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B R I E F I N G

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An Overview of the Wheat Gluten Industry

Michael Boland, Gary W. Brester, Mykel R. Taylor

Agricultural Marketing Policy Center
Linfield Hall
P.O. Box 172800
Montana State University
Bozeman, MT 59717-2920
Tel: (406) 994-3511
Fax: (406) 994-4838
email: ampc@montana.edu
website: www.ampc.montana.edu

Contact:

Gary W. Brester
(406) 994-7883
gbrester@montana.edu

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Introduction

Approximately 80 percent of U.S. spring wheat is produced in Montana, North Dakota, and South Dakota. In Montana, about 3.5 million acres of spring wheat (other than durum) are planted annually. This represents about 60 percent of total wheat plantings. Montana's semi-arid climate encourages the production of high protein levels in spring wheat. Wheat protein contains gluten which is necessary for producing high-quality baked products. Historically, protein premiums have been available in years when the overall U.S. wheat crop has contained relatively low protein levels.

Wheat gluten is included in baked goods either through the use of high-protein wheat in flour production or as an additive during dough production. Thus, wheat gluten additives are substitutes for high protein wheat. Wheat gluten additives are produced from wet wheat milling processes. The competitiveness of the wheat gluten industry has changed in recent years. In addition, the industry has been the subject of international trade rulings which have altered competitive strategies of U.S. producers. Thus, understanding the wheat gluten industry is important for hard spring wheat producers because wheat gluten is a substitute for their products. This Briefing describes the wheat milling, flour, and baking industries as it relates to gluten production.

The Wheat Production, Milling, and Baking Industries

A typical bushel of wheat weighs 60 pounds. Three parts of a wheat kernel -- endosperm, bran, and germ -- are separated during dry milling processes. The endosperm (50 pounds) is the source of white flour and contains the greatest proportions of protein, carbohydrates, iron, and major B-vitamins such as riboflavin, niacin, and thiamine. The bran (8.5 pounds) is included in whole wheat flour (or marketed separately) and contains a small proportion of protein, trace minerals, dietary fiber, and major B-vitamins. Germ (1.5 pounds) is the embryo or sprouting section of the seed. It has a high fat content (10 percent) that, if not separated from endosperm during flour production, causes dough to be unmanageable.

Wheat kernels are covered with bran coatings that contain the greatest amounts of fiber and protein. A layer of aleurone, which also contains protein, lies under the bran. The endosperm is composed of thin-walled starch cells. Starch contains gluten particles that provide cohesiveness in dough.

Although endosperm contains most wheat protein, its protein quality is lower than that in the bran and germ because it is less concentrated. Approximately 80 percent of protein is gluten. Thus, as wheat protein levels increase, so does the amount of gluten.

Production

The wheat marketing chain consists of three distinct stages: production, milling, and baking. Wheat is produced on farms in most regions of the United States. The U.S. Department of Agriculture categorizes wheat into six classes: durum, hard red winter, soft red winter, hard red spring, hard white, and soft white. All other wheat is described as 'unclassed' wheat. Mixtures of wheat classes are described as 'mixed' wheat. Hard red winter and spring wheat are primarily used for making bread. Thus, bread producers are particularly interested in hard red winter and spring wheat protein levels.

Protein levels determine wheat end-uses. However, protein content depends upon several factors. First, wheat class is a major determinant of protein levels. Hard red wheat varieties typically have the highest protein levels among wheat classes. Conversely, soft wheat varieties tend to have the lowest protein levels among wheat classes. Second, protein levels vary within each wheat class depending upon wheat variety. Third, weather plays a large role in determining protein content through its effects on kernel size and growth. Relatively dry conditions reduces per acre yields but increase protein levels.

In general, wheat breeders select varietal development strategies by balancing yield and disease tolerance characteristics. These characteristics are more easily identifiable than milling characteristics. In addition, their effects on farm revenues are more easily quantifiable because protein premiums vary annually based upon weather factors that determine the supply of high protein wheat. Producers consider several factors in choosing the type of variety to plant but agronomic factors such as yield and drought tolerance are major factors (Boland, Dhuyvetter, and Howe).

Milling

After harvest, producers deliver wheat to grain elevators where it is aggregated and shipped to terminal elevators. At terminal elevators, wheat is generally sorted, graded, and measured for protein. Wheat is then marketed to flour millers. Flour millers separate wheat into starch, bran, germ, and flour. This process involves several steps. First, wheat is cleaned and moistened. Then, it is sent through various pairs of rollers that break the kernels into fine particles and separate the bran and flour. The particles are rolled and sifted until as much flour as possible is created. On average, 45 pounds of flour are milled from 50 pounds of endosperm. The remaining 5 pounds of endosperm is used as livestock feed.

Baking

Dough cohesiveness is largely determined by flour gluten levels. Different levels of cohesiveness are needed to produce specialty products such as whole grain breads, cakes, and pastries. Consequently, wheat protein levels partially determine end-use. Because protein levels vary annually because of weather, bakers supplement flour with gluten to improve dough cohesiveness. Bakers purchase ingredients several months in advance of their needs to maintain processing efficiencies and reduce uncertainty of flour protein levels.

Wheat Products from Wet Milling

Dry flour milling processes produce flour that is composed of protein (primarily gluten) and starch. Conversely, vital wheat gluten is produced using a wet milling process that fully separates starch and gluten (Boland, Domine, and Steigert). Wheat wet milling is a process in which flour is softened by soaking in warm water and an alkaline solution. A series of screens is used to separate protein that is dried into a powder. The protein is further separated into gluten and other specialty protein products. Approximately 80 percent of the protein is gluten.

A starch slurry is formed after gluten and wheat proteins have been extracted from the flour. The slurry is further processed to extract premium wheat starch. Wheat starch is dried into powder and sold in packaged or bulk form. The remaining slurry is mixed with water and either corn or sorghum, and enzymes are added to convert starch to glucose. Yeast is added to ferment glucose from the slurry. The resulting product is called stillage. Stillage is further separated into thin stillage and condensed distillers' solubles by removing solids. The residue of the distilling operation is dried and sold as a high protein additive for animal feed.

Vital Wheat Gluten

Vital wheat gluten is the only commercially available high protein food additive that has elastic characteristics when added to dough or otherwise reconstituted with water. Gluten has a bland flavor and is able to absorb more than two times its weight in water. Its elastic properties make it useful as an additive to baked products, breakfast cereals, and processed fish and meat products. Gluten's unique characteristics result from two main proteins -- glutenin and gliadin. Glutenin is responsible for the elastic character of vital wheat gluten. It increases the strength and toughness of bread dough, improves the freeze-thaw characteristics of frozen dough, and is used as a functional protein source in processed and restructured meat products. The use of too much glutenin produces overly strong dough. Gliadin, the smaller of the two molecules, is soluble in water and other liquids including alcohol, and is responsible for the viscous properties of wheat gluten. These characteristics make it ideal for improving the texture of noodles and pasta as well as crackers, cookies, and food coatings. Gliadin is also used in a number of cosmetics and personal care products. The use of too much gliadin produces soft, overly expansive dough.

Vital wheat gluten improves the texture, strength, shape, nutritional content, and volume of baked products. The cohesiveness and elasticity of gluten enables bread dough to rise. Vital wheat gluten is also added to white bread and hamburger bun dough to improve its strength and cohesiveness. Vital wheat gluten is added to hot dog bun dough to provide greater hinge strength.

Vital wheat gluten is a substitute for protein in wheat. When wheat (and resulting flour) protein levels are low, bakers add vital wheat gluten to flour. Conversely, if wheat protein levels are relatively high, bakers use little vital wheat gluten.

Wheat gluten is used almost exclusively in food manufacturing. Gluten use in the food market segment has increased in recent years because of increasing demands for refrigerated and frozen dough products that require stronger and more flexible dough. Most vital wheat gluten is used in bagels, hearth breads, and multigrain breads because it helps support the weight of ingredients such as raisins and nuts. Wheat gluten is sold to cereal manufacturing and baking companies such as Kellogg Co., H.J. Heinz, and Interstate Bakeries. Several Canadian wheat breeders are considering functional characteristics of glutenin and gliadin in wheat breeding programs. However, substantial improvements in gluten production from wheat breeding programs are not likely to occur soon. Consequently, no substitutes are available for vital wheat gluten other than the protein inherent in wheat.

Starch

Premium wheat starch and unique modified starches are used primarily as additives to improve the physical characteristics of food and industrial products. Food products such as cakes, pastries, and frostings include starch to improve palatability and texture. Industrial products such as special laminates for carbonless paper, wallpaper paste, and adhesives, and lubricants in oil drilling operations have been developed from wheat starch. The food and industrial products industries' demand for wheat starch is increasing slowly. Starch products are sold to firms such as Keebler, Pillsbury, and General Mills.

Alcohol

Wet wheat milling produces alcohol which has both food and industrial uses. Wheat beverage alcohol typically is processed into vodka and gin. Demand for alcohol in this segment is relatively stable. Demand for industrial alcohol is increasing, but synthetic alcohol has a dominate share of this market.

Demand for fuel alcohol (ethanol) is increasing because of regulatory policies banning the use of MTBE (methyl tertiary-butyl ether) as a fuel oxygenate. Most ethanol is produced from corn. The supply of fuel alcohol continues to expand faster than demand.
Distillers' feeds and carbon dioxide are the primary by-products obtained from alcohol production. Distillers' feeds are fed to livestock, and carbon dioxide produced during the fermentation process is sold for industrial uses.

Summary

Vital wheat gluten provides important characteristics to baked products and is included in dough production either by using high protein wheat flour or by adding it during dough production. Wheat classes and varieties within those classes produce contain different gluten levels. Gluten is also obtained from wet wheat milling processes along with starch, alcohol, livestock feed, and carbon dioxide.

References

Boland, M.A., N. Domine, and K. Steigert. "Midwest Grain Products: A Change in Strategy Due to Trade Issues." *International Food and Agribusiness Management Review* 3(2000): 457-72.

Boland, M.A., K. Dhuyvetter, and M. Howe. "Economic Issues with Certified and Bin-Run Wheat Seed." MF-2498, K-State Research and Extension publication, 2000.