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Wheat Characteristic Demand and Implications for Development of Genetically Modified Grains

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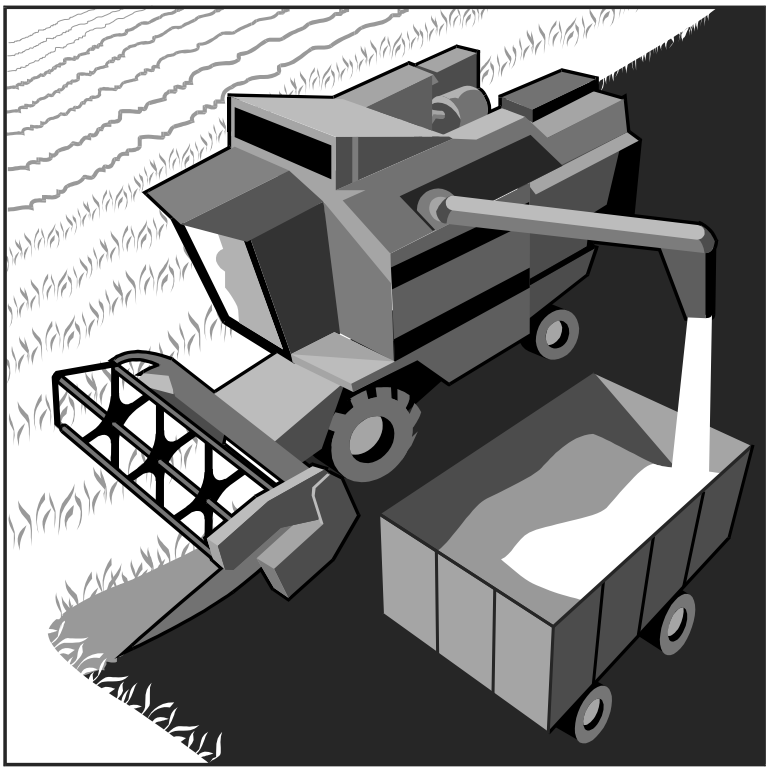

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ABSTRACT

Agricultural biotechnology is advancing rapidly and is embracing all major crops. The adoption of genetically modified corn, soybeans, and cotton have reached high levels in the United States. Wheat is the next major crop confronting the biotechnology issue, but no commercial varieties of genetically modified (GM) wheat have been released yet. Primary opportunities for GM developments in wheat center around improvements that meet consumer and end-user needs/issues in addition to meeting producer efficiencies. Developers and proponents of GM wheat must focus on education of consumers and restoration of worldwide confidence in the regulatory systems. The most desired wheat quality trait among millers and bakers is the assurance of consistent quality.

Key Words: wheat, wheat-based foods, agricultural biotechnology, genetically modified, GM, herbicide-tolerant, functional foods, nutraceuticals.

HIGHLIGHTS

The prospect of using genetic modification of wheat to enhance end-use traits has a great deal of appeal to the wheat industry. In anticipation of these developments, the purpose of this research was to analyze the sources of changes in demands for wheat quality characteristics and to identify how these may impact the prospective development of wheat varieties. Changes in product consumption were analyzed to identify the products with the fastest growth rates. A survey was conducted of domestic end-users of their desired characteristics in hard wheats, as well as their views on genetic modification and identity preservation.

Results indicated that there have been quite radical shifts in consumption of wheat-based products. Categories that have been growing the fastest are frozen pizza and tortillas, both benefitting from the demand for convenient, fast foods. The bagel category grew rapidly during the 1990s but has reached the status of a mature market. In contrast, there has been a decline in traditional pan bread consumption and the emergence of an upscale market for variety and hearth breads. It is clear the major trends driving consumption of these products are the demands for convenience, health benefits, and ethnicity.

Consistency is the most desired wheat quality trait among millers and bakers and most firms would be willing to pay more for greater consistency. Following consistency, the characteristics most important to these end-users were absorption, dough stability, and flour color. Wheat protein and falling numbers were also important and are the characteristics most commonly measured.

Results indicate that genetic modification to improve end-use characteristics will more likely be accepted than genetic modification to improve production characteristics. A majority of the firms indicate they would likely be indifferent toward purchasing wheat/flour that has been genetically modified to improve agronomic characteristics, but a significant percentage of the respondents said they would be less willing to buy such wheat or flour. Unwillingness by millers and bakers to purchase GM wheat is due mostly to consumer concerns.

Identify preservation is considered important by most companies. A majority think wheat should be identity preserved by both variety and geographic regions.

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Edward L. Janzen, Jeremy W. Mattson, and William W. Wilson*

1. INTRODUCTION

Wheat is used to produce numerous products both domestically and abroad. These products generally are made of flour produced from combinations of up to five different classes of wheat, each comprising numerous varieties that potentially have different end-use characteteristics. Varieties are produced in many different geographical locations with different climatological and agronomic conditions. Consequently, there is the prospect for immense heterogeneity in the supply of wheat characteristics. The desirability of wheats with different characteristics is highly dependent on the products produced, processing technology, and on competing supplies. All of these provide opportunities for variety development strategies. The ability to develop new varieties through traditional breeding techniques has been somewhat limited due in part to the inexactness and time necessary for breeding. However, these market characteristics provide immense opportunities and challenges for the development of genetically modified (GM) wheats. Conceivably, with better information on desired quality traits, there are niche end-uses that may be better served through more target-market specific strategies.

All of these opportunities are further compounded by concerns of customers over the safety of GM grains, as well as by the policy/strategy of competing suppliers. There are many recent and emerging developments related to this problem. These include much of what has been experienced in the development of GM corn and soybeans. Of importance here are the apparent problems of growing varieties prior to them being approved for food use, the very stringent concerns of buyers over food safety, and the apparent difficulties and near inability to effectively segregate grains within the market system. In addition to these problems, there are several that are somewhat unique in the wheat marketing system. First, wheat is already a highly differentiated commodity and the marketing system has responded to accommodate this development. Second, a larger portion of the wheat crop is exported making concerns of importers, as well as policies of competing exporters, more important.

The purpose of this report is to document changes in demand for wheat quality characteristics and identify how these may impact the prospective development of wheat varieties. Specific objectives are to identify changes in domestic consumption patterns of wheat products. In Section 2 some of the developments in the rapidly changing arena of GM grains are described. Though GM wheats are only now in the development and review stage, many issues have already surfaced that are crucially important. The following section provides an analysis of changes in demand for wheat end-use products. Though there have been recent reductions in the consumption of wheat-based products, there are major changes in the form of products consumed. Results of a survey of major domestic users of hard red spring (HRS) wheat about the demands for selected characteristics are then summarized. Results provide some indication of the importance of desired characteristics. The final section provides a summary of findings and discusses some of the implications for the development of wheat varieties.

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2. GM DEVELOPMENTS and HARD WHEATS

2.1. Background

Biotechnology refers generally to the application of a wide range of scientific techniques that are used to create, improve, or modify plants, animals, and microorganisms that are of economic importance. Agricultural biotechnology is that area of biotechnology involving applications to agriculture. Genetic engineering is a subset of biotechnology which describes the technique(s) used to alter or move genetic materials (genes) of living cells to improve productivity, quality, or performance (National Grain and Feed Association).

The basic knowledge of how plant traits are transmitted was discovered in the 19th century by Gregor Mendel. His experiments and concepts showed that traits were controlled by units of heredity, called genes. The application of biotechnology to agriculturally important crops has traditionally involved the use of selective breeding to bring about an exchange of genetic material between two parent plants to produce off-spring having desired traits such as increased yields, disease resistance, and enhanced product quality. The traditional methods of gene exchange are limited to crosses between the same or very closely related species. Frequently, the characteristics of interest do not exist in any related species and it can take considerable time to achieve desired results.

GM crops differ from their conventional counterparts by addition of one or more new genes (DNA sequences) into the plant genome. Each gene tells the plant to produce a new protein that confers a new trait. Examples are a bacterial gene (Bt) that tells the plant to produce a new protein that is toxic to certain insect pests and a bacterial gene for a protein that confers resistance to Roundup herbicide.

The application of recombinant DNA technology (developed in the 1970s following a series of complementary advances in the field of molecular biology) allows scientists to take a piece of DNA containing one or more specific genes from nearly any organism, including plants, animals, bacteria, or viruses, and introduce it into a specific crop species. The application of recombinant DNA technology frequently has been referred to as genetic engineering. An organism that has been modified, or transformed, using modern techniques of genetic exchange is commonly referred to as a genetically-modified organism (GMO). Plants that have been genetically modified using this technique to introduce a gene from either the same or different species are also know as transgenic plants (Persley and Siednow).

The application of genetic engineering to facilitate genetic exchange in crops has several advantages over traditional breeding methods. The exchange is far more precise because only a single specific gene that has been identified as providing a useful trait is being transferred to the recipient plant. Application of genetic engineering to plant breeding also allows more rapid development of varieties containing new and desirable traits. The specific gene being transferred is known, so the genetic change taking place to bring about the desired trait is also known, which is not the case with traditional breeding methods. The ability to transfer genes from any other plant or organism markedly expands the range of useful traits that can be applied to the development of new crop varieties.

Scientists have been working to improve plants and animals for human benefit for hundreds of years using conventional techniques, such as selective breeding. Modern techniques of biotechnology now enable scientists to move genes (and therefore selected traits) in ways they could not before. Modern biotechnology vastly increases the precision and reduces the time with which these changes in plant characteristics can be made, and it greatly increases the potential resources from which desirable traits can be obtained.

2.2. First Wave of Agricultural Biotechnology

The early stage of agricultural biotechnology has focused on production agriculture. New developments are being used to increase crop productivity, primarily by reducing the costs of production by reducing input requirements. Despite inherent measurement difficulties, Kalaitzandonakes points to a number of studies that suggest the first generation agricultural biotechnologies have delivered tangible economic benefits on the farm. Such benefits come in the form of the following: cost reductions in pesticide management, yield increases (partly due to yield traits, but primarily as a result of less competition with weeds and insect pests), improved risk management and insurance against pests, management time savings, reductions in equipment outlays associated with no-tillage production systems, and land-use efficiency gains from improved plant spacing. Not all of these benefits apply to all technologies or are enjoyed by all farmers. However, where the benefits are obvious adoption has been pretty aggressive.

Biotechnology's first stage continues to feature crops with improved agronomic qualities – input traits – valued by farmers. Input traits such as pest resistance and herbicide tolerance represent the "first wave" of the new agricultural biotechnology (Riley, Hoffman, and Ash). The rapid adoption of biotechnology can be attributed to several factors (Hillyer). These include:

1) Cost savings. Herbicide- and insect-resistant crops generally lower pesticide use and require fewer trips across the field, lowering energy costs.
2) Convenience. Farmers are familiar with the new technology and know what to expect in weed control performance in addition to the broad spectrum control offered with a herbicide like Roundup. Fewer trips across the field are also regarded as a convenience factor in addition to a cost savings factor.
3) Environmentally Friendly. Less pesticides reduce the odds of potential runoff, plus many of the GMOs encourage the use of conservation tillage practices.

On a more global scale, the benefits of first stage agricultural biotechnology developed crops include the potential to fight hunger and to address environmental issues. Disease and pest resistant plants and plants with increased yield traits may allow farmers to increase yields and feed more people. Increased yields can signal less need to convert rain forests and marginal land into crop production to maintain a sufficient supply of food. Pest resistant crops reduce the farmers reliance on insecticides and herbicides, thereby helping the environment. Other first stage benefits being researched include development of crops that could grow on land or in climates that are currently too hostile for significant production – too dry, too cold or hot, too saline, etc.

2.3. GMO Developments

The early success stories in agricultural biotechnology have been genetically engineered crops for pest management, most notably in corn, soybeans, and cotton. Corn and soybeans are the two most important field crops in the United States and have, so far, been the primary biotech crops used in the production of food and feed. Corn and soybeans are prevalent throughout the food supply system, with a wide variety of food items containing these crops as inputs in varying forms [U.S. Department of Agriculture (USDA), April 12, 2000]. Adoption rates for pest-tolerant and herbicide-resistant crops have been very rapid. Herbicide-resistance means that a herbicide can be sprayed on a field to kill weeds without harming the crop itself.

Bt and Herbicide-Tolerant Corn. Bt corn is designed to resist damage from the European corn borer, a major insect pest in the corn belt. Because the borer tunnels inside the stalk, the impact is not always apparent until damage has occurred. Bt corn incorporates a protein from *Bacillus thuringiensis*, a naturally occurring soil bacteria. It was first approved for sale in 1996 and use expanded greatly in 1997. Its use grew to 26 percent of planted corn acreage in 2001.

Herbicide-Tolerant Soybeans. Insertion of a single gene, derived from a common soil microorganism, makes soybeans immune to glyphosate, the active ingredient of Monsanto's Roundup herbicide or to glufosinate, the active ingredient of AgrEvo's Liberty Link®. The first year of commercial production, 1996, U.S. farmers planted about a million acres of GM soybeans. Plantings of GM varieties expanded to 68 percent of the soybean acreage in 2001.

Bt and Herbicide-Tolerant Cotton. Another major first stage biotech crop is cotton. Acreage of herbicide-tolerant cotton has expanded rapidly, reaching about 69 percent of acres planted in 2001. Acreage of biotechnology varieties for these three crops continued to expand in 1999 (Table 2-1 and Figure 2-1). Planting intentions for these major crops experienced a slight decline in 2000 as farmers were faced with uncertainties in the acceptance of GMO varieties in the marketplace. This dilemma is discussed in more detail in the following section.

The United States leads the world in the adoption of GM crops. More than 70 percent of the land in the world that is planted in GM crops is in the United States. Canada and Argentina are the only other significant producers of GM crops at the present (Figure 2-2).

Table 2-1. Farmer Reported Biotechnology Varieties, United States

	1998	1999	2000	2001
	(percent of acres planted of crop)			
Corn	30	33	25	26
Soybeans	42	57	54	68
Cotton	46	55	61	69

Source: USDA/NASS, *Acreage Report*, June 2000, June 2001.

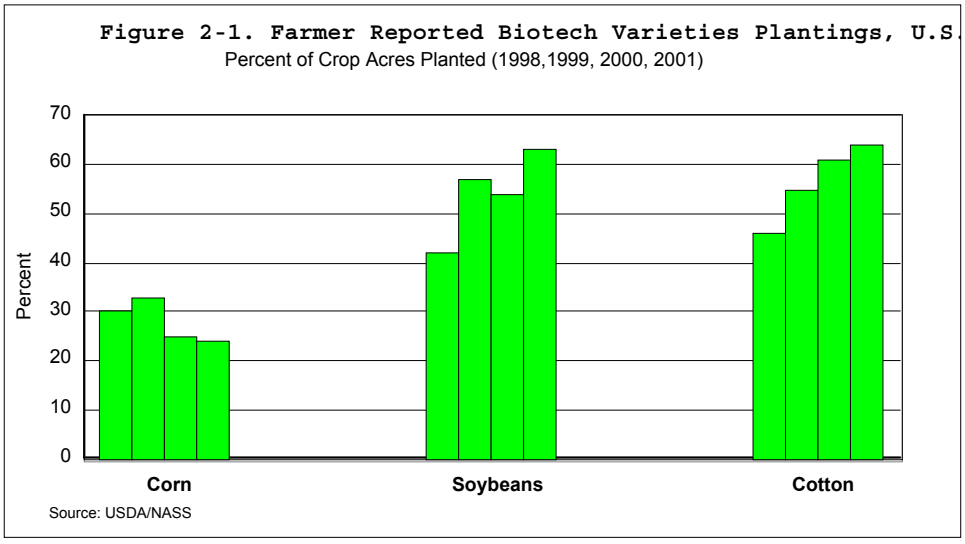


Figure 2-1. Farmer Reported Biotech Varieties Plantings, U.S.
Percent of Crop Acres Planted (1998,1999, 2000, 2001)
Percent
70
60
50
40
30
20
10
0
Corn
Soybeans
Cotton
Source: USDA/NASS

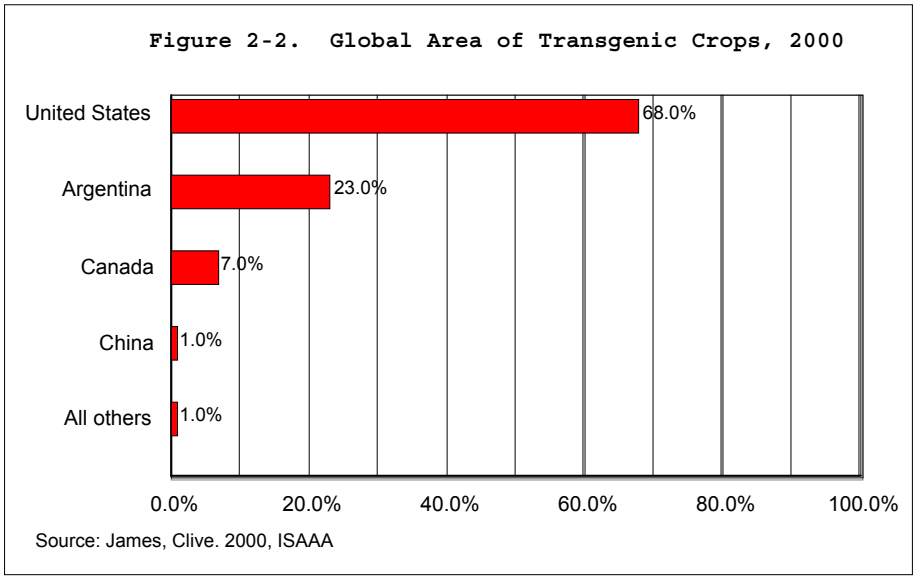


Figure 2-2. Global Area of Transgenic Crops, 2000
United States
Argentina
Canada
China
All others
68.0%
23.0%
7.0%
1.0%
1.0%
0.0%
20.0%
40.0%
60.0%
80.0%
100.0%
Source: James, Clive. 2000, ISAAA

2.4. Major Issues in GMO Acceptance

Several significant issues have arisen that are, temporarily at least, slowing the rate of adoption of GMO crop varieties. While briefly discussed individually, these issues are very much intertwined. Uncertainty of consumer acceptance is the major factor slowing adoption of GMO varieties. The reluctance of major customers like the European Union (EU) and Japan to embrace GMO crops creates a very uncertain market situation. Their concern centers in part on the perceived issue of food safety and long-term effects on human health. In the EU, recent food scares (such as "mad-cow disease") and a distrust in their own government regulatory systems are creating restrictions that are slowing the general acceptance of GMO crops. Even in the United States, where a National Research Council panel has concluded that no evidence has emerged suggesting foods on the market today are unsafe as a result of genetic modification, there is public concern related to potential risks.

Several major food manufacturers have, for the present at least, opted against the use of GM sources of grains. Frito-Lay (division of PepisCo), Gerber Products, and The Hain Food Group have said they will not be using GMOs in their products. Seagram, one of the world's largest distillers, said it would not use GM products in its spirits and McCain Foods, a french fry giant, said it will not accept GM crops. Kellogg's shareholders recently defeated a resolution to stop using genetically altered crops.

A primary topic currently, both abroad and domestically, is the issue of labeling. In part the labeling issue is raised to counter some of the concerns expressed with respect to safety and health. The EU has adopted rules that require foods and food ingredients to be labeled if they contain individual ingredients that exceed a 1 percent threshold of biotechnology-enhanced crops. However, even though the EU is looked at as a single trading block, individual countries within the EU are taking their own stance on the issue of GM grains (Howie).

In Japan, a new labeling system is expected to go into effect that will target soy, corn, potato, cotton, and rapeseed crops. In contrast to the EU, food manufacturers are expected to be allowed to label corn and soy products as "not genetically modified" if the GM content in the product is less than 5 percent of the total (Cornell, 1998). The Japanese government recently accepted a proposal to require safety tests for genetically altered food, whether produced domestically or abroad. In a related note, Japan has started to substitute non-GM wheat in food products in place of corn or soy. This is their safe way of avoiding GMOs as GM wheat is not yet commercialized.

In spite of pressure from some activist groups in the United States, the Food and Drug Administration (FDA) announced plans to tighten regulation of foods derived from biotechnology but does not plan to require labeling of foods that contain GMO ingredients. U.S. food and agribusiness industries adamantly oppose mandatory labeling, saying it is too costly and would potentially scare consumers away from genetically engineered foods (*GRAINNET*, May 3, 2000). Opponents to mandatory labeling claim that mandatory labeling implies there is a difference between food produced through genetic engineering and food produced through traditional breeding.

In addition to labeling restrictions, there is general market uncertainty as some countries move to ban the use of GMOs all together or make the testing requirements so tight that it is extremely difficult to comply. One of the difficulties with identification of GMOs and tolerance labels is the inadequacy of current testing procedures. Current procedures generally test for only a single type of trait and are time consuming and costly.

Another issue in the marketing of genetically engineered crops is the challenge of developing strategies to keep GMO grains separate from non-biotech grain. The most critical issue for grain handlers and food processors is to establish reliable testing procedures and permissible tolerance levels to facilitate the flow of both GM and non-GM crops through the food chain. As long as demand exists to keep the grains separated, the impact on the food supply chain is immense. Identity preservation or segregation requires extra precautions during harvesting, loading and unloading, storage, and transportation. The ERS estimates that segregation could add about 22¢/bushel to marketing costs of non-biotech corn from the country elevator to the export elevator and as much as 54¢/bushel for segregation of non-biotech soybeans at these elevators, excluding any producer premium in both cases (Lin and Chambers).

Globally, food security is a significant issue related to acceptance of GMOs as many countries are struggling to feed their current and expanding populations. Developing nations view biotechnology as their hope to develop crops for their environmentally challenged areas and attain a degree of food security. Developing nations see the possibilities of considerable production advantages giving them a better chance to feed a population in both quantity and quality (Garnier).

2.5. Second or "Next" Wave of Agricultural Biotechnology

The first wave of agricultural biotechnology developments was oriented toward input traits which benefitted farmers by lowering farm-level production costs. The next wave will be focused on output traits which will benefit users and consumers. Biotechnology is likely to accelerate the change in the way farmers do business. Production driven agriculture is giving way to a demand driven system where many differentiated products are grown in response to consumer demands for specific characteristics (Klein, Kerr, and Hobbs).

Current research focused on "second-generation" transgenics will feature a wider range of traits, many of which are likely to be of greater benefit to consumers. They will include enhanced nutritional and/or industrial values. Health-promoting products that help lower cholesterol, prevent cancer, and enhance overall health are the focus of most of the food industry giants. With the development of so-called "functional foods" and "nutraceuticals" the lines between food and medicine are blurring, further enticing food processors, agbiotech firms, and drug companies to merge complementary interests in food, biotechnology, and pharmaceuticals (Rural Advancement Foundational International).

Several terms are used to describe additives that supplement the nutritional value of various foods. The American Institute of Baking has offered the following definitions of some of the more commonly used terms (Spooner):

Designer food: Processed food that is supplemented with food ingredients naturally rich in disease-preventing substances. It may involve genetic engineering of foods.

Functional food: Any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains.

Nutraceuticals: Any substances that may be considered a food or part of a food and provides medicinal or health benefits, including the prevention and treatment of diseases.

Phytochemical: A substance found in edible fruits and vegetables that may be ingested by humans daily in gram quantities and that exhibits a potential for modulating human metabolism in a manner favorable for cancer prevention.

In addition to enhancing the health and nutritional profile of food products, traits might be developed to help create new flavors, improve product functionality, and enable the creation of new products. There are other desirable output traits of interest to the consumer that are not health- related. Characteristics that improve processing techniques, allow for new products or processing techniques, enhance freshness, or increase shelf life are some of the other benefits that can and will be addressed by new research in agricultural biotechnology.

Many industrial (non-food) possibilities also exist. They include expansion of plant-based renewable resources for raw materials, industrial feedstocks (e.g., plastics from corn, etc.), chemicals, and energy.

2.6. Biotechnology and GM Developments in Wheat

Wheat lags behind the other major crops with respect to biotechnology developments. Even first wave (input trait oriented) biotech varieties are not yet commercially available. Wheat is a genetically complex plant and, thus, has lagged behind advancements seen in corn, soybeans, cotton, and rice, according to wheat breeders. There are currently no transgenic varieties of wheat (or barley) registered for commercial production anywhere in the world (*GRAINNET*, May 4, 2000). However, there are field trials of GM wheat in many countries including the United States, Egypt, South Africa, Australia, and Canada. At the recent U.S. Wheat Quality annual meeting, wheat experts stated that the introduction of biotech wheat may still be three to five years away as agricultural companies race to bring herbicide-tolerant wheat to the market (Gillam).

Introducers of GM wheat will try to avoid the marketing mistakes that have plagued soybean and corn processors (*Milling & Baking News*, May 9, 2000). Entering the market with first stage developments may be difficult as some consumers have balked at acceptance of transgenic crops whose primary benefit is to production agriculture. In Japan, non-GM wheat is replacing GM corn and soybeans in its food products because there is no commercialization of GM wheat. It is becoming increasing difficult for Japan to find non-GM corn and soybeans coming out of the United States (*AGWEEK*). Introduction of GM wheat will cloud the export market for wheat unless there is a reversal in attitudes toward acceptance of biotech crops in major markets like Japan and the EU.

Cyanamid Crop Protection is developing a herbicide-tolerant wheat which is currently completing its registration process (Briere). This wheat is designed to be a key component of their *Clearfield Production System* and is tolerant of their family of custom-designed herbicides. The seed varieties in the *Clearfield Production System* are **not** produced through transgenics.

Monsanto has numerous products in its pipeline, several of which are being developed with partners. With respect to wheat, they are working on disease-protected wheat, higher-yielding wheat, improved-quality wheat, and Roundup Ready® wheat. The earliest estimated date of commercial launch for each of these products is "beyond 2002." The completion and timing of commercialization depend on the successful completion of such factors as research, field and clinical trials, and regulatory approvals (Monsanto).

A recent news item noted that AgCanada's cereal research center will continue its eight-year partnership with Monsanto for genetically engineered HRS wheat, although it is "backing away" from proposals to fund research into GM durum wheat. AgCanada will invest $800,000 to match Monsanto's million dollar investment for GM spring wheat. It could be on the market by 2003, according to AgCanada (U.S. Wheat Associates, 2000).

The Canadian Wheat Board issued a Biotechnology Position Statement in early 2000 indicating that it does not want GM wheat registered in Canada until there is buyer acceptance and practical ways to segregate it from traditional wheat varieties. They note that current grain handling technology is not capable of efficiently and effectively identifying and segregating large volumes of transgenic grain varieties and until such technologies are in place, and assuming some important markets still require that their grain shipments not contain GM products, such wheat and barley varieties should not be registered for production in western Canada. Such varieties could be considered for registration as soon as effective segregation strategies are available (*GRAINNET*, May 4, 2000).

The current CWB Biotechnology Position Statement (Appendix A) states that their objective is to ensure that the introduction of GM wheat and barley varieties for production, handling, and marketing be accomplished in a manner that will satisfy customers' requirements and result in net financial and other benefits to western Canadian farmers. They state that their current strategy is to engage farmers, the grain industry, and the life sciences companies in a rigorous cost-benefit analysis of the introduction of transgenic wheat varieties.

The U.S. wheat industry is also taking a very cautious approach to the commercialization of GM wheat so as not to jeopardize their export markets. The U.S. Wheat Associates, National Association of Wheat Growers, and the Wheat Export Trade Education Committee have jointly adopted a Biotechnology Position Statement (Appendix B). They state that "The U.S. wheat industry commits itself absolutely to the principle that our customers' needs and preferences are the most important consideration. We support the ability of our wheat customers to make purchases on the basis of specific traits. We will work with all segments of the industry to develop and assure that a viable identity preservation system and testing program is instituted prior to commercialization of products of biotechnology."

The USDA, through its Grain Inspection, Packers and Stockyards Administration, is setting up a GMO testing lab in its Kansas City, MO, Technical Center in response to the grain market's need for independent sources to verify the reliability and credibility of biotech analyses for grain. They will review laboratories testing grains for the presence of biotechnology-derived grains and will accredit those laboratories that meet performance standards. In addition, they will evaluate test kits against the manufacturer's performance specifications for determining the presence of biotechnology-derived grains in bulk grain to ensure that these tests are accurate and reliable. These reviews and evaluations will be performed upon request of the lab or test kit manufacturer.

Some of the improvements that are being researched in wheat biotechnology are altered seed protein compositions which include adding genes to make extra strong flours; adding genes for lysine- and threonine-rich proteins to make flours with nutritionally complete amino acid profiles; and adding genes for processing enzymes to make them part of flour composition instead of ingredients that bakers need to add (Cornell, 1998). Other possibilities include altered starch compositions for making bread that better resists staling or for flours optimized for frozen dough applications. Reducing amylose levels in wheat starch would make it more desirable for noodle making because it improves noodle texture, and reduced-amylose flour might also improve dough for frozen foods like pizza crusts or ready-to-bake breads by helping maintain flavor (Wood).

Biotechnology offers benefits to the baking industry. It has the potential to provide the baking industry with raw materials of desirable composition, make products more nutritious and functional, and increase food quality. Wheat researchers will also address the area of nutraceuticals or functional foods that could conceivably provide immunity to a disease or improve the health characteristics of traditional food.

Producing wheat that will yield bread that naturally stays fresh longer is among the possibilities foreseen by Fred Miller, McKinsey & Co (*Milling & Baking News*, May 18, 1999). Naturally fresh bread could have significant impacts on the baking business. It would allow bakers to centralize production, go directly to warehouse-based distribution, reduce the number of deliveries to retail sites, and significantly reduce product waste. Miller indicated that bio-engineered wheat could take out as much as 12 percent of the cost structure for bakers. Modifying wheat starch could also make it more suitable for any of hundreds of industrial uses ranging from pastes to papers to textiles.

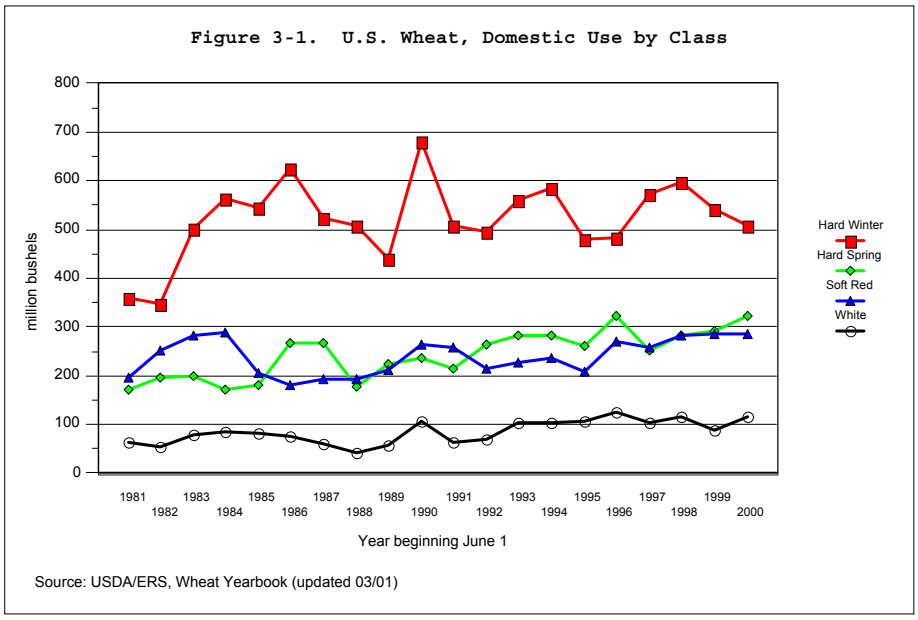
3. WHEAT FOODS TRENDS

3.1. Background

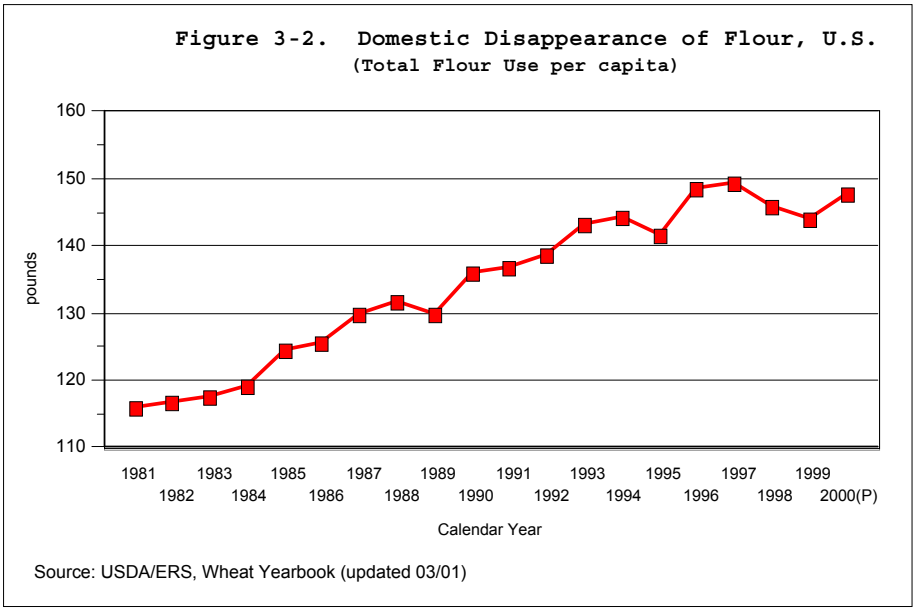
This section provides a review of consumer trends in wheat product consumption. Progressing from wheat to flour to the major wheat foods categories, trends, and patterns in consumption are reviewed to help identify areas where it would be potentially most beneficial to focus wheat breeding research.

3.2. Domestic Utilization of Wheat

The primary classes of wheat used for baking purposes in the United States include hard red winter (HRW), hard red spring (HRS), soft red winter (SRW), and white wheat. Domestic utilization of wheat in the United States in 2000 consisted of 38.0 percent HRW, 24.1 percent HRS, 21.5 percent SRW, and 8.7 percent white wheat, with the balance being durum wheat. Historical patterns of U.S. domestic utilization of wheat by class are shown in Figure 3-1.



U.S. per capita consumption of flour has generally trended upward since 1981 and reached a peak of 149.5 pounds in 1997. Per capita consumption fell to 145.9 pounds in 1998 and to 144.0 pounds in1999, but rebounded to 147.8 pounds in 2000. The trend in domestic disappearance (per capita consumption) of flour in the United States is shown in Figure 3-2.



3.3. Consumer Trends and Issues

Convenience, health benefits, and ethnicity are among the trends currently tapped as key drivers in grain-based foods consumption, according to Charles M. Kingery, senior vice president, Information Resources, Inc., Chicago. Economic trends, population trends, and lifestyle trends will continue to be the major influence in grain-based food consumption (*Milling & Baking News,* June 29, 1999).

Fundamental shifts in consumer lifestyles are influencing eating and purchasing habits in all food areas and bakery products are no exception. Convenience (which may mean eating on the run, little or no preparation time, and efficiency of purchasing) is one of the most significant trends in the food industry. In the baking industry this translates into strong growth in hand-held foods, a strong comeback in frozen food, and the prevalence of convenience stores to serve the busy on-the-go consumer. Gingery states that approximately 20 percent of all meals are eaten in the car. Taste continues to remain the major factor influencing product appeal and acceptability.

Gingery also states that the growth of children born to the baby boom generation (Generation Y) is emerging as one of the most important generations in decades. They will be the most independent, worldly, and busy generations in decades and are likely to demand more in terms of convenience and healthy foods and be environmentally conscious. He states that currently, kids influence approximately 43 percent of all consumer purchases.

The hottest trend in the food industry is the demand for products with supplementary health benefits. Nutraceuticals, sometimes referred to as functional foods, are the fastest growing segment of today's food industry (Sloan). These are foods promoted specifically for their health or medicinal properties. Changing demographics influencing consumer choices in

the food industry include the continuing growth of minority populations (Hispanic and Asian in particular) and exploding growth of the elderly population in the United States. Consumer demand for freshness and quality and millers' and bakers' demand for quality wheat/flour with consistent quality attributes continue to be key issues in the wheat foods area.

3.4. Wheat-based Foods

Dollar sales by category for grain-based foods for a recent 52-week period are noted in Table 3-1. The fastest growing grain-based food categories for the period noted were frozen pizza and tortillas, which combined represented only 11 percent of dollar sales of total grain-based food. Crackers showed the largest dollar sales increase and accounted for 12.7 percent of total grain-based food dollar sales for the year. This is consistent with the trends toward convenience and fast food categories. Cereals remain the number one category of grain-based foods with bread the number two category in overall dollar sales. Pasta sales were the only category reflecting a decline (1.3 percent) during the year.

Table 3-1. Grain-based Foods: Dollar Sales, by Category, 52 Weeks, Ended July 18, 1999

Category	1998	Sales Increase	1999	Pct Chg	1999 Sales Pct of Total
	----------($mil)----------				
RTE Cereal	7,547.3	78.5	7,625.8	1.0%	28.3%
Bread	5,221.2	74.7	5,295.9	1.4%	19.7%
Cookies	4,315.7	77.3	4,393.0	1.8%	16.3%
Crackers	3.23	184.4	3,419.5	5.7%	12.7%
Frozen Pizza	2,034.9	168.9	2,203.8	8.3%	8.2%
Pasta	1,125.2	-14.6	1,110.6	-1.3%	4.1%
Bakery Snacks	934.6	42.1	976.7	4.5%	3.6%
Tortillas/Taco Kits	710.1	45.4	755.5	6.4%	2.8%
Refrigerated Dough	459.3	6.4	465.7	1.4%	1.7%
Fresh Bagels	368.3	16.2	384.5	4.4%	1.4%
Frozen Pies	249.6	18.7	268.3	7.5%	1.0%
	26,201.4	697.8	26,899.2	2.7%	100.0%

Source: Sosland, L. Joshua, "Heady Sales Growth Continues for Top Frozen Pizza Breads, *Milling & Baking News*, October 26, 1999.

3.5. Breakfast Cereal

The largest category of grain-based foods was breakfast cereal, with more than 90 percent of the cereal being "ready-to-serve" breakfast foods. In 1999, cereal represented more than 28 percent of grain-based foods based on dollar sales. Value of shipments by cereal type for the last three census periods is shown in Table 3-2. In total the value of shipments for breakfast cereals increased by more than 53 percent from 1987 to 1992, but declined by just over 2.5 percent from 1992 to 1997.

The wheat component of the ready-to-serve category declined significantly, from 29 percent of value shipped in 1987 to 18 percent in 1997. Percentage of value shipped by major cereal grain for each of the last three census reports is shown in Figure 3-3.

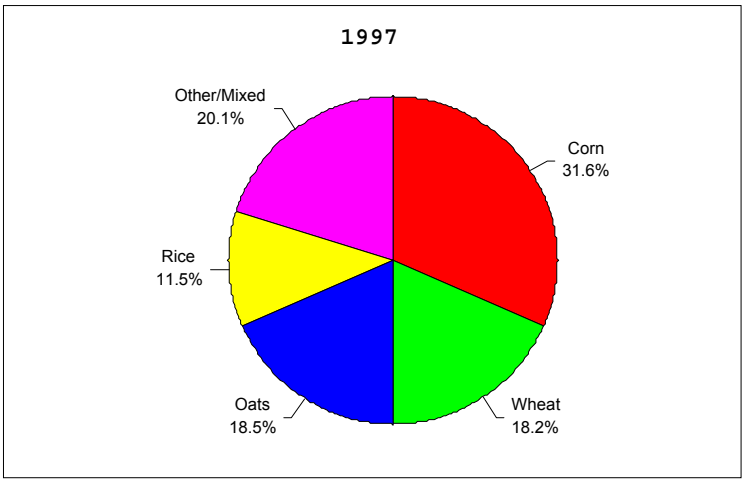
Table 3-2. Breakfast Cereal: Value of Shipments

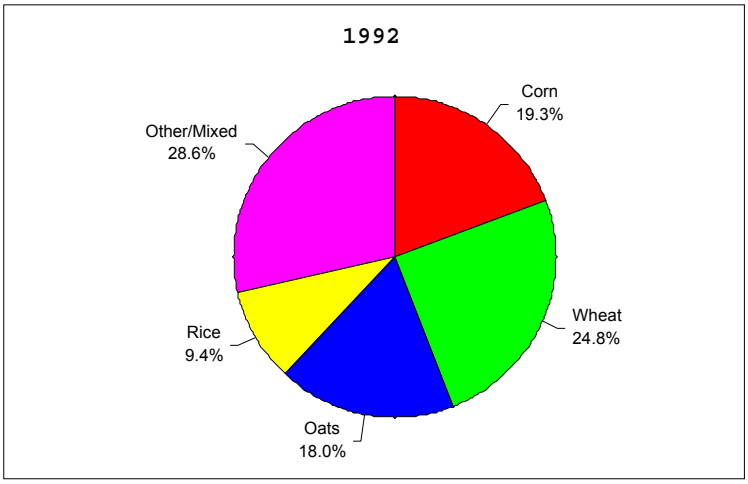
	1997	1992	1987
	mil $	mil $	mil $
Ready-to-serve cereals			
Corn	2,175.0	1,400.6	1,302.3
Wheat	1,253.3	1,801.7	1,359.6
Oats	1,274.3	1,307.2	706.9
Rice	789.5	681.7	518.1
Other/Mixed Grains	1,385.6	2,078.4	743.1
Other cereals (1)	717.0	525.8	451.1
	7,594.8	7,795.4	5,081.1

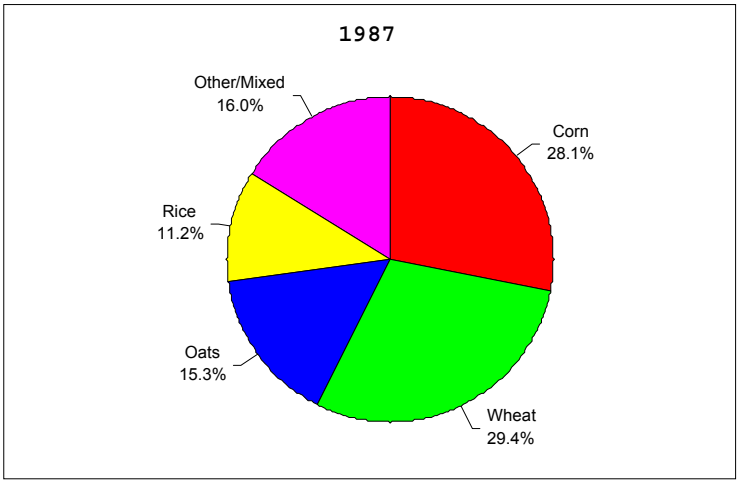
(1) Other cereal breakfast foods, including infant cereals, and cereals intended to be cooked.

Source: U.S. Census Bureau Data

Figure 3-3. Breakfast Cereal (ready-to-serve), Percent of Shipments, by Cereal Type







Source: U.S. Census Bureau Data

3.6. Bakery Products

The largest users/direct consumers of flour are commercial bakers. Primary bakery product categories as defined in U.S. census data include bread, rolls, bagels, soft cakes, pies, cake-type donuts, yeast donuts, pastries, and other sweet goods. Shipments and value of shipments from commercial bakeries for the last three census reports are shown in Table 3-3a and Table 3-3b, respectively. The trends in shipments by major product category are shown in Figure 3-4. Percent change is show in Figure 3-5a and net shift percent[1] is shown in Figure 3-5b. Because of the size of the category, bread experienced the lowest percent decline while deviating further from the average growth rate than the other categories from 1987 to 1997.

Product category shares of value of shipments for commercial bakeries are shown in Figure 3-6. Based on value of shipments, the most significant changes are the decline of bread from 45.9 percent of bakery products in 1987 to 41.5 percent in 1997, an increase in bagels from 2.1 percent in 1987 to 4.9 percent in 1997, and an increase in the rolls category from 23.3 percent in 1987 to 25.6 percent in 1997.

Bread: Key trends noted in the bread industry are a decline in the traditional pan bread market and the emergence of an upscale bread market (*Packaged Facts)*. White bread is still a "flagship" of the industry but percentage of the market is decreasing as variety breads increase. In 1976, white bread had 74 percent of the bread market; in 1997, 53 percent. In 1976 hearth and variety breads had 26 percent of the total bread market. In 1999 this segment had 47 percent of the bread market and 58 percent of the sales ($3 billion) (Adams). Different flavors and textures are capturing a larger share of the bread market. Flavored or breakfast bread is one of the growth segments. Differences in suppliers, local tradition and taste, and demographics lead to regional variations in the bread market while freshness, consistency, and quality remain the fundamentals of marketing branded bread.

The trends in shipments by major bread type are shown in Figure 3-7. Percent change is shown in Figure 3-8a, and net shift percent is shown in Figure 3-8b. Shipments of hearth bread grew at a faster rate than the growth for the overall bread category.

Changes in value of bread shipments by type for the last three census periods are shown in Figure 3-9. White hearth bread, as a percentage of the value of bread shipments, has increased from 12 percent in 1987 to 18 percent in 1997, mainly at the expense of whole wheat bread, which declined from 24 percent to 19 percent of the value of bread shipments. White pan bread remains the largest bread type but declined slightly in the 10-year period.

[1] The net shift percent is an alternative measure for ranking growth. This measure estimates the percent of deviations from the average growth rate captured by each category. It provides perspective on the rate of growth for each category in relation to the market as a whole (see Lou and Wilson).

Table 3-3a. Commercial Bakeries: Shipments

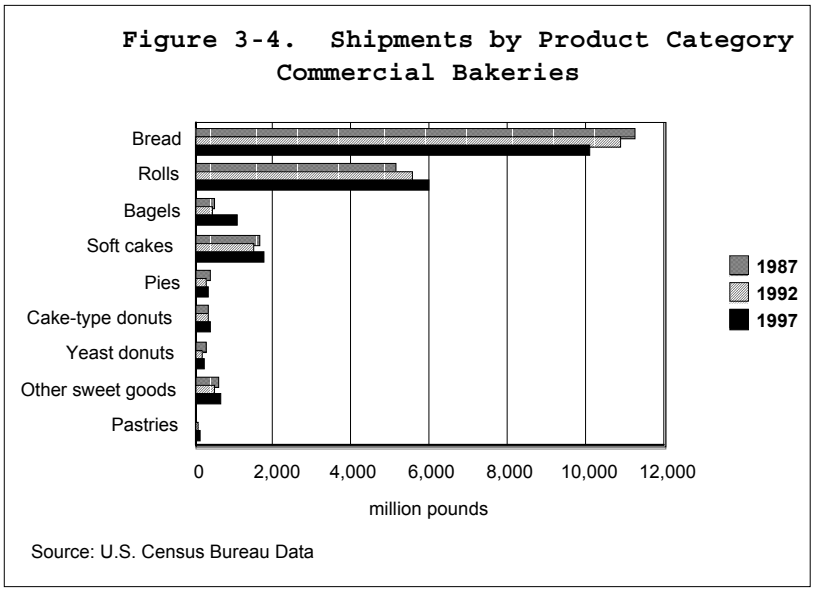
	1997		1992		1987
	mil lbs	change from 1992	mil lbs	change from 1987	mil lbs
White pan bread	5,882.8	1%	5,811.8	-10%	6,456.1
Whole wheat bread	1,645.6	-28%	2,290.5	1%	2,271.0
White hearth bread	1,587.5	-10%	1,769.5	29%	1,374.0
Rye bread	385.1	3%	375.0	-18%	459.0
Other variety bread	621.9	-5%	651.9	-11%	731.8
Bread, not specified	x		x		x
	10,122.9	-7%	10,898.7	-3%	11,291.9
Hamburger & wiener rolls	3,637.3	9%	3,350.3	7%	3,125.1
English muffins	410.7	8%	381.5	-8%	416.8
Hearth rolls	342.8	33%	257.3	-19%	319.3
Brown and serve rolls	335.7	3%	324.9	1%	320.7
Croissants	106.9	-18%	130.6	52%	86.1
Other rolls	580.4	2%	570.8	24%	461.2
Bread stuffing, croutons, crumbs	589.5	4%	565.2	41%	400.8
Rolls, not specified	x		x		x
	6,003.3	8%	5,580.6	9%	5,130.0
Bagels	1,108.6	143%	456.6	-13%	522.1
Soft cakes	1,746.1	17%	1,489.0	-10%	1,657.0
Pies	348.5	28%	272.7	-33%	406.5
Cake-type donuts	415.5	14%	363.5	1%	359.3
Yeast donuts	228.8	17%	195.7	-29%	277.5
Other sweet goods	680.6	39%	488.4	-19%	602.4
Other sweet goods, not specified	x		x		x
	1,324.9	26%	1,047.6	-15%	1,239.2
Pastries	148.9	95%	76.3		x
	20,803.2	5%	19,821.5	-2%	20,246.7
Not specified	x		x		x
	20,803.2		19,821.5		20,246.7

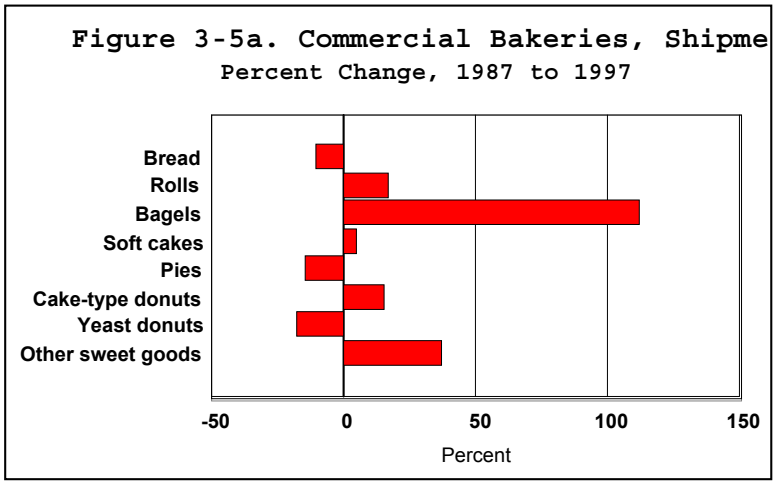
Source: U.S. Census Bureau Data

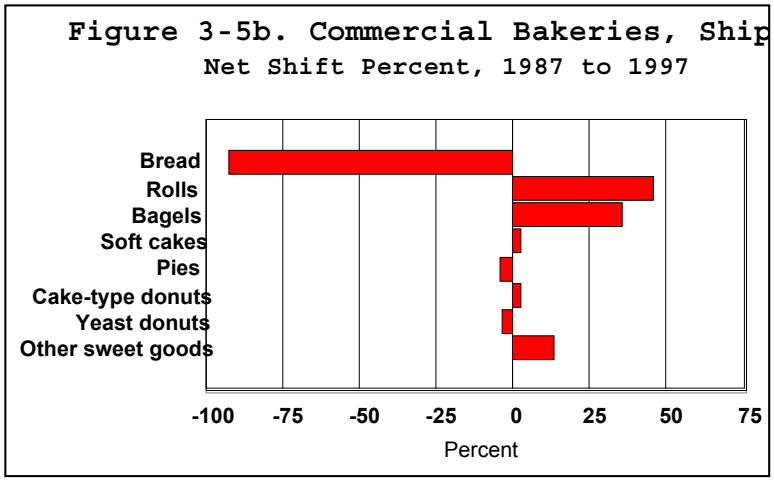
Table 3-3b. Commercial Bakeries: Value of Shipments

	1997		1992		1987
	mil $	change from 1992	mil $	change from 1987	mil $
White pan bread	3,586.9	24%	2,893.1	-4%	3,006.7
Whole wheat bread	1,312.8	0%	1,312.2	6%	1,240.6
White hearth bread	1,275.7	31%	973.0	39%	699.6
Rye bread	307.9	14%	270.9	-7%	291.2
Other variety bread	543.2	22%	447.0	-2%	457.7
Bread, not specified	134.3		87.8		98.9
	7,160.8	20%	5,983.9	3%	5,794.7
Hamburger & wiener rolls	2,406.0	21%	1,990.1	19%	1,677.3
English muffins	436.4	18%	370.2	39%	266.9
Hearth rolls	316.3	46%	216.3	29%	168.0
Brown and serve rolls	272.7	29%	210.8	-3%	218.3
Croissants	168.3	6%	159.4	114%	74.4
Other rolls	470.4	23%	381.8	28%	298.7
Bread stuffing, croutons, crumbs	299.4	-8%	326.8	53%	213.6
Rolls, not specified	53.7		26.1		26.4
	4,423.2	20%	3,681.5	25%	2,943.6
Bagels	853.2	140%	354.8	32%	268.4
Soft cakes	2,272.6	20%	1,888.2	7%	1770.3
Pies	544.4	31%	415.2	-5%	435.7
Cake-type donuts	578.5	16%	498.4	25%	399.7
Yeast donuts	308.6	94%	159.1	-39%	258.7
Other sweet goods	867.8	30%	668.0	-8%	722.7
Other sweet goods, not specified	26.0		12.5		13.3
	1,780.9	33%	1,337.9	-4%	1,394.4
Pastries	266.0	84%	144.9	377%	30.4
	17,301.1	25%	13,806.5	9%	12,637.5
Not specified	1,134.2		x		x
	18,435.3		13,806.5		12,637.5

Source: U.S. Census Bureau Data

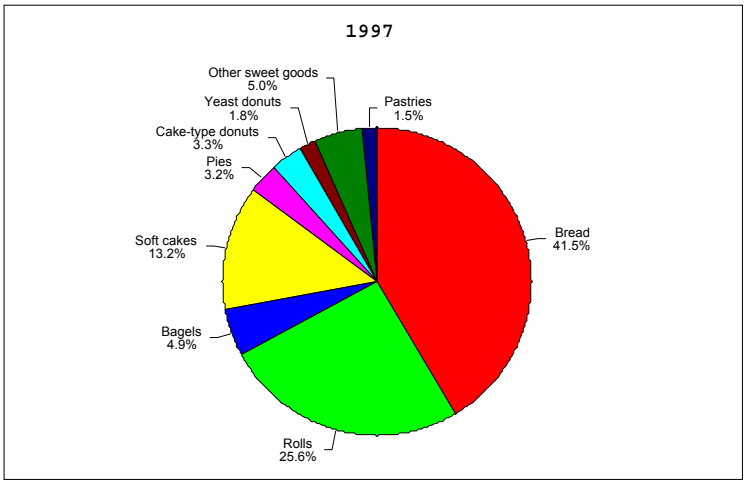


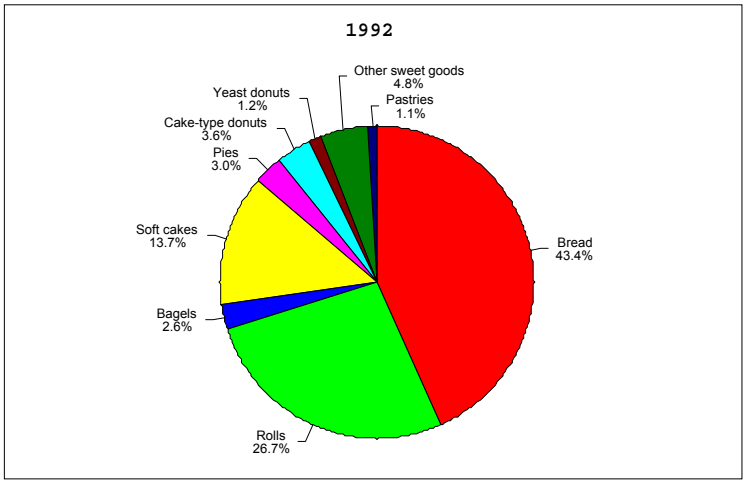


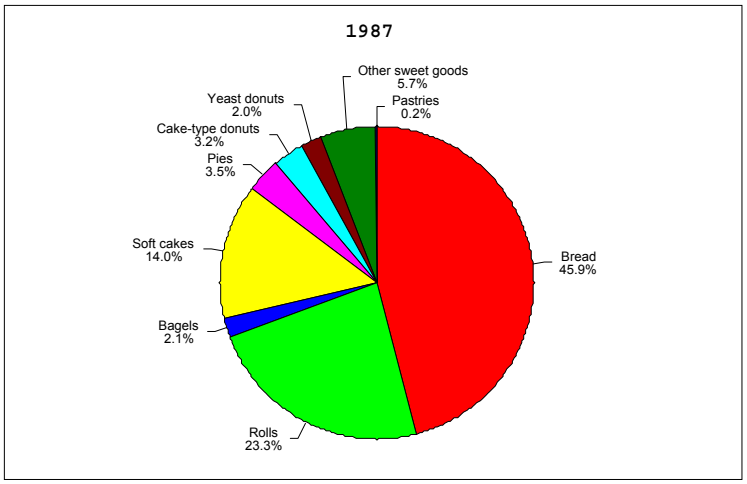


Source: U.S. Census Bureau Data

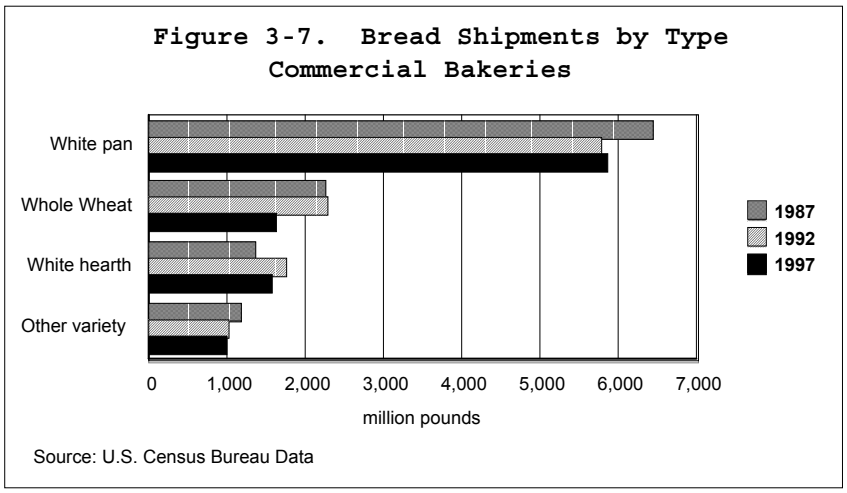
Figure 3-6. Commercial Bakeries, Percent of Shipments (based on value), by Product Category

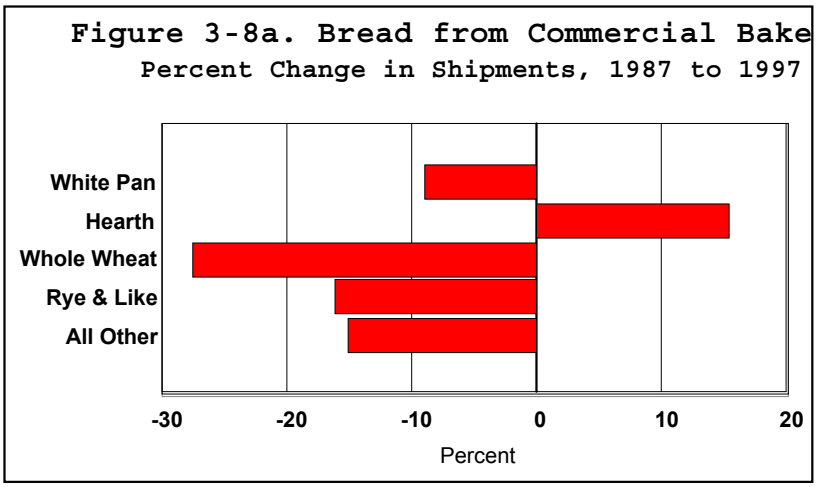


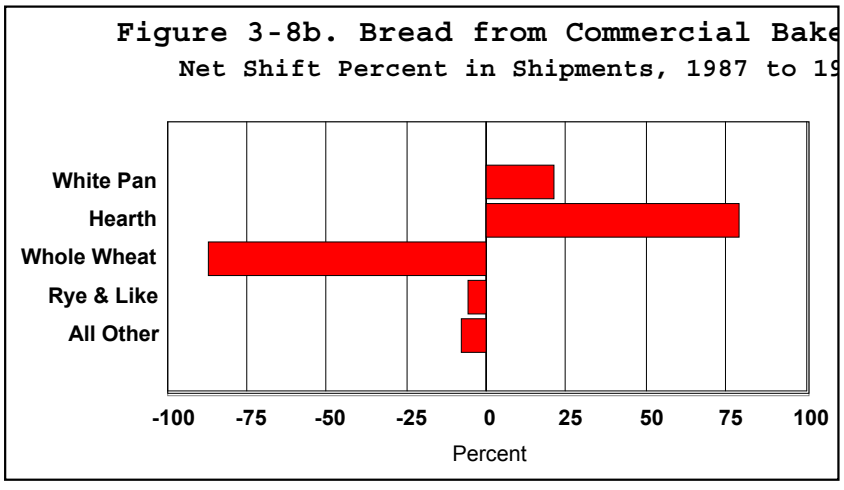




Source: U.S. Census Bureau Data

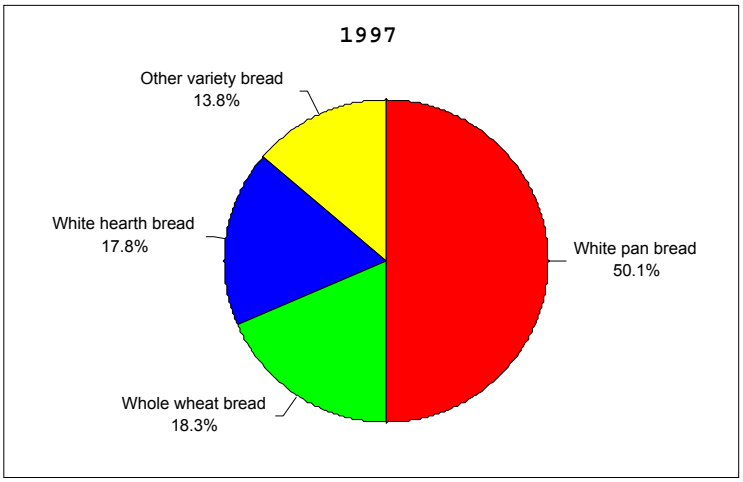


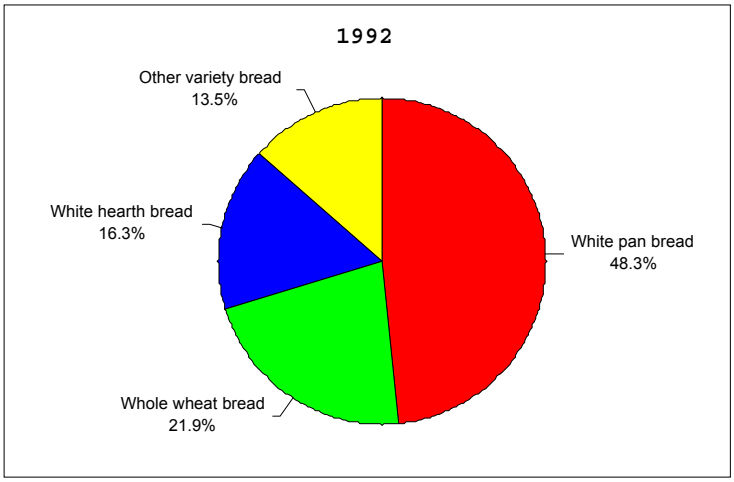


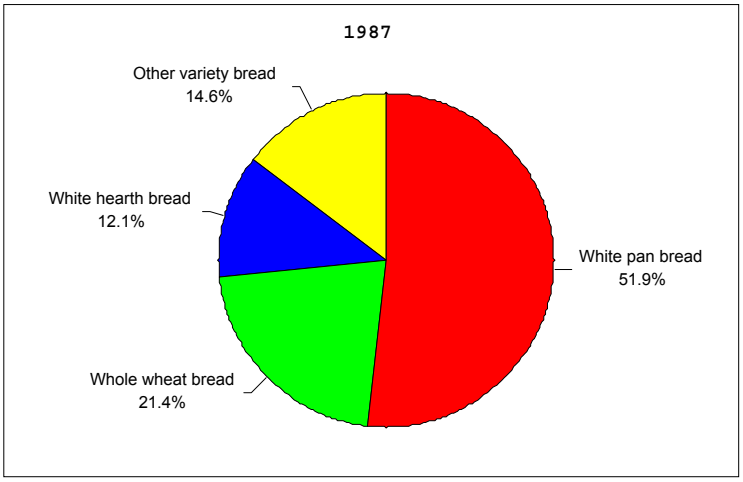


Source: U.S. Census Bureau Data

Figure 3-9. Bread Shipments from Commercial Bakeries, Percent of Shipments (based on value), by Product Category







Source: U.S. Census Bureau Data

Flatbread: One of the relatively new but growing segments of the grain-based foods industry is flatbreads - pita, focaccia, lavash, and tortillas, to name some of the "new" bread types. Flatbread describes bread that uses flour, water, salt, and little or no yeast. These unleavened breads are typically made from whole grain flours and are found in a variety of shapes, sizes, and flavors. The most popular application for flatbread in the United States is the wrap, fostered by the trend for convenience. They are flexible and versatile. Although starting from a relatively small base, the flatbread category is currently experiencing a growth rate of 14 percent per year (Cornell, 1999). With the exception of tortillas, however, most flatbread varieties have yet to hit the mainstream market.

Tortillas: Tortillas are one of the fastest growing sectors in the U.S. baking industry. Although originally considered an ethnic food popular with the Hispanics in the Southwestern United States, the popularity of tortillas is expanding at a much faster rate than the Hispanic population. While the Hispanic population in the United States grew 35 percent from 1990-1998, tortilla sales jumped 133 percent. Consumers in the eastern and southern states, although they eat considerably less Mexican food than people in other parts of the country, have accelerated their use of flour tortillas using the product as a bread substitute (MacDonnell).

Tortilla volume has increased 10 percent per year since 1980, fueled by the convenience trend and the popularity of the wrap as a delivery means for various hand-held foods. Nearly 60 percent of tortillas are consumed by non-Hispanics. Two-thirds of the tortilla product market is wheat flour; the other third is made from corn (Adams).

Flour Mixes and Doughs: The value of shipments of flour mixes and doughs increased by 30 percent from 1992 to 1997 based on the Economic Census reports (U.S. Census Bureau). The frozen doughs and batters segment within this category increased to 35 percent in 1997 from 30 percent in 1992, in part due to the growing popularity of frozen pizza and the increase in acceptance of frozen bread and bread-type rolls.

Frozen Pizza: Frozen pizza continues to be the fastest growing category in the grain-based foods industry. Capitalizing on the consumer interest for convenience, it shows no signs of slowing in popularity. The frozen pizza category is currently growing at around 8 percent per year.

Bagels: After enjoying a consumption increase of 187 percent in over the past 10 years, bagels have reached the status of a mature market. With the rapid expansion in the 1990s, the number of stores outgrew demand. The fresh and refrigerated bagel market is still growing, while the frozen bagel market is decreasing (Adams). While the growth in shipments of bagels increased significantly from 1987 to 1997, during the past ten years the number of new bagel stores outgrew demand contributing to Chapter 11 bankruptcy for a couple of major bagel store operator/franchisors.

4. END-USER SURVEY

4.1. Survey Objectives

Market response to the production of genetically modified wheat is an important factor that must be considered. Genetically altered wheat may be beneficial to producers, due to its advantageous production characteristics, but may not be desired by end-users. A survey of millers and bakers was conducted to determine what end-users want. The purpose of the survey was to better understand the demands of millers and bakers and to determine the marketability of genetically modified wheat.

Genetically modified crops can be beneficial to end-users, such as millers and bakers, and ultimately the consumer. Benefits may include improvements in processing and end-use characteristics such as greater water absorption, better crumb color, greater loaf volume, longer shelf life, etc. Other benefits of genetically modified crops in general, and for wheat specifically, could be improvements in the nutritional content and functional traits (e.g., pharmaceutical traits or other health factors) of the resulting food products.

Wheat producers may see their greatest benefit from biotechnology advances through agronomic factors such as increased yield and resistance to disease and chemicals. However, end-users, such as millers and bakers, will likely see little or no benefit from these factors. They may, in fact, be less willing to purchase wheat that has been genetically altered for these purposes because of consumer concerns regarding GMOs. One of the objectives of the survey is to determine the attitudes of millers and bakers regarding the use of wheat that has been genetically modified for improved production performance.

While millers and bakers may be hesitant to use wheat genetically modified for production purposes, they may be interested in wheat that has been genetically modified to improve end-use characteristics. One objective of the survey is to determine the attitudes of millers and bakers regarding wheat that has been genetically modified for this purpose.

Another objective is to determine which end-use characteristics are most important. The survey includes a list of 21 wheat quality characteristics and asks the survey participant to rate the importance of each characteristic. The results of this survey should be helpful in developing wheat with the most desired characteristics.

The survey asks participants to rate the importance of each quality characteristic and their willingness to pay a premium for wheat with an improved quality characteristic. While end-users may want more of a certain quality factor, they may not be willing to pay for it. Willingness to pay is important in determining whether wheat of improved quality can be sold at a premium. The survey also asks the end-user's degree of willingness to pay less or more for wheat that had been genetically modified for different purposes: improved yield, disease resistance, herbicide resistance, improved processing or end-use factors, functional traits, and nutritional factors.

4.2. Previous Survey

A previous survey conducted by Ag-Nomics Research and published by the Minnesota Association of Wheat Growers and the Minnesota Wheat Research & Promotion Council (1994) questioned end-users on flour quality. The overall objective of their study was to identify and define the key quality criteria for spring wheat flour in the domestic market so spring wheat growers could gain a better understanding of how bakers measure and assess flour quality. Ag-Nomics conducted phone interviews with 50 users of spring wheat flour including wholesale bakers, frozen dough manufacturers, mix manufacturers, pizza crust makers, bagel manufacturers, and bread and roll manufacturers.

Their results identified seven factors important to spring wheat flour users: consistency, protein levels, absorption, mixing tolerance, grain and texture, loaf volume, and ash. Of these factors, consistency, protein levels, and absorption were found to be most important. Mixing tolerance was also found to be very important for wholesale bakers and bagel manufacturers. Loaf volume was very important for frozen dough and mix manufacturers and for makers of bread and rolls. Their survey, like ours, asked participants to rate the importance of different quality characteristics. A difference between their survey and ours is that ours asked participants to rate the importance of price and their willingness to pay for each quality factor. In addition to baking companies, our survey was also sent to milling companies.

4.3. Wheat Quality Characteristics

The twenty wheat quality factors that respondents were asked to rate are shown in Table 4-1. Price is also included as an additional factor. Price and consistency are expected to be very important to millers and bakers for obvious reasons. End-users desire higher quality wheat, but willingness to pay for it will vary. Consistency is also very important to reduce uncertainty. It's quite possible that end-users may prefer slightly lower quality wheat if they know for certain what they are getting. Millers and bakers may be able to adapt to wheat/flour quality problems, but these adjustments take time and effort. Millers and bakers prefer not to make new adjustments every time they make a purchase. The other quality characteristics may need further explanation.

Flour Extraction: Flour extraction refers to the portion of the wheat kernel that can be milled into flour, which is also called flour yield. This factor is important to millers.

Test Weight: Test weight is expected to be important to millers. Wheat of greater test weight tends to have higher levels of flour extraction, though this may not always be the case.

Protein: Protein is often viewed as a key quality factor for millers and bakers. Protein levels are often directly related to other quality factors, such as loaf volume and water absorption (Tipples, Kilborn, and Preston).

Water Absorption: Water absorption is a very important factor for bakers. It is the amount of water that can be added to flour to make dough. If water absorption is high, which is preferred, bakers can make more dough from a given quantity of flour.

Table 4-1. Wheat Quality Factors

Price
Consistency
Flour Extraction
Test Weight
Protein
Water Absorption
Ash
Flour Color
Moisture
Falling Number
Amylograph
Arrival Time
Peak Mix Time
Dough Stability
Mechanical Tolerance Index
Time to Breakdown
Peak Height
Peak Time
Width at 8 Min
Peak Viscosity
End Viscosity

Ash: Ash content is a measure of milling efficiency. Ash content relates to color; breads made from flour with a low ash content tend to be whiter. The flour also tends to be more refined (North Dakota Wheat Commission).

Flour Color: Flour color is important to bakers who prefer a whiter end-product.

Moisture: Moisture is important for economic reasons. Millers and bakers do not want to purchase wheat or flour with high moisture content because they are paying for water. Dry wheat also stores better.

Falling Number and Amylograph: Both of these factors measure soundness, the level of alpha-amylase activity in wheat or flour. Alpha-amylase is an enzyme needed to obtain ideal loaf volume, but too much can result in low water absorption, sticky dough, and sticky bread crumb (Tipples, Kilborn, and Preston).

Farinograph Analysis: The farinograph is commonly used to measure dough quality. The farinograph measures the length of time required to mix dough to a definite consistency and the dough's tolerance to overmixing. Bakers prefer a relatively short mixing time and high mixing tolerance. The farinograph is also a measure of gluten strength. Five farinograph measures are included in the survey: arrival time, peak time (mixing time), dough stability, mechanical tolerance index (mti), and time to breakdown. These measures are expected to be important to bakers and also millers trying to provide bakers with a desirable product (North Dakota Wheat Commission).

Mixograph Analysis: The mixograph is similar to the farinograph, measuring some of the same factors of dough quality. The mixograph measures used in the survey are peak height, peak time, and width at eight minutes.

RVA Analysis: The Rapid Visco Analyzer (RVA) is used to measure peak viscosity, which measures the level of sprouting and amylase activity and end viscosity. The results of the RVA analysis are correlated with product quality measures, such as crust color and rolling ability, in tortillas and different flat breads (Newport Scientific).

Other End-use Characteristics: Characteristics of the end-product, such as loaf volume, crumb color, crumb grain, and crumb texture, are factors that most concern the baker. These factors are not included in the survey because they are directly influenced by many of the factors that are included, such as protein content, water absorption, flour color, soundness, and the farinograph results.

4.4. Survey Method

A listing of millers and bakers was obtained from two sources, the Wheat Quality Council *Member Directory* and the *Bakery Production and Marketing Red Book, 1999*. A list of the top millers and bakers in the United States was developed. Each company was contacted by phone, first to determine the correct person in the organization most qualified to complete the survey, and then to determine willingness to participate. Once the contact person gave some willingness to look at the survey, it was faxed or e-mailed to them. In a few cases, surveys were sent without having spoken directly to the person. The survey was sent to a total of 38 companies. Fourteen surveys were returned, eight from milling companies and six from baking companies. A copy of the survey is shown as Appendix C.

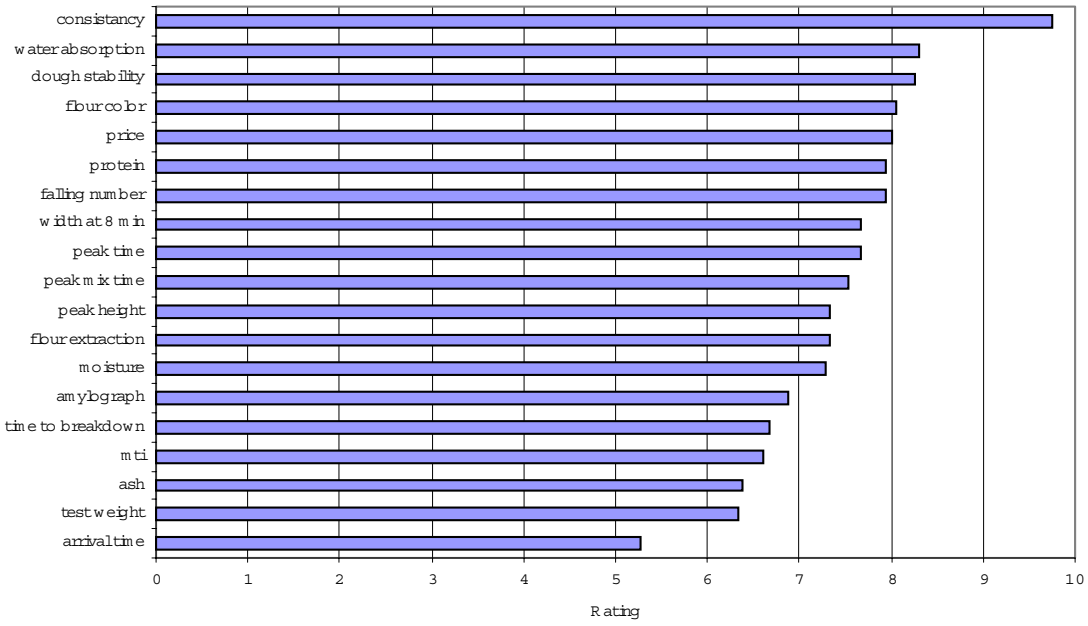
4.5. Survey Results

Wheat Quality Factors

First, millers and bakers are asked to rate the importance of wheat quality factors. The question asks survey participants to rate the importance of each factor on a scale of 1 - 10 (1 = low importance, 10 = high importance), or mark it with an X if it is not measured or considered important. The survey asks the companies to give different ratings for each of their top products because a company may view a certain quality characteristic as important for one of their products, but not for another. Because some companies give more than once response, there are a total of twenty responses regarding the importance of quality factors, ten from milling companies and ten from baking companies.

Results demonstrate the importance of consistency. Nearly every company indicated that consistency is an important factor, more important than price. Most firms seem to be willing to pay more to ensure consistent quality. Figure 4-1 shows the average response for each factor. Peak viscosity and end viscosity are not included because no company considered these factors important. Mixograph analysis is also seldom used. Only three companies indicated that they monitor peak height, peak time, or width at eight minutes.

Figure 4-1 Wheat Quality Factor Ratings



Consistency (9.75) is rated as most important and is given a rating on all twenty responses. Water absorption (8.29), dough stability (8.27), and flour color (8.06), are rated as the next three most important factors by those that monitor these factors. The average rating for these factors is higher than the rating for price (8.0), which may indicate that these firms are willing to pay a premium for wheat with higher quality water absorption, dough stability, or flour color. Price, though, has a higher weighted average rating. Seventeen of the respondents consider water absorption important, 15 consider dough stability important, and 16 consider flour color important. All twenty respondents consider price an important factor.

Companies did not rate factors they do not monitor. Not all factors, therefore, have the same number of responses. Figure 4-2 shows the weighted average response, which is the average response multiplied by the percent of respondents that gave a rating for that particular factor. Of the factors other than consistency and price, protein is the most widely monitored quality factor. All twenty respondents consider protein important. With an average rating of 7.95, protein is considered to be almost as important as price. Falling number is also an important factor, with an average rating of 7.94 and a weighted average rating of 7.15.

Figure 4-2 Factor Ratings, Weighted Average

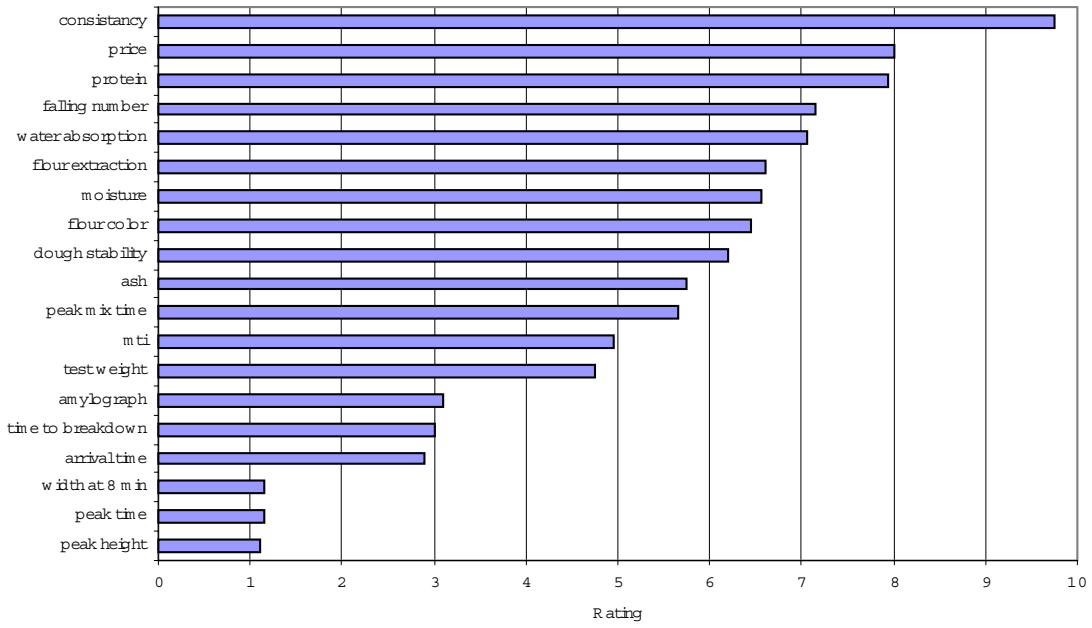


Table 4-2 shows the number of respondents that consider each factor important. The first column shows the number of respondents that monitor each factor. The second and third columns show how many of those are bakers and how many are millers. Figure 4-3 shows the average rating given by bakers and the average rating given by millers. Consistency, price, and protein are of high importance to both millers and bakers. Millers place a high degree of importance on flour extraction, whereas bakers do not. Bakers consider falling number important, as do millers, but to a greater degree. Both millers and bakers consider water absorption and dough stability important. Flour color is also important, especially for bakers. Only three baking companies monitor time to breakdown, but those that do, consider it very important. These results suggest that bakers may be willing to pay more for consistency, higher protein, better falling number, higher water absorption, whiter flour color, or better dough stability. Milling companies may be willing to pay more for consistency, higher flour extraction, and better water absorption.

Correlations are calculated between the ratings that the respondents gave for the different quality factors to determine if companies that value a certain quality characteristic also tend to value another characteristic. These correlations are shown in Table 4-3. The ratings for flour extraction and test weight are highly correlated, indicating that companies that value high flour extraction also value test weight. This result is expected because flour extraction and test weight are both valued by millers, but not bakers. Companies that consider moisture important also consider falling number, arrival time, and peak mix time important. The ratings for flour color and test weight are negatively correlated. Bakers consider flour color important but have little interest in test weight.

Table 4-2. Total Responses by Baking and Milling Companies

Factor	Total	Baking	Milling
Consistency	20	10	10
Price	20	10	10
Protein	20	10	10
Falling Number	18	8	10
Flour Extraction	18	9	9
Moisture	18	9	9
Ash	18	10	8
Water Absorption	17	8	9
Flour Color	16	9	7
Dough Stability	15	7	8
Mechanical Tolerance Index	15	7	8
Test Weight	15	5	10
Peak Mix Time	15	7	8
Arrival Time	11	5	6
Amylograph	9	4	5
Time to Breakdown	9	3	6
Peak Time	3	1	2
Width at 8 Min	3	1	2

Figure 4-3 Average Ratings by Millers and Bakers

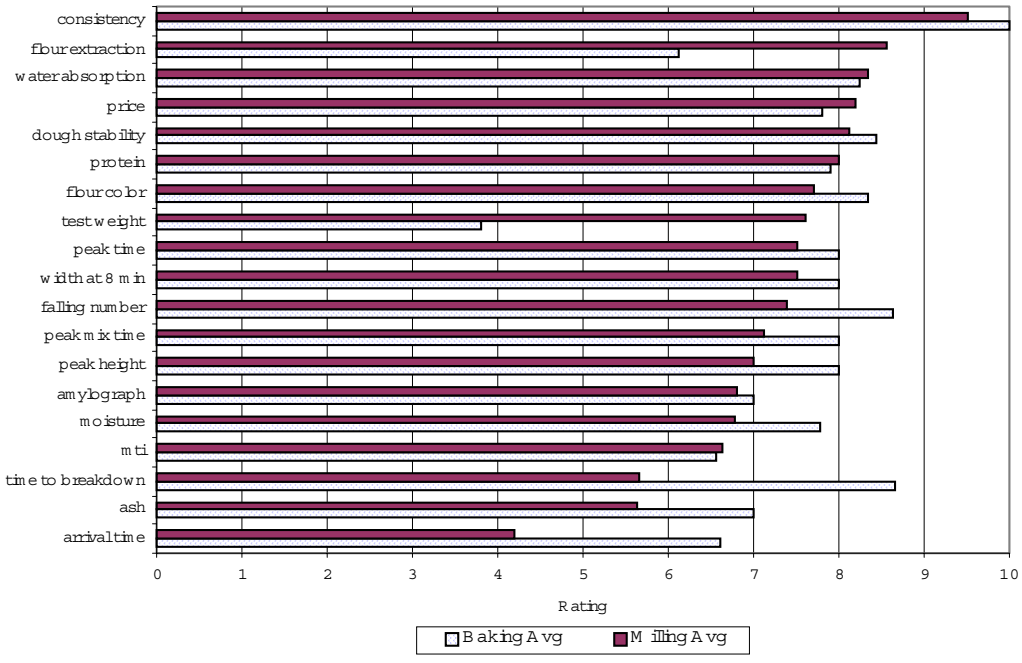


Table 4-3. Correlations of Factor Ratings

	price	consis-tency	flour extrac-tion	test weight	protein	water absorp-tion	ash	flour color	mois-ture	falling number	arrival time	peak mix time	dough stability
price													
consistency	-0.21												
flour extraction	0.41	-0.17											
test weight	0.55	-0.10	0.79										
protein	0.48	-0.15	0.61	0.49									
water absorption	-0.18	-0.07	-0.14	-0.51	-0.18								
ash	0.24	0.00	0.26	0.24	0.27	-0.31							
flour color	-0.23	0.25	0.20	-0.65	-0.17	0.26	-0.20						
moisture	0.13	0.48	0.19	0.31	0.25	-0.41	0.33	0.17					
falling number	0.04	0.36	-0.31	-0.03	-0.07	-0.36	0.39	-0.04	0.85				
arrival time	0.13	0.34	0.26	0.39	0.38	-0.06	0.16	0.13	0.76	0.43			
peak mix time	0.12	0.46	0.00	0.19	0.30	-0.09	0.11	-0.18	0.78	0.55	0.72		
dough stability	-0.08	0.12	-0.47	-0.17	-0.30	-0.16	0.29	-0.26	-0.20	0.17	-0.36	-0.18	
mechanical tolerance	0.05	0.24	0.02	0.70	0.23	-0.51	0.40	-0.59	0.55	0.41	0.57	0.58	0.23

An additional question is asked of survey participants regarding their company's willingness to pay more for a certain factor of better quality than their current requirement. This question asks participants to rate on a scale from 0-3 the degree of value received or the willingness to pay for quality greater than the current requirement (0 signifies no value for quality greater than the current requirement and 3 signifies high value).

The number of responses to this question is not as great, so interpretation is difficult. Table 4-4 shows the average response for this question for each quality factor. It also indicates the number of responses given by bakers and millers and the averages for each. The quality characteristics that these firms are most willing to pay for are flour extraction, test weight, protein content, and water absorption. Millers are most willing to pay for higher protein content and greater flour extraction, while bakers are most willing to pay for increased water absorption.

Attitudes Towards GM Wheat

The second part of the survey asks questions regarding the attitudes of milling and baking companies towards the use of genetically modified wheat. Companies are asked if they would be more likely, indifferent, or less likely to purchase wheat genetically modified to enhance only production characteristics. Most indicate they would be less likely or indifferent, as expected. Of the fourteen responses to this question, eight indicate indifference toward purchasing wheat genetically modified solely to enhance production characteristics. Five companies indicate they would be less likely to purchase such wheat.

The second question asks if the company would purchase wheat genetically modified to improve processing or end-use performance. All but one of the fourteen respondents indicate that they would purchase genetically modified wheat with improved processing or end-use performance. One of the respondents qualified the answer, saying purchases depend on customer acceptance.

Table 4-4. Willingness to Pay for Improved Quality

Factor	Average response			Number of responses	
	Total	Bakers	Millers	Bakers	Millers
Flour extraction	1.30	1.00	1.43	3	7
Protein	1.27	0.67	1.50	3	8
Test Weight	1.22	1.00	1.29	2	7
Water absorption	1.11	1.33	1.00	3	6
Peak mix time	1.00	0.33	1.33	3	6
Dough stability	1.00	0.33	1.33	3	6
Amylograph	0.83	1.00	0.75	2	4
Flour color	0.80	0.67	1.00	3	2
Mechanical tolerance index	0.78	0.33	1.00	3	6
Falling number	0.73	0.67	0.75	3	8
Time to breakdown	0.67	0.00	1.00	2	4
Moisture	0.50	0.33	0.57	3	7
Arrival time	0.42	0.33	0.50	3	4
Ash	0.33	0.33	0.33	3	6

Customer concerns are important for milling and baking companies. Question No. 5 asks if opposition to buying genetically modified wheat/flour is due to customer concerns or the company's own concerns. Seven companies indicate opposition due to opposition or concern from their customers. One company indicates that opposition is due to the company's own concerns about genetically modified wheat. The remaining firms indicate no opposition to buying genetically modified wheat.

Question No. 4 asks survey participants to give their acceptable tolerance level of genetically modified wheat. Since many firms indicate some willingness to purchase genetically modified wheat, this question seeks to find if these companies have a limit of how much GM wheat they would allow. Twelve responses were obtained for this question. Six respondents indicate they would be willing to accept more than 40 percent genetically modified wheat. One respondent, though, qualified this answer by saying their company will accept this level of GM wheat only if it is acceptable to the customers. Another firm qualified the answer saying that more than 40 percent GM wheat is acceptable only if enhanced end-use performance is available. Two respondents indicate they will not accept any GM wheat/flour. One of these two respondents is a baking company that states that the company would not be willing to accept any genetically modified wheat/flour based on current consumer attitudes and preferences. This respondent indicates that this attitude is subject to change as the benefits to the consumer are shown and acceptance is gained.

Question No. 8 asks survey participants which potential characteristics or factors they think would be of most interest in wheat biotechnology in the future. They are asked to rate their degree of interest on a scale of 1 - 5 (1 is the lowest degree of interest and 5 is the highest degree of interest) for five characteristics of wheat biotechnology: improved yield, disease resistance, herbicide resistance, improved processing or end-use factors, functional traits (e.g., pharmaceutical or other health factors), and improved nutritional content. The results of this question are shown in Table 4-5. Processing and end-use factors are of most interest to millers

and bakers, followed by GM wheat with functional traits. Improved yield and herbicide resistance are least interesting to these companies, though there still is some interest.

Table 4-5. Interest in Biotechnology Traits

Trait	Degree of Interest	Willingness to Pay
Yield	3.50	-0.43
Disease resistance	3.93	0.14
Herbicide resistance	3.54	0.00
Processing or end-use Factors	4.50	1.14
Functional traits	4.14	1.21
Nutritional	3.71	0.64

The next part of the question asks survey participants to indicate their willingness to pay for each factor. Willingness to pay is indicated on a scale of -2 to 2, where a negative number indicates they would pay less, a positive number indicates willingness to pay more, and 0 indicates no effect on how much they are willing to pay. These results show that millers and bakers are willing to pay more for wheat that has been genetically modified to include functional traits or to enhance processing or end-use factors. Some companies are also willing to pay more for wheat with higher nutritional value. Genetic modification for disease or herbicide resistance has little effect on companies' willingness to pay. They would not pay a premium, but would also not ask for a discount. Some firms, however, would discount the value of wheat genetically modified to improve yield. These results show that genetic modification to improve end-use characteristics would more likely be accepted by millers and bakers than genetic modification to improve production characteristics.

Identity Preservation

Identity preservation is an important issue regarding genetically modified crops. Question No. 3 asks the milling and baking companies if they need to know if the wheat/flour they purchase is genetically modified. Of the fourteen responses, twelve indicate that they need to know. One company indicates that it is a customer requirement.

The sixth question relates to identity preservation. It asks for the percentage of their wheat/flour that they think will be identity-preserved sourced in five years, and in ten years. The second part of the question asks if they think wheat/flour should be identity preserved by variety and/or geographic region. Responses to this question varied considerably, indicating no majority opinion. One respondent, a user of strictly spring wheat, thought that 100 percent of their wheat would be identity preserved in five years. Other respondents thought that as little as 2 percent or 5 percent will be identity preserved in five years. The average response is slightly under one third. These companies do expect the identity preservation trend to continue long-term. The average response regarding the expected percentage of identity preserved wheat ten years from now is slightly over 50 percent.

There is also some variation in responses to the second part of the question, whether they think wheat should be identity preserved by variety and/or geographic region. Nine of the twelve responses to this question said wheat should be identity preserved by variety. Eight of the twelve think it should be identity preserved by geographic region. One milling company comments that identity preservation is most important by specific trait.

Product Growth

The survey also asks participants a question regarding projected product demand growth. The results of this question indicate where product demand is growing or declining, which is important when determining which quality characteristics of wheat are important. Question No. 9 asks millers and bakers how they foresee the growth (or decline) in consumption of a number of wheat-based products in the next 5 to 10 years. The wheat-based products included in the survey are bakery products (white pan bread, buns, rolls), specialty products (hearth breads, variety breads, hard rolls, multigrain products), bagels, frozen dough, par-baked products, pizza crust, and tortillas.

Bakery products such as white pan bread, buns, and rolls are not expected to have very much growth, and may experience decline. Of the fourteen respondents, six predict a decline in demand for these products, three predict no change, and five predict small growth. Specialty products such as hearth breads, variety breads, hard rolls, and multigrain products are expected to have high growth rates. All but one response, which predicted no change in demand, predict growth in these product markets. Some predict high growth rates in these markets, as high as 20 percent in the next 5 to 10 years. Growth is also expected in the frozen dough, par-baked, pizza crust, and tortilla markets. Most respondents predict positive growth in these markets, some predict high growth. The bagel market, on the other hand, is not expected to experience much growth. Many of the respondents predict decline in the bagel market.

The results of this question suggest that the greatest product market growth is likely for specialty products, frozen dough, par-baked products, pizza crust, and tortillas, while growth is stagnate or in decline for white pan bread, buns, rolls, and bagels. Specialty/variety breads, hearth breads, hard rolls, and multigrain products are likely growing in popularity at the expense of white pan bread due to change in consumer preferences.

5. CONCLUSIONS

5.1. Summary

Key opportunities for GM developments in wheat center around improvements that meet consumer and end-user needs/issues. Functional foods that focus on health issues are a hot consumer topic with a growing interest and demand. Focus on nutritionally fortified ingredients and ingredients that enhance convenience, freshness, storeability, etc. provide excellent opportunities for acceptance of GM wheat. Since GM wheat varieties are not yet commercially available there are opportunities for first stage biotechnology developments focusing on the output side of the wheat industry. Globally there are opportunities for development of wheat varieties that demonstrate resistance or improved tolerance to environmental stresses (drought, heat, frost, salt, acid soils, etc.).

These output traits which address consumer interests must be accompanied by producer benefits or price premiums sufficient to offset the market risks to growers before they can be expected to grow GM wheat. Avoidance of the mistakes evident in the introduction of other GM crops is the major challenge facing the introduction and acceptance of GM wheat. Introduction of first stage traits that benefit producers with little direct benefit to consumers and without an understanding of consumer concerns and market acceptance have impacted and slowed the acceptance of GM crops.

Developers and proponents of GM wheat must focus on education of consumers and restoration of worldwide confidence in the U.S. regulatory process. The U.S. and worldwide grain handling infrastructure must be enhanced to efficiently and effectively handle segregation of grains for traceability and preservation of trait and qualities of interest.

Another significant challenge to the introduction and acceptance of products utilizing GM ingredients is the pressure in many parts of the world and the United States for more stringent labeling requirements. The significant costs associated with additional labeling requirements will impact the introduction and acceptance of products with GM ingredients.

5.2. Major Trends in Wheat Product Consumption

Convenience, health benefits, and ethnicity are among the trends identified as the key drivers in grain-based food consumption. Shifts in consumer lifestyles are influencing eating and purchasing habits in all food sectors. Convenience is one of the most significant trends. In the grain-based foods area, this trend fosters strong growth in hand-held foods, renewed interest in frozen bakery items, and the prevalence of convenience stores to serve the busy on-the-go consumer. The hottest trend in the food industry is the demand for products with supplementary health benefits. Foods promoted specifically for their heath or medicinal properties, referred to as functional foods or nutraceuticals, are the fastest growing segment of today's food industry.

Per capita flour consumption in the United States reached a peak of 149.5 pounds in 1997 but declined the next two years, dropping to 144.0 pounds in 1999. Categories currently growing the fastest are frozen pizza and tortillas, both benefitting from the demand for convenient, fast foods. The bagel category grew rapidly during the 1990s but has reached the status of a mature market. In the bread category there has been a decline in the traditional pan

bread market and the emergence of an upscale bread market. Variety and hearth breads have grown at a faster rate than the overall bread category.

5.3. Summary of Survey Results

Consistency is the most desired wheat quality trait among millers and bakers. Most firms seem to be willing to pay more to ensure consistent quality. Water absorption, dough stability, and flour color, are rated as the next most important factors by those that monitor these factors. Protein is the most widely monitored quality factor and is considered almost as important as price. Falling number is also important. Consistency, price, and protein are of high importance to both millers and bakers. Millers place a high degree of importance on flour extraction. Bakers consider falling number important, as do millers, but to a greater degree. Both millers and bakers consider water absorption and dough stability important. Flour color is also important, especially for bakers. Millers are most willing to pay for higher protein content and greater flour extraction, while bakers are most willing to pay for increased water absorption.

Results show that genetic modification to improve end-use characteristics will more likely be accepted than genetic modification to improve production characteristics. A majority of the companies said that they are indifferent towards purchasing wheat/flour that has been genetically modified to improve agronomic characteristics, but a significant percentage of the respondents said they would be less willing to buy such wheat/flour. Unwillingness by millers and bakers to purchase GM wheat is due mostly to consumer concerns. Almost all of the companies that responded to the survey said they would be willing to purchase wheat/flour genetically modified for end-use characteristics. This attitude is probably a result of companies believing that consumers will more likely accept GM food if there is a direct benefit to the consumer, such as better quality or increased nutritional content.

Identity preservation is considered important by most companies, and a majority of respondents think wheat should be identity preserved by both variety and geographic region. Projections for the degree of identity preservation in the near future is varied. Respondents project that the greatest product growth market is likely for specialty products, frozen dough, par-baked products, pizza crust, and tortillas, while growth will likely stagnate or decline for white pan bread, buns, rolls, and bagels.

5.4. Recommendations

There is currently a high level of consumer interest in foods that are healthy and nutritious. Functional foods that are nutritionally enhanced naturally or offer non-drug alternatives that reduce the risk of diseases are of special interest to consumers. Efforts might be focused on wheat with naturally higher levels of essential vitamins and other nutrients. Health benefits of interest include non-drug alternatives to help lower blood cholesterol levels and control blood sugar levels in people with diabetes. Clearly defined benefits to the consumer are essential for consumer acceptance of food biotechnology.

Producers may also benefit from GM wheat with enhanced end-use characteristics by realizing premiums from millers. Consistency, protein content, flour extraction rates, and water absorption are characteristics of interest to millers and bakers. They may offer a premium for

these traits, but they are not willing to pay more for wheat or flour that has been genetically modified to benefit only the producer. They may, in fact, discount or even refuse to accept such a product, because of consumer concerns. Traits that enhance the freshness of the end-use product and increase the storeability of the products are also of interest to the processors and the consumer.

It is important to pay special attention to the demands of the producers, processors, and consumers of the higher growth rate products such as frozen dough, par-baked products, pizza crusts, tortillas, and specialty bread products. Attention needs to be focused on developing wheat with characteristics that meet the interests and needs of the higher growth markets.

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3118D Cookie and Cracker Manufacturing (11/29/99)
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APPENDIX A

CWB Biotechnology Position Statement

April 4, 2001

The CWB respects the right and desire of consumers to have confidence in the food products they purchase and consume. The CWB acknowledges the concerns that many CWB customers express in relation to food ingredients that are the result of modern biotechnology. The CWB also recognizes the potential benefits that biotechnology may provide to consumers and to wheat and barley farmers in western Canada.

The CWB's objective is to ensure that the introduction of genetically modified wheat and barley varieties for production, handling and marketing be accomplished in a manner that will satisfy customers' requirements and result in net financial and other benefits to western Canadian farmers.

There are currently no transgenic varieties of wheat or barley registered for commercial production anywhere in the world. The earliest any transgenic wheat variety could be considered for registration in Canada is 2003 or later.

In addition to rigorous assessment of health and environmental safety issues and tests of functional and agronomic properties to which all proposed varieties are routinely subjected, the CWB believes potential market impact and the status of segregation capability must be considered before new transgenic wheat or barley varieties become available for production in Canada. Measures must also be implemented to prevent the importation of transgenic wheat and barley varieties into Canada for production and/or marketing until they are approved for production in Canada.

The key of the CWB's position is that transgenic wheat and barley varieties should not be available for production in western Canada until proven technologies and associated protocols and procedures are in place to efficiently and effectively segregate transgenic from non-transgenic varieties in order to satisfy customer requirements, including, where necessary, guarantees that shipments meet agreed-upon maximum levels of transgenic varieties.

The CWB is committed to supporting research into the development of required detection technologies through the Automated Quality Testing (AQT) initiative. This technology will be needed to support an effective and accountable system of quality assurance in order for the CWB to meet its commitment to supply customers the food ingredients they are asking for.

The CWB is also committed to working with its customers and through domestic and international forums to assure established regulations and agreements support sound commercial practices for the marketing of transgenic and non-transgenic wheat and barley.

Source: Canadian Wheat Board, http://www.cwb.ca (accessed July 2, 2001).

APPENDIX B

Biotechnology
U.S. Wheat Industry Position Statement on Biotechnology

BIOTECHNOLOGY POSITION STATEMENT

adopted by
U.S. Wheat Associates
National Association of Wheat Growers
Wheat Export Trade Education Committee

Biotechnological research holds great promise for the future, and the U.S. wheat industry recognizes these advancements. In preparation for the future commercialization of biotechnologically-derived wheat, we take the following positions:

1. The U.S. wheat industry commits itself absolutely to the principle that our customers' needs and preferences are the most important consideration. We support the ability of our wheat customers to make purchases on the basis of specific traits.

2. We will work with all segments of the industry to develop and assure that a viable identity preservation system and testing program is instituted prior to commercialization of products of biotechnology. We strongly urge technology providers to obtain international regulatory approval and to ensure customer acceptance prior to commercialization.

3. We urge the adoption of a nationally and internationally accepted definition of biotechnologically-derived products.* We also urge international harmonization of scientific standards and trade rules.

4. We support voluntary labeling of food products, provided it is consistent with U.S. law and international trade agreements and is truthful and not misleading. We oppose government-mandated labeling of wheat products in both the U.S. and international markets based upon the presence or absence of biotechnologically-derived traits that do not differ significantly from their conventional counterpart.

5. We support the establishment of a reasonable threshold level for adventitious or accidental inclusion of biotechnologically-derived traits in bulk wheat or wheat food products in both U.S. and international markets.

6. We invite valued and interested customers to join with us in a working partnership to explore the emerging biotechnology industry.

***U.S. wheat industry definition of biotechnologically-derived (genetically modified) organisms:** Genetically modified organisms (commonly referred to as "transgenic") are organisms derived from somatic cell fusion or direct insertion of a gene construct, typically but not necessarily from a sexually-incompatible species, using recombinant DNA techniques and any genetic transformation technology (e.g., bacterial vectors, particle bombardment, electroporation).

[1, 2, 3, 6] Adopted by: USW Board of Directors on 6/27/00; NAWG Board of Directors on 10/17/00; WETEC Board of Directors on 6/25/00.
[4, 5] Adopted by: USW Board of Directors on 1/30/01; NAWG Board of Directors on 2/03/01; WETEC Board of Directors on 1/29/01.

Source: U.S. Wheat Associates, http://www.uswheat.org (accessed July 2, 2001).

APPENDIX C

Wheat End-User Survey

Company name / Contact _____

Location _____

Total Hard Wheat used _____

Percent of Hard Wheat that is Hard Red Spring _____

Title / area of responsibility of person filling out the survey_____

[FOR BAKERS ONLY]

Types of products: indicate the approximate percentage of production that is contributed by each product and the approximate percentage of flour for each product that comes from HRS wheat.

Product	Percent of Total Production		Percent HRS
Bakery Products (white pan bread, buns, rolls)			
Specialty Products (hearth breads, variety breads, hard rolls, multigrain products)			
Bagels			
Frozen Dough			
Par-baked			
Pizza Crust			
Tortillas			
Other			

Description of following table

Column 1: List of quality factors.

Column 2: Rate the importance of each factor on a scale from 1 - 10 (1 = low importance, 10 = high importance), or mark it with an X if it is not measured or considered important.

Column 3: List your current requirement for each quality factor that you monitor or consider important. Indicate if it is a minimum or maximum requirement.

Column 4: Rate on a scale from 0 - 3 the degree of value received or the willingness to pay for quality greater than the current requirement, where 0 signifies no value for quality greater than the current requirement and 3 signifies the most value.

Fill out this table for your each of your top three products.

Product_____

Quality Factor	Importance (1=low, 10=high, X=not measured)	Current Requirement	Value if better than requirement
price			
consistency			
flour extraction (%)			0 1 2 3
test weight (lbs/bushel)			0 1 2 3
protein (%)			0 1 2 3
water absorption (14% mb)			0 1 2 3
ash (14% mb)			0 1 2 3
flour color (L-value)			0 1 2 3
moisture (%)			0 1 2 3
falling number (seconds)			0 1 2 3
amylograph (bu)			0 1 2 3
Farinograph analysis			
- arrival time (minutes)			0 1 2 3
- peak mix time (minutes)			0 1 2 3
- dough stability (minutes)			0 1 2 3
- mechanical tolerance index (bu)			0 1 2 3
- time to breakdown (minutes)			0 1 2 3
Mixograph analysis			
- peak height (%)			0 1 2 3
- peak time (minutes)			0 1 2 3
- width at 8 min (%)			0 1 2 3
RVA analysis			
- Peak Viscosity			0 1 2 3
- End Viscosity			0 1 2 3
Other:			0 1 2 3

1. Would your company be more or less likely to purchase wheat or flour from wheat that was genetically modified to enhance production characteristics but had no effect on end-use quality, or would you be indifferent?

   Less likely Indifferent More likely

2. Would your company purchase wheat or flour from wheat that was genetically modified to improve processing or end-use performance?

   Yes No

3. Is it in your interest to know whether what you purchase is genetically modified?

   Yes No

		Degree of Interest					Willingness				
		Low	Moderate			High	to pay				
	Yield	1	2	3	4	5	-2	-1	0	1	2
	Disease Resistance	1	2	3	4	5	-2	-1	0	1	2
	Herbicide Resistance	1	2	3	4	5	-2	-1	0	1	2
	Processing or End-use Factors	1	2	3	4	5	-2	-1	0	1	2
	Functional Traits(1)	1	2	3	4	5	-2	-1	0	1	2
	Nutritional	1	2	3	4	5	-2	-1	0	1	2
	Other:_____	1	2	3	4	5	-2	-1	0	1	2
	Other:_____	1	2	3	4	5	-2	-1	0	1	2
(1) Pharmaceutical or other health factors											

4. What is your acceptable tolerance level of genetically modified wheat/flour?

   0% 5% 10% 15% 20% 25% 30% 35% 40% >40%

5. If your company is opposed to buying genetically modified wheat/flour, is that due to customer concerns or your own concerns?

____Not opposed to buying genetically modified wheat/flour

____Customer opposition / concerns

____Our own concerns

6. a. What percent of your wheat/flour do you think might be identity preserved sourced in:

5 years _____ 10 years _____

b. Do you think wheat/flour should be identity preserved by

variety: Yes No geographic region: Yes No

7. With respect to hard ***white*** wheat as an alternative to HRS:

a. Where do you anticipate the greatest demand in the future?

soft white wheat **hard** white wheat

b. Are supplies of white wheat currently adequate to meet your requirements?

soft white wheat: Yes No **hard** white wheat: Yes No

c. Should efforts be directed toward development of wheat with:

superior "noodle" quality "dual purpose" superior "bread" quality

8. What potential characteristics or factors do you think would be of most interest in wheat biotechnology in the future? Indicate your willingness to pay for each factor on a scale of -2 to 2, where a negative number indicates you would pay less, a positive number indicates a willingness to pay more, and 0 indicates no effect on how much you are willing to pay.

9. How do you foresee the growth (or decline) in consumption of the following wheat-based products in the next 5 to 10 years? Indicate percentage if possible, otherwise simply check the appropriate box.

		Decline		No		Grow th	
		<		Change		>	
PRODUCT CATEGORIES	- - -	- -	-	=	+	+ +	+ + +
Bakery Products (white pan bread, buns, rolls)							
Specialty Products (hearth/variety breads, multigrain products)							
Frozen Dough							
Par-baked							
Bagels							
Pizza Crust							
Tortillas							
Other:							
Other:							