that figure, item 5 concerning traceability documentation could be added to the Miller's list. Traceability is required for any foodstuff processed in the EU or transiting the EU (Section 2.1.9.1). Therefore, this is a need that should be added to the Miller's list (in Table 6.2) as item 25. Traceability fits within the Regulatory compliance (III) grouping.

Traceability carries with it the implicit requirement for segregation. Some literature requires identity preservation (IP) in order to support segregation while other literature doesn't comment. Regardless, the use of segregation, IP and traceability does increase costs. So a grower might consider offering IP as a premium product and try to recoup some of the outlay associated with segregation/traceability. However, IP also requires that the varietal traits being preserved are known and quantifiable. This would be impossible to achieve without seed that certifies what those traits are. So the Baker's item 1 (in Figure 6.1) is essentially included when IP is provided. But IP is effectively the same as item 21 ("Miller mandates varieties" in Table 6.2), so that the tertiary label (in Table 6.4) would be updated to reflect a desire for IP. Traceability has been added, IP has been integrated, but segregation still remains. Segregation could be added as item 26 (in Table 6.2) and tertiary label 26 (in Table 6.4). These changes would generate three children for Regulatory compliance (III). However, keeping the Regulatory compliance label for tertiary item 3 (Table 6.2) doesn't distinguish it from its secondary label. Therefore the Miller's requirements (Table 5.7) need to be reviewed again. The Miller's requirement was that the product comply with regulations in the markets where the Miller operates (i.e. the U.S. and the EU), so the tertiary label could be revised to reflect that; the new label being Meets U.S. and EU laws (as seen in Table 6.4).

Returning to Figure 5.13 of the Baker's needs, item 6 requests the use of a HACCP plan. Also as discussed in earlier chapters, the Codex guidelines recommend that *all* entities in the food chain adopt HACCP or a similar plan for food safety. Therefore, HACCP plan could become item 27 on the Miller's list (in Table 6.1) and tertiary label 27 (in Table 6.4). Item 8, documented pathogen testing, on the Baker's list (in Figure 5.13) also pertains to food safety. However, if a proper HACCP plan were in place, this item could be accommodated in the plan, as pathogens are clearly specified as hazards by Codex. So item 8 isn't added, but this thesis considers whether or not detrimental characteristics (exhibited by defects in protein-to-starch ratio or amylose-to-amylopectin ratio) could enter the product. Therefore, the prevention of these two defects are added to the Miller's list as items 28 and 29 (in Table 6.1) and tertiary labels 28 and 29 (in Table 6.4). [Note: While it might seem like unnecessary detail to add protein/starch defects as two items rather than one, there are different areas where only one or the other might occur. Therefore, two items were required]. These changes would now generate three children for Food safety compliance (IV), as well. But, as with the secondary and tertiary labels for Regulatory compliance, the tertiary label for item 4 (Food safety compliance) doesn't distinguish it from its secondary label parent (Table 6.2). Therefore, further investigation of the Miller's needs (Table 5.7) found that the specific issue of no pathogens was incorporated into the Use of HACCP (as item 27). But, the possible non-disclosure of GMO wheat (and its particular biological origins) was overlooked, causing the tertiary label for item 4 to be revised to 'Disclosure of GMO' (Table 6.4).

The balance of the Baker's needs (from Figure 5.13) have been included in other areas of the Miller's list. So, the next issue is to return to the dendogram and to question why six children exist for Superior breadmaking (secondary label VI in Figure 6.1). Further examination shows that three of the items (11, 12 and 14) are directly connected to Superior breadmaking but three other items are only indirectly connected. That is, items 10, 13 and 15, are directly connected to Superior flour. So a new secondary label is created for Superior flour (item IX) and tertiary labels 10, 13 and 15 are moved to that grouping. [Note: 'Superior' isn't intended to reflect a premium product. Superior breadmaking was a category that originated in the translations of the French literature. ‘Perfect’ or ‘near perfect’ are more likely to fit the intended meaning but Superior breadmaking has been used repeatedly by the French industry when documents were produced in English. Therefore, the same choice of terms was used here]. Superior breadmaking (VI) retains three children, items 11, 12 and 14 (Figure 6.2).

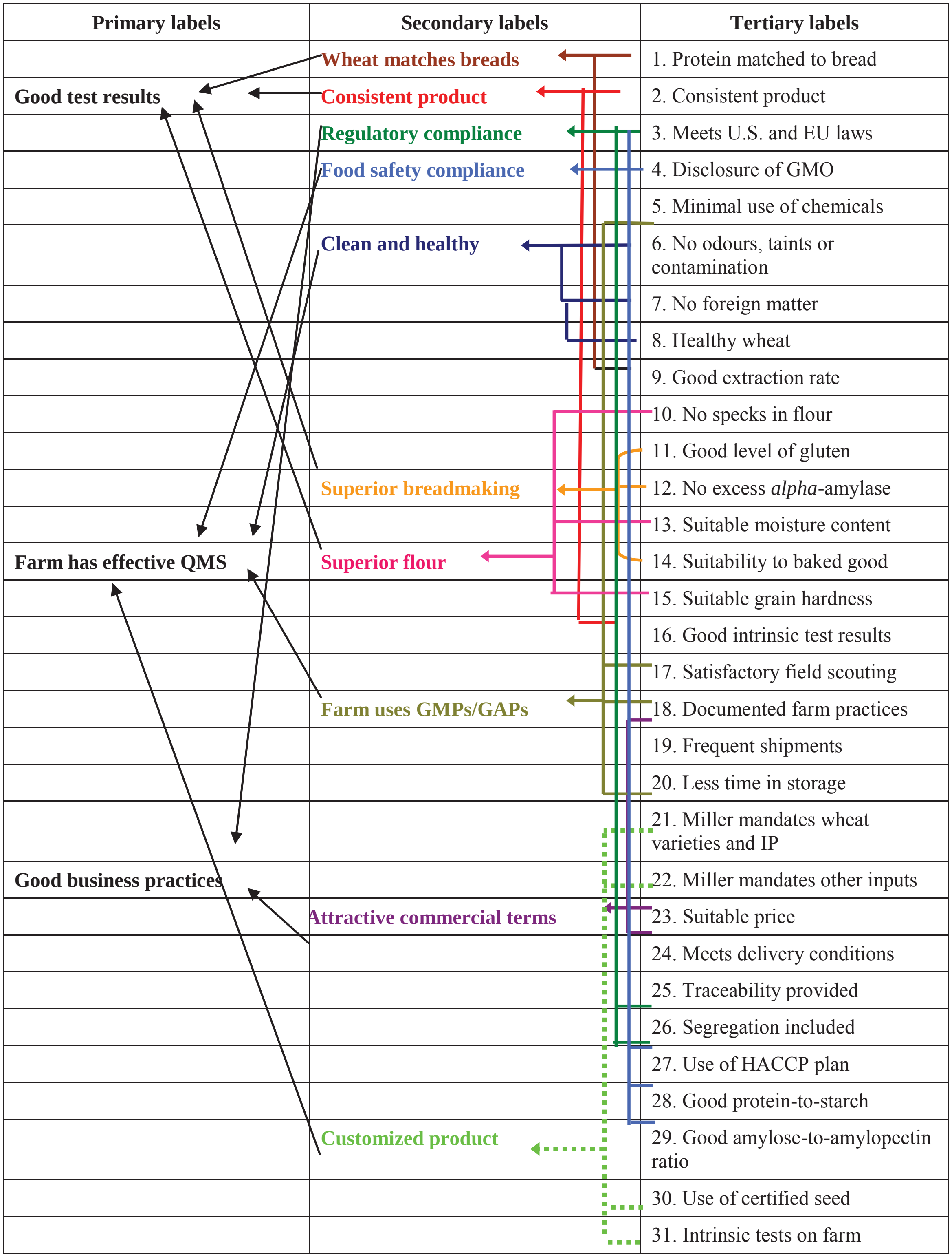
Farmer GMPs/GAPs (secondary label VIII in Figure 6.1) shows six children. In the initial list (shown as Table 6.1), items 17 and 18 (satisfactory field scouting and documented farm practices) are treated independently of one another. However, by adding item 27 (the use of a HACCP plan), field scouting to prevent various pathogens (such as development of mycotoxins) would need to be addressed and documented. So item 17 could be incorporated into item 18 (documented GMPs) -- as long as item 27 (use of HACCP plan) exists -- and reduces the number of children to five. Items 21 and 22 (use of IP and certified seed as well as all other inputs mandated by the miller) are desirable items that should be performed as GAPs. But, carefully managed, it would be possible to make some substitutions and still conform to GAPs. For example, farmer-saved seed in France is not officially certified but it does meet scientific requirements that INRA helps the farmers to establish. In the U.S., farmer-saved seed is (presumably) cleaned by the farmer but used without any external intervention. In the French example, the GAP could be met without using certified seed. As a result, item 21 could be split into two items (use of IP and use of certified/certifiable seed). But the ‘certified/certifiable’ phrase doesn’t match the customer’s voice – the Baker requested ‘certified’ seed (as item 1 in Figure 6.4). Therefore item 21 becomes use of IP and a new item, number 30 (use of certified seed) is created. All three items (21, 22 and 30) are very desirable to the Miller but returning to Kano’s philosophy of “Must be” vs. “Attractive” qualities, these are not “Must be” qualities. However, this opens up a new sales opportunity for the grower as Custom products (with a new secondary label of X). This creates the possibility for one or more premium products. As a result, item 16 (which was originally "Successful intrinsic testing prior to transport to miller") can be split into two versions: one based on intrinsic tests upon arrival at the mill (as item 16) and another premium category that offers intrinsic tests prior to transport to the mill (as item 31). These changes revise the primary labels, as well. Although the same initial groups are retained, "Good test results" increases from three to four children; "Good business practices" remains unchanged with the same two children; and an "Effective QMS" increases from three to four children. All of these changes are reflected in the revised versions of Tables 6.1 and 6.2 and Figure 6.1. Table 6.1 is seen as Table 6.3; Table 6.2 becomes Table 6.4; Figure 6.1 becomes Figure 6.2.

Table 6.3
Revised list of Miller demands

1) Each delivery matches protein levels by bread type:
   Discount 'soft'; branded 'soft'; branded high quality or artisan-appearing; artisan; competition.
2) Consistent product
3) Meets regulatory standards in the U.S. and the EU
4) Meets existing food safety standards, including disclosure of GMO
5) Minimal use of pesticides, fertilizers, herbicides
6) No odd odours, taints or contaminants
7) No foreign matter in the wheat
8) Healthy wheat
9) Good extraction rate
10) Wheat that won't result in specks in flour
11) Good level of gluten
12) No excess of *alpha*-amylase
13) Suitable moisture content
14) Overall suitability to baked good
15) Suitable grain hardness
16) Successful intrinsic testing upon arrival at mill
17) Satisfactory field scouting
18) Farmer documentation of practices
19) More frequent shipment intervals
20) Less time in storage
21) Wheat variety identity preserved (IP)
22) Choice of other inputs agreed or mandated by customer
23) Suitable price
24) Agreed conditions are met
25) Traceability
26) Segregation
27) Use of HACCP plan
28) Protein-to-starch ratio
29) Amylose-to-amylopectin ratio
30) Use of certified seed
31) Successful intrinsic testing prior to transport to miller.

Source: Compiled from author's own research.

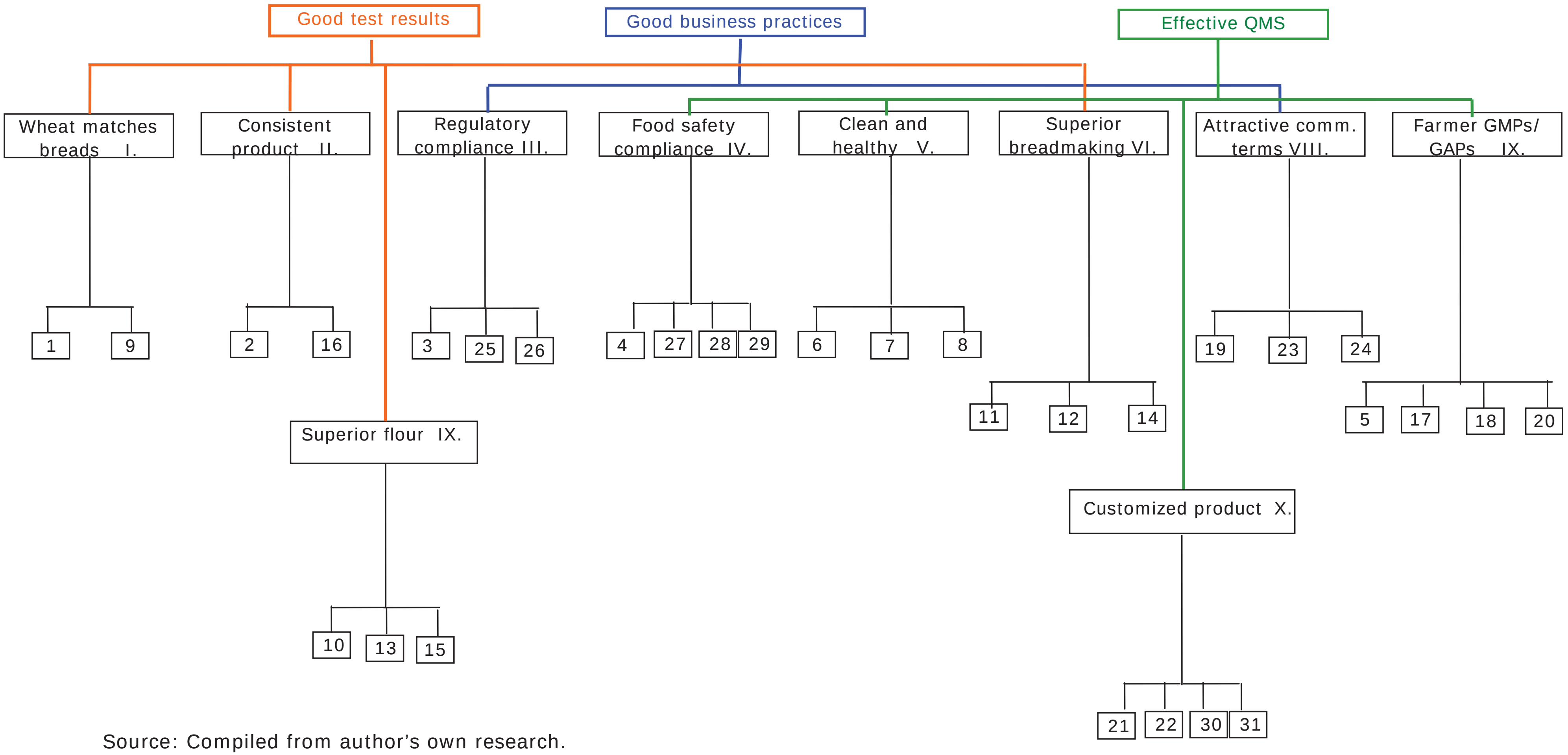
Table 6.4
Revised KJ view of Miller needs – step 3



Primary labels	Secondary labels	Tertiary labels
	Wheat matches breads	1. Protein matched to bread
Good test results	Consistent product	2. Consistent product
	Regulatory compliance	3. Meets U.S. and EU laws
	Food safety compliance	4. Disclosure of GMO
		5. Minimal use of chemicals
	Clean and healthy	6. No odours, taints or contamination
		7. No foreign matter
		8. Healthy wheat
		9. Good extraction rate
		10. No specks in flour
		11. Good level of gluten
	Superior breadmaking	12. No excess *alpha*-amylase
		13. Suitable moisture content
Farm has effective QMS	Superior flour	14. Suitability to baked good
		15. Suitable grain hardness
		16. Good intrinsic test results
		17. Satisfactory field scouting
	Farm uses GMPs/GAPs	18. Documented farm practices
		19. Frequent shipments
		20. Less time in storage
		21. Miller mandates wheat varieties and IP
Good business practices		22. Miller mandates other inputs
	Attractive commercial terms	23. Suitable price
		24. Meets delivery conditions
		25. Traceability provided
		26. Segregation included
		27. Use of HACCP plan
		28. Good protein-to-starch
	Customized product	29. Good amylose-to-amylopectin ratio
		30. Use of certified seed
		31. Intrinsic tests on farm

Source: Compiled from author's own research.

Figure 6.2
Revised KJ view of Miller's needs – step 4



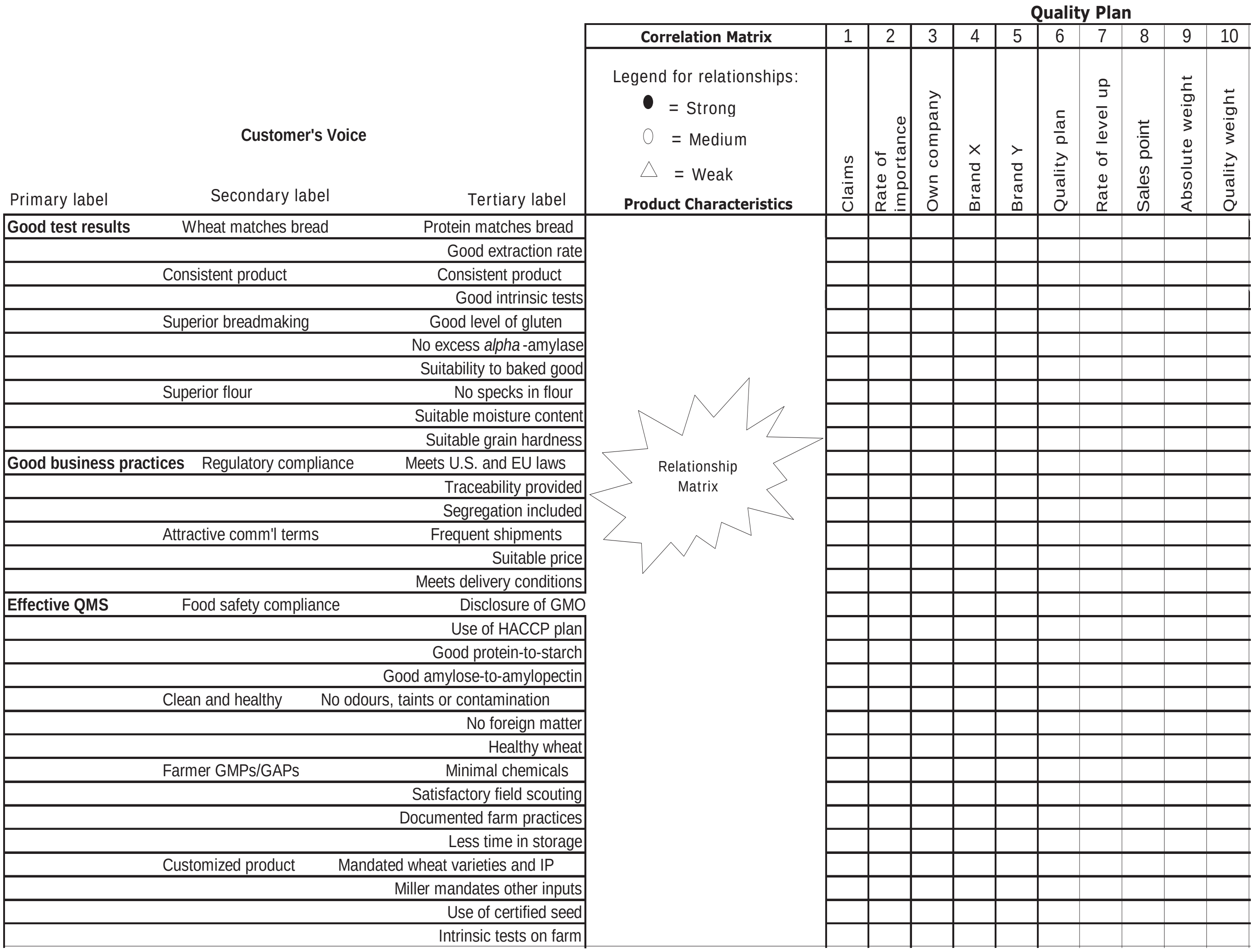
Source: Compiled from author's own research.

As can be seen from Figure 6.2, the sets of children give a more balanced appearance (i.e. no single children and no large groups of children). This is the desired end result and completes the definition of product characteristics.

6.1.3 Revised view of Miller's needs (i.e. 'Customer's voice')

The next step is to insert the product characteristics into the QFD matrix (Figure 6.3) and to develop the competitive evaluation section of the matrix.

Figure 6.3
QFD development of Product plan 1



Quality Plan

Legend for relationships:
● = Strong
○ = Medium
△ = Weak

Customer's Voice

			Correlation Matrix	1	2	3	4	5	6	7	8	9	10
Primary label	Secondary label	Tertiary label	**Product Characteristics**	Claims	Rate of importance	Own company	Brand X	Brand Y	Quality plan	Rate of level up	Sales point	Absolute weight	Quality weight
Good test results	Wheat matches bread	Protein matches bread											
		Good extraction rate											
	Consistent product	Consistent product											
		Good intrinsic tests											
	Superior breadmaking	Good level of gluten											
		No excess *alpha* -amylase											
		Suitability to baked good											
	Superior flour	No specks in flour											
		Suitable moisture content											
		Suitable grain hardness											
Good business practices	Regulatory compliance	Meets U.S. and EU laws											
		Traceability provided											
		Segregation included											
	Attractive comm'l terms	Frequent shipments											
		Suitable price											
		Meets delivery conditions											
Effective QMS	Food safety compliance	Disclosure of GMO											
		Use of HACCP plan											
		Good protein-to-starch											
		Good amylose-to-amylopectin											
	Clean and healthy	No odours, taints or contamination											
		No foreign matter											
		Healthy wheat											
	Farmer GMPs/GAPs	Minimal chemicals											
		Satisfactory field scouting											
		Documented farm practices											
		Less time in storage											
	Customized product	Mandated wheat varieties and IP											
		Miller mandates other inputs											
		Use of certified seed											
		Intrinsic tests on farm											

Source: Compiled from author's own research.

While much of this section discussed the procedure that was followed, a comparison of Table 6.1 with the 'Customer's voice' in Figure 6.3 shows how much more specific—and meaningful—the resulting requirements are. Figure 6.3 shows how the 31 requirements from the first revision of the Miller's needs (Table 6.3) were developed more strongly into primary and secondary groupings (via Table 6.2, Figure 6.1, Table 6.4 and Figure 6.2). The resulting three primary groupings are extremely relevant to quality management: Good test results; Good business practices; and an Effective QMS (Figure 6.3).

6.1.4 Development of the competitive evaluation

The product characteristics with primary, secondary and tertiary labels are shown on the left side of Figure 6.3 and the quality planning section (which incorporates a competitive evaluation section) is seen on the right side. The competitive evaluation incorporates competitive analysis, strategic positioning and merchandising strategy. In kaizen, these activities are some of the most important responsibilities for Top management.

The quality planning section contains ten subject headings: Claims, Rate of importance, Own company, Brand X, Brand Y, Quality plan, Rate of level up, Sales point, Absolute weight, and Quality weight. Each of these topics has a relationship with the competitive position of the product. Values are assigned to each category using a 1-to-5 scale with 1 being lowest and 5 being highest values. The definition of each subject by column heading and its application is as follows:

1 Claims – refers to the ability of "Our company" to provide proper product warranty or service claims (Soin 1992). A 'zero' will be assigned in each category for purposes of this thesis.

2 Rate of importance – refers to the importance customers (Millers) placed on each of the product characteristics developed in the initial product planning stage (Table 6.4).

3, 4, 5 Competitive evaluations – are three columns that relate to performance by product characteristic; column 3 (“Miller’s Expected product”) shows what was expected by the customer (Miller); the two main competitors--Brand X (France) and Brand Y (U.S.)--represent the French and U.S. wheat growers; the performance data are shown in columns 4 and 5.

6 Quality plan – states the level of quality (in column 6) needed per product characteristic in order to remain competitive. Top management must decide strategic issues (e.g. whether to provide a specifically high level of quality when there’s no competitive threat; deciding which priorities to assign to multiple opportunities for quality improvement).

7 Rate of level up – refers to whether Our company is improving, maintaining or decreasing quality in comparison to the competition. ‘Rate of level up’ (column 7) is determined by dividing the ‘Quality plan’ value by the ‘Competitive evaluation’ value for ‘Our company’ (i.e. column 6/column 3 = Rate of level up; the higher the Rate, the greater the gap).

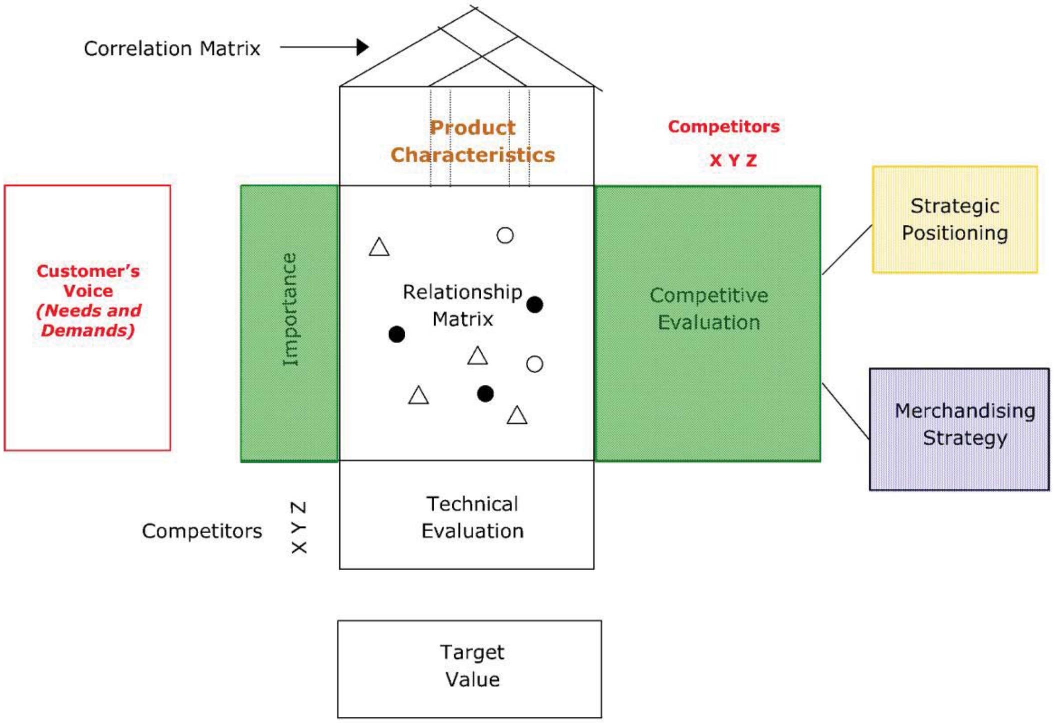
8 Sales point – Sales points (column 8) are used in marketing/sales campaigns; each product characteristic is considered. Top management determines the most important ‘Sales points’ after studying customer’s needs and position of the competition. Those with the highest importance are identified and prioritised as either “primary” or “secondary”. Characteristics that management chooses not to develop in the marketing/sales campaigns are left blank. Each company tends to assign its own numerical values to the column (Soin 1992). For purposes of the model, one of the more simplistic methods described by Soin is shown. Soin’s rating system assigns 1.5 to the ‘primary’ characteristics and 1.2 to the ‘secondary’ ones.

9 Absolute weight – (column 9) is a calculation derived from multiplying the Rate of importance (column 2), Rate of level up (column 7) and Sales point (column 8). All absolute weights (for each product characteristic) are added together.

10 Quality weight – (column 10); the sum of Absolute weight is normalized to a base of 100 to obtain revised values for each individual Absolute weight. An individual Quality weight is shown per product characteristic. (The sum of the Quality weight column will be 100).

House of Quality was introduced in Figure 5.14. Figure 6.4 shows the House of Quality (or Matrix of Matrices) as an overview diagram indicating where each of the main sections of product analysis fit into the matrix/matrices.

Figure 6.4
Initial development of House of Quality

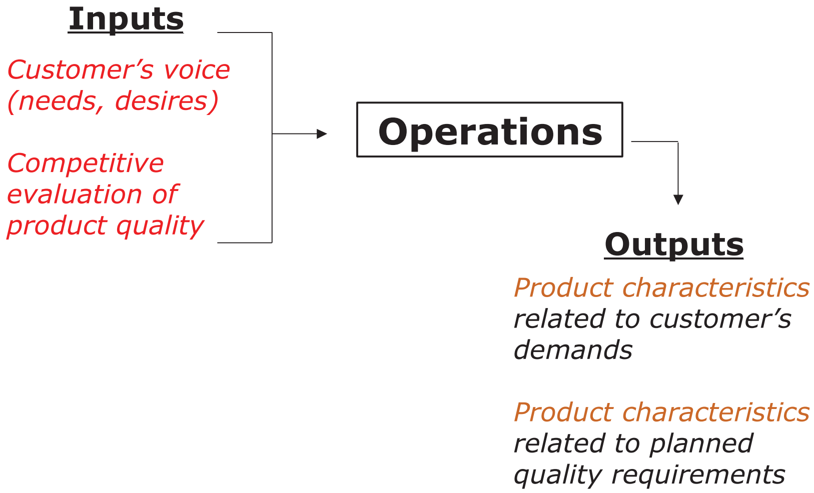


Source: Compiled from author's own research and based on Soin 1992.

The colours used in Figure 6.4 indicate the main inputs and outputs (e.g. 'Customer's voice' appears in red). The Customer's needs and demands pass through a 'filtering process' (denoted as Importance and shown in green). The output becomes Product characteristics (shown in orange). These 'filtering' steps convert the Miller's requirements (Table 5.7) to the 'Customer's voice' (Figure 6.3) using the KJ method.

An overview of the process for development of the quality plan for the product characteristics can also be seen in Figure 6.4. The Product Characteristics (seen in orange in Figure 6.4) become one of the inputs to the quality planning process; competitive data (shown in red as Competitors XYZ) are the other input. These two inputs pass through the Competitive evaluation filtering process (shown in green), which comprises the multiple 'filters' of Strategic positioning (shown in yellow) and Merchandising strategy (shown in blue). The systems view of these two initial analysis stages (Figure 6.5) uses the same colour-coding scheme as Figure 6.4.

Figure 6.5
Main inputs and outputs to Product characteristics



Source: Compiled from author's own research.

The next stage, the further development of Product plan 1 was the competitive evaluation that produced a quality plan for the product design. In this thesis, that represents the company's view of what the customer wants. In actual practice, the next step may be an initial technical design, with the output checked again by another visit to the customer(s). In either scenario, the output of these efforts would be Product plan 2 (also part of the QFD Phase I). Section 6.2 populates the QFD matrix (Figure 6.3) for Product plan 1 (Figure 6.12) and Section 6.3 populates the QFD matrix for Product plan 2 (Figure 6.14).

6.2 Populating the QFD matrix for Product plan 1

6.2.1 The competitive evaluation portion of the quality plan

Figure 6.3 is populated with French and U.S. data to become the competitive evaluation for Product plan 1 (Figure 6.6). Two additional columns were inserted in the Quality Plan (Figure 6.6): 1) Column Add. 1 "Characteristic number (Table 6.3)" maps to the numbering used in Miller's requirements (Table 6.3); 2) Column Add. 2 "Kano rating" shows whether a characteristic represents a 'Must be' (M) or an 'Attractive' (A) quality (highlighted in orange). The rest of the competitive evaluation is merely illustrative, but the procedure used to construct it is described in Appendix 6.A.

6.2.1.1 Analysis of product characteristics by quality weights

The 31 product characteristics can also be ranked by their quality weights. This shows some interesting patterns (Table 6.5).

Table 6.5
Rankings of Primary labels based on quality weight

3.32	Effective QMS [Note: Removing protein-to-starch and amylose-to-amylopectin ratios reduces Effective QMS to 3.22].
3.25	Good test results
2.95	Good business practices

Source: Compiled from author's own research.

Figure 6.6
Competitive evaluation in Product plan 1

						Quality Plan									
		Tertiary label:	Correlation Matrix	Add.1	Add.2	1	2	3	4	5	6	7	8	9	10
Primary label:	Secondary label:	**Customer's voice**	Legend for relationships: ● = Strong ○ = Medium △ = Weak **Product Characteristics**	Characteristic number (table 9.4)	Kano rating	Claims	Rate of importance	Miller's Expected product	Brand X (France)	Brand Y (U.S.)	Quality plan	Rate of level up	Sales point	Absolute weight	Quality weight
Good test results	Wheat & bread match	Protein matches bread	Relationship Matrix	1	M	0	5	5	5	5	5	1.00		5.00	3.16
		Good extraction rate		9	M	0	5	5	5	5	5	1.00		5.00	3.16
	Consis. Prod.	Consistent product		2	M	0	4	5	4	2	5	1.00	●	6.00	3.79
		Good intrinsic tests		16	A	0	5	5	5	1	5	1.00	●	7.50	4.74
	Superior breadmaking	Good level of gluten		11	M	0	5	5	5	1	5	1.00		5.00	3.16
		No excess *alpha* -amylase		12	M	0	5	5	4	1	5	1.00		5.00	3.16
		Suitability to baked good		14	M	0	5	5	5	2	5	1.00		5.00	3.16
	Superior flour	No specks in flour		10	M	0	4	5	5	1	5	1.00		4.00	2.53
		Suitable moisture content		13	M	0	4	5	5	4	5	1.00		4.00	2.53
		Suitable grain hardness		15	M	0	5	5	5	5	5	1.00		5.00	3.16
Good business	Reg. compliance	Meets U.S. and EU laws		3	M	0	5	5	5	4	5	1.00		5.00	3.16
		Traceability provided		25	M	0	5	5	5	3	5	1.00		5.00	3.16
		Segregation included		26	M	0	4	5	5	2	5	1.00		4.00	2.53
	Attract. comm'l terms	Frequent shipments		19	A	0	4	5	4	4	5	1.00		4.00	2.53
		Suitable price		23	M	0	5	5	4	5	5	1.00		5.00	3.16
		Meets delivery conditions		24	M	0	5	5	4	4	5	1.00		5.00	3.16
Effective QMS	Food safety compliance	Disclosure of GMO		4	M	0	4	5	5	1	5	1.00		4.00	2.53
		Use of HACCP plan		27	A	0	3	5	1	1	5	1.00	●	4.50	2.84
		Good protein-to-starch		28	A	0	5	5	2	1	5	1.00	○	6.25	3.95
		Good amylose-to-amylopectin		29	A	0	5	5	2	1	5	1.00	○	6.25	3.95
	Clean and healthy	No odours, taints or contamination		6	M	0	5	5	5	4	5	1.00		5.00	3.16
		No foreign matter		7	M	0	5	5	5	2	5	1.00	○	6.25	3.95
		Healthy wheat		8	M	0	5	5	5	3	5	1.00	○	6.25	3.95
	Farmer GMPs/GAPs	Minimal chemicals		5	A	0	4	5	4	1	5	1.00	○	5.00	3.16
		Satisfactory field scouting		17	A	0	3	5	5	1	5	1.00	●	4.50	2.84
		Documented farm practices		18	A	0	3	5	5	1	5	1.00	●	4.50	2.84
		Less time in storage		20	A	0	5	5	4	1	5	1.00	○	6.25	3.95
	Customized product	Mandated wheat varieties and IP		21	A	0	4	4	4	1	4	1.00	○	5.00	3.16
		Miller mandates other inputs		22	A	0	4	4	1	1	4	1.00	○	5.00	3.16
		Use of certified seed		30	A	0	4	4	4	3	5	1.25	○	6.25	3.95
		Intrinsic tests on farm		31	A	0	4	4	2	1	3	0.75	○	3.75	2.37
							138	151	129	72	151	31.00		158.25	100.01

Source: Compiled from author's own research.

For instance, of the three primary label categories (Table 6.5), an Effective QMS ranked most highly, followed by Good test results with Good business practices coming in last place. Even when the two arbitrary characteristics of good protein-to-starch and good amylose-to-amylopectin ratios were removed, the rating was nearly the same as an Effective QMS.

Rankings for secondary labels showed that characteristics associated with a Consistent product ranked much more highly than others (Table 6.6). However, the next three most highly ranked categories addressed cleanliness, food safety and use of GMPs/GAPs. More sophisticated requirements actually ranked lower (such as Superior breadmaking or Customized product). Although the model has been constructed as a general illustration of the Miller/Baker's expectations, it would seem that the Miller/Baker's main goals represent very basic issues of a dependable, clean and good food-quality product.

Table 6.6
Rankings of Secondary labels based on quality weight

4.27	Consistent product	3.16	Superior breadmaking
3.69	Clean and healthy	3.16	Customized product
3.32	Food safety compliance	2.95	Regulatory compliance
3.20	Farmer GMPs/GAPs	2.95	Attractive commercial terms
3.16	Wheat matches bread	2.74	Superior flour
Total for all Secondary labels: 32.59			

Source: Compiled from author's own research.

The tertiary labels actually are the product characteristics. Table 6.7 ranks each characteristic and whether they are a "Must be," or an "Attractive," quality. (The "Attractive" qualities have been highlighted in light orange to make them easier to see).

Table 6.7
Rankings of Tertiary labels based on quality weight

4.74	**Good intrinsic tests**	**16 A**
3.95	**Good protein-to-starch**	**28 A**
3.95	**Good amylose-to-amylopectin**	**29 A**
3.95	No foreign matter	7 M

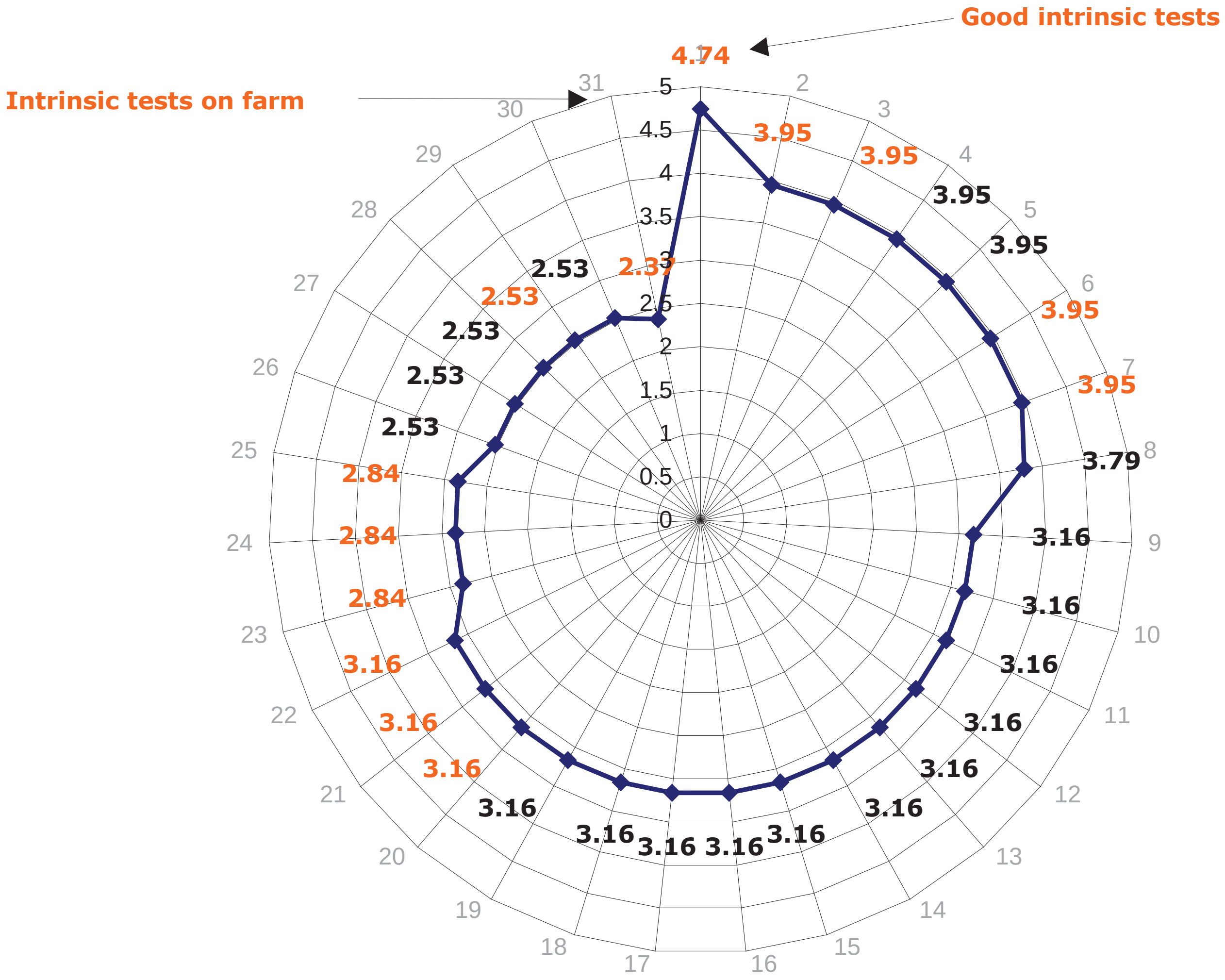
Continuation of Table 6.7

3.95	Healthy wheat	8 M
3.95	**Less time in storage**	**20 A**
3.95	**Use of certified seed**	**30 A**
3.79	Consistent product	2 M
3.16	Protein matches bread	1 M
3.16	Good extraction rate	9 M
3.16	Good level of gluten	11 M
3.16	No excess *alpha*-amylase	12 M
3.16	Suitability to baked good	14 M
3.16	Suitable grain hardness	15 M
3.16	Meets U.S. and EU laws	3 M
3.16	Traceability provided	25 M
3.16	Suitable price	23 M
3.16	Meets delivery conditions	24 M
3.16	No odours, taints or contamination	6 M
3.16	**Minimal chemicals**	**5 A**
3.16	**Mandated wheat varieties and IP**	**21 A**
3.16	**Miller mandates other inputs**	**22 A**
2.84	**Use of HACCP plan**	**27 A**
2.84	**Satisfactory field scouting**	**17 A**
2.84	**Documented farm practices**	**18 A**
2.53	No specks in flour	10 M
2.53	Suitable moisture content	13 M
2.53	Segregation included	26 M
2.53	**Frequent shipments**	**19 A**
2.53	Disclosure of GM	4 M
2.37	**Intrinsic tests on farm**	**31 A**

Source: Compiled from author's own research.

When the qualities' rankings are viewed as a radar chart (Figure 6.7), it is interesting that the "Attractive" qualities have ended up at the endpoints of the range of rankings.

Figure 6.7
Tertiary rankings as radar chart



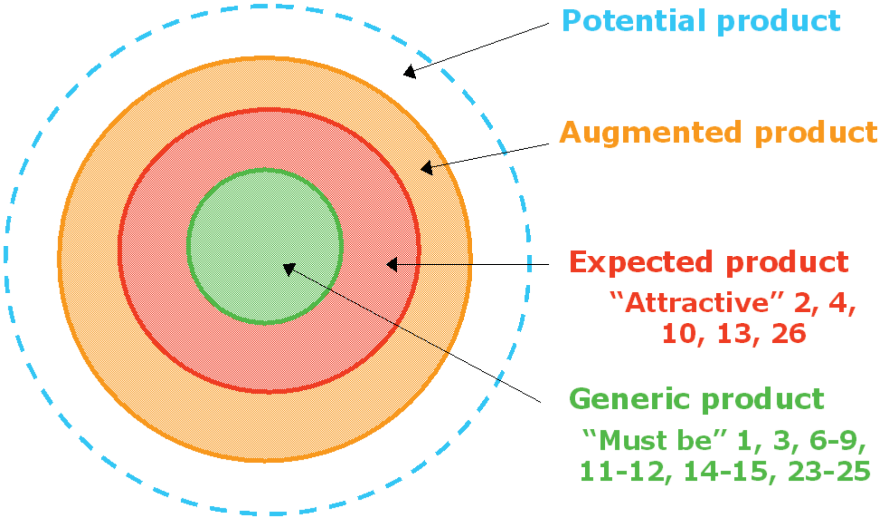
Source: Compiled from author's own research.

The rankings in Figure 6.7 are in the same sequence as in Table 6.7, with the "Attractive" qualities shown in orange and "Must be" shown in black. While scores of 3.16 are predominant, these are mostly "Must be" qualities with a few "Attractive" qualities, as well. It should also be remembered that the higher the score, the more likely it is that the customer will be expecting that characteristic. The first characteristic, Good intrinsic tests, might be very important to the miller/baker that values quality, but there are also customers who buy wheat without any intrinsic testing (e.g. buying from the U.S.); however, the same customers might be extremely pleased to receive a surprise set of Good intrinsic tests with their shipped order. This comes from the ideas of Kano and Levitt regarding which product category a specific product fits, based on its quality characteristics (Section 5.1.4).

Levitt's model of concentric product categories (Figure 5.6) was adapted to show the impact of Kano's view of "Must be" and Attractive" quality dimensions (Figure 5.7) for the first two inner rings of Levitt's model (i.e. a Generic product and an Expected product) based on the Miller's requirements. (Table 6.7 and Figure 6.7). The Miller's 'Generic product' (Figure 6.8) and the Miller's 'Expected product' (Figure 6.9) show that, regardless of the actual (Levitt) product category, a product will still contain (Kano's) "Must be" and "Attractive" qualities.

For the miller that buys the Generic product, the "Must be" characteristics (listed by tertiary label number) are shown in the diagram as comprising the Generic product itself. If the same miller received any of the five "Attractive" characteristics that are also listed on the diagram, the buyer's expectations would be exceeded.

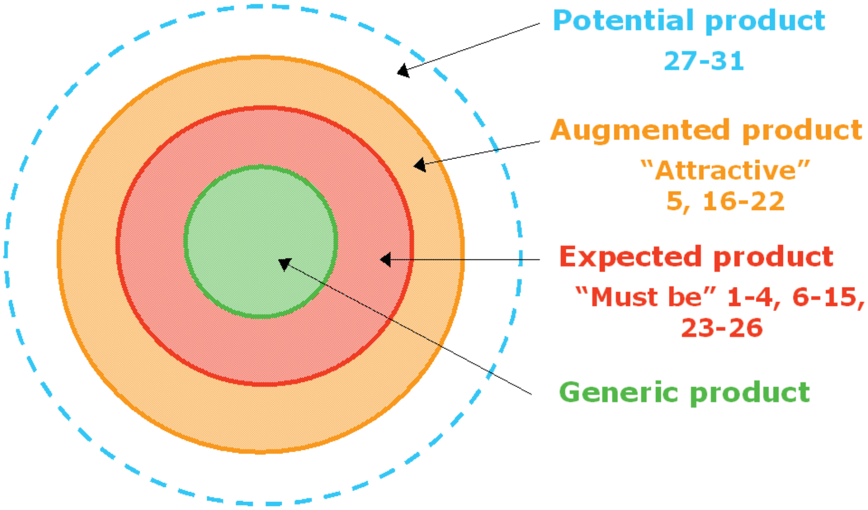
Figure 6.8
Miller's Generic product expectations



Source: Compiled from author's own research.

However, the benchmark for just meeting the miller's needs – let alone exceeding them – becomes more complex when the product is positioned in the Expected product category. The five characteristics that were "Attractive" to the Generic product buyer aren't "extras" to the miller that purchases from the Expected product category. The bar has been raised, and now all of the characteristics of the Generic product (both "Must be" and "Attractive" need to be included) just to keep the miller satisfied. But, to really impress this Miller, Top management must design a product that includes characteristics from the Augmented product category, and simultaneously begin to develop plans for future integration of the characteristics currently in the Potential product category.

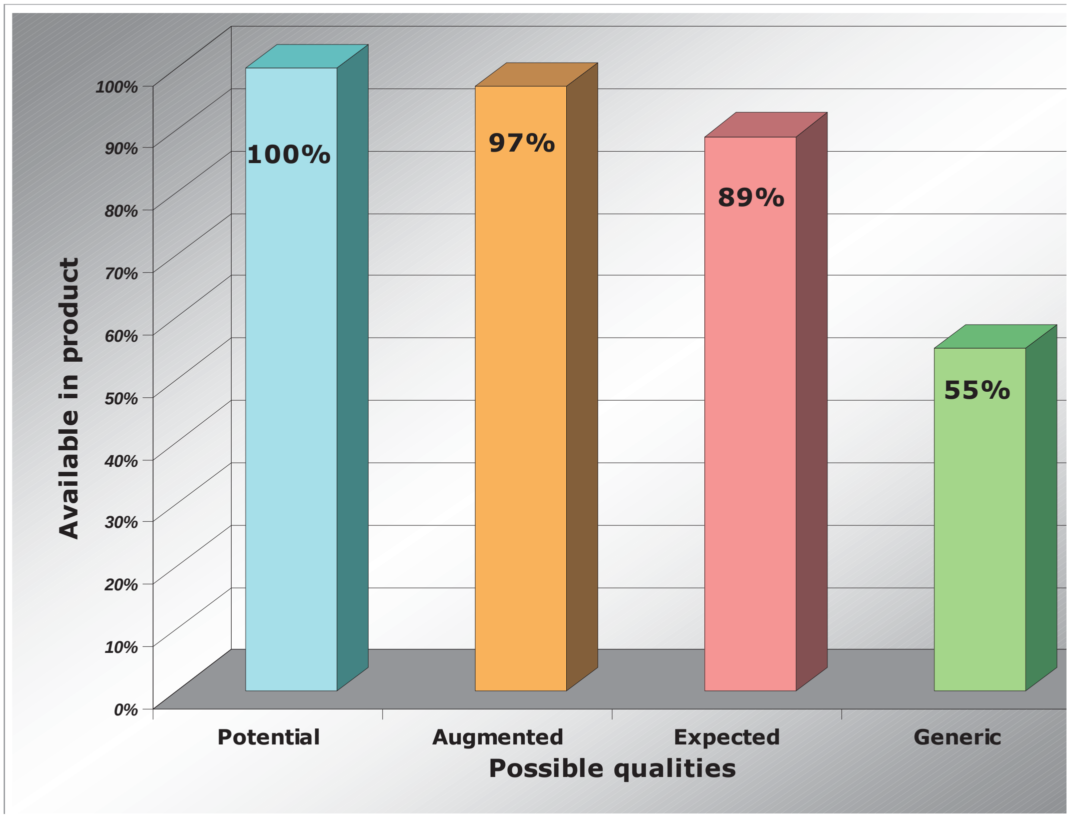
Figure 6.9
Miller's Expected product expectations



Source: Compiled from author's own research.

In the relationship between the four product categories, the Potential product carries all the possibilities that Top management can envision, while at the other end of the spectrum, the Generic product includes some 55 percent of those same characteristics (Figure 6.10).

Figure 6.10
Split of possible qualities by availability per product category



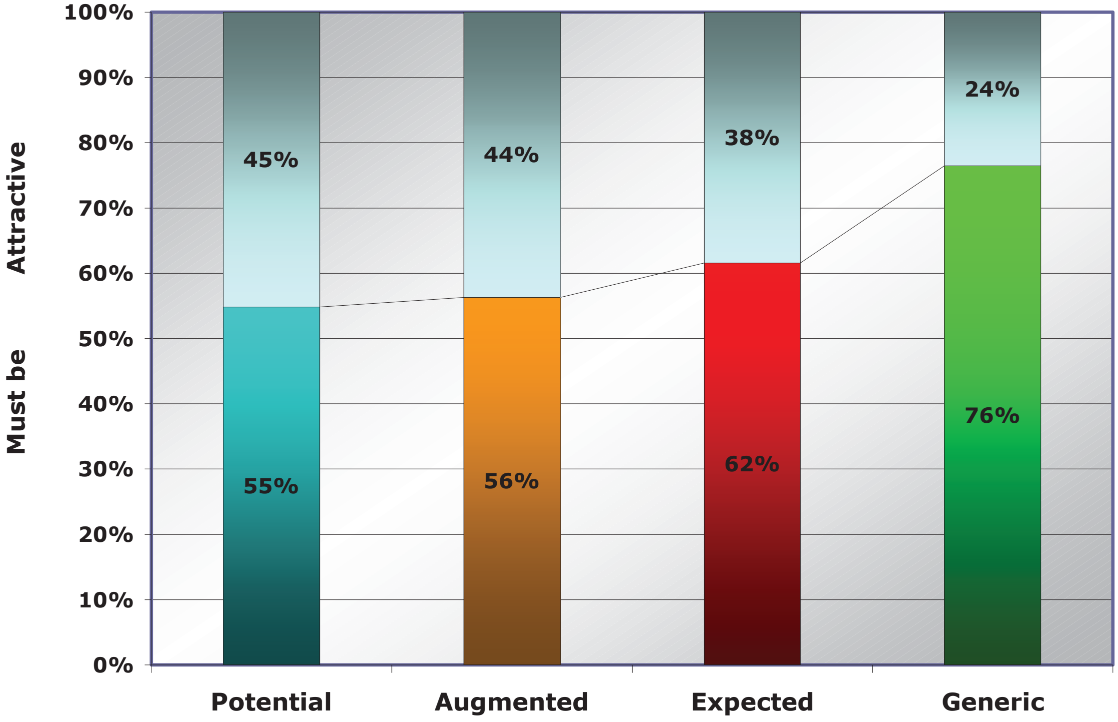
Source: Compiled from author's own research.

When the four product categories are split by "Must be" and "Attractive" characteristics within each category, 55 percent of the characteristics in the Potential product are "Must be", and these represent the (entire) Generic product (Figure 6.11). Also, as the product moves from Generic toward the Potential product category, the share of "Must be" versus "Attractive" characteristics decreases (Figure 6.11) as the customer becomes more discerning.

6.2.2 The Relationship matrix for Product plan 1 (i.e. 'Customer's eyes')

While the product characteristics represent what the customer says ('Customer's voice') about requirements, the final part of the competitive evaluation is devoted to what the customer sees (i.e. ‘Customer’s eyes’). This is the section shown as the Relationship matrix for Product plan 1 (Figure 6.6).

Figure 6.11
Split of Must be and Attractive qualities by product category



Source: Compiled from author’s own research.

There are other kaizen tools that could be used for this particular part of the competitive strategy in the annual plan (Akao’s *Hoshin Kanri*[1]), but the pictorial competitive evaluation, or ‘Customer’s eyes’, was chosen because of its simplicity; a farmer or other business person without professional marketing training should be able to use it effectively. When the Relationship matrix has been completed, it should be easy to see the strengths and weaknesses of Our company in comparison with the competition (Figure 6.12). Appendix 6.B discusses Figure 6.12 in more depth and then takes the comparison further by explaining the impact of the Kano “Must be” and “Attractive” qualities (Figure 6.13).

---

[1] See Soin 1992 for further detail.

Figure 6.12
Product plan 1 Relationship matrix

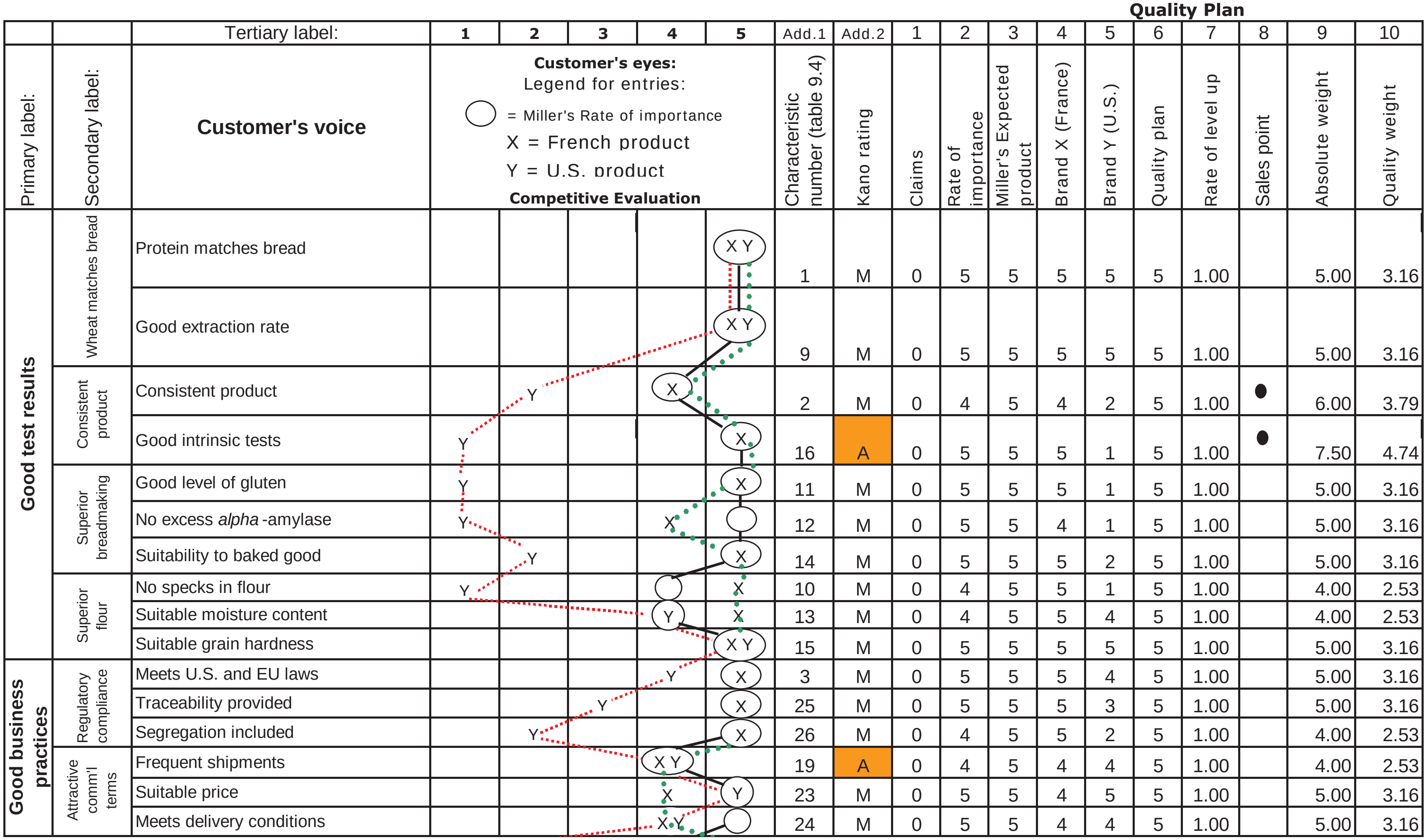
								Quality Plan								
		Tertiary label:	**1**	**2**	**3**	**4**	**5**	2	3	4	5	6	7	8	9	10
Primary label:	Secondary label:	**Customer's voice**	**Customer's eyes:** Legend for entries: ○ = Miller's Rate of importance X = French product Y = U.S. product **Competitive Evaluation**					Rate of importance	Miller's Expected product	Brand X (France)	Brand Y (U.S.)	Quality plan	Rate of level up	Sales point	Absolute weight	Quality weight
Good test results	Wheat matches bread	Protein matches bread					○ X Y	5	5	5	5	5	1.00		5.00	3.16
		Good extraction rate					○ X Y	5	5	5	5	5	1.00		5.00	3.16
	Consistent product	Consistent product		Y		○ X		4	5	4	2	5	1.00	●	6.00	3.79
		Good intrinsic tests	Y				○ X	5	5	5	1	5	1.00	●	7.50	4.74
	Superior breadmaking	Good level of gluten	Y				○ X	5	5	5	1	5	1.00		5.00	3.16
		No excess *alpha* -amylase	Y			X	○	5	5	4	1	5	1.00		5.00	3.16
		Suitability to baked good		Y			○ X	5	5	5	2	5	1.00		5.00	3.16
	Superior flour	No specks in flour	Y			○	X	4	5	5	1	5	1.00		4.00	2.53
		Suitable moisture content				○ Y	X	4	5	5	4	5	1.00		4.00	2.53
		Suitable grain hardness					○ X Y	5	5	5	5	5	1.00		5.00	3.16
Good business practices	Regulatory compliance	Meets U.S. and EU laws				Y	○ X	5	5	5	4	5	1.00		5.00	3.16
		Traceability provided			Y		○ X	5	5	5	3	5	1.00		5.00	3.16
		Segregation included		Y			○ X	4	5	5	2	5	1.00		4.00	2.53
	Attractive comm'l terms	Frequent shipments				○ X Y		4	5	4	4	5	1.00		4.00	2.53
		Suitable price				X	○ Y	5	5	4	5	5	1.00		5.00	3.16
		Meets delivery conditions				X Y	○	5	5	4	4	5	1.00		5.00	3.16

Figure 6.12 (page two)
Product plan 1 Relationship matrix

		Tertiary label:	1	2	3	4	5	2	3	4	5	6	7	8	9	10
								Quality Plan								
Primary label:	Secondary label:	**Customer's voice**	**Customer's eyes:** Legend for entries: ○ = Miller's Rate of importance X = French product Y = U.S. product **Competitive Evaluation**					Rate of importance	Miller's Expected product	Brand X (France)	Brand Y (U.S.)	Quality plan	Rate of level up	Sales point	Absolute weight	Quality weight
Effective QMS	Food safety compliance	Disclosure of GMO	Y			○	X	4	5	5	1	5	1.00		4.00	2.53
		Use of HACCP plan	X Y		○			3	5	1	1	5	1.00	●	4.50	2.84
		Good protein-to-starch	Y	X			○	5	5	2	1	5	1.00	○	6.25	3.95
		Good amylose-to-amylopectin	Y	X			○	5	5	2	1	5	1.00	○	6.25	3.95
	Clean and healthy	No odours, taints or contamination				Y	○X	5	5	5	4	5	1.00		5.00	3.16
		No foreign matter		Y			○X	5	5	5	2	5	1.00	○	6.25	3.95
		Healthy wheat			Y		○X	5	5	5	3	5	1.00	○	6.25	3.95
	Farmer GMPs/GAPs	Minimal chemicals	Y			○X		4	5	4	1	5	1.00	○	5.00	3.16
		Satisfactory field scouting	Y		○		X	3	5	5	1	5	1.00	●	4.50	2.84
		Documented farm practices	Y		○		X	3	5	5	1	5	1.00	●	4.50	2.84
		Less time in storage	Y			X	○	5	5	4	1	5	1.00	○	6.25	3.95
	Customized product	Mandated wheat varieties and IP	Y			○X		4	4	4	1	4	1.00	○	5.00	3.16
		Miller mandates other inputs	X Y			○		4	4	1	1	4	1.00	○	5.00	3.16
		Use of certified seed			Y	○X		4	4	4	3	5	1.25	○	6.25	3.95
		Intrinsic tests on farm	Y	X		○		4	4	2	1	3	0.75	○	3.75	2.37

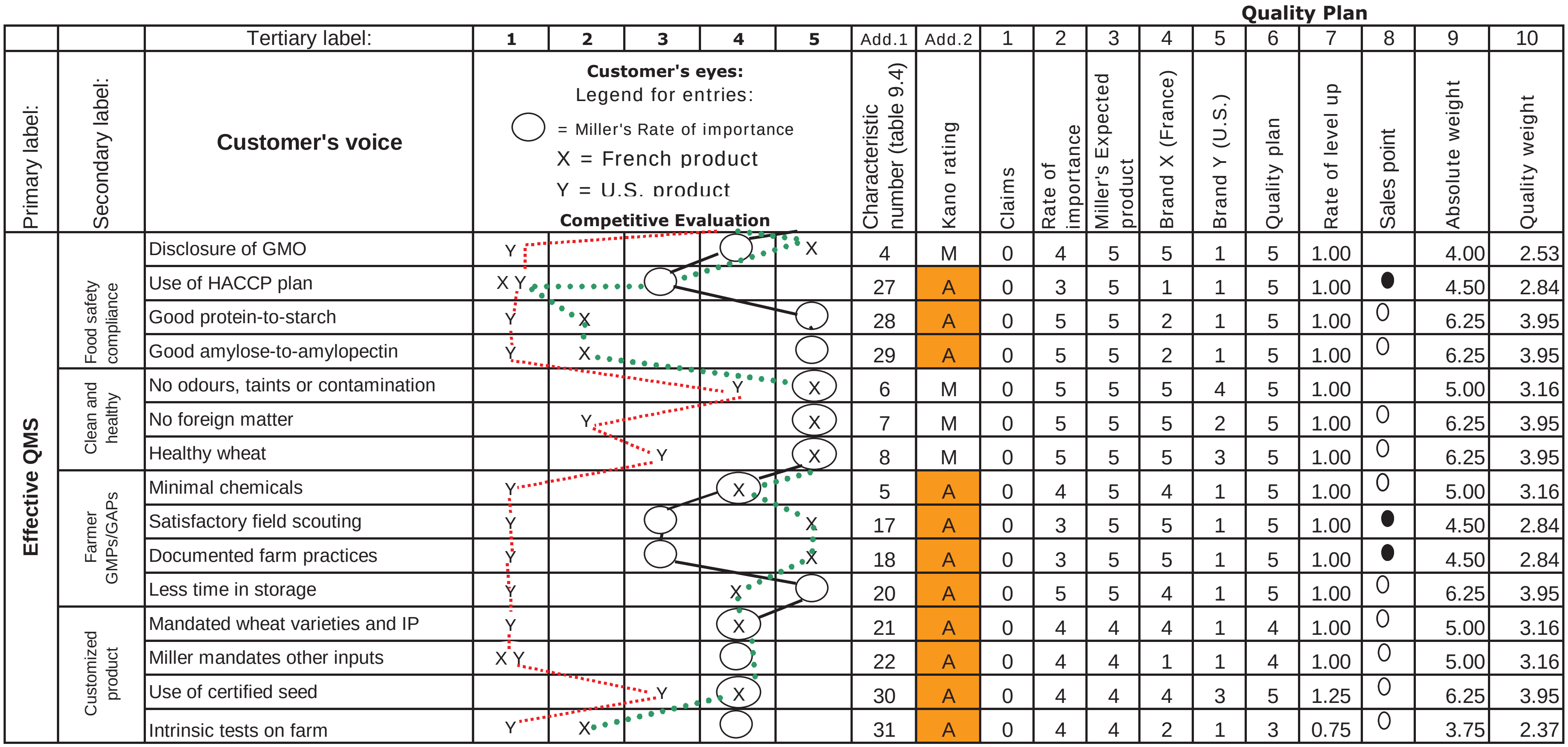
Source: Compiled from author’s own research.

Figure 6.13
Product plan 1 Relationship matrix with Kano effects



										Quality Plan									
		Tertiary label:	1	2	3	4	5	Add.1	Add.2	1	2	3	4	5	6	7	8	9	10
Primary label:	Secondary label:	Customer's voice	Customer's eyes: Legend for entries: ○ = Miller's Rate of importance X = French product Y = U.S. product Competitive Evaluation					Characteristic number (table 9.4)	Kano rating	Claims	Rate of importance	Miller's Expected product	Brand X (France)	Brand Y (U.S.)	Quality plan	Rate of level up	Sales point	Absolute weight	Quality weight
Good test results	Wheat matches bread	Protein matches bread					(X Y)	1	M	0	5	5	5	5	5	1.00		5.00	3.16
		Good extraction rate					(X Y)	9	M	0	5	5	5	5	5	1.00		5.00	3.16
	Consistent product	Consistent product		Y		(X)		2	M	0	4	5	4	2	5	1.00	●	6.00	3.79
		Good intrinsic tests	Y				(X)	16	A	0	5	5	5	1	5	1.00	●	7.50	4.74
	Superior breadmaking	Good level of gluten	Y				(X)	11	M	0	5	5	5	1	5	1.00		5.00	3.16
		No excess *alpha* -amylase	Y			X	○	12	M	0	5	5	4	1	5	1.00		5.00	3.16
		Suitability to baked good		Y			(X)	14	M	0	5	5	5	2	5	1.00		5.00	3.16
	Superior flour	No specks in flour	Y			○	X	10	M	0	4	5	5	1	5	1.00		4.00	2.53
		Suitable moisture content				(Y)	X	13	M	0	4	5	5	4	5	1.00		4.00	2.53
		Suitable grain hardness					(X Y)	15	M	0	5	5	5	5	5	1.00		5.00	3.16
Good business practices	Regulatory compliance	Meets U.S. and EU laws				Y	(X)	3	M	0	5	5	5	4	5	1.00		5.00	3.16
		Traceability provided			Y		(X)	25	M	0	5	5	5	3	5	1.00		5.00	3.16
		Segregation included		Y			(X)	26	M	0	4	5	5	2	5	1.00		4.00	2.53
	Attractive comm'l terms	Frequent shipments				(X Y)		19	A	0	4	5	4	4	5	1.00		4.00	2.53
		Suitable price				X	(Y)	23	M	0	5	5	4	5	5	1.00		5.00	3.16
		Meets delivery conditions				X Y	○	24	M	0	5	5	4	4	5	1.00		5.00	3.16

Figure 6.13 (page two)
Product plan 1 Relationship matrix with Kano effects



Quality Plan

		Tertiary label:	1	2	3	4	5	Add.1	Add.2	1	2	3	4	5	6	7	8	9	10
Primary label:	Secondary label:	**Customer's voice**	**Customer's eyes:** Legend for entries: ○ = Miller's Rate of importance X = French product Y = U.S. product **Competitive Evaluation**					Characteristic number (table 9.4)	Kano rating	Claims	Rate of importance	Miller's Expected product	Brand X (France)	Brand Y (U.S.)	Quality plan	Rate of level up	Sales point	Absolute weight	Quality weight
Effective QMS	Food safety compliance	Disclosure of GMO	Y			○	X	4	M	0	4	5	5	1	5	1.00		4.00	2.53
		Use of HACCP plan	X Y		○			27	A	0	3	5	1	1	5	1.00	●	4.50	2.84
		Good protein-to-starch	Y	X			○	28	A	0	5	5	2	1	5	1.00	○	6.25	3.95
		Good amylose-to-amylopectin	Y	X			○	29	A	0	5	5	2	1	5	1.00	○	6.25	3.95
	Clean and healthy	No odours, taints or contamination				Y	○X	6	M	0	5	5	5	4	5	1.00		5.00	3.16
		No foreign matter		Y			○X	7	M	0	5	5	5	2	5	1.00	○	6.25	3.95
		Healthy wheat			Y		○X	8	M	0	5	5	5	3	5	1.00	○	6.25	3.95
	Farmer GMPs/GAPs	Minimal chemicals	Y			○X		5	A	0	4	5	4	1	5	1.00	○	5.00	3.16
		Satisfactory field scouting	Y		○		X	17	A	0	3	5	5	1	5	1.00	●	4.50	2.84
		Documented farm practices	Y		○		X	18	A	0	3	5	5	1	5	1.00	●	4.50	2.84
		Less time in storage	Y			X	○	20	A	0	5	5	4	1	5	1.00	○	6.25	3.95
	Customized product	Mandated wheat varieties and IP	Y			○X		21	A	0	4	4	4	1	4	1.00	○	5.00	3.16
		Miller mandates other inputs	X Y			○		22	A	0	4	4	1	1	4	1.00	○	5.00	3.16
		Use of certified seed			Y	○X		30	A	0	4	4	4	3	5	1.25	○	6.25	3.95
		Intrinsic tests on farm	Y	X		○		31	A	0	4	4	2	1	3	0.75	○	3.75	2.37

Source: Compiled from author’s own research.

6.2.2.1 The' Customer's eyes' and 'good protein' qualities

As Figures 6.12 and 6.13 show, 'good protein' qualities appear to be ranked more highly by the Millers/Bakers than by the wheat producers in France or the U.S.: the Millers/Bakers would prefer a ranking of five ('highest' Rate of importance) while the French were ranked with a 'two' and the U.S. with a 'one'. In reality, intrinsic testing verifies the degree of good protein qualities. Therefore, the French are likely producing wheat that meets the quality characteristics of good protein, but not advertising these qualities. The 'Customer's eyes' represents the impression the customer gets from seeing the product, associated literature or other marketing/sales data. Since there doesn't appear to be references to these characteristics in the French (non-academic) wheat literature, the rank of two was assigned. Since there is no intrinsic testing of wheat in open production in the U.S. (without the customer ordering the tests and paying for them), and because wheat is commingled (making it impossible to accurately report on intrinsic properties), the rank of one was assigned.

6.2.3 Purposes for Product plan 1

The primary purpose of this section was to compare wheat production in France with the U.S. Therefore, this section showed some of the competitive differences in how each country's growers respond to the Miller's set of requirements. Another purpose was to show the progressive development of Product Plan 1 toward a more competitive agricultural product.

6.3 Populating the QFD matrix for Product plan 2

Product plan 1 dealt with the competitive evaluation of the product offering; Product plan 2 deals with the production planning side of the product. Section 6.3.1 develops the relationship matrix for production of the characteristics that the grower would like to provide. Sections 6.3.2 and 6.3.3 discuss the production of those characteristics and Section 6.3.4

considers production in terms of 'good protein' qualities. Section 6.3.5 compares delivery of the product characteristics in France and the U.S.

6.3.1 The Relationship Matrix for Product plan 2

The House of Quality (as shown in Figure 6.4) serves as a sort of 'roadmap' for carrying out the development of the QFD matrices that comprise the four separate VS/kaizen phases that start with the Customer's voice and end with production standards. The QFD matrix for Product plan 2 begins where the matrix for Product plan 1 ended. Viewed from the perspective of the House of Quality, or 'matrix of matrices,' the matrix for Product plan 1 progresses horizontally across the House of Quality, moving from left to right. The matrix for Product plan 2 progresses along a vertical axis through the House of Quality. However, both matrices comprise Phase I. Product plan 2 combines Product Characteristics and Target Values, and using a Technical Evaluation, develops the Relationship Matrix.

The actual mechanics of completing the relationship matrix were described in previous sections. But in short, each quality characteristic of the Customer's voice (i.e. the WHATs) is redefined as a production characteristic (i.e. the HOWs) with measurable values for achieving the HOW (i.e. Target values). Every HOW and every WHAT are checked against one another – not just a comparison of the initial pairs of WHATs and HOWs. Black circles indicate a strong relationship between the WHAT and the HOW; white circles indicate a medium-strength relationship, white triangles indicate a weak relationship and an empty space indicates no relationship between the WHAT and the particular HOW.

In Figure 6.14, the QFD matrix for Product plan 2, two additional columns (Add. 1 and Add. 2) were added to show the original connection to the Miller's requirements (Table 6.3) and to show the effect of the Kano approach to "Must be" and "Attractive" qualities. The same 31 characteristics that represented the Customer's voice (i.e. WHATs for Product plan 1) in Figures 6.12 and 6.13, but there are 38 production characteristics (i.e. HOWs). The additional HOWs were added for several WHATs that required categories to better define what would be produced. For example, the first quality characteristic (Protein matches bread) generated a HOW (Suitable match of protein levels to bread category) but that particular HOW needed to be defined against five different Target values (protein content of ~9.5%, 9-10%, 10-11%, 11.5-12% and 12.5% and above). Another variation was the multiple categories that were needed for HOWs to meet the (Secondary label) characteristics of Superior breadmaking and Superior flour. This required three HOWs for Successful flour rheology and breadmaking tests (i.e. good results from Farinograph, Alveograph and Successful breadmaking tests). In a similar manner, the WHATs related to (Secondary label) Customized product required additional HOWs. Finally, two arbitrary HOWs were created for the 'good protein' qualities (Good protein-to-starch ratio and Good amylose-to-amylopectin ratio; these two columns are highlighted in light orange). This permitted a direct comparison against any of the other WHATs.

6.3.2 Product plan 2: The WHATs & HOWs

Each of the 'intersections' where WHATs and HOWs meet in the relationship matrix (Figure 6.14) can be assigned a value based on the symbol assigned. For instance, a black circle can be assigned 1.75, a white circle is assigned 1.50 and a triangle is assigned a value of 1.25. Although a blank space isn't assigned a value, it is counted in the sum of 'intersections' to be considered. A weighted average can be calculated for each of the WHATs by dividing the sum of values assigned to relationship symbols by the sum of 'intersections.' The weighted average shows the overall strength – or operational need – to meet the technical requirements

Figure 6.14

Relationship matrix for Product plan 2

		Tertiary label:	Add.1	Add.2		A	A$_1$	A$_2$	A$_3$	A$_4$	A$_5$	B	C	D	E	F	G	H	I	J
Primary label:	Secondary label:	Legend for relationships: ● = Strong ○ = Medium △ = Weak Blank = No relationship **Customer's voice**	Characteristic number (table 9.4)	Kano rating	**Product Characteristics (HOWs)**	Suitable match of protein levels to bread category:	Artisan baguette	Discounted 'soft' white, industrial	Branded 'soft' white, industrial & CBP	General purpose baking	Competition and specialty	No pre-blending or commingling of wheat without Miller's agreement	Regulations used match miller's and baker's market	Free from pathogens or mycotoxins	Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance	Written records for pesticides, herbicides and fertilizers available for viewing	No unusual odours, dampness or musty, mouldy wheat	No contamination from delivery vehicle	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain
Good test results	Wheat matches bread	Protein matches bread	1	M		--	●	●	●	●	●	●	△	●	○	△	●	●	△	●
		Good extraction rate	9	M																
	Consist. product	Consistent product	2	M		●	--	--	--	--	--	●	△	●	●	○	●	●	●	●
		Good intrinsic tests	16	A		●	--	--	--	--	--		△	●	○	△	●	●	●	●
	Superior breadmaking	Good level of gluten	11	M		●	--	--	--	--	--	○	△	○	○	△	△	△	△	●
		No excess *alpha* -amylase	12	M		○	--	--	--	--	--	○	△	○	○	△	△	△	△	●
		Suitability to baked good	14	M		●	--	--	--	--	--	●	△	○	○	△	●	●	●	●
					Target values	Wheat protein content (14% moisture base) + 0.7% overhead:	Soft French wheat of ~9.5%	Soft wheat of 9-10%	Medium hard wheat of 10-11.0%	Hard wheat of 11.5-12%	Hard wheat of 12.5% and above	Single variety or binned delivery	Product conforms to EU,US and laws in miller's market	Tests for pathogens	Use of pesticides, fertilizers, herbicides agreed in advance with customer	Documented use of pesticides, fertilizers, herbicides aavailable for customer review	Sanitary standards for wheat tested and documented	Sanitary standards for al equipment tested and documented	Impurities not to exceed 2 in a 100 gram sample	In a 100 gram sample: Broken kernels not to exceed 4; sprouted not to exceed 2.

Figure 6.14 (page 2)
Relationship matrix for Product plan 2

		Tertiary label:	Add.1	Add.2		K	L	M	N	O	P$_1$	P$_2$	P$_3$	Q	R	S
Primary label:	Secondary label:	Legend for relationships: ● = Strong ○ = Medium △ = Weak Blank = No relationship **Customer's voice**	Characteristic number (table 9.4)	Kano rating	**Product Characteristics (HOWs)**	High test weight	Suitable ash content	Good results on gluten test	Suitable Hagberg FN test result	Moisture level that permits safe storage up to 12 months	Successful flour rheology tests: -- Farinograph,	Successful flour rheology tests: -- Alveograph	Successful breadmaking tests:	Grain hardness test results matched to flour strength	Choice of tests mandated by miller with documented results	Specific management practices agreed with miller
Good test results	Wheat matches bread	Protein matches bread	1	M		●	△	○	○	●	●	●	●	●	○	○
		Good extraction rate	9	M		●	●		●					○		
	Consist. product	Consistent product	2	M		○	○	○	○	●	○	○	○	○	●	●
		Good intrinsic tests	16	A		○	○	○	●	●	●	●	●	○	●	●
	Superior breadmaking	Good level of gluten	11	M				●					●			
		No excess *alpha* -amylase	12	M		●			●		●	●	●	○	△	
		Suitability to baked good	14	M		●	●	●	●	○	●	●	●	●	○	○
					Target values	-- 70 kg/hl for soft (and biscuit) wheat; -- 80 kg/hl for bread wheat.	≤ 0.5% ash content	≥ Zeleny Index of 25 ml	≥ 250 seconds	≤ 15% moisture content	Trial milling to match test standards; Hydration: amount of water added in relation to dough of 14%; Degree of softening in FUs; Stability expressed in minutes	Trial milling to match test standards; Baking strength (W); Degree of extensibility of dough (G); Balance between tenacity and extensibility (P/L)	Hydration: amount of water added to reach dough of 14%; Volume in cm^3; Composite score based on suitable system for customer	On the AACC scale of 1 to 100: -- 25 for soft (and biscuit) wheat; -- 75 for (hard) bread wheat.	Negotiate tests with customer	Documented practices; specific practices to be agreed with customer

Figure 6.14 (page 3)
Relationship matrix for Product plan 2

Legend for relationships:
● = Strong
○ = Medium
△ = Weak
Blank = No relationship

		Tertiary label:	Add.1	Add.2		T	U	V	W	X	Y	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6
Primary label:	Secondary label:	**Customer's voice**	Characteristic number (table 9.4)	Kano rating	**Product Characteristics (HOWs)**	Written reports of field checks mandated by miller	Shipments matched to production levels	Shorter storage time leading to better quality and lower costs	Disclosure of GMO	Seed selection agreed or mandated by customer	Predictable varietal traits	Choice of non-seed inputs agreed or mandated by customer	Price related to wheat quality characteristics	Verify that health & safety practices are followed	Delivery timing, shipment quantity and price are suitable	Good protein-to-starch ratio	Good amylose-to-amylopectin ratio
Good test results	Wheat matches bread	Protein matches bread	1	M		○	△	△		●	●	○	△	○	△	●	●
		Good extraction rate	9	M												○	
	Consist. product	Consistent product	2	M		●	△	●	○	●	●	●	△	△	△	●	●
		Good intrinsic tests	16	A		○		△	△	○	○	○	△	△		●	●
	Superior breadmaking	Good level of gluten	11	M							○	△				○	○
		No excess *alpha* -amylase	12	M						○	●	△				○	●
		Suitability to baked good	14	M		○	○	○	○	○	●	○	△	△	△	●	●
					Target values	Documented field reports; negotiate specific practices and format with customer	Collect miller production data; negotiate shipments with customer	Storage not to exceed 6 months	Tests for GMO	Negotiate seed selection with customer	Use of certified seed and identity preservation	Negotiate non-seed inputs with customer	Develop scale relating price and quality; discuss with customer	Document health & safety practices; discuss with customer	Negotiate deliveries, quantities and price with customer	Varietal selection has good protein-to-starch and amylose-to-amylopectin ratios	Practice management during Growing phase will avoid stress to plants that could result in altered protein or starch

Figure 6.14 (page 4)
Relationship matrix for Product plan 2

Legend for relationships:
● = Strong
○ = Medium
△ = Weak
Blank = No relationship

Primary label:	Secondary label:	Tertiary label: Customer's voice	Add.1 Characteristic number (table 9.4)	Add.2 Kano rating	**Product Characteristics (HOWs)**	A Suitable match of protein levels to bread category:	A_1 Artisan baguette	A_2 Discounted 'soft' white, industrial	A_3 Branded 'soft' white, industrial & CBP	A_4 General purpose baking	A_5 Competition and specialty	B No pre-blending or commingling of wheat without Miller's agreement	C Regulations used match miller's and baker's market	D Free from pathogens or mycotoxins	E Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance	F Written records for pesticides, herbicides and fertilizers available for viewing	G No unusual odours, dampness or musty, mouldy wheat	H No contamination from delivery vehicle	I No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	J Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain
Good tests	Superior flour	No specks in flour	10	M		○	--	--	--	--	--	●	△	○	○	△	●	●	●	●
		Suitable moisture content	13	M		○	--	--	--	--	--			○	○	△	●	○	○	●
		Suitable grain hardness	15	M		●	--	--	--	--	--	○		○	○	△	●	○	●	●
Good business practices	Regulatory compliance	Meets U.S. and EU laws	3	M		△	--	--	--	--	--	○	●	●	○	△	○	○	○	○
		Traceability provided	25	M								●	●	●	○	○	○	○	○	○
		Segregation included	26	M								●	○	●	○	○	○	○	○	○
	Attractive comm'l terms	Frequent shipments	19	A		△	--	--	--	--	--	△		△			△		△	△
		Suitable price	23	M		△	--	--	--	--	--			△	△		△	△	△	△
		Meets delivery conditions	24	M		△	--	--	--	--	--			△			○	●	●	○
					Target values	Wheat protein content (14% moisture base) + 0.7% overhead:	Soft French wheat of ~9.5%	Soft wheat of 9-10%	Medium hard wheat of 10-11.0%	Hard wheat of 11.5-12%	Hard wheat of 12.5% and above	Single variety or binned delivery	Product conforms to EU,US and laws in miller's market	Tests for pathogens	Use of pesticides, fertilizers, herbicides agreed in advance with customer	Documented use of pesticides, fertilizers, herbicides aavailable for customer review	Sanitary standards for wheat tested and documented	Sanitary standards for al equipment tested and documented	Impurities not to exceed 2 in a 100 gram sample	In a 100 gram sample: Broken kernels not to exceed 4; sprouted not to exceed 2.

Figure 6.14 (page 5)
Relationship matrix for Product plan 2

		Tertiary label:	Add.1	Add.2		K	L	M	N	O	P_1	P_2	P_3	Q	R	S
Primary label:	Secondary label:	Legend for relationships: ● = Strong ○ = Medium △ = Weak Blank = No relationship **Customer's voice**	Characteristic number (table 9.4)	Kano rating	**Product Characteristics (HOWs)**	High test weight	Suitable ash content	Good results on gluten test	Suitable Hagberg FN test result	Moisture level that permits safe storage up to 12 months	Successful flour rheology tests: -- Farinograph,	Successful flour rheology tests: -- Alveograph	Successful breadmaking tests:	Grain hardness test results matched to flour strength	Choice of tests mandated by miller with documented results	Specific management practices agreed with miller
Good tests	Superior flour	No specks in flour	10	M		●	●		●		△	△	△	△	△	
		Suitable moisture content	13	M		△				●	●	●	●	○		
		Suitable grain hardness	15	M		●			○		○	○	○	●		
Good business practices	Regulatory compliance	Meets U.S. and EU laws	3	M		○	○							○	△	○
		Traceability provided	25	M		○										●
		Segregation included	26	M											○	●
	Attractive comm'l terms	Frequent shipments	19	A						○						○
		Suitable price	23	M												
		Meets delivery conditions	24	M						○						
					Target values	-- 70 kg/hl for soft (and biscuit) wheat; -- 80 kg/hl for bread wheat.	≤ 0.5% ash content	≥ Zeleny Index of 25 ml	≥ 250 seconds	≤ 15% moisture content	Trial milling to match test standards; Hydration: amount of water added in relation to dough of 14%; Degree of softening in FUs; Stability expressed in minutes	Trial milling to match test standards; Baking strength (W); Degree of extensibility of dough (G); Balance between tenacity and extensibility (P/L)	Hydration: amount of water added to reach dough of 14%; Volume in cm^3; Composite score based on suitable system for customer	On the AACC scale of 1 to 100: -- 25 for soft (and biscuit) wheat; -- 75 for (hard) bread wheat.	Negotiate tests with customer	Documented practices; specific practices to be agreed with customer

Figure 6.14 (page 6)
Relationship matrix for Product plan 2

Legend for relationships:
● = Strong
○ = Medium
△ = Weak
Blank = No relationship

		Tertiary label:	Add.1	Add.2		T	U	V	W	X	Y	Z_1	Z_2	Z_3	Z_4	Z_5	Z_6
Primary label:	Secondary label:	**Customer's voice**	Characteristic number (table 9.4)	Kano rating	**Product Characteristics (HOWs)**	Written reports of field checks mandated by miller	Shipments matched to production levels	Shorter storage time leading to better quality and lower costs	Disclosure of GMO	Seed selection agreed or mandated by customer	Predictable varietal traits	Choice of non-seed inputs agreed or mandated by customer	Price related to wheat quality characteristics	Verify that health & safety practices are followed	Delivery timing, shipment quantity and price are suitable	Good protein-to-starch ratio	Good amylose-to-amylopectin ratio
Good tests	Superior flour	No specks in flour	10	M						○	●	●	△	△		○	△
		Suitable moisture content	13	M						○		△		△	△	○	○
		Suitable grain hardness	15	M						○	●	○	△	△	△	●	○
Good business practices	Regulatory compliance	Meets U.S. and EU laws	3	M		△	△	○	●			○		○			
		Traceability provided	25	M		○	○	○	●		○	△		●	○		
		Segregation included	26	M		● ○	○	○	○		○	△		○		△	△
	Attractive comm'l terms	Frequent shipments	19	A		△	●	●							○	△	
		Suitable price	23	M				△			○	○	●	△	○		
		Meets delivery conditions	24	M			○	○					○	△	●		
					Target values	Documented field reports; negotiate specific practices and format with customer	Collect miller production data; negotiate shipments with customer	Storage not to exceed 6 months	Tests for GMO	Negotiate seed selection with customer	Use of certified seed and identity preservation	Negotiate non-seed inputs with customer	Develop scale relating price and quality; discuss with customer	Document health & safety practices; discuss with customer	Negotiate deliveries, quantities and price with customer	Varietal selection has good protein-to-starch and amylose-to-amylopectin ratios	Practice management during Growing phase will avoid stress to plants that could result in altered protein or starch

Figure 6.14 (page 7)
Relationship matrix for Product plan 2

		Tertiary label:	Add.1	Add.2		A	A_1	A_2	A_3	A_4	A_5	B	C	D	E	F	G	H	I	J
Primary label:	Secondary label:	Legend for relationships: ● = Strong ○ = Medium △ = Weak Blank = No relationship **Customer's voice**	Characteristic number (table 9.4)	Kano rating	**Product Characteristics (HOWs)**	Suitable match of protein levels to bread category:	Artisan baguette	Discounted 'soft' white, industrial	Branded 'soft' white, industrial & CBP	General purpose baking	Competition and specialty	No pre-blending or commingling of wheat without Miller's agreement	Regulations used match miller's and baker's market	Free from pathogens or mycotoxins	Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance	Written records for pesticides, herbicides and fertilizers available for viewing	No unusual odours, dampness or musty, mouldy wheat	No contamination from delivery vehicle	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain
Effective QMS	Food safety compliance	Disclosure of GMO	4	M								●	●		○	○				△
		Use of HACCP plan	27	A		△	--	--	--	--	--	△	●	●	○	●	○	○	○	○
		Good protein-to-starch	28	A		●	--	--	--	--	--	●	△	○	○	△	○	○	○	●
		Good amylose-to-amylopectin	29	A		●	--	--	--	--	--	●	△	○	○	△	○	○	○	●
	Clean and healthy	No odours, taints or contamination	6	M		○	--	--	--	--	--		○	●	○	△		●	●	●
		No foreign matter	7	M									○	○			○	○	●	△
		Healthy wheat	8	M		●	--	--	--	--	--	●	○	●	●	○	●	●	●	●
	Farmer GMPs/GAPs	Minimal chemicals	5	A		○	--	--	--	--	--	△	●	●	●	○	○		○	●
		Satisfactory field scouting	17	A		●	--	--	--	--	--	△	△	●	△				△	●
		Documented farm practices	18	A		●	--	--	--	--	--	○	○	○	○	●		△	△	△
		Less time in storage	20	A		●	--	--	--	--	--		△	●	●	△	○		●	●
	Customized product	Mandated wheat varieties and IP	21	A		●	--	--	--	--	--	●	○	△	○	○				△
		Miller mandates other inputs	22	A		●	--	--	--	--	--	○	○	●	●	●	○		△	●
		Use of certified seed	30	A		●	--	--	--	--	--	●	△	△	○	△				△
		Intrinsic tests on farm	31	A		●	--	--	--	--	--	●	△	○	△		○		△	○
					Target values	Wheat protein content (14% moisture base) + 0.7% overhead:	Soft French wheat of ~9.5%	Soft wheat of 9-10%	Medium hard wheat of 10-11.0%	Hard wheat of 11.5-12%	Hard wheat of 12.5% and above	Single variety or binned delivery	Product conforms to EU,US and laws in miller's market	Tests for pathogens	Use of pesticides, fertilizers, herbicides agreed in advance with customer	Documented use of pesticides, fertilizers, herbicides aavailable for customer review	Sanitary standards for wheat tested and documented	Sanitary standards for al equipment tested and documented	Impurities not to exceed 2 in a 100 gram sample	In a 100 gram sample: Broken kernels not to exceed 4; sprouted not to exceed 2.

Figure 6.14 (page 8)
Relationship matrix for Product plan 2

<u>Legend for relationships</u>:

● = Strong

○ = Medium

△ = Weak

Blank = No relationship

Primary label:	Secondary label:	Tertiary label: Customer's voice	Add.1 Characteristic number (table 9.4)	Add.2 Kano rating	Product Characteristics (HOWs)	K High test weight	L Suitable ash content	M Good results on gluten test	N Suitable Hagberg FN test result	O Moisture level that permits safe storage up to 12 months	P_1 Successful flour rheology tests: -- Farinograph,	P_2 Successful flour rheology tests: -- Alveograph	P_3 Successful breadmaking tests:	Q Grain hardness test results matched to flour strength	R Choice of tests mandated by miller with documented results	S Specific management practices agreed with miller
Effective QMS	Food safety compliance	Disclosure of GMO	4	M											△	○
		Use of HACCP plan	27	A											○	○
		Good protein-to-starch	28	A		○	△	△	△	○	○	○	○	○	△	○
		Good amylose-to-amylopectin	29	A				△		○	○	○	○	○	△	○
	Clean and healthy	No odours, taints or contamination	6	M		○			○	●					△	●
		No foreign matter	7	M									○		○	●
		Healthy wheat	8	M		○		○	●	●	●	●	●	○	△	●
	Farmer GMPs/GAPs	Minimal chemicals	5	A		△				△	△	△	○	△	△	●
		Satisfactory field scouting	17	A		○	○	○	○	△	○	○	●	○	△	●
		Documented farm practices	18	A				△	△	△			○		●	○
		Less time in storage	20	A		○			○	○	○	○	●	○	△	●
	Customized product	Mandated wheat varieties and IP	21	A		●	●	●	●	●	●	●	●	●	○	●
		Miller mandates other inputs	22	A		○	○		○	○	○	○	●	○	●	●
		Use of certified seed	30	A		●	●	●	●	○	●	●	●	●	○	○
		Intrinsic tests on farm	31	A		●	●	●	●	○	○	○	●	●	●	○
					Target values	-- 70 kg/hl for soft (and biscuit) wheat; -- 80 kg/hl for bread wheat.	≤ 0.5% ash content t	≥ Zeleny Index of 25 ml	≥ 250 seconds	≤ 15% moisture content	Trial milling to match test standards; Hydration: amount of water added in relation to dough of 14%; Degree of softening in FUs; Stability expressed in minutes	Trial milling to match test standards; Baking strength (W); Degree of extensibility of dough (G); Balance between tenacity and extensibility (P/L)	Hydration: amount of water added to reach dough of 14%; Volume in cm^3; Composite score based on suitable system for customer	On the AACC scale of 1 to 100: -- 25 for soft (and biscuit) wheat; -- 75 for (hard) bread wheat.	Negotiate tests with customer	Documented practices; specific practices to be agreed with customer

Figure 6.14 (page 9)
Relationship matrix for Product plan 2

Legend for relationships:
● = Strong
○ = Medium
△ = Weak
Blank = No relationship

Primary label:	Secondary label:	Tertiary label: Customer's voice	Add.1 Characteristic number (table 9.4)	Add.2 Kano rating	Product Characteristics (HOWs) T Written reports of field checks mandated by miller	U Shipments matched to production levels	V Shorter storage time leading to better quality and lower costs	W Disclosure of GMO	X Seed selection agreed or mandated by customer	Y Predictable varietal traits	Z_1 Choice of non-seed inputs agreed or mandated by customer	Z_2 Price related to wheat quality characteristics	Z_3 Verify that health & safety practices are followed	Z_4 Delivery timing, shipment quantity and price are suitable	Z_5 Good protein-to-starch ratio	Z_6 Good amylose-to-amylopectin ratio
Effective QMS	Food safety compliance	Disclosure of GMO	4	M	○	△		╲	●	●	○	△	△	○	○	○
		Use of HACCP plan	27	A	●	△	●	○		△	△		●	△	△	△
		Good protein-to-starch	28	A	△				○	●	○	△	△	△	╲	╲
		Good amylose-to-amylopectin	29	A	△				○	●	○	△	△	△	╲	╲
	Clean and healthy	No odours, taints or contamination	6	M	●	○	●				△	△	●	○	○	○
		No foreign matter	7	M	○						△	○	●	△		
		Healthy wheat	8	M	●	○	●	●	○	●	●	○	○	△	●	●
	Farmer GMPs/GAPs	Minimal chemicals	5	A	○		△	●	●	●	●	○	●	△	●	●
		Satisfactory field scouting	17	A	○		△	○	△	△	○	○	●		●	●
		Documented farm practices	18	A	●	△	△	●	△			○	●	△	△	△
		Less time in storage	20	A	△	●	●		△	△	○	△	△	○	●	●
	Customized product	Mandated wheat varieties and IP	21	A	○			●	●	●	●	○	△	△	●	●
		Miller mandates other inputs	22	A	○		△	○	△	●	╲	○	△	△	●	●
		Use of certified seed	30	A	○		△	●	●	●	○	○	△	△	●	●
		Intrinsic tests on farm	31	A	△	△	○	●	△	△	○	△	○	△	●	●
				Target values	Documented field reports; negotiate specific practices and format with customer	Collect miller production data; negotiate shipments with customer	Storage not to exceed 6 months	Tests for GMO	Negotiate seed selection with customer	Use of certified seed and identity preservation	Negotiate non-seed inputs with customer	Develop scale relating price and quality; discuss with customer	Document health & safety practices; discuss with customer	Negotiate deliveries, quantities and price with customer	Varietal selection has good protein-to-starch and amylose-to-amylopectin ratios	Practice management during Growing phase will avoid stress to plants that could result in altered protein or starch

Source: Compiled from author's own research.

(HOWs and target values) for actually producing the product. The weighted average for all product characteristics is shown in Table 6.8, along with the Kano assignment of “Must be” or “Attractive”. (Attractive characteristics are highlighted in orange. The two key quality characteristics, i.e. Protein-to-starch ratio and Amylose-to-amylopectin ratio, are highlighted in Table 6.8 and examined throughout the rest of the models).

Table 6.8
Strength of relationship of WHATs to HOWs

Characteristic	Kano	Customer requirement	Weighted ranking
2	M	Consistent product	1.598
8	M	Healthy wheat	1.598
14	M	Suitability to baked good	1.591
1	M	Protein matches bread	1.500
16	A	Good intrinsic tests	1.432
31	A	Intrinsic tests on farm	1.432
22	A	Miller mandates other inputs	1.406
21	A	Mandated wheat varieties and IP	1.379
30	A	Use of certified seed	1.379
28	A	Good protein-to-starch	1.306
5	A	Minimal chemicals	1.295
20	A	Less time in storage	1.295
17	A	Satisfactory field scouting	1.265
29	A	Good amylose-to-amylopectin	1.177
10	M	No specks in flour	1.136
18	A	Documented farm practices	1.091
15	M	Suitable grain hardness	1.076
6	M	No odours, taints or contamination	1.070
12	M	No excess *alpha*-amylase	1.008
27	A	Use of HACCP plan	0.985
3	M	Meets U.S. and EU laws	0.939
13	M	Suitable moisture content	0.917
26	M	Segregation included	0.909
25	M	Traceability provided	0.902
4	M	Disclosure of GMO	0.789
11	M	Good level of gluten	0.712
7	M	No foreign matter	0.636
19	A	Frequent shipments	0.545
24	M	Meets delivery conditions	0.545
23	M	Suitable price	0.530
9	M	Good extraction rate	0.250

Source: Compiled from author’s own research.

The four most highly ranked (WHATs) characteristics are all “Must be” qualities and all are in the 1.50 to 1.60 range (Table 6.8). This places them considerably higher than the next set of “Must be” qualities that range from 1.01 to 1.14. In fact, the ten characteristics ranked most highly (ranging between 1.14 and 1.50) are all “Attractive” qualities. What is most interesting is that these ten particular characteristics could, in fact, be treated as HOWs for achieving the four most highly valued WHATs. I.e. if these ten characteristics were provided, the four most highly valued WHATs would also be produced as a consequence. In true kaizen form, the emphasis was placed solely on quality; no sort of compromise (quality vs. cost) was included. But a significant strategic value emerges from use of the QFD tool combined with Kano’s perspective on “Must be” and “Attractive” qualities: Top management has a roadmap for introducing new quality features that most closely link customer satisfaction to operational product design in order to get the most business value out of the new features.

6.3.3 Analysis of HOWs by weight

Product characteristics and target values can also be ranked by weight (Table 6.9). If the relationship weights have been properly assigned, the most significant characteristics should appear at the top of the list. As seen in Table 6.9, the characteristics ranked most highly are those that are so important they simply cannot be ignored; without addressing them, the product would have serious defects. E.g. characteristic J (Minimum of diseased/shrivelled/heat-damaged/sprouted grain) carried the highest weight and characteristic D (Free from pathogens or mycotoxins) was ranked second highest. The third most highly ranked characteristic, A (Suitable match of protein to bread type), is a core requirement for successful breadmaking; ‘good protein’ ranks fifth and tenth highest.

While Table 6.9 shows overall weight for each product characteristic and its target value, an analysis of the characteristics based only on black circles (the strongest relationships) gives an indication of the most important production design elements for the grower (Table 6.10).
Of design characteristics with the strongest relationships (i.e. denoted by black circles) to customer requirements, the highest rank is on avoiding quality problems from kernels with defects. Suitable match of protein to bread type and Predictable varietal traits rank second and third, respectively. Protein-to-starch ratio ranks fourth and amylose-to-amylopectin ratio places fifth.

Table 6.9
Ranking HOWs by accumulated weight

HOW Characteristic		Weighted ranking	HOW Rank
J	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain	1.532	1
D	Free from pathogens or mycotoxins	1.468	2
A	Suitable match of protein levels to proper bread category	1.347	3
E	Usage of pesticides herbicides, fertilizers (type, amount, frequency) agreed in advance	1.323	4
Z_5	Good protein-to-starch ratio	1.319	5
I	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	1.315	6
Z_1	Choice of non-seed inputs agreed or mandated by customer	1.275	7
Z_3	Verify that health & safety practices are followed	1.242	8
G	No unusual odours, dampness or musty, mouldy wheat	1.233	9
Z_6	Good amylose-to-amylopectin ratio	1.216	10
S	Specific management practices agreed with miller	1.210	11
Y	Predictable varietal traits	1.194	12
B	No pre-blending or commingling of wheat without Miller's agreement	1.185	13
C	Regulations used match miller's and baker's market	1.145	14
P_3	Successful breadmaking tests	1.113	15
T	Written reports of field checks mandated by miller	1.105	16
F	Written records for pesticides, herbicides and fertilizers available for viewing	1.073	17
K	High test weight	1.073	18
R	Choice of tests mandated by miller with documented results	1.065	19
H	No contamination from delivery vehicle	1.048	20
Q	Grain hardness test results matched to flour strength	1.000	21
Z_4	Delivery timing, shipment quantity and price are suitable	0.992	22
X	Seed selection agreed or mandated by customer	0.976	23
Z_2	Price related to wheat quality characteristics	0.976	24
O	Moisture level that permits safe storage up to 12 months	0.952	25
V	Shorter storage time leading to better quality and lower costs	0.952	26
N	Suitable Hagberg FN test result	0.927	27
P_1	Successful flour rheology tests: Farinograph	0.919	28
P_2	Successful flour rheology tests: Alveograph	0.919	29
W	Disclosure of GMO	0.808	30
U	Shipments matched to production levels	0.685	31
L	Suitable ash content	0.661	32
M	Good results on gluten test	0.645	33

Source: Compiled from author's own research.

Table 6.10
Ranking HOWs by weight of black circles

HOW Characteristic		Weighted black circle
J	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain	0.960
A	Suitable match of protein levels to bread category:	0.903
Y	Predictable varietal traits	0.790
Z_5	Good protein-to-starch ratio	0.784
Z_6	Good amylose-to-amylopectin ratio	0.784
B	No pre-blending or commingling of wheat without Miller's agreement	0.734
D	Free from pathogens or mycotoxins	0.734
P_3	Successful breadmaking tests	0.734
S	Specific management practices agreed with miller	0.677
I	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	0.565
K	High test weight	0.508
N	Suitable Hagberg FN test result	0.508
G	No unusual odours, dampness or musty, mouldy wheat	0.467
W	Disclosure of GMO	0.467
H	No contamination from delivery vehicle	0.452
P_1	Successful flour rheology tests: Farinograph	0.452
P_2	Successful flour rheology tests: Alveograph	0.452
O	Moisture level that permits safe storage up to 12 months	0.395
Z_3	Verify that health & safety practices are followed	0.395
L	Suitable ash content	0.339
Q	Grain hardness test results matched to flour strength	0.339
V	Shorter storage time leading to better quality and lower costs	0.339
X	Seed selection agreed or mandated by customer	0.339
Z_1	Choice of non-seed inputs agreed or mandated by customer	0.292
C	Regulations used match miller's and baker's market	0.282
E	Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance	0.282
M	Good results on gluten test	0.282
R	Choice of tests mandated by miller with documented results	0.282
T	Written reports of field checks mandated by miller	0.282
F	Written records for pesticides, herbicides and fertilizers available for viewing	0.169
U	Shipments matched to production levels	0.113
Z_2	Price related to wheat quality characteristics	0.056
Z_4	Delivery timing, shipment quantity and price are suitable	0.056

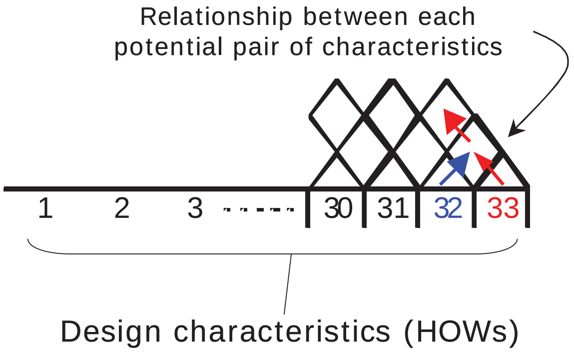
Source: Compiled from author’s own research

But, the concern of this thesis in relation to protein-to-starch ratio and amylose-to-amylopectin ratio (i.e. 'good protein') is whether or not defects in these ratios could enter the product. Naturally, intrinsic testing that includes the values for these two ratios would be one way to prevent faults. But, as a practical matter, the U.S. doesn't perform intrinsic testing, and wheat is commingled; although the French routinely perform intrinsic testing, protein-to-starch and amylose-to-amylopectin ratios are not part of those tests. Therefore, a question arises as to whether or not other product characteristics (i.e. one or more other HOWs) might be able to serve as surrogate benchmarks. In order to investigate this further, the correlations between HOWs need to be reviewed (Section 6.3.4).

6.3.4 Using the Correlation Matrix for analysis of protein qualities

The Correlation Matrix (or roof) of the House of Quality model (Figures 5.15 and 6.4) provides a useful tool to examine the relationships between HOWs. Each HOW is compared with every other HOW to determine the strength of the paired relationship. Figure 6.15 shows a generic portion of how the Correlation Matrix could be constructed to compare only two HOWs: characteristic numbers 32 (protein-to-starch ratio) and 33 (amylose-to-amylopectin ratio).

Figure 6.15
Correlation Matrix for HOWs



Source: Compiled from author's own research.

The red arrows show how amylose-to-amylopectin ratio would be considered first against protein-to-starch ratio (shown by the blue arrow). A black circle would be inserted in the diamond-shaped space (where red and blue arrows converge). The next step would be to consider whether a relationship exists with characteristic 31 (‘Delivery timing, shipment quantity and price are suitable’); after entering the appropriate symbol, then the next pair would be evaluated, and so forth until all possible combinations have been reviewed. In actual practice, the Correlation Matrix is built up to provide support for decisions to be made in QFD Phase II (Part Deployment). While quality is the primary goal in construction of matrices used in Phase I, there may be conflicting design goals, overlapping characteristics or design criteria that cannot be achieved in an early product version, or other constraints. Therefore, the roof matrix also serves as a tool to help product engineers determine stages for introduction of characteristics that need to be sequenced.

Development of the portion of the correlation matrix to show the relationship between protein-to-starch and amylose-to-amylopectin ratios and all the other design characteristics (HOWs) can be simplified. Product plan 2 includes protein-to-starch and amylose-to-amylopectin ratios, both as customer requirements (WHATs) and as design characteristics (HOWs). Therefore, the correlations between protein-to-starch (p-s) and amylose-to-amylopectin (a-a) ratios—the ‘good protein’ qualities—and the other characteristics have already been evaluated and appear in the relationship matrix for Product plan 2 (pages 7 to 9 of Figure 6.14). These correlations are reproduced in Table 6.11.

As Table 6.11 shows, there are twelve characteristics that would most strongly indicate good protein quality:

- Proper level of protein for bread type;
- No commingling of varieties;
- Free from pathogens or mycotoxins;
- No unusual odours, or musty/mouldy wheat;
- Minimal use of grain with defects;

Table 6.11
Correlation matrix for ‘good protein’ qualities

Nº	Item	Characteristic	p-s	a-a
1	A	Suitable match of protein levels to bread category	●	●
2	B	No pre-blending or commingling of wheat without Miller's agreement	●	●
3	C	Regulations used match miller's and baker's market	△	△
4	D	Free from pathogens or mycotoxins	●	●
5	E	Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance	○	○
6	F	Written records for pesticides, herbicides and fertilizers available for viewing	△	△
7	G	No unusual odours, dampness or musty, mouldy wheat	●	●
8	H	No contamination from delivery vehicle	○	○
9	I	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw	○	○
10	J	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain	●	●
11	K	High test weight		
12	L	Suitable ash content	○	
13	M	Good results on gluten and/or sedimentation tests	●△	●
14	N	Suitable Hagberg FN test result	●	●
15	O	Moisture level that permits safe storage up to 12 months		
16	P_1	Successful flour rheology tests: Farinograph	●	●
17	P_2	Successful flour rheology tests: Alveograph	●	●
18	P_3	Successful breadmaking tests	○	○
19	Q	Grain hardness test results matched to flour strength	●	●
20	R	Choice of tests mandated by miller with documented results	△	△
21	S	Specific management practices agreed with miller	○	○
22	T	Written reports of field checks mandated by miller	△	△
23	U	Shipments matched to production levels		
24	V	Shorter storage time leading to better quality and lower costs		
25	W	Disclosure of GMO	●	●
26	X	Seed selection agreed or mandated by customer	○	○
27	Y	Predictable varietal traits		
28	Z_1	Choice of non-seed inputs agreed or mandated by customer	●	●
29	Z_2	Price related to wheat quality characteristics	○	○
30	Z_3	Verify that health & safety practices are followed	△	△
31	Z_4	Delivery timing, shipment quantity and price are suitable	△	△
32	Z_5	Good protein-to-starch ratio	△̸	△̸
33	Z_6	Good amylose-to-amylopectin ratio	○̸	○̸

Source: Compiled from author’s own research.

- Good results on gluten/sedimentation tests;
- Suitable Hagberg FN test;
- Proper moisture content;
- Good Alveograph tests;
- Good level of grain hardness test;
- Disclosure of GMO (as most GMOs are based on altered proteins);
- Predictable varietal traits.

Essentially, all the characteristics could be achieved with healthy wheat in single variety (segregated, not commingled) lots with a declared variety (identity preserved). While intrinsic (end product) testing to verify variety would be an option, that would not have been necessary under the system envisioned by WTO in the Uruguay agreements: A declared variety protected under sufficient PVP laws should be able to be visually identified as representative of that variety. However, there would be (at least) two obstacles to relying on physical grading even of a single variety in the U.S. as there are now more than 30,000 varieties (compared with 50 to 80 in most other major wheat export countries). It simply isn’t feasible for an expert to be familiar with the physical characteristics of that many potential varieties. Secondly, the U.S. implementation of the PVP laws made no attempt to preserve the varietal characteristics – rather, PVP laws are treated as laws to protect the intellectual property of the breeder. Therefore, it seems unlikely that a physical inspection of U.S. wheat—even of a well-known and stated single variety—would consistently and correctly identify the specific variety. While the U.S. eschews intrinsic testing, it is the U.S. system that would seem to make it necessary if a buyer wants good protein qualities from a shipment of U.S. wheat.

Intrinsic testing could be used to prove that the good protein qualities exist. But this raises another issue. Satisfactory results on intrinsic tests are an example of controlling the end product; they aren't an example of good process management and control (GMPs/GAPs/GHPs), which form the basis for Codex guidelines and application of HACCP plans. Absent end product testing, could the processes be better managed and therefore, prevent these defects in protein quality?

6.3.5 Comparison of French and U.S. HOWs

While there is much that could be compared between the overall breadmaking wheat produced in the two countries, the most important HOWs in terms of this thesis are those that relate to protein quality. The (generic) importance of HOWs to protein quality in wheat was shown in Table 6.11. Appendix 6.C describes the comparison of the product characteristics (HOWs) and target values that were developed in Product plan 2 for wheat production in France and in the U.S.; this is summarized as Table 6.12.

Table 6.12
Comparison of French and U.S. wheat with HOWs and target values

Nº	Item	Target value	FR	US	Nº	Item	Characteristic (HOW)
1	A	Wheat protein content (14 percent moisture + 0.7 percent overhead:			1	A	Suitable match of protein levels to bread category:
	A_1	Soft French wheat of ~9.5 percent	X	Y		A_1	Artisan baguette
	A_2	Soft wheat of 9-10 percent	X	Y		A_2	Discounted 'soft' white, industrial
	A_3	Medium hard wheat of 10-11.0 percent	X	Y		A_3	Branded 'soft' white, industrial & CBP
	A_4	Hard wheat of 11.5-12 percent	X	Y		A_4	General purpose baking
	A_5	Hard wheat of 12.5 percent and above	X	Y		A_5	Competition and specialty
2	B	Single variety or binned delivery	X		2	B	No pre-blending or commingling of wheat without Miller's agreement
3	C	Product conforms to EU, US and laws in miller's market	X	Y	3	C	Regulations used match miller's and baker's market
4	D	Tests for pathogens and mycotoxins	X		4	D	Free from pathogens or mycotoxins

Continuation of Table 6.12

Nº	Item	Target value	FR	US	Nº	Item	Characteristic (HOW)
5	E	Use of pesticides, fertilizers, herbicides agreed in advance with customer			5	E	Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance
6	F	Documented use of pesticides, fertilizers, herbicides available for customer review	X		6	F	Written records for pesticides, herbicides and fertilizers available for viewing
7	G	Sanitary standards for wheat tested and documented	X	Y	7	G	No unusual odours, dampness or musty, mouldy wheat
8	H	Sanitary standards for all equipment tested and documented	X	Y	8	H	No contamination from delivery vehicle (or other farm equipment)
9	I	In a 100 gram sample: Impurities not to exceed 2.	X		9	I	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw
10	J	In a 100 gram sample: Broken kernels not to exceed 4; sprouted not to exceed 2.	X		10	J	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain
11	K	-- 70 kg/hl for soft (and biscuit) wheat; -- 80 kg/hl for bread wheat	X	Y	11	K	High test weight
12	L	≤ 0.5 percent ash content	X		12	L	Suitable ash content
13	M	≥ Zeleny Index of 25 ml	X		13	M	Good results on gluten test
14	N	≥ 250 seconds	X	▨	14	N	Suitable Hagberg FN test result
15	O	≤ 15 percent moisture content	X	Y	15	O	Moisture level that permits safe storage up to 12 months
16	P_1	Trial milling to match test standards; Hydration: amount of water added in relation to dough of 14 percent; Degree of softening in Fus; Stability expressed in minutes	X	▨	16	P_1	Successful flour rheology tests: Farinograph
17	P_2	Trial milling to match test standards; Baking strength (W); Degree of extensibility of dough (G); Balance between tenacity and extensibility (P/L)	X		17	P_2	Successful flour rheology tests: Alveograph
18	P_3	Hydration: amount of water added to reach dough of 14 percent; Volume in cm^3; Composite score based on suitable system for customer	X		18	P_3	Successful breadmaking tests
19	Q	On the AACC scale of 1 to 100: -- 25 for soft (and biscuit) wheat; -- 75 for (hard) bread wheat.	X		19	Q	Grain hardness test results matched to flour strength
20	R	Negotiate tests with customer			20	R	Miller mandates choice of tests with documented results

Continuation of Table 6.12

Nº	Item	Target value	FR	US	Nº	Item	Characteristic (HOW)
21	S	Documented practices; specific practices to be agreed with customer	X		21	S	Specific management practices agreed with miller
22	T	Documented field reports; negotiate specific practices and format with customer	X		22	T	Written reports of field checks mandated by miller
23	U	Collect miller production data; negotiate shipments with customer			23	U	Shipments matched to production levels
24	V	Storage not to exceed 6 months	X		24	V	Shorter storage time leading to better quality and lower costs
25	W	Tests for GMO	X		25	W	Disclosure of GMO
26	X	Negotiate seed selection with customer			26	X	Seed selection agreed or mandated by customer
27	Y	Use of certified seed and identity preservation	X		27	Y	Predictable varietal traits
28	Z_1	Negotiate non-seed inputs with customer			28	Z_1	Choice of non-seed inputs agreed or mandated by customer
29	Z_2	Develop scale relating price and quality; discuss with customer			29	Z_2	Price related to wheat quality characteristics
30	Z_3	Document health & safety practices; discuss with customer	X		30	Z_3	Verify that health & safety practices are followed
31	Z_4	Negotiate deliveries, quantities and price with customer			31	Z_4	Delivery timing, shipment quantity and price are suitable
32	Z_5	Varietal selection has good protein-to-starch and amylose-to-amylopectin ratios			32	Z_5	Good protein-to-starch ratio
33	Z_6	Practice management during Growing phase to avoid stress to plants that could result in altered protein or starch			33	Z_6	Good amylose-to-amylopectin ratio

Legend:
X = French data; wheat growers comply.
Y = U.S. data; wheat growers comply.
Shading with an X or Y = substantially comply, but with some exceptions.
Shading only (without an X or Y) = Growers could probably comply, but no currently reported data.
Blank space = no form of compliance found.

Source: Compiled from author's own research.

6.3.5.1 Comparison of French and U.S. protein quality characteristics

If the characteristics (in Table 6.11) related to protein quality characteristics were sorted by strength of relationship, and the French and U.S. data (from Table 6.12) were added to the diagram, the results would be as shown in Figure 6.16. Black circles indicate the characteristics with the strongest link to good protein; white circles have a medium-strong relationship; white triangles have a weak relationship; and blank spaces have no relationship.

As page one of Figure 6.16 shows, the French wheat conforms to the most important characteristics that indicate good protein. The U.S. conforms in terms of protein quantity, but protein quality characteristics are largely unknown, or possibly ignored. Both countries' producers are unlikely to make agreements directly with customers (items E, X, Z_1, R, Z_2, Z_4 and U) except in cases of contract production.

Figure 6.16
Comparison of good protein to French and U.S. HOWs

HOW	Target value	Rating in table 9.12	No conformance	Likely conforms	Partially conforms	Conforms	Description of HOW characteristic
A	Wheat protein content (14 percent moisture + 0.7 percent overhead:	●				X Y	Suitable match of protein levels to bread category:
A_1	Soft French wheat of ~9.5 percent	●				X Y	Artisan baguette
A_2	Soft wheat of 9-10 percent	●				X Y	Discounted 'soft' white, industrial
A_3	Medium hard wheat of 10-11.0 percent	●				X Y	Branded 'soft' white, industrial & CBP
A_4	Hard wheat of 11.5-12 percent	●				X Y	General purpose baking
A_5	Hard wheat of 12.5 percent and above	●				X Y	Competition and specialty
B	Single variety or binned delivery	●	Y			X	No pre-blending or commingling of wheat without Miller's agreement
D	Tests for pathogens and mycotoxins	●		Y		X	Free from pathogens or mycotoxins
G	Sanitary standards for wheat tested and documented	●			Y	X	No unusual odours, dampness or musty, mouldy wheat
J	In a 100 gram sample: Broken kernels not to exceed 4; sprouted not to exceed 2.	●	Y			X	Minimum of diseased or shrivelled grain; minimum of heat-damaged or sprouted grain
M	≥ Zeleny Index of 25 ml	●	Y			X	Good results on gluten and sedimentation test
N	≥ 250 seconds	●		Y		X	Suitable Hagberg FN test result
O	≤ 15 percent moisture content	●				X Y	Moisture level that permits safe storage up to 12 months
P_2	Trial milling to match test standards; Baking strength (W); Degree of extensibility of dough (G); Balance between tenacity and extensibility (P/L)	●	Y			X	Successful flour rheology tests: Alveograph
Q	On the AACC scale of 1 to 100: - 25 for soft (and biscuit) wheat and 75 for (hard) bread wheat.	●	Y			X	Grain hardness test results matched to flour strength
W	Tests for GMO	●	Y			X	Disclosure of GMO
Y	Use of certified seed and identity preservation	●	Y			X	Predictable varietal traits

Figure 6.16 (page 2)
Comparison of good protein to French and U.S. HOWs

HOW	Target value	Rating in table 9.12	No conformance	Likely conforms	Partially conforms	Conforms	Description of HOW characteristic
C	Product conforms to EU, US and laws in miller's market	O			Y	X	Regulations used match miller's and baker's market
E	Use of pesticides, fertilizers, herbicides agreed in advance with customer	O	X Y				Usage of pesticides, herbicides, fertilizers (type, amount, frequency) agreed in advance
H	Sanitary standards for all equipment tested and documented	O			Y	X	No contamination from delivery vehicle (or other farm equipment)
I	In a 100 gram sample: Impurities not to exceed 2.	O	Y			X	No string, paper, nails, stones, no infestation from insects or mice; no weeds or straw
K	70 kg/hl for soft (and biscuit) wheat and 80 kg/hl for bread wheat	O				X Y	High test weight
P_1	Trial milling to match test standards; Hydration: amount of water added in relation to dough of 14 percent; Degree of softening in FUs; Stability expressed in minutes	O		Y		X	Successful flour rheology tests: Farinograph
P_3	Hydration: amount of water added to reach dough of 14 percent; Volume in cm^3; Composite score based on suitable system for customer	O	Y			X	Successful breadmaking tests
S	Documented practices; specific practices to be agreed with customer	O	Y			X	Specific management practices agreed with mille
X	Negotiate seed selection with customer	O	X Y				Seed selection agreed or mandated by customer
Z_1	Negotiate non-seed inputs with customer	O	X Y				Choice of non-seed inputs agreed or mandated by customer
F	Documented use of pesticides, fertilizers, herbicides available for customer review	△	Y			X	Written records for pesticides, herbicides and fertilizers available for viewing
L	≤ 0.5 percent ash content	△	Y			X	Suitable ash content
R	Negotiate tests with customer	△	X Y				Choice of tests mandated by miller with documented results
T	Documented field reports; negotiate specific practices and format with customer	△	Y			X	Written reports of field checks mandated by miller

Figure 6.16 (page 3)
Comparison of good protein to French and U.S. HOWs

HOW	Target value	Rating in table 9.12	No conformance	Likely conforms	Partially conforms	Conforms	Description of HOW characteristic
Z_2	Develop scale relating price and quality; discuss with customer	△	X Y				Price related to wheat quality characteristics
Z_3	Document health & safety practices; discuss with customer	△	Y			X	Verify that health & safety practices are followed
Z_4	Negotiate deliveries, quantities and price with customer	△	X Y				Delivery timing, shipment quantity and price are suitable
U	Collect miller production data; negotiate shipments with customer		X Y				Shipments matched to production levels
V	Storage not to exceed 6 months		Y			X	Shorter storage time leading to better quality and lower costs

Source: Compiled from author's own research.

6.4 Chapter summary

As the figures, tables and discussion showed in this section, wheat with less than optimal protein quality can enter the market. This is largely the case when intrinsic testing isn't used. However, even without intrinsic testing, the likelihood of such grain being sold can be reduced through choice of variety, maintaining varietal purity and including practices to support identity preservation (IP). Although IP might only be under the grower's control up to the point of the (first) grain elevator, choice of variety is part of the grower's own production management practices. Even though choice of variety very strongly influences the resulting grain protein quality, other production management practices also have an effect. Two of these practices are discussed in Chapter seven.

Chapter 7

HACCP and VSM models of French and U.S. wheat production processes

Chapter 7

HACCP and VSM models of French and U.S. wheat production processes

7.1 Evaluating wheat production practices

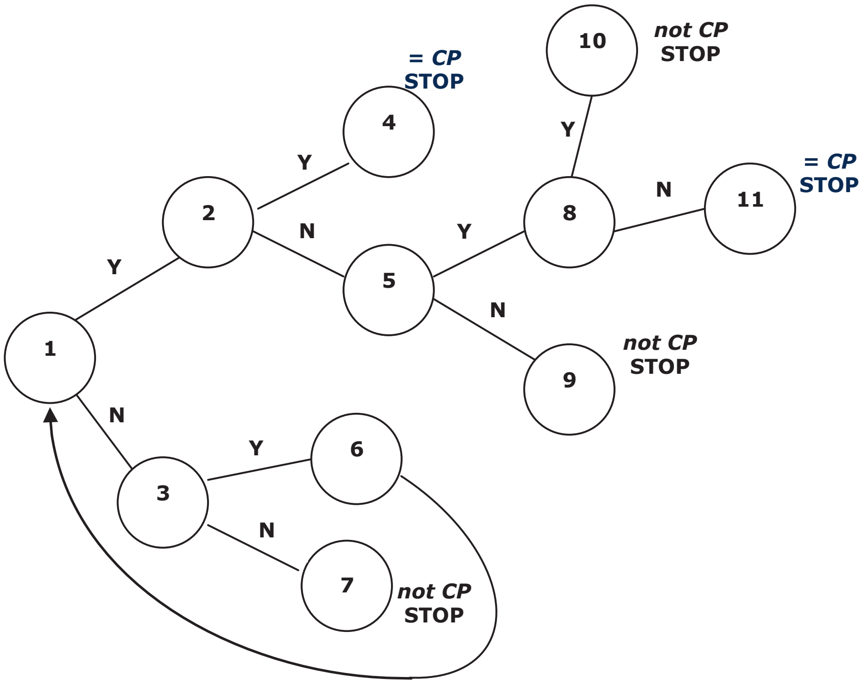
Gemba is "where value is added. In manufacturing it usually means the shop floor" (Imai 1997). Although selecting wheat variety (Figure 5.27) is one of the production management activities, the visible 'manufacturing' of the crop occurs during the Growing phase (Figures 5.29 and 5.30). Nevertheless, planning of materials needed for production as well as managing continuous-flow operations processes are just as important in wheat growing as to managers in any other manufacturing enterprise. Section 7.2 concentrates on the issues involved in wheat seed selection in relation to potential protein quality defects. Section 7.3 discusses how processes can be measured and modelled based on the Zadoks scale of wheat development. Particular attention is paid to the wheat plant's growing stages that involve protein quality characteristics. Nitrogen is strongly associated with protein quantity, and quality characteristics, in the wheat harvest. Sections 7.3.5 and 7.3.6 show how management practices in nitrogen fertilization can result in improvements/defects in protein quantity and quality.

7.2 Using HACCP decision process model to compare processes

Figure 2.6 introduced the HACCP decision process for CCPs as a network diagram. There are strict rules of HACCP regarding use of CCPs; they're reserved only for prevention of the three main conventional hazards (biological, chemical and physical contamination). Therefore, Control points (CPs) have been substituted for CCPs (Figure 7.1). HACCP operates as a type of 'pruning' algorithm. Each task in the process or set of work instructions can be tested in the following manner:

- Each link in the HACCP diagram represents an answer to the question of how the process/task is performed. A link could carry a value of Y (yes, performing the task this way is a 'best practice' or GMP/GAP/GHP) or a value of N (no, it is not a GMP/GAP/GHP and could cause a product defect).
- As each link is 'traversed' (i.e. considered), it is either cut (pruned) or generates a new traversal. This continues until one of the endpoints is reached (i.e. nodes 4, 7, 9, 10 or 11), shown as STOP points in Figure 7.1.

Figure 7.1
HACCP decision process for GMPs/GAPs/GHPs



Source: Compiled from author's own research.

7.2.1 Testing use of GMPs/GAPs/GHPs in processes with HACCP model

The HACCP decision process is comprised of four questions. Each of the tasks or work instructions (WIs) in the process can be tested against the following four questions (Qs):

1 Is the work instruction associated with a control point (CP)? [This is Node 1. If Y, then → Q2; if N, then → Q1.1]

  1.1 Is control at this step necessary to prevent a detrimental quality characteristic? [This is Node 3. If Y, then → Q1.1.1; if N, then → Node 7 and STOP.]

    1.1.1 If step is necessary to prevent a detrimental quality characteristic, then modify (i.e. prevent through use of GMP/GAP/GHP) the WI, process or product. [This is Node 6, and begins an iterative process that returns to Node 1 and Q1.]

2 If the WI was specifically inserted (as a CP) to eliminate a likely occurrence of a detrimental quality characteristic, does it eliminate it? [This is Node 2. If Y → Node 4 and STOP but log this as a CP; and if N then → Q3.]

3 Could the WI contribute to a detrimental quality characteristic in excess of an acceptable level or could it increase a tolerable level to unacceptable levels? [This is Node 5. If Y, then → Q4; and if N → Node 9 and STOP.]

4 Will a subsequent step eliminate the identified detrimental quality characteristic or reduce its likely occurrence to an acceptable level? [This is Node 8. If Y, then → Node 10 and STOP; and if N → Node 11 and STOP but log this as a CP.]

Arriving at Nodes 4 or 11 requires a review of the WI to see if it could be redesigned using a GMP/GAP/GHP to eliminate using it as a CP to prevent the potential link to the detrimental quality characteristic. After the redesign, the evaluation process for the revised WI starts again at Q1 (Node 1).

7.2.2 Ranking the likelihood of a defect related to each HACCP traversal

It can be seen in Figure 7.1 that there are six possible ‘branches’ or traversals. Each of these carries a varying degree of likelihood to be associated with the defective quality characteristic under consideration. These branches, though, could be ranked based on ‘least likely’ to ‘most likely’ of being associated with the potential failure (Table 7.1).

Table 7.1
Ranking HACCP decision ‘branches’ from least to most likely link to failure

Node Path	Link Decisions	Endpoint	Comment	Risk
1-2-4	Y - Y	4	Likelihood of failure identified and addressed.	1
1-3-6	N – Y - loop	6	Work in progress; no decision yet.	2
1-3-7	N - N	7	No association with health quality characteristics; initial decision is critical to outcome.	3
1-2-5-9	Y – N - N	9	Initial decision was that likelihood exists; decision at Node 5 is critical to outcome and estimates likely degree of risk.	4
1-2-5-8-10	Y – N – Y - Y	10	Likelihood is certain but will be eliminated by a subsequent step.	5
1-2-5-8-11	Y – N – Y - N	11	Likelihood is certain and will NOT be eliminated by a subsequent step; requires a redesign.	6

Source: Compiled from author’s own research.

As Table 7.1 shows, the path from Node 1 to 4 carries the lowest degree of risk; as the comment shows, the potential cause of failure was identified and eliminated. The path from Node 1 to 11 (at the bottom of the table) carries the highest degree of risk, and in fact, the failure is a certainty. Therefore, any WI connected to the path from Node 1 to 11 must be corrected and re-evaluated. The path from Node 1 to 7 might appear to be rated ‘unfairly’ with a 3, but the underlying issue is that this decision path refers to a task that has more or less been accepted at face value, and not reworked. Therefore it does carry some hidden risk of the unknown.

7.2.3 Modelling the U.S. version of "Choose wheat seed" with HACCP

This section describes how the evaluation system (Table 7.1) can be applied to a comparison of the "Choose wheat seed" process in relation to impacting protein quality in France and the U.S. The tasks for "Choose wheat seed" in the U.S. might appear as seen in Table 7.2.

Table 7.2
Tasks related to U.S. version of "Choose wheat seed"

Choose wheat seed
1. Review seed catalogues
2. Review data from extension services
3. Discuss with farm-neighbours; visit to 'open field' days
4. Check quantity and viability of saved seed from last crop
5. Determine 3-4 varieties for new crop
6. Purchase quantities needed of new seed
7. Clean and prepare saved seed for use

Source: Compiled from author's own research based on literature from KSU Extension Service (1997).

Note: Although it doesn't appear that any CP exists in the tasks shown in Table 7.2, there is an implicit CP in the form of physical inspection by the USDA's grain inspectors in order to sell the product. So it could be assumed that the seven tasks have one associated CP prior to the redesign of the tasks (Section 7.2.4).

7.2.4 Redesign of U.S. version of "Choose wheat seed"

HACCP Q4 asks if any subsequent step will eliminate/reduce the potential source(s) of failure. In order to address Q4, the potential sources of protein quality failure related to "Choose wheat seed" first need to be identified (Table 7.3). During the HACCP decision process, each of the tasks (Table 7.2) is compared with the potential types of failure (Table 7.3). E.g. 'Task 1 Review seed catalogues' is checked against each of the six possible causes of failure but the task cannot be associated with a potential failure and the HACCP path traversed is from Node 1 to Node 3 to Node 7, resulting in an assigned ranking of '3' and no need to consider redesigning the task for eliminating/reducing risk of failure.

Table 7.3
Potential sources of failure related to "Choose wheat seed"

Potential causes of protein quality defects
1) Genetics are responsible for a third of the wheat variety's 'good protein' qualities (i.e. good* protein-to-starch and amylose-to-amylopectin ratios); the chosen wheat variety's intrinsic characteristics must meet criteria of 'good protein'.
2) Weather is responsible for a third of the wheat variety's 'good protein' qualities; the chosen wheat seed must match the expected weather conditions and climate.
3) Agronomic practices are responsible for a third of the wheat variety's 'good protein' qualities; chosen seed must fit grower's agronomic practices, or the grower must adapt to variety.
4) Varietal characteristics may not be preserved with wheat that is not grown from certified seed.
5) Regulations for 'certified seed' vary from one location to another.
6) Farmer saved seed might not be properly cleaned and/or treated; varietal traits might not remain true to the genotype. Varieties may be mixed[1].

Source: Compiled from author's own research.

When all of the tasks have been considered, the summary of results is an initial set of ratings for the tasks (Table 7.4).

Table 7.4
Ranking of risk in tasks related to U.S. version of "Choose wheat seed"

Choose wheat seed	Path	Decision	Rank	Need redesign
1. Review seed catalogues	1-3-7	N-N	3	No
2. Review data from extension services	1-3-7	N-N	3	No
3. Discuss with farm-neighbours; visit 'open field' days	1-3-7	N-N	3	No
4. Check quantity and viability of saved seed from last crop	1-2-5-8-11	Y-N-Y-N	6	Yes
5. Determine 3-4 varieties for new crop	1-2-5-8-10	Y-N-Y-Y	5	Yes
6. Purchase quantities needed of new seed	1-2-5-8-11	Y-N-Y-N	6	Yes
7. Clean and prepare saved seed for use	1-2-5-8-11	Y-N-Y-N	6	Yes

Source: Compiled from author's own research.

7.2.5 Identifying tasks for redesign to eliminate/reduce potential causes of failures

As Table 7.4 showed, Tasks 1 through 3 are not likely to be related to potential causes of protein quality failure, but the rest of the tasks need to be reconsidered:

---

[1] This source of potential failure was added by Dr. L. Bona during validation of agronomic practices.

Task 4 concerns use of farmer saved seed and is connected to potential failures from items 4) and 6) in Table 7.3. Task 4 raises questions about potential connections to the protein quality characteristics. Therefore, when Task 4 is checked against the initial question at Node 1, the answer is 'Yes.' This leads to the second question (Q2) at Node 2 that asks if Task 4 was specifically inserted as a CP for the process. The answer to Q2 is 'No' so this leads to Q3 at Node 5 (*Could the task contribute to a protein quality characteristic in excess of an acceptable level or could it increase to unacceptable levels?*). The answer here is possibly 'Yes'—i.e. it cannot be an unequivocal 'No' so it is assigned 'Yes'. This leads to Node 8 and Q4 (*Will a subsequent step eliminate the identified protein quality characteristic or reduce its likely occurrence to an acceptable level?*). Since the answer to Q4 is 'No,' this leads to Node 11; the procedure for Task 4 needs to be reviewed and, if possible, redesigned using a GMP/GAP/GHP to eliminate the potential risk of the protein quality characteristic. If this cannot be done, the task should be treated as a CP or another task should be inserted as a CP.

Task 5 concerning choice of 3 or 4 varieties is not clear whether potential failures from items 1), 2), 3) and 5) (in Table 7.3) are related. The grower may have already determined the 'less risky' varieties to grow. However, there are increased risks associated with multiple varieties due to the increased agronomic knowledge required. As a result, Task 5 needs to be reconsidered, as well.

Task 6 regarding the actual purchase of new seed could be connected to potential failures from items 4) and 5)--and assuming items 1) through 3) were already safely addressed.

Task 7 regarding cleaning and treatment for farmer saved seed can be connected to potential failures from items 4) and 6). But indirectly, there are also connections to items 1) through 3) because it isn't certain which intrinsic characteristics the seed will retain.

7.2.6 Redesigning the tasks to eliminate/reduce potential failures

The six types of potential failures (Table 7.3) can be addressed through the use of GMPs/GAPs/GHPs. All of the six potential types of failures impacting protein quality can be addressed via five GMPs/GAPs/GHPs (Table 7.5).

Table 7.5
GMPs/GAPs/GHPs for "Choose wheat seed"

GMPs/GAPs/GHPs
(A) Require variety with good protein quality characteristics (proven through intrinsic tests)
(B) Require certified seed
(C) Require seed testing in nationally certified laboratory
(D) Use clean seed (free from pathogens and mixed wheat strains) and use treated seed
(E) Require certified seed cleaner

Source: Compiled from author's own research.

7.2.7 Redesign and insertion of new task related to Task 4

Item (A) of the five GMPS/GAPs/GHPs (Table 7.5), can be inserted as an addendum to Task 4 to specifically address the potential failures (discussed in Section 7.2.5). This would result in a Task 4a being added (i.e. *"Determine that seed represents a variety with good protein quality characteristics*). The next step is to check that Task 4a would prevent poor quality protein characteristics. So starting again at Node 1, and using Task 4a, it can be seen that the decision path would be from Node 1 to Node 2 to Node 4 (where it would be listed as a CP). The revised version of Task 4 (i.e. Task 4rev) is then checked; its new path ends at Node 10 and indicates that while the task could be associated with an unfavourable protein characteristic, the insertion of Task 4a has already solved the issue.

7.2.8 Balance of task revisions

Task 5 was the decision of which three to four varieties should be grown. Like Task 4rev, the potential relationship to protein quality characteristics from Task 5 can be solved through the CP established as Task 4a.

Task 6 has to do with the purchase of new seed. While Task 4a prevents the choice of a variety that doesn't represent good protein quality, there can still be a problem if the farmer doesn't buy certified seed. Therefore, Task 6 would also need to be revised to include Item (B) of the five GMP/GAP/GHPs (Table 7.5). So Task 6a (i.e. *"Determine that seed is certified"*) gets added as a CP to fit with Task 6rev. But when Task 6a is itself checked against the HACCP decision process, it turns out that another CP should be added to address the fact that regulation of seed certification varies from state to state in the U.S. Therefore, this is addressed by requiring that certification must mean that it was awarded from a nationally certified laboratory, or Item (C) of the five GMP/GAP/GHPs. This doesn't require an independent CP but rather a slight addition to Task 6rev (i.e. *"Determine that seed is certified* ***by a nationally certified laboratory****"*).

Task 7 concerns the cleaning of farmer -saved seed. Some U.S. states require that seed be cleaned professionally; others do not. Therefore, the Items (D) and (E) of the five GMPs/GAPs/GHPs need to be added as a CP for Task 7. This addition (i.e. *"Determine that seed is cleaned and treated professionally by certified agent and is tested as being free of pathogens"*) becomes Task 8.

The revised set of tasks for the U.S. version of "Choose wheat seed" is shown in Table 7.6. After all revisions, 10 tasks remain with a total of 33 points versus seven tasks and 32 points at the outset. This results in an average 'risk ranking' per task of 3.3 after the revisions compared with 4.6 per task at the outset.

Table 7.6
Revised ranking of risk in tasks related to U.S. version of "Choose wheat seed"

Choose wheat seed	Path	Decision	Rank	Is a CP?
1. Review seed catalogues	1-3-7	N-N	3	No
2. Review data from extension services	1-3-7	N-N	3	No
3 Discuss with farm-neighbours; visit 'open field' days	1-3-7	N-N	3	No
4a. Determine that seed represents a variety with good protein quality characteristics	1-2-4	Y-Y	1	Yes
4rev. Check quantity and viability of saved seed from last crop + (A), (D) and (E)	1-2-5-8-10	Y-N-Y-Y	5	No
5. Determine 3-4 varieties for new crop	1-2-5-8-10	Y-N-Y-Y	5	No
6a. Determine that all seed used is certified by a nationally certified laboratory = (C)	1-2-4	Y-Y	1	Yes
6rev. Purchase quantities needed of new seed + (B)	1-2-5-8-11	Y-N-Y-N	6	Yes
7rev. Clean and prepare saved seed for use + (D) and (E)	1-2-5-8-10	Y-N-Y-Y	5	No
8. Determine that seed is cleaned and treated professionally by certified agent and is tested as being free of pathogens = (D) + (E)	1-2-4	Y-Y	1	Yes

Source: Compiled from author's own research

7.2.9 The French version of "Choose wheat seed"

The French version of "Choose wheat seed" appears in Table 7.7.

Table 7.7
French version of "Choose wheat seed"

0) Determine market target type	5) Determine single best variety for new crop
1) Review seed catalogues	6) Check quantity, viability and varietal suitability of saved seed from last crop
2) Review data from prior crop's intrinsic testing	7) Check with INRA re quality of seed and preservation of varietal traits in saved seed
3) Discuss with fellow co-op members and customers (bakers, millers and animal feed buyers)	8) Purchase quantities needed of new certified seed
4) Review with crop scientists and human/animal health researchers from ARVALIS, ONIGC and INRA	9) Clean and prepare saved seed for use in conformance with INRA advice.

Source: Compiled from author's own research based on literature from ARVALIS and ONIGC (2000).

There is no table of suggested GMPs/GAPs/GHPs because the CPs that needed to be added to the U.S. version (Sections 7.2.7 and 7.2.8) already exist in the French version (Table 7.7). In several cases the CPs precede the task that they control. This would tend to show that the

French growers are focused on preventing defects in the protein quality characteristics through good process management.

The difference in approach compared with the U.S. can also be seen when the HACCP evaluation of each French task is performed (Table 7.8). There are no revisions required; nearly every task includes an element that addresses the potential of defects in protein quality characteristics. There are 10 tasks and a total of 16 points resulting in an average 'risk ranking' of 1.6 per task.

Table 7.8
Results of evaluation of French version of "Choose wheat seed"

Task	Path	Results	Rank	No. of revisions	CPs
0	1 – 3 - 7	N- N	3		0
1	1 – 3 - 7	N- N	3	0	0
2	1 – 2 – 4	Y - Y	1	0	1
3	1 – 3 - 7	N- N	3	0	0
4	1 – 2 – 4	Y – Y	1	0	1
5	1 – 2 – 4	Y - Y	1	0	1
6	1 – 2 – 4	Y - Y	1	0	1
7	1 – 2 – 4	Y - Y	1	0	1
8	1 – 2 – 4	Y – Y	1	0	1
9	1 – 2 – 4	Y – Y	1	0	1
			Total results:	None	7

Source: Compiled from author's own research.

7.2.10 Comparison of the U.S. and French versions of "Choose wheat seed"

A comparison of the U.S. and French performance of the "Choose wheat seed" process can be seen in Table 7.9. The differences are revealing. The set of U.S. tasks required six revisions just to eliminate the more obvious links to potential wheat quality defects (identified in Table 7.3); other links are likely to exist but would require more thorough research to identify them. Even though the redesign raised the ratio of CPs per task from 0.14 to 0.40, overall it seems the U.S. set of tasks appear less reliable (or stable) than the

French. This is particularly clear in the comparison of 'risk ranking' per task (Table 7.9). (Highlighting in Table 7.9 shows increased risk; light yellow indicates the stability of the French process compared to the U.S. Dark yellow shows the dramatic difference in risk ranking that remains even after significant improvement in the U.S. process).

Table 7.9
Performance comparison of "Choose wheat seed"

Characteristic of performance	U.S.	France
Number of tasks at outset/end	7/10	10/10
Number of revisions needed	6	0
Number of CPs at outset/end	1/4	7/7
CPs-per tasks at outset/end	0.14/0.40	0.70/0.70
'Risk ranking' per task at outset/end	4.6/3.3	1.6/1.6

Source: Compiled from author's own research.

While the longer-term goal is to eliminate as many CPs as possible (through use of more GMPs/GAPs/GHPs), in the short term they help to reduce process variance by drawing attention to specific benchmarks that must be obtained. Thus, usage is linked to how well each process is (measurably) performed.

7.3 Development of VSM models of production processes

This section describes some places in the wheat Growing phase that could affect the formation of good protein quality in the grain. While choice of wheat variety is the larger factor, practice management also plays a role.

7.3.1 Measuring wheat plant development

Three scales representing wheat plant development are in use: Zadoks, Feekes and Haun (highlighted in green, beige and blue, respectively, in Table 7.10). Each was developed for a specific purpose: 1) Feekes was intended to identify optimum stages for chemical treatments;

2) Haun scale emphasizes leaf development; 3) Zadoks scale provides the most complete description of wheat plant growth stages (Fowler 2002).

Table 7.10
Comparison of wheat development scales

Zadok Scale	Feekes Scale	Haun Scale	Description
			Germination
00			Dry seed
01			Start of imbibition
03			Imbibition complete
05			Radicle emerged from seed
07			Coleoptile emerged from seed
09			Leaf just at coleoptile tip
		0.0	**Seedling growth**
10	1		First leaf through coleoptile
11		1.+	First leaf unfolded
12		1.+	2 leaves unfolded
13		2.+	3 leaves unfolded
14		3.+	4 leaves unfolded
15		4.+	5 leaves unfolded
16		5.+	6 leaves unfolded
17		6.+	7 leaves unfolded
18		7.+	8 leaves unfolded
19			9 or more leaves unfolded
			Tillering
20			Main shoot only
21	2		Main shoot and 1 tiller
22			Main shoot and 2 tillers
23			Main shoot and 3 tillers
24			Main shoot and 4 tillers
25			Main shoot and 5 tillers
26	3		Main shoot and 6 tillers
27			Main shoot and 7 tillers
28			Main shoot and 8 tillers
29			Main shoot and 9 or more tillers
			Stem Elongation
30	4-5		Pseudo stem erection
31	6		1st node detectable
32	7		2nd node detectable
33			3rd node detectable
34			4th node detectable
35			5th node detectable
36			6th node detectable
37	8		Flag leaf just visible
39	9		Flag leaf ligule/collar just visible
			Booting
40			-
41		8-9	Flag leaf sheath extending
45	10	9.2	Boots just swollen

Continuation of Table 7.10

Zadok Scale	**Feekes Scale**	**Haun Scale**	**Description**
47			Flag leaf sheath opening
49		10.1	First awns visible
			Inflorescence emergence
50	10.1	10.2	First spikelet of inflorescence visible
53	10.2		1/4 of inflorescence emerged
55	10.3	10.5	1/2 of inflorescence emerged
57	10.4	10.7	3/4 of inflorescence emerged
59	10.5	11.0	Emergence of inflorescence completed
			Anthesis
60	10.51	11.4	Beginning of anthesis
65		11.5	Anthesis half-way
69		11.6	Anthesis completed
			Milk development
70			-
71	10.54	12.1	Kernel watery ripe
73		13.0	Early milk
75	11.1		Medium milk
77			Late milk
			Dough development
80			-
83		14.0	Early dough
85	11.2		Soft dough
87		15.0	Hard dough
			Ripening
90			-
91	11.3		Kernel hard (difficult to divide with thumbnail)
92	11.4	16.0	Kernel hard (no longer dented with thumbnail)
93			Kernel loosening in daytime
94			Overripe, straw dead and collapsing
95			Seed dormant
96			Viable seed giving 50% germination
97			Seed not dormant
98			Secondary dormancy induced
99			Secondary dormancy lost

Source: Compiled from author's own research based on Zadoks, *et al*. 1974; KSU 1997; Stapper 2007.

Wheat experts in various parts of the world have developed various measurement tools based on the Zadoks Decimal Scale. From literature search, it appears that the bulk of research, though, has been devoted to using the Z-scale in diagnosing specific problems. The range of applications found in the literature extended from a computerized decision support tool (Stöckle and Debaeke 1996) to a guide designed for measuring nitrogen uptake and comparison of application methods developed by INRA in France (David *et al*. 2006; Jeuffroy 2002) to the development of a web application from Virginia Polytechnic University for checking impact of temperature on wheat growth (Thomason et al, 2004). The work of Stapper and Fischer seems to have been the most extensive toward defining an entire practice management system (for the wheat Growing phase) using Zadoks' system as benchmarks, and then creating a collection of simple measurements to guide application of management practices (Stapper and Fischer 2007, 1990, 1986). Much of their work has been adopted by the International Maize and Wheat Improvement Center (CIMMYT) in Mexico – the FAO's site for grain breeding, experiments and testing. One of the reasons for this is likely to be the simple and inexpensive test methodology that Stapper and Fischer designed. [2]

One can see (from Table 7.10) how the scales differ from one another, especially at key stages in the plant's development (e.g. Zadoks Tillering stages Z20 to Z30 are barely represented in Feekes and not addressed by Haun). Advisers to U.S. wheat growers mostly use the Feekes scale while advisers to French wheat growers use Zadoks. Despite differences in choice of scale, growers in both France and the U.S. would agree that, "Tillering is essential for productivity" (KSU 2002).

Tiller development plays a crucial role in grain yield and in grain quality. Tillering is "an important determinant of grain yield" (Virginia State Extension Service 2004); other agronomic experts agree (Stapper 2007; Rawson 2000; Stapper and Fischer 1990). Tiller development occurs between Zadoks stages Z00 to Z30. The ending stages of tiller development initiate the critical source and sink process that occurs between Z39 to Z65. This is also the stage of wheat plant development that is critical to protein quality characteristics in the grain.

---

[2] With the helpful advice from the Industry thesis advisor (S. Cauvain), the work of Stapper and Fischer was used as the basis for VSM models of crop measurement and management practices in this chapter.

7.3.2 Development of nutritional source-to sink-in wheat

The wheat plant—through the development of a system of ‘source’ and ‘sink’—captures carbon dioxide with solar energy in the plant’s greenery (source) and through photosynthesis, synthesizes carbohydrates and nutrients for final deposit in the grain kernels (sink).

7.3.2.1 Significance of tiller development stage

Tiller development plays a crucial role in grain yield and in grain quality. Tillering is “an important determinant of grain yield” (Virginia State Extension Service 2004); other agronomic experts agree (Stapper 2007; Rawson 2000; Stapper and Fischer 1990).

7.3.2.2 Key stages for nutritional development of source and sink: Z39 to Z65

Although Z65 represents achievement of the critical mid-flowering point, there is a sub-process within Z39 to Z65 that also must be successfully completed: “From flag leaf till full-boot (**Z39** to **Z45**) the spike grows and develops roughly from 10 mm to 100 mm [seen in Figure 7.2a]. This is an important first part of ***sink*** size determination where before the crop had been developing primarily the ***source*** with roots to feed it. Where ***source*** is the green matter of leaves and stems for the capture of carbon dioxide with solar energy (=photosynthesis) and ***sink*** the final depository of carbohydrates and nutrients in grain, determined by spike and kernel numbers and sizes” (Stapper 2006). These types of issues are much more clear when observed as VSM models. (For the interested reader, Appendix 7.A describes in detail the rationale behind development of the VSM models).

7.3.2.3 Production outcome is a result of good management practices

“Pre-sowing fertiliser needs therefore to be conservative for high yield targets, and the crop then needs to be managed with herbicides, fertilisers, irrigation water and fungicides to achieve proper shoot density, green leaf area duration, and reduced lodging risk. From the plant configuration established, management before flowering has to build a canopy structure that can carry and fill the most grain. That is, [to] manage the canopy to achieve the desired outcome. Efforts in canopy management can go to waste with poor combinations of both variety/sowing-date and sowing-rate/row-spacing (i.e. plant establishment)" (Stapper 2007).

7.3.2.4 There is a business management perspective to these GAP issues

"…***source*** (leaves/stems) and ***sink*** (spike/kernels) need to be balanced with canopy management to achieve the [highest yield] potential. At the higher production levels crop yields are becoming more sensitive to the correct timing of management practices in relation to both stage of development and plant configuration. Faster crop growth rate shortens the period available to apply key inputs required for maximum yield and timeliness of management decisions becomes critical. The plant configuration achieved will determine management options. Inappropriate or incorrect applications of fertilizers, herbicides or fungicides may result in low or even negative economic returns. Therefore, accurate identification of crop status is important" (Stapper 2006). There is a business case to be made for objective measurement of crop status.

7.3.2.5 Using VSM to model stages Z37 to Z92

Crop development during these critical management stages (Z37 to Z92) can be viewed as a VSM model. Figures 7.2a and 7.2b show the VSM view of processes from Z37 until harvest (Z92). Figure 7.3 is an overview of Figures 7.2a and 7.2b.

Several significant points should be noted:

1) Nearly every process during this phase of crop development is a key process.

Figure 7.2a
VSM view of Z37 through Z71

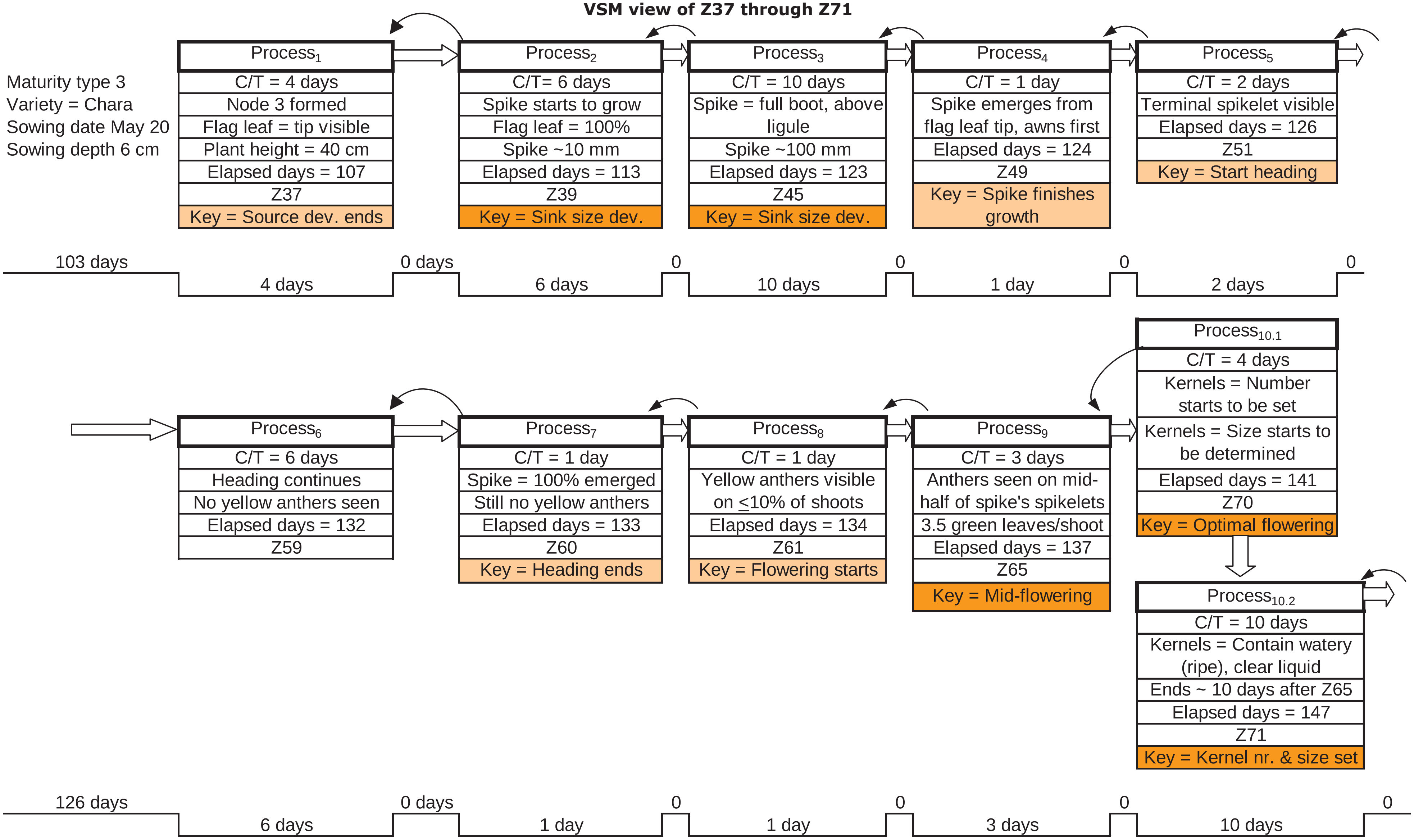
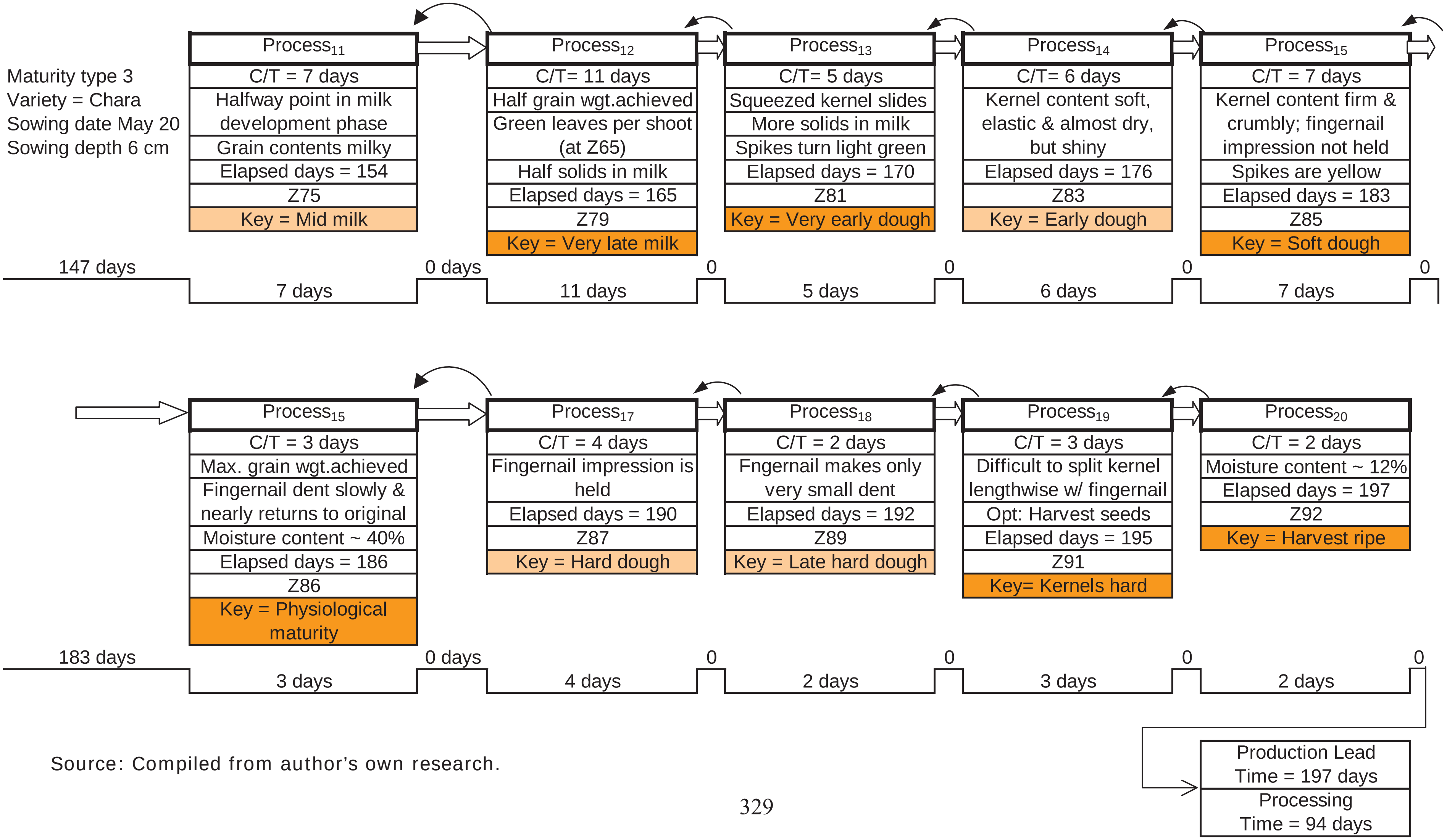
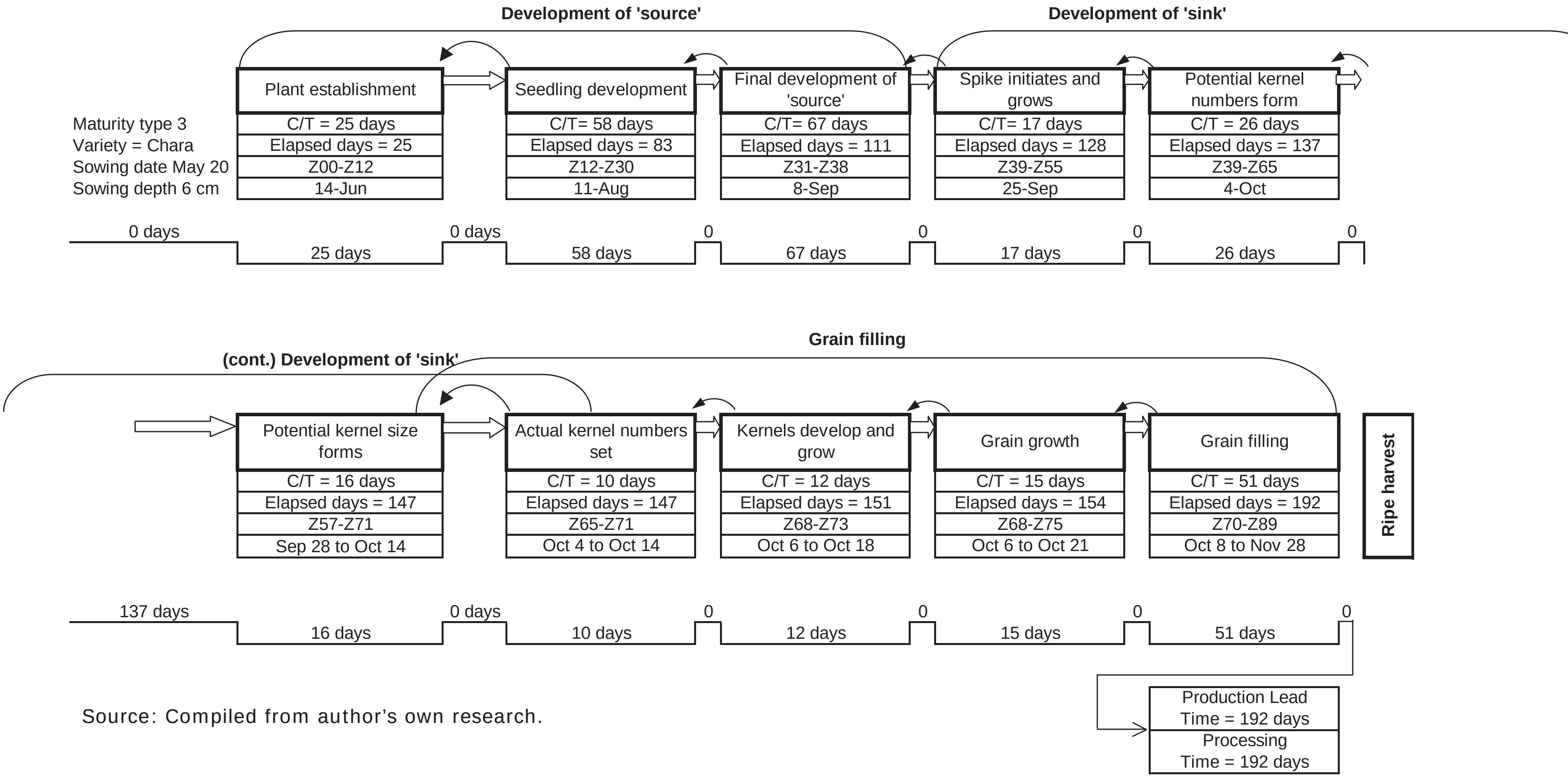


Figure 7.2b
VSM view of Z75 to Z92



Source: Compiled from author's own research.

Figure 7.3
VSM summary view of Z37 to Z92



Source: Compiled from author's own research.

2) Two of the processes (Z70 and Z71) are overlaid, occurring simultaneously to some degree. These same two processes happen relatively quickly and play a strong role in the grain quality produced. (Stapper introduced ten additional sub-stages to assist growers in determining what is taking place each day from Z70 through Z71).

3) The success of Z79 is dependent on the success of Z65. It could be said, though, that all of the processes are dependent on the success of those that precede them during the Growing phase. This should be expected, based on the kanban-style of information flow that directs the plant's growth (Figure 5.29).

4) Growers relying on Feekes scale rather than Zadoks would not be able to distinguish most of the critical stages that occur during tiller development, and probably not able to determine the tillering development characteristics between Z20 and Z29—let alone the finer differences between Z70 and Z71 (Table 7.10).

7.3.2.6 VSM models can reflect wheat production practices and plant growth

This section described the generic growth pattern for wheat during specific Zadoks stages. Examples of VSM models were developed and show that VS/kaizen tools can be used to capture both the production framework and growth patterns of wheat plant development.

The point, with regard to this thesis, is that managing the plant establishment phase has an impact on end quality. However, the choice of variety most likely outweighs the influence of practice management in that varieties not only have predictable traits related to end product quality, but variety-associated needs require attention during the plant's growth and development. Without the use of certified seed, though, or at least some degree of expert intervention that helps a grower with issues of trait preservation (as in the assistance given by INRA to the French farmers), the initial stages of plant (tiller) development up to Zadoks stage Z30 are seemingly left to chance.

7.3.3 What could go wrong?

Wheat plant growth and crop development can be summarized as four main stages: Development of 'source' (Z-stages prior to Z39); Development of 'sink' (Z39 to Z65); Grain filling (Z70 to Z89); and Ripe harvest (at Z92). These were seen in the VSM overview (Figure 7.3). While the VSM model shows how the crop progresses through these stages in a suitable environment, that environment is dependent on a number of factors. "Crop growth is determined by incoming solar energy, temperature, water, nutrients and ground cover during the season. The first two factors are beyond control, water and nutrients can be managed to a degree but ground cover depends completely on management…Ground cover determines crop growth rates" (Stapper 2007). If management is responsible for crop growth rates (i.e. the smooth and orderly pace of production through the system), it is reasonable to think that errors do occur and GMPs/GAPs/GHPs are not always the norm. But, what could go wrong that could impact 'good protein' qualities? Section 7.3.4 highlights some of the more significant problems that could occur. Finally, in Section 7.3.5, management practices in France and the U.S. are compared in order to evaluate whether it is possible for wheat grain with damaged protein/starch to enter the food production system in either country.

7.3.4 Where might protein defects occur?

Each of the four main stages of crop growth can be considered against the possibility of contributing to defects in protein. Although Stapper refers to management of ground cover as the key to management of crop growth rate, the end goal is to optimally balance source and sink. Achieving that end goal depends on choice of some types of GMPs/GAPs/GHPs (e.g. fertilization and irrigation decisions) to prevent source-limitations and other GMPs/GAPs/GHPs (e.g. choice of variety, sowing rate/density and sowing date) to counter sink-limitations. (For the interested reader, Appendix 7.A provides additional details of how 'source' and 'sink' should develop).

7.3.5 VSM comparison of six different nitrogen (N) applications

Like the Growing stages, GMPs/GAPs/GHPs can also be modelled in VSM. For instance, nitrogen stress during the tillering stage can be a possible contributor to defects in protein. GMPs/GAPs/GHPs for nitrogen (N) application can be modelled and compared as 'report cards' (Figure 7.4a and 7.4b). The figures represent six variations of N application for a single variety crop sown on May 20, 2004 at a seed density of 100 kg/ha or 60 kg/ha with a medium maturity type (3); based on Australian data (Stapper 2007). For all six plantings, 30 kg/ha of N was applied with sowing (at Z00). Then N was applied a second or third time (in rates of 40 kg/ha or 60 kg/ha) as topdressing at one or more of the three standard topdressing application stages (i.e. Z32, Z46 and Z63). The lone exception was Example A (Figure 7.4a), which was not fertilized again after the initial application. N quantity and application date is shown within the process data for each topdressing application (Figures 7.4a and 7.4b); a 'report card' follows stage Z63 based on the following data:

Total N quantity = the total kilograms per hectare of nitrogen applied.

Grain yield = the number of tonnes per hectare at harvest time.

Dry matter = the total vegetation at harvest, excluding the grain, shown in tonnes per hectare; maximum daily production of dry matter is 250 kilograms per hectare.

Harvest index (HI) = As stated above, the aim is to grow dry matter for grain and have the smallest stubble remaining, that is, having a high harvest index. Therefore, grain yield divided by dry matter determines the HI percentage.

N harvest index = is the nitrogen removed in the grain as protein, and expressed as a percentage; a rate of approximately 80% NHI is typical for wheat.

Kernel number = number of kernels per square meter.

Figure 7.4a
Nitrogen topdressing applications

Maturity type 3
Variety = Arrivato
Sowing date May 20
Sowing depth 6 cm
Sowing rate = 100 kg/ha (A, B, C, E, F)
Sowing rate = 60 kg/ha (D)

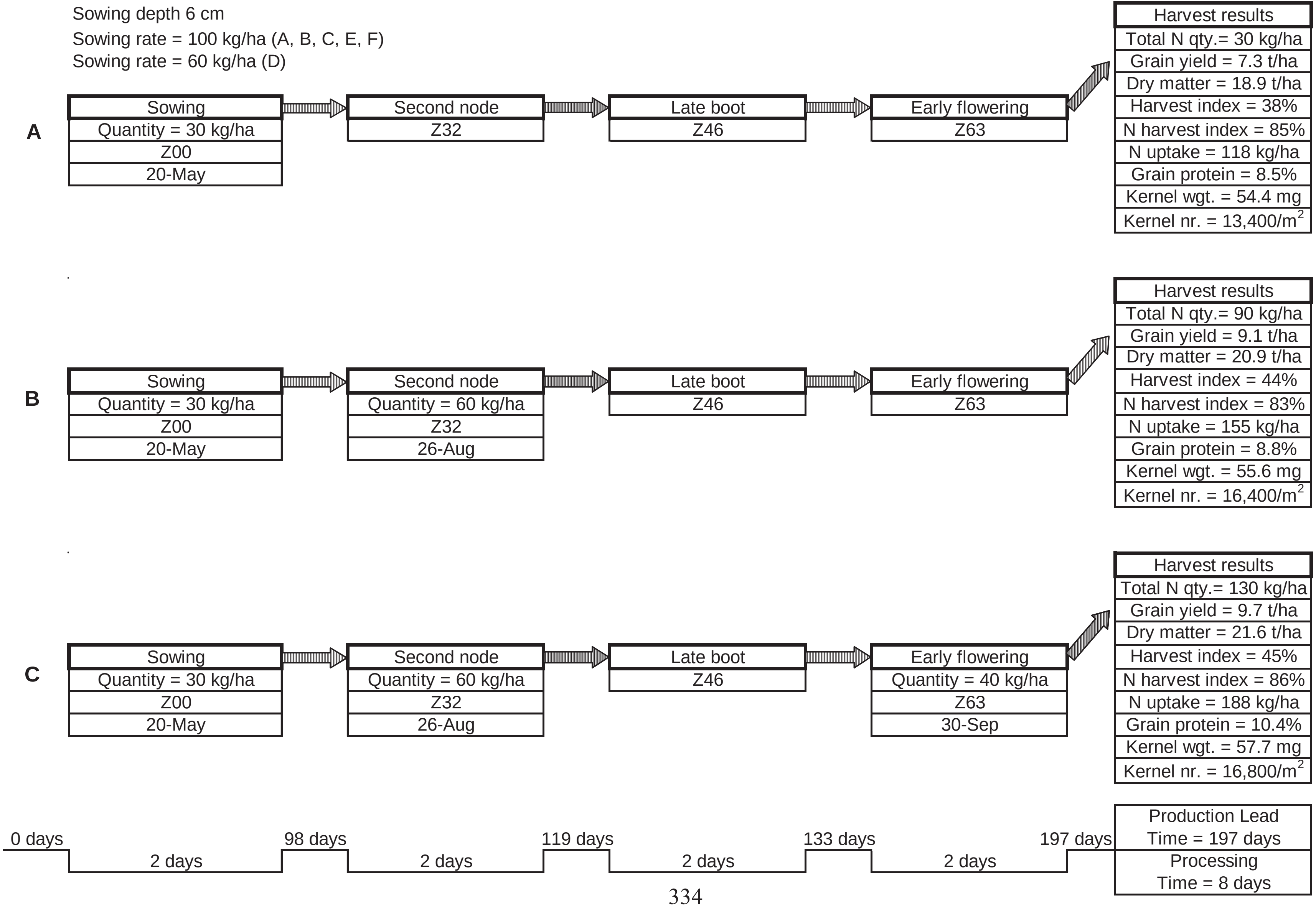
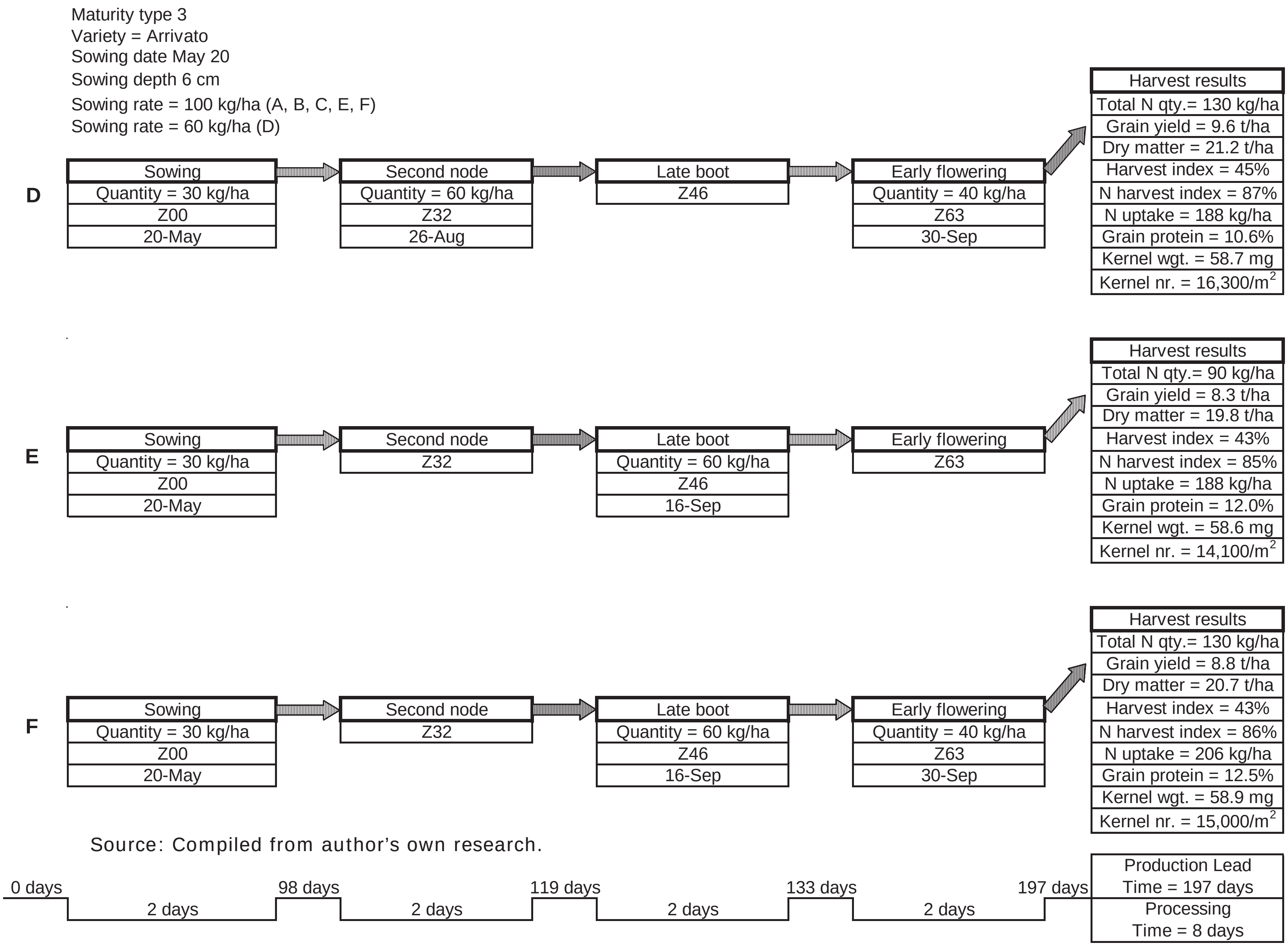


Figure 7.4b
Nitrogen topdressing applications



Source: Compiled from author's own research.

N uptake = shown as kilograms per hectare, and includes both residual nitrogen in the soil and nitrogen applications; typical daily maximum nitrogen uptake is 3 kg/ha, for crops reaching canopy closure at or before Z30.

Grain protein = protein content measured in the grain

Kernel weight = the weight of an average kernel shown in milligrams.

7.3.5.1 Results of N application trials

At the outset, there was no difference in spike density – all were approximately 475 spikes per square meter. The only variation was that application D had been sown with only 60 kg/ha rather than 100 kg/ha, as were the other applications. When the results are ranked by protein content, more N does not necessarily lead to higher protein content (Table 7.11).

Table 7.11
Protein content of varying N applications

Application	Protein %	Total N
F	12.5	130
E	12.0	90
D	10.6	130
C	10.4	130
B	8.8	90
A	8.5	30

Source: Compiled from author's own research.

Application of N topdressings is indicated by 0 = none or N = nitrogen (Table 7.12).

Table 7.12
Protein content and N application sequence

Application	Protein %	Total N	Sequence
F	12.5	130	ONN
E	12.0	90	ONN
D	10.6	130	NON
C	10.4	130	NON
B	8.8	90	NOO
A	8.5	30	OOO

Source: Compiled from author's own research.

Not only did topdressing impact protein, but the sequence and timing of the topdressing applications made a difference, as well. The highest rates of protein were connected to topdressing applications at Z46 and Z63 (Examples E and F, Figure 7.4b). The highest protein content is related more to timing of nitrogen application than to the quantity of nitrogen; this can be seen more clearly in Table 7.13.

Three examples (F, D and C) received 130 kg/ha of N, with Example F producing the highest protein (12.5%) for the sample set. Yet Examples E and B received only 90 kg/ha of N, and Example E achieved the second highest protein rate (12%) while Example B only achieved the second lowest protein rate (8.8%). As Table 7.13 shows in the Sequence column, it is most significant for high protein to apply topdressing at Z46 and Z63.

Table 7.13
Protein, nitrogen and grain yield

Application	Protein %	Total N	NHI	KWT	K Nr.	Yield	Sequence
F	12.5	130	86%	58.9	15,000	8.8	ONN
E	12.0	90	85%	58.6	14,100	8.3	ONN
D	10.6	130	87%	58.7	16,300	9.6	NON
C	10.4	130	86%	57.7	16,800	9.7	NON
B	8.8	90	83%	55.6	16,400	9.1	NOO
A	8.5	30	85%	54.4	13,400	7.3	OOO

Source: Compiled from author's own research.

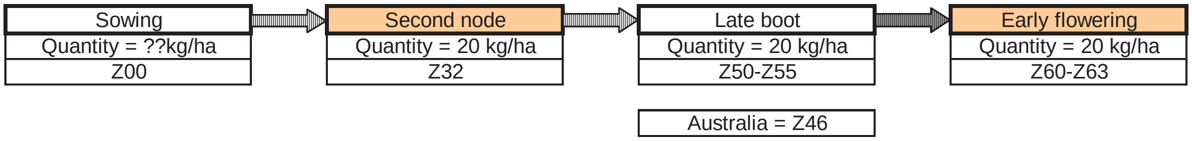
The highest yields, though, (Examples D, C, B rows) occurred when N topdressing was applied at Z32. The reason for this is that nitrogen applied at Z32 boosts growth of kernels per spike as Z32 occurs just before a rapid spike growth begins. Z46, on the other hand, is when spike growth is nearly finished (Stapper 2007). In terms of NHI, it can be seen that Examples D and C make the most efficient use of N (in terms of grain yield). The results are also dependent on the balance of source and sink. Stapper points out that inefficient use of N comes with a source-sink imbalance created when sowing date is too early for a late maturing variety. In a trial using the same parameters as the applications above, an early April sowing (rather than late May) resulted in an NHI of only 54% (Stapper 2007). Here again, varietal characteristics need to be respected to obtain the best results.

7.3.5.2 The French perspective on N applications

The French "Charter" includes sections devoted to proper application of N (and other nutrients, as well). The 2004 edition of the Charter recommends two different categories of application based on whether the variety is winter or spring wheat. (Prior to 2004, the French growers only focused on spring wheat). The benchmark examples (Figures 7.4a and 7.4b) were for winter wheat. The French Charter recommends that total N should not exceed 60 units per hectare (or 60 kg/ha). The farmer should split the planned maximum use of nitrogen into two, or preferably three, portions for each application. The decision is (based on pilot trials by the farmer) in order to achieve the desired protein content. The application times are recommended as "in line with the stage when the ear has reached approximately one cm. [Ear peep begins at Z50; one cm is between Z50 and Z55]. The last applications would be most effective at the beginning of the stages of two nodes [Z32] and flowering [Z60]. …Dosages should meet local laws of the sanitation department. In their absence, the Code of Good Agricultural Practices (CBPA [or GAPs]) defined within the EU Nitrates Directive should be respected" (translated from *Chartre de Production Blé tendre* 2004).

It seems that the French recommendation expects topdressing to occur between Z50-Z55, and preferably also at Z32 and Z60. These stages and dosages can be mapped and compared with Stapper's recommendations (Figure 7.5).

Figure 7.5
French nitrogen applications for winter wheat



Source: Compiled from author's own research.

The timing of the first and third topdressings (highlighted in orange) match Stapper's topdressings, and the second topdressing nearly matches. Quantities are kept much lower, though, and this is in line with the EU Nitrates Directive.[3] Comparing Figure 7.5 with Table 7.13 makes it easier to see the (likely) rationale for the timing of topdressing recommended in the French Charter. In Table 7.13, the four best topdressing regimens (in terms of protein content) were sequenced as ONN, ONN, NON and NON. The French recommended pattern would be NNN, to cover the best possible timing related to protein content.

7.3.5.3 The U.S. perspective on N applications

The U.S. perspective on nitrogen applications for winter wheat can be considered, as well. Considerable, and very detailed, information is given by the KSU extension service to assist the farmer to calculate the precise amount of N required, allowing for residual nitrogen from previous crops and cattle, soil texture, soil test results, etc. (KSU 1995). This is very much needed information, but the French "Charter" recommends the use of a consultant or a testing laboratory, as well as staying within regulatory limits. With fewer regulations, the U.S. grower has both the opportunity and the burden to work out the optimal levels of N (and several other nutrients) to be used. The KSU literature stipulates that, "Proper timing…is determined by the growth stage, not by the calendar date." The text mentions that either Zadoks or Feekes scale may be used, but shows the Feekes scale in the recommendations. Topdressing is recommended for any time between the winter dormancy phase of Stage 3 up to the middle of Stage 6. The equivalent Z-stages would be approximately Z15,23 or Z1x,26 up to the middle of Feekes Stage 6, which is only Z31. The number of topdressings is specified as only one.

7.3.6 Comparing national approaches of N applications

By comparing the N topdress application timings to the VSM wheat growth models (from Figure 7.2a and 7.2b), it is easier to visualize how the possible management practices relate to

---

[3] EU Nitrates Directive is 91/676/EEC.

plant development (Figures 7.6a and 7.6b). Stapper's **Australian applications are overlaid in blue** and only B, E and F are shown as B represents the minimal possible topdressing while E and F are the most desirable for increasing protein content. The **French optimal recommendation (of three applications) appears in green** and the **U.S. version appears in red broken lines**. Production lead-time is shown along the bottom of each diagram. It is the composite of all time required to produce one unit (one wheat plant). In each process box, Elapsed days refers to the number of days prior to the specific process beginning added to the C/T time needed. In the upper part of the diagram where the topdressing applications are shown, the 'Days before' data box only refers to the number of days before the application is likely to be used. In this way, the two different sets of processes could be viewed simultaneously while showing approximate relationships of timing.

What is clear in the Australian and French practices is the goal of using N to boost the growth stage following N's application. The U.S. version leaves the purpose open to speculation. The U.S. topdress timing (prior to Z31) doesn't really optimize protein development. It does, however, match the application B pattern shown in Table 7.13, which was the minimal topdress (above nil) and resulted in a very slight increase in protein content (compared with nil). Having pointed out that nitrogen should be applied based on growth stage rather than calendar date, the KSU literature goes on to recommend that summer preplanting and spring topdress (i.e. calendar seasons) are the recommended times for N application. The preplanting isn't a topdress, so it can be ignored. But the advantage for the spring topdress is described as "better knowledge of moisture situation [water being a necessity for optimal N utilization] and crop condition prior to expenditure of money for nitrogen and a shorter period of capital tie-up prior to harvest" (KSU 1995). While multiple authors contributed to the KSU "Wheat Production Handbook," the difference in these two approaches to topdress

Figure 7.6a
Comparison of topdressing timing

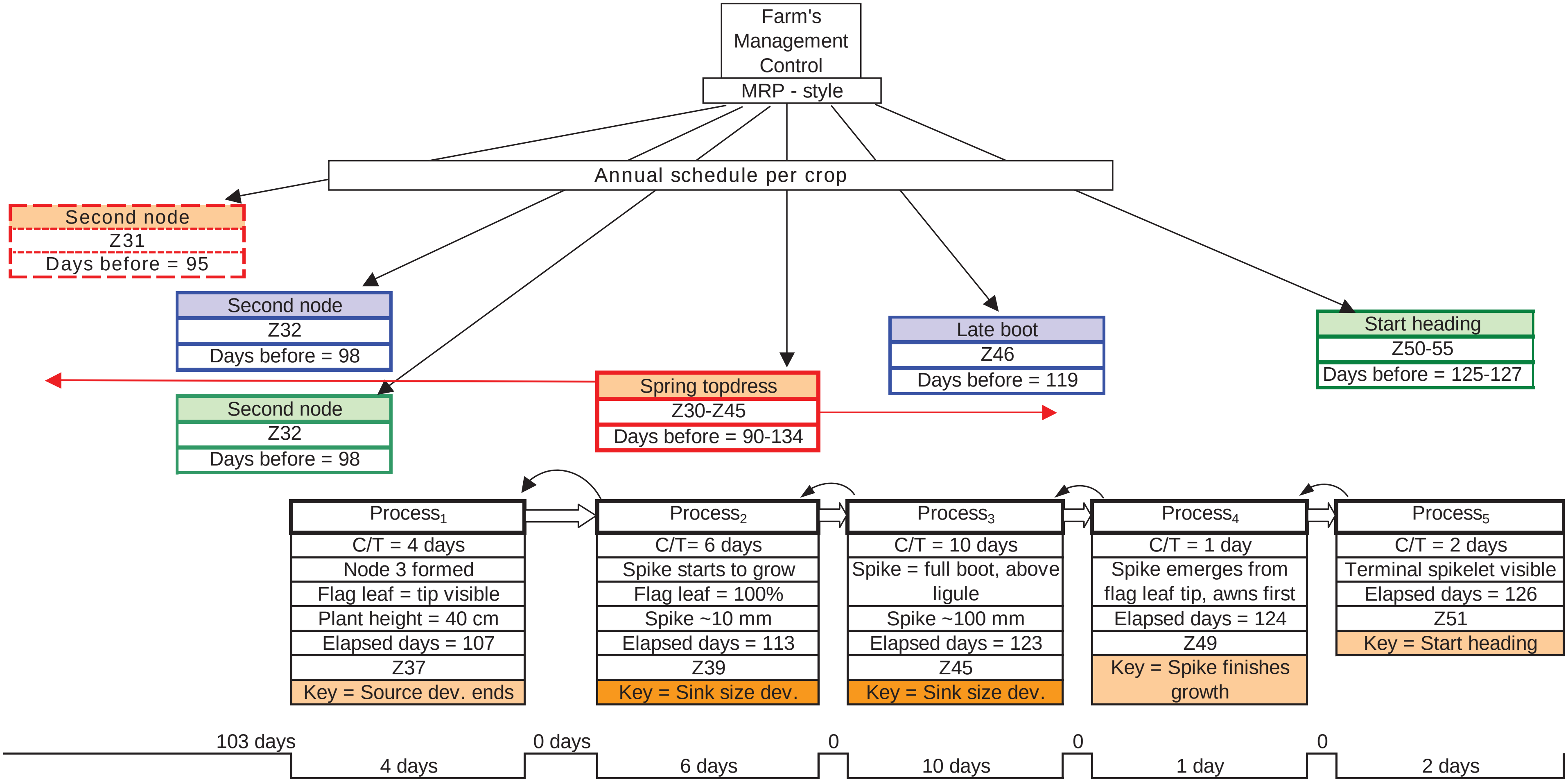
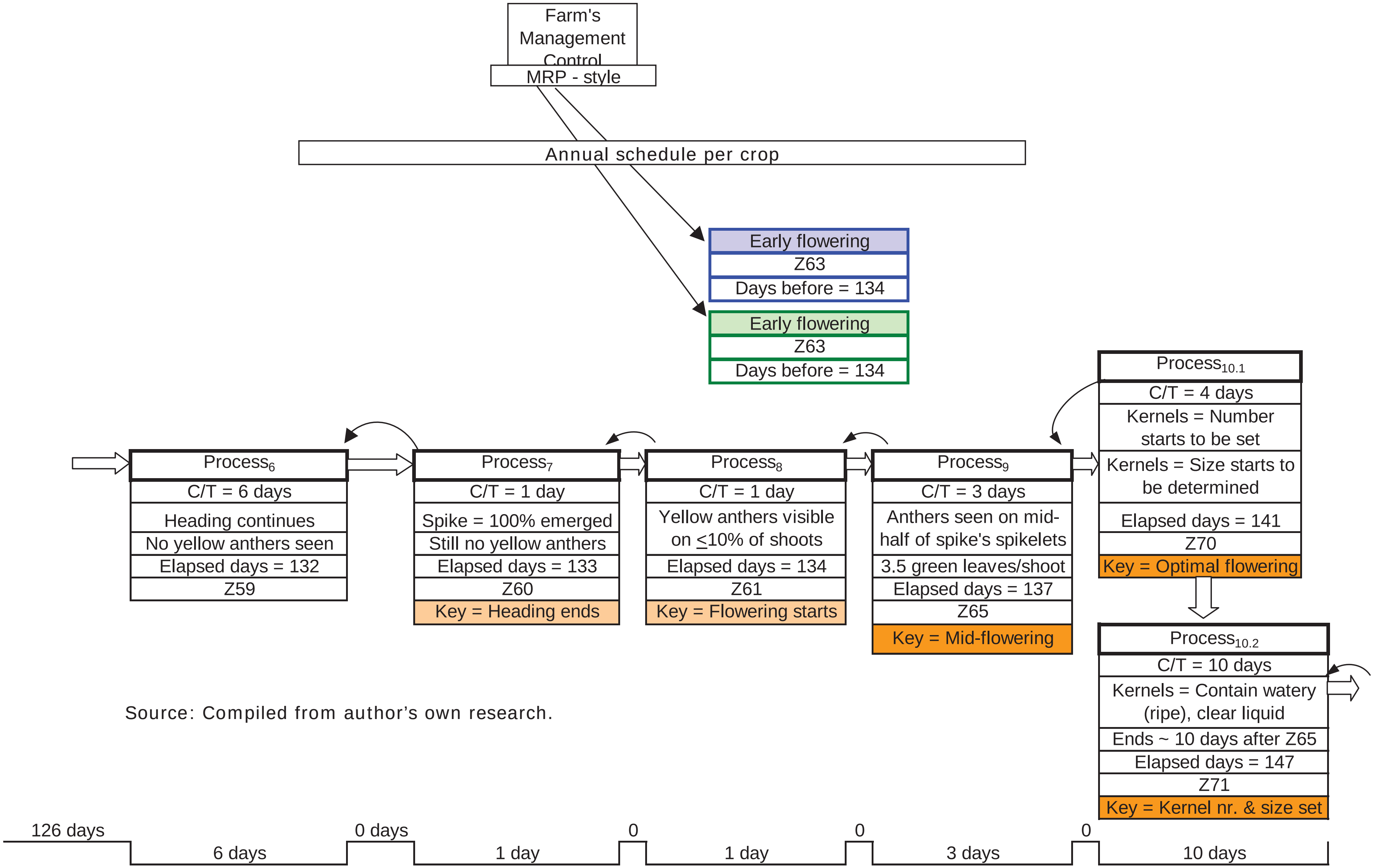


Figure 7.6b
Comparison of topdressing



Source: Compiled from author's own research.

timing seems dramatic, especially considering that there will only be one topdress application for the overall crop season. Spring topdress would mean from Feekes stages 5 through 10, or based on the Zadoks scale, the spring topdress could occur anytime from Z30 to Z45. Therefore, this possibility has been mapped on Figure 7.6a in solid red. As can be understood from Stapper's research, this range of timing for topdress is better than the earlier option of 'up to Z31' (seen in the broken red line). But, regardless of which option is selected, it is clear that the timing is not synchronized to particular wheat development stages.

In a special section of the KSU "Handbook" titled, "Fertilizing for Protein," more information is given: "Nitrogen fertilization for ensuring high protein in wheat requires nitrogen rates in excess of those for optimum grain production. Farmers undertaking a fertilization program for high protein must combine the practice with a marketing program to receive a protein premium to pay for the additional nitrogen. [Note: As discussed in Section 3.3.2.3, the "marketing program" is not a marketing/advertising initiative but a strategy for achieving the best mix of futures contracts.] Additional nitrogen applied as topdress above the recommended rate will favour higher protein. However, many climatic and genetic factors also are involved" (KSU 1995). This last phrase is likely the most significant – that genetic factors are involved. Stapper's (and other Australian) research first categorizes varieties based on maturity type – even combining durum, hard wheats and biscuit wheats – then looking at particular characteristics associated with variety. But Australia has 50 to 60 wheat varieties (Stapper 2007); France has 60 to 80 (Le Stum 2007); and the U.S. has more than 30 000 varieties (NAMA 2006). As KSU literature points out, "The Federal Plant Variety Protection Act stimulated private breeding and sales of variety seed by providing a plant patent protection to originators" which complicates the growing number of choices for growers (KSU 1995). On one hand, the plant variety protection laws were intended to preserve varietal traits, and it seems that the U.S. interpretation doesn't support that aspect of the URAA.

7.3.6.1 U.S. approach to protein and starch development

The KSU "Handbook" in a section titled, "Grain Quality" states that, "The major use of Kansas wheat is bread wheat for human consumption. Therefore, it is important that the grain be of a quality needed by the millers and bakers to produce a quality end product. Quality is determined by variety as well as by growing conditions" (KSU 1995). But even putting aside the issue of choice of variety, the wheat product that results from these 'growing conditions' and passes the one-to-three minute physical intake inspection at the grain elevator, seems to shift responsibility for quality to the millers/bakers.

By way of comparison of overall growing conditions for grain quality, the KSU literature describes the development of protein and starch in much the same way as Stapper and the French literature does: "Protein and starch are the most important constituents of the wheat kernel. Most of the protein comes from nitrogen previously accumulated in the leaves, and most of the starch is from sugars made by photosynthesis during the grain-filling period. The nitrogen moves into the filling kernels to form protein during early grain [i.e. Z68-Z73] development. Under good growing conditions, grain protein can be increased with nitrogen fertilizer" (KSU 1995).

The KSU description of protein and starch development is less specific than Stapper's descriptions that focus on the mechanics of plant development at each growth stage. For instance, in the KSU description of protein development, there is no distinction made for various developments in ground cover. As Stapper's earlier comments described, ground cover starts with tillering but later depends on spike density and green leaves per shoot.

Additionally, the KSU description sees photosynthesis in the awns (which first appear at Z49) as providing ten to twenty percent of grain weight. Yet, Stapper's description puts more emphasis on the Z70-Z71 stages. Likewise, there are differences between which stages are most significant to kernel development and even to the expected moisture content at physiological maturity (with KSU predicting 30-35 percent and the Australian literature predicting ~40 percent). Even if both overall texts are correct, what seems most striking is the less specific nature of the KSU description. Possibly this is due to use of the Feekes scale versus the Zadoks, but it appears to be part of a larger issue of increased focus on end result rather than on process management.

7.4 Chapter summary

HACCP decision process models

Section 7.2 worked through examples of how HACCP decision process models could be used to evaluate process performance. In the examples, wheat seed selection in the U.S. and France were compared. The models showed that the French approach resulted in better control over protein quality characteristics in the final product. But, the examples also showed that the HACCP models could be used to analyse and improve process performance for a variety of GMPs/GAPs/GHPs.

VSM process models

In Section 7.3 VSM models proved useful both in depicting wheat plant growth and any attendant management practices. Two main areas of wheat production were described in the models. Figure 7.3 established an overall VSM framework to show desirable wheat plant growth throughout a critical stage (i.e. tillering) for development of good protein quality characteristics. At the same time, more detailed models (Figures 7.2a and 7.2b) showed points of management intervention by the farmer (i.e. manual tests to determine Z-stage) that are necessary throughout the entire process to monitor development toward predictable protein quality characteristics at harvest. The second group of VSM models examined a single process in detail (i.e. use of nitrogen fertilizer topdressing). A benchmarked process based on actual field trials (from Australia) was modelled first, then French and U.S. approaches to the same process (in open production) were modelled and compared to the benchmark. As the models showed, the French growers use an approach that balances optimization of protein with staying within European regulatory limits on the use of nitrates. The U.S. growers do apply nitrogen fertilizer but there seems to be little relationship between matching application to improved protein quality characteristics in the end product. This could be expected, though, in a system of commingled wheat and lack of intrinsic testing.

Chapter 8

Findings, recommendations and conclusion

Chapter 8

Findings, recommendations and conclusion

Answers to the three Research questions (introduced in Section 0.1.1) are discussed in Sections 8.1 through 8.3.

8.1 Research question one

"What effects have changes since 1994 in government policy and industry strategies had on bread VC decisions that contribute to quality characteristics related to human health?"

8.1.1 Answer to RQ1

Changes in international trading agreements affecting agriculture began in 1994 and culminated in the transformation of General Agreement on Tariffs and Trade (GATT) to World Trade Organization (WTO) that same year. Liberalization of international agricultural trade and the agreement to remove subsidies in agriculture set the stage for various kinds of government policy and industry strategy changes. In the case of France and the U.S., changes in government policy and industry strategy since 1994 have played a major role in shaping VC decisions, particularly in terms of primary producers. Whether or not the financial outcome for primary producers was positive or negative, there was a direct impact on wheat, flour and bread quality (associated with better or poorer protein qualities in the wheat). This, in turn, impacted bread conformance and reliability (food safety).

Government policy and industry strategy

In France, the situation has improved, year on year. Government health policy has advocated lower GI/GL breads and increased levels of good protein qualities and micronutrients in grains. Government policy concerning France's role in the international market for wheat and wheat-based products reflects the strategy of the wheat growers. Industry strategy, driven by the wheat growers, involved working in association with the millers and bakers and assisted by scientific entities, such as INRA and ARVALIS.

The situation in the U.S. since 1994 was a near opposite, both in comparison to France and in terms of comparing the industry before changes that took place. Prior to 1994, U.S. wheat growers, like their French counterparts, were in favour of liberalized agricultural trade. U.S. wheat farmers had long argued that removal of government subsidies—across-the-board—would lead to increased share of export markets for U.S. agriculture. However, only one year after the URAA came into effect, U.S. wheat growers were receiving the highest subsidies in the OECD, and at a rate 50 times greater than the pre-URAA era. During the period from 1995 to 2007, the U.S. share of the world wheat market declined to some 40 percent, but eventually levelled off at roughly 50 percent. However, the market share never approached its pre-URAA levels of 75-80 percent.

In contrast, French growers' share of the international wheat market has increased. Their wheat quality has increased dramatically since 1999 when intrinsic testing was introduced. Millers and bakers have also increased their proportion of export sales. Although French wheat farmer wages have increased substantially since 1994, by 2005 they were still less than GNI.[1] This occurred despite French farms being a bit more than one-third as large as U.S. farms, and by 2005, French growers were employing three people compared with just two in the U.S., metric tonnes per hectare were 60 percent greater in France while production costs per hectare were 10 percent lower than in the U.S. In other words, the French had considerably smaller farms, hired an extra person, spent less on production costs but grew 60

---

[1] However, farmers also earn from their holdings in the grain cooperatives and this income is not included with wheat farm wages.

percent more wheat – all of this while the U.S. growers received the highest subsidies in the OECD and most (80 percent by 2005) were in need of public assistance payments just to survive.

Chapters one and three described the U.S. policy that encourages grain/cotton farmers to plant as many acres as possible, yet forbids them to plant other (possibly more profitable) crops. While this anachronistic policy and the antiquated wheat grading system (from 1916) contribute to wheat with poor protein quality characteristics, these same influences existed prior to 1994. Literature review showed international criticisms of U.S. wheat quality and cleanliness since the mid-1980s. Wheat farmers may have been somewhat shielded from knowing the competitive weaknesses of their own product because they were producing toward a goal indirectly driven by futures contracts, rather than the quality characteristics required by millers/bakers. In fact, no evidence was found to show that cooperative work (as in France) between wheat growers and millers/bakers exists in open production in the U.S.

VC decisions that contribute to quality characteristics related to human health

The effect in France of introducing the URAA:

The URAA and its removal of subsidies seemed to catapult the French wheat growers toward defining a more competitive position for their product and its use. Already one of the strongest lobbies in Europe, the growers petitioned their government to make it a national priority that French wheat and wheat products should be positioned as the highest quality in the international market. The involvement of experts in plant health (as well as human health) shows the level of professionalism involved, but the real commitment can be seen in the fact that farmers themselves are paying for these services. To the degree possible, bread VC decisions in France—and in other countries where bakers and millers are customers of the French wheat growers—reflect the highest quality characteristics that the French growers can achieve at a particular point in time. As competencies improve, so do the thresholds for quality (e.g. continuous improvement to the grading system via ever more difficult benchmarks).

Many aspects of the French national food safety programme were already in place when the WTO negotiations took place. One of the more significant aspects of government policy was the influence coming from the 1992 national initiative to include the nutritional component in all disease research. Another important influence was that the Afssa (food safety agency) serves as a facilitator to bring various actors together from industry, human health research, primary production and consumer groups to develop consensual understanding of the issues in food safety policy and regulation. In addition to the benefits of a more cohesive and representative policy, the French approach allows for expert involvement from a wide variety of scientific disciplines. As food safety issues become increasingly complex (e.g. BSE crisis, use of nanotechnology, prevention of bioterrorism), this cooperative approach seems likely to bring better decision-making considering the breadth of specialist knowledge included. The possibility of an unanticipated food safety problem is likely to be lower in France than in other countries (such as the U.S.) that don't have the benefit of scientific advice from a variety of experts working together.

The effect in the U.S. of introducing the URAA:

The effects on government policy in the U.S. were very dramatic, possibly even overshadowing the importance of the URAA and WTO Agreements. Prior to 1994, fewer than 40 percent of the wheat farmers earned so little income that they also needed public assistance payments (welfare aid). Yet, by 2005, that figure had climbed to more than 80 percent of the wheat-only farmers. The situation was likely exacerbated by the possible oligopsony formed when three large grain processors and their joint venture (railroad) partners acquired more than 90 percent of all grain elevators, a sizable majority of flourmills and the ability to reconfigure and re-price the rail transport system between farmers and grain terminals. Based on a competitive analysis of 'value added' shares in the bread VC, it appears that very large increases in the grain processing and baking VC-entities may have been (at least partially) the result of a redistribution of value added that might have previously been allocated to the farmers. These problems in wheat farm income may have contributed to decreased or poor protein quality characteristics.

Actual changes in wheat over time can't objectively be measured in the U.S. because no intrinsic testing takes place. But as the QFD, HACCP and VSM models showed in Chapters six and seven, it would be very unlikely that U.S. wheat farms are producing wheat without defects in protein qualities, or of the quality level of French farmers.

Impact of government policy and industry strategy on the consumer

Although French consumers have shown less interest than Americans in lower GI/GL breads, national health initiatives have advocated wholegrain breads over white baguette. Although the short-term policy goal is better consumer health and lower rates of obesity in the long term, success depends on prevention of epidemics of costly complications of obesity (e.g. diabetes and/or heart disease).

As for American consumers, they adopted low-carbohydrate diets, often demanding lower GI/GL breads. However, while per capita consumption of bread decreased substantially, per capita consumption of wheat flour increased, driven by the flour added as “fillers” to packaged foods. Thus, it could be said that the U.S. population as a whole has only shifted its main source of consumption while increasing intake of (soft) wheat flour that is very likely to possess higher GI/GL levels.

8.2 Research question two

“How do differences in national food safety programmes in the U.S. and France affect decisions in the bread VC that contribute to quality characteristics related to human health?”

8.2.1 Answer to RQ2

Decisions in the bread VC that affect quality characteristics related to human health are influenced in different ways by the national food safety programmes in France and the U.S.

<u>Decisions in the bread VC concerning France:</u>

The relationship between producer decisions in the bread VC, human health and the food safety programme could be described as more symbiotic than in the U.S. Both the food safety programme and producer decisions are oriented toward human health. What may be a very significant difference is the French national priority (adopted in 1992) that advocates the inclusions of the nutritional component in all health research. It seems likely that after more than 15 years being in effect, that the policy has influenced how the French public health authorities regard raw commodities (e.g. wheat). Decision-makers in the bread VC would not have been likely to be unaffected by this perspective. So one contributor to VC decisions is French government policy.

Although French government policy also led to the design and implementation of the French food safety programme so that it very closely reflects the Codex guidelines, this probably played a less significant role in decision-making in the bread VC. Rather, another unique characteristic in France, i.e. the adoption by the French wheat growers of the 'highest quality' strategy as competitors in the international wheat (and wheat-based foods) market, played a vital role. This strategy led to even closer cooperation between wheat growers, millers and bakers – along with INRA, ARVALIS and ONIGC – so that human health, food safety and wheat quality characteristics are simultaneously considered in bread VC decisions.

The Codex guidelines recommend the application of GMPs/GAPs/GHPs to prevent any adverse quality characteristics that could affect human health and the use of HACCP (or HACCP-like) plans to prevent the three 'conventional hazards' (i.e. biological, physical or chemical contamination). The French wheat growers defined their most important GMPs/GAPs/GHPs and incorporated a type of HACCP-like plan into their "Charter of Good Production Practices". By combining industry forces along the entire VC (i.e. millers and bakers tell the growers what their quality requirements are) and collaborating with the scientific disciplines (crop scientists, experts in human nutrition and food safety) needed to produce a safe and high quality wheat crop, growers have managed to preserve the 'good protein qualities' while making their businesses more profitable. Year on year, the growers have improved protein quality characteristics in a greater percentage of the total wheat available in France.

Decisions in the bread VC concerning the U.S.:

A nearly opposite situation exists in the U.S. than in France. While the three sets of kaizen models (Chapters six and seven) focused on changes to protein quality that could result in higher GI/GL levels, the lack of better control of management practices raises a question about the occurrence of the three main hazards that HACCP is meant to prevent. E.g. mycotoxins are a severe public health risk[2] coming from moulds (i.e. microorganisms that are classed as a biological hazard among the three HACCP categories). Checking for the presence of certain mycotoxins (such as DON[3]) has been introduced over the years, but intrinsic testing is only done when an inspector using organoleptic methods suspects the presence of mycotoxins. While the use of GMPs/GAPs/GHPs and the adoption of HACCP plans could minimize the risk of mycotoxins, HACCP plans are not applied to wheat farms and inspections based on organoleptic observations will only be able to detect the most severe cases. In another example, U.S. wheat farmers objected to cleaning equipment between its use for GMO wheat and for non-GMO wheat on the grounds that such cleanings increased expense. Essentially, this is a declaration that GHPs are probably not being applied; if cleanings between loads were already occurring (to reduce transfer of microorganisms from affected wheat to healthy wheat), then there would be no additional expense for handling the GMO and non-GMO wheat. However, even if a wheat producer wanted to grow wheat with better protein quality characteristics, and adopted GMPs/GAPs/GHPs and use of a HACCP plan, in the open production system the end product would be commingled with wheat of variable quality and there would be little, if any, financial reward.

---

[2] Please see Chapter three regarding the dangers to public health from mycotoxins.

[3] DON is a known immunosuppressant and suspected to cause kidney problems (Hawk 2008).

The primary obstacle for wheat growers, and consumers, in the U.S. is the regulatory environment. This is exhibited in a number of examples: the characterization by the U.S. government that wheat growing is an 'extractive industry' like crude oil production or mining, and not part of food manufacture; the dramatic rise in direct government payments (subsidies) and public assistance payments (welfare) to wheat farmers along with the restrictions on what they may grow and encouraging as many wheat acres as possible; the resistance to intrinsic testing while adhering to a century-old wheat grading system designed by commodities traders; the seeming oligopsony configuration of wheat buyers (created by the ownership changes in the grain elevator-transport-mill segment of the bread VC following the deregulation of the railroads); the transfer of government-held wheat stocks to private stocks; the encouragement of commodities trading for farmers (who have a very limited choice of financial alternatives). In addition, there are two other regulatory examples (not directly connected to wheat growing) that may also contribute to VC decisions that affect quality characteristics in wheat: products (including food) are 'safe unless proven otherwise;' and high levels of food safety should be an expected outcome of a self-regulated market.

Some of these regulatory characteristics combine to suggest increased dangers. For instance, in the open production system, wheat is commingled. Since wheat is a commodity extracted from the earth (and not a food subject to food safety rules), the secondary processor (the miller) is the first point of entry into the food chain. It is the miller who is responsible for wheat's quality characteristics. Certainly the miller has a vested interest in not selling wheat that is contaminated from biological, physical or chemical agents (i.e. the HACCP hazards). Although use of a HACCP plan is voluntary, bakers often demand the miller use one. But, if the miller also wanted to provide better protein quality characteristics to the bakers or to simply provide them with a more consistent product, this is not possible using the commingled open production system. Additionally, even using intrinsic testing, the miller can only test a sample of all of the wheat received in a lot. Presumably precautions are taken to identify the most obvious concerns (e.g. possible presence of mycotoxins or signs of sprouting), but the less obvious issues (e.g. incipient sprouting) are not that easily detected. Additionally, the miller and the grower are not likely to know one another so the grower is not likely to hear the miller's (and indirectly the baker's) requirements. More importantly, they do not share common business goals. The grower's primary strategy is driven by planting the maximum number of acres possible to obtain the highest degree of subsidies, spend the minimum possible that will still result in a wheat harvest in Category 1 or 2, and buy futures contracts in hopes that this will help to cover any financial losses. The miller's primary strategy likely depends on whether or not the business is an independent mill or one of the large grain processor/railroad entities that are strongly connected to commodities trading. This leaves the baker as the remaining VC-entity likely to be pursuing food safety practices that match the original intent of the national food safety programme or comply with Codex recommendations. This overall configuration of government policy and industry strategy would not realistically be expected to be producing bread that preserves the good protein quality characteristics.

8.3 Research question three

"Could national food safety programmes produce benefits to primary producers beyond food safety?"

8.3.1 Answer to RQ3

A primary difference in levels of bread VC-safety between the two countries has to do with the quality-based strategy initiated by the French wheat growers from 1998 onward. A follow-on effect of that can be seen in the cooperative work between the growers and INRA (and paid for by the growers) that emphasizes both the human and botanical health aspects of the wheat. Certainly the fact that the growers are also the owners of the grain elevators and take professional pride in their product also plays a strong role in the quality characteristics of the wheat. But national food safety programmes are able to produce benefits beyond food safety. The broader benefits mentioned by participant firms in the FDA study were: 1) more effective and efficient operations; and 2) greater customer satisfaction. Improved employee performance was frequently cited, as were improved on-time delivery, better control over processes and increased sales (Section 2.3.4). National food safety programmes can help producers achieve these benefits by encouraging the use of the Codex guidelines (i.e. adoption of GMPs/GAPs/GHPs as a preliminary programme and use of HACCP or HACCP-like plans).

The operations management explanation for why the HACCP system can benefit producers rests in the issue of 'stable processes.' Processes that are not stable are not in the SDCA-side of Deming's cycle, and unstable processes lead to both costly production faults and food safety risks. The HACCP decision-making methodology (Figure 2.6) forces a producer to look more deeply at the performance of processes. When food safety regulators (such as the FDA) or other actors (such as those organizations seconded by the French wheat growers) assist the producer to concentrate on better performance and measurement of processes, along with the adoption of GMPs/GAPs/GHPs, then this sets the stage for a working environment that enables the producer to carefully move processes from the PDCA cycle into the SDCA cycle. These are important caveats and based on the works of Deming, Shewhart, Imai, Ohno and other Japanese quality experts: benefits accrue when processes are stable and when the product and processes meet the customer's expectations; more sustainable benefits accrue when the customer's expectations are exceeded. The French wheat growers have shown that GMPs/GAPs/GHPs can be adopted and incorporated with a HACCP-like plan to form a sort of primary producer's version of QMS. They've also shown that this leads to profitability in their businesses. The next step for the French growers is to exceed their customers' expectations. The next step for the U.S. growers is to identify their key processes and determine what is necessary to convert them to GMPs/GAPs/GHPs or to HACCP procedures.

8.4 Key research findings

8.4.1 Wheat grower-VC is most common source of protein quality characteristics

Poor protein quality characteristics in wheat contribute to high GI/GL values; good protein quality characteristics are likely to produce lower GI/GL values. These protein quality characteristics are carried through the VC into the final product (bread). Although the protein quality characteristics found in bread and related to human health impacts could be caused by the baker/miller, the primary producer (wheat grower) is by far the most frequent and most likely source of these problems.

8.4.2 Protein quality characteristics are not regulated

There is no regulation of the protein quality characteristics that impact GI/GL levels. Although wheat growers in France have voluntarily adopted practices that for the most part eliminate the risk of detrimental protein quality characteristics being passed on to consumers, there is no regulation in the U.S.

8.4.3 Inadequately implemented HACCP systems

In the original HACCP system that Pillsbury developed, a ‘prerequisite programme’ included the application of GMPs and GHPs; Codex later added GAPs. The prerequisite programme was the equivalent of a QA/QC programme for product conformance and food safety; the HACCP plan was the final backstop against a failure from a HACCP-hazard. The GMPs/GAPs/GHPs and/or the prerequisite programme were meant to include CPs, and if properly implemented (standardized), should prevent defects *a priori*. Regulatory safeguards (when they exist today) require a HACCP plan, and indirectly require the use of a prerequisite programme. [4] The regulatory application of HACCP in the U.S. only requires hygienic practices be incorporated in the prerequisite programme, and refers to these as GMPs. [5] In general, this leads to *a posteriori* prevention of defects unrelated to hygienic practices, and thus, should also lead to unnecessary and avoidable expense for the producer.

8.4.4 Not all actors in the food chain are required to adopt the HACCP system

Both the original HACCP system and the Codex recommendations require all actors in the food chain, including primary producers, to participate (i.e. adopt use of GMPs/GAPs/GHPs as the ‘prerequisite programme’ and a HACCP or HACCP-like plan). Neither HACCP plans nor prerequisite programmes are legally required of wheat growers in France or the U.S. However, in France the wheat growers have voluntarily adopted a code of good practices that avoids the processes that could lead to poor protein quality characteristics as well as to HACCP hazards.

---

[4] HACCP cannot be implemented without an existing prerequisite programme.

[5] In the U.S., the FDA requires a prerequisite programme for primary producers in some industries but does not require HACCP.

8.4.5 Not all categories of food contaminants are included in the HACCP system

The original HACCP system was designed to prevent food contaminants that might exist in a NASA space capsule. As a result, only biological, physical and chemical hazards were included. Zoonoses were not addressed; examples of this hazard include bovine spongiform encephalopathy (BSE), paragonimus and schistosomes. Although producers and the public are aware of the dangers of BSE, paragonimus and schistosomes are less well known. Paragonimus come from eating raw or undercooked seafood that is contaminated. Cooking utensils, other raw ingredients and even the cook's hands may spread the contamination. Today's strong interest in sushi combined with seafood products being exported throughout the world increases the likelihood of exposure. Schistosomes are similar to paragonimus, but found in contaminated drinking water (mostly in tropical countries). While they are less likely to be exported, they present a danger to tourists and locals alike.

8.4.6 HACCP gaps due to misunderstandings of '*a priori*' prevention

Perhaps the biggest gap in HACCP coverage is the inadequate approach based on *a posteriori* control of management processes. HACCP is based on kaizen, which requires *a priori* prevention of a fault or risk. Prerequisite programmes (as discussed in Section 2.1.8.1) and other 'best practices' must be tested and validated to ascertain that *a priori* prevention has been included, and works properly (i.e. that the practices perform consistently and are standardized as in Deming's SDCA cycle). As seen in Table 2.2, there are misunderstandings (dating from the early 1970s in the U.S.) around the concepts of WIs/SOPs, standardized processes and *a priori* prevention of defects. Likewise, intervention in the form of FDA audits may bring additional benefits to the firms due to the similarity the audits have with basic kaizen concepts.

8.4.7 Lack of awareness of production issues across entire VC

8.4.7.1 Some bakers/millers are unaware of upstream problems

In general, bakers and millers (i.e. the downstream bread VC) seem unaware of the upstream production problems in most countries. France is an exception in that the bakers and millers work together with the growers at the end of each production year (and prior to planting the new crop) to identify any needed modifications.

8.4.7.2 U.S. wheat growers are disconnected from bakers/millers

The goals of the growers in the U.S. are not oriented toward ‘food quality characteristics’ for the consumer, the baker or even the miller. This is exacerbated by government policy (e.g. subsidies based on acres planted; penalties for not growing wheat on so-designated acres; wheat is ‘not a food product, but rather an extracted commodity’ to be traded on financial markets; laws advocating ‘safe unless proven otherwise’, and more recently, that the ‘market should self-regulate’) and farmers’ mistaken belief that downstream actors can solve any quality problem (e.g. blending to produce ‘higher quality’ rather than growing wheat to specification).

8.4.8 Government policy and industry strategy play key roles in wheat farm-VC

Government policy and industry strategy play a key role in wheat grower behaviour. In the case of France, the growers drive government policy and, indirectly, also drive the industry strategies downstream (i.e. millers and bakers). In the U.S., government policy forces the growers to adopt a *de facto* (low-cost supplier) strategy with very limited options. The growers are disconnected from millers and bakers; the growers produce based on a ‘strategy’ regulated by the USDA and sell to the (likely) oligopsony created by three grain processors and their railroad partners. Growers invest in futures contracts in hopes of helping to defray costs. The three grain processors also operate commodities trading businesses that sell contracts to the farmers. In addition, it is likely that the grain processor/railroad-JVs gain some financial benefit from having large quantities of wheat in their possession earlier (e.g. loaded into railroad wagons) than if they had waited for delivery at a grain elevator to open a bookkeeping transaction.

8.5 Recommendations

8.5.1 HACCP systems need to be upgraded

HACCP regulations across the world need to be upgraded to ascertain that: 1) primary producers participate in a HACCP system; and 2) that HACCP addresses zoonoses.

8.5.1.1 Primary producers should be treated the same as other VC-entities

Of course, regulatory safeguards are dependent on the framework of the national food safety programme in each country. However, primary producers should be treated the same as other actors in the food chain. If a primary producer were to implement a HACCP system (i.e. use of GMPs/GAPs/GHPs and a HACCP plan), the producer would be required to show that the GMPs/GAPs/GHPs also met scientific food safety criteria. In the FDA study (Sections 2.3.3. and 2.3.4), the participating firms employed their own on-staff experts with this level of knowledge and the FDA verified that practices were in keeping with the prevention of hazards. The primary producer would need to compensate for not having an employee with specific food safety knowledge. However, this issue was addressed in the French example by farmers sharing the costs of access to outside organizations with highly specialized knowledge (such as INRA, ARVALIS, ONIGC).

Wheat growers should apply the Codex recommendations (i.e. use of GMPs/GAPs/GHPs and adoption of HACCP/HACCP-like plans), institute a grading system that uses intrinsic testing, and adhere to policies of segregation/IP[6] and traceability. Industry strategy should be in favour of taking these steps, not only to reduce the likelihood of food safety (reliability) issues, but also in order to raise other qualities (product conformance) of the wheat produced. Government policy should not obstruct wheat growers from adopting such a strategy. Present restrictive regulations on U.S. grain and cotton[7] growers encourage quantity and penalize quality. In addition, the likely oligopsony configuration of wheat buyers for open production in the U.S. also prevents growers from pursuing a competitive quality-oriented strategy. Government policy in the U.S. should include deregulation of the grain and cotton markets and the dismantling of any oligopsony configurations.

8.5.1.2 HACCP needs to address all forms of food hazards

As discussed above (Section 8.4.5), zoonoses are an example of a food safety hazard that was not included in the original HACCP system due to their unlikely appearance in a zero gravity space capsule. This gap in HACCP coverage–and any others–should be eliminated.

8.5.2 U.S. wheat growers need to establish an ‘alternative supply chain’

In order to reduce wheat grower dependence on a combination of welfare payments and subsidies, and to encourage open production of wheat with good protein qualities, funding should be provided to establish independent wheat-processing entities (combining storage and sales functions) that are driven by quality characteristics. While the French wheat growers’ grain cooperatives provide a model for other farmer-owned cooperatives, it should be noted that these entities are centuries old and their success may partially reflect French

---

[6] Identity preservation (IP) by wheat variety.

[7] Wheat, along with other grains and cotton, are all regarded as similarly regulated commodities by USDA.

business culture. An example of an arrangement that might be more easily adapted to the U.S. is the Camgrain initiative in the U.K. that pursues a strategy of selling ‘assured quality grain’ along with conventional grain storage activities (BERR and Camgrain 2010). While this recommendation would require governmental cooperation--likely for funding but certainly for moving away from USDA’s rather rigid view of how wheat production and sales should operate.

An alternative approach that U.S. growers might initiate on their own could be to reserve a small portion of land for growing high quality wheat. Perhaps this could be achieved in keeping with regulations that provide subsidies and public assistance payments. While the growers are unlikely to have immediate access to potential buyers, they would at least have a small financial cushion to cover intrinsic testing, IP seed and other start-up costs until they developed their own set of independent miller/baker customers.

8.5.3 Adoption of the HACCP system by primary producers

Research question three addresses the issue of whether national food safety programmes might bring unintended benefits to primary producers that adopt the Codex recommendations (i.e. application of GMPs/GAPs/GHPs and use of HACCP). As the answers to these research questions showed and as the literature (from FDA, in particular) has described, there are benefits to producer firms that implement Codex recommendations. Some of these benefits are obvious and relate to the fact that the firms are involved in agrifood production: use of HACCP reduces likelihood of the presence of biological, physical or chemical contaminants in food; this, in turn reduces the risk of an expensive product recall. Other benefits affecting sustainability of the firm are less obvious. One example, though, is customer loyalty when a medium or large-scale bakery using automated production lines is consistently offered a high quality and predictable wheat flour. To such a baker, this not only translates into a higher quality end product leading to better GI/GL levels (e.g. the Warburtons scenario, Section 1.2.5), but to fewer production defects and lowered operating costs (Section 4.7).

While no changes would be needed in the Codex recommendations or in national food safety programmes if primary producers were to adopt the use of a HACCP system, there would be additional benefits to the producers if the national programmes provided training for the producers and in particular, for inspections teams skilled in the underlying kaizen methodology of HACCP and the use of GMPs/GAPs/GHPs. The FDA study (Section 2.3.4) showed some examples of how the food safety inspections (part of the U.S. national food safety programme) could help to create an environment that could improve overall food safety through better performance of the GMPs/GAPs/GHPs. This, in turn, enables producers to become more competitive—as the French growers showed—through improved product quality.

If experts helped the primary producer to define the key GMPs/GAPs/GHPs, then the primary producer and the specialists would have identified the fundamental steps of the key processes that need to be performed and monitored. An external audit could be performed by a third-party, but as in the French example, the various intrinsic tests also serve as an indication of whether or not GMPs/GAPs/GHPs have been carefully followed.

8.5.4 Recommendations to U.S. policymakers

There are several steps that policymakers should take:

1) Incorporate all of the Codex recommendations from farm-to-fork into the national food safety programme. It would be a benefit to the producers if the Codex recommendations and the national food safety programmes *required* the use of HACCP or a HACCP-like plan, rather than only suggesting it. This would help to make the producers more competitive and profitable, while providing better levels of food safety for the consumer—both in terms of preventing the three conventional hazards (biological, chemical and physical contaminations) and in preventing protein quality characteristics that could contribute to high GI/GL levels.

2) Set aside budget money to assist businesses with proper use and maintenance of HACCP (or HACCP-like) plans and adoption of prerequisite programmes (GMPs/GAPs/GHPs). As the FDA study (Sections 2.3.3 and 2.3.4) showed, even very sophisticated large multinationals had difficulty properly designing a HACCP plan. FDA auditors were able to help these businesses via workshops so that in the future the businesses could take on the responsibility themselves. Encourage industries to take ownership of such an initiative, much as the French wheat (and other grain) growers did. Over time this reduces the need for public money and places the responsibility for the on-going success of the initiative with the producers.

3) Adopt a science-based grading system that incorporates intrinsic testing of wheat. While the French farmers themselves paid for the new grading system, the U.S. farmers would need financial assistance. The goal is to create a grading system that encourages higher quality wheat and increased international market share. Charging the customers for intrinsic testing does not encourage new sales, but rather turns potential customers away in favour of competitors (such as the French growers who incorporate intrinsic testing and IP wheat at no extra charge). Funding might be derived from: budget allocated for direct subsidy payments;

an extraordinary (and temporary) tax on wheat commodity trades; a permanent tax on commercial wheat stock-holdings (perhaps similar to tax on inventory, based on quantity and duration held).

8.5.5 Specific recommendations to U.S. growers

There are a variety of actions that U.S. growers could take. Some actions are more likely to be achievable than others:

1) Establish HACCP (or HACCP-like) plans. The exercise of establishing HACCP plans forces the development of documented procedures for GMPs/GAPs/GHPs. Test and improve processes. Use kaizen tools where possible because they're easy to implement and have little cost (e.g. Deming's cycle, Taguchi functions, HACCP decision process model). Consider use of the Stapper and Fischer method of measuring wheat plant/crop growth. Like kaizen, there is very little cost involved and it is easy to understand. On the marketing side, approach bakers and/or millers, consumer groups and other potential wheat buyers who have an interest in quality. Combine efforts with farm neighbours.

2) Demand an end to the federal policy of wheat-only plantings, but couple this with an orderly phase out of direct government subsidies. Farmers need to be able to respond to market demand (i.e. local, national or export) and customer requirements. If other crops are more profitable than wheat or in greater demand, then farmers should be permitted to make the business decision to grow those crops.

3) Initiate contacts with potential customers (millers/bakers/retailers and the public). The goal is to develop an alternative supply chain (based on quality criteria) rather than

responding to commodities-market influences. A number of actions could increase visibility (e.g. open field days, local farmers' markets, websites, cooperatively owned and produced wheat products). Develop formal presentations to millers/bakers with a goal of securing contract production arrangements.

4) Petition the Antitrust Chief of the U.S. Department of Justice to provide a level playing field for transportation, storage and purchase of grain. A possible oligopsony is not in the interest of the growers or the public; in the interim, work toward the goal of identifying new buyers.

8.5.6 Recommendations to French growers

Much has already been achieved in terms of quality and competitiveness. But, as seen in the QFD models in Chapter six, more can be done to 'exceed the customers' expectations'.

Additionally, there are producers in other countries that need help to adopt the "Charter of Good Management Practices". One possible set of clients could be U.S. wheat producers, but another is likely to be NAMA members or bakers who want the quality obtained from closed production but do not want to enter new lines of business resulting from 'make rather than buy' decisions. An interim solution could be using sub-contracted wheat experts from France to grow bespoke wheat on rented U.S. (wheat-designated) land.

8.5.7 Recommendations to bakers and millers

Don't make purchases of wheat from open production that does not include identity preservation (IP), segregation, traceability and intrinsic testing. Not only are food safety risks involved, but also the expense from production losses is high, particularly for medium and large-scale bakers. Please see also Section 8.5.6.

8.5.8 Recommendations to consumers

8.5.8.1 Recommendations for U.S. consumers:

Don't purchase wheat-based products without knowing their pedigree (i.e. where were they grown, how were they grown, what tests were conducted, etc.). Don't consume wheat-based products without following guidelines for GI/GL-type diets (such as the websites and articles from the Harvard School of Public Health, University of Sydney[8], University of Toronto). Don't consume packaged foods without taking into consideration the GI/GL impacts of wheat flour 'fillers.'

8.5.8.2 Recommendations for French consumers:

Enjoy French bread products—but follow INRA and Afssa's guidelines for healthy consumption.

8.6 Conclusion

The main research question was: *How do VC decisions in bread production contribute to quality characteristics related to human health?* Some positive measures have been taken in both France and the U.S. to prevent quality characteristics that could be adverse to human health from entering the final product. However, the QFD, HACCP and VSM models in Chapters six and seven gave specific examples of how adverse health characteristics are likely to be prevented in wheat production in France but are not likely to be prevented in the U.S. As the answer to Research question one showed, government policy and industry

---

[8] www.glycemicindex.com

strategies were very strongly related to the wheat grower decisions that led to increased interest in a high-quality product in France (and also less likely to contribute to raised GI/GL levels) but resulted in questionable quality wheat in the U.S. In France, the wheat growers' strategy that France should pursue an international market niche based on quality was adopted as a government initiative. In the U.S., the wheat growers appeared to have no real strategy while the three large grain processors and their two joint venture railroad partners began to reorganize the bread VC from the mid-1990s onward. Possibly the reorganization created a oligopsony situation; within a decade there was a severe drop in earnings for U.S. wheat growers with part of the shortfall made up from direct government subsidies and public welfare payments. Archaic federal legislation prevents the wheat farmers from easily departing this uneconomic activity. Businesses operating at near-subsistence levels are not likely to produce quality products, and as the models in Chapters six and seven showed, wheat quality in open production in the U.S. isn't likely to be of sufficient quality to prevent adverse health characteristics (i.e. increased GI/GL levels).

Two key elements were primarily responsible for consistent quality improvement in French wheat from 1999 to date: 1) the adoption of intrinsic testing of the wheat crop (both as a requirement of the wheat grading system and also in follow-up analyses of each year's harvest); 2) the development and use of the wheat growers' "Charter of Good Production Practices." While adoption of intrinsic testing requires both industry strategy and government policy, the development and use of good production practices could result from an industry decision alone. The French wheat growers' "Charter of Good Production Practices" was a collection of key GMPs/GAPs/GHPs combined with a type of HACCP-plan. Research question three began to consider whether the use of GMPs/GAPs/GHPs and application of a HACCP plan (i.e. one of the requirements of a national food safety programme based on the Codex recommendations) might produce business benefits to the firms that adopted them. This was analysed in terms of the research material discussed in Chapter two. Based on literature review, and particularly analysis of a multiyear FDA study, businesses that use GMPs/GAPs/GHPs and a HACCP plan accrue benefits beyond an improvement in food safety; it appears that those benefits are primarily related to improvements in product quality, but may also contribute to longer-term sustainability of the business. The methodological reasons behind this seem to be coming from HACCP's kaizen origins. Regardless, the French wheat growers invested considerable money and time to create and refine their "Charter of Good Production Practices" (now in its third edition). This approach resulted in a very positive return on investment for the French. The French wheat growers are one of the most powerful agricultural lobbies in Europe; as individual growers their businesses are profitable and stable. So one caveat might be that chances for success increase if the plan is as small and simple as possible and implementation is carefully managed.

Throughout the thesis a tacit assumption was made that producers strive to produce safe food while making a profit and that policymakers want to produce legislation that prevents food safety problems from affecting the public. However, as much of the thesis discussion and the QFD, HACCP and VSM models showed, this was probably a naive assumption. The early WTO members foresaw risks associated with food safety and public health and incorporated the Food Safety Programme (drafted jointly by FAO and the WHO) along with SPS and TBT Agreements into the WTO Agreements for addressing those risks. Signatories to the WTO Agreements committed to incorporate the elements of the FAO/WHO plan into national food safety programmes in each country. One element of the plan relied on Codex guidelines for specific practices that each producer from farm-to-fork should perform. However, the guidelines are only recommendations; whether or not law mandates their use for all actors in the farm-to-fork chain depends on government policy in each country. But, as seen in the example of the U.S., raw commodities (e.g. wheat) can be defined to be outside the scope of foods to be regulated.

As this thesis showed, there are some gaps between what was anticipated with the signing of the WTO Agreements and what was actually implemented in national food safety programmes. This is true for both France and the U.S., although in several aspects the French implementation has surpassed the Codex recommendations. Unfortunately, although the U.S. programme was well designed and functioned as a near model at its outset, more recent government changes (aimed at eliminating excessive government regulation) have resulted in a near dismantling of the national food safety programme. At the same time, a food producer is (usually) a for-profit business with an agenda that places much importance on profitability. Therefore, whatever minimum level of effort that could be expected is more likely to be performed if there is a clear benefit to the producer. Although regulatory measures such as fines and other punishment might be successful deterrents, they are not likely to encourage producers to adopt a specific approach. The French approach not only relies on voluntary compliance, but also has shown that active and willing participation by industry actors can improve overall business performance while preventing both detrimental protein quality characteristics and food safety hazards. It should be remembered that prior to introduction of the new grading system 1998/1999, the French wheat growers were not performing as well as their counterparts in the U.S. (Table 1.11); change was driven by business opportunity. U.S. wheat growers, as well as their downstream customers and the end consumer, all deserve the opportunity to enjoy the same benefits the French wheat growers strived so hard to provide.

Appendices

Table of contents

List of figures and tables

Appendices

to Chapter 1

Appendix 1.A

Comparison of general economic and bakery industry data

Appendix 1.A

Comparison of general economic and bakery industry data

Tables 1.A-1 through 1.A-4 provide detailed data for 2004 and 2005 comparing France with the U.S. in terms of general economic output and also productivity of the bakery industry. Table 1.A-5 also provides more detailed data for bakery productivity in the U.S.

Table 1.A-1 compares the general economy of France with that of the U.S.:

- The French GDP was roughly 15 percent of the U.S.' although the population represented 21 percent of the U.S.
- The employed share of the population in France was some 41 percent compared with 48 percent in the U.S.
- It could be said that the U.S. population was somewhat 'wealthier' (higher GNI per capita) and more 'productive' (higher share of the population employed) than the French in 2004 and 2005.

Table 1.A-1
Economic comparison of France and the U.S. (2005 and 2004)

	Shown as	**2005 France**	**2004 France**	**2005 U.S.**	**2004 U.S.**
Population	Millions	60.8	60.5	296.4	293.7
Population Growth	%	0.58	0.61	0.94	0.97
GNI per capita	USD	$30 401	$29 286.6	$41 657.1	$39 590.3
Inflation, consumer prices	%	1.9	1.7	2.9	2.7
Total employment	Thousands	24 921	23 327	141 729.7	139 251.9
Unemployment	%	9.86	9.57	5.09	5.53
GDP	Billions USD	$1 897.800	$1 807.800	$12 455.1	$11 657.3
GDP per capita	USD	$31,214	$29,881	$42,021	$39,691
GDP Growth	%	1.2%	2.3%	3.3%	3.9%

Source: Compiled from author's own research based on OECD 2006; FAOSTAT 2006; World Bank 2006; France in Figures 2007; U.S. Bureau of Labor Statistics 2006.

Table 1.A-2 shows an economic comparison of the bakery industries in France and the U.S.:

- While the French bakery industry contributed more to national GDP than the U.S. bakeries did, bakeries in both countries represented less than one percent of national GDP.
- The French bakery GDP contributes a higher share to the national GDP using fewer workers than the U.S. bakery industry. For example, in 2004/2005, the French bakery share of national GDP was approximately 0.4% versus less than 0.2% in the U.S.
- The rate of retail sales per French bakery worker was three to four times that of the rate in the U.S. bakeries.

Table 1.A-2
Economic comparison of bakeries in France and the U.S.
(2005 and 2004)

	Shown as	**2005** France	**2004** France	**2005 U.S.**	**2004 U.S.**
Bakery GDP (Retail sales)	Billions USD	$7.4454	$7.4133	$19.4257	$18.8558
Bakery GDP/Total GDP	%	0.39%	0.41%	0.16%	0.16%
Bakery workforce	Thousands	35	30	280.0	287.8
Bakery/Total Workforce	%	0.14%	0.13%	0.20%	0.21%
Retail price per kilo	USD	$2.06	$2.08	$2.30	$2.20
Bakeries per inhabitant	Unit	1 per 18,000		1 per 29,000	
Bakery GDP (Sales)/ Bakery workforce	Thousands USD	$212.7	$247.1	$69.4	$65.5

Source: Compiled from author's own research based on France in Figures 2007; U.S. Bureau of Labor Statistics 2007; FEBPF 2007; Euromonitor International 2007.

It's also possible that the higher share of GDP might mean the French bakers were able to obtain a higher retail price for their bread. But, as Table 1.A-2 shows, the price of bread per kilo was somewhat higher in the U.S. In fact, when wheat flour content is considered, U.S. bread is sold for roughly twice the price as the same quantity in France.

A comparison of retail sales (bakery GDP) per worker highlights the differences in productivity. The French bakery workers contributed three to four times more to total sales than in the U.S. Given that Table 1.A-1 showed the overall French economy as "sluggish" in comparison to that of the U.S., the productivity-per-worker comparison is surprising. This is all the more surprising because of the differences in economies of scale between the French and U.S. bakeries. Bakeries in France serve a smaller number of inhabitants than in the U.S. In other words, the bakeries are likely to be smaller and more geographically dispersed. This characteristic should lead to less productivity due to the duplication of some activities in each establishment. Therefore, a comparison of production levels of bread volume might be more representative of workforce productivity.

Comparison of bakery production levels

Euromonitor International kindly provided figures for French and U.S. bakeries in 2004 and 2005 (seen in Table 1.A-3).

Table 1.A-3
French and U.S. bakery data details for 2005 and 2004

BREAD	2005	2004	Rate of change
France - retail value RSP US$ million	$7,445.40	$7,413.30	0.43%
USA - retail value RSP US$ million	$19,425.70	$18,855.80	3.02%
France - total volume '000 tonnes	3,606.10	3,568.20	1.06%
USA - total volume '000 tonnes	8,461.20	8,563.90	-1.20%
France – retail value per kilo	$2.06	$2.08	-0.96%
USA – retail value per kilo	$2.30	$2.20	4.55%

Source: Euromonitor International 2007

"The rate of change" column shows:

- U.S. bakers outperformed the French financially by extracting a much higher price per kilo.
- During the same period, the French increased their production volume but not their revenue per kilo (Euromonitor International 2007).

Table 1.A-4 provides a closer look at production volume.

Table 1.A-4
Production volume-per-worker for bakeries in France and the U.S.

France:	Million pounds	000s Tonnes:	000s FTE's	Tonnes/FTE
2004	‘--	3568.20	30.0	120.2
2005	‘--	3606.10	35.0	101.9
U.S.:				
2004	17,127.8	8563.90	334.1	25.6
2005	16,924.4	8462.20	329.0	25.7

Source: Euromonitor International 2007

- The French bakery workers produced some four to five times the volume of U.S. workers.
- Although productivity-per-worker decreased in both countries, the French remained some four times more productive than the U.S. per worker (Euromonitor International 2007; U.S. Census Bureau 2006, 2005; FEBPF 2007).

The lower rate of productivity-per-worker in the U.S. bakery industry may have influenced the price increase in 2005 of some 4.6 percent (Table 1.A-3). But this figure is understated; due to an archaic law on weights and measures[1], U.S. bread is sold based on its overall finished weight. Although bakers use other ingredients (such as sugars and fats) roughly half the weight of the U.S. bread is from water (U.S. Census Bureau 1992, 1997, 2002). As Table 1.A-5 shows, a pound of bread in the U.S. contains slightly more than one-half pound of flour. “In France, the sale of bread is regulated based on the dry weight of its ingredients. Considering shrinkage during baking, a loaf of bread in France is likely to contain some 97 to 99 percent flour” (Cauvain 2007). Therefore, taking into account the differences in flour content, it would seem that the effective price per kilo of bread in the U.S. should be approximately $4.26, rather than $2.30 (Table 1.A-3), or roughly twice as expensive as a kilo of bread in France.

---

[1] The law on weights and measures dates back to the 1700s and was brought from England by the Colonists. There has been little challenge to it; one ‘recent’ case was in Chicago in 1912 (Schmidinger v. City of Chicago 1912).

Table 1.A-5
Share of flour to bread in U.S. bakery production

	Flour purchases million lbs.	Production volume million lbs.	Proportion of bread to flour	Proportion of flour to bread
1992	9,299.8[1]	18,304.1[1]	1.968	50.8%
1997	9,704.1[1]	17,605.7[1]	1.814	55.1%
2002	9,273.7[1]	est.17,538.8	avg.1.891	52.9%

Source: Compiled from author's own research based on [1] U.S. Economic Census of Manufactures 1997, 2002 and 2003 [2].

---

[2] In order to show 2002 production volume for the U.S., the figure had to be estimated. Changes in U.S. Government reporting practices after 1997 removed considerable historical detail and production data from the *Economic Census of Manufactures*.

Appendix 1.B

Details of value added and labour productivity in U.S. and French bakeries

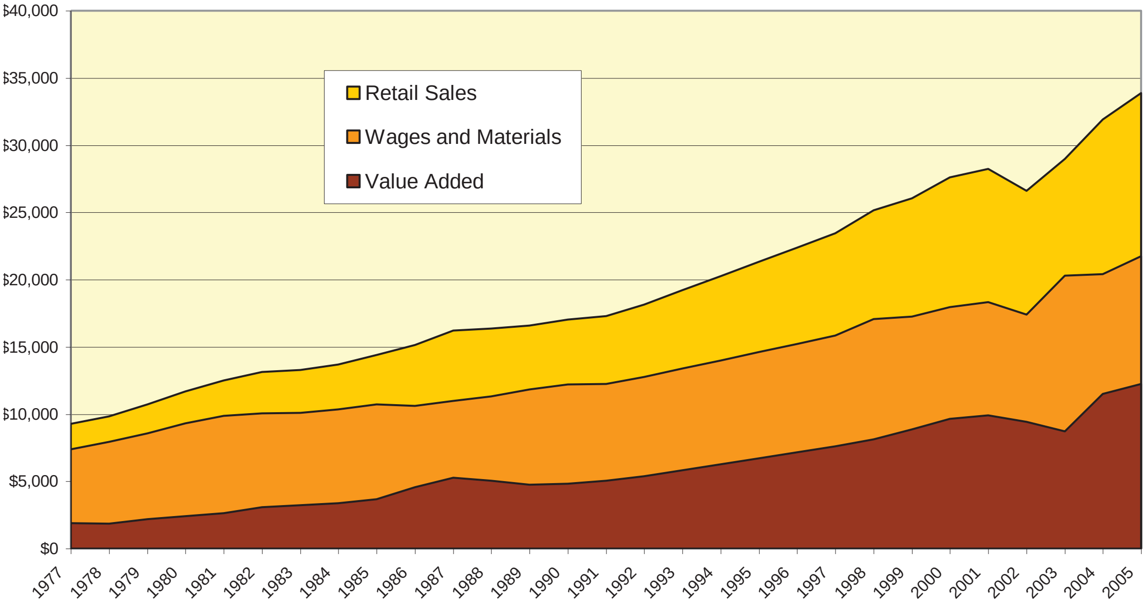
Appendix 1.B

Detailed look at the U.S. bakery industry

Value added compared with cost of wages and materials

Figure 1.B-1 is a composite of U.S. bakery industry data showing the share of value added compared with the combined cost of wages and materials used in production in relation to overall retail sales (U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006). In the early years, wages and materials were a much higher proportion of retail sales than was value added. Value added started to increase in the mid-1980s. With the exception of a dip in 2003, value added increased throughout the nearly thirty-year period. It appears that the U.S. bakery industry pursued a strategy of increasing margins for competitive advantage.

Figure 1.B-1
Share of value added in retail sales in U.S. bakeries
(in millions USD)

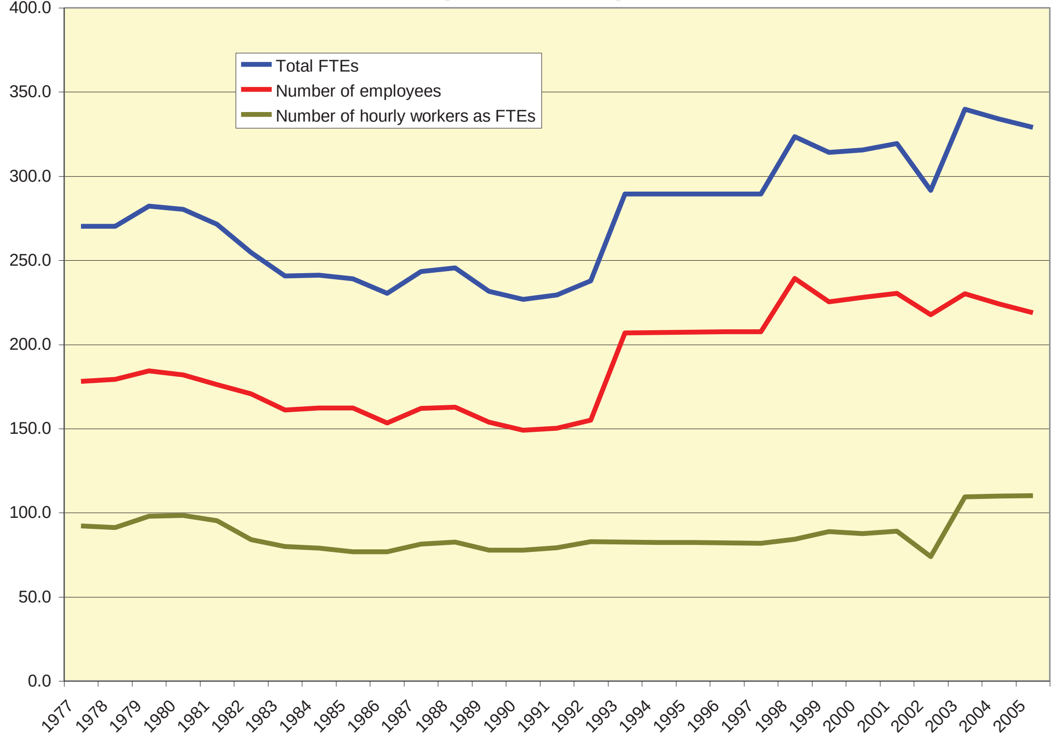


Source: U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006.

Labour policy

Figure 1.B-2 shows the trend in bakery labour over time (U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006).

Figure 1.B-2
Total number of U.S. bakery industry workers
(in thousands)

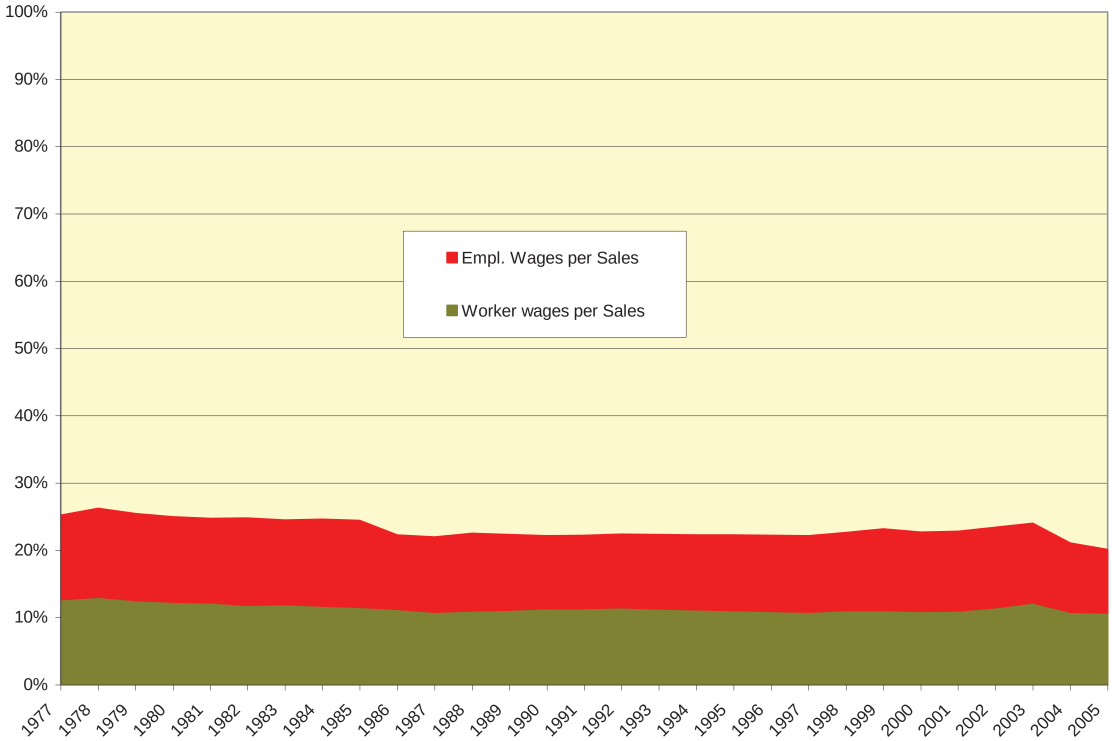


Source: U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006.

The U.S. government statistics report workers in two groups: those who are full-time employees (2,080 hours per annum); and, those termed "production workers" and paid on an hourly basis. From an operations perspective, the use of production (hourly) workers might seem a cost-effective and practical way to deal with rapid increases or decreases in production requirements because the work is considered 'temporary,' leaving the employer with fewer responsibilities toward workers' pensions, healthcare premiums, vacation pay, or other overhead associated with full-time employees. But production workers accounted for roughly 30 percent of the total bakery workforce and were a more stable element of total labour than full-time employees until 1993/1994 when a rapid increase in total FTEs and full-time employees occurs. When industry revenues drop in 2002, the cut in production workers was deeper than for total FTEs or full-time employees. However, when retail sales picked up again in 2003, there were cutbacks in full-time employees and more production workers were hired—both of these could be examples of using hourly workers to perform Porter's support activities, or in other words, another indication of a strategy aimed at 'increasing margins.'

If this were true, then an impact on labour costs should appear. Figure 1.B-3 looks at the total wages paid for full-time employees and production workers, relative to retail sales.

Figure 1.B-3
Wage categories relative to retail sales



Source: U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006.

As shown, wages as a share of retail sales decrease over time for both worker categories. But wages for production workers decrease more slowly and are more closely related to volume of retail sales. Therefore, it can probably be assumed that more pressure to lower wages was applied to the higher-paid full-time employee positions, and would also be consistent with a strategy of 'increased margins'.

Worker productivity versus industry financial performance

Although Figures 1.B-1, 1.B-2 and 1.B-3 describe the influence of 'increasing margins,' none of them explain the low U.S. rate of production volume per worker. Table 1.B-1 compares MTs of dough produced by French FTEs versus U.S. FTEs. The U.S. workers produce just one-fourth to one-fifth the rate of dough as the French do. One possible explanation might be that production volume-per-worker appears lower when there are more 'support activity' workers.

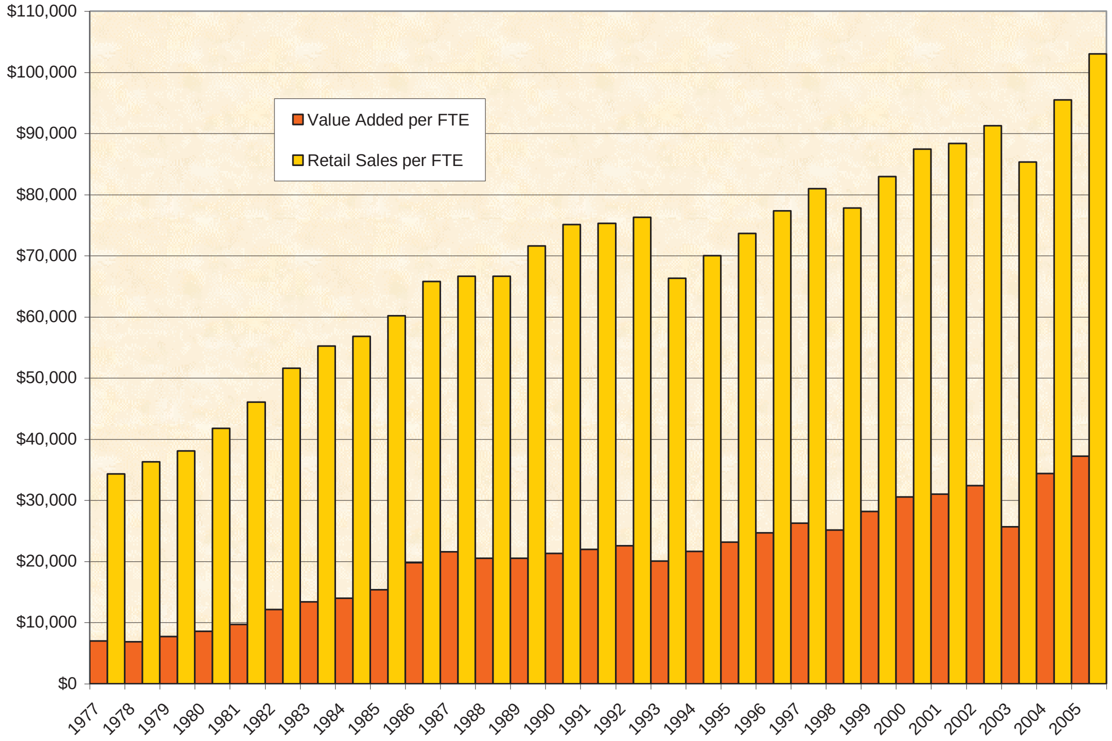
Table 1.B-1
Production volume-per-worker for bakeries in France and the U.S.

France:	**Million pounds**	**000s Tonnes:**	**000s FTE's**	**Tonnes/FTE**
2004[1]	'--	3568.20	30.0 [3]	120.2
2005[1]	'--	3606.10	35.0 [3]	101.9
U.S.:				
2004	17,127.8[1]	8563.90[1]	334.1[2]	25.6
2005	16,924.4[1]	8462.20[1]	329.0[2]	25.7

Source: [1] Euromonitor International 2007; [2] U.S. Census Bureau 2006; [3] FEBPF 2007

Figure 1.B-4 looks at financial productivity per total FTE. With the exception of downturns in 1993 and 2003, Figure 1.B-4 shows financial productivity per worker increasing during the roughly thirty-year period (U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006). However, this also raises a question of whether strategies based on increased margins might distort the accuracy of reported production efficiency. For example, if a financial manager looked at Figure 1.B-4 it might appear that the industry was increasingly productive. Both retail sales-per-worker and value added-per-worker continually increased (excepting the oddities in 1993 and 2003), but this doesn't reflect the operational realities seen in Table 1.B-1.

Figure 1.B-4
Financial productivity per FTE



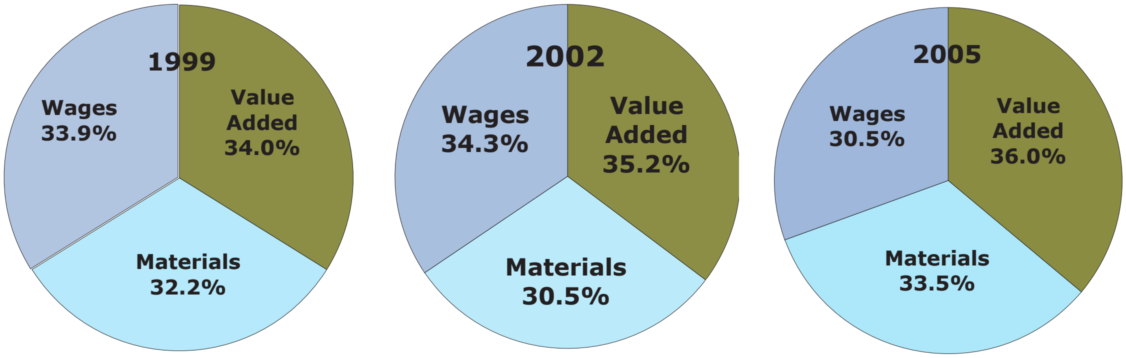
Source: U.S. Economic Census of Manufactures 1997, 2002 and 2003 through 2006.

Value added appears to be independent of changes in value of retail sales

As mentioned in the main text (Section 1.3.3), value added dropped in 2002 and 2003 but returned to outpacing materials and wages in 2004 and 2005, but at a higher rate than before the 2002/2003 setback.

The issue can be seen more clearly in Figure 1.B-5 where value added, wages and materials are shown in their proportions to retail sales for 1999, 2002 and 2005 (U.S. Economic Census of Manufactures 2002 and 2003 through 2006). Even in bad economic years (such as 1999 and 2002), the share of value added is higher than that of materials or of labour. In the years with highest increase in value added, the increase was as much as 4.5 percent (1986) or 6.9 percent (for the combined years of 1986 and 1987); yet retail sales grew 5 percent and 5.8 percent, respectively. In other words, value added was not directly related to changes in the value of retail sales. This is another indication that the bakery industry was probably following a VC strategy.

Figure 1.B-5
Value added, wages and materials as share of sales for specific years



Source: Compiled from author's own research based on U.S. Economic Census of Manufactures 2002 and 2003 through 2006.

Detailed look at the French bakery industry

Artisans and worker productivity

Each year additional artisans are graduated from baking institutes and roughly 1,000 enter the bakery workforce (INBP 2005; FEBPF 2007). This does represent a shift in the overall number of artisans in the bakery industry. Between 2004 and 2005, new artisans appeared at a rate of four percent while non-artisan workers increased by 16 percent. Overall number of artisans changed from 80 percent of total bakery workforce in 2004 to 71.4 percent in 2005. Despite the decline in French artisan bakers as a share of the workforce, the figure is dramatically different than the 16 percent of trained bakers found in the U.S. bakery industry.

Appendix 1.C

Detailed look at retail sales and labour productivity in the U.S. and French grain processor industries

Appendix 1.C

In year 2000 there were 1,343 mills in France while there were only some 360 in the U.S.; despite industry revenue in France that was double that of the U.S., the sales per mill were only $10.2 million versus $18.4 million in the U.S. (Table 1.C-1).

Table 1.C-1
Comparison of milling industry in France with U.S.

Year	No. of mills	Revenue (in millions USD)	FTE-Workers	Sales per FTE
France[1]:				
2000	1,343	$13,754.1	34,092	$403,442
U.S.[2]:				
1997[2]	382	$8,002.0	22,563	$354,651
2000[2]	n.a. (est. 360)	$6,612.1	22,224	$297,521
2002[2]	340	$6,905.7	20,470	$337,357
2002 from ASM[3]	340[3]	$9,086.1[3]	28,115[3, 4]	$323,176

Source: Compiled from author's own research based on [1] INSEE 2007; [2] *U.S. 2002 Economic Census*, U.S. Census Bureau 2005; [3] *Statistics for Industry Groups and Industries: 2003*, Annual Survey of Manufactures, Dept. of Commerce 2005. [4] Note: Data showed 15,987 employees with another 12,128 equivalent full-time employees (FTEs) based on 25.266 million hours worked by "production workers".

Concentration in the U.S. milling industry (Section 1.3.7) may explain the larger U.S. revenue per mill. Yet the French milling industry employed (one-and-one-half times) more workers than the U.S. and produced gross sales per employee that were 35 percent greater. The average mill in the U.S. had many more workers than in France—some 62 workers in the U.S. compared with only 25 in a French mill. It may be that VC strategies with organizational structures to include Porter's support activities led to higher employment in the U.S. mills than in the French ones; this could explain the considerably higher French sales per employee. However, even as sales and cost of wages and materials declined in the U.S., value added generally increased—having gone from 24 percent to 29 percent between 1997-2002—and reaching a peak of 32 percent in 2000 (Table 1.C-2).

Table 1.C-2
Financial results for U.S. milling 1997-2002

	2002	2001	2000	1999	1998	1997
Retail sales	$6,905.73	$6,255.57	$6,612.11	$6,270.60	$7,359.80	$8,001.98
Cost of wages and materials	$4,922.51	$4,568.52	$4,498.71	$4,592.76	$5,471.83	$6,099.51
Value added	$2,003.87	$1,684.36	$2,116.02	$1,666.11	$1,863.97	$1,894.62
VA as share of sales	29.02%	26.93%	32.00%	26.57%	25.33%	23.68%

Source: *U.S. 2002 Economic Census*, Dept. of Commerce 2005

Both the comparatively lower sales per employee in the U.S. and the larger size of each mill suggest that the U.S. grain processors pursued a VC strategy. The continuous rise in value added between 1997 and 2002 would seem to confirm this. At the same time, the French seemed to place more focus on serving their customer base; one example would be the density of the mills (1 343 in a country the size of France versus just 360 in the U.S. in 2000).

Appendix 1.D

Comparison of production expenses of French and U.S. growers

Appendix 1.D

Comparison of production expenses of French and U.S. growers

This appendix provides a further analysis of the cost detail discussed as topic "Comparison of wheat production costs in France and the U.S." in Section 1.3.13. Table 1.D-1 shows productivity data for French and U.S. wheat growers in 1989. Although the U.S. produced three times as much wheat overall, the French produced nearly three times as much per hectare while employing some 130 000 more farmers than the U.S. did.

Table 1.D-1
Comparison of total wheat produced in 1989

	France	U.S.
Number of wheat farms	400 000	Approx. 270 000
Number of hectares with wheat	4 million	28 million
Metric tonnes produced	25 million	74 million
Tonnes/hectare	6.25	2.65

Source: Le Stum and Camaret 1990.

Table 1.D-2 shows the cost detail in the UNIGRAINS analysis (introduced in Section 1.3.13). Columns were added to show cost type as a share of the total; the shares were nearly the same in both countries. Following Table 1.D-2 are descriptions of the various line items.

Table 1.D-2
Costs incurred by wheat farmers in France and U.S. in crop year 1987

Line Nº	Item	France (in FF)	France costs as % of total	U.S. (in $)	U.S. costs as % of total
1	**Variable expenses**	2 255	28.2%	375	28.2%
2	**Specific taxes**	515	6.4%	86	6.5%
	Structural expenses:				
3	**-- Level 1**	2 235	28.0%	371	27.9%
4	**-- Level2**	1 880	23.5%	312	23.5%
5	**Family labour**	845	10.6%	140	10.5%
6	**Cost of owned capital**	265	3.3%	44	3.3%
7	**Total**	7 995	100%	1 328	99.9%

Source: Compiled from author's own research and based on Le Stum and Camaret 1990.

Variable expenses (Line 1 and 2)

Most US. wheat production in 1989 was winter wheat while French producers grew spring wheat. This causes a difference in profitability in that the U.S. producers waited longer for return on investment than did the French. For example, if interest rates in 1989 were 12% per annum and the U.S. farmer waited 10 months to retrieve an investment of $1,328, then a financial cost of $133 was incurred (i.e. 10% of the total per hectare investment). The French farmer may have been fortunate enough to wait only 3 months for the return of the $1,428 investment, thereby incurring an additional $43 in financial costs.

The UNIGRAINS analysis is also beneficial for comparing characteristics of financial decisions taken by farmers and their business advisors. In France, the difference between receipts and variable expenses plus specific taxes (lines 1 and 2) is gross margin and provides the basis for the choice of crop in the rotation decision (Le Stum and Camaret 1990). These expenses are treated a little differently in the U.S. In the UNIGRAINS analysis, variable expenses (line 1) represent both general business overhead (such as expenses for telephone and office supplies) and direct operating expenses related to the specific crop (such as seed, fertilizer, pesticide and custom operations). Also included are general taxes assessed by both France and the EU. They are paid for each ton of wheat sold, similarly to value added tax on other products. Although the U.S. doesn't use a value added tax scheme, the inclusion of tax obligation is consistent with U.S. accounting behaviour. But, the specific taxes category (line 2) are for the most part non-existent for the U.S. farmer.

Specific taxes (Line 2)

The specific taxes category is related to the French cereals and oilseed tax and is assessed based on the acreage of each farm. The tax is used to pay for farmer representation in the wheat board (i.e. ONIC) and professional organizations, general agricultural extension services and a special added contribution for social security. The social security contribution is the only part of the tax that U.S. farmers would experience – as would all independent businesspeople in the U.S. The U.S. wheat export authority (being part of the USDA) was paid by taxes from the general treasury. Membership in professional organizations would be an individual's personal choice with membership paid by the farmer and considered part of operating expense. Agricultural extension services are provided free of charge and are jointly sponsored by the national network of county extension agents (part of the USDA) and the state agricultural universities. Thus, they are provided by a combination of federal and state monies.

Crop rotation decisions

In addition to the variation in treatment of the specific taxes (line 2), U.S. wheat farmers are encouraged to make crop rotation decisions slightly differently than described for French wheat farmers. U.S. producers would be less likely to look at gross margin and more likely to consider the market price of alternative crops and the variable costs associated with each of those crops. For the most part these are items such as seed, herbicide, custom labour, fuel and oil, but there is also a consideration given to potential nitrogen credits (primarily from legumes) that could be gained by choice of crop (e.g. KSU 1997). As fertilizer is one of the largest input costs, nitrogen credits could be considered a type of "income contribution" or expense avoidance. In effect, the strategy aims to maximize short-term profits with less emphasis on managing the long-term business as a whole.

Current operating expenses (not directly related to current crop)

Level 1 structural expenses (line 3) in Table 1.D-2 are operating expenses that are not directly attributable to the present crop. For instance, machinery repairs, fuel, lubrication and electricity are included. Le Stum and Camaret go on to say that French farm management specialists do not usually use the figure of revenue over these expenses. That would be inconsistent with U.S. management behaviour in that all cash expenses are deducted from revenue to evaluate cash-basis income. The risk of not including level 1 structural expenses would be that a farmer inadvertently spends too much on specific expense items. In other words, it might not be a good practice for the farm as a business operation, but it's not likely to adversely impact wheat management practices.

Financial benchmarking

The most important financial benchmark used by both banks and government institutions in France is the level of revenue after subtracting variable expenses (line 1), specific taxes (line 2) and both structural level 1 (line 3) and level 2 (line 4) expenses. The net figure is considered "agricultural income" and defines the health of the farm business (Le Stum and Camaret 1990). Structural level 2 expenses (line 4) are essentially the depreciation and amortizations associated with long-term assets, and this approach to agricultural income (excepting the issues with the cereal and oilseeds tax) would be consistent with U.S. financial analysis, as well. However, lines 5 and 6 would tend to overstate expenses when viewed from the U.S. perspective. The USDA definition of a financially viable farm is "if its revenue fully covers economic costs (cash costs plus an allowance for depreciation plus imputed returns to management, land, and unpaid labor of the operator and family)" (USDA/ERS 2005).

Line 5 (family labour) is used to arbitrarily assign a value to labour provided by the farm family. In the U.S. system, the number of individuals are counted in the census as "non-paid farm labour" but not included in any financial analysis. Line 6 (cost of owned capital) was arbitrarily assigned by UNIGRAINS because it's not usually calculated by French accountants (Le Stum and Camaret 1990). The figure represents the cost of non-land equity and was assigned at the rate of 6%. U.S. accounting practices would have included a similar amortization in structural level 2 expenses (line 4) for the equity associated with physical assets.

Table 1.D-2 was recast to show expenses for both countries in a single currency, U.S. dollars (Table 1.D-3). As Table 1.D-3 shows, U.S. wheat farmers experienced lower production costs overall by roughly 7.5 percent. However, this doesn't take into account the turnaround time needed for the U.S. farmers to recoup their investment costs – which tended to be some two to three times longer than the French farmers. Adjusting for this difference causes the overall costs to be $1,471 for the French farmer and $1,461 for the U.S. farmer. The main point is that it appears 1987 production costs are not very different between the two countries.

Table 1.D-3
Costs incurred by wheat farmers in France and U.S.

N$^{o.}$	Item	France (in $)	U.S. (in $)	Variance France vs. U.S.
1	**Variable expenses**	403	375	+7.5%
2	**Specific taxes**	92	86	+7.0%
	Structural expenses:			
3	**-- Level 1**	399	371	+7.5%
4	**-- Level2**	336	312	+7.7%
5	**Family labour**	151	140	+7.9%
6	**Cost of owned capital**	47	44	+6.8%
7	**Total**	1 428	1 328	+7.5%

Note: The average conversion rate from French francs to U.S. dollars for 1987 was 5.6 FF per USD, and this is the rate used to construct Table 1.18.

Source: Compiled from author's own research.

However, accounting treatment of several items on the U.S. side may have been misunderstood and, therefore, overstated. There isn't actually a U.S. equivalent to Line 2 (Specific taxes); Line 5 (Family labour) and Line 6 (Cost of owned capital) aren't included in USDA figures. Therefore, these three items are deducted from the U.S. figures (Table D.1-4). The difference in turnaround time of investments (mentioned previously) is shown as

Cost of money that increases the total expenses. After making these adjustments, the French cost per ha is $1 471 versus $1 191 in the U.S. Yet, the French cost per MT is $235 versus $451 in the U.S.

Table 1.D-4
Recap of adjusted production costs comparison

N$^{o.}$	Item	France (in $)	Adjustment France	U.S. (in $)	Adjustment U.S.
1	**Variable expenses**	403		375	--
	Cost of money (12%)		+ 43		+ 133
2	**Specific taxes**	92		86	- 86
	Structural expenses:				
3	**-- Level 1**	399		371	--
4	**-- Level2**	336		312	--
5	**Family labour**	151		140	- 140
6	**Cost of owned capital**	47		44	- 44
7	**Total**	1 428	+ 43	1 328	- 137
	Adjusted cost per ha	**1 471**		**1 191**	
	Costs per tonne produced	**235**		**451**	

Appendix 1.E

Processes in the bread VC linked to GI/GL levels

Appendix 1.E

Processes in the bread VC linked to GI/GL levels

Table 1.E-1
Summary of literature linking bread to high GI response

Characteristic	Utah[1]	Canada[2]	Australia[3]	Harvard[4]	INSERM[5]
Cooking and preparation methods:					
-- Higher temperature heat	X	X			X
-- Longer cooking times	X	X			X
-- Use of thermal treatments	X	X			X
-- Processes that allow more softening and swelling	X	X			
-- More processing or refining	X	X			X
-- Force applied in production					X
-- Breadmaking method used					X
Physical grain particles:					
-- Finer particles				X	X
Fibre content:					
-- Fibre not intact to shield starch				X	
-- Less soluble fibre	X				
-- No wholly intact grains		X			X
Type of starch:					
-- Less amylose/more amylopectin	X	X			X
-- Ease of conversion to sugar				X	
Sugar variety:					
-- Less fructose	X				
Fat content:					
-- Less fat		X	X	X	
-- Saturated fats				X	
-- Damaged fats				X	
Protein content:					
-- Less protein		X	X		
Acid content:					
-- Less acids (phytic, others)		X		X	
-- Types of fermentation					X
-- Fermentation process					X
GI or GL value:					
-- Level of net available carbohydrate	X	X	X	X	X

Source: Compiled from author's own research.

[1] Utah = Utah State University Extension Service (2004)
[2] Canada = Canadian Diabetes Association Nutrition Guidelines (2008)
[3] Australia = Australian Nutrition Foundation Inc. (2002)
[4] Harvard = Harvard School of Public Health (2004)
[5] INSERM = The French National Institute of Health and Medical Research (INRA/CRNH), Department of Diabetes (INSERM) and Department of Biochemistry at Hospital Hotel-Dieu, Paris (2006)

Processing and refining and GI/GL levels

The GI/GL level of starchy foods (such as grains) can be altered primarily by processing conditions (Björck 1996) and the structure of the food (Jenkins *et al*. 1988, Granfeldt *et al*. 1995). Although a particular method of processing might cause a high GI level, other ingredients used could moderate the response. In addition, the GI/GL level can be altered by whether or not the food was consumed with a meal or independently (Jenkins *et al*. 1982, Golay *et al*. 1992, Liljeber *et al*. 1999). This suggests the consumer plays a role, as well.

Effects of starch gelatinisation

Gelatinisation in bread refers to the temperature point when the fluid properties in the dough are set and the bread becomes a solid (Yasunaga *et al*. 1968).

Degree of gelatinisation

Processes that disrupt native starch and degree of gelatinisation in baking are two of the ways gelatinisation is related to glycaemic response from bread consumption (Granfeldt *et al*. 2000) "…degree of gelatinisation introduced in food processing is also extremely important in affecting glucose and insulin responses" (Liu 2003). CRNH researched gelatinisation during bread baking showing that use of high amylose flour with a lower melting temperature resulted in bread with an incomplete gelatinisation during baking and connected to a lower glycaemic response. The higher proportion of amylose also contributed to a greater degree of starch resistance and further contributed to a lower glycaemic response (CRNH 1999).

Effects of heating grains

"Glucose and insulin responses in healthy subjects were found to be significantly higher after ingestion of cooked compared with raw starch from wheat (Berthold and Mohamed 1976)…"

(Granfeldt *et al*. 2000). When cereals are added to bread they increase the likelihood of high GI response in the final product. "This is due to the fact that processing by heat is the most common method for manufacturing cereal products" (Granfeldt *et al*. 2000). When a grain is processed under heat, its starch is more or less already gelatinised before it gets added to the dough mix. "An alternate method of production (i.e. 'flaking') steams and rolls the cereal kernels, usually resulting in incomplete gelatinisation" (Holm *et al*. 1988).

<u>Effects of heat and water on cut grain vs. intact grain</u>

Boiled intact (i.e. uncut) cereal grains cause low glucose and insulin responses (Granfeldt *et al*. 1995; Jenkins *et al*. 1988). However, when the raw materials are ground into flours before boiling, GI/GL levels increase significantly compared with boiled intact seeds (Granfeldt *et al*. 1994; Liljeberg *et al*. 1992; O'Dea *et al*. 1980; Tovar *et al*. 1992). Rolling of steamed cereal grains is enough disruption to increase GI/GL levels (Granfeldt *et al*. 2000).

Effects of particle size and fibre on GI/GL levels

One recent study showed that "the greater the particle size of the grain, the lower the glucose and insulin response, regardless of whether or not the grain was subsequently boiled" (Hallfrisch and Behall 2000). A similar finding was reported in study on the effects of fibre: "Foods high in soluble fibre, or foods that are resistant to gelatinisation, show slower rates of digestion and absorption and may be called low glycaemic index foods" (Wolever 1994).

Table 1.E-2
Links between ingredients and/or processing effects on GI/GL levels

<u>Beneficial actions</u>	**<u>Potentially undesirable</u>**
Addition of magnesium	**Resistant starch**
• Found in wholegrain	• Lack of resistant starch leads to higher starch availability for digestion and absorption in the small intestine
• Found in sea salt	
	Refining and milling

Continuation of Table 1.E-2

Beneficial actions	**Potentially undesirable**
Addition of intact fibre	• Increased levels of refining and/or milling
• Found in wholegrain	• Smaller the particle size, greater the destruction of fibre
Addition of intact grain	**Gelatinisation in milling and refining of cereals added to the dough mix**
• Applies to grain that has minimal exposure to heat or heat and water	• Processed under heat prior to adding to bread dough
	• Flaking (i.e. steaming and rolling afterward) causes incomplete gelatinisation
	• Raw materials ground into flour, then boiled
	• Degree of thickness of cereal flakes
	Amylose vs. amylopectin
	• Proportion of amylose less than 50%
	Ingredients used in dough
	• Incompletely fermented dough (containing yeasts that are still active) -- Insufficient level of phytic acid to aid digestion
	Treatment in dough mix
	• Undue force in mixing the bread dough
	Gelatinisation in baking
	• Overly gelatinised; unduly long baking time
	• Temperature required to bring core temperature of bread to melting point for starch crystals
	• Processes that cause swelling of starch granules in heat and water
	Consumer behaviour with high GI food
	• Consumed at breakfast
	• Consumed without other food
	• Consumed without healthy fat/fibre

Source: Compiled from author's own research based on Björck 1996; http://www.brittanysalt.com/2007; CRNH 1999; Eisenberg 1992; Englyst *et al*. 1995; Garzon and Eisenberg 1998; Golay *et al*. 1992; Goodlad and Englyst 2001; Granfeldt *et al*. 1994; Granfeldt *et al*. 1995; Granfeldt *et al*. 2000; Guerrero-Romero *et al*. 2002; Hallfrisch and Behall 2000; Holm *et al*. 1988; HSPH 2005; INRA 2002; Jenkins *et al*. 1982; Jenkins *et al*. 1988; Krauss *et al*. 1996; Le Cordon Bleu 2005; Liljeberg *et al*. 1992; Liljeberg *et al*. 1999; Liu 2003; Ma *et al*. 1995; Marquart *et al*. 2002; McKeown, *et al*. 2004; Meyer *et al*. 2000; National Institute of Medicine, Food and Nutrition Board 1999; NIH 2005; O'Dea *et al*. 1980; Saris *et al*. 2000; Snow and O'Dea 1981; Stevens *et al*. 2002; Tovar *et al*. 1992; USDA 2003; USDA 2008; Willett, *et al*. 2002; Wirfält *et al*. 2001; Wolever 1994; Yasunaga *et al*. 1968;

Appendix 1.F

Review process for veterinary and animal feed literature

Appendix 1.F

Review process for veterinary and animal feed literature

The literature that was found was sorted following three main steps:

1 The first step was to create a set of terms used in the veterinary literature that were relevant to wheat characteristics. These terms needed to be further defined in order to match them to equivalent concepts described in the general 'wheat literature'.

2 The second step was, using the set of defined terms, to separate those articles and topics that could also be connected to human health characteristics. As was the case in the earlier literature search, some of these topics could have had a detrimental impact on human health, but others might have had a beneficial effect.

3 It turned out that when the health result was detrimental, the veterinary literature connected it farm management decisions. These could be further sorted and found to be of three types. In the first two categories, the articles did not definitely state that a farmer would know that a fault could or did occur. This is in contrast to the third category where the fault is known, but nothing prevents its detrimental characteristics in the final product. The three main types of management behaviours were:

  3.1 Faulty management decisions at the farm;

  3.2 Possibly no management decision occurred;

  3.3 Result of poor (or lack of) quality control. This category was slightly different from the first two groups because the literature was clear about what the proper management decision should have been. The problems related to lack of proper quality control.

Veterinary/animal feed literature that was reviewed

Literature was found from the following sources: Choct and Anniston 1992; Choct *et al*. 1999; Rowe *et al*. 1999; Kim *et al*. 2005a, 2005b, 2004; Kim 2006; Zijlstra 2006; Hoffman 2009.

The terminology used in the literature

In the literature regarding grains, wheat flour and human health, terms are used that describe the various nutrients. For example, cellulose, hemicellulose, beta glucans appear quite often. In the veterinary/animal feed literature, the same plant products are referred to as various categories of dietary fibre. As a result, a set of definitions was created (from the veterinary/animal feed literature) for use as a cross-reference during the literature review.

According to the veterinary/animal feed literature, the types of plant material that are included within the definitions of dietary fibre (DF) may be divided into several forms. Those forms are shown below along with an example of how the veterinary/animal feed literature links to the human health literature (using Hallfrisch and Behall 2000 as the example):

- Insoluble dietary fibre (IDF) includes celluloses, some hemicelluloses and lignin. Wheat is predominantly IDF (Hallfrisch and Behall 2000).
- Soluble dietary fibre (SDF) includes beta glucans, pectins, gums, mucilages and some hemicelluloses. More effective (than IDF) at improving insulin sensitivity in humans; SDF is found in oats, rye and barley (Hallfrisch and Behall 2000).
- Acid detergent fibre (ADF) primarily consists of cellulose, lignin, silica and insoluble crude protein and ash, which are the least digestible parts of the plant for cows and pigs—but useful as dietary fibre for humans (as are IDF and SDF).

“The IDF and SDF compounds, apart from lignin, are known collectively as <u>non-starch polysaccharides (NSP)</u>, which was one of the original definitions of DF. However, the Codex definition of NSP recognizes that “there are other materials that are not hydrolysed within the human digestive tract, the principal class of these being the resistant starches and lignin.” NSPs are the non-starch polysaccharides (such as celluloses, some hemi-celluloses, gums and pectins) as well as resistant starches, and are also known as pentosans (IFST 2007).

By way of comparison, the following is a summary of two bread articles describing pentosans. (Pentosans include IDF and SDF but not ADF). As can be seen, the bread literature is discussing the same wheat characteristics as the veterinary/animal feed literature:

Pentosans, which are a non-starchy polysaccharide material, are a minor component of wheat flour present at the 2% to 3% level. They are half water-soluble and half water-insoluble. A number of researchers have investigated the effect of pentosans on staling rates and concluded that they retard starch retrogradation, especially the water-insoluble fraction (Kim and D’Appolonia 1977; Jankiewicz and Michniewicz 1987).

Appendix 1.G

Converting the data from Table 1.16 to Figure 1.10

Appendix 1.G

Converting the data from Table 1.16 to Figure 1.10

Table 1.16 is a summary of the literature linking the bread VC to GI/GL health characteristics. Figure 1.10 shows the cause-and-effect relationship between the health characteristics and the VC-entities where they could occur, or how consumer behaviour could be a cause.

The bakery VC-entity

Table 1.G-1 shows the production steps used for a loaf of bread. The eleven separate process stages are generic across all types of bread, and can also be applied to any method of bread production (Cauvain 1998).

Table 1.G-1
Overview of the stages for making breads

Stage	Name of stage	Description of each stage
		Dough production phase
1	Main mixing stage	Mixing of main ingredients (flour, water, yeast and salt).
2	Energy introduction	Development of gluten structure through introduction of energy during mixing, i.e. traditional kneading or work input in industrial plants.
3	Aeration stage	Incorporation of air bubbles, as well as fermentation gases, while mixing.
		Fermentation phase
4	Ripening stage	Continued 'development' of gluten structure due to kneading; modifies rheological properties of the dough and improves ability to expand when gas pressures increase due to generation of carbon dioxide gas in the fermenting dough; also known as 'ripening' or 'maturing'.
5	Flavour modification	Creation or modification of flavour compounds in the dough.
		End stages
6	Dough division	Division of the dough into pieces.
7	Preliminary shaping	Preliminary shaping of each piece.
8	Short proof	Short delay to allow further modification of physical properties.
9	Final shaping	Shaping of the dough pieces into required shapes.
10	Final proof	‘Proof’ stage -- fermentation and further expansion of shaped dough pieces.
11	Baking and cooling	Further expansion and fixation of the final bread structure.

Source: Cauvain 1998.

The quality characteristics (listed as Items a) through A17) in Table 1.16) can be mapped to the breadmaking stages (Table 1.G-1) to show where the health characteristic might occur (Table 1.G-2). (Highlighted columns in Table 1.G-2 indicate upstream and downstream partners).

Table 1.G-2
Health characteristics mapped to bakery processes

Links to health characteristics	0 Raw materials	1 Main mixing stage	2 Energy introduction	3 Aeration stage	4 Ripening stage	5 Flavour modification	6 Dough division	7 Preliminary shaping	8 Short proof	9 Final shaping	10 Final proof	11 Baking, and cooling	12 Packing and distribution
Detrimental:													
Non-wheat Ingredients:													
Sugar variety (A9, A10)	X	X											
Enzymes (A13)	X	X			?	?							
Additives (A13)	X	X			?	?							
Preservatives (A13)	X	X			?	?						X	?
Less fats (A11)	X	X				?							
Damaged/saturated fats (A12)	X	X				?							
Wheat-based Ingredients:													
Amylose-to-amylopectin ratio in wheat (z, A1, A3)	X	X										X	?
Overall grain choice (z, A1, A2)	X	X				?							
Fibre defects (q, r, s)	X	X	?										
Processing related:													
Particle size of flour (j, k)	X	X											
Gelatinisation (a, b, g)												X	
Force applied (f)			X										
Fermentation time (n, o, p)			X	X	X	?							
Yeast level (p)		X				?							
Beneficial:													
Ingredients:													
Fibre (wholegrain) (A21)	X	X											
Resistant starch (w)	X	X	?										
Intact grain (y, A22)	X	X											
Magnesium (A19)	X	X											
Added micronutrients (A20)	?	X											

Source: Compiled from author's own research.

Columns numbered 1 through 11 (Table 1.G-2) represent the various production stages for bread (from Table 1.G-1). There are two additions: Column 12 and Column 0. Column 12 represents an additional process for the packing and distribution of finished product. This process may or may not belong to the baking plant depending on how the business has organized its distribution functions. Column 0 represents the various raw materials received from external suppliers. When an item is marked with an "X" it indicates that there is a definite connection to the process stage described in the literature review (Table 1.16). Use of a “?” indicates that there appears to be a correlation based on the literature review, but the literature might not have been conclusive.

As can be seen, the most frequent links in the literature are associated directly with the raw materials, or when they are incorporated into the mixing process at Stage 1. But, the raw materials (in Stage 0) aren’t likely to be produced by the bakery; they are more likely to be ‘end products’ of many other producers. Therefore, any health characteristics related to processing or use of a specific ingredient, prior to its arrival at the baking plant, would not appear in Table 1.G-2. In theory, the next step should be to examine the processes for each of the raw materials produced upstream of the bakery-VC. However, this is impractical within the timeframe of PhD research. Therefore, the decision was made to limit investigation to just one ingredient and its processing; wheat flour was selected since it is the chief ingredient used in bread.

The mill VC-entity

The next VC element upstream from the bakery is the mill. The milling processes are shown in Table 1.G-3. Like the bakery, the mills in France and the U.S. both utilize the same basic stages. The milling processes are then linked to the summary of health-related characteristics (Table 1.16); the results are seen in Table 1.G-4. (The highlighted column in Table 1.G-4 represents the upstream supplier).

Each health-related characteristic linked to wheat flour (from Table 1.16) is mapped to the milling process stage where it could occur (Table 1.G-3). Columns headed 01 through 09 represent each of the nine main milling processes. (The numbering has been altered to distinguish milling processes that share an identical number with baking processes, from

Tables 1.G-1 and 1.G-2). Column 00 represents the 'raw ingredient' coming from the wheat farm.

The items listed under ingredients—amylose-to-amylopectin ratio, grain choice and fibre defects—reflect wheat that arrives at the mill with (intrinsic) protein qualities that the miller may or may not decide to accept. Therefore, they are positively correlated to both the wheat farm and the mill. Particle size is an operations decision taken at the mill and likely agreed with the customer (baker). Gelatinisation would appear to also be an operational decision but changes in protein-to-starch and amylose-to-amylopectin ratios (i.e. the 'good protein' quality characteristics) could influence the final flour produced as well as the miller's possible decision regarding processing during the purification stage (07); therefore, this characteristic also appears in both VC-entities (i.e. the mill and the farm). Use of enzymes and additives are part of the miller's processes for dressing the flour, but in some instances might reflect the wheat quality characteristics upon arrival at the mill. The degree of fibre and resistant starch are both beneficial. Depending on wheat quality, they may arrive at the mill with these intrinsic characteristics, or the miller may add either fibre or resistant starch to the flour. In a sense that would seem to indicate that the beneficial aspect is more related to the mill. However, as protein quality in the wheat decreases, the linkage becomes a 'detrimental' health characteristic attributable to the wheat farm. The decision to produce wholegrain flour is an operational element within the mill. Added magnesium and other micronutrients does include the wheat farm because choice of farm land, season and other environmental and production management issues can impact the levels of magnesium and other micronutrients found in the wheat. However, the miller can also choose to add them to the flour.

Table 1.G-3
Overview of the milling stages for wheat flour

Stage	Name of stage	Description of each stage
Wheat arrival phase		
1	Sampling load	Checking the truckload of wheat for contamination, taints and other obvious defects.
2	Wheat testing	Laboratory tests carried out prior to truck tipping the load of wheat:
2.1	Appearance, odours check	Trained staff checks for unusual odours, especially mustiness, contamination, even fuel odours.
2.2	Screen impurities	Intrinsic impurities (shrivelled or diseased grains, straw, fungi) and extrinsic (string, paper, nails) are screened against wheat merchant's specifications.
2.3	Wheat density	Hectolitre weight or bushel weight indicates the probable extraction rate
2.4	Ground sample	Having passed tests 2.1 – 2.3, small sample is ground in the laboratory and checked further:
2.4.1	Gluten content	Good gluten is vital in breadmaking. Sample is checked for vitality and strength.
2.4.2	Hagberg Falling Number	Measures the degree of cereal *alpha*-amylase in the wheat. Higher Hagberg number indicates lower amount of amylase.
2.4.3	Moisture content	Must be low enough to prevent spoilage for long periods (typically 4 to 12 months).
2.4.4	Protein content	Protein content and protein quality are main factors for wheat trading; measured with near infrared.
2.4.5	Hardness	Indicates wheat endosperm texture.
2.4.6	Electrophoresis test	Optional test: Used to authenticate wheat variety; splits protein fraction into amino acids for comparison against known samples.
2.5	Storage stage	Having passed tests 2.4.1 – 2.4.6, truck dumps load and wheat is moved to storage bunkers. Wheat may be kept short time, but longer storage requires to be turned completely on a regular basis.
Screenroom phase		
3	Dry cleaning	Designed to remove wide range of impurities form the wheat:
3.1	Size separation	Multiple screenings remove large (string, straw) and fine (sand, dust) impurities.
3.2	Specific gravity	Removes heavier items (stones) that are same size as wheat.
3.3	Shape separation	Separation of seeds, wheat, and oats, barley or unthreshed grain.
3.4	Magnetic separation	May eliminate both ferrous and non-ferrous metals.
3.5	Aspiration	Air resistance is used to remove light impurities (dust, fine dirt, chaff).
3.6	Conditioning	Wheat is dampened with water to ease removal of bran layers from endosperm.
Milling phase		
4	Break system stage	First grinding that separates semolina (endosperm) from the bran.
5	Scalping, grading, and dusting	Separation of semolina and bran after 'breaking' apart.
6	Scratch system	Remove last fragments of endosperm from bran.
7	Purifiers	Cleans the semolina by lifting out any fine bran.
8	Reduction system	Final phase of grinding. Cleaned semolina is reduced to finished flour by series of up to 12 different sets of reduction rollers.
9	Flour dressing	Each pair of rollers is followed by a sifter making 3 to 5 separations; flakes and other distortions are managed, then various flour streams are blended into final products.

Source: Cauvain and Catterall 1998.

Table 1.G-4
Health characteristics mapped to milling processes

Links to health characteristics	00 Wheat farm	01 Sampling load	02 Wheat testing	03 Screenroom phase	04 Breaking stage	05 Scalp, grade, dust	06 Scratch system	07 Purifiers	08 Reduction system	09 Flour dressing
Detrimental:										
Ingredients:										
Amylose-to-amylopectin in wheat (z, A1, A3)	X		X							
Overall grain choice (z, A1, A2, A3, A4)	X		X							
Fibre defects (q, r, s, w)	X		X							
Processing related:										
Particle size (e, j, k, l, m)									X	X
Gelatinisation (c, d, e, h, I, u)	X		X					X		
Enzymes (A13)										X
Additives (A13)										X
Beneficial:										
Ingredients:										
Fibre (wholegrain) (A21)	X									?
Resistant starch (w)	X									?
Intact grain (A22)	X	X							X	
Magnesium, other micronutrients (A19, A20)	X									?

Source: Compiled from author's own research.

The wheat farm VC-entity

Wheat farm production processes could be segregated according to just three categories found in the literature (Choice of wheat variety, Production practices and Grain storage practices). The wheat farm also has an upstream set of suppliers, indicated as Input suppliers. The health-related characteristics (Table 1.16) are mapped to the wheat farm characteristics (Table 1.G-5). (The highlighted column in Table 1.G-5 represents the Input supplier).

Table 1.G-5
Health characteristics mapped to farming processes

Links to health characteristics	Input suppliers	Choice of wheat variety	Production practices	Grain storage practices
Detrimental:				
Ingredients:				
Insecticides, herbicides, fertilizers (A5)	X	X	X	

Links to health characteristics	**Input suppliers**	**Choice of wheat variety**	**Production practices**	**Grain storage practices**
Detrimental (Cont.):				
Wheat seed quality (A3, A4, A5)	X	X	X	
Wheat variety:				
Protein/starch problems (z, A1, A2, A3, A4, A5)	?	X	X	?
Choice of growing season (A4)		X	X	?
Resistance to insects, weeds, disease (A5)	X	X	X	?
Processing related:				
Too little irrigation or precipitation (A6)	?	X	X	
Influence on aspects of 'good protein' (A7)	?	X	X	X
More sugar, less fibre, less protein (A8)	?	X	X	X
Exposure to high temperatures (a)				X
Undue force applied in harvesting (f)			?	
Processed under heat/artificial drying (i)				X
Fibre not intact (q, t)		?	?	?
Fibre defects (r, s, w)	?	X	X	X
Beneficial:				
Ingredients:				
Fibre (wholegrain) (A21)	?	X	X	X
Resistant starch (w)	?	X	X	X
Intact grain (A22)		?	X	?
Magnesium, other micronutrients (A19, A20)	?	X	X	X

Source: Compiled from author's own research.

Relationships to consumer behaviour

There are steps the consumer should take to avoid eating 'high GI' foods or preparing food in a manner that increases the likelihood of a high GI response when the food is consumed. These quality characteristics (Table 1.16) are mapped to consumer behaviour (Table 1.G-6).

While the majority of consumption characteristics are under the control of the consumer, consumption characteristics are also dependent on the bread choices available. This can be seen in Table 1.G-6 (highlighted column titled "Retail suppliers"). As Items 1 through 4 show, the consumer needs an available selection of breads that include offerings that are less likely to contribute to high GI/GL levels. But as Item 5 shows, most consumers will need help to determine which breads are a better choice and information that describes the carbohydrate quality and net quantity in a bread. Items 6, 7, 8 and to some degree Item 5, are related to a need for consumer education.

Table 1.G-6
Health characteristics mapped to consumer behaviour

Item N^o.	Links to health characteristics	Retail suppliers	Choice of bread variety	Preparation practices	Consumption practices
1	Choice of bread with less sugar or 'unhealthy' fats (A9, A10, A12)	X	X		
2	Choice of bread with added fibre, wholegrain or added intact grain (x, A21, A22)	X	X		
3	Choice of bread with added grain high in beta glucans such as oats, rye, barley (y)	X	X		
4	Choice of bread with more magnesium (sea salt, wholegrains) and other micronutrients (A19, A20)	X	X		
5	Consumes too great a quantity of carbohydrate at one time (A14, A18)	?	X	X	X
6	Quantity consumed at breakfast (A15)			X	X
7	Consumed without other food (A16)			X	X
8	Consumed without healthy fat/fibre (A17)		?	X	X

Source: Compiled from author's own research.

Summary

Tables 1.G-2 and 1.G-4 showed, there are a limited number of processes that occur in the bakery and the mill that are related to the protein quality characteristics found in the literature that can impact health. As a practical matter, the wheat farm introduces the majority of the identified linkages found in the bakery and the mill. Excluding the links to non-wheat ingredients (such as sugar, fats, added chemicals), the wheat farm has a relationship with nearly all of the remaining quality characteristics (Table 1.16). Figure 1.10 is an Ishikawa (fishbone) diagram depicting cause-and-effect relationships between the characteristics that impact GI/GL levels (Table 1.16) and the VC-entities where they could occur or where consumer behaviour could be implicated.

Appendices

to Chapter 3

Appendix 3.A

Grading wheat in the U.S.

3.A.0 Grading wheat in the U.S.

3.A.1 U.S. wheat grading system

Table 3.A-1 offers a simplified view of U.S. wheat grading standards. This is followed by a discussion of the various elements of the standards.

Table 3.A-1
Wheat Grades and Grade Requirements

	Grades U.S.Nos.[1]				
Grading Factors	**1**	**2**	**3**	**4**	**5**
Minimum pound limits of:					
Test Weight					
Hard Red Spring wheat or White Club wheat (lbs/bu)	58.0	57.0	55.0	53.0	50.0
All other classes and subclasses (lbs/bu)	60.0	58.0	56.0	54.0	51.0
Maximum percent limits of:					
Defects					
Damaged kernel					
Heat (part of total)	0.2	0.2	0.5	1.0	3.0
Total	2.0	4.0	7.0	10.0	15.0
Foreign material	0.4	0.7	1.3	3.0	5.0
Shrunken and broken kernels	3.0	5.0	8.0	12.0	20.0
Total[1]	3.0	5.0	8.0	12.0	20.0
Wheat of other classes[2]					
Contrasting classes	1.0	2.0	3.0	10.0	10.0
Total[3]	3.0	5.0	10.0	10.0	10.0
Stones	0.1	0.1	0.1	0.1	0.1
Maximum count limits of:					
Other material					
Animal filth	1	1	1	1	1
Castor beans	1	1	1	1	1
Crotalaria seeds	2	2	2	2	2
Glass	0	0	0	0	0
Stone	3	3	3	3	3
Unknown foreign substance	3	3	3	3	3
Total[4]	4	4	4	4	4
Insect-damaged kernels in 100 grams	31	31	31	31	31

Source: Compiled from Subpart M—United States Standards (May 2006).

[1] Includes damaged kernels (total), foreign material, and shrunken and broken kernels.
[2] Unclassed wheat of any grade may contain not more than 10.0 percent of wheat of other classes.
[3] Includes contrasting classes.
[4] Includes any combination of animal filth, castor beans, crotalaria seeds, glass, stones, or unknown foreign substance.

The following pages (in this section) are part of the wheat grading standards, Subpart M—United States Standards (May 2006). Each standard is explained, an indication is given for the definition of each descriptor that might be applied and finally an example of the grading is shown as an overview.

Definition of wheat

Grain that, before the removal of dockage, consists of 50 percent or more common wheat (*Triticum aestivum* L.), club wheat (*T.compactum* Host.), and durum wheat (*T.durum* Desf.) and not more than 10 percent of other grains for which standards have been established under the United States Grain Standards Act and that, after the removal of the dockage, contains 50 percent or more of whole kernels of one or more of these wheats.

Definitions of classes

(a) There are eight classes for U.S. wheat: Durum wheat, Hard Red Spring wheat, Hard Red Winter wheat, Soft Red Winter wheat, Hard White wheat, Soft White wheat, Unclassed wheat, and Mixed wheat.

(1) **Durum wheat.** All varieties of white (amber) durum wheat. This class is divided into three subclasses.

(2) **Hard Red Spring wheat.** All varieties of Hard Red Spring wheat. This class is divided into the following three subclasses:

(i) ***Dark Northern Spring wheat.*** Hard Red Spring wheat with 75 percent or more of dark, hard, and vitreous kernels.

(ii) ***Northern Spring wheat.*** Hard Red Spring wheat with 25 percent or more but less than 75 percent of dark, hard, and vitreous kernels.

(iii) ***Red Spring wheat.*** Hard Red Spring wheat with less than 25 percent of dark, hard, and vitreous kernels.

(3) **Hard Red Winter wheat.** All varieties of Hard Red Winter wheat. There are no subclasses in this class.

(4) **Soft Red Winter wheat.** All varieties of Soft Red Winter wheat. There are no subclasses in this class.

(5) **Hard White wheat.** All hard endosperm white wheat varieties. There are no subclasses in this class.

(6) **Soft White wheat.** All soft endosperm white wheat varieties. This class is divided into the following three subclasses:

(i) ***Soft White wheat.*** Soft endosperm white wheat varieties which contain not more than 10 percent of white club wheat.

(ii) ***White Club wheat.*** Soft endosperm white club wheat containing not more than 10 percent of other soft white wheats.

(iii) ***Western White wheat.*** Soft white wheat containing more than 10 percent of white club wheat and more than 10 percent of other soft white wheats.

(7) **Unclassed wheat.** Any variety of wheat that is not classifiable under other criteria provided in the wheat standards. There are no subclasses in this class. This class includes any wheat which is other than red or white in color.

(8) **Mixed wheat.** Any mixture of wheat that consists of less than 90 percent of one class and more than 10 percent of one other class or a combination of classes that meet the definition of wheat.

Contrasting classes

(b) Contrasting classes are:

(1) Durum wheat, Hard White wheat, Soft White wheat, and Unclassed wheat in the classes Hard Red Spring wheat and Hard Red Winter wheat.

(2) Hard Red Spring wheat, Hard Red Winter wheat, Hard White wheat, Soft Red Winter wheat, Soft White wheat, and Unclassed wheat in the class Durum wheat.

(3) Durum wheat and Unclassed wheat in the class Soft Red Winter wheat.

(4) Durum wheat, Hard Red Spring wheat, Hard Red Winter wheat, Soft Red Winter wheat, and Unclassed wheat in the classes Hard White wheat and Soft White wheat.

Other terms used

(c) **Damaged kernels.** Kernels, pieces of wheat kernels, and other grains that are badly ground-damaged, badly weather-damaged, diseased, frost-damaged, germ-damaged, heat-damaged, insect-bored, mold-damaged, sprout-damaged, or otherwise materially damaged.

(d) **Defects.** Damaged kernels, foreign material, and shrunken and broken kernels. The sum of these three factors may not exceed the limit for the factor defects for each numerical grade.

(e) **Dockage.** All matter other than wheat that can be removed from the original sample by use of an approved device (an equivalent procedure using hand sieves is described on page 7) according to procedures prescribed in FGIS instructions. Also, underdeveloped, shriveled, and small pieces of wheat kernels removed in properly separating the material other than wheat and that cannot be recovered by properly re-screening or recleaning.

(f) **Foreign material.** All matter other than wheat that remains in the sample after the removal of dockage and shrunken and broken kernels. Determine the amount of foreign material in wheat by handpicking.

(g) **Heat-damaged kernels.** Kernels, pieces of wheat kernels, and other grains that are materially discolored and damaged by heat which remain in the sample after the removal of dockage and shrunken and broken kernels.

(h) **Other grains.** Barley, corn, cultivated buckwheat, einkorn, emmer, flaxseed, guar, hull-less barley, nongrain sorghum, oats, Polish wheat, popcorn, poulard wheat, rice, rye, safflower, sorghum, soybeans, spelt, sunflower seed, sweet corn, triticale, and wild oats.

(i) **Shrunken and broken kernels.** All matter that passes through a 0.064 x 3/8” oblong-hole sieve after sieving according to procedures prescribed in the FGIS instructions.

Basis of determination

Each determination of heat-damaged kernels, damaged kernels, foreign material, wheat of other classes, contrasting classes, and subclasses is made on the basis of the grain when free from dockage and shrunken and broken kernels. Other determinations not specifically provided for under the General Provisions are made on the basis of the grain when free from dockage, except the determination of odor is made on either the basis of the grain as a whole or the grain when free from dockage.

(b) **Grades and grade requirements for Mixed wheat.** Mixed wheat is graded according to the U.S. numerical and U.S. sample grade requirements of the class of wheat that predominates in the mixture, except that the factor wheat of other classes is disregarded.

Special Grades and Special Grade Requirements

(a) **Ergoty wheat.** Wheat that contains more than 0.05 percent of ergot. [Note: Ergoty wheat is dangerous because it causes convulsions and abortions in both humans and livestock (Catterall 1998)].

(b) **Garlicky wheat.** Wheat that contains in a 1,000-gram portion more than two green garlic bulblets or an equivalent quantity of dry or partly dry bulblets.

c) **Infested wheat.** Wheat that is infested with 2 or more live insects injurious to stored grain.

(d) **Light smutty wheat.** Wheat that has an unmistakable odor of smut, or which contains, in a 250 gram portion, smut balls, portions of smut balls, or spores of smut in excess of a quantity equal to 5 smut balls, but not in excess of a quantity equal to 30 smut balls of average size.

(e) **Smutty wheat.** Wheat that contains in a 250-gram portion smut balls, portions of smut balls, or spores of smut in excess of a quantity equal to 30 smut balls of average size.

(f) **Treated wheat.** Wheat that has been scoured, limed, washed, sulfured, or treated in such a manner that the true quality is not reflected by either the numerical grades or the U.S. sample grade designation alone.

U.S. Sample Grade is wheat that has any one or more of the following defects:

(a) Does not meet the requirements for U.S. Grade Numbers. 1, 2, 3, 4, or 5; or

(b) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or

(c) Is heating or of distinctly low quality.

Grading procedures

Wheat is graded as follows:

Step 1. Examine the sample for heating, odor, animal filth, castor beans, crotalaria seeds, garlic, glass, insect infestation, unknown foreign substances, and other unusual conditions.

Step 2. Divide out a representative portion from the sample and determine its moisture content.

Step 3. Determine the percentage of dockage in the sample.

Step 4. Examine the dockage-free sample for ergot, smut, stones, and treated seeds.

Step 5. Determine the test weight per bushel of the dockage-free sample.

Step 6. When deemed necessary, divide out a representative portion from the dockage-free sample and determine the percentage of protein.

Step 7. Divide out a representative portion from the dockage-free sample and determine the percentage of shrunken and broken kernels (SHBN).

Step 8. When deemed necessary, divide out representative portions from the SHBN-free sample and determine the percentage of class, contrasting classes, damaged kernels, heat-damaged kernels, foreign material, subclass, and wheat of other classes.

Portion Sizes

The standards refer to the portion sizes shown in Table 3.A-2.

Table 3.A-2
Conditions and portion sizes

Condition	Quantity
Damaged kernels	15 grams
Dockage	250 grams
Shrunken and broken	200 grams
Foreign material	30 grams
Heating	The lot as a whole.
Infestation	The original sample or lot as a whole.

Moisture	The amount recommended by the instrument manufacturer.
Objectionable odors	The original sample or lot as a whole.
Test weight	An amount sufficient to cause per bushel grain to overflow a kettle.

Procedure for Determining Dockage with Hand Sieves

Step 7.1. Nest the appropriate sieve(s) on top of a bottom pan. Place a 12/64-inch round-hole sieve on top of a 5/64-inch round-hole sieve.

Step 7.2. Pour the sample into the center of the top sieve, place the sieve(s) in a mechanical grain sizer, set the sizer's timer to 20, and turn it on. If a mechanical sizer is not available, hold the sieves and bottom pan level. Then, using a steady motion, move the sieve from right to left approximately 10 inches and then return from left to right. Repeat this operation 20 times.

Step 3. Remove the dockage. Consider dockage to be all coarse material that remains on top of the sieves and all material that passed through the bottom sieve.

Test Weight per Bushel

Test weight per bushel is the weight of the volume of grain that is required to fill a Winchester bushel (2,150.42 cubic inch) to capacity. Since test weight per bushel tends to increase as moisture content decreases, determine it as quickly as possible after the grain is sampled. Determine test weight per bushel *after* the removal of dockage.

Step 7.1. Pour the sample through a funnel into a kettle until the grain overflows the kettle.

Step 7.2. After pouring the grain into the kettle, level it off by making three, full-length, zigzag motions with a stroker.

Step 3. Then weigh the filled kettle on either (1) a special beam scale attached to the funnel stand, (2) an electronic scale programmed to convert gram weight to test weight per bushel, or (3) a standard laboratory scale.

Shrunken & Broken Kernels

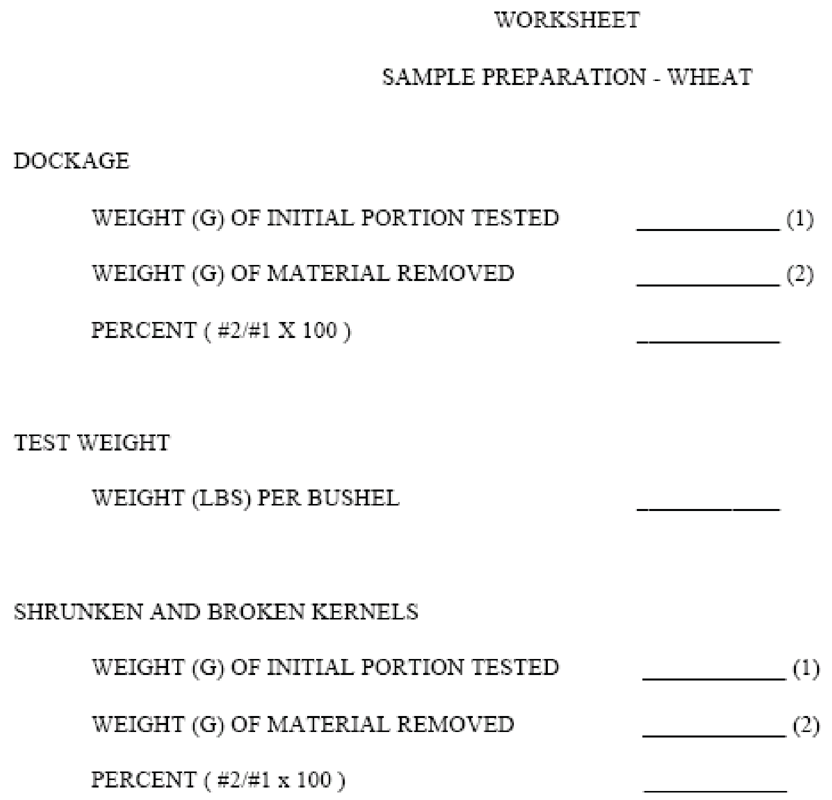
Repeat hand sieving procedures listed above using a 0.064 inch x 3/8 inch oblong-hole sieve.

3.A.2 Administering wheat grading tests

This section shows a wheat testing worksheet as well as photographs of various defects in wheat kernels. As can be seen from the test descriptions in Section 3.A.1 – and more easily in the photographs – only visual tests are administered.

The following is a sample of a wheat grading worksheet. As can be seen, it represents the tests performed at the country grain elevator which is the first point after the harvested wheat leaves the farm in the U.S. (Herrman and Reed 2002).

Figure 3.A-1
Wheat grading worksheet



WORKSHEET

SAMPLE PREPARATION - WHEAT

DOCKAGE

WEIGHT (G) OF INITIAL PORTION TESTED ___________ (1)

WEIGHT (G) OF MATERIAL REMOVED ___________ (2)

PERCENT (#2/#1 X 100) ___________

TEST WEIGHT

WEIGHT (LBS) PER BUSHEL ___________

SHRUNKEN AND BROKEN KERNELS

WEIGHT (G) OF INITIAL PORTION TESTED ___________ (1)

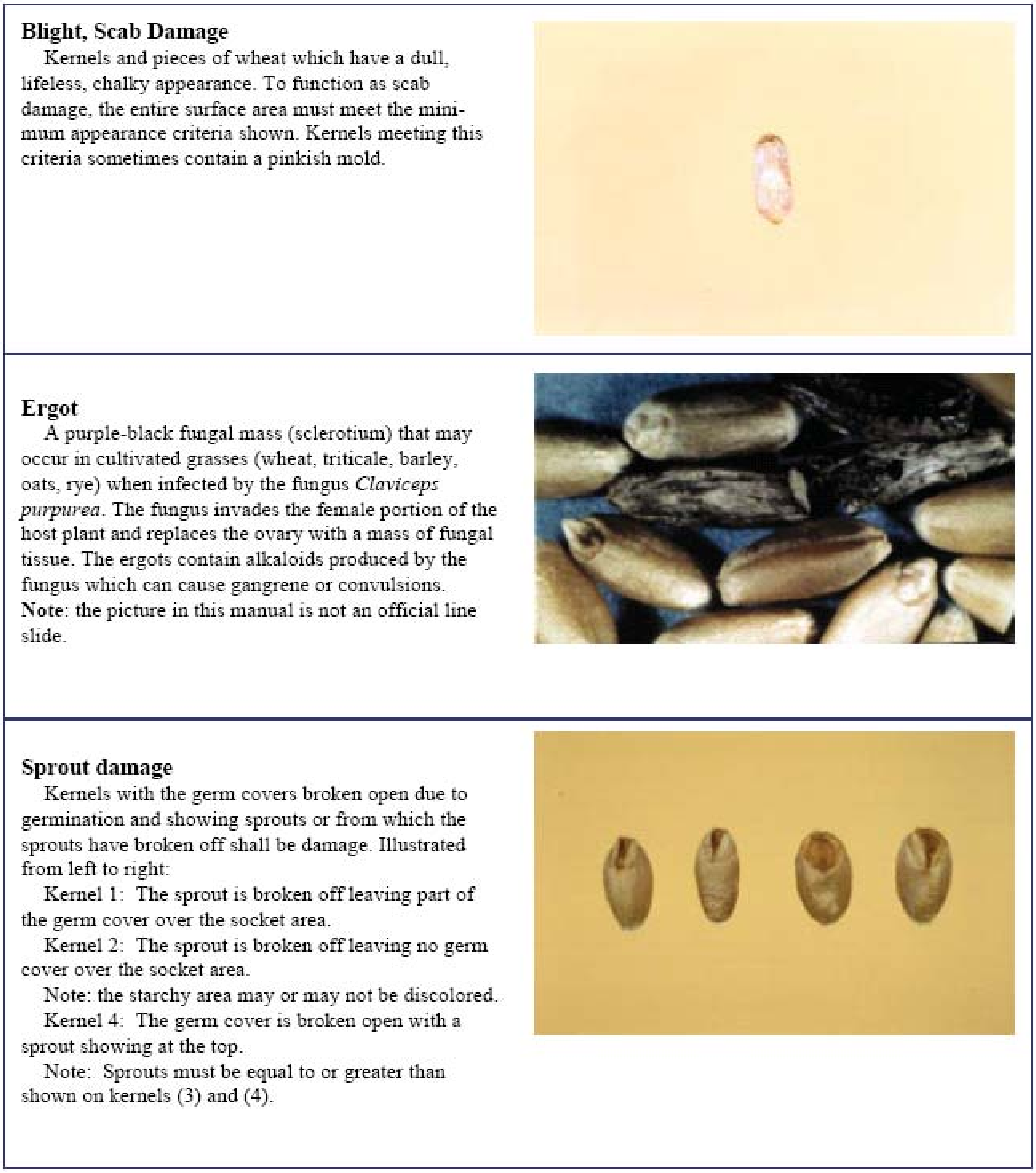
WEIGHT (G) OF MATERIAL REMOVED ___________ (2)

PERCENT (#2/#1 x 100) ___________

Source: KSU – Herrman and Reed 2000

Pictures of wheat kernel defects – page 1 of 3

The following pictures show a variety of common defects found in wheat kernels, and described in the U.S. grading standards.



Blight, Scab Damage

Kernels and pieces of wheat which have a dull, lifeless, chalky appearance. To function as scab damage, the entire surface area must meet the minimum appearance criteria shown. Kernels meeting this criteria sometimes contain a pinkish mold.

Ergot

A purple-black fungal mass (sclerotium) that may occur in cultivated grasses (wheat, triticale, barley, oats, rye) when infected by the fungus *Claviceps purpurea*. The fungus invades the female portion of the host plant and replaces the ovary with a mass of fungal tissue. The ergots contain alkaloids produced by the fungus which can cause gangrene or convulsions. **Note**: the picture in this manual is not an official line slide.

Sprout damage

Kernels with the germ covers broken open due to germination and showing sprouts or from which the sprouts have broken off shall be damage. Illustrated from left to right:

Kernel 1: The sprout is broken off leaving part of the germ cover over the socket area.

Kernel 2: The sprout is broken off leaving no germ cover over the socket area.

Note: the starchy area may or may not be discolored.

Kernel 4: The germ cover is broken open with a sprout showing at the top.

Note: Sprouts must be equal to or greater than shown on kernels (3) and (4).

Source of all Pictures of wheat kernel defects: KSU and Seedburo Equipment Company 2000.

Pictures of wheat kernel defects – page 2 of 3

Heat Damage

Pieces of kernels of wheat damaged by heat and materially discolored to the extent shown. Whole kernels of wheat must occasionally be cross-sectioned (see Kernel 3) to confirm the entire face of both halves are as dark or darker than shown in Kernels 1 or 2.

Germ Damage (Sick-Damaged as result of Respiration)

Kernels with germs as dark or darker than the kernel shown shall be damage.

Procedure: Kernels should be scraped carefully with a sharp instrument such as picks, to avoid scraping too deeply and destroying the evidence of damage.

Note: Germs with more intense discoloration require less coverage to be considered damage.

Wheat Weevil or Insect Bored Damage

Kernels that have been bored or tunneled by insects shall be damage. Illustrated from left to right:

Kernel 1: Kernel that has been tunneled.

Kernels 2 & 3: Kernels that have been bored.

Pictures of wheat kernel defects – page 3 of 3

Wheat - Black Tip Damage (Fungus)

Kernels affected by black tip fungus to the extent that the discoloration (fungus growth) extends beyond the germ and continues around at least one cheek and into the crease. All conditions must be met to be considered damage.

Kernel 1: The minimum degree of discoloration and amount of coverage required on the germ.

Kernel 2: The minimum degree of discoloration required in the "continuous band" that extends around the cheek. The width of the band is irrelevant.

Kernel 3: The minimum degree of discoloration required to extend into the crease. The amount of discoloration (area of coverage) is immaterial

Appendix 3.B

Three studies comparing profits from futures trading to profits related to good production practices

3.B.0 Comparing profits from futures trading to profits from good production practices

This appendix is a collection of three sets of research conducted by Kansas State University's (KSU's) Department of Agricultural Economics (Kastens and Nivens 1999; Kastens, Dhuyvetter and Nivens 2001; Kastens and Dhuyvetter 2005). All three studies were concerned with a comparison of profits coming from futures trading with profits related to several benchmarks for good production practices. The research covers data collected from some 1000 Kansas farms during three overlapping time periods (i.e. 1987-1996; 1990-1999; and 1995-2004).

3.B.1 The first study

The first study covered 1987-1996. Its abstract gives a good overview of farm management alternatives, as viewed from the late 1990s. While the 1996 bill mentioned in the following excerpt refers to deregulation of the market, the "marketing issues" mentioned in the first sentence refer to futures markets rather than a farmer's attempts to sell a product:

"The removal of target price payments wrought by the 1996 Freedom to Farm bill has increased farmers' interest in marketing issues. If this increased interest in marketing issues results in farmers 'trying to pick high prices in the futures market,' it could mean disappointment for those farmers. Empirical evidence supporting efficient grain futures suggests that it is difficult to garner profits trading futures (Garcia, Hudson, and Waller; Kolb, 1992, 1996; Kastens and Schroeder; Zulauf and Irwin; Tomek). Kastens and Schroeder found that Kansas City wheat futures are generally efficient, and that the efficiency has been increasing over the past 50 years. This implies that even if profitable futures trading or hedging strategies were possible in the past, such strategies likely became less profitable over time. Zulauf and Irwin note that 'evidence exists that individuals can beat the market, although the number who can consistently do so is small. The primary attributes of these individuals are that they have superior access to information and/or possess superior analytical ability'."

The research questions of the study were: "What is good management? As used in this research, good management, or economic success, is persistently achieving greater profits than one's neighbors across years. For agricultural producers, what defines economic success? Does it have to do with obtaining higher yields, lower costs, or higher prices? Or, is it related more closely to knowing when to adopt new technologies? The issue facing producers is where to focus their management efforts. As a producer, is it easier to lower your cost, or to increase your yield? Will profit be more affected by changing technology or by 'picking' good prices?" 'Picking' a good price sounds like it might describe a marketing strategy in the conventional business sense, but it refers to choosing (guessing) a price at planting time for the likely price of the crop on the commodities exchange at harvest time.

Kastens and Nivens went on to create a conceptual model to describe the various parameters of good management as:

Profit = f (prices, yields, costs, technology adoption, farm size),

where, all variables are relative to one's neighbors (Kastens and Nivens 1999).

This same basic model was used in each of the three studies and the results are very interesting. The conclusions in the first study showed that: "Price was generally unrelated to other individual management traits and profitability. In a regression framework, having persistently low costs relative to neighboring farms, having persistently high yields, and persistently being ahead of one's neighbors in less-tillage adoption were each important drivers of profitability. Having persistently higher prices than one's neighbors had only a small and statistically insignificant impact on profitability. When model impacts were computed for 'being in the best third' of each management category, it appears that it should be easier for producers to enhance profits by focusing on costs, yields, and less-tillage adoption, than by focusing on price. In commodity based crop production, with relevant futures markets that are generally efficient, it should not be surprising to find reduced payoffs to focusing management on price as opposed to other management factors." (Kastens and Nivens 1999).

Some of the other findings of the original Karstens and Nivens (1999) study were described in another publication of the KSU Extension Service (*Grain Marketing Plan for Farmers* 2000):

"This study indicated that differences in no-till technology adoption, yields, cost of production, and profits were more persistent or consistent than differences in selling prices among farms…. The 'good' one-third of farms for each of these management measures had 16 percent greater yields, 31 percent lower costs, 8 percent higher prices, and adopted no-till technologies sooner than the middle one-third of farms.

Conversely, for each of these measures, the lowest one-third of farms had 16 percent lower yields, 25 percent higher costs, 8 percent lower prices, and slower no-till technology adoption than the middle one-third of farms. Other results in this study show the difficulty of obtaining higher than average prices.

This study assumed that all of these farmers took the same approach to marketing their crops. Whether they used formal marketing plans or specific preharvest or postharvest marketing strategies was not identified. The results of this study do not necessarily show that grain-marketing decisions are not important for farmers. Instead, they reinforce the principle that a crop has to be efficiently produced before it can be effectively marketed" (KSU – O'Brien 2000).

3.B.2 The second study

In 2001 the research was repeated for the period from 1990-1999. The 2001 research study incorporated the idea that good management played a role in profitability and the research questions were broadened: "An operator could be more profitable than his neighbors for a number of reasons. Perhaps he tends to get higher crop yields. Or perhaps he is a better marketer and consistently gets higher crop prices. Maybe he does a better job of controlling costs than his neighbors. Or maybe he does a better job of using fixed assets such as land in planting intensity. Or, does the more profitable manager do a better job of determining when and how to adopt new agricultural technologies – such as less tillage? Other questions also arise. Are profitable operators especially good at one thing? Or, are they better than average at a number of tasks? How easy is it to be better than average at cutting costs or increasing crop prices? How are profits impacted by having input costs that are 10% lower than average?"

The conclusions were that: "Farmers are most able to differentiate themselves from their neighbors in terms of planting intensity, technology adoption, and costs, followed next by yields, and last by prices. Among those management factors, being a good cost manager was most important for increasing profitability, followed by planting intensity, yield, and technology adoption. Price management did not have a statistically significant impact on profit. Increasing the variability in farm income also would increase overall profit, however this is generally not a goal of producers. Increasing size and government payments would make a significant impact on profitability as well, however these are often outside the control of the current manager. In all regions of Kansas, farms have been expanding herbicide expenditures relative to machinery operation expenditures, indicating the adoption of less-till practices. Less-till adoption has been especially rapid in western Kansas, likely due to yield-enhancing moisture retention from less tillage. As a profit-maximizing management goal, increasing planting intensity ranked second in importance to being a low cost operator. It ranked more important than managing for high yields and being ahead of one's neighbors in adopting less-till, both of which ranked more important than seeking high prices" (Kastens, Dhuyvetter and Nivens 2001).

3.B.3 The third study

The third Kansas farm study covered the period from 1995-2004. The research questions had become more sophisticated, with an increased interest in business management practices rather than economic theory. However, the "double entendre" remained for terms such as 'price' or 'marketing'. Price still reflected what the farmer could capture from the futures markets and being a good marketer meant how skillfully the farmer participated in the market: "Perhaps he tends to get higher crop yields. Or perhaps he is a better marketer and consistently gets higher crop prices. Maybe he does a better job of controlling costs than his neighbors. Or maybe he does a better job of using fixed assets such as land in planting intensity. Or, does the more profitable manager do a better job of determining when and how to adopt new agricultural technologies – such as less tillage? Other questions also arise. Are profitable operators especially good at one thing? Or, are they better than average at a number of tasks? How easy is it to be better than average at cutting costs or increasing crop prices? How are profits impacted by having input costs that are 10% lower than average?" (Kastens and Dhuyvetter 2005).

The conclusions from the 1995-2004 data showed that: "Farmers are most able to differentiate themselves from their neighbors in terms of land tenure, planting intensity, technology adoption, and costs, followed next by yields, and last by prices. Increasing the variability in farm income would increase overall profit as well, however this is generally not a goal of producers. Increasing size and government payments would make a significant impact on profitability as well, however these are outside the control of the manager – at least in the short-run. Consequently, being in the low cost of a region's farms was substantially more important than being in the high price. In three regions of Kansas, farms have been expanding herbicide expenditures relative to machinery operation expenditures, possibly indicating the adoption of less-till practices. As a profit-maximizing management goal, increasing the percent of crop acres that are rented ranked second behind being a low-cost operator and increasing planting intensity ranked third. Both of these management factors were more important than substituting herbicide for machinery and managing for high yields, both of which ranked more important than seeking high prices" (Kastens and Dhuyvetter 2005).

Appendix 4.A

Thesis validation research project

Thesis validation project

This Appendix describes attempted validation research used in the thesis.

4.A.1 Overview of validation process

- Goal of validation;
- Steps to be taken in the validation process;
- Variables to be assessed;
- Logic of validation analysis.

4.A.1.1 Validation goal

To show that certain wheat protein quality characteristics are present in the flour and carried from the wheat producer to the miller and to the baker.

4.A.1.2 Steps to be taken in the validation process

Compare quality loss experience based on quality characteristics of wheat used:

1.1 Determine present specifications for incoming wheat flour in ten or more medium-to-large-scale bakeries.

1.2 Determine potential and actual throughput of defect-free units, present rate of defects.

1.3 Calculate impact of quality loss on production for the bakeries.

1.4 Standardize data and compare to data from Stan's 6,000 unit/hour U.K. example.

1.5 Identify potential savings in production outages or defective units.

1.6 Separate respondents into four groups: Group I: those buying from open production with specifications that match good protein quality characteristics and provide identity preservation (IP) and segregation; Group II: those buying from open production but any or all of the three criteria (from Group I) is missing; Group III: those buying from contract production with specifications that match good protein quality characteristics and provide identity preservation (IP) and segregation; and, Group IV: those buying from contract production but any or all of the three criteria (from Group III) is missing.

4.A.1.3 Variables to be assessed

1. Physical production characteristics: Number of lines in operation; Equipment manufacturer, model and age of each line; Number of mixers per line; Equipment manufacturer, model and age of each mixer; QA/QC signalling system manufacturer, model and age.

2. Capacity and throughput: Maximum number of units that could be produced per hour per line (line capacity); Number of units actually produced per hour per line (throughput); Number of units per mixer; Time needed per dough batch.

3. Production throughput per line: Number of hours uptime per day; Number of hours uptime per week; Length of time (in hours) for scheduled maintenance per week; Number of production outages per week; Number of production outages per month; Average length of time for typical outage; Manager's estimate of "maximum number of production hours per week".

4. Labour-related costs: Average number of staff involved in searching for cause of outages;

5. Production quality characteristics: Expected rate of defects (per company's Quality Policy); Actual rate of defects per 24-hour period.

8. Flour-related characteristics: Specifications provided to miller; Wheat's country of origin; Typical cost of flour per tonne.

4.A.1.4 Logic of survey analysis

1 Rule out any extraneous cause for increased levels of quality loss; i.e. eliminate or identify differences that are not related to flour characteristics;

1.1 Sources of possible extraneous cause for error:

1.1.1 Differences in production lines (e.g. make, model, capacity);

1.1.2 QA/QC signalling system more prone to error (e.g. make, model);

1.1.3 Differences in mixers (e.g. make, model, capacity);

1.1.4 Number of in-service hours for production line;

1.1.5 Degree of maintenance performed;

1.1.6 Age of equipment.

2 Compare data to similar users (i.e. Groups I-IV); if possible, create sub-groups based on equipment similarities.

3 Look for patterns that are not likely to be influenced by the possible extraneous factors.

4 Compute production impact for each respondent.

5 Determine whether Groups I and III experience a lower rate of production outages and defective units than Groups II and IV do.

4.A 1.5 List of potential survey participants

- ‘Super-groups’ to be used for finding actual participants:

  Bakers associations: AIB International (formerly American Institute of Baking); American Bakers Association; Bakery equipment manufacturers; Sosland Publishing (Baking Business.com; Milling and Baking News); 🟨. Wheat Associates (comprised of 19 U.S. state wheat associations); North American Millers Association; USDA/FSIS; AGPB; Bakers connected to CSIRO (in Australia). = planned, but not sent

- Individual bakers as possible participants:

  Paul’s Breads; large bakers in Jordan.

4.A 1.6 Sample letter

Dear ________,

I’m an American Ph.D. student (Management Science) at the University of Strathclyde in Glasgow. I’m examining how variability in supplies of incoming wheat flour lead to production losses for medium-to-large-scale bakeries (i.e., those using automated lines of 6 000 units per hour or greater). Informal research suggests that an increase in production problems occurs and costs the baker some 7 to 10 percent of potential revenue.

I want to formalize the research and develop a more precise estimate of the bakers’ cost exposure. If interest permits, I’d like to test to what degree a change in wheat specifications might improve the situation. Would your organization have members or perhaps baking/milling associates that might be interested in participating in a short survey on this topic? Naturally all company identification would be kept confidential but I would share the summary results with all participants. I would be happy to answer any question or provide more information. Please let me know what would be helpful.

Thank you very much in advance for your help with this!

Kind regards,
Victoria Hill

4.A 1.7 Timeline for validation project

4.A 1.7.1 Tasks

1. Send letters for finding sample participants.

2. Develop survey tool.

3. Prepare cover letter (to accompany survey tool in pilot and actual survey).

4. Find sample group.

5. Test survey tool on pilot group.

6. Revise survey tool as needed.

7. Send out survey tool and cover letter.

8. Deadline for survey responses

9. Analyse responses.

4.A 1.7.2 Validation project schedule

Nº	Task description	Completion date
1.	Send letters for finding sample participants.	Nov. 3
2.	Develop survey tool.	Nov. 8
3.	Prepare cover letter (to accompany survey tool in pilot and actual survey).	Nov. 8
4.	Find sample group.	Nov. 22
5.	Test survey tool on pilot group.	Dec. 3
6.	Revise survey tool as needed.	Dec. 5
7.	Send out survey tool and cover letter.	Dec. 6
8.	Deadline for survey responses	Jan. 3
9.	Analyse responses.	Jan. 10

4.A 1.7.3 Actions taken (as of Nov. 3, 2010)

Nº	Actions taken	Completion date	Outcome
1.	Send letters for finding sample participants.	Nov. 3	--
1.1	Letter sent to Rick Callies, VP Marketing at U.S. Wheat Associates; (response received Nov. 3);	Nov. 2	Recommended AIB & NAMA; also said that variability/lack of specifications are big problem for small bakers, too.
1.2	Letter sent to Josh Sosland of Sosland Publishing;	Nov. 2	No reponse
1.3	Letter sent to AIB Marketing Department; Response received from Rick Dempster Nov. 4.	Nov. 3	Rick is Dir. Of Research and working on variability in flour; will try to help me.
1.4	Letter sent to Rob MacKie, ABA Pres. & CEO;	Nov. 3	No response
1.5	Letter sent to Mary Waters, NAMA President; Response received Nov. 8	Nov. 3	Group has no baker contacts; suggested trying AIB or ABA.

4.A 2 Outcome

Five requests for research assistance were sent; three parties responded: two declined but suggested AIB, and AIB itself responded. Dr. Rick Dempster from AIB is involved in research concerning flour variability. He offered to hand out the surveys (Section 4.A 2.1) to 30 to 35 professional bakers attending a course at AIB. Unfortunately, there were no responses.

The next attempt was to ask a large U.S. baker what their experiences were with flour variability and production problems. Rick Dempster very kindly offered to contact an acquaintance at the largest single-owned group of bakeries in the U.S. to see if they might be willing to help with the research, but they are in a consolidation project and not able to help at the present time.

The next approach was to consider existing research at AIB that might be a reasonable substitute for the validation goal. With assistance from Stan Cauvain, the Industry thesis advisor, it was decided to consider past testing by AIB to attempt to prove the reverse of the validation that had been tried (i.e. a single wheat variety with good protein quality characteristics would NOT lead to production problems). Rick forwarded two slides from research that was part of a patent application. The slides (comparing mix time to absorption rate) show that three identity-preserved (IP) varieties grown from first generation certified seed performed consistently in mix tests (using near infrared testing). However, when the same varieties (with similar protein levels as would occur in commingled lots) were mixed at a 50 percent ratio, they lost the ability to perform predictably (Section 4.A 2.2, Figures 4.A-1 and 4.A-2). While this result doesn't support a claim that 'commingled wheat will behave unpredictably', it does show that three wheats that independently performed predictably, and were expected to maintain similar curves when blended, did not. If this inconsistent behaviour was the result of an impact on the individual wheats' protein quality characteristics (i.e. protein-to-starch and amylose-to-amylopectin ratios), then it might be likely that the same negative impact also contributes to an increased GI/GL level for consumers who eat the final product. Unfortunately, there isn't enough data to make this claim.

The next step was to ask AIB's baking and dough quality specialist, Tom Lehmann, if he could review the survey and comment based on his 40 some years experience. He very kindly agreed. The survey response along with some additional questions are shown in Section 4.A 2.2, Figure 4.A-1.

4.A 2.1 The survey

The following survey was prepared and revised with the kind help of AIB staff:

Baking performance survey questions

Purpose of the survey:
This survey is to support Ph.D. research aimed to identify the sources of variability in baking operations and how that variability might affect bakery production and/or the rate of defective units (loaves of bread). Your own experiences are vital in helping to define operational areas that are particularly susceptible to variability. Although the survey is anonymous and the data is confidential, if you would like to receive the composite results, please indicate your email address: ________________________________. In order to be sure your data is included in the survey, please return the questionnaire no later than November 30. In case of any questions, please contact Ms. Vicki Hill, University of Strathclyde, Department of Management Science, Glasgow, Scotland via email at ve.victoria@gmail.com or Dr. Richard Dempster at AIB, RDEMPSTER@aibonline.org. Thank you very much for your interest and help!

Respondent's details:

Country and region of baking plant ____

Years of baking experience ____________ Baking training was learned in which country(ies)? ____

Please answer the following questions regarding the baking facility where you are presently employed. If you work in a multi-line facility, please select the closest line that represents bread production and answer all questions per this selected line.

1. Physical production characteristics:

1.1 Number of lines in operation _____________

1.2 Equipment manufacturer _____________

1.3 Model and age of each line _____________

1.4 Number of mixers per line _____________

1.5 Mixer manufacturer _____________

1.6 Model and age of each mixer _____________

1.7 QA/QC signalling system manufacturer _____________

1.8 QA/QC signalling system model and age _____________.

2. Capacity and throughput:

2.1 Maximum number of units that *could* be produced per hour per line (line capacity) _____________

2.2 Number of units *actually* produced per hour per line (throughput) _____________

2.3 Number of units per mixer _____________

2.4 Time needed per dough batch _____________.

3. Production throughput per line:

3.1 Number of hours uptime per day _____________

3.2 Number of hours uptime per week _____________

3.3 Length of time (in hours) for scheduled maintenance per week _____________

3.4 Number of production outages per week _____________

3.5 Number of production outages per month _____________

3.6 Average number of staff involved in searching for cause of outages _____________

3.7 Average length of time for typical outage _____________

3.8 The baking plant manager's estimate of "desired maximum number of production hours per week" _____________.

4. Production quality characteristics:

4.1 Expected rate of defects (per company's Quality Policy) _____________

4.2 Actual rate of defects per 24-hour period _____________.

5. Flour-related characteristics:

5.1 Specifications provided to miller (*Please describe or attach a copy*.) ______________

____

5.2 Wheat's country of origin ____

5.3 Wheat comes from 'open production' or from 'contract production'? ______________

5.4 Typical cost of flour per tonne _____________.

Additional comments:

If there are any additional remarks you would like to add, please use the following lines:

____

____

____

____

____

____

4.A 2.2 Blending curves from R. Dempster of AIB

Figure 4.A-1
Comparison of Dominator and Tomahawk

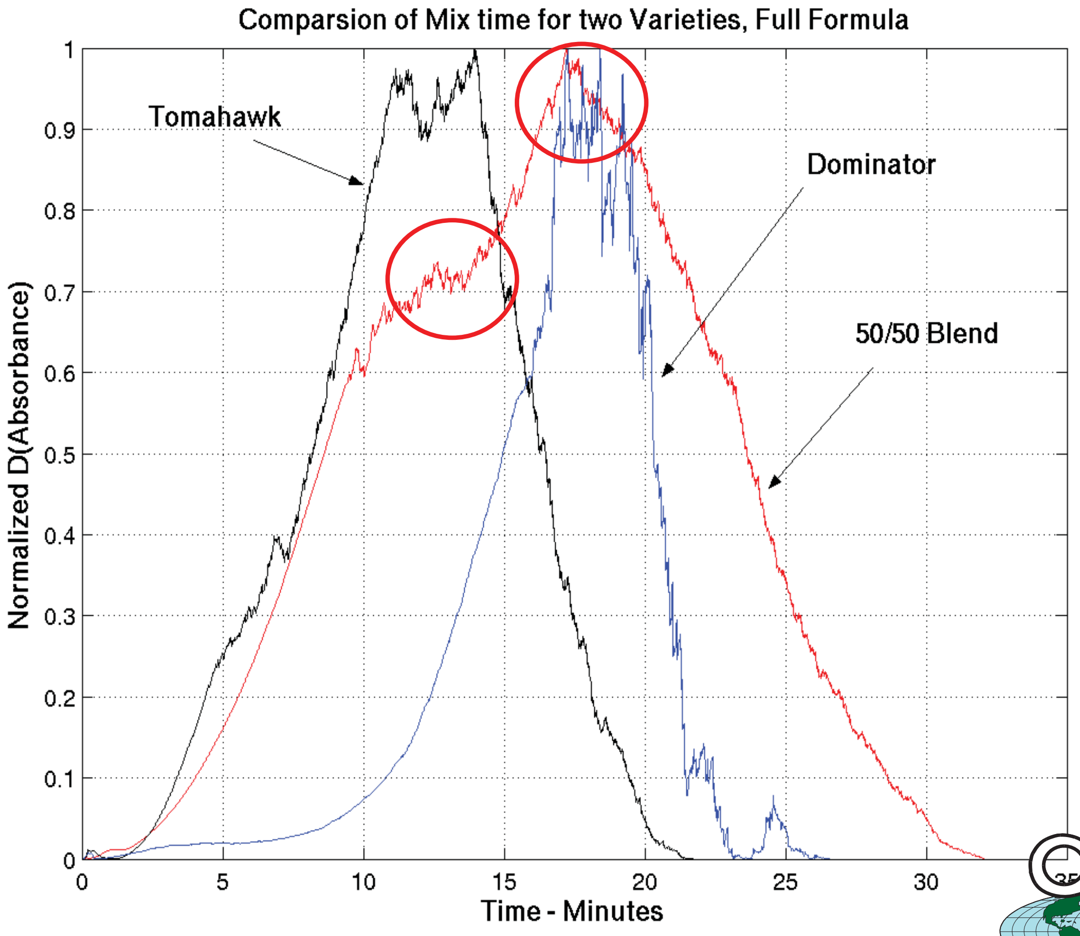
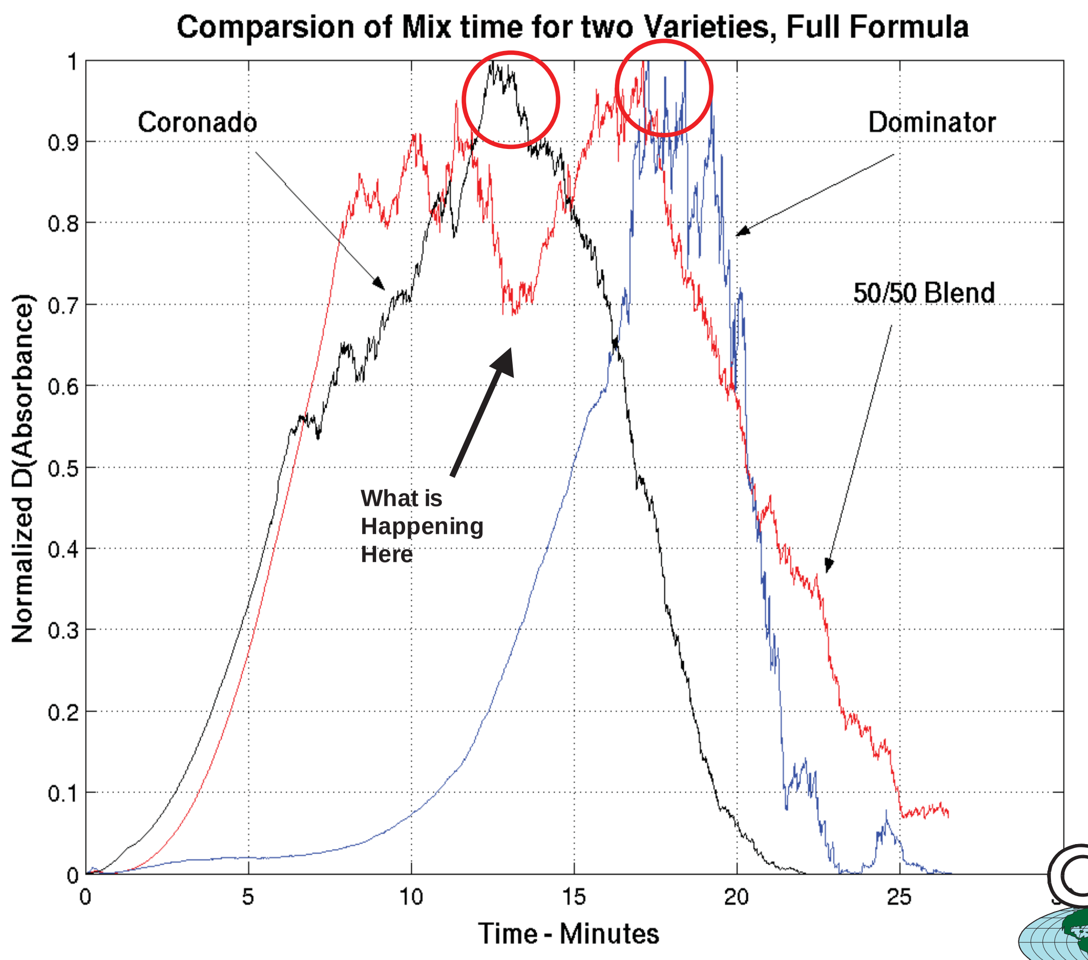


Figure 4.A-2
Comparison of Dominator and Coronado



Since 1919

4.A. 2.3 Survey response describing U.S. bakers' experience

Dear Tom,
I'm a Ph.D. student at the University of Strathclyde in Glasgow examining how variability in supplies of incoming wheat flour lead to production losses for medium-to-large-scale bakeries (i.e., those using automated lines of 6 000 units per hour or greater). Informal research suggests that an increase in production problems occurs causing the baker a loss in potential revenue. Based on your professional experience, what would be your assessment of the typical costs to the baker and likely cause(s) of these production issues? If it would be more convenient to describe a specific (but anonymous) operation, please feel free to do that and indicate the country where the baking plant is located.

Thanks very much for your kind help with this!
Victoria Hill

Some possible variables involved

1. Capacity vs. throughput:

What do you find to be the typical difference between the maximum number of units that *could* be produced per hour per line (line capacity) and the *actual* number of units produced per hour per line (throughput)?

_Actually, essentially all production lines in the U.S. run at a speed somewhat slower than the maximum production speed of the equipment. The actual production speed of a line is that which will provide for the most consistent quality product achievable. This will vary to some extent with the specific product being produced. As an example, many bun lines will have a maximum production capacity of 120 to 125-cuts per minute, typically with 4 buns to the cut, but most lines are operating at only 90 to 100-cuts per minute as the lower production speed results in greater scaling accuracy as well as a reduction in production cripples (lost product). With a production line operating at peak efficiency, there is typically, a 1.5 to 2% loss through the production process (total production cripple rate) that is the result of any number is processing issues. If the total production cripple rate much exceeds the 2% value, the job of the production supervisor may be "on the line". Some plants will report a total cripple loss of 1% or less. It all depends upon the equipment in the plant and the dedication of the bakers operating that equipment.

2. Production throughput per line:

2.1 Typical number of uptime hours per week. This is highly variable. Some plants report that they operate 23-hours a day, shutting down for only one hour a day for cleaning and maintenance. Many other plants will operate upwards of 16 to 20-hours per day with two shifts.

2.2 Length of time (in hours) for scheduled maintenance per week. My take on this is between 5 and 20-hours per week, depending upon the equipment.

2.3 Typical number of production outages per week. I don't have any specific data on this.

2.4 Average length of time for typical outage. From the times when I've been in a plant with a production problem, I would guess the answer to this might be 15-minutes or less.

2.5 Average number of staff involved in searching for cause of outages. I don't have any specific data on this, but from my observations, I would say that 2 or 3 persons are typically involved in resolving a mechanical issue on a production line.

3. Production quality characteristics:

3.1 Expected rate of defects (per company's Quality Policy) 1.5 to 2% appears to be the "norm".

3.2 Actual rate of defects per 24-hour period. This can vary considerably. On an especially bad day, it might be as high as 4 to 6% of the total production for that period, but this is rare for a well automated plant.

4. Flour-related characteristics:

4.1 Typical specifications provided to miller (*Please describe*.) Moisture, ash, protein, Farinograph, and Falling Number.

4.2 Wheat comes from 'open production' or from 'contract production'? Almost always from open production.

4.3 Wheat's country of origin Typically, U.S.A. and Canada.

5. Influence from equipment in the facility:

5.1 Might the physical environment in the baking plant be more likely to cause production outages and defective loaves than flour variability could? Yes _____ No _X____

5.2 Might some bakery equipment manufacturers' lines/mixers be more sensitive to causing production outages than the incidents caused by flour variability? Yes __X___ No _____

5.3 Perhaps a faulty QA/QC signalling system could cause more production outages and line stoppages than flour variability? Yes __X___ No _____ Rarely _____

5.3.1 If yes, are some QA/QC signalling system manufacturers' systems more sensitive to production outages? Yes __X___ No _____

6. Additional comments:

In addition to the quality and consistency/uniformity of raw ingredients, equipment age and mechanical order, and effectiveness of the QC/QA programs, the type of bread making process employed at the bakery can have a great influence on the overall operating efficiency of a bakery. For example, bakeries operating with a liquid ferment system appear to have more problems with crust color as well as crumb grain/structure (potentially resulting in lost product) than plants operating with a more traditional sponge and dough bread making process. Plants with traditional, pocket type dividers will almost always suffer losses due to scaling weight issues, while those using one of the newer extrusion dividers will seldom experience losses due to scaling weight fluctuations. The equipment match/mis-match can have a significant impact on its overall operating efficiency. In a bread bakery, even the type and condition of the pans can have a significant impact in the number of production losses suffered during any one period of time.

Second set of questions:
>>> Victoria Hill <ve.victoria@gmail.com> 1/11/2011 1:01 PM >>>
Hi Tom,

1) How much importance would you place on certain quality characteristics (e.g., protein-to-starch ratio and amylose-to-amylopectin ratio)? I'm thinking in terms of dough performance, defective loaves (those cripples), and flour variability.

2) My other question has to do with the equipment sensitivity issues you pointed out in the Q5 of the survey. In an 'ideal world' with all the equipment/systems running perfectly, to what degree do you feel flour variability would still be a source of cripples and possibly line outages?

3) How frequently are farinograph tests run on a single lot of flour (coming from commingled wheat)?

Thanks,
Vicki

Victoria:
Starting with the easiest first.

#3) All the time. Bakers will typically set specification ranges for Farinograph absorption, arrival time, and MTI. It is the flour miller's job to select a grist that will provide a finished flour meeting these parameters. Additionally, the baker will set an allowable range for ash content as this is an indication of extraction rate, which loosely relates protein quantity to flour strength (gluten quality).

Due to the quantities ordered, flour millers typically mill a flour to a customers specifications, generally defined by the above specifications with the addition stating that the flour shall be milled from spring wheat, winter wheat, or a blend of the two. As a cost saving feature, many bakeries specify the use of winter wheat, and may additionally specify a straight grade flour with a higher ash content.

#2) With the line tuned in, and running perfectly, a change in the flour could certainly "upset the apple cart" resulting in an increase of production cripples. Bakeries experience this to a greater or lesser degree every year when the new flour crop comes in, and the wheat going into the grist is an unknown, for the most part, to both the baker and the miller, however, once the millers and bakers become familiar with the new crop characteristics, things soon return to normalcy (if there is such a thing for millers and bakers). Once in a while something goes terribly wrong, such as the time (many years ago) when a rye gene was inserted into much of the standard winter wheats grown that particular year. The result was that essentially all of the flour milled that year exhibited pronounces sticky dough characteristics that could not be alleviated by any actions of the miller or baker. They just had to live with it and tough it out for the remainder of the crop year. That mistake never happened again. For the most part, any variances in the flour are recognized at the mill and corrected through their wheat blending procedures, but when one does slip through, the baker is pretty quick to pick up on it and corrective action is taken almost immediately within one or two batches of dough, so losses are minimized.

#1) Bakers don't think in terms of protein to starch ratio, but instead only think in terms of protein content, and to some extent protein quality as indicated by the ash content of the flour. With the starch, bakers do have a concern for the level of damaged starch since high levels of damaged starch is not compatible with the longer fermentation times employed in their bread making processes. For the most part, our flours seem to run in the 6 to 8% damaged starch range. While in many other countries, especially those where retail/window bakeries are more of the norm, dough fermentation is not a part of the bread making process as it is here in the U.S., and since the higher level of damaged starch allows the flour to carry more water (higher dough absorption) the bakers see this as a good thing, but really it isn't, though we'll never convince them of it. Aside from that, bakers have little interest in the starch fraction of the flour.

Tom

Table 4.A-1
Comparison of U.S. response with U.K. example

Issue	U.K.	U.S.
Maximum capacity	100 loaves/min.	120-125 bun cuts/min.
Actual throughput	83 loaves/min.	90-100 bun cuts/min.
Throughput as percentage	~83 percent	75-80 percent
Production loss (defective units):		1.5-2 percent
Estimated at ±3σ	0.27 percent	
Actual at ±3σ with 11 stages	97.07	
Loss including S.D. of ±1.5σ	6.681 percent	
Loss on extreme days		4-6 percent
Uptime per day	3 shifts	16-20 hrs. up to 23 hrs.
Scheduled maintenance per week	12 hours	5-20 hrs.
Typical number of outages per week	200-250	No data
Average length of outage	20 min.	15 min.
Average staff assigned to solve mechanical outage	3	2-3
Sensitivity of equipment & QA/QC signalling systems	No data	Equipment & QA/QC signalling systems can be more prone to cause outages than flour variability does. Processing equipment (e.g. pans and dividers) and choice of ingredients (e.g. liquid ferment vs. sponge & dough) can greatly affect production losses.
Flour specifications provided to miller	ACTUAL: Open production but no specifications given. IDEAL: In a 100-gram sample: impurities not to exceed 2; broken kernels not to exceed 4; sprouted not to exceed 2.	ACTUAL: Moisture, ash, protein, farinograph (i.e. peak mix time, stability, absorption rate), and Falling Number.
High test weight (surrogate for extraction rate)	-- 70 kg/hl for soft wheat; -- 80 kg/hl for bread wheat	

Issue	U.K.	U.S.
Ash content	≤ 0.5 percent ash content [or 70% extraction rate]	The baker will set an allowable range for ash content as this is an indication of extraction rate which loosely relates protein quantity to flour strength (gluten quality). As a cost saving feature, many bakeries specify the use of winter wheat, and may additionally specify a straight grade flour [76-78% extraction rate] with a higher ash content [0.6%+].
Gluten test	≥ Zeleny Index of 25 ml	
Falling Number	≥ 250 seconds	
Moisture content	≤ 15 percent moisture content	
Flour source	Open production	Open production in U.S. or Canada
Frequency of farinograph tests on a single lot	N.A.	All the time. Bakers will typically set specification ranges for Farinograph absorption, arrival time, and MTI. It is the flour miller's job to select a grist that will provide a finished flour meeting these parameters
In an 'ideal world' with all equipment/systems running perfectly, to what degree would flour variability still be a source of defective units and possibly line outages?	No data	With the line tuned in, and running perfectly, a change in flour could certainly result in an increase of defective units. Bakeries experience this to a greater or lesser degree every year when the new flour crop comes in, and the wheat going into the grist is an unknown, for the most part, to both the baker and the miller. For the most part, any variances in the flour are recognized at the mill and corrected through their wheat blending procedures, but when one does slip through, the baker is pretty quick to pick up on it and corrective action is taken almost immediately within one or two batches of dough, so losses are minimized.
How much importance would you place on certain quality characteristics (e.g., protein-to-starch ratio and amylose-to-amylopectin ratio)?	Reductions in protein lead to baking problems. Increases in starch reduce protein. Amylopectin is more beneficial in breadmaking than amylose is. [All of the above is true for GI/GL levels, but the effects of amylose and amylopectin are reversed].	Bakers don't think in terms of protein to starch ratio, but instead only think in terms of protein content, and to some extent protein quality as indicated by the ash content of the flour. With the starch, bakers do have a concern for the level of damaged starch since high

		levels of damaged starch is not compatible with the longer fermentation times employed in their bread making processes. For the most part, our flours seem to run in the 6 to 8% damaged starch range.

Source: Compiled from author's own research based on communications with T. Lehmann (U.S. 2011) and S. Cauvain (U.K. 2009)

Appendices

to Chapter 6

Appendix 6.A

Completing the competitive evaluation for the ‘Customer’s Voice’

6.A.0 Completing the competitive evaluation for the 'Customer's voice'

Sections 6.A.1 through 6.A.7 describe the use of the columns in the Quality plan (Figure 6.3) to complete the competitive evaluation.

6.A.1 Claims

Column number 1, the Claims column, is populated with zeroes because there is no (illustrative) data that fits this section.

6.A.2 Rate of importance and Miller's Expected product

Rate of importance (Column 2) signifies how highly the customer(s) valued each product characteristic. For purposes of this model and considering that Our company is fictitious, both Column 2 (Rate of importance) and Column 3 (Miller's Expected product) were used to describe which characteristics the customer (i.e. Miller) values. Column 2 is from Our company's perspective and assumes a strategy that values quality, but only introduces a new (quality) characteristic when forced by competitors. Column 3 offers a view on what most millers and bakers would value in importance in the 'Expected product'. These rankings were developed through consultations and advice from the Thesis' industry advisor (S. Cauvain). Both columns apply a 1 to 5 rating system with five being the highest.

The Rate of importance (Column 2): Although the majority of product characteristics were mostly ranked five, but some were rated less importantly. The rationale behind the rankings were:

- Consistent product (Characteristic 2) received a four. While consistency is one of the most sought after characteristics, the miller/baker are skilled in adjusting the unpredictability of each delivery of wheat/flour. However, these adjustments incur extra time and expense on the part of the millers/bakers.

- No specks in flour (Characteristic 10) received a four. Both miller and baker desire 'clear' flour with no specks, but this is strongly dependent on the extraction rate (Characteristic 9), which is ranked five. Therefore, No specks in flour was ranked four.
- Suitable moisture content (Characteristic 13) received a four. Proper moisture content is vital to both miller and baker. However, moisture content is a physical characteristic that both the U.S. and French grading systems report. The desired moisture level is the same in both countries and it would be difficult to sell grain that is outside the limits. However, climatic conditions during shipment might increase moisture (due to rains or heavy humidity) or dry the grain excessively (due to extreme heat). Again, it is largely up to the miller to correct these problems before grinding the wheat.
- Segregation included (Characteristic 26) received a four, as well. As Traceability provided (Characteristic 25) was ranked five, this impacts Segregation as it wouldn't be possible to carry out traceability without segregating each load to match its accompanying (traceability) documentation.
- Frequent shipments (Characteristic 19) would be very desirable but might not be practicable depending on elevator's supply and/or the logistics involved. Therefore, this characteristic was ranked four.
- Disclosure of GMO (Characteristic 4) received a four. Although customers in many markets (outside the U.S.) would insist on this, it is a legal requirement in those same markets that disclosure of GMO be made. Therefore, it seems likely that Our

company might adopt a more ‘relaxed’ approach and only disclose presence or use of GMO when legally forced to do that.

- Use of HACCP plan (Characteristic 27) only received a three. Competitors, for the most part, do not yet use HACCP plans. Therefore, it has importance, but not requiring urgent implementation.
- Minimal chemicals (Characteristic 5) was assigned a four. While it is understood that most buyers prefer as few chemical treatments as possible, the protection of the crop may depend on them – which is also counter-balanced by the grower’s desire to keep costs as low as possible.
- Satisfactory field scouting (Characteristic 17) just received a three. This characteristic is likely to be seen as interference, rather than assistance, in crop production. Also, it carries the potential to become a customized offering.
- Documented farm practices (Characteristic 18) also received a three, and for reasons similar to Satisfactory field scouting. While the customer might find this desirable, the grower sees it as extra effort and potential interference. But, it does have the upside of being an advantage to offer select customers for an additional fee.
- The last four Characteristics -- Mandated wheat varieties and IP (21), Miller mandates other inputs (22), Use of certified seed (30) and Intrinsic tests on farm (31) – would be customized offerings in both France and the U.S. While these might become lucrative offerings in a contract production arrangement, they do not qualify as requiring immediate focus and therefore, received a rank of four.

Miller’s Expected product (Column 3) shows the rank of importance that most millers and/or bakers would assign to the product characteristics. Excluding the last four Characteristics (21, 22, 30 and 31 or those associated with a customized product), all are ranked with a five.

This is reasonable, as otherwise they would not have appeared on the original Miller's list of requirements. The four Characteristics connected with a customized product have been assigned a slightly lower rank of four.

6.A.3 Brand X (France) and Brand Y (U.S.) columns

The Brand X (France) and Brand Y (U.S.) columns four and five are meant to reflect the ranking of what is available to a customer based on the open production systems in each country. These columns are intended as an illustration of how Top management (or a wheat growing entity) might develop a competitive evaluation. A more thorough investigation of the product design characteristics in both countries is discussed in later sections. Although the same 1 to 5 rating system (described above) is used for the two Brand X (France) and Brand Y (U.S.) columns, some rankings of one's and two's appear for the first time. A 'one' indicates that there is no offering of the product characteristic under open production. A 'two' appears where producer literature suggests that the product characteristic is available, but other literature raises questions about how plausible the claims might be.

It is perhaps easier to compare the offerings for Brand X and Y by looking at the product characteristics associated with each secondary label. Therefore, the initial primary label category is Good test results and it contains four secondary labels:

1) Wheat matches bread; both France and the U.S. offer the required levels of protein by bread type as well as good extraction rates, therefore both Brand X and Brand Y received a rank of five for each of the characteristics;

2) Consistent product; the offerings from France and the U.S. were more variable. It appears that France offers consistent product, yet that was never directly stressed in the literature, so in terms of ranking by importance, an assumption was made that Brand x might rank that as a

four. The opposite might be said about product in the U.S. Although the literature suggests that consistency isn't a problem, it would be incompatible for a commingled system to offer a consistent product unless the commingling was monitored and kept the same proportions each time. Therefore, Brand Y received a rank of two. Good intrinsic tests made the comparison of consistent product easier to grasp: France places a very high value on intrinsic testing so Brand X received a five; the U.S. doesn't perform intrinsic testing per se so Brand Y received a one.

3) Superior breadmaking depends on Good levels of gluten, No excess *alpha*-amylase and Suitability to the baked good. France excels in most of Superior breadmaking, but reported some problems with *alpha*-amylase in recent years; therefore Brand X was assigned a four and the other two categories received a rank of five. Because the U.S. doesn't perform intrinsic testing, it is not possible to know what level of gluten or *alpha*-amylase activity might exist in a purchase. Brand Y received a rank of one for each of these categories but a two for Suitability to baked good, as absent intrinsic tests, it might still be possible for good breadmaking characteristics to exist in the product.

4) Superior flour requires No specks in flour, Suitable moisture content and Suitable grain hardness. Brand X (France) also performs well across these categories; Brand Y (U.S.) has some problems in this area: no intrinsic testing causes a one to be assigned to No specks in flour; some literature suggests that overly dry grain may occur, so a four is assigned to Moisture content but a five is assigned to Suitable grain hardness.

Good business practices is the next primary label and contains Regulatory compliance and Attractive commercial terms. Brand X receives fives for each of the categories associated with Regulatory compliance (i.e. Meets U.S. and EU laws, Traceability provided, Segregation included). Brand Y meets U.S. laws but has some problems with EU laws concerning traceability and disclosure of GMOs – which results in a four being assigned. But the practice of 'partial traceability' and lack of segregated product results in a three for each of the last two categories.

Attractive commercial terms includes: Frequent shipments, Suitable price and Meets delivery conditions. Brand X received fours in each of these categories because sales literature lacked comments about these areas. Brand Y did slightly better, earning a four for frequent shipments and delivery conditions, with a five assigned for suitable price.

The last primary label, Effective QMS, caused more differentiation between the two brands. Effective QMS includes Food safety compliance, Clean and healthy (product), Farmer GMPs/GAPs and the topic of Customized product. In the Food safety category, Brand X (France) scored a five for disclosure of GMO but a one for not using a HACCP plan, and addressing the 'good protein' issues (good protein-to-starch and good amylose-to-amylopectin ratios) was nearly on-existent – therefore, only a two was assigned to each. Brand Y (U.S.) was assigned a one in each of the categories because they are either non-existent or not possible to determine the level of compliance (e.g. disclosure of GMO).

Clean and healthy wheat was no problem for Brand X, with a five in each category. Brand Y got a four for No odours, taints or contamination; No foreign matter received a rank of only two, and Healthy wheat got a three.

Farmer's GMPs/GAPs contains four other categories (Minimal chemicals, Satisfactory field scouting, Documented farm practices and Less times in storage). Brand X received a five for field scouting and documentation; minimal chemicals and less time in storage each received a four. Brand Y received a one in all four categories.

The Customized product includes four separate categories (Mandated wheat varieties and IP, Miller mandates other inputs, Use of certified seed and Intrinsic test on farm); Brand X did better than Brand Y but leaves some competitive gaps. Brand X very nearly provides mandated varieties and IP, so a four was assigned. But the possibility of the miller mandating other inputs seemed very unlikely – therefore, a one was assigned. Certified seed is used in nearly half the wheat crops with the others using farmer-saved seed under the guidance of INRA. Therefore, a four was assigned to this area. And, although intrinsic tests aren't performed on the farm per se, they could be – so a two was assigned. For Brand Y, nearly all of the categories were non-existent, meaning a rank of one was assigned. Only certified seed could be assigned a number above one. Like France, approximately half of the seed used is certified, but the balance of farmer-saved is carried out independently by the farmer and not monitored; therefore, a three was assigned.

6.A.4 Quality plan

Top management reviews the other completed columns and based on that data determines the level of quality required to remain competitive in each category. The Quality plan (in column 6) has been developed with mostly 'fives' in each category. The only exception are the characteristics associated with a Customized product. The ranking of five was arbitrarily assigned to reflect an overall strategy designed to meet the Miller's perspective of importance. The Customized product characteristics were split as follows: Mandated wheat varieties and IP and Miller mandates other inputs both were assigned a rank of four – which moves them up to the level of importance defined by the Miller. Use of certified seed and

Intrinsic tests on farm are highlighted in light orange. The reason for this is they differ from the overall strategy of matching the Miller's perspective of importance (and the deviation helps to illustrate how the QFD tool operates). Use of certified seed was raised a level above the highest competitor (Brand X that had a four), and consequently a five was assigned. Although the Miller views Intrinsic tests on farm as worthy of a four, there is no competitive pressure to immediately implement such a program. Therefore, a three was assigned with the intent that initial design discussions should take place (which would lead to shortened implementation when competitive pressures increase).

6.A.5 Rate of level up

Rate of level up is obtained by dividing the rank for each planned quality level by the rank for the Miller's view of importance. As the strategy was primarily to match the Miller's point of view, most of the characteristics received a "1.00" for Rate of level up. The variations are seen in Use of certified seed and Intrinsic tests on farm where the 'mini-strategy' (described in the last paragraph) was applied. As can be seen, the more aggressive approach toward certified seed raises the Rate of level up to 1.25, while the more cautious approach to intrinsic testing receives 0.75. The next column, Sales point, incorporates this match-up of customer preferences and producer intentions with anticipated competitor behaviours.

6.A.6 Sales point

Top management decides what it wants to emphasize in sales and marketing campaigns during the coming year. As described in more detail in Section 6.1.4, each characteristic is reconsidered against the accumulated data, and a determination is made of which characteristics to be put into the annual sales and marketing campaign. Those that are selected for the upcoming campaign are then prioritised with a primary sales point being assigned a black circle and a secondary point receiving a white circle.

While this may seem extremely theoretical for an individual grower, annual sales campaigns do occur in the international wheat export market. By reviewing the literature from various countries (France, U.S., Australia, Canada for example), it is possible to see the changes in focus each year. While it isn't likely that the wheat export authorities from all of these countries decided to adopt a practice of designing an annual marketing strategy, the changes show in the marketing literature of each country (which are tied to annual crop production). At the level of an individual grower, working through this type of process could have value if that grower is competing with other farmers to obtain contracts for production. Although the process may seem somewhat tedious, it guides a novice in marketing/business strategy through the key steps. For large organizations with multiple departments, it has the benefit of being visual and making it easier to focus on this aspect of Top management's annual goals.

6.A.7 Absolute weight and Quality weight

Absolute weight is a continuation of the process for identifying sales points. The individual weight assigned to each black or white circle is usually dependent on company practices (Soin 1992). For purposes of this example, a simple system of assigning a weight of 1.50 to each black circle and 1.25 to each white circle suffices. The absolute weight is then calculated by multiplying the Rate of level up (the intended new emphasis on quality per characteristic) by the rank assigned to what "Our company" currently provides, and multiplied again by the weight for each sales point. Since "Our company" is represented (in this example) by Rate of importance, or column two. To illustrate, the first product characteristic – Protein matches bread – carries a 5 in Rate of importance and received a value of 1.00 in Rate of level up which multiplied together gives 5.00 as the Absolute weight. Consistent product, characteristic two, would have an Absolute weight of 4.00 if it had not been assigned a Sales point. Therefore, the black circle-sales point causes 4.00 to be multiplied by 1.50 to return 6.00. The rest of the values are calculated and summed. In this example, the total for Absolute weight is 158.25. Quality weight is then determined by dividing 100 by the sum of Absolute weight, which returns 63.2 percent. Each product characteristic's absolute weight is multiplied by 63.2 percent to show its contribution to the composite of overall level of planned quality and priorities of the annual sales and marketing campaign.

Appendix 6.B

Completion of the ‘Customer’s eyes’ in Product plan 1

Completion of the 'Customer's eyes' in Product plan 1

6.B.0 Introduction

The Relationship matrix for Product plan 1 shows how competitors and Our company meet the Miller's view of what is important, based on a ranking system of one-to-five, with five being highest. Values that were assigned to Brand X, Brand Y and Our company are indicated in the Relationship matrix (Figure 6.12). The values assigned to Our company were taken directly from Rate of importance (Column 2, Figures 6.6 and 6.12). As shown in Figure 6.12, the first entry (for Protein matches bread) places all three competitors in the same space for a rank of five. In the Superior flour section, No specks in flour shows none of the three competitors with the same ranking. After all the entries have been made, the large circles (representing Our company) are connected to more easily visualize how Our company measures up against the competition; in other words, what does the customer actually see.

6.B.1 Ranking Good test results

Figure 6.12 gives an easy-to-understand view of individual strengths and weaknesses; any entry appearing for a competitor to the right of the entry for Our company shows that the competitor is stronger than Our company for that individual characteristic. Any entry on the left side of Our company shows a competitive strength for Our company. E.g. in the Good test results (primary label) section, Our company led the market in the characteristic of 'No excess *alpha*-amylase' but Brand X was stronger in 'No specks in flour' and 'Suitable moisture content.' However, for all other characteristics of the Good test results section, Our company performed very competitively (Figure 6.12).

6.B.2 Ranking Good business practices

In the section for Good business practices, Our company (possibly) recognized the need last year for greater flexibility in delivery conditions, and this year Our company is able to count 'Meets delivery conditions' as a market-leading strength.

6.B.3 Ranking Effective QMS

In the section for an Effective QMS, Our company performed very strongly, especially in terms of Food safety compliance and use of Farmer GMPs/GAPs. The potential use of a HACCP plan, as well as addressing quality characteristics associated with good protein, would position Our company considerably ahead of competitors. Likewise, informing the customers of Our company's (presumably) already good record of quality management practices (such as field scouting and documented practices) would enhance the competitive position against Brand X, and make it much harder for Brand Y (which appears to be notably weak in these areas) to catch up to Our company. A check of the Sales points assigned for these last two characteristics shows that Top management already noted the opportunity and assigned both characteristics a black circle, denoting strong emphasis for this coming year.

6.B.4 Combining the 'Customer's eyes' with the Kano approach

One characteristic that makes kaizen tools especially appealing is their ability to be combined with one another. For instance, the 'Customer's eyes' evaluation (Figure 6.12) could be combined with Kano's approach to "Must be" and "Attractive" characteristics (Figure 6.13). In Figure 6.13, the "Attractive" qualities (Column Add. 2, Kano rating) have been highlighted in orange. Each ('Customer's eyes') entry for each competitor is connected to more easily visualize the strategy employed by each competitor: Brand X is shown with green lines; Brand Y with red; and Our company is shown in black lines. A quick glance (at the shape of the lines) easily shows that Brand X and Our company share similar points of emphasis, at least in terms of Good test results and Good business practices. However, several differences in Effective QMS emerge, but with Our company lagging mostly in terms of providing the “Attractive” characteristics. There is a discrepancy between the level of GMO purity that Brand X reports and the lower (but legal) level that Our company provides. But, Top management (presumably) determined that the reduced crop surface area that increased buffer strips (to obtain higher rates of non-GMO purity) would require, were not economically justifiable at this point in time—particularly as the customer had rated the characteristic with a four, rather than a five.

In terms of the general strategy of Brand Y, the lines at first appear to be erratic, but then when considered in terms of the “Must be” and “Attractive” characteristics, a slightly different emphasis emerges. It would seem that Brand Y prefers to avoid offering any “Attractive” quality; the only exception is Frequent shipments, which would also reduce the storage costs incurred by Brand Y. In fact, in terms of “Must be” qualities, Brand Y provides them at a consistently lower level than the competition—with the exception of the two ‘Wheat matches bread’ characteristics of suitable protein and extraction rate, both of which can be determined with testing of physical characteristics. Clearly, Brand Y is the low-cost generic offering.

Figure 6.13 can be used to help Top management (the analyst) to distinguish between several similar interpretations of competitive data. For example: 1) focusing on a characteristic not well-addressed in the market, (which might indicate a strategic opportunity) needs to be balanced against introducing a desirable characteristic too soon in terms of market need; 2) overlooking enhancement of a characteristic as a strategic opportunity because the characteristic already appears to be well-covered by the competition. ‘Use of a HACCP plan’ might be an example of the first instance. On one hand, the Miller would like to know that the product has already been vetted against a formal HACCP plan to prevent contamination from various pathogens. But no other competitors provide it, so the question requires further discussion with millers as to whether or not the HACCP plan would generate additional sales or a possible premium category for product covered by HACCP. In Figure 6.13, the black circle can be presumed to mean that discussions with customers were favourable and the introduction of a HACCP plan would be a key opportunity worth developing. But the two characteristics that follow it, related to good protein, turn out to be premature – although discussions with the miller have been favourable, there is no opportunity (in the coming crop season) for a price premium. Therefore, these two characteristics begin to receive sales attention, but not aggressively (as with the HACCP plan). An example of the second instance might be further development of ‘Consistent product’ and ‘Good intrinsic tests.’ Brand X provides the same level of coverage for both characteristics as Our company, and Brand Y is far behind. But neither Brand X nor Brand Y is ready to offer ‘Intrinsic test on farm’ (characteristic 31). A partial, but competitive, step toward this could be an arrangement where test samples are collected from Our company’s farm and tested at the off-site (certified) laboratory that already performs intrinsic tests for export wheat. Naturally, the most important part of this strategy is to make sure the customers know that this will happen. But, the strategy relies on enhancement of an “Attractive” characteristic that should excite customers, rather than enhancement of a “Must be” quality that is likely to be received with some resignation and less excitement -- “It is about time I got that” might be the response.

Appendix 6.C

Comparison of HOWs in French and U.S. wheat

Comparison of HOWs in French and U.S. wheat

6.C.0 Introduction

In order to compare French and U.S. wheat, a similar market category and crop season needs to be chosen. Since the value stream addresses bread, the wheat to be compared needs to be breadmaking wheat (rather than soft biscuit or noodle wheats). For the French data, this is relatively simple because growers adhere to four categories of wheat:

- Superior breadmaking wheat (*Blé Panifiable Supérieur* or BPS);
- Standard breadmaking wheat (*Blé Panifiable Courant* or BPC);
- Corrective wheat (*Blé Améliorant ou de Force* or BAF);
- Wheat for purposes other than breadmaking (*Blé pour d'Autres Usages que la panification* or BAU).

There are two national grading systems, one for wheat for human consumption and another for animal feed. Both of the grading systems utilize intrinsic testing, and the only difference between the two has to do with the increased level of nitrogen (and expressed as higher protein) that animals require in comparison with human nutritional needs. Annual crop production is measured against the appropriate grading system and results are publicly reported.

Wheat in the U.S. is split into six classes based on protein content and with durum existing in a class of its own. While the USDA reports on annual export sales by class of wheat, characteristics are limited to the physical characteristics of the U.S. wheat grading system. There is no separate grading system for animal feed; wheat that doesn't conform to the higher categories in the grading system can be utilized as animal feed (USDA 2005). The main breadmaking wheats are the ‘hard wheats’ (i.e. Hard Red Winter/HRW, Hard Red Spring/HRS and Hard White Winter/HWW).

Data for 2006 was chosen for comparison because it was the only year with data that included results of intrinsic testing. Kansas State University’s Wheat Quality Laboratory in the Department of Grain Science and Industry began a programme in 2006 to test the milling and baking qualities of HRW wheat. The KSU programme included data for both graded (physical criteria) and non-graded (intrinsic criteria) characteristics, but only addressed HRW because it is the predominant wheat in the Great Plains region. But these two sources, USDA and KSU, give a fuller picture of what is being sold by the U.S. growers (for HRW wheat). KSU samples were collected from 33 production regions in six states. The samples were collected from the same grain elevators that would have shipped wheat for the 2006 export sales. In 2006, the U.S. exported a total of 13,764,850 metric tons (MTs) of hard wheat: 7,404,999 MTs of HRW; 6,340,125 MTs of HRS; and a negligible 19,726 MTs of HWW. Hard Red Winter (HRW) wheat represented 53.8% of the total hard wheat exports (USDA 2006).

The French data also comes from two sources; one set of tests are provided by the official wheat grading system (as with the USDA data), and the other set is provided by Office National Interprofessionnel des Céréales (ONIGC) – but both are reported by ONIGC and ARVALIS Institut du végétal (formerly the Institut Technique des Céréales et des Fourrage/ITCF)—and both include intrinsic testing. When the programme began in 1999, ONIGC (ONIC at the time) tested bread wheat export sales samples from 49 French *départements* that comprise 17 wheat-growing regions, representing 88 percent of the total surface area in France devoted to bread wheat. (ONIGC also tested durum wheat samples coming from the durum-growing regions). In addition, ONIGC collected samples for overall quality tests at harvest time (during May and June) by post from 500 producers; an additional 1230 samples were collected directly from farms (during July and August); and 650 more samples were taken during harvest time from 200 silos belonging to cooperatives or merchants.

By 2006, export sales were coming from 51 French *départements* comprising 17 wheat-growing regions, and representing 89 percent of the total bread wheat surface area; and, ONIGC collected samples during May and June harvest by post from 32,000 producers across 67 *départements* as well as an additional 1250 samples directly from farms (during July and August); and 650 more samples are taken during harvest time from 200 silos belonging to cooperatives or merchants (ONIGC/ARVALIS 2006). The total number of wheat (including both bread and durum) growers in France number 150,000 and the total number of elevators is 1,500 (France Export Céréales 2007).

Table 6.12 compares each of the product characteristics (HOWs) and target values that were developed in Product plan 2 for product 'manufacture.' As in Product plan 1, Brand X represents the French growers and Brand Y represents the U.S. Some of the 'intersections' in the table are shaded. Where shading appears, along with an X or a Y, the intent is that the growers substantially comply, but with some exceptions; where only shading appears (no X or Y) the meaning is that growers could probably comply, but no currently reported data was found. A blank space indicates that no form of compliance was found.

6.C.1 Discussion of entries in Table 6.12

The following section contains notes to clarify entries in Table 6.12:

Item 1 Protein levels

The U.S. wheat grading system does indicate the various wheat protein levels, and wheat is separated and stored according to protein level. USDA data for U.S. HRW wheat exported in 2006 showed (on a 12 percent moisture basis): the highest protein at 15.1 percent and the lowest at 10.8 percent. On an ‘as is’ basis, the highest protein was 15.3 percent and the lowest was 10.9 percent. Lower levels of protein would have been found in the sales of Soft Red Winter wheat (SRW) and Soft White (SW) wheat.

The KSU data was segregated into four composite protein levels: less than 11.5 percent (low) [by U.S. standards]; 11.5 to 12.5 percent (medium), 12.5 to 13.5 percent (high), and greater than 13.5 percent (strong). Despite the four composite protein levels, the lowest protein reported at 12 percent moisture level was 12.5 percent and the highest was 15.2 percent. On an ‘as is’ basis, the range was 13.8 percent to 17.3 percent.

The French data for 2006 showed (on an ‘as is’ basis): 11 percent of all French bread wheat sold or sampled contained ≥ 13 percent protein; 21 percent contained 12.5 to 12.9 percent protein; 36 percent contained 12 to 12.4 percent protein; 22 percent contained 11.5 to 11.9 percent protein; and 10 percent contained ≤ 11.5 percent protein. The French tests are conducted according to protocols in the NF V03-750 standard.

Item 1 Summary

Both France and the U.S. can provide target value protein levels, although data provided by USDA show that the highest protein levels are found in Grade 2. This would mean that a buyer desiring high protein would need to sacrifice other grading factors. An additional, but key point, is that HRW wheat represents a class of wheat (i.e. composite varieties make up the HRW class, and all others excepting durum) and the ONIGC testing was based on specific varieties. In the ONIGC samples, any varietal or regional blends were verified through electrophoresis testing of at least five samples per blend. The electrophoresis testing establishes the specific varieties so that differences in milling and baking performance can be related to the varietal type and region. While the KSU samples represented 33 different locations, the wheat was already commingled. While electrophoresis testing could have been carried out, the results would have had only the random possibility of matching what a buyer of HRW would be receiving (since the wheat not sampled could be any combination in the commingled collection).

Item 2 Single variety

Wheat that has not been commingled is not available in the U.S., other than via contract production arrangements. A nearly opposite situation exists in France. The French wheat growing system focuses on single varieties and their fit for specific purposes (such as bread, pasta or animal feed). The miller purchasing wheat from France would not only have choice of specific varieties, but the opportunity to purchase wheat varieties that have been recommended by the *Association Nationale de la Meunerie Française* (ANMF). Every variety grown (for commercial rather than experimental purposes) is included in the list of varieties suitable for breadmaking prepared by the *Blé Panifiable Meunerie Française* (BPMF).

In both the first edition (year 2000) and second edition (2004) of the "Charter of Good Production Practices for Soft Wheat," the growers commit to harvest and store only single and pure varieties. The exception in 2000 was for blends that have been specially requested by the grain elevator. In 2004 that exception was revised to be blends that have been requested by the customer. It is interesting to note that although the GAP wasn't revised, the definition of who is a customer was amended. This emphasis on customer needs extends to the responsibilities of the elevator. Each elevator employs blending experts who are familiar with the needs of each miller that buys from the firm. These experts prepare special grists that match the preferences of the millers (Le Stum 2007).

Item 3 Regulatory conformance

The U.S. practice of "partial traceability" doesn't conform to the EU regulation requiring traceability from farm-to-fork. The argument on the U.S. side is that implementing traceability back to the farm gate would be prohibitively expensive. One study indicated that a farm would need gross revenues of at least \$10 million per annum to be able to implement and benefit from such a system (Sparling 2005).

French farmers comply with regulations in both markets. In addition, compliance is easy because segregation is already part of standard GMPs for the French farmer. Figure 6.C-1, taken from the cover of the "Charter of Good Production Practices," shows how the farmer bins and harvests all at one time. In terms of the traceability regulation, this is actually a step beyond what the EC directive requires. The directive is aimed at traceability from the farm gate; in France traceability takes place directly from the field (as seen in Figure 6.C-1).

Item 4 Test for pathogens

Recent legislation in the EU (i.e. EC regulation 2005/856 which took effect 1 July 2006) now requires testing for fusarium spp. mycotoxins. This regulation limits the level of the deoxynivalenol toxin (DON, and also known as vomitoxin) and zeralenon to 1250 µg/kg in unprocessed wheat intended for human consumption. (Slightly higher limits of 1750 µg/kg are permitted for durum wheat).

Figure 6.C-1
Harvesting wheat in France

Source: ARVALIS-Institut du vegetal, IRTAC Agrofood and Technological Research Institute and UNIP Interprofessionnal Union for grain legumes 2007.

In the U.S., regulations allow mycotoxins at a maximum of 20 parts per billion in unprocessed wheat. The FDA established new advisory levels for DON in wheat in 1993. This followed a random analysis that found 40 percent of wheat tested had levels of DON higher than existing permitted levels [3]. The 1993 FDA ruling set limits as follows: DON should not exceed 1 part per million (ppm, or 1000 µg/kg) in *finished* wheat products for human consumption. The rationale behind directing this only at milled wheat was the idea that normal milling practices and additional technology available to millers could substantially reduce DON levels. FDA advisory levels are guidelines to be followed voluntarily. According to the FDA, the "significance of DON in human health is yet to be demonstrated (CAST, 1989)" (KSU 1995). Federal Grain Inspection Service (FGIS) and other private laboratories will perform mycotoxin testing for a fee. However, there's no

---

[3] "The former FDA 'advisory level' for DON of 2000 µg/kg for wheat entering the milling process was 'updated' in 1993, when about 40% of the analyzed wheat samples had higher contamination levels." Rosner, H. and Van Egmond, H.P.: Mykotoxin-Höchstmengen in Lebensmitteln. Bundesgesundheitsblatt 12 (1995), 467-473.

indication in the literature that the U.S. will adopt legislation and testing similar to that of the EU. As discussed in earlier chapters, the precautionary principle doesn't apply in U.S. legislation; rather, products are assumed safe unless proven otherwise. The 1993 FDA response to DON in levels higher than existing regulations permitted, is a good example of the absence of the effect of the precautionary principle. Although the FDA decreased the tolerable limit of DON, the overall monitoring system remained unchanged. As the citation from KSU shows, the U.S. preference is not to regulate unless definite harm can be proven.

In France, in addition to the EU regulation, the "Charter of Good Production Practices for Soft Wheat" made a number of adjustments in its second edition (2004; third edition to be released in 2008) to accommodate risk assessments for biological and chemical pathogens. The changes were directed across several activity areas (such as Evaluation of the parcel of land, Crop protection during the growing phase and Harvest and storage practices). Therefore, it could be said that French farmers not only provide end product testing against pathogens and mycotoxins, they also adhere to good process management to prevent the dangers in the first place.

Although there was no reference to kaizen or Codex principles in the French wheat literature, this approach reflects an application of both. In comments from AGPB, the explanation was that the Codex and FAO guidelines are only recommendations and the French wheat industry had implemented what was considered valuable in terms of food safety. The same perspective was taken with regard to the industry's emphasis on process management rather than end product testing: "We don't want to become [overly] concerned with end product testing. Therefore, we are more interested in the care taken during production" (Le Stum 2007).

Additionally, although WTO agreements point to Codex guidelines that expect a HACCP plan (or similar type of plan to prevent hazards) to be in place for every entity involved in international agricultural trade, there's no evidence that U.S. or French farmers comply. The second edition of the French "Charter of Good Production Practices" very nearly incorporates a HACCP-like plan. As a practical matter, the HACCP-related elements could be extracted to create a stand-alone plan. But, there is simply no equivalent in the U.S., leaving the issue up to the miller to solve. Millers in both countries are generally required by law to have a HACCP plan.

Item 5 Agreed use of chemicals

Agreements between grower and customer regarding the use of pesticides, fertilizers and herbicides are only possible in contract production arrangements in both countries.

Item 6 Documented use of chemicals

Although university extension services recommend keeping written records of specific chemicals, there is no formal practice in the U.S. and would be no documents available for customer review. The situation in France is very different. The first edition of the French "Charter of Good Production Practices" in its opening paragraph states one objective for the charter as 'increased transparency of the production techniques used to create grains.' To this end written records of chemical use are maintained (at least by those growers committed to the Charter) and available for customer review. For their part, the various professional organizations (such as the Research Institute for Grain Technology in Food Processing/IRTAC and the Technical Institute for Grains in Feed/formerly ITCF and now ARVALIS) identify the key points in the processes where chemicals are needed, which ones should be applied and the data elements to be recorded. All of this is incorporated into the process descriptions in the Charter. The actual documentation required is minimal but sufficient to meet the requirements of the Charter.

Item 7 Documented sanitation standards for wheat

The U.S. grading system requires that wheat with "musty, sour or objectionable odor" automatically be assigned the Sample Grade designation, thus preventing it from being sold for use in food products. It is likely that a grower would comply with good sanitation practices during the growing phase, as otherwise, the harvest wouldn't pass the wheat intake tests (described in earlier chapters) when sold to the country elevators. But, documentation of practices is unlikely.

In France, two ministries carry out spot testing and random sampling: the DG Alimentation checks for any food safety issues, such as mycotoxins. In addition, the DGCCRF (or finance and budget ministry) carries out checks to prevent consumer fraud; weights and measures and other areas of potentially deceptive practices are monitored (Le Stum 2007).

The need for documentation in France is initially addressed in the first edition of the "Charter of Good Production Practices" but expanded to be more specific in the second edition: 'Phytosanitary conditions are to be respected and the aspects of intervention are to be documented.' A checklist for risk assessment of sanitary dangers is also included in the Charter. The checklist separates biological, chemical and physical dangers—matched to HACCP and Codex categories, although not stated as such. Some of the dangers are common in most literature on wheat cultivation (such as heat-producing insects, infestations from birds or mice, weeds that cause disease, need for proper ventilation during storage, pieces of glass or metal) but others are less common (such as the avoidance of heavy metal contamination [e.g. cadmium]) and an entire section on environmental (soil and water) protection. Key data elements to be recorded are recommended, and documentation would be available for customer review.

Item 8 Sanitation standards for equipment

The situation in the U.S. regarding proper care and cleaning of equipment is similar to the description above, in item 7. University extension services and various equipment vendors recommend procedures for cleaning and checking equipment. However, documentation is lacking.

The French "Charter of Good Production Practices" formalizes the process and documents the processes. In addition, the charter also addresses certain business management aspects that enter the processes (such as the recommendation to take additional care when checking equipment that is approaching five years use). But, there is no specific data to be recorded related to sanitation of equipment. While it might seem excessive, this level of data capture is expected in QMS such as ISO 9001.

Item 9 Dockage and impurities

The U.S. grading system tests and reports dockage and foreign material as two separate items. Dockage is determined as a percentage from a sample of 250 grams; foreign material is based on a percentage in a 30 gram-sample. (Both are permitted at increased levels as the grade category decreases. Only "animal filth, stones, unknown foreign substances and insect damaged kernels" are graded against the same maximum percentage for all categories.) The USDA data for HRW in 2006 showed the lowest level at 0.1 percent and the highest at 1.9

percent. The KSU data shows a low of 0.3 percent to a high of 2.2 percent. France discontinued grading of physical characteristics in 2000 and focuses on intrinsic tests. However, in 1999, the grading system didn't permit more than 2 percent in any wheat category. (Unlike the U.S. approach, dockage and foreign material were objectionable—regardless of wheat grade). The French "Charter of Good Production Practices" describes procedures that should be carried out to eliminate dockage and foreign material, mostly during grain storage.

Item 10 Broken and sprouted kernels

In line with the remarks concerning item 9, above, France discontinued grading of physical characteristics in 2000. However, prior to that time, for all categories of wheat grades, the French system would only accept wheat for sale with fewer than 3 broken kernels per 100 grams and 2 sprouted kernels per 100 grams. While the weight of a single kernel determines the number of kernels in the 100-gram sample, a single kernel typically weighs 25 to 30 mg. Therefore, kernels of 25 mg each would number 4000 in a sample and kernels of 30 mg size would result in 3300 kernels. On a percentage basis, this would result in broken kernels at 0.075 to 0.091 percent and sprouted kernels at 0.05 to 0.061 percent.

The U.S. grading system (categories 1 through 2) permits 3 percent to 5 percent broken kernels in a 200-gram sample (and 8 to 20 percent in categories 3, 4 and 5, which had no sales in 2006). If the broken kernel sample size for France were doubled to 200 grams (or some 8000 kernels), as in the U.S., 6 broken kernels would still result in a percentage rate of 0.075 to 0.091 percent. This means that the U.S., by comparison, permits a broken kernel rate 40 to 55 times greater than was permitted in France.

Despite the importance of sprout damage (as was discussed in previous chapters), the U.S. grading system has no category for sprout damage *per se*. But, there is a category for damaged kernels that shouldn't exceed 2 percent to 4 percent in a 15-gram sample (in grade categories 1 and 2, and 7 to 15 percent in categories 3, 4 and 5). There is also a category for "insect damaged kernels" that permits 31 kernels in a 100-gram sample (across all categories). Assuming each of the insect damaged kernels weighed 25 mg each, which would be generous, as insect damage would cause the kernel to weigh less than a healthy kernel—and there could be some protein quality loss (Cauvain 2008). Therefore, a sample of 4000 kernels (as described in the previous paragraph) with 31 insect damaged kernels would result in a percentage rate of 0.775 percent. If damaged kernels and insect damaged kernels were added together, this would allow a rate 2.8 to 4.8 percent—or 56 to 79 times greater than what was allowed in France.

To get a better perspective of this issue, it is useful to compare the KSU data for the same period. The KSU data didn't report insect damaged kernels, but showed broken kernels and damaged kernels as two distinct categories. The lowest figure for broken kernels was 0.7 percent and the highest was 2.4 percent. Both figures would be within the range for U.S. category 1 wheat, which limits broken kernels to no more than 3 percent. Damaged kernels were reported mostly ranging from 0.1 to 0.4 percent, with a single instance of 0.0 percent and another single instance of 0.5 percent. The USDA data for 2006 export sales showed the percent of broken kernels ranging from 0.2 to 2.5 percent and damaged kernels ranging from 0.0 percent to 2.5 percent. However, these figures are limited to categories 1 and 2; as no sales took place for lower categories. Comparing the 2006 USDA rate for broken kernels to that of the previous French grading system (from 1999) would result in an experienced rate of 1.3 to 13.7 times greater for customers of U.S. wheat. A similar comparison of actual damaged kernels to sprout damaged kernels (permitted by the French grading system) would result in a rate ranging from 'no difference' to 41 times greater.

While the U.S. rates seem rather poor, there is also the issue that the U.S. growers (either through design or by chance) have positioned their product in the lowest-cost generic category. Actual buying patterns, as seen in the USDA data, show that even though the U.S. grading system supports five categories, the international market will only accept categories 1 and 2. Given that the U.S. grading system allows increased levels of defects (ranging from 3 to 20 percent) as the grade decreases, and other grading systems (such as the French prior to 2000) support universal maximum limits of defects and dockage, it is likely that buyers would be receiving higher rates of defects and dockage in U.S. wheat than if they had purchased the same grade from other countries. For example, a buyer that purchased category 2-wheat from the U.S. (in 1999) would have accepted a maximum of five percent defects and dockage vs. the French system that permitted less than two percent. It is not surprising that international buyers were complaining about excessive defects in U.S. wheat (Uri and Hyberg 1996 and discussed in Chapter seven).

Item 11 High test weight

The USDA figures show the U.S. wheat fitting comfortably into the target values for test weight. Low test weight was 77.3 kg/hl and high was 84.1 kg/hl. The KSU data ranged from 76.3 kg/hl to 81.5 kg/hl. The differences between the USDA and KSU data might have been due to testing methodologies or possibly moisture levels at test time. Regardless, the test weights are similar to those from France for 2006: 85 percent of the harvest had a test weight greater than 76 kg/hl; the average was 77.3 kg/hl; the lowest weight was 76.2 kg/hl and the highest was78.3 kg/hl.

Item 12 Ash content

Ash content refers to the mineral content in flour. It is an important factor in breadmaking but can't be measured accurately in countries that fortify flour with additional minerals (Cauvain and Catterall 1998). The U.S. grading system doesn't measure ash content, but the KSU study showed that out of 172 samples tested, only 29 of them had ash content levels ≤ 0.5 percent. In France, ash content in wheat isn't tested, but the miller is responsible for determining which category (≤ 0.50, 0.65 and 0.80 percent ash content) that flour should be labelled. Therefore, an implicit relationship to suitable ash content would exist.

Item 13 Zeleny (gluten) test

The French literature initially described the Zeleny Index (test standard NF ISO 5529) as "an index that provides a global qualitative and quantitative indication of gluten. It is accepted that this index is proportional to baking strength" (ONIC and ITCF 1999). In 2006, ONIGC and ARVALIS (formerly ONIC and ITCF) redefined the Zeleny Index to be a sedimentation test (test standard NF ISO 5529) that is "an index that provides a global qualitative and quantitative indication of protein. The test is conducted by mixing flour in a suspension liquid composed of lactic acid, isopropyl alcohol and a colouring agent. The mixture is shaken and sediment is allowed to form. The height of the sediment deposited is measured (in ml) and this produces the test value" (ARVALIS 2006). Increasingly references to gluten are being replaced by references to protein quality in wheat and flour. The Zeleny (and sedimentation tests in general) attempts to separate proteins from flour based on their different affinities for water, acid, alcohol, etc., the reasoning being that not all of the wheat protein fractions contribute to product quality. The appreciation of which protein fractions contribute to protein quality has changed as knowledge has improved (Cauvain 2008).

Although the U.S. grading system doesn't test gluten, the KSU testing did perform wet gluten tests. The results showed nearly every site had favourable results – only one was below 25 ml. The ONIGC tests in France showed nearly all sites passed successfully (with one failure), with a range between 26 ml to 49 ml. The KSU data ranged from 29.7 to 38.7. The differences in the two reported ranges raise a question about whether the same test procedures were used. Regardless, it would still appear that U.S. wheat has suitable gluten performance, even if it is not officially reported.

Item 14 Hagberg FN test

In the French literature, the Hagberg falling number test is described as indicative of sprouted and sprouting kernels. Germination is connected with *alpha* amylase activity. The activity is acceptable in the range of 180 to 250 seconds. Beyond 250 seconds indicates insufficient activity, but may easily be corrected. Below 180 seconds indicates high amylase activity that may be detrimental for breadmaking. Below 120 seconds makes the batch unsuitable for baking (ONIC and ITCF 1999). (In addition, the French wheat grading system also grades wheat for animal feed based on Hagberg FN result). In 2006, 85 percent of the French wheat tested higher than 350 seconds; 11 percent was in the range of 300 to 349 seconds; 1 percent was 270 to 299 seconds; no wheat was in the range of 220 to 269 seconds; 3 percent was less than 220 seconds. Based on the target value of $\geq$ 250 seconds, 97 percent of the French crop would have been acceptable.

The KSU data showed results ranging from 350 to 441 seconds. So it is possible that the U.S. wheat meets suitable FN values, but just not reported.

Item 15 Moisture content

The USDA data showed a range of 8.3 to 12.4 percent, while the KSU data showed a range of 9.5 to 13.5 percent. Both ranges would meet the target value of $\leq$ 15 percent. The French grading system discontinued moisture content tests in 2000. However, in 1999, the grading system criterion was a maximum rate of 15 percent. In 2006, ONIGC tests showed a national average of 12.5 percent within a total range of 'less than 12 percent and more than 13 percent.' ONIGC describes the moisture content of the 2006 crop as "perfect for storage and the best level in ten years."

Item 16 Farinograph

Farinograph tests refer to the hydration rate and evolution of dough consistency during kneading. Hydration is the quantity of water required to obtain a dough with an arbitrary consistency of 500 farinograph units (FU). The value is expressed in relation to a dough with a water content of 14 percent. The time elapsed, in minutes, from the start of water addition to obtaining a dough with the consistency of 500 FUs, represents dough stability (ONIC and ITCF 1999). In 2004, the tests were discontinued. It is likely that other tests performed by ONIGC replace the farinograph. Prior to their discontinuance, the test standard used was NF ISO 5530.1

KSU also performed farinograph tests, but the literature doesn't mention which test standard was applied. A reference to the fact that the farinograph has been widely used in flour testing since the 1930s would seem to indicate that millers have been responsible for performing this test (KSU 1995). Therefore, it seems likely that U.S. wheat would pass farinograph tests.

Item 17 Alveograph

Rheology is concerned with the deformation and flow of matter (Oxford 2007). Dough rheology is measured through Alveograph testing, and reported as values of W, G and P/L. W represents the deformation of the dough and gives a good indication of baking strength. G, or swelling value, gives an indication of the extensibility of the dough. P/L reflects the balance between tenacity and extensibility (ONIC and ITCF 1999). In France, the test standard is the NF ISO 5530.4 and the W value from Alveograph tests is one criterion in the official wheat grading system. Chopin Technologies, which continues to produce equipment based on the original machine developed by Marcel Chopin nearly a century ago, describes the test as follows: The process for using the Alveograph is begins with dough formed with flour and salt water, and placed over a pneumatic pump that blows air into the dough to force it to be come a large 'bubble'. The Alveograph measures the pressure inside the bubble as well as the pressure over time. As the quantity of air is increased to a fixed volume, the internal pressure increases (which is represented as P). The higher the P value, the higher the dough tenacity. When the dough cannot continue resisting the pressure, the bubble starts to inflate. As the bubble increases in size, the internal pressure decreases. When the maximum extension of the dough bubble is reached, the bubble bursts and the test ends. The system measures the time during which the bubble can extend. The maximum extension of the dough is the L value. The higher the L value, the higher the extension properties of the dough. The deformation work is the W value, also referred to as the strength of the flour, and represents the work necessary to complete the deformation of the dough bubble.

The Alveograph is used for a number of purposes, but its main applications are for: 1) measurement control of raw material—either wheat or flour—for production consistency; 2) optimizing blends of wheat or flour, particularly in terms of meeting the blending law based on the respective P, L and W parameters); 3) detection of insect-infested wheat (Chopin 2007). In addition, the French grading system also evaluates the W value for wheat to be used for animal feed. The French 2006 harvest produced wheat that showed an average W value of 204, and an average P/L of 59 percent which would indicate ease in kneading the resulting bread dough.

While some of the French varieties showed P/L ratios of more than 100 percent, most were considerably lower and most values were not as far apart as in the KSU data. It is not possible to be certain without knowing more about how the KSU tests were performed if the U.S. samples compared with French breadmaking wheat were actually that different or merely that the tests were conducted differently.

Item 18 Breadmaking

USDA provides no tests for breadmaking. KSU tested breadmaking properties in their laboratories, which results reported as scores for loaf volume (in cc), crumb grain and crumb texture (both scored on an eight-point scale). The tests were performed in test facilities by laboratory technicians. The French tests are performed by professional bakers in a bakery-like setting, rather than in a laboratory. The goal is to evaluate how the wheat will perform in its intended setting. But the larger difference is that breadmaking tests in France are carried out on varieties – not on a class of mixed varieties. In addition, even varietal tests are split into additional tests to reflect the performance of each variety correlated to the region where it was grown.

The entire approach as to how a specific crop should be categorized is different in France. The U.S. system is, effectively, driven by its grading system: wheat varieties represent one of the six classes and the resulting quality at harvest time determines its category (which might or might not be suitable for breadmaking). In France, prior to sowing, the grower needs to determine for which end product the crop is destined and then select an appropriate variety for that category. The choices are: Superior breadmaking wheat; Standard breadmaking wheat; Corrective wheat (with extremely high protein for blending purposes); and Wheat for other purposes. The breadmaking tests are a form of feedback for the grower as to how well the variety (or blend) performed. The scores for the breadmaking tests are as follows against a maximum of 300 points: above 211= perfectly acceptable; 211 to 180 = acceptable after correction; and below 180 = not acceptable. The lowest score reported in 2006 was 190 and a number of scores were in the upper 280s. In contrast, in 1999 when reporting of the test results began, there were ten scores that year below 200 and the highest scores were 233, with only two samples achieving that level.

Amongst "other purposes" in the French wheat variety classification system is wheat grown for animal feed. This classification has its own grading system (that forms a level of feedback to the grower) and is also based on intrinsic testing.

Item 19 Grain hardness

The French grain hardness tests are based on test standard AACC 3970.A. The purpose of the test is to measure the hardness, or cohesiveness, of the grain based on near infrared spectrometry "using the American system of calibration." The various classes of hardness (extra-soft, soft, medium-soft, medium-hard, hard and extra-hard) are expressed by an index on a graduated, continuous scale ranging form 0 to 100. Conventionally, an index of 25 corresponds to the average value of 'soft' wheats and a value of 75 corresponds to 'hard' wheats. Hardness is mainly a varietal characteristic (ONIC and ITCF 1999). The 2006

French data shows a range of values from 53 to 97, with most of the highest values seeming to link variety and its growing region. (For example, Amiens produces some of the highest values within each varietal category).

The USDA doesn't report grain hardness, nor did the KSU study attempt it. There was no comment in the literature but presumably the results would have been meaningless in the commingled system of open production in the U.S., and therefore not attempted.

Item 20 Tests chosen by customer

In both the U.S. and France, the customer may request specific tests only in contract production arrangements. However, given the broad number of tests provided overall by ONIGC, the need for special requests would seem to be lower for the buyer of French wheat.

Item 21 Documented practices agreed with customer

This is very similar to item 20 in that special requests are only possible under contract production. But the French "Charter of Good Production Practices" describes and documents the GMPs that wheat-growing experts at ONIGC and ARVALIS have defined. It would seem unlikely that most buyers would need additional GMPs, but that could be accommodated via contract production. On the U.S. side, there's no equivalent other than contract production.

Item 22 Documented field reports agreed with customer

Again, as with items 20 and 21, the most significant field checks in terms of quality have been included in the French "Charter of Good Production Practices". Additional requests would require contract production arrangements and all requests would be via contract production in the U.S.

Item 23 Shipments matched to production levels

For both countries this would require contract production arrangements.

Item 24 Storage not to exceed 6 months

In the U.S. this would require contract production arrangements. In France it depends on the type of storage under consideration. On-farm storage may not exceed a capacity of 5,000 cm per national regulations. In addition, the “Charter of Good Production Practices” recommends that growers only store by single (pure) variety or a mix of varieties based on “the requirements of the customer”. Therefore, it seems likely that a request for storage of less than six months would be possible without entering into strict contract production.

Item 25 Tests and disclosure of GMO

Under EU law EC178/2002 that requires traceability, GMO and non-GMO grain would need to be separated. Given that the U.S. position is “partial traceability” and commingling of wheat in open production, it is not very likely that disclosure of GMO grain would take place at all. In France, there is currently no GMO wheat grown so testing/disclosure would not be an issue.

Item 26 Negotiate seed selection

In both countries this would require contract production arrangements.

Item 27 Use of certified seed and IP

Growers in both countries tend to split use of certified seed and farmer-saved seed at roughly 50-50 levels (USDA-ERS 2002; Le Stum 2007). At the outset in France, the farmer always uses certified seed. Then, some farmers continue to use it every year and others go back to it every second or third year. Crop rotation follows a 3-year cycle: the "head" of the rotation is sugar beets, potatoes, rapeseed or corn; the *second* crop is wheat; and the *third* is wheat or barley (Le Stum 2007). This would more or less place use of certified seed at a minimum of once per 3-year cycle. *[This also means using the land for wheat only one or two years out of three. To match this to the U.S. practice of a 6-year cycle, the French farmer would produce 2 to 4 crops per 6-year cycle; the U.S. farmer would produce either 3 or 4 crops in the same cycle. Also, the non-wheat periods are treated differently: in the U.S., the non-wheat parts of the cycle are either fallow or a summer crop, such as legumes, and the start of the cycle is wheat rather than a crop that prepares the soil for wheat. While the practices are not directly related to use of certified seed, they relate to the fact that even certified seed cannot overcome possible soil depletion.]* Additionally in France, the National Institute for Food Research (INRA) assists the growers with testing and GMPs for use of farmer-saved seed. A key issue is not to lose varietal traits while re-using the farmer-saved seed (Le Stum 2007).

INRA provides assistance to plant breeders wishing to produce new varieties, as well. The most expensive part of breeding is the initial design and research. Therefore, the French government underwrites this with the support of INRA. The same help and support is given to the farmers with their saved seed and to the seed certification agency. France today has as many as 60 to 80 different wheat varieties and it is not economical for the breeder if a new variety isn't better than an existing variety. It is doubtful that a breeder could introduce a new variety and make a profit; one reason being the high front-end development costs, but the other is the inability to protect the seeds from unauthorized use (Le Stum 2007).

Although the split between use of certified and farmer-saved seed is approximately the same in the U.S., much else differs. University extension services recommend GMPs to farmers for use of saved seed. Whether they follow the recommendations or not is an open issue. Farmers have the option of taking their saved seed to services that clean (and also often certify seed). But the regulations of what constitutes 'certified' vary by state. This is more obvious in differences between regulations in two states with one contiguous production region, e.g. Kansas and Colorado (Kansas Crop Improvement Association 2009; Kansas Department of Agriculture 2006; Colorado Seed Growers Association 2006; Colorado Department of Agriculture 1999). Additionally, farmers tend to use saved seed until yields begin to decrease. Also, unlike the assistance INRA provides the French farmers to protect the original varietal traits, there was no evidence of a similar process in the U.S. This may be tied to the difference in interpretation of the PVP laws (which was discussed in earlier chapters concerning international regulation). The international interpretation is that traits of plants (and animals) are afforded legal protection. The U.S. interpretation is that the traits are a form of intellectual property belonging to the developer of a variety. Any entity may develop a new variety and apply for certification, although all of the initial research and development is a very expensive process. Despite the costs, there are more than 30,000 wheat varieties in the U.S. Unlike the French system with only 60 to 80 varieties, the sheer logistics involved to annually track varietal characteristics and changes in production quality for 30,000 varieties would likely be close to impossible.

All of this results in a key difference between the two countries: the U.S. can only provide identity preservation (IP) and use of certified seed under contract arrangements, while the buyer of French wheat can achieve nearly the same – but within the open production system.

Item 28 Negotiate non-seed inputs with customer

In both countries this would only be possible under contract production arrangements.

Item 29 Pricing scale related to quality

In both countries this would only strictly be possible with contract production. But, the French system and its strong drive toward continuous quality improvement provides a similar result. Rather than paying premiums for quality (which might be found in a contract production arrangement), the French system provides adequate information concerning various quality characteristics to the potential buyer. The buyer can make a purchase decision based on the quality characteristics, and may pay more (for wheat plus transportation costs) for the same quantity of wheat as other exporting countries sell (such as from the U.S.), but be relatively certain of the qualities to be received.

Item 30 Documented health and safety practices

In the U.S., there are various laws, usually at the state level that define which practices must be documented. In addition, the Office for Safety and Health Administration (OSHA) oversees the use of certain types of equipment, including farm machinery (OSHA Standard No. 1928.57 [4]). So it is likely that at least a minimum level of documentation would be available in the U.S.

---

[4] www.osha.gov accessed April 2, 2011.

For France, the situation is similar to the discussion concerning sanitation standards, above, in items 7 and 8. The "Charter of Good Production Practices" gives guidelines for some of the most important issues—including health and safety (air, water and soil quality) related to the environment. The French growers could review such documentation with the customer.

Item 31 Negotiated commercial terms and deliveries

In both countries this could be accomplished more easily via a contract production arrangement. However, in France, the special relationship between the elevators and their set of miller-customers could likely be extended to suit commercial issues (and not only production characteristics).

Item 32 Good protein-to-starch and amylose-to-amylopectin ratios

Neither country informs buyers of the wheat's particular protein-to-starch and amylose-to-amylopectin characteristics. In the U.S., this would be especially complicated by the fact that protein-to-starch is closely related to wheat variety. Since, absent contract production, there's no varietal purity or identity preservation, it wouldn't be possible (in the existing framework) to incorporate a program that emphasizes this characteristic. The situation in France is not clear whether varieties with specifically 'good' protein-to-starch and amylose-to-amylopectin ratios already exist, but it would not be difficult to introduce such a variety and fit its/their documentation and publication of characteristics into the existing system.

Item 33 Use of GMPs to preserve good amylose-to-amylopectin ratio

This situation is very similar to item 32. The necessary framework (i.e. documenting and standardizing wheat production practices) doesn't exist at present. The French "Charter of

Good Production Practices" could be adapted to include those specific process-related elements needed to avoid stress that damages the plants during the Growing phase.