
Value-Added Opportunities and Alternative Uses for Wheat and Barley

December 2012

By:
Dr. Neil C. Doty
N. C. Doty & Associates, LLC

Praxis Strategy Group

A special thanks to our funding partners on this research: Minnesota Wheat Research & Promotion Council and the Minnesota Association of Wheat Growers. Thanks, too, to the Minnesota Barley Growers Association for their consultation throughout the project.

Contents

Executive Summary.....	1
Introduction	1
Background	2
Wheat Production Overview	2
Barley Production Overview	5
King Corn.....	5
Wheat Processing	7
Barley Processing	8
Uses Overview.....	8
New or Improved Uses for Wheat and Barley.....	10
Wheat Beer	10
Biodegradable Plastics from Wheat Starch	12
Blasting/Paint Stripping with Wheat Starch	14
Wheat-Based Cat Litter.....	15
Wheat-Based Raw Materials for Cosmetics	16
Wheat Conversion to Ethanol.....	17
Wheat in Aquaculture and Turkey Feed	19
Meat Substitutes from Wheat	21
New or Improved Wheat and Barley Characteristics	23
Antioxidants from Wheat and Barley	23
Aleurone Flour from Wheat and Barley.....	26
Whole Grain Products from Wheat and Barley	29
Hard White Wheat	35
Biotech Wheat and Barley	40
Improving Agronomic Yield.....	40
Low Phytate Wheat.....	41
High Folate Wheat and Barley	41
High Antioxidant Wheat and Barley	41
Omega 3 Fatty Acids from Wheat and Barley.....	41
Transgenic Wheat and Barley Enhancements	43
Wheat with High Molecular Weight Glutenins.....	43
Low Calorie or Low Carbohydrate Flour in Wheat and Barley	44
Non-Allergenic Wheat.....	44
Waxy Wheat.....	45
Nutraceuticals/Pharmaceuticals from Wheat (and Barley).....	47
Organic Wheat and Barley	49
Support the University of Minnesota’s Minnesota Institute for Sustainable Agriculture	
Perennial Wheat and Barley	51
High Beta-Glucan Barley	53
New or Improved Uses for Wheat By-Products.....	55
Wheat (and Barley) Straw Composites.....	55
Ethanol from Wheat or Barley Straw or Middlings	57

Combustion Energy from Wheat and Barley Straw	58
Other Potential New or Improved Uses.....	59
Chips, Tortillas, Nut Substitutes from Barley	59
Coffee and Tea Substitutes from Wheat and Barley	59
Conclusion.....	60
Appendix I: Minnesota Companies	1

Executive Summary

Introduction

The Agricultural Utilization Research Institute, the Minnesota Wheat Research & Promotion Council, and the Minnesota Association of Wheat Growers have commissioned a study to identify value-added opportunities and alternative uses for wheat and barley. This study involved doing an update of the National Association of Wheat Growers' "New and Improved Wheat Uses Audit" report completed in September 2002 and expanding the scope to also capture barley. The 2002 Audit report focused on identifying value-added opportunities and alternative uses for all classes of wheat grown in the U.S. This update includes value-added opportunities and alternative uses for barley as well.

This study focuses on value-added opportunities and alternative uses of wheat and barley as they relate directly to benefit Minnesota Growers. This Minnesota Grower focus concentrates the study onto strategic advantages exhibited by Minnesota grown wheat and barley. Some of the new and improved uses for wheat identified in the 2002 report are better suited for other regions of the U.S. due to imbedded infrastructure of type of wheat class grown in the region. The Minnesota region has the ability to produce high-quality spring and winter wheat varieties as well as a wide range of malting, feed, and food barley products. These agronomic abilities are taken into account when evaluating new and improved uses of wheat and barley.

A simplified look at the categories involved in evaluating new and improved uses of wheat and barley can be formatted into five broad areas of intermediate and end products.

- Structural Components – Derived from Straw, Starch, Protein
- Fuel – Derived from Straw, Starch
- Feed – Derived from Wheat, Barley, DDGS
- Food – Derived from Milled Wheat, Milled Barley
- Nutraceuticals/Pharmaceuticals – Derived from Milled Wheat, Milled Barley

This study follows the same formatting as the 2002 New and Improved Wheat Uses Audit with additional new and improved wheat and barley uses.

Background

Wheat Production Overview

U.S. wheat production has been relatively flat over the last decade (Figure 1). The overall trend of U.S. spring wheat production has been increasing slightly in the last decade due to increasing yields, taking into account the drastic reduction in spring wheat production in 2011 due to unfavorable weather conditions. (Figure 2) However, even though yields have increased, acreage dedicated to spring wheat production in the U.S. has been reduced drastically over the last 20 years. (Figure 3) Conversely, Figure 4 shows the increase in acreage for corn and soybeans over 10 years in the U.S. of 14 million more acres at the expense of other major crops including spring and winter wheat. The world annual production of wheat has increased through yield improvements from 20 billion bushels in the early 1990s to nearly 25 billion bushels in 2012. The U.S. exports about half of its annual wheat production.¹

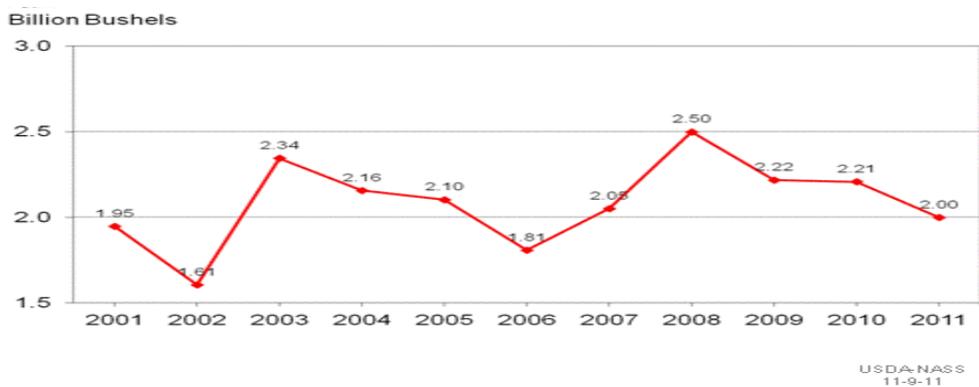


Figure 1: U.S. All Wheat Production 2001 to 2011.
Source: USDA-NASS 11-9-11

¹ USDA, NASS, Wheat Data, Table 4: World and US. Wheat Production, June 12, 2012, <http://www.ers.usda.gov/data-products/wheat-data.aspx>

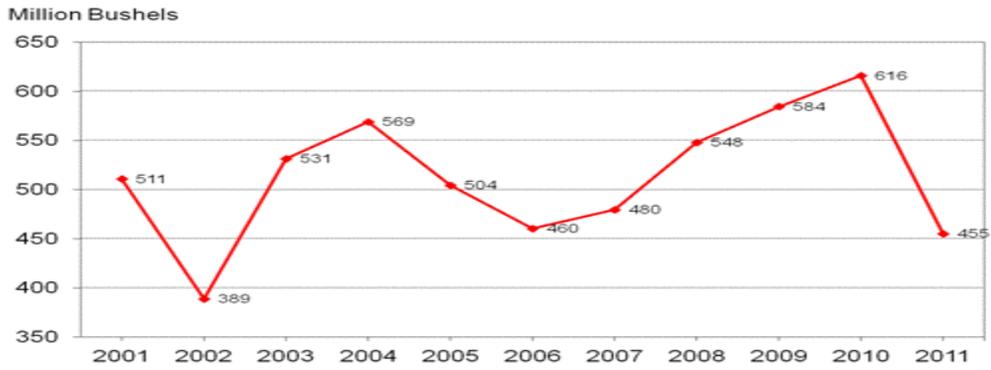


Figure 2: U.S. Spring Wheat Production 2001-2011
Source: USDA-NASS 11-9-11

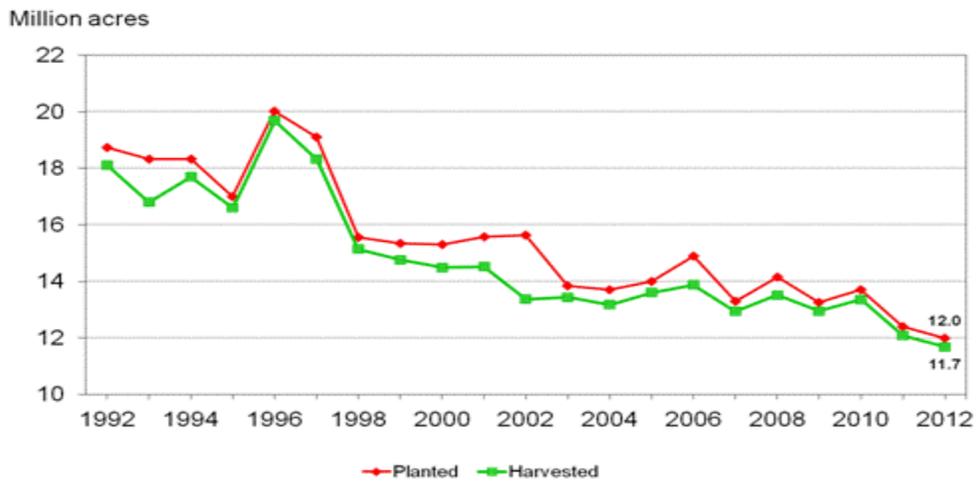


Figure 3: U.S. Spring Wheat Acres 1992 – 2012
Source: USDA-NASS 06-29-12

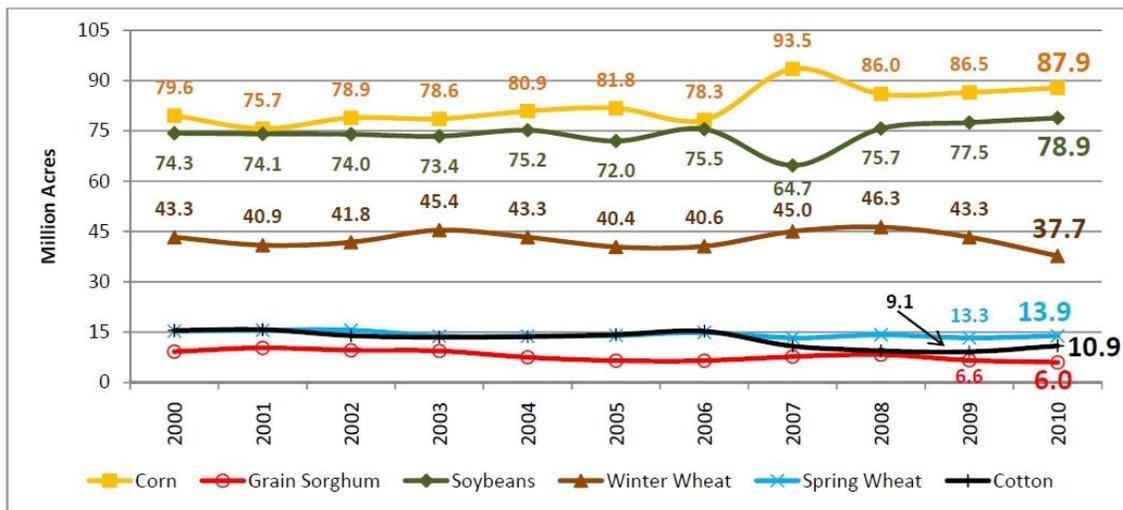


Figure 4: US Crop Acreage for Major Crops – 2000 to 2010

(Source: USDA, NASS Prospective Plantings Report, June 30, 2010)

Minnesota

<u>Crop</u>	Bushels		
	<u>2009</u>	<u>2012</u>	<u>2011</u>
Spring Wheat	82,150,000	85,250,000	69,000,000
Winter Wheat	2,025,000	2,820,000	1,456,000
Barley	4,880,000	4,340,000	3,060,000

Table 1: Minnesota Wheat and Barley Production 2009-2011

Barley Production Overview

Minnesota harvested 60,000 acres of barley in 2011 compared with 70,000 acres in 2010. Yields in 2001 were 11 bushels less than the 2010 yield of 62 bushels per acre. Most of the barley grown in Minnesota is utilized in malt production.² In the U.S., approximately 76% of barley is grown for food (includes malt), 22% for feed, and 3% for export, historically to Mexico and Canada.³ Figure 5 shows the decline in harvested barley acres in the U.S. since 1960.

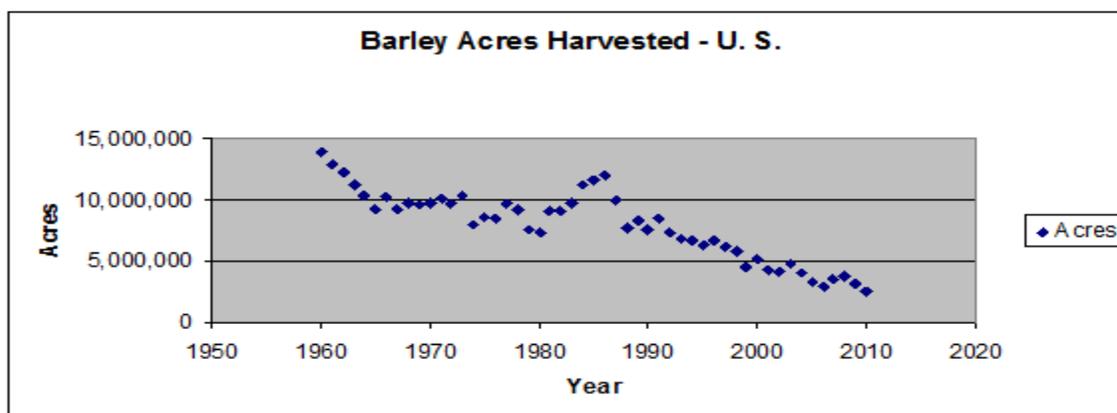


Figure 5: U.S. Barley Acres Harvested 1960-2011

Source: USDA-NASS

King Corn

Favorable economics due to demand is driving the move toward farmers planting more acres into primarily corn and secondarily soybeans as a rotation crop. Figure 6 shows the increase in overall corn production in the last decade and Figure 7 shows the increase in U.S. corn acreage over the last 20 years, which has been driven in large part by ethanol biofuel production increases. In 2011, 27.3% of the U.S. corn crop was dedicated to ethanol production. (Figure 8) At present, there exists no major similar external driving force, such as ethanol production, to dramatically increase demand for other cereal grains such as wheat or barley. However, the trend toward utilizing whole grains in foods shows promise for increasing wheat and barley consumption particularly in the U.S.

² Strong Market Brews for Malt Barley, The Farmer, Minnesota News Watch, March 2012, page 7, <http://magissues.farmprogress.com/TFM/TF03Mar12/tfm007.pdf>

³ Ibid, 2

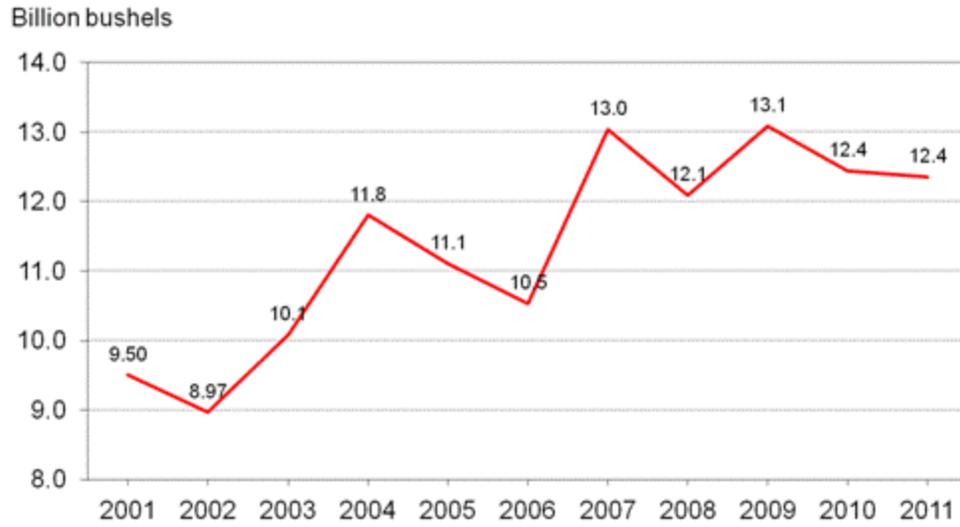


Figure 6: U.S. Corn Production 2001-2011
 Source: USDA, NASS 01-12-12

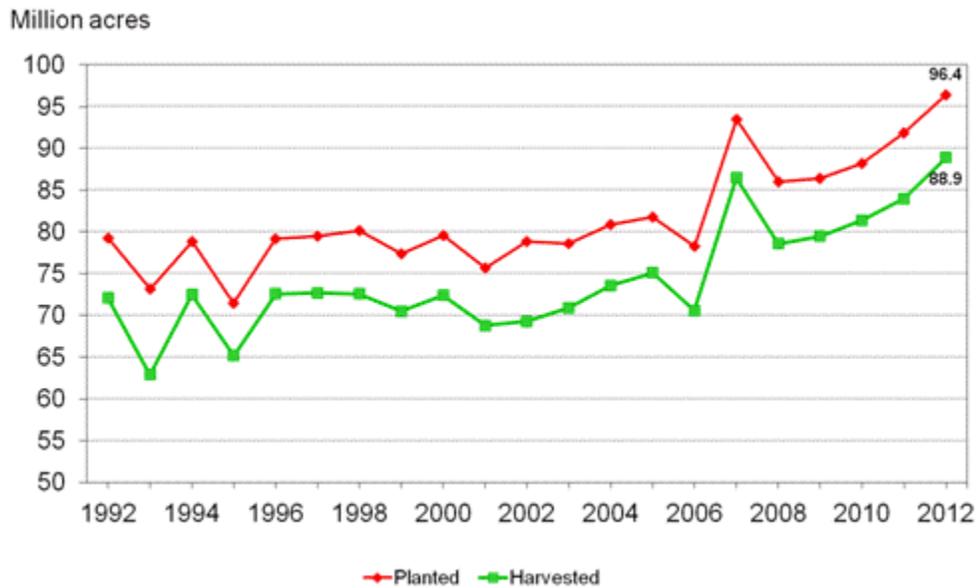


Figure 7: U.S. Corn Acres 1992-2012
 Source: 06-29-12

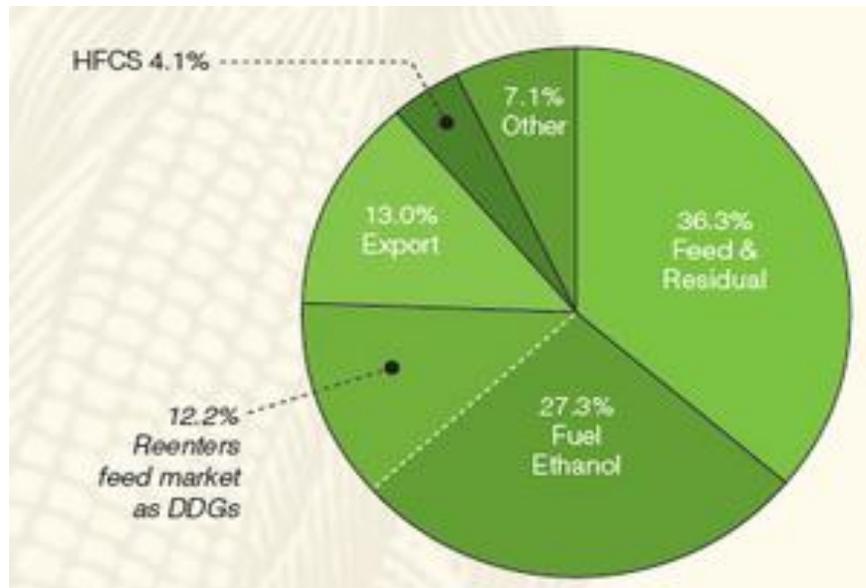


Figure 7: U.S. Corn Usage by Segment, 2011
 Source: National Corn Growers Assn: 2012 World of Corn

Corn production has benefited from ethanol production, biotechnology advances, innovation for industrial uses, and warmer climatic conditions. Wheat and barley production has not benefited from industrial uses, biotechnology, or warmer climactic conditions. In the competition for crop acres, agricultural economics on return per acre has favored primarily planting corn over small grains. This study lists potential intermediate and finished product opportunities for Minnesota Wheat and Barley Growers.

Wheat Processing

Most spring and winter wheat grown in Minnesota is delivered to regional mills for the production of flour products for human consumption. A modern wheat flour milling operation follows the simplified process shown in Figure 9, but in actuality produces a wide range of mill products for a number of uses primarily for human nutrition and animal feeding. The main use of spring wheat flour is for the production of baked goods and cereal products. Bran and secondary flours from the milling process are most often marketed as livestock and poultry feed.

Wheat flour from milling operations is the source material for the production of vital wheat gluten, which is primarily used as a protein source to improve baking characteristics of flour. The fermentation industry also hydrolyzes gluten into hydrolyzed vegetable protein for food and feed as well as producing glutamic acid as a flavor enhancer. Wheat flour, which is processed to obtain vital wheat gluten, has wheat starch as its byproduct.

In vital wheat gluten operations, the by-product, wheat starch, is most often utilized as a source material for ethanol production. In Europe, 1/3 of all food starches produced are from wheat, which totals 3 million tons of wheat starch annually. More than 40% of European starch production is utilized by the paper production industry. European wheat starch is also used for ethanol production, sweeteners, and food thickeners.⁴ Most of the new or improved uses for wheat utilize milled products or gluten/starch production products.

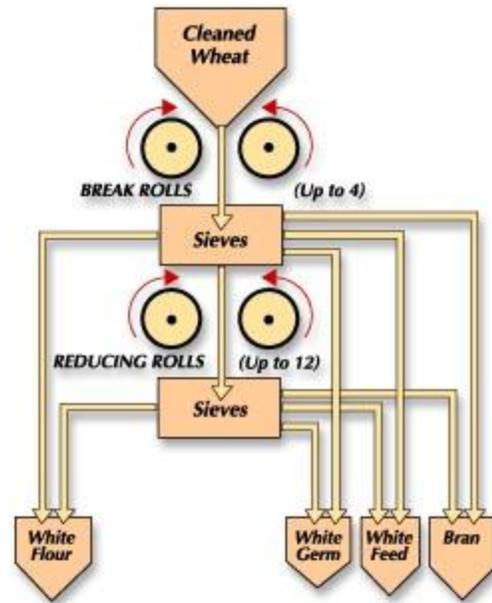


Figure 9: Simplified Wheat Mill Diagram
 Source: School of Biological Sciences, U. of Bristol, England

Barley Processing

Most barley grown in the U.S. is destined for malting for the brewing industry. Barley is processed by dehulling barley with hulls and then either grinding to produce whole barley flour or pearling to produce pearled barley. Hullless barley, whose hulls are easily removed during harvest, can also be ground into flour or pearled into pearls. Feed barley is generally ground or rolled with hulls for hogs, poultry, and cattle. Ground feed barley is a common ingredient for dry mix feed rations and as a component of pelleted feed.

Uses Overview

The following table is a grading summary of new and improved uses of wheat and barley for Minnesota growers. Grading for many of the uses will vary depending on the grain growing region. The grading scale for Minnesota Growers is (v) Low Potential, (v v) Medium Potential, (vvv) High Potential, and (vvvv) Very High Potential.

⁴ International Starch Institute A/S, Aarhus, Denmark, 2012, <http://www.starch.dk/isi/starch/tm33wheat.asp>

New or Improved Uses for Wheat and Barley

- √√Wheat Beer
 - √Biodegradable Plastics from Wheat Starch
 - √Blasting/Paint Stripping with Wheat Starch
- √√Wheat-Based Cat Litter
 - √Wheat-Based Raw Materials for Cosmetics
 - √Wheat Conversion to Ethanol
- √√Wheat in Aquaculture and Turkey Feed
 - √Meat Substitutes from Wheat

New or Improved Wheat Characteristics

- √√√√Antioxidants fromWheat and Barley
- √√√√Aleurone Flour from Wheat and Barley
- √√√√ Whole Grain Food Formulations for Wheat and Barley
- √√√√ Hard White Wheat
 - √√√ Biotech Wheat and Barley
 - √√√ Transgenic Wheat and Barley Enhancements
- √√√√Nutraceuticals/Pharmaceuticals
 - √√√ Organic Wheat and Barley
 - √ Perennial Wheat and Barley
- √√√√ High Beta-Glucan Barley

New or Improved Uses for Wheat and Barley By-Products

- √√√ Wheat and Barley Straw Composites
 - √ Ethanol from Straw or Middlings
- √√ Combustion Energy from Straw

Other Potential New or Improved Uses

- √√√ Chips, Tortillas, Nut Substitutes from Barley
- √√ Coffee and Tea Substitutes from Wheat and Barley

New or Improved Uses for Wheat and Barley

Wheat Beer

Medium Priority

Category – Use of Wheat

Market - Existing

Wheat beer demand is on the rise across the United States. Once the domain of smaller, craft breweries, as demand has increased, larger multinationals have entered the sector, offering their own entries to wheat beer consumers. According to industry analysts, wheat beer demand has outstripped even the booming craft beer sector, up over 25% according to one 2011 industry release, a growth rate three times that seen in the craft and micro markets.⁵ Craft brewers, leaders in adoption of new brewing ingredients and alternative beer styles including wheat based brews, have seen their market share double since 2004, reaching 6% of the overall beer market in 2011.⁶

As is the case for malting barley, malting wheat with lower proteins are preferred by brew masters for increased starch for fermentation and decreased haze in finished beer by reducing excess protein. Companies that produce malting wheat, such as Breiss Malt and Ingredients Company, Chilton, WI, use soft red and soft white wheat as their malting substrate for these purposes.⁷ Also, Rahr Malting Company, Shakopee, MN, markets red wheat and white wheat malts through their craft brewing subsidiary, Brewers Supply Group.⁸ The utilization of wheat for beer production affects the soft red and soft white wheat markets directly and affects hard red and hard white wheat markets very indirectly.

Minnesota is home to a number of craft brewers who belong to the Minnesota Craft Brewers Guild, Minneapolis, MN. The 34 current members, for the most part, brew wheat beers, and barley + wheat-based beers.⁹ Discussions with Dr. Paul Schwarz, Director, Institute of Barley and Malt Sciences, North Dakota State University, Fargo, ND revealed that his staff routinely gets phone calls from craft brewers across the U.S. asking how to grow and malt barley and wheat in their own states. The craft brewers want to be able to differentiate from their competitors by saying that they have state-grown, malted, and brewed barley and/or wheat for

⁵ Amstel Press Release, Aug. 2011. Available at <http://www.brewbound.com/news/amstel-enters-the-growing-wheat-beer-category>

⁶ “Craft beers brew up booming business across USA,” USA Today, May 25, 2012. <http://www.usatoday.com/money/industries/food/story/2012-05-26/craft-breweries/55203882/1>

⁷ Breiss Malt and Ingredients Company, Chilton, WI, Website, <http://www.brewingwithbriess.com/Products/Wheat.htm#Red>

⁸ Rahr Malting Company, Shakopee, MN, Website, <http://www.rahr.com/index.geni?mode=content&id=181>

⁹ Minnesota Craft Brewers Guild, Minneapolis, MN, Website, <http://www.rahr.com/index.geni?mode=content&id=181>

their customers. That opportunity might exist for entrepreneurial Minnesota wheat and barley growers for the members of the Minnesota Craft Brewers Guild.

Wheat Beer Growth Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 1 million bushels annually

Premium Potential – Very low - < \$0.10/bushel

Technical Probability of Success – Medium – High Protein Penalty

Timeframe for Commercialization – Very Short – In Production

Cost of Development – Low – Identify Lower Protein, White Wheat Variety

Entrepreneurial Potential – High – Focus on Malting Wheat for MN Craft Brewers

MN Research and Development Recommendations

Identification of Minnesota grown white and red wheat varieties with high diastatic enzyme potential and low protein (<14%) for tests with Minnesota craft brewers. Craft brewers could feature Minnesota grown wheat malt.

Biodegradable Plastics from Wheat Starch

Low Priority

Category – Use of Wheat

Market - Existing

Demand for biodegradable plastics and packaging appears to be on the rise. While overall market numbers for food packaging proved hard to find, one analyst listed the overall global market for biodegradable plastics as having reached “\$1.85bn in 2011.”¹⁰ Another source reports that experts at the German chemical company BASF project that the market for biodegradable plastic products will increase by 20-30% over the next several years. According to the quoted BASF VP, this demand is being driven by end users, who want to make use of more “sustainable solutions”.¹¹

An excellent example of biodegradable plastic manufacturer is NatureWorks, LLC, the largest lactic acid manufacturing plant in the world, produces polylactic acid (PLA) plastics from the fermentation of corn dextrose obtained from high fructose corn syrup production. The Blair, NE plant produces 40,000 pounds of biodegradable plastic pellets per day. The PLA pellets are used to manufacture plates, eating utensils, bags, textiles, plastic cases, credit cards, and bottles. This Cargill owned company has announced plans to build a second facility in Thailand shortly.¹²

Cargill has developed a process with Dow Chemical to utilize dextrose from its massive Blair, NE corn processing facility in order to take advantage of economies of scale. Cargill has markets for other products derived in its Blair plant. A stand alone biodegradable PLA plastics manufacturer would have to compete with NatureWorks, LLC and others for market share. Companies that manufacture wheat gluten produce wheat starch as a by-product. Wheat starch from gluten producers generally becomes raw material for ethanol production. Wheat starch can be enzymatically and chemically reduced to dextrose (glucose) as a raw material for lactic acid and ultimately PLA plastics. As discussed in the following section on meat substitutes from wheat, the wheat gluten/starch industry in the U.S. is concentrated in Kansas, where winter wheat is the primary raw material. Manildra Group, Australia, had built a wheat gluten and starch facility in Minneapolis in 1979, but subsequently moved operations to Hamburg, IA, which is on I-29 in between Omaha and Kansas City. As with other gluten facilities, its starch is primarily dedicated toward ethanol production. Without wheat gluten/starch facilities in close

¹⁰ “The Biodegradable Plastic Packaging Market 2011-2021,” <http://www.prnewswire.com/news-releases/the-biodegradable-plastic-packaging-market-2011-2021-134580908.html>

¹¹ “Biodegradable plastics growth linked to composting infrastructure,” March 31, 2011, <http://www.icis.com/Articles/2011/04/04/9448561/biodegradable-plastics-growth-linked-to-composting-infrastructure.html>

¹² NatureWorks, LLC, Website, <http://www.natureworkslc.com/>

proximity for wheat starch as a raw material, the Minnesota region is out of economic viability unless it possesses intellectual property for the production of superior quality biodegradable plastics that are in demand.

Biodegradable Plastics Growth Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 1 million bushels annually

Premium Potential – Very low - < \$0.01/bushel

Technical Probability of Success – Low – Starch Production in Kansas

Timeframe for Commercialization – Medium – In Production

Cost of Development – High – Add on Production for Starch Facilities

Entrepreneurial Potential – Low – High Capital Costs

MN Research and Development Recommendations

Monitor biodegradable plastic research from Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN where wheat starch may have unique properties in the manufacturing of proprietary plastics.

Blasting/Paint Stripping with Wheat Starch

Low Priority

Category – Use of Wheat

Market – Existing

ADM Milling markets a Wheat Starch Paint Stripper product known as EnviroStrip Wheat Starch. The ADM product is targeted toward removing paint and adhesives from aircraft surfaces. Wheat starch is safe for use on delicate composites, plastics, and alloys. Wheat starch allows the separation of abraded paint or epoxy by simply adding water and filtering out toxic materials for proper disposal.¹³ ADM Milling has spent the time, energy, and money to obtain industry and regulatory approval for its EnviroStrip Wheat Starch product. ADM also markets an EnviroStrip Corn Polymer product for paint stripping. ADM dominates the wheat starch paint stripping marketplace.

As discussed by the 2002 New and Improved Wheat Uses Audit, wheat starch blasting requires expensive equipment to ensure moisture control, dust control, media recovery, and environmental disposal of blasted coatings. Interestingly, Boeing engineers reported that continued use of recycled wheat starch improves its stripping effect due to the generation of additional sharp surfaces on starch crystals.¹⁴ The market is quite small and highly dependent upon approvals for each aircraft type to be blasted. Once again, the Minnesota region does not have a ready, low cost source of wheat starch as does ADM, a gluten/starch manufacturer.

Blasting/Paint Stripping with Wheat Starch Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 100,000 bushels annually

Premium Potential – Very low - < \$0.01/bushel

Technical Probability of Success – High – In Production

Timeframe for Commercialization – Very Short – In Production

Cost of Development – High – Industry and Regulatory Approvals Required

Entrepreneurial Potential – Low – High Market Development Costs

MN Research and Development Recommendations

None

¹³ ADM, EnviroStrip, Website, <http://www.adm.com/en-US/products/brands/envirostrip/Pages/default.aspx>

¹⁴ Low Toxicity Paint Stripping of Aluminum and Composite Substrates, Nona Larsen, Boeing Aerospace, Seattle, WA, page 55, <http://infohouse.p2ric.org/ref/25/24033.pdf>

Wheat-Based Cat Litter

Medium Priority

Category – Use of Wheat

Market – Existing

Sales of Cat litter continue to increase. Reported as “an approximately \$1 billion industry” in the 2002 NAWG report, overall sales of cat litter reached a reported \$1.51 billion in 2005, and \$1.83 billion in 2009.¹⁵ Detailed market information on wheat based litters is difficult to come by, but there are signs that demand for such products is increasing. Swheat Scoop®, a Detroit Lakes based company, recently announced plans to increase the size of their production facilities, nearly doubling manufacturing capacity to 100,000 bushels of wheat per month.¹⁶ Pet industry trade publications have reported increased interest in “natural” litter products, with wheat- and corn-based products mentioned as market alternatives to traditional clay based products.¹⁷

Swheat Scoop®, a Farmers Union Industries company, has nationwide distribution and is featured on Amazon.com and Google.com. The Minnesota Association of Wheat Growers should encourage the growth of Swheat Scoop® and not engage in activities that could limit the Minnesota-based company’s efforts.

Wheat-Based Cat Litter Growth Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 100,000 bushels annually

Premium Potential – Very low - < \$0.01/bushel

Technical Probability of Success – High – In Production

Timeframe for Commercialization – Very Short – In Production

Cost of Development – High – Industry and Regulatory Approvals Required

Entrepreneurial Potential – Low – High Market Development Costs

MN Research and Development Recommendations

Support Swheat Scoop® efforts through co-promotion and press releases.

¹⁵ Newman, Adam Andrew “Addressing Your Cat’s ... Ahem ... Solid Waste,” *New York Times*, Oct. 7, 2010. <http://www.nytimes.com/2010/10/08/business/media/08adco.html>

¹⁶ Pet Business, Dec. 27, 2011. <http://www.petbusiness.com/articles/2011-12-27/Swheat-Scoop-Plans-Production-Facility-Expansion?print=true>

¹⁷ Pet Business, “The Scoop on Natural Cat Litter,” May 1, 2012 <http://www.petbusiness.com/articles/2012-05-01/The-Scoop-on-Natural-Cat-Litter>

Wheat-Based Raw Materials for Cosmetics

Low Priority

Category – Use of Wheat

Market – Existing

Wheat germ oil has been used as a skin conditioning agent for decades. The natural vitamin E in wheat germ oil benefits the skin. Wheat germ glycerides are used in the manufacture of lipsticks and moisturizers. Wheat gluten is used in makeup, hair conditioners, and skin conditioners due to its binding effect.¹⁸ According to the National Institutes for Health, wheat germ oil has 100% of the daily value for humans of vitamin E (20.3 mg) in a single tablespoon.¹⁹ China and India produce more wheat annually than the U.S. and both countries have dozens of milling companies that are actively marketing wheat germ oil in the U.S. for use in cosmetics.

Efforts to warn celiac patients about the dangers of using cosmetics with wheat ingredients are increasing. Using the phrase “gluten free cosmetics” produces about 370,000 Google® results. As stated in the 2002 New and Improved Wheat Uses Audit, most of the wheat components used in the cosmetics industry is produced by the participants in the wheat gluten/starch manufacturing industry. The Minnesota region does not have a ready, low cost source of wheat components for the cosmetics industry.

Wheat-Based Raw Materials for Cosmetics Growth Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 100,000 bushels annually

Premium Potential – Very low - < \$0.01/bushel

Technical Probability of Success – High – In Production

Timeframe for Commercialization – Very Short – In Production

Cost of Development – High – High Development and Marketing Costs

Entrepreneurial Potential – Low – High Market Development Costs

MN Research and Development Recommendations

None

¹⁸ Triticum Vulgare Wheat Germ and Wheat Gluten, Cosmeticsinfo.org Website, http://www.cosmeticsinfo.org/ingredient_details.php?ingredient_id=1066

¹⁹ Vitamin E, Dietary Supplement Fact Sheet, Office of Dietary Supplements, National Institutes of Health, <http://ods.od.nih.gov/factsheets/VitaminE-HealthProfessional/>

Wheat Conversion to Ethanol

Low Priority

Category – Use of Wheat

Market – Existing

As noted by the 2002 NAWG study, while wheat is a fermentable feedstock for ethanol production, its cost premium to corn made it “unlikely” to become competitive with corn as a major source of ethanol in the “foreseeable future.” That projection largely came to pass over the past decade, but recent upswings in corn price did lead some ethanol producers to take a closer look at the feasibility of wheat as a feedstock. According to Reuters, some plants did look at wheat during 2011, but had not made a switchover because the “costs of capital investment, reduction in yield and loss of the by-product distillers’ dried grain outweigh the short-term potential of a cheaper supply source.”²⁰ As a result of these costs, and the typical cost premium for wheat, as of 2008 only two plants nationally were producing ethanol from wheat starch.²¹ According to the University of Illinois, around 90% of ethanol nationally is produced using corn, with the remainder coming from wheat, milo, and cheese whey.²²

While wheat currently finds itself at a market disadvantage to corn in the United States, it is worth noting that it has made up a much more important feedstock source in other markets. Up to 15% of ethanol in Canada and 70% of European ethanol was produced using wheat according to a 2006 study. Wheat gluten operations typically route their wheat starch by-product into ethanol production. Ongoing research related to waxy wheat varieties- which show higher potential for use as a feedstock due to higher ethanol yields- and other new wheat varieties may allow for increased use in the future.²³ At the present, however, the main impact on wheat related to ethanol may be the “impact on projected acreage declines for wheat” as acres devoted to corn have increased to feed ethanol production, contributing “to declines in wheat area” nationwide.²⁴

Wheat Conversion to Ethanol Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 100,000 bushels annually

Premium Potential – Very low - < \$0.01/bushel

Technical Probability of Success – High – In Production

²⁰ Gillam, Carey. “Analysis: U.S. ethanol plants toy with wheat, committed to corn,” Reuters, June 15, 2011.

<http://www.reuters.com/article/2011/06/15/us-ethanol-wheat-idUSTRE75E0MQ20110615>

²¹ “Biofuel Feedstocks,” <http://www.mhprofessional.com/downloads/products/0071487492/DrapchoCh4.pdf>

²² <http://web.extension.illinois.edu/ethanol/>

²³ Graybosch, Robert A. et. al., “New Uses for Wheat and Modified Wheat Products,” chapter from *Wheat: Science and Trade*, Brett F. Carver, editor. (Wiley-Blackwell, 2009). Pg. 538-539.

²⁴ USDA Wheat Baseline, 2012-21, <http://www.ers.usda.gov/briefing/wheat/2012baseline.htm>

Timeframe for Commercialization – Long – >24 – 36 Month Development Process
Cost of Development – High – High Capital Costs
Entrepreneurial Potential – Very Low – High Capital Costs/Economic Disadvantage

MN Research and Development Recommendations

None

Wheat in Aquaculture and Turkey Feed

Medium Priority

Category – Use of Wheat

Market – Existing

The price premium for wheat as a feed continues to be a problem for growth in this sector. Major poultry feeder Tyson Foods recently announced plans to stop the use of wheat as feed at its facilities due to price concerns. The company had started use of wheat a year earlier, given concerns about corn prices.²⁵ Given the variety of grain options available to feed users, such price shopping will probably continue to be a key driver of overall demand, with shifting prices driving overall demand of each feed class.

However, with high corn prices still affecting the animal production industry, the use of wheat as feed should continue to be higher than previously seen. According to Reuters, “The U.S. Department of Agriculture has projected feed and residual use of U.S. wheat for the 2012/13 marketing year that began June 1 at 230 million bushels, a 50 million-bushel rise from the previous year and the highest level in four years.” A livestock market expert interviewed by Reuters reported that the poultry industry would be the main user. One quoted feed buyer noted that whatever is cheapest is what they will buy²⁶ - which may make wheat’s run as a feed choice for certain industry sectors short-lived.

Export markets also show some promise for feed wheat demand. Soft white wheat, typically marketed for milling, has seen nearly 25 million bushels of sales in late 2011 to poultry feeders in Asia and Mexico due to competitive pricing.²⁷ Minnesota growers typically produce higher value, milling quality wheat that commands prices well above soft wheat and thereby are becoming uncompetitive in the feed marketplace.

Aquatic agriculture has been a sector of major growth over the past two decades. This has led to increased demand for feed. According to the FAO, world “industrial compound aqua feed production increased more than threefold, from 7.6 million tonnes in 1995 to 29.2 million tonnes in 2008, with production growing at an average rate of 11.0 percent per year.” The FAO

²⁵ Reuters, “Tyson Says Stops Buying Wheat for Feed Due to Cost,” June 11, 2012.

<http://www.reuters.com/article/2012/06/11/wheat-tyson-feed-idUSL1E8HBC3J20120611>

²⁶ “Whichever one we can buy the most of at the cheapest price per pound relative to the other, that's the one we'll always feed the most of,” said Prestage. <http://www.reuters.com/article/2012/06/11/wheat-tyson-feed-idUSL1E8HBC3J20120611>

²⁷ “Overseas Markets Buying U.S. Wheat for Feed,” March 26, 2012. <http://www.capitalpress.com/newest/mw-U-S--Wheat-feed-wheat-033012>

projects that overall production will reach 71.0 million tons by 2020.²⁸ Wheat and other cereal proteins stand poised to make up part of this growth as the use of fishmeal decreases in the face of increased regulations brought about by depleted worldwide wild fish populations. Wheat gluten is currently being utilized as a binder in aquaculture rations. Other mill fractions used in fish feed are wheat bran, wheat germ, red dog flour, and middlings.

Wheat in Aquaculture and Turkey Feed Growth Affect on Minnesota Wheat Growers

Volume Potential – Medium - < 5 million bushels annually

Premium Potential – Low - < \$0.01/bushel

Technical Probability of Success – High – In Production

Timeframe for Commercialization – Short – In Production

Cost of Development – Very Low – Match Product to Market Demand

Entrepreneurial Potential – Low – Highly Competitive Markets/Freight Disadvantage

MN Research and Development Recommendations

None

²⁸ “Demand and supply of feed ingredients for farmed fish and crustaceans: Trends and prospects”
<http://www.fao.org/docrep/015/ba0002e/ba0002e.pdf>, page x.

Meat Substitutes from Wheat

Low Priority

Category: Uses of Wheat

Market: Existing

The market for meat substitutes, including wheat based products, is on the rise. According to market analysts “frozen meat substitute sales reached \$267 million in 2011,” up from the \$194 million in 2001 reported in the NAWG study.²⁹ Adjusted for inflation, the 2011 total would equal roughly 210 million in sales in 2001.³⁰

This increase in sales appears to be continuing in 2012, with an industry analyst reporting that as of March “for the latest 52-week period, frozen meat substitute sales (supermarkets, drugstores and mass market retailers excluding Wal-Mart) totaled \$278,256,900 – up 1.20 percent from the same 52-week, one-year earlier period.”³¹ Overall sales of meat substitutes have been on the rise as well, but some analysts predict the rate of increase will slow towards mid-decade. According to market analyst Datamonitor, the overall North American market for meat substitutes was \$326 million in 2009, and increased at a compound annual growth rate of 3.1% between 2004 and 2009. They project this to slow to a compound annual growth rate of 2.5%, with sales reaching \$368 million by 2014.³²

The primary wheat-based ingredient used in meat substitutes and meat fillers is wheat gluten. Also, wheat protein isolates (>80% protein) are used as meat fillers. Wheat protein isolates are proteins isolated in the gluten/starch production process that are not incorporated into the gluten fraction. The four U.S. companies that manufacture gluten products (as well as wheat starch) are Archer Daniels Midland Company, Overland Park, KS, Manildra Milling Corporation, Shawnee Mission, KS, MGP Ingredients, Inc., Atchison, KS, and White Energy, Russell, KS. It should be noted that the wheat gluten/starch industry is concentrated in Kansas. This is primarily due to the proximity to hard red winter wheat and several wheat milling operations. These American companies, along with 13 foreign operations, belong to the International Wheat Gluten Association, Overland Park, KS.³³

²⁹ “Meat Substitutes Market Beefs Up,” NPR, March 2012

<http://www.npr.org/blogs/thesalt/2012/03/19/148923598/meat-substitute-market-beefs-up>

³⁰ US Bureau of Labor Statistics Inflation Calculator http://www.bls.gov/data/inflation_calculator.htm

³¹ <http://www.meatpoultry.com/Writers/Bryan%20Salvage/Are%20meat%20analogs%20in%20industrys%20future.aspx?p=1&cck=1> March 2012.

³² Heller, Lorraine. “Have Meat Substitutes Missed the Boat?” <http://www.foodnavigator.com/Financial-Industry/Have-meat-substitutes-missed-the-boat>

³³ International Wheat Gluten Association, Overland Park, KS, Website, http://www.iwga.net/become_mem_contact.htm

Members belonging to the Wheat Gluten Industry are quite guarded with respect towards discussing their technology and new product development activities. It was revealed, however, that the Wheat Gluten Industry has doubled in size in the last decade, even though competition remains keen among the members. The current members in the Wheat Gluten Industry have survived and prospered by being low cost producers, while striving to open new markets. Two markets targeted for growth are the addition of vital wheat gluten to whole grain products to improve their functionality and the addition of vital wheat gluten to vegetarian meat analogs or meat substitutes.

Meat Substitutes from Wheat Growth Affect on Minnesota Wheat Growers

Volume Potential – Very low - < 1 million bushels annually

Premium Potential – Very low - < \$0.10/bushel, Transportation Penalty to Kansas

Technical Probability of Success – Medium – High Protein Penalty

Timeframe for Commercialization – Very High – In Production

Cost of Development – Low – Winter Wheat Required to be Competitive

Entrepreneurial Potential – Very Low – High Market Entry Barriers

MN Research and Development Recommendations

None

New or Improved Wheat and Barley Characteristics

Antioxidants from Wheat and Barley

Very High Priority

Category: Characteristic of Wheat

Market: Emerging

The pathology of a number of chronic diseases involves cellular damage from oxidation. Reactive Oxygen Species (ROS) are molecules, like hydrogen peroxide, that can damage other molecules and the living tissue in which they reside. Although ROS molecules are necessary for specific metabolic functions in humans and animals, excess ROS molecules can cause a number of chronic illnesses including coronary heart disease and cancer. Antioxidants from food can minimize oxidation damage from ROS molecules. Antioxidants can halt damage associated with excess ROS molecules and prevent health issues and diseases.³⁴

The “Antioxidant and Health Promoting Properties of Wheat” in Chapter 9 in the newly published book, “Cereals and Pulses: Nutraceutical Properties and Health Benefits.”³⁵ This chapter details the antioxidants present in wheat components and also describes how to use post harvest processing to make the antioxidants bioavailable in human nutrition. Antioxidants in wheat bran exist in the forms of vitamins (tocopherols – vitamin E), minerals (selenium), phenolic acids (ferulic acid, vanillic acid), tocotrienols, phytic acid, phytosterols, flavonoids, and carotenoids (lutein).³⁶ Wheat species have widely differing quantities of antioxidants. An example is the ancient grain, Einkorn, has nearly eight times the lutein content of modern wheat varieties. Einkorn could be the source material for breeding high-lutein content wheat for eye health.³⁷ Antioxidant content in modern white wheat varieties has tested to be lower than antioxidant content in modern red wheat varieties.³⁸

³⁴ Enhancing Antioxidant Availability in Wheat-based Foods for Improving Human Health, NRI Research Highlights, 2007, No. 6, USDA, CSREES, Dr. Liangli Lu, Dept. of Nutrition and Food Science, Univ. of MD, College Park, MD, http://www.csrees.usda.gov/funding/nri/highlights/2007_no6.pdf

³⁵ Moore, J. and Hao, J. (2012) Antioxidant and Health Promoting Properties of Wheat (*Triticum spp.*), in Cereals and Pulses: Nutraceutical Properties and Health Benefits (eds L. (. Yu, R. Tsao Information and F. Shahidi), Wiley-Blackwell, Oxford, UK. doi: 10.1002/9781118229415.ch9

³⁶ Bioactive Compounds and Their and Their Antioxidant Capacity in Selected Primitive and Modern Wheat Species, El-Sayed M. Abdel-Aal and Iwona Rabalski, Agriculture and Agri-Food Canada, Guelph Food Research Center, Guelph, Ontario, CA, The Open Agriculture Journal, 2008, 2, 7-14, <http://www.benthamscience.com/open/toasi/articles/V002/7TOASJ.pdf>

³⁷ Ibid

³⁸ Phenolic Acid Profiles and Antioxidant Activities of Wheat Bran Extracts and the Effect of Hydrolysis Conditions, Kyung-Hee Kim, Rong Tsao, Ramond Yang, Stephen W. Cui, Food Chemistry, Vol. 95:3, April 2006, pp. 466-473, <http://www.sciencedirect.com/science/article/pii/S0308814605001056>

Minnesota growers are growing wheat (and barley) varieties that are antioxidant powerhouses. Most consumers are unaware of the tremendous nutritional benefits obtained by consuming whole wheat, wheat bran, wheat germ, and aleurone flour products. Americans are consuming dietary supplements in record numbers and could obtain the benefits of dietary supplements in a much more cost effective way and consume a much wider range of antioxidants by adding whole grains to their diets. Minnesota growers could develop a strategy to position their wheat and barley products as premier whole grain products and as powerhouses of antioxidant beneficial properties.

Commercial whole grain products that label and advertise their products as possessing antioxidant content have been plagued by U.S. Food and Drug Administration regulatory actions. Kellogg's has made health claims for its whole grain cereal products over the last four years and have been served with warning letters from the FDA to refrain from making ³⁹ Other large companies, such as General Mills (cereals) and Unilever (tea) have received warning letters from the FDA to discontinue antioxidant claims on their products. The FDA is noticeably increasing its enforcement of food labeling regulations and is targeting unauthorized antioxidant claims. Authorized antioxidant claims are regarded as ambiguous and limited in providing consumer information by limiting claims to only three nutrients that have official daily values; beta-carotene, vitamin C, and vitamin E.⁴⁰

Minnesota Association of Wheat and Barley Growers' support of communicating the importance of antioxidants in whole grains through The Whole Grains Council, The Grain Foods Foundation, The National Association of Wheat Growers, and the National Barley Growers Association should help educate the consuming public on increasing antioxidant consumption through whole grains. By engaging in a planned strategy of disseminating information on the health benefits from antioxidants from Minnesota wheat and barley, Minnesota growers can position their grain, or even specific varieties of grain and milled products, as a preferred grain for whole grain food consumption.

A discussion with Dr. David Klurfeld, National Program Leader for Human Nutrition, USDA, Beltsville, MD, revealed that studies are required to determine the effect of differing wheat classes and varieties on human health. In the last decade, "feed and bleed" nutrition studies on human health have not been conducted in any meaningful way due to the scientific community's propensity to gravitate toward more glamorous research, such as genetic mapping.⁴¹

³⁹ Kellogg's New Antioxidant Labeled Cereal Makes No Health Claims, Nutraingredients-USA.com, Jane Byrne, July 21, 2010, <http://www.nutraingredients-usa.com/Industry/Kellogg-s-new-antioxidant-labelled-cereal-makes-no-health-claims>

⁴⁰ Dietary Supplements, Foods, and Beverages, Nutritional Outlook, Elizabeth Campbell and Judith Mellentin, March 30, 2011, <http://www.nutritionaloutlook.com/article/dietary-supplements-foods-and-beverages-tightening-antioxidants>

⁴¹ Direct Communication with Dr. David Klurfeld, National Program Leader for Human Nutrition, USDA, Beltsville, MD.

A discussion with Dr. David Gallaher, who is a professor in the Department of Food Science and Nutrition at the University of Minnesota, St. Paul, MN, revealed exciting research currently being conducted. Dr. Gallaher studies the effects of wheat and wheat components on lab rates. His studies have shown that red wheat is far more effective at reducing precancerous lesions in carcinogen-treated rats than white wheat. Dr. Gallaher has developed a proprietary method of releasing ferulic acid (an antioxidant) from arabinoglycans (biopolymer) from wheat bran which promises to have potential of lowering cholesterol as shown in rat studies. Ferulic Acid also has shown that it decreases adiposity (fat storage) in lab animals. Most phenolic compounds, such as ferulic acid, are bound to wheat bran and aleurone biopolymers and are not available for absorption by humans. By cost effectively releasing phenolic compounds, wheat bran and aleurone flour could provide significantly more antioxidant properties than untreated mill fractions alone. Dr. Gallaher stated that additional research could reveal positive prevention and treatment of diabetes, colon cancer, atherosclerosis, and macular degeneration with antioxidants from grains.⁴²

Dr. Ronald Madl, Director, Bioprocessing and Industrial Value-Added Program, Grain Science and Industry, Kansas State University, Manhattan, KS, stated that the aleurone layer, particularly, in wheat, oats, and barley have very significant levels of a wide range of antioxidants. The antioxidants have profound effects on preventing and treating cancer. Dr. Madl is seeking to develop an understanding of how to breed grain with uniform levels of antioxidants and link them to cancer suppression in test animals.⁴³

Antioxidants from Wheat and Barley Growth - Affect on Minnesota Growers

Volume Potential – Very High - >5 million bushels annually
Premium Potential – Low - < \$0.20/bushel
Technical Probability of Success – Very High – In Production
Timeframe for Commercialization – Multi-Year – Educate the Public
Cost of Development – Medium – Support Antioxidant Research and Marketing
Entrepreneurial Potential – Very High – New Foods and Supplements

MN Research and Development Recommendations

Assist researchers to identify and develop varieties that have uniform, consistent levels of antioxidants for the prevention and treatment of health issues and disease.

⁴² Direct Discussion with Dr. Daniel Gallaher, Professor, Department of Food Science and Nutrition, University of Minnesota, St. Paul, MN.

⁴³ Direct Discussion with Dr. Ronald Madl, Director, Bioprocessing and Industrial Value Added Program, Grain Science and Industry, Kansas State University, Manhattan, KS.

Develop an effective communication strategy that conveys the importance of antioxidants in Minnesota-grown wheat and barley to prevent and treat health issues and diseases.

Aleurone Flour from Wheat and Barley

Very High Priority

Category: Uses of Wheat

Market: Emerging

The aleurone layer in wheat contains the highest level of bioactive components. The aleurone layer (Figure 12) lies in between the bran layer and the endosperm of wheat. Aleurone flour from wheat was originally called wheat white shorts or red dog flour and consisted of primarily the aleurone layer with small amounts of bran, germ, and flour. Red dog flour is a mill by-product and is generally considered suitable only for animal feed in that it would discolor white patent flour if blended. Breakfast cereals and breads containing wheat aleurone could reduce the risk of heart disease, according to the European Union's research project, The Health Grain Project, which showed that wheat aleurone reduces inflammation and LDL cholesterol.⁴⁴

⁴⁴ ADM Milling, Current Issues, May 2010, <http://www.admmilling.com/news/archive.asp>

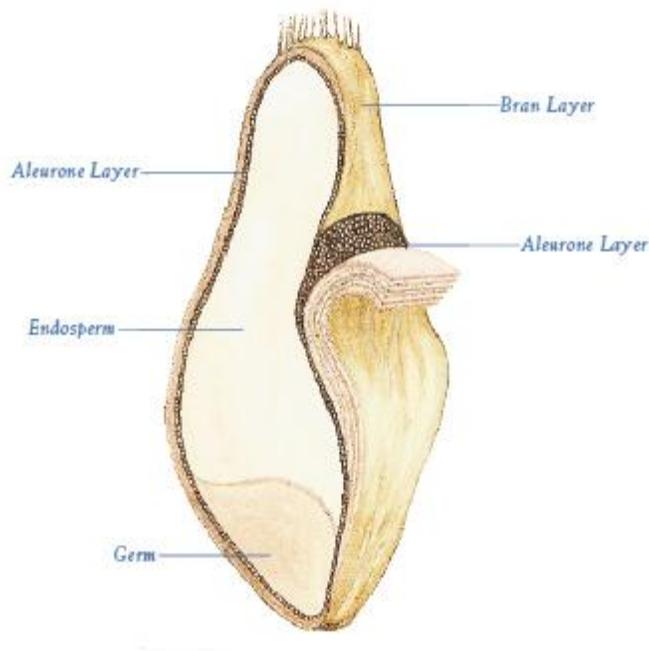


Figure 12: Parts of the Wheat Kernel
Source: Horizon Milling

Horizon Milling (Cargill) has developed a proprietary process of obtaining aleurone flour from their milling operations. Their GrainWise® Wheat Aleurone is derived from the aleurone layer in wheat kernels where most of the bioavailable nutrients in wheat are located. Cargill's literature states that isolated aleurone is preferable to using straight bran in that isolated aleurone contains a higher concentration of nutrients while having 45% by weight as dietary fiber. Isolated aleurone is a concentrated source of vitamins including vitamin B6, Niacin, and Vitamin E; is a concentrated source of minerals including potassium, magnesium, calcium, iron, and zinc; and is a source of most major antioxidants.⁴⁵

Cargill introduced GrainWise® Wheat Aleurone in 2005 to provide a means of adding dietary fiber and other nutrients to flour-based products while maintaining color, taste, and texture of traditional products. As the public becomes more aware of the benefits of whole wheat (and barley) and their antioxidant contributions, mill products like aleurone flour will be in demand to supply a concentrated source of nutrients. Aleurone flour, once thought to be a low-value by-product, most probably will gain importance as a cost-effective, concentrated source of effective antioxidants. Cargill, a Minnesota company, is at the forefront of pioneering aleurone flour in the U.S. and carving out a market for aleurone flour that should increase grain consumption.

⁴⁵ Cargill GrainWise® Wheat Aleurone, Website, <http://www.cargill.com/food/na/en/products/HorizonMilling/Products/GrainWiseWheatAleurone/index.jsp>

Aleurone Flour from Wheat and Barley Growth - Affect on Minnesota Growers

Volume Potential – Medium - >1 million bushels annually

Premium Potential – Low - < \$0.20/bushel

Technical Probability of Success – Very High – In Production

Timeframe for Commercialization – Short – In Production

Cost of Development – Low – Milling Technology in Place

Entrepreneurial Potential – Very High – New Food and Supplements

MN Research and Development Recommendations

Assist researchers to identify and develop varieties that have uniform, consistent levels of antioxidants in their aleurone layers for the prevention and treatment of health issues and disease.

Develop an effective communication strategy that conveys the importance of antioxidants in Minnesota-grown wheat and barley Aleurone Flours to prevent and treat health issues and diseases.

Whole Grain Products from Wheat and Barley

Very High Priority

Category: Characteristic of Wheat and Barley

Market: Existing

A March 2012 report entitled *Whole Grain and High Fiber Foods* by Global Industry Analysts, San Jose, CA, forecasted that the Whole Grain Food Market will grow to \$27.6 billion by 2017 with the United States leading. Even though the U.S. is the largest whole grains market, the Asia-Pacific region is forecasted to grow fastest at 6.82% through 2017.⁴⁶ Mintel Global New Product Database, Chicago, IL, reported that there were 20 times as many whole grain product introductions in 2010 as in 2000. Mintel also reported that in 2006, 1601 whole grain product introductions took place and five years later in 2011, whole grain product introductions more than doubled to 3,378. Of those introductions in 2011, 1228 were bakery products, 1,039 were breakfast cereals, and 484 were snack foods.⁴⁷

Currently, there are two FDA approved health claims for coronary heart disease and two claims for cancer that meet significant scientific agreement for the consumption of fiber-containing grain foods.

Title 21:101.77 Health claims: fruits, vegetables, and grain products that contain fiber, particularly soluble fiber, and risk of coronary heart disease.

(1) Diets low in saturated fat and cholesterol and rich in fruits, vegetables, and grain products that contain some types of dietary fiber, particularly soluble fiber, may reduce the risk of heart disease, a disease associated with many factors.

(2) Development of heart disease depends on many factors. Eating a diet low in saturated fat and cholesterol and high in fruits, vegetables, and grain products that contain fiber may lower blood cholesterol levels and reduce your risk of heart disease.

Title 21:101.76 Health claims: fiber-containing grain products, fruits, and vegetables and cancer.

(1) Low fat diets rich in fiber-containing grain products, fruits, and vegetables may reduce the risk of some types of cancer, a disease associated with many factors.

⁴⁶ Whole Grain Food Market to Hit \$26.7 Billion by 2017 with the U.S. Leading the Way, BakeryandSnack.com, Stephen Daniells, April 6, 2012, <http://www.bakeryandsnacks.com/Markets/Whole-grain-food-market-to-hit-27.6-billion-by-2017-with-US-leading-the-way>

⁴⁷ Idib.

(2) Development of cancer depends on many factors. Eating a diet low in fat and high in grain products, fruits, and vegetables that contain dietary fiber may reduce your risk of some cancers.⁴⁸

The Food and Nutrition Service of the USDA had determined on April 26, 2012 that the National School Lunch Program (NSLP) and School Breakfast Program (SBP) will phase in whole grain foods into its program. The requirements to offer whole grain-rich products will be phased in for the school meal programs over the next two school years (SY).

For school lunch, beginning July 1, 2012 (SY 2012-2013), through June 30, 2014 (SY 2013-2014), half of the grains offered during the school week must meet the whole grain-rich criteria. Beginning July 1, 2014, (SY 2014-2015), all grains must meet the whole grain-rich criteria.

For school breakfast, beginning July 1, 2013 (SY 2013-2014), half of the grains offered during the school week must meet the whole grain-rich criteria. Beginning July 1, 2014, (SY 2014-2015), all grains must meet the whole grain-rich criteria.

After SY 2013-2014, all grains must be whole grain-rich in order to meet NSLP and SBP nutrition standards. The USDA is in the process of updating several resources to assist school foodservice administrators and program operators with identifying whole grain-rich foods for availability by summer 2012.

In accordance with USDA Food and Nutrition Service NSLP and SBP regulations at 7 CFR Parts 210 and 220, the following criteria are to be used as the basis for crediting items to meet the whole grain-rich requirement: Foods that qualify as whole grain-rich for the school meal programs are foods that contain 100-percent whole grain or contain a blend of whole-grain meal and/or flour and enriched meal and/or flour of which at least 50 percent is whole grain. Whole grain-rich products must contain at least 50 percent whole-grains and the remaining grain, if any, must be enriched.⁴⁹

The Food and Nutrition Service's mandate of dramatically improving the nutritional quality of the National School Lunch Program and the School Breakfast Program by the 2014 school year will certainly accelerate the use of whole wheat products. To underscore the importance of the Food and Nutrition Service's pronouncement, attendance and interviews were accomplished at the Whole Grains Summit, From Theory to Practice, Minneapolis, MN on May 20-22, 2012.

⁴⁸ U.S. Food and Drug Administration, Health Claims Meeting Significant Scientific Agreement, January 5, 2011, <http://www.fda.gov/food/labelingnutrition/labelclaims/healthclaimsmeetingsignificantscientificagreements/default.htm>

⁴⁹ USDA, Food and Nutrition Service, Grain Requirements for the National School Lunch Program and School Breakfast Program, April 26, 2012, <http://www.fns.usda.gov/cnd/Governance/Policy-Memos/2012/SP30-2012os.pdf>

Key information was obtained at the Summit that supports the sea change caused by the USDA Food and Nutrition Service’s whole grain directive. Dr. Roger Clemens, Chief Scientific Officer, E.T. Horn, La Mirada, CA, stated that Americans are woefully deficient in dietary fiber intake. If all Americans achieved the 2010 USDA Dietary Guidelines for dietary fiber, currently, the U.S. would need more than 10.3 million acres of vegetable production, 4.7 million more acres of fruit production, 1.4 million more acres of whole grains (wheat, barley, oats, rice, cornmeal) production, which is a 3% increase in overall U.S. harvested cropland.⁵⁰

Dr. Sylvia Scott-Stump reported that whole grains are health promoting with the principal components, endosperm, germ, and bran. They provide fiber, phytochemicals, lignins, carbohydrates, protein, and antioxidants as components for a healthy diet. Whole grains have been shown to lower risk for chronic diseases such as obesity, type 2 diabetes, coronary heart disease, and certain cancers. Currently, only one percent of Americans adhere to the 2010 Dietary Guidelines for Americans’ recommendation of three whole grain servings per day.⁵¹

Ms. Kathy Wiemer, Registered Dietician, General Mills Bell Institute of Health and Nutrition, Minneapolis, MN, stated that modern millers have adopted the procedure of recombining wheat mill fractions after heat treating bran and/or germ to inactivate enzymes that would otherwise decrease the shelf life and the nutritional value of whole wheat flour.⁵² This recombination whole grain milling technology was confirmed by Dr. B. Jan-Willem van Klinken, Director of Nutrition, PepsiCo, Barrington, IL.⁵³ Dr. Mette Kristensen, Assistant Professor of Human Nutrition, University of Copenhagen, Denmark, added that human blood pressure is definitely reduced with whole grain consumption and that research has seen a 17% reduction in colon cancer with increased whole grain consumption.⁵⁴

Dr. Klinken stated that momentum is building rapidly for the increased consumption of whole grains. In the top 20 trends, as surveyed among chefs by the National Restaurant Association for 2012, is the preparation of healthful kid’s meals featuring whole grains. The replacement of 50% of refined grains with whole grains in commonly consumed school foods like breads, pizza, cereals, rice, and pasta can increase whole grain intake from 0.5 ounces per day up to 2.2 ounces per day. The target quantity of dietary fiber for school children is 6 grams per day compared to only today’s consumption rate of 0.6 grams per day.⁵⁵

The Center for Disease Control and Prevention published information on how rapidly Americans have become obese. Figure 9 shows by state in 1992, the percentage of adults who have a body mass index (BMI) over 30. A BMI of 18.5 – 24.99 is considered normal and a BMI of 25 to

⁵⁰ Whole Grains & Health: From Theory to Practice, Whole Grains Summit, 2012, May 20-22, 2012, Grains for Health Foundation, Minneapolis, MN.

⁵¹ Nutrition Research Review, 2004; 17:00 – 110.

⁵² Ibid: 50

⁵³ Ibid: 50

⁵⁴ Ibid: 50

⁵⁵ Ibid: 50

29.99 is considered overweight. Figure 10 shows the dramatic rise in the percentage of adults who have a BMI greater than 30.⁵⁶ These alarming statistics are driving the Federal government to improve its feeding programs starting with the school feeding programs.

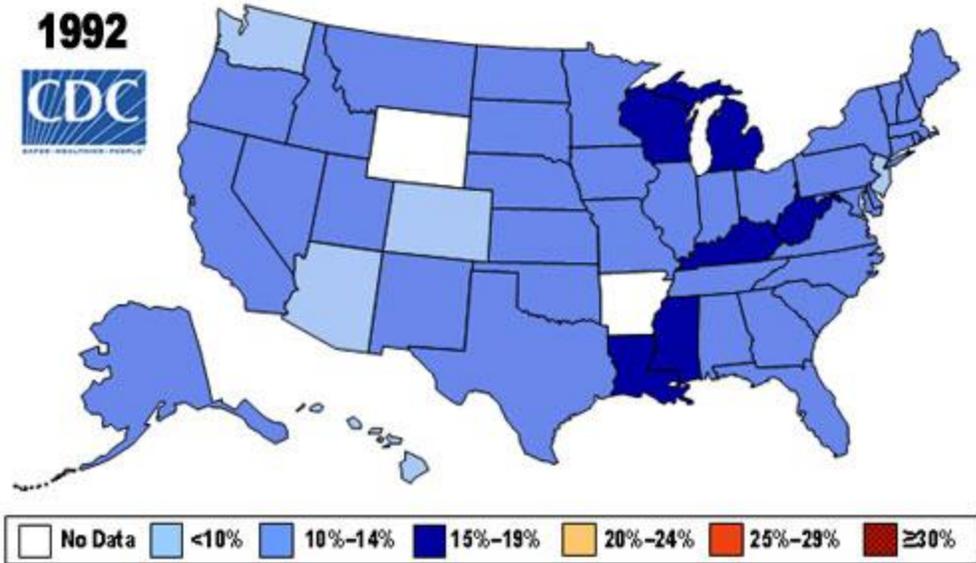


Figure 9: U.S. Obesity Rates in 1992 by State
 Source: Centers for Disease Control and Prevention

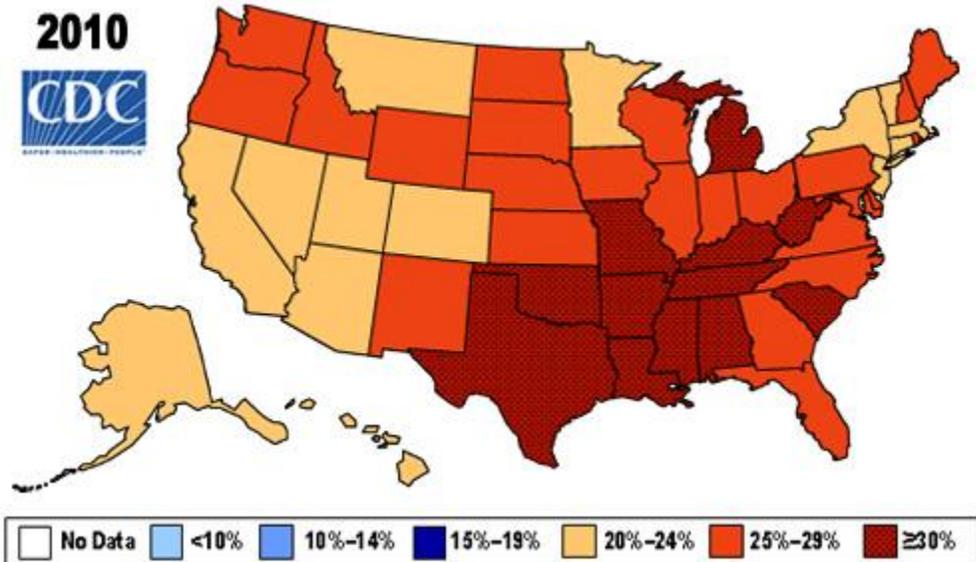


Figure 9: U.S. Obesity Rates in 1992 by State
 Source: Centers for Disease Control and Prevention

⁵⁶ Centers for Disease Control and Prevention, April 27, 2012, Website, <http://www.cdc.gov/obesity/data/adult.html/>

... The United Nations World Health Organization has published information on the accelerating increase in obesity across the globe.

- Worldwide obesity has more than doubled since 1980.
- In 2008, more than 1.4 billion adults, 20 and older, were overweight. Of these more than 200 million men and nearly 300 million women were obese.
- 65% of the world's population lives in countries where being overweight and obese kills more people than being underweight.
- More than 40 million children under the age of five were overweight in 2010.
- Obesity is preventable.⁵⁷

The Nielsen Company reported that whole wheat breads overtook white breads in sales in August of 2010.⁵⁸ As whole wheat continues to overtake refined grain, conventional thinking would reason that overall wheat demand will be reduced due to the shift of 30% of wheat's mill components, germ and bran, from animal feed to human consumption. This may be the case for a potential wheat acreage reduction overall, however, whole wheat products generally require elevated protein levels to ensure whole wheat flour products have equivalent rheological and texture characteristics of refined wheat flour products.

The requirement for elevated protein levels for whole wheat products is an opportunity for Minnesota wheat growers, due to their ability to provide high quality wheat with superior rheological properties. Wheat produced in Minnesota will be in higher demand than lower protein level wheat grown in other parts of the U.S. and the world.

Whole Grain Foods Growth - Affect on Minnesota Wheat Growers

Volume Potential – Very High - >5 million bushels annually
Premium Potential – Low - < \$0.20/bushel
Technical Probability of Success – Very High – In Production
Timeframe for Commercialization – Very High – In Production
Cost of Development – Low – Done by Food Manufacturers
Entrepreneurial Potential – High – New Whole Grain Foods

MN Research and Development Recommendations

Support Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN (Dr. James Anderson) agronomy research on improving hard white spring wheat varieties.

⁵⁷ United Nations World Health Organization, Geneva, Switzerland, 2012 Website, <http://www.who.int/mediacentre/factsheets/fs311/en/index.html>

⁵⁸ Small Victory: Whole Wheat Bread Sales Outpace White Bread in the Past Year, Fiber is the Future, Katie Clark, <http://fiberisthefuture.com/2010/08/small-victory-whole-wheat-bread-sales-outpace-white-bread-in-the-past-year/>

Focus on yield improvement, baking quality, straw strength, reduction of pre-harvest sprouting, and importantly, reduction of polyphenol oxidase activity (makes noodles and other products grey in color over time).

Focus on improvement of the post-harvest Identity Preserved delivery, storage, and distribution supply chain.

Monitor varietal improvements from WestBred, AgriPro, ADM, North Dakota State University, South Dakota State University, and Agriculture and Agri Food Canada.

Hard White Wheat

Very High Priority

Category: Characteristic of Wheat

Market: Existing

“Stealth Health” for Kids by the USDA “How to Trick Kids into Eating Whole Grains”

Introduction of Whole White Wheat Food Products into the School Feeding System is the Gateway for Training America’s Youth to Accept and Choose Whole Grain Foods to Combat the Obesity and Diabetes Epidemic. Over time the gradual introduction of Whole Red Wheat Products can Overcome Color, Taste and Texture Objections.

A very important subset of whole wheat consumption is whole white wheat consumption. As was previously stated, the USDA Food and Nutrition Service had fostered “Stealth Health” for children with regard to the nation’s school feeding programs.⁵⁹ A prime example of Stealth Health is the utilization of whole white wheat flour to mask the visual, taste, and texture objections normally associated with children’s perception of whole wheat foods. Wheat breeders, millers, and food manufacturers involved in school feeding through foodservice have embraced the use of whole white wheat to stealthily introduce whole grains into the school foodservice industry.

Industry and scholarly experts project that hard white wheat “represents a major opportunity for increasing wheat use in Asian noodles and whole wheat products” moving forward.⁶⁰ Such experts point to the preference seen among international buyers for white wheat products, and note that research institutions around the nation have put effort into breeding new varieties of hard white wheat over the past two decades to meet that demand, potentially offering producers new crop options suited to their needs.⁶¹

While the 2002 NAWG report projected a medium-high technical probability of success for the crop, it did note that the crop faced challenges as U.S. producers were “hesitant to grow HWW without a defined market outlet.” This warned challenge appears to have come into play over the past 10 years. According to industry sources, while overall production of white wheat in 2008/2009 was 255 million bushels,⁶² hard white wheat production in 2009 was only a fraction

⁵⁹ Ibid, 50

⁶⁰ Graybosch, Robert A. et. al., “New Uses for Wheat and Modified Wheat Products,” chapter from *Wheat: Science and Trade*, Brett F. Carver, editor. (Wiley-Blackwell, 2009). Pg. 521.

⁶¹ Ibid., pg. 525.

⁶² USDA ERS <http://www.ers.usda.gov/data/wheat/YBtable10.asp>

of this total- 26 million bushels.⁶³ The class did, however, show signs of growth when compared to the U.S. total production of 10 million bushels cited by the 2002 NAWG study.

There are signs that demand will support production levels beyond this level of growth. According to published reports, U.S. internal demand consumes the vast majority of hard white wheat produced in the nation, leaving international buyers, which present a potentially much larger market, with limited U.S. sources for the product. With hard white wheat often serving as the “preferred wheat of commerce in a number of international markets,”⁶⁴ due to its differentiation from Hard Red Wheat on a number of use qualities, it appears that there will be continued demand for growth in the class. However, the issue of attracting buyers and persuading producers to start growing a new crop appear to remain a challenge to the sector, as noted in the 2002 report

ConAgra Foods, Inc. stated that it has been working with a wide range of food manufacturers to increase the level of whole grains in their foods, as reported at the recent 2012 annual Institute of Food Technology conference in Las Vegas in the last week in June.⁶⁵ ConAgra is a leader in the development of whole white wheat flour product offerings. With incoming mandates for increasing the level of whole grains in the National School Lunch Program and with a documented concern for the rise in childhood obesity, Con Agra has called upon food manufacturers to reformulate their products to increase the level of whole grain content.⁶⁶

Mr. Bill Stoufer, President, ConAgra Mills, Omaha, NE stated that the school feeding requirement for whole grain foods in 2014 has added renewed growth in new product development and existing product modification in the food industry. Mr. Stoufer indicated that the focus for millers and food manufacturers is to ensure that taste and texture of familiar foods are maintained upon reformulating with whole grains.⁶⁷ ConAgra introduced Ultragrain to the food industry in 2004. Ultragrain is a whole white wheat flour product (proprietary hard and soft varieties) produced with patented milling technology. Ultragrain allows food manufacturers to add whole wheat to their product offerings while minimizing the alteration of taste and texture of familiar products, such as pizza crusts, bread, rolls, pasta, and snack foods.⁶⁸

⁶³ “Hard white wheat outlook improves,” June 2011, http://www.agriculture.com/crops/wheat/production/hard-white-wheat-outlook-improves_145-ar16926 The total breaks down to 18 million bushels of Hard White Winter, and 8 million bushels of Hard White Spring.

⁶⁴ Graybosch, pg. 526

⁶⁵ Kids’ Foods ‘Big Opportunity for Whole Grains’: ConAgra, FoodNavigator-USA.com, June 28, 2012, Caroline Scott-Thomas, <http://www.foodnavigator-usa.com/Market/Kids-foods-big-growth-opportunity-for-whole-grains-ConAgra>

⁶⁶ Kids’ Foods ‘Big Growth Opportunity for Whole Grains’: Con Agra, BakeryandSnack.com, Caroline Scott-Thomas, June 28, 2012, http://www.bakeryandsnacks.com/Markets/Kids-foods-big-growth-opportunity-for-whole-grains-ConAgra/?utm_source=newsletter_daily&utm_medium=email&utm_campaign=Newsletter%2BDaily&c=w7NdkSriWl3DrnwUkJhRqg%3D%3D

⁶⁷ Ibid, 50

⁶⁸ ConAgra Mills, Ultragrain-The future of Whole Grains Today, Website, http://www.conagramills.com/our_products/ultragrain.jsp

ConAgra Mills' competitors, ADM Milling (Diamond White Whole Wheat Flour), Bay State Milling (GrainEssentials White Whole Wheat Flour), Horizon Milling (Wheat Select White Spring Wheat Flour), and North Dakota Mill and Elevator (Specialty White Spring Wheat Flour) have committed abundant resources toward supplying the whole grains food marketplace with white wheat flour products to shift the American diet toward whole grains without increasing plate waste due to inferior taste and texture.

Food and nutrition experts in the federal government are committed to reversing the obesity and diabetes epidemic in the U.S. Most American children have become accustomed to consuming enriched, refined grains when given a choice between refined and whole grains. In order to obtain objective information on increasing whole grain consumption with children, Texas A&M collaborated with the University of Minnesota on a USDA Food and Nutrition Service study. Seven studies were conducted in 2007 through 2009.

Dr. Cynthia Warren, Institute for Obesity Research and Program Evaluation, Texas A&M, Denton, TX stated that the studies culminated with school children in 43 U.S. states and territories that studied hamburger buns, sandwich bread, pasta, tortillas and pancakes. Using Horizon Milling (Cargill) Wheat Select White Spring Wheat Flour as the base flour ingredient, students ranked the whole grain products acceptable with the pancakes and tortillas scoring the highest. Students ranked color (white) as the most important attribute with flavor (lower bitter phenolic compounds compared to red wheat) second and texture following flavor.⁶⁹ Dr. Warren stated that the Osseo, MN public schools were included in the study and that the students in Osseo gave the whole grain products from white spring wheat high marks. The challenge is to provide highly acceptable whole wheat foods on a budget of only \$2.05 per meal.⁷⁰

Ms. Karen Wilder, Director of Scientific and Regulatory Affairs, Schwan Foods, Marshall, MN, stated that her company has worked diligently to formulate whole grain foods for school foodservice customers. Schwan Food's LiveSmart School Initiative seeks, among other goals, to convert its grain based products, such as pizza crusts, to 51% whole grain by 2014. Ms. Wilder stated their food scientists have worked in collaboration with major milling companies such as Horizon Milling, ADM Milling, and ConAgra Mills to produce highly acceptable whole grain products for school lunch programs nationwide. Schwan Foods is utilizing whole white wheat flour to ensure acceptability by students in the school lunch program.⁷¹

Mr. Chance Elm, Director of Research and Development, MOM Brands (formerly Malt-O-Meal Company), Northfield, MN stated that MOM Brands has been developing new whole grain hot and ready-to-eat cereal products. Mr. Elm pointed out that there is an intersection in the

⁶⁹ Ibid, 50

⁷⁰ Ibid, 50

⁷¹ Ibid, 50

breakfast cereal industry marketplace where whole grains can feature health-driven benefits, great taste and eye appeal, while providing great consumer value. Whole grain cereals are well suited for weight management, healthy heart maintenance, and digestive health improvement.⁷²

The opportunity for Minnesota Wheat Growers is to engage white spring wheat breeders to optimize hard white wheat varieties for Minnesota's wheat growing regions. WestBred LLC was recently acquired by Monsanto in July 2009 for \$45 million. This acquisition gave Monsanto an excellent platform to expand its wheat genetics portfolio. WestBred has a number of hard white spring wheat varieties in test plots with their Hyalite variety in commercial production.⁷³

AgriPro Seed, Inc. was purchased by Garst Seed Company, Inc., Slater, IA in 1998 and Garst was acquired in 2004 by agricultural inputs giant Syngenta, a Swiss company. AgriPro has developed the hard white spring wheat variety, Alpine, which is marketed through Dakota Pride Cooperative, Jamestown, ND.⁷⁴ Northern plains farmers who raise Alpine wheat utilize Dakota Pride Cooperative to market that variety of hard white spring wheat primarily to the North Dakota State Mill and Elevator.⁷⁵ Alpine white wheat is a certified seed variety listed by the North Dakota State Certified Seed Department, Fargo, ND.⁷⁶

The North Dakota State Mill and Elevator reported that they expect to continue to grow their hard white spring wheat flour offerings.⁷⁷ The March 2008 issue of Prairie Grains expressed ambivalence toward hard white spring wheat production, distribution and end use. A primary agronomic issue stated was pre-harvest sprouting with existing varieties.⁷⁸ Private company wheat breeders are well aware of that issue and are engaged in addressing pre-harvest sprouting. With the boost from the USDA Food Nutrition Service's directive on increasing whole grain consumption in school feeding programs, the demand for hard white spring wheat will increase and offer greater opportunity for Minnesota Wheat Growers to diversify their crop options.

Hard White Wheat Growth - Affect on Minnesota Wheat Growers

Volume Potential – High - > 10 million bushels annually

Premium Potential – Medium - < \$0.35/bushel

Technical Probability of Success – Very High – Requires Agronomic Research

Timeframe for Commercialization – Short – Varieties Currently Available

⁷² Ibid, 50

⁷³ Monsanto's Wheat Platform, 2012, Website, <http://www.monsanto.com/products/Pages/wheat.aspx>

⁷⁴ Agripro Syngenta, Hard Spring Wheat, 2012, Website, <http://agriprowheat.com/wheat-variety/northern-plains/alpine>

⁷⁵ Direct Communication with North Dakota State Mill and Elevator, Grand Forks, ND

⁷⁶ North Dakota State Certified Seed Department, Fargo, ND, http://www.nd.gov/seed/field_directory/index.aspx

⁷⁷ Ibid, 41

⁷⁸ Prairie Grains, Where are We with White Spring Wheat?, Issue 91, March-April 2008.

Cost of Development – Medium – Private and University Wheat Breeders Engaged
Entrepreneurial Potential – Very High – New Product Development Opportunities

Research Recommendation

Support Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN (Dr. James Anderson) agronomy research on improving hard white spring wheat varieties.

Focus on yield improvement, baking quality, straw strength, reduction of pre-harvest sprouting, and importantly, reduction of polyphenol oxidase activity (makes noodles and other products grey in color over time).

Focus on improvement of the post-harvest Identity Preserved delivery, storage, and distribution supply chain.

Monitor varietal improvements from WestBred, AgriPro, ADM, North Dakota State University, South Dakota State University, and Agriculture and Agri Food Canada.

Biotech Wheat and Barley

High Priority (or Perhaps No Priority)

Category: Characteristic of Wheat and Barley

Market: New

The National Association of Wheat Growers, U.S. Wheat Associates, North American Millers Association, Independent Bakers Association, and the Wheat Foods Council published “The Case for Biotech Wheat,” where the group stated that biotechnology can make a significant contribution to position wheat as a viable production alternative for growers.⁷⁹ The group supports a goal of increasing average wheat yield by 20% by 2018 by using biotechnology and non-biotechnology methods.

Wheat-related organizations have become alarmed at the spread of a wheat stem rust pathogen known as UG-99 that is thought to have originated in Uganda. Even though conventional wheat breeding has identified wheat varieties that have UG-99 resistance, wheat-related organizations advocate for the use of biotechnology to accelerate the development of disease resistant wheat varieties. Wheat markets in Europe, Japan, and South Korea are generally opposed to the introduction of biotech wheat into their food distribution systems.⁸⁰ These areas are major markets for U.S. wheat, and wheat breeding programs in the U.S. have adopted a go-slow approach toward the eventual introduction of biotech wheat into the human food network.

Dr. Matthew Morell, Commonwealth Scientific and Industrial Research Organization, Clayton, Victoria, Australia stated that transgenic wheat is on its way. Agronomic improvements from biotechnology will have the highest priority initially in order to increase wheat yield and overall crop quality. Possible wheat improvements from biotechnology for the future could include high beta-glucan, high amylose, ultra low gluten, high mineral content, high vitamin content (folate), epa oils, resistant starch, high arabinoxylan, and increased fructooligosachharides; all for improving human health. It is important to note that biotech wheat will require Identity Preservation from point of innovation through consumption. Any added value from biotechnology must exceed added costs to provide profitability throughout supply chains.⁸¹

Improving Agronomic Yield

⁷⁹ The Case for Biotech Wheat, How the Introduction of Modern Genetic Technology in Wheat Can Help Address a Competitiveness Crisis, September 17, 2009, <http://www.wheatworld.org/wp-content/uploads/biotech-case-for-biotech-wheat-20090917.pdf>

⁸⁰ Ibid

⁸¹ Ibid, 17

Building on Monsanto's, Dow Agrisciences', and other biotech companies' previous experience with soy and corn, biotech products in wheat could be developed in less than 10 years with potential agronomic traits for higher yields including:

- improved yield
- drought tolerance
- reduced fertilizer (nitrogen) use
- herbicide tolerance traits
- disease resistance

Once agronomic enhancements take place with biotech wheat and the consuming public is accepting of the technology, specialty wheat characteristics can be introduced to enhance wheat quality. Some of the current needs in the area of wheat characteristics are:

Low Phytate Wheat

Phytic acid is the storage mechanism for phosphorus in wheat bran and is known as phytate. Phytate is not digestible in humans or nonruminant animals. Phytate also binds dietary iron and zinc and thereby removing those bound minerals from absorption. Phytic acid is also an antioxidant and may be involved in the prevention of certain cancers. The reduction of phytate in wheat through biotechnology would assist the absorption of minerals in humans and nonruminants.⁸²

High Folate Wheat and Barley

In 1998, the U.S. established the folic acid fortification plan to reduce the incidence of neural tube defects in newborns. Folic acid, a B-vitamin, is involved in many other metabolic benefits that include heart health and preventing cancer. Biotech methodology can produce wheat and barley with not only high folate levels but improve the bioavailability of folate for absorption into the body.

High Antioxidant Wheat and Barley

Biotech methodology has the potential to increase antioxidant levels in wheat and barley and also has the potential of increasing the bioavailability of antioxidants. A good example is breeding the characteristic of free, bioavailable ferulic acid in wheat and barley. Ferulic acid is a potent antioxidant in grain, but most is bound to arabinoglycan biopolymers.

Omega 3 Fatty Acids from Wheat and Barley

⁸² Phytic Acid, How Far Have We Come?, M.Ali, et.al., African Journal of Biotechnology Vol. 9(11), pp. 1551-1554, 15 March, 2010, <http://academicjournals.org/ajb/PDF/pdf2010/15Mar/Ali%20et%20al.pdf>

Omega 3 fats from cold water fish have been well established in the literature as an excellent source of nutrition. As cold water fish become depleted and the risk of heavy metal contamination from consuming fish oil increases, plant sources of Omega 3 fatty acids becomes more important.

Biotech Wheat Growth - Affect on Minnesota Grain Growers

Volume Potential – High - > 10 million bushels annually

Premium Potential – Low - < \$0.10/bushel

Technical Probability of Success – High – Requires Biotech Research

Timeframe for Commercialization – Low – Estimate at 10 years

Cost of Development – High – Private and University Wheat Breeders

Entrepreneurial Potential – Low – Focus on Yield Improvement

Research Recommendation

Monitor Biotech wheat and barley advances by University and private companies. Monitor the attitudes of primary wheat customers Japan, South Korea, and the European Union for acceptance of biotech wheat.

Transgenic Wheat and Barley Enhancements

High Priority

Category: Characteristic of Wheat and Barley

Market: New or Emerging

The USDA Agricultural Research Service (ARS) has embarked upon utilizing transgenic or biotech means to enhance grain to meet certain goals. Transgenic techniques can use biotechnology or traditional breeding methodologies. Areas of interest of the ARS are shown below.

Wheat with High Molecular Weight Glutenins

Minnesota wheat exhibits superior rheological characteristics primarily due to their high amount of High Molecular Weight (HMW) Glutenins. Researchers at the USDA Agricultural Research Service (ARS) have successfully expressed HMW Glutenins in winter wheat. The scientists used genetic engineering methods to increase the copy number of genes encoding specific HMW glutenin subunits. The results were an increase in the HMW glutenin subunits in both the grain and milled flour. There was no change in grain yield or physical grain qualities except for an increase in hardness, which is detrimental to milling. There was a marked increase in dough strength and in fact, the dough strength was too strong for commercial use.⁸³

Transgenic increases of HMW glutenins in all wheat classes could have either benefits or detriments for Minnesota Wheat Growers. On the benefit side, the promise of standardizing high gluten strength in Minnesota grown wheat by adjusting gene expressed glutenin levels according to environmental factors could improve the preference for Minnesota wheat in the wheat supply chain. On the detriment side, HMW glutenin increases in softer wheat could improve their rheological characteristics to the level that reduces the demand for harder wheat grown in Minnesota. It is most likely that transgenic enhancements in wheat will occur on the agronomic side first to increase yield without affecting milling and baking performance. It is likely that only after transgenic agronomic enhancements are accepted and in practice years from now will transgenic increases in HMW glutenins occur.

HMW Glutenins Enhancement - Affect on Minnesota Wheat Growers

Volume Potential – High - > 10 million bushels annually

Premium Potential – Low or High – Can Soft Wheat Compete with Hard Wheat?

Technical Probability of Success – High – Agronomic Research Reported

Timeframe for Commercialization – Long – Requires Biotech Acceptance

Cost of Development – Medium – Private and University Wheat Breeders Engaged

⁸³ Genetic Improvement and Evaluation of Hard Winter and Hard Spring Wheats, Cereal Chemistry. 88(1):95-102., Robert Graybosch, et. al., http://www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=258227

Entrepreneurial Potential – Very Low – Affects Wheat Supply Chain Primarily

Research Recommendation

None

Low Calorie or Low Carbohydrate Flour in Wheat and Barley

The USDA Food and Nutrition Service has determined that the inclusion of increased amounts of fruits, vegetables, and whole grains in the American diet is the answer to combating the obesity and diabetes epidemic that we are currently fighting. A reduction in the carbohydrate level or calorie level in wheat is an interesting concept that was gaining momentum to be in vogue when the 2002 New and Improved Wheat Uses Audit was researched and published. The Atkins Diet, low carbohydrate – high protein – high fat, reached its peak in 2003 to 2004 for 30 million Americans and has since waned to the level of a specialty diet for a small subset. Current nutrition emphasis advocates a balance of proteins, fats, and complex carbohydrates; all of which are represented in whole grains. Future efforts to produce wheat or barley with low calories or low carbohydrates would require transgenic research.

Low Calorie or Low Carbohydrate - Affect on Minnesota Wheat and Barley Growers

Volume Potential – Very Low - < 100,000 bushels annually

Premium Potential – Medium – >\$0.50 per bushel

Technical Probability of Success – Low – Biotech Research Required

Timeframe for Commercialization – Long – Requires Biotech Acceptance

Cost of Development – Medium – Private and University Wheat Breeders Engaged

Entrepreneurial Potential – Very Low – Long Development Timeline

Research Recommendation

None

Non-Allergenic Wheat

In 2009, the Mayo Clinic released the results from a study that stated that the incidence of celiac is four times more common in the U.S. than in the 1950's. The Mayo Clinic conducted the study in collaboration with the University of Minnesota School of Medicine.⁸⁴ The presence of gluten protein in wheat, barley, or rye triggers an attack on the immune system, which in turn, destroys the villi in the small intestine. Researchers are unsure of the dramatic increase in what was a rare disease, but now affects one in every 100 Americans.

⁸⁴ Mayo Clinic Study Finds that Celiac Disease is Four Times More Common than in the 1950's, July 1, 2009, Mayo Clinic Website, <http://www.mayoclinic.org/news2009-rst/5329.html>

The use of biotechnology could enhance wheat by reducing the gliadin protein content in wheat that is responsible for celiac disease response. Even though glutenin protein is more important for baking quality, the removal of gliadin protein could be detrimental for baking performance. Researchers would have to ensure that the inherent qualities of wheat should be maintained while removing gliadin protein from wheat. A nonallergenic wheat crop would have to engage in the most stringent identity preservation protocol in order to ensure that the crop would not be contaminated with conventional grains.

Nonallergenic Wheat - Affect on Minnesota Wheat Growers

Volume Potential – Medium - < 1 million bushels annually
Premium Potential – Medium – >\$0.50 per bushel
Technical Probability of Success – Medium – Biotech Research Required
Timeframe for Commercialization – Long – Requires Biotech Acceptance
Cost of Development – Medium – Private and University Wheat Breeders Engaged
Entrepreneurial Potential – Medium – New Food Products Potential

Research Recommendation

None

Waxy Wheat

Waxy wheat is wheat that has amylopectin starch, but has no amylose starch. Conventional wheat has 76% amylopectin and 24% amylose. Waxy wheat, for years, was a solution in search of a problem.⁸⁵ In recent years, waxy wheat flour has been targeted for use in products that need structural integrity when subjected to the rigors of refrigeration or freezing. Recent studies of waxy wheat showed that its bread baking qualities are very limited due to dark color and poor appearance with large gas cells in the crumb with the loaf becoming unstable and collapsing. Blending 50% waxy wheat flour with conventional wheat flour did not significantly improve quality.⁸⁶

The USDA ARS is researching the modification of waxy starch wheat using biotechnology to derive wheat varieties with unique starch characteristics.⁸⁷ Kampffmeyer Food Innovations, Gmbh, Hamburg, Germany is marketing a type of waxy wheat flour for use in processed

⁸⁵ New Waxy Wheat Presents Innovation Opportunities, FoodNavigator-USA.com, Lorraine Heller, November 25, 2005, <http://www.foodnavigator-usa.com/Science/New-waxy-wheat-presents-innovation-opportunities>

⁸⁶ Protein and Quality Characterization of Complete and Partial Near-Isogenic Lines of Waxy Wheat, Jonnala, et. al. Cereal Chemistry, Nov 10, 2010, Vol. 87:6, pp 538-545, http://www.aaccnet.org/publications/cc/2010/November/Pages/87_6_538.aspx

⁸⁷ USDA, ARS, Dr. Robert Graybosch Research Objectives, Jan 18, 2012, <http://www.ars.usda.gov/pandp/people/people.htm?personid=2095>

foods.⁸⁸ Biotech modification of waxy wheat could improve the use of wheat starch as a food thickener.

Waxy Wheat - Affect on Minnesota Wheat Growers

Volume Potential – Low - < 100,000 bushels annually
Premium Potential – Low – <\$0.10 per bushel
Technical Probability of Success – Medium – In Production
Timeframe for Commercialization – Medium – In Production, Markets Needed
Cost of Development – Medium – Private and University Wheat Breeders Engaged
Entrepreneurial Potential – Low – Used as food manufacturing ingredient

Research Recommendation

None

⁸⁸ Kampffmeyer Food Innovations, Gmbh, Website, <http://kfi.kampffmeyer.com/en/products/functional-flours/thickening-systems/waxy-wheat>

Nutraceuticals/Pharmaceuticals from Wheat (and Barley)

Very High Priority

Category: Characteristic of Wheat

Market: New

Wheat (and barley) possesses significant quantities of compounds that can positively affect human and animal health. The wide range of positive nutritional properties of wheat include carbohydrates, proteins, fibers, minerals, vitamins, antioxidants (polyphenols) and phytates. Interestingly, the effects of the nutritional properties within wheat and barley can be dramatically enhanced through physical, chemical, or biological processing.

A discussion with Dr. David Gallaher, who is a Professor in the Department of Food Science and Nutrition at the University of Minnesota, St. Paul, MN, revealed exciting research currently being conducted. Dr. Gallaher studies the effects of wheat and wheat components on lab rates. His studies have shown that red wheat is far more effective at reducing precancerous lesions in carcinogen-treated rats than white wheat. Dr. Gallaher has developed a proprietary method of releasing ferulic acid (an antioxidant) from arabinoglycans (biopolymer) from wheat bran which promises to have potential of lowering cholesterol as shown in rat studies.

Ferulic Acid also has shown that it decreases adiposity (fat storage) in lab animals. Most phenolic compounds, such as ferulic acid, are bound to wheat bran and aleurone biopolymers and are not available for absorption by humans. By cost effectively releasing phenolic compounds, wheat bran and aleurone flour could provide significantly more antioxidant properties than untreated mill fractions alone. Dr. Gallaher stated that additional research could reveal positive prevention and treatment of diabetes, colon cancer, atherosclerosis, and macular degeneration with antioxidants from grains.⁸⁹

Dr. Ronald Madl, Director, Bioprocessing and Industrial Value Added Program, Grain Science and Industry, Kansas State University, Manhattan, KS, stated that the aleurone layer, particularly, in wheat, oats, and barley have very significant levels of a wide range of antioxidants. The antioxidants have profound effects on preventing and treating cancer. Dr. Madl is seeking to develop an understanding of how to breed grain with uniform levels of antioxidants and link them to cancer suppression in test animals.⁹⁰

By confirming the health related effects of wheat and barley nutraceuticals (and potentially pharmaceuticals), the value of varieties specific for each isolation process could dramatically increase the value of grain.

⁸⁹ Ibid, 42

⁹⁰ Ibid, 43

Nutraceuticals/Pharmaceuticals Growth - Affect on Minnesota Wheat and Barley Growers

Volume Potential – Low - < 1 million bushels annually

Premium Potential – Very High - < Up to 2X Conventional per bushel

Technical Probability of Success – High – Requires Advance Research

Timeframe for Commercialization – Long – Market Development Required

Cost of Development – High – Protection of Intellectual Property

Entrepreneurial Potential – High – New Product Development

Research Recommendation

Support University of Minnesota (Dr. Dan Gallaher), Food Science and Nutrition research on wheat and barley antioxidant effects on test animals.

Organic Wheat and Barley

Very High Priority

Category: Characteristic of Wheat and Barley

Market: Existing

The U.S. was the largest market for organic foods in 2011 with 45% of the global marketplace. The U.S. had \$31.5 billion in sales according to the Organic Trade Association's "2012 Organic Industry Survey." The survey identified that the U.S. organic market grew by \$2.5 billion in 2011 with the fruit and vegetable category contributing almost 50% of the 2011 sales increase.⁹¹ The Organic Trade Association conducted a study entitled, "2011 U.S. Families Organic Attitudes and Beliefs Study" that found that 78% of American families are buying some organic foods and that 72% of parents are familiar with the USDA Organic Seal. The study reported that one third of households surveyed were new entrants into the organic market.⁹² The Tabs Group Inc. conducted the "2011 Annual Organic Products Study" and reported that people under age 30 bought a larger number of differing organic products compared to people over 60 years of age. The study concluded that increased loyalty to organic products by young people will likely proportionately increase organic product sales and market share over time.⁹³

The U.S. Census Bureau reported USDA data where U.S. organic wheat acreage grew from 181,000 acres in 2000 to 416,000 acres in 2008.⁹⁴ The Minnesota Department of Agriculture published its 2012/13 Directory of Organic Farmers that shows dozens of Minnesota farmers engaged in the production of organic small grains.⁹⁵

The USDA Agricultural Marketing Service reported in May 2012 that organic food grade wheat averaged \$14.30 per bushel and organic feed grade wheat averaged \$10.98 per bushel.⁹⁶ Conventional hard red spring wheat cash prices during May 2012 was \$7.45 to \$7.85 per bushel.⁹⁷ Organic food grade wheat was reported in tight supply during direct discussions with a major organic mill, the North Dakota State Mill and Elevator. The North Dakota Mill is

⁹¹ Organic Trade Association, 2012 Press Releases, Consumer Driven U.S. Organic Market Surpasses \$31 Billion in 2011, April 23, 2011, <http://www.organicnewsroom.com/>

⁹² Organic Trade Association, 2011 Press Releases, Seventy-Eight Percent of U.S. Families Say They Purchase Organic Foods, November 2, 2011,

http://www.organicnewsroom.com/2011/11/seventyeight_percent_of_us_fam.html

⁹³ Tabs, The Analytical Business Solution, Organic Products on the Rise, 2012,

<http://www.tabsgroup.com/2012/01/organic-products-on-the-rise/>

⁹⁴ U.S. Census Bureau, Section 17, Agriculture, 2011, <http://www.census.gov/prod/2011pubs/11statab/agricult.pdf>

⁹⁵ Minnesota Department of Agriculture, 2012/13 Directory of Organic Farmers,

<http://www.mda.state.mn.us/~media/Files/food/organicgrowing/organicdirectory.ashx>

⁹⁶ USDA Livestock and Grain Market News, National Organic Grain and Feedstuffs Report, June 2012.

⁹⁷ The Prairie Star, Spring Wheat Market Rebounds After Early May Slump, May 31, 2012,

http://www.theprairiestar.com/news/markets/spring-wheat-market-rebounds-from-early-may-s slump/article_51e78686-aa9f-11e1-b7c3-0019bb2963f4.html

interested in increasing organic wheat acreage in Minnesota.⁹⁸ Low prices in 2010 and adverse weather conditions in 2011 reduced availability of organic hard red spring and winter wheat and have affected pricing into 2012. Figure 10 shows data from the USDA Economic Research Service Agricultural Resource Management Survey that in 2009, organic wheat farmers earned much more than conventional wheat producers.⁹⁹

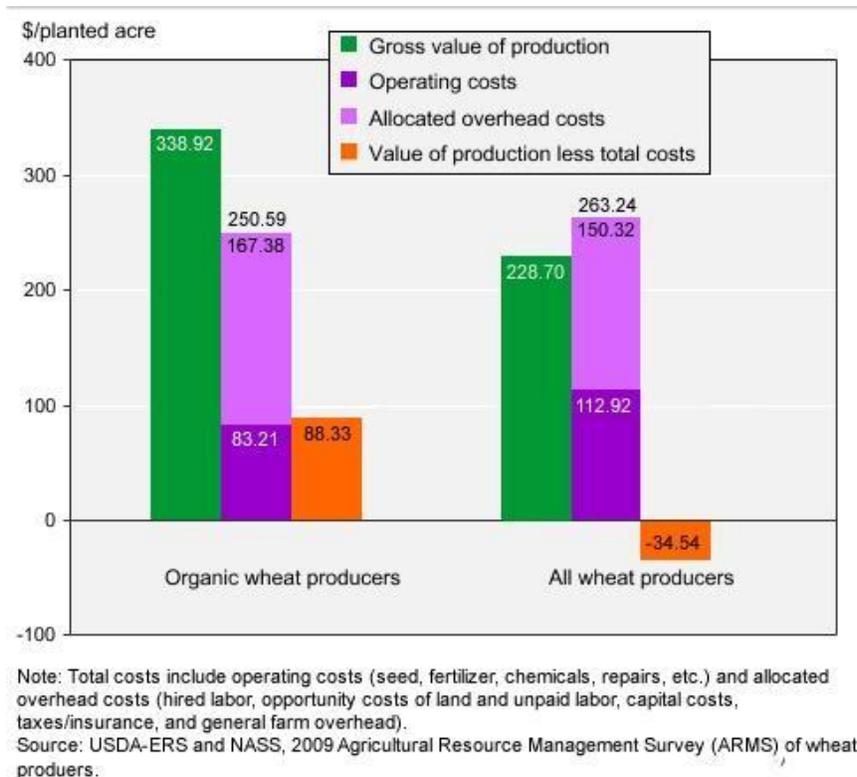


Figure 14: Value of Organic Farming Wheat vs. Traditional Farming Wheat

Organically grown and certified livestock and poultry must be fed organically certified feed. Organic barley grown in Minnesota is generally in the form of organic feed barley. According to Grain Millers, Inc., Eden Prairie, MN, organic barley is rapidly becoming a major feed ingredient in the fast growing Organic Dairy Industry.¹⁰⁰ Organic grain prices dropped precipitously in the recession years of 2008 through 2010 but have now rebounded. Organic feed barley prices are now nearly double conventional feed barley prices.

Organic Wheat and Barley Growth - Affect on Minnesota Wheat Growers

⁹⁸ Ibid, 41

⁹⁹ Organic Wheat Producers Earn Much More Than Conventional Wheat Producers in 2009, Big Picture Agriculture,

¹⁰⁰ Grain Millers, Inc., Feed Ingredients, Website, http://www.grainmillers.com/Feed_Ingredients.aspz

Volume Potential – Medium - < 5 million bushels annually
Premium Potential – Very High - < Up to 2X Conventional per bushel
Technical Probability of Success – High – Requires Intense Management
Timeframe for Commercialization – High – Markets Currently Available
Cost of Development – Low – 3 Year Land Transition
Entrepreneurial Potential – Very High – Marketing in the Grower Hands

Research Recommendation

Support the Minnesota Department of Agriculture’s Organic Production and Certification Program.

Support the University of Minnesota’s Minnesota Institute for Sustainable Agriculture

Perennial Wheat and Barley

Low Priority

Category: Characteristic of Wheat

Market: New

Michigan State University-Kellogg Biological Station has made large strides toward developing a commercially viable perennial wheat crop. They have wheat sourced from Washington State University and the Land Institute in Kansas that lives for seven years. The work is in its infancy, however, if yield and wheat quality trials are successful, the varieties will be transferred to organic farmers for commercial evaluation. Researchers have pointed out that they believe that perennial wheat is not a replacement for annual wheat, but is an alternative that could be instrumental in rebuilding soil health.¹⁰¹

Perennial Wheat and Barley Growth - Affect on Minnesota Wheat and Barley Growers

Volume Potential – Low - < 1 million bushels annually

Premium Potential – Very Low - < \$0.01per bushel

Technical Probability of Success – Low – Yield and Quality Requirements

Timeframe for Commercialization – Long – Minimum Decade of Testing

Cost of Development – High – Staff and Land Requirements for Years

Entrepreneurial Potential – Low – Traditional Alternative

Research Recommendation

None

¹⁰¹ Perennial Wheat Research at KBS, Kellogg Biological Station, Michigan State University, East Lansing, MI, <http://www.kbs.msu.edu/people/faculty/snapp/perennial-wheat>

High Beta-Glucan Barley

Very High Priority

Category: Characteristic of Barley

Market: Emerging

Consumption of beta-glucans (soluble fiber) from oats and barley have been shown to lower serum cholesterol in humans. Barley contains resistant starch that is only digested by colon bacteria. ConAgra has introduced SustaGrain® High Fiber Barley Flour to the marketplace. More than 50% of SustaGrain® is dietary fiber of which 40% is beta-glucan. This level of dietary and soluble fiber is three times the level in whole oats. This makes SustaGrain® a low Glycemic Index flour for blood sugar maintenance. SustaGrain® High Fiber Barley is available in flour or flake form. The flakes are suitable to be cooked as a hot cereal.¹⁰² Mr. Ron Ueland, President of Northern Seeds, LLC, Conrad, MT (former president of WestBred) and owner of BG Life Barley has stated that the health benefits of barley are so important that barley should have been the dominant grain grown in the world.¹⁰³

A Crookston, MN-based company, PolyCell Technologies, had developed a high beta-glucan barley concentrate (28% beta-glucan content) and launched the company in 2000. Currently, PolyCell Technologies sells its products in 32 countries. The company produces its Barley Balance® 28% beta-glucan and Bran Balance™ products in Canada and markets Glucage1™ a 75% beta-glucan product made in India. PolyCell Technologies has alliances with DKSH Performance Materials, Zurich, Switzerland, SunOpta Ingredients Group, Chelmsford, MA, Petrus Chemicals and Materials Ltd., Israel, EN Nutrition, Malaysia and other International marketing companies.

Mr. Tom Jorgens, President, has stated that momentum is growing for public acceptance and demand for barley beta-glucan rich foods and nutraceuticals. PolyCell Technologies has been sponsoring dietary and medical research at Oxford University, England on the positive effects on glycemic levels, satiety, weight loss, and blood glucose management through the consumption of barley beta-glucan concentrates.

The PolyCell Technologies web site points out that the European Food Safety Authority (EFSA) announced on December 8, 2011 that its Panel on Dietetic Products, Nutrition and Allergies has issued its scientific opinion that Beta-glucan from Barley lowers blood cholesterol and reduces the risks of developing coronary heart disease. In order to make a Claim, a food or beverage product must contain 1 gram of barley beta-glucan in each serving. In the European Union,

¹⁰² SustaGrain®, ConAgra Milling Company Website, http://www.conagramills.com/our_products/sustagrain.jsp

¹⁰³ Direct Communication, Ron Ueland, Northern Seed, LLC, Conrad, MT.

barley beta-glucan now carries comparable Article 14 Health Claim standing that had been earlier awarded for oat beta-glucan.¹⁰⁴ Recently a Heart Health Claim was also given by Health Canada.

Poly-Cell Technologies markets its products as ingredients for food, nutraceutical, and dietary supplement companies. An exciting area of developing interest stated by Mr. Jorgens is the incorporation of PolyCell Technologies barley-based products into healthy beverages. As consumers seek food and nutritional products with increased health benefits from beta-glucan products, barley is becoming the preferred grain source due to efforts by PolyCell Technologies and others.

High Beta-Glucan Barley Growth - Affect on Minnesota Barley Growers

Volume Potential – Medium - >5 million bushels annually
Premium Potential – Medium - < \$0.25per bushel
Technical Probability of Success – High – In Production
Timeframe for Commercialization – Short – In Production
Cost of Development – Low – Agronomy to Raise Beta-Glucan Levels
Entrepreneurial Potential – High – Develop New Food Products

Research Recommendation

Support Department of Agronomy and Plant Genetics, University of Minnesota, St. Paul, MN (Dr. Kevin Smith) agronomy research on improving hulled and hullless barley varieties.

Focus on yield improvement, beta-glucan level, and straw strength.

Focus on improvement of the post-harvest Identity Preserved delivery, storage, and distribution supply chain.

Monitor varietal improvements from WestBred, AgriPro, ADM, North Dakota State University, South Dakota State University, and Agriculture and Agri Food Canada.

Maintain an open dialogue with PolyCell Technologies to discuss future potential manufacturing opportunities for PolyCell Technologies products within the State of Minnesota.

¹⁰⁴ Polycell Technologies Web Site, www.poly-cell.com

New or Improved Uses for Wheat By-Products

Wheat (and Barley) Straw Composites

Medium Priority

Category: Use of Straw

Market: Emerging

Major paper companies also appear to be exploring the use of wheat as a production material moving forward. Kimberly Clark, as part of a new goal to shift production to 50% alternative fibers by 2025, has been developing and “test marketing tissue products made in part with alternative fibers, including wheat straw.”¹⁰⁵

Demand for biodegradable paper-like packaging products could also open up markets for wheat straw based products. Ultra Green, a biodegradable food packaging company, recently announced plans to expand its wheat straw based production at new facilities in North Dakota.¹⁰⁶ Other companies have also looked to wheat straw as an alternative to sugarcane based products, or more traditional, non biodegradable components.¹⁰⁷ Ford Motor Company is using a wheat straw reinforced plastic in its Ford Flex vehicles starting in 2010.¹⁰⁸

One of the most successful wheat board manufacturing facilities is the Masonite Primeboard facility located in Wahpeton, ND. The company began operations in 1995 and has expanded its operation to become the world’s largest composite board manufacturer that utilizes wheat as its primary structural material. Many other wheat straw composite start-ups (in Minnesota, the Dakotas, Canada, and Kansas) have failed in wheat growing regions around the world. Many wheat growers lost money on those investments and are reluctant to reinvest in the technology.

Discussions with Dr. Chad Ulven, Professor, Department of Mechanical Engineering, North Dakota State University, Fargo, ND, and with Dr. Ulrike Tschirner, Professor, Department of

¹⁰⁵ “Kimberly-Clark to Use 50% Alternative Wood Fiber by 2025,” Environmental Leader, June 19, 2012.

<http://www.environmentalleader.com/2012/06/19/kimberly-clark-to-use-50-alternative-wood-fiber-by-2025/>

¹⁰⁶ “Wheat straw fiber plant planned for ND”, Agweek, March 12, 2012.

<http://www.agweek.com/event/article/id/19626/>

¹⁰⁷ “Excellent Packaging launches wheat straw containers”, The Packer, June 27, 2011.

<http://www.thepacker.com/fruit-vegetable-news/Excellent-Packaging-launches-wheat-straw-containers-124591644.html>

¹⁰⁸ Wheat Deal, Ford Uses Wheat Straw, MotorTrend, Scott Evans, Nov 11, 2009.

Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN indicated significant research was underway to use crop residue in composite plastics for a wide range of products. As discussed Ford Motor Company is using wheat straw plastic and other large companies, such as John Deere and Agco, are interested in applying the technology to their composite components on machinery.¹⁰⁹

Wheat and Barley Straw Composites - Affect on Minnesota Wheat and Barley Growers

Volume Potential – Low - < 100,000 tons annually
Premium Potential – Very Low - < \$50 per acre
Technical Probability of Success – Medium – In Production
Timeframe for Commercialization – Medium – In Production
Cost of Development – Medium – High Capital Costs
Entrepreneurial Potential – Very Low – High Capital Costs

Research Recommendation

None

¹⁰⁹ Direct Communications.

Ethanol from Wheat or Barley Straw or Middlings

Low Priority

Category: Use of Straw

Market: New

Producing biofuels from lignocellulosic feedstock is technically feasible as shown by the USDA ARS.¹¹⁰ Ethanol can be produced from wheat straw using enzymatic technology or gasification technology. The issue is that producing ethanol from wheat straw by either method is not cost competitive to producing ethanol from corn. Great River Energy conducted a study to determine whether they could establish and profitably operate a cellulosic ethanol production facility next to their coal fired power plant located in Spiritwood, ND. Their evaluation showed that the production of ethanol from wheat straw would not be cost effective at this time even though the lignin produced by the process could be burned in its power plant and that secondary steam could supply heat for ethanol production.

The derivation of biofuels from wheat straw could be feasible in the future with new technology to effectively produce glucose from cellulose. The federal government has authorized the issuance of up to \$1 billion in grants, loan guarantees, and other assistance for the development of cellulosic ethanol since 2007. So far, there is no appreciable volume generated using cellulosic ethanol guarantees.¹¹¹ At present, cellulosic ethanol from grain straw is many years from fruition.

Ethanol from Straw - Affect on Minnesota Wheat and Barley Growers

Volume Potential – Medium - < 1 million tons annually
Premium Potential – Very Low - < \$50 per acre
Technical Probability of Success – Low – Extensive Research Required
Timeframe for Commercialization – Very Long – 10 years
Cost of Development – Very High – High Capital Costs
Entrepreneurial Potential – Very Low – High Capital Costs

Research Recommendation

None

¹¹⁰ Continuous Production of Ethanol from Wheat Straw Hydrolysate, USDA, ARS, Badal Sahs, August 27, 2010, http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=255891

¹¹¹ Biofuels Incentives, A summary of Federal Programs, Congressional Research Service, Jan 11, 2012, <http://www.fas.org/sgp/crs/misc/R40110.pdf>

Combustion Energy from Wheat and Barley Straw

Medium Priority

Category: Use of Straw

Market: New

Dr. Roger Ruan, Professor, Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN, has developed a unique microwave system to provide on-the-farm electrical energy through the combustion of wheat or barley straw. His methodology involves grinding straw, microwave heating straw through pyrolysis, converting heat into electrical energy, and capturing ash (fertilizer) and sludge (lignins, antioxidants, etc.). His system is located as a stationary unit on the St. Paul campus and as a mobile unit on a 52 foot truck flatbed. Both units serve as demonstration units to determine how cost effective the units can be for farm use.

The project was started when all energy costs started to climb. At this time, natural gas is selling at the well head for about \$3.00 a dekatherm, which is a bargain. However, not everyone has access to natural gas, so the Straw Pyrolysis Combustion Mobile Unit could be of use for off gas line grid use. Dr. Ruan is evaluating the economics of the system at this time. On farm straw could be pelletized prior to pyrolysis as well; however, the energy required for pelletizing could prove to be economically detrimental.¹¹²

Ethanol from Straw - Affect on Minnesota Wheat and Barley Growers

Volume Potential – Medium - < 1 million tons annually
Premium Potential – Very Low - < \$50 per acre
Technical Probability of Success – Medium – Pilot Unit Tested
Timeframe for Commercialization – Short – Equipment Specified
Cost of Development – Medium – Off the Shelf Components
Entrepreneurial Potential – Medium – Market to Off Grid Users

Research Recommendation

Support Dr. Roger Ruan, Professor, Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN, research to have units be cost competitive.

¹¹² Direct Communication, . Roger Ruan, Professor, Department of Bioproducts and Biosystems Engineering, University of Minnesota, St. Paul, MN

Other Potential New or Improved Uses

Chips, Tortillas, Nut Substitutes from Barley

High Priority

Category: Use of Barley

Market: New

Discussions with Dr. Nancy Ames, Research Scientist, Agriculture and Agri-Food Canada Research Centre, Winnipeg, MB, Canada, revealed that her research group has been successful in developing tortillas and snack foods with barley flour. Remarkably, by selecting the proper barley flour, Dr. Ames' tortillas can be made with two ingredients: water and barley flour. Dr. Ames reported that her barley tortillas and barley snack chips scored very well in organoleptic testing.¹¹³

Coffee and Tea Substitutes from Wheat and Barley

Medium Priority

Category: Use of Barley

Market: New

Coffee and tea contain abundant levels of antioxidants as do wheat and barley kernels. Coffee and tea also naturally contain caffeine. Coffee and tea substitutes made from wheat and barley have been produced for a century; however, limited research has gone into the antioxidant benefits from roasted wheat and coffee beverages. As the benefits of wheat and barley antioxidants become better known, the wheat and coffee beverage markets may emerge as well.

¹¹³ Direct Discussion, Dr. Nancy Ames, Research Scientist, Agriculture and Agri-Food Canada Research Centre, Winnipeg, MB, Canada

Conclusion

Minnesota Wheat and Barley Growers will witness a turnaround in eating habits in America starting with our young people. The USDA Food and Nutrition Service's mandate requiring whole grains in school feeding programs should provide the impetus toward consuming whole grains in much larger quantities.

Minnesota has historically been a producer of high-quality, high-functionality grains. The new whole grain requirement will need high-protein wheat and high-functionality barley to ensure that whole grain products fed to our populace will meet and exceed their expectations.

Communicating the tremendous health benefits potential of antioxidants and other nutrients in wheat and barley will turn the public's attention toward the consumption of more whole wheat and barley, as well as specialty products that provide high levels of nutrition. The nation is at a crossroads concerning its obesity and diabetes epidemic and it is up to Wheat and Barley Growers in concert with federal, state, and private industry authorities to educate the public on the benefits of consuming wheat and barley.

Appendix I: Minnesota Companies

Minnesota Brewers and Maltsters

August Schell Brewery
1860 Schell Road
New Ulm, MN 56073
Phone: 800-770-5020

Barley John's Brew-Pub
781 old Highway 8 SW
New Brighton, MN 55112
651-636-4670

Big Wood Brewery
985 E. Berwood Ave.
Vadnais Heights, MN
55110
612-360-2986

Boathouse Brew Pub
47 East Sheridan St.
Ely, MN 55731
218-365-4301

Boom Island Brewing
Company
2201 2nd Street North
Minneapolis, MN 55411

Borealis Fermentary
PO Box 130
Knife River, MN 55609
218-834-4856

Brau Brothers Brewing
201 1st Street
Lucan, MN 56255
507-747-BEER

Canal Park Brewing
Company
300 Canal Park Drive
Duluth, MN 55802

Carmody Irish Pub &
Brewing
308 E. Superior St.
Duluth, MN 55802
218-740-4747

Castle Danger Brewery
3067 E. Castle Danger Rd.
Two Harbors, MN 56073
218-834-5800

Cold Spring Brewing
219 Red River Ave N
Cold Spring, MN 56320
320-685-8686

Dubroe
211 East 2nd St.
Duluth, MN 55805
218-341-0988

Excelsior Brewing
Company
421 3rd Street | Excelsior,
MN 55331 | 952-474-7837

Finnegan's
609 South 10th St., Suite
102
Minneapolis, MN 55404
612-454-0615

Fitger's Brew House
600 E Superior Street
Duluth, MN 55802
218-279-2739

Flat Earth Brewing
Company
2035 Belmont Avenue
St. Paul, MN 55116
651-698-1945

Fulton Beer
440 6th Ave. N.,
Minneapolis, MN 55401
612-333-3208

Granite City Food &
Brewery
3330 Pilot Knob Road
Eagan, MN 55121
651-452-4600

Great Waters Brewing
Company
426 St. Peter St.
St. Paul, MN 55429
651.224.BREW

Harriet Brewing Company
3036 Minnehaha Ave
Minneapolis, MN 55406
651-491-8979

The Herkimer
2922 Lyndale Ave S.
Minneapolis, MN 55408
612-821-0101

Indeed Brewing Company
711 15th Ave NE
Minneapolis, MN 55413
612-843-5090

Lake Superior Brewing
Company
2711 W Superior St # 204
Duluth, MN 55806
218-728-4000

Leech Lake Brewing
Company
195 Walker Industries Blvd
Walker, MN 56484-1364
218-547-4746

Lift Bridge Brewing
Company
1900 Tower Drive
Stillwater, MN 55082
888-430-BEER

Lucid Brewing
6020 Culligan Way
Minnetonka, MN 55345
612-412-4769

Mankato Brewery
1119 Center Street
North Mankato, MN 56003
507-386-2337

Minneapolis Town Hall
Brewery
1430 Washington Ave S
Minneapolis, MN 55454
612-339-8696

Northbound Smokehouse
& Brewpub
2724 East 38th St.
Minneapolis, MN 55406
612-208-1450

Northgate Brewing
3134 California Street NE
#122
Minneapolis, MN 55418

Olvalde Farm & Brewing
16557 County Road 25
Rollingstone, MN 55969
507-205-4969

Rock Bottom Brewery
800 LaSalle Plaza
Minneapolis, MN 55402
612-332-2739

Staple Mills Brewing
Company
402 Main Street North
Stillwater, MN 55082 651-
472-5552

Steel Toe Brewing
4848 W 36th Street
St. Louis Park, MN 55416
952-955-9965

Summit Brewing Company
910 Montreal Circle
St. Paul, MN 55102
651-265-7800

Surley Brewing Company
4811 Dusharme Dr.
Brooklyn Center, MN
55429
763-535-3330

Third Street Brewhouse
219 Red River Ave N
Cold Spring, MN 56320
320-685-8686

Vine Park Brewing
Company
1254 West 7th Street
St. Paul, MN 55102
651-228-1355

612 Brew
945 Broadway Street Suite
#188
Minneapolis, MN 55413
612-217-0437

A Perfect Pint
3725 38th Ave. S.
Minneapolis, MN 55406
612-724-4514

Brewers Supply Group
800 West First Ave.
Shakopee, MN 55379
800-374-2739

Cargill, Inc.
P.O. Box 9300
Minneapolis, MN 55440-
9300
800-227-4455

The Four Firkins
5630 W. 36th St.
St. Louis Park, MN 55416
952-938-2847

Midwest Supplies
5825 Excelsior Blvd.
Minneapolis, MN 55416
952-925-9854

Rahr Malting Co.
800 West First Avenue
Shakopee, MN 55379
952-445-1431

Minnesota Composite Materials Manufacturers

Natur-Tec®
4201 Woodland Rd., P.O. Box 69
Circle Pines, MN 55014 USA
Phone: +1(763) 404-8700

PackNBoxNow
8600 Wyoming Ave. N.
Minneapolis, MN 55445
866-493-7725

NatureWorks LLC
15305 Minnetonka Boulevard
Minnetonka, MN 55345
952-742-0400

All-Pak, Inc.
4800 Quebec Ave. N
New Hope, MN 55428
612-522-8291

Advanced Extrusion, Inc.
14300 Liberty Ln.
Becker, MN 55308
763-262-4480

Conwed Plastics
1300 Godward St. NE #5000
Minneapolis, MN 55413
800-426-6933

Minnesota Wheat Starch Utilization Companies

3M Corporate Headquarters
3M Center
St. Paul, MN 55144-1000
888-364-3577

NQP Starch & Chemicals
P.O. Box 240972
St. Paul, Minnesota 55124
952-953-3446

Minnesota Cat Litter Company

Pet Care Systems (Farmers Union Industries, LLC)
1421 Richwood Road
Detroit Lakes, MN 56502
800-794-3287

Minnesota Cosmetic Manufacturing Companies

TMC Industries, Inc.
1423 Mill Lane
Waconia, MN 55387
952-442-1140

Aveka, Inc.
2045 Wooddale Dr.
St. Paul, MN 55125
651-730-1729

Birchwood Laboratories, Inc.
7900 Fuller Rd.
Eden Prairie, MN 55344
952-937-7921

Aurora Henna Company
5010 Highway 169
North Minneapolis, MN 55428
763-592-4770

Kapra Cosmetics
655 19th Ave.
Minneapolis, MN 55418
612-782-3941

Apex International
134 Columbia Court
Chaska, MN 55318
952-227-3000

Z Bigatti Labs
235 Roselawn Avenue East
St. Paul, MN 55144
651-489-2058

Minnesota Ethanol Facilities

Bushmills Ethanol, Inc. Atwater, MN	Fergus Falls, MN	Winthrop, MN
Chippewa Valley Ethanol Company Benson, MN	Poet, LLC Glenville, MN	Gevo-Agri-Energy, LLC Luverne, MN
Poet, LLC Bingham Lake, MN	Granite Falls Energy, LLC Granite Falls, MN	Archer Daniels Midland Company Marshall, MN
Purified Renewable Energy, LLC Buffalo Lake, MN	Heron Lake BioEnergy Heron Lake, MN	Denco II, LLC Morris, MN
Al-Corn Clean Fuel Claremont, MN	Guardian Energy Janesville, MN	Poet, LLC Preston, MN
Buffalo Lake Energy Corp. Fairmont, MN	Poet, LLC Lake Crystal, MN	Valero Renewables Welcome, MN
Green Plains Renewable Energy, Inc.	Highwater Ethanol, LLC Lamberton, MN	Corn Plus Ethanol Winnebago, MN
	Central MN Ethanol Co-op Little Falls, MN	
	Heartland Corn Products	

Minnesota Turkey and Aquaculture Feed Companies

Holden Farms, Inc.
12346 Hall Avenue
Northfield, MN 55057

ADM Alliance Nutrition, I
1101 Elliott Avenue S.
Glencoe, MN

All American Co-op
113 4th St. SE
Stewartville, MN

Big Gain, Inc.
416 Matthews St.
Mankato, MN

Buffalo Lake Mill, LLC
300 Milwaukee Road
Buffalo Lake, MN

Burkel Grain Service, Inc.
Highway 11 East
Greenbush, MN

Cargill, Inc., Nutrena Feeds
100 County Road 43
Big Lake, MN

CHS Nutrition
202 6th Avenue
Madison, MN

Devenish Nutrition
2222 Lake Avenue
Fairmont, MN

FCA Coop
127 County Road 23
Jackson, MN

Form-A-Feed, Inc.
740 Bowman St.
Stewart, MN

Golden Plump Poultry
Farms
6070 Lark Road NW
Sauk Rapids, MN

Greenwald Elevator, Inc.
151 1st Ave. S.
Greenwald, MN

Harvest Land Cooperative
Highway 67 West
Morgan, MN

Hubbard Feeds, Inc.
3rd Ave. & Harper St.
Mankato, MN

JBS United, Inc.
310 2nd Ave. SW
Waseca, MN

Jenny-O Turkey Store
Highway 212 & 25
Dawson, MN

Klapheke Feed Mill, Inc.
36177 County Road 186
Melrose, MN

Land O' Lakes Purina Feed,
LLC
1110 13th Avenue SE
Detroit Lakes, MN

Nutripro Feeds
501 Oxford St.
Worthington, MN

The Feed Mill
321 Center Ave. N.
Madelia, MN

Melrose Feed Mill, Inc.
224 E. 1st St. S.
Melrose, MN

Meschke Poultry
19157 Twin Lakes Road
Little Falls, MN

Meyer Turkey Farms
Rural Route #3
Worthington, MN

Munson Feed Company,
Inc.
118 North 3rd Ave. N.
Melrose, MN

Munson Lakes Nutrition
917 6th St.
Howard Lake, MN

New Vision Coop
867 1st Avenue
Windom, MN

Quali Tech, Inc.
318 Lake Hazeltine Drive
Chaska, MI 64

Ralco-Mix Products, Inc.
1600 Hahn Road
Marshall, MN

Ridley Block Operations
County Hwy 35 East
Worthington, MN

Royal Milc, Inc.
8860 Upper 208th St. West
Lakeville, MN

Sargeant Grain Company
West Main Street
Sargeant, MN

Trouw Nutrition USA, LLC
917 N Business 71
Willmar, MN

United Farmers
Cooperative
316 North Main
LeSueur, MN

United Mills
330 Dupont Avenue
Renville, MN

Watonwan Farm Service
823 First Avenue South
St. James, MN

Farm Service Elevator
3939 West First Avenue
Willmar, MN

Western Consolidated
Cooperative
121 Central Avenue
Sunburg, MN

Westway Feed Products,
LLC
2225 Childs Road
St. Paul, MN

Minnesota Flour Milling and Malt Manufacturing Companies

CHS, Inc.
5500 Cenex Drive
Inver Grove Heights, MN
651-355-6000

General Mills, Inc.
1 General Mills Blvd.
Minneapolis, MN 55440
800-248-7310

Horizon Milling, LLC
15407 McGinty Road West
Wayzata, MN
952-742-7575

Grain Millers, Inc.
10400 Viking Drive, Suite
301
Eden Prairie, MN
952-829-8821

Sun Opta Grains and
Foods, Inc.
3824 SW 93rd St.
Hope, MN
507-451-4724

Cargill, Inc. (Malt)
15407 McGinty Road W.
Wayzata, MN
952-742-7575

Rahr Malting Company
(Malt)
800 1st Avenue West
Shakopee, MN
952-445-1431

Canadian Harvest USA, LP
1001 Cleveland Street S.
Cambridge, MN
763-689-5800

Loon Foods, Inc.
8057 James Avenue North
Minneapolis, MN
763-569-0026

Mgi Grain Processing, LLC
316 5th Ave. NE
East Grand Forks, MN
218-773-7564

Domata, LLC
5424 Grove Street
Minneapolis, MN
952-303-5484

Swany White Flour Mill
206 2nd St. SE
Freeport, MN
320-836-2174

Natural Way Mills
24509 390th St. NE
Middle River, MN
218-222-3677

Sportsman's Recipes, Inc.
8565 Highway 65 NE
Minneapolis, MN
763-780-3170

ADM Milling, Atkinson Mill
3745 Hiawatha Avenue
Minneapolis, MN
612-729-2301

Nutrition Mom, Inc.
107 4th St. NE
Montgomery, MN
507-491-0413

Whole Grain Milling Company
1579 120th Avenue
Welcome, MN
612-922-1159

Minnesota Malting Company (Malt)
918 North 7th Street
Cannon Falls, MN
507-263-3911

Busch Agricultural Resources, Inc. (Malt)
2101 26th St. S.
Moorhead, MN
218-236-747

Minnesota Breakfast Cereal Manufacturers

General Mills, Inc.
1 General Mills Blvd.
Minneapolis, MN 55440
800-248-7310

Kay's Processing, LLC
100 1st Ave. SE
Clara City, MN
320-847-3220

Mom Brands Company
80 S. 8th St.
Minneapolis, MN
952-322-8000

Nuvex, Inc.
1640 West 1st St.
Blue Earth, MN
507-526-7575

Minnesota Tortilla Manufacturers

Catallia Mexican Foods, LLC
2965 Lone Oak Circle
Eagan, MN 55121
651-647-6808

Tortilleria la Perla
1515 East Lake Street
Minneapolis, MN
612-728-5444

Tortillas Payan, LLC
2616 27th Ave. S.
Minneapolis, MN
612-724-1134

Gloria's Tortillas, Inc.
1517 Central Ave. NE
Minneapolis, MN
612-781-2388

Minnesota Wholesale Bakers

Gingerbread House
1104 Broadway Ave. N.
Rochester, MN
507-288-2621
Pan O Gold
7870 Fairview Road

Baxter, MN
218-825-9535
Metz Baking Company
653 Highway 34 East
Detroit Lakes, MN
218-847-5529

Oven Hearth Wholesale
Bakery
825 Montreal Way
St. Paul, MN
651-298-9666

Franklin Street Bakery
1020 East Franklin Ave.
Minneapolis, MN 55404
612-879-5730

651-224-5761

New Prague, MN
952-758-7021

Pj Murphy's Bakery
1279 Randolph Ave.
St. Paul, MN
651-699-9292

Taystee Bread
5490 Mountain Iron Drive
Virginia, MN
218-741-6754

Great Northern Baking
Company
443 Hoover St. ND
Minneapolis, MN
612-331-1043
Baldinger Bakery
215 Eva Street
St. Paul, MN

Country Fresh Bakery
1924 S. 10th Street
Brainerd, MN
218-828-0804
New Prague Pie & Bread
306 2nd Ave. SW

Saint Agnes Baking
Company
644 Olive Street
St. Paul, MN
651-290-7633

Denny's 5th Avenue Bakery
7840 5th Avenue S.
Minneapolis, MN
952-881-4445

Holsum Bread
1417 Old West Main
Street
Red Wing, MN
651-388-4331

Wonder & Hostess
3803 3rd Avenue
Mankato, MN
507-625-4927

Minnesota Frozen Dough Manufacturers

General Mills, Inc.
1 General Mills Blvd.
Minneapolis, MN 55440
800-248-7310

Royal American Foods, Inc.
410 West Industrial Street
Le Center, MN
507-357-4161

The Schwan Food Company
115 West College Drive
Marshall, MN
(800) 533-5290

Best Brands Corp.
1765 Yankee Doodle Road
St. Paul, MN
651-454-5850

Gregory's Foods, Inc.
1301 Trapp Road
St. Paul, MN
651-454-027

Minnesota Snack Foods Manufacturers

Mahnomen Baked Chips LLC
850 E. Adams Ave.
Mahnomen, MN
218-936-5670

Cookies By Design
10100 6th Avenue North
Minneapolis, MN
763-545-5777

Lucore Foods
800 Lasalle Ave.
Minneapolis, MN
612-338-6751

Barrel O' Fun
800 4th St. NW
Perham, MN
218-346-7000

Edible Solutions
17934 68th Avenue North
Maple Grove, MN
763-592-9771

Old Dutch Foods, Inc.
2375 Terminal Rd.
St. Paul, MN
651-633-8810

Minnesota Nutraceutical Manufacturing Companies

Amerilab Technologies, Inc.
2765 Niagara Lane North
Minneapolis, MN
763-525-1262

Blue Mountain Nutraceuticals, LLC
1643 Roberts Street South
West St. Paul, MN
651-765-9759

UAS Laboratories, Inc.
9953 Valley View Road
Eden Prairie, MN
952-935-1707

Chemi Nutraceuticals Inc.
4463 White Bear Parkway
St. Paul, MN
651-407-0400

ANC Americas Nutraceutical
31265 County 24 Blvd.
Cannon Falls, MN
507-263-7996

Medisyn Technologies, Inc.
6109 Blue Circle Drive
Minnetonka, MN
952-475-8084

Suntava, LLC
3290 South St. Croix Trail
Afton, MN
651-998-0723