Gluten-free Product Development

J. Engleson
Cargill, Inc.
Plymouth, MN

B. Atwell
Cargill, Inc.
Plymouth, MN

- Although it is considered a niche market, gluten-free bakery sales grew more than 56% last year.
- Gluten is a remarkably versatile ingredient that plays an important role in baked goods, particularly bread.
- It is important that we identify or create ingredients that can mimic the properties of gluten and formulate high quality, nutritious baked products with them.

Imagine not being able to enjoy freshly baked bread, not being able to have a steaming hot muffin with your coffee in the morning, or not being able to serve a cake to your child at his or her birthday party. This situation is the reality for the 1% of the global population afflicted with celiac disease. Actually the number of people affected is significantly higher as gluten-free diets are now being prescribed for many other ailments as well. Unfortunately the options for good quality, gluten-free bakery products in the marketplace are very limited and the cost associated with even low quality baked products is excessive. Developing baked products devoid of gluten is difficult and the degree of difficulty is closely associated with how functional gluten is in the particular product system. The quality of the products in the marketplace reflect this relationship. Good quality cookies are available. Batter based products are good but generally not at parity with their gluten containing counterparts. Breads are significantly inferior to those made from wheat flour. There is, however, a significant effort ongoing in our industry now to develop products in all of these categories that are the equivalent of their gluten containing complements.

Gluten-free Diets: Who Needs Them

Gluten is a protein complex found in the triticeae tribe of grains, which includes wheat, barley, and rye. The gluten protein complex, upon entering the digestive tract, breaks down into peptide chains like other protein sources, but the resulting gluten-related peptide chain length is longer than for other proteins. For this and other reasons, in some people, these longer peptides trigger an immune response commonly referred to as celiac disease. Celiac disease (CD) is an autoimmune disorder with genetic, environmental, and immunologic components at a prevalence of about 1% of the population, but this varies per country. It is characterized by inflammation, villous atrophy, and crypt hyperplasia in the intestine (2). In other words, tiny hair-like projections in the small intestine that absorb nutrients from food are damaged upon exposure to gluten. This interferes with the ability of the body to absorb basic nutrients like protein, carbohydrate, fat, vitamins, minerals such as calcium, and in some cases, water and bile salts. If CD is left untreated, damage to the small intestine can be chronic and life threatening, causing an increased risk of associated disorders such as anemia, osteoporosis, short statue, infertility, and neurological problems. Celiac disease is also associated with increased rates of cancer and other autoimmune disorders.

The early diagnosis of celiac disease, followed by treatment of celiac disease by eliminating gluten from the diet, leads to clinical and histologic improvement, thereby helping to reduce the probability that some of the associated, irreversible disorders will occur in a person diagnosed with celiac disease. A gluten-free diet is the mainstay of safe and effective treatment of celiac disease (2).

There are other medical reasons for following a gluten-free diet. The prevalence of gluten sensitivity is at least equal to the 1% prevalence of celiac disease. Gluten sensitivity is not an immune reaction necessarily, but it can be. Patients with Crohn's disease, ulcerative colitis, irritable bowel syndrome, dermatitis herpetiformis, or autism are sometimes recommended or prescribed to follow a gluten-free diet. In addition, some people experience an IgE-mediated response or allergy to wheat

Percentage of U.S. general population who strongly or somewhat agree

	General population	Adult with allergy	Child with allergy
I wish restaurants would carry more gluten free options	30%	37%	59%
I would like my store to carry more gluten free foods	28%	30%	48%
I would like my store to carry more wheat free foods	25%	29%	48%
I started buying gluten and wheat free foods because it's better for my family	17%	19%	38%

Source: NMI HealthBeat Interactive, 2006 (NMI)

Fig. 1. Children's food allergies are strong drivers of consumer buying behavior. Figure reprinted from Packaged Facts Gluten-Free Foods and Beverages, 2006.

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protein. There is also a growing segment of the population choosing to follow a gluten-free diet for nonmedical reasons. These people may have family or friends with gluten intolerance or they may simply feel better on a gluten-free diet.

There is not a lot of information on the people choosing to follow a gluten-free diet for nonmedical reasons. Estimates of this population segment range from 2 million to as high as 10 million people in the United States (6). The data shown in Figure 1 address gluten-free by nonmedical choice, and the trends are really interesting. When a person has a family member (a child in this case) with an allergy, the percentage of people strongly or somewhat agreeing with statements like "I started buying gluten-free foods because it's better for my family" almost doubles. And so food allergies or intolerances of a family member are strong drivers of consumer buying behavior.

The prevalence of gluten as a potential allergen has resulted in the U.S. Food and Drug Administration being required to issue regulations regarding the definition and requirements in order for a product to be labeled gluten-free by 2008. Europe and Canada have regulations currently in effect which define gluten-free labeling for food products. Therefore, there is also a compelling need for a diet that would meet regulatory bodies' definitions of a gluten-free label.

The Gluten-free Bakery Marketplace

There is clearly a market opportunity for gluten-free foods. Gluten-free food systems are a value-added subset of traditional bakery and food items that attract the health conscious as well as those in which gluten initiates an undesirable biological response. Today the gluten-free bakery market is considered a niche market at $217 million relative to bakery markets like whole grain and fiber, but it is growing steadily; in fact, gluten-free bakery sales grew more than 56% last year and gluten-free is one of the fastest growing labeling claims (1,6). The gluten-free market is evolving rapidly and gluten-free products are now appearing in major supermarkets. Figure 2 summarizes the current retail environment. Gluten-free FDM (food, drug, mass, the largest traditional class of retailers in the United States) bakery sales grew 44% over last year (1). In 2006, the gluten-free category had an 86% jump in new product introductions (4). Gluten-free products were introduced in July 2005 at Wal-Mart and Wal-Mart suppliers are now required to identify whenever gluten is used in Wal-Mart's private-label products (3). Today Wal-Mart's gluten-free bakery offerings comprise about 5% of the total gluten-free bakery sales.

There is some speculation that gluten-free products may become accepted as a superior dietary alternative in the mass market. This is exciting, and it is really exciting as a food scientist because many gluten-free products lack good taste, texture, and shelf life—so we have a real research and development opportunity here. Perhaps even more importantly for people with celiac disease, many of these products fail to deliver good nutrition. We need to make nutrition a high priority. Today we do not have adequate data to determine specific nutritional recommendations for patients with celiac disease and therefore nutritionists refer to the Dietary Reference Intakes as reasonable guidelines. Key nutrients that are often low in the gluten-free diet include: fiber, iron, calcium, vitamin D, folate, B2, B3, and B12, and the sophistication lies in the balancing of the micronutrient content to ensure proper absorption and utilization (5,8). It is important to note that alternative gluten-free grains can provide adequate amounts of most nutrients. Can these grains be used to formulate high quality bread? Not today, but we can use them in recipes that taste good.

Gluten-free Product Development

The gluten in wheat flour provides desirable organoleptic properties, such as texture and taste, to innumerable bakery and other food products. Gluten also provides the processing qualities familiar to both the home baker as well as the commercial food manufacturer. In short, gluten is considered by many to be the heart and soul of bakery and other food products.

Gluten is a remarkably versatile ingredient and most often it plays an important role in a bakery product. In cookies gluten

GF Bakery Market	$ Sales 52 wks ending 10/6/07
Health/Natural Foods (40%)	$ 86,843,124
FDM (22.5%)	$ 48,849,257
Internet/Mail (20%)	$ 43,421,562
Other (12%)	$ 26,052,937
Wal-Mart (5.5%)	$ 11,940,929
Total GF Bakery	**$ 217,107,809**

Other includes: C-Stores, Dollar, Club and Other

Source: AC Nielsen 52 wks ending 10/6/07

Fig. 2. Gluten-free (GF) retail bakery market. FDM—food, drug, mass, the largest traditional class of retailers in the United States.

Table I. Cookie results as a function of water mass

Cookie #	Starch or flour	Water (g)	Height (mm)	Spread (mm)	Hardness (g)	Fracturability (mm)	L	a	b
1	Pastry flour	54.84	58	393	5,269.622	0.779	98.185	–0.095	1.815
2	White rice flour 7011	54.84	70	317	4,340.550	0.835	63.643	8.703	28.800
3	Potato flour 205	54.84	65	278	12,566.300	2.168	39.877	15.827	18.010
4	Tapioca starch	54.84	106	308	4,766.772	6.862	62.960	6.185	25.795
5	Brown rice flour coarse 45121	54.84	63	392	2,028.670	1.110	63.937	7.610	29.287
6	OSA starch Emtex 06238	54.84	79	330	5,850.953	2.220	79.987	2.287	14.027
7	Resistant starch Actistar RT	54.84	86	284	2,434.095	0.914	71.060	5.403	25.547
8	High amy. & dent starch Set 957N1	54.84	74	284	2,232.023	1.114	68.573	5.740	23.710
9	Instant tapioca starch HiForm 72348[a]	54.84	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1	Pastry flour	64.84	60	404	5,211.706	1.203	64.257	10.457	30.427
2	White rice flour 7011	64.84	72	321	2,965.645	1.088	62.557	9.860	29.833
3	Potato flour 205	64.84	80	284	9,450.684	3.469	40.757	15.443	18.907
4	Tapioca starch	64.84	95	379	2,252.431	2.500	56.450	7.670	24.343
5	Brown rice flour coarse 45121	64.84	61	397	1,681.203	1.185	60.867	9.740	29.270
6	OSA starch Emtex 06238	64.84	89	285	8,499.596	2.698	80.197	2.377	15.333
7	Resistant starch Actistar RT	64.84	79	299	4,748.220	1.176	68.887	6.327	26.070
8	High amy. & dent starch Set 957N1	64.84	83	285	4,951.068	1.732	64.100	6.793	24.743
9	Instant tapioca starch HiForm 72348[a]	64.84	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

[a] Too dry.

helps set the structure, but it does not play a major role in gas retention as it does in bread. In cakes it may affect the viscosity and subsequently help retain gas, but it does not play a major role in setting the structure. Processing on high-speed dough lines is very dependent on the rheological properties that gluten imparts to the dough. Obviously, gluten provides a number of functionalities in baked product systems including providing the viscous and elastic nature necessary to process dough, providing a three-dimensional gluten matrix that inhibits gas diffusion through the dough mass, and enabling shear alignment and strain hardening of the cell walls in baking bread dough. But all of these functionalities are not required in every baked product and therefore the difficulty of replacing gluten is dependent on the level of functionality it has in the particular product (Fig. 3). In general, cookies and similar products are easiest to formulate to be gluten-free because gluten plays a limited role in defining the processability and end-product quality of a cookie. Cake and other batter-based products are intermediate with respect to the degree of formulation difficulty. Wheat flour is not easily replaced in a cake formula due to the roles both gluten and starch play. The most challenging product to formulate and produce is bread. Gluten plays many important roles in breadmaking and producing gluten-free bread that is the equivalent in quality to a wheat containing bread is the biggest prize in the gluten-free baked product arena.

Cookies

To develop gluten-free cookies, common gluten-free flours and starches were surveyed. This was done using AACC Intl. Method 10-50D. One hundred percent of wheat-containing pastry flour was replaced with one of the following ingredients:

1. Pastry flour
2. Fine white rice flour
3. Potato flour
4. Tapioca starch
5. Brown rice flour (coarse grind)
6. OSA modified starch
7. Resistant starch
8. Modified high amylose dent starch
9. Instant tapioca starch

Water level was varied. Dependent variables included cookie height, spread, day 1 hardness (3-point bend test), and color (lab). The best ingredients from a taste, texture, and appearance standpoint were selected.

Table I lists results for two water levels. The potato flour treatment tasted too strong (like potato chips), did not spread, and burned in the oven. The tapioca starch had a very different texture compared to the control pastry flour; this is most apparent in the fracturability result. It also gave a pasty mouthfeel. The brown rice flour treatment was not hard enough. None of the modified starch treatments had a pleasant mouthfeel compared to the control. All of the starches gave harder cookies at higher water mass. The resistant starch was close to the pastry flour control with respect to hardness and fracturability at higher water mass. This treatment also had the higher spread and lower height compared to the OSA and high amylose modified starches at higher water mass.

The flavor, texture, and appearance of the white rice flour at both water masses were well liked. Increasing water in the white rice flour treatment decreased hardness. Results (Table I) suggested that cookie attributes (hardness in particular) could be optimized by combining the white rice flour and the resistant starch. Additionally, the health benefits of resistant starch made it an appealing variable to work with.

Table II compares the previous results for the controls, the white rice flour, and the resistant starch treatments to a treatment of 50:50 white rice flour to resistant starch. The effect of increased shortening and sugar in a white rice flour treatment (Table II) was also studied. The results suggest that a designed experiment around level of shortening, sugar, and ratio of white rice flour to resistant starch could lead to a cookie with optimized attributes—with results similar to the pastry flour control.

Statistical design was applied to optimize important variables like hardness, spread, and color in a model cookie for-

Table II. Cookie results as a function of water mass and a blended treatment

Cookie #	Starch or flour	Water (g)	Height (mm)	Spread (mm)	Hardness (g)	Fracturability (mm)
1	Pastry flour	54.84	58	393	5,269.622	0.779
1	Pastry flour	64.84	60	393	5,211.706	1.203
2	White rice flour 7011	54.84	70	317	4,340.550	0.835
2	White rice flour 7011	64.84	72	321	2,965.645	1.088
3	White rice, up 5% shortening (94 g)	54.84	66	319	5,235.593	1.528
4	White rice, up 5% sugar (165 g)	54.84	74	336	7,071.931	2.426
2	50:50 white rice: resistant starch	64.84	66	391	2,614.526	1.145
7	Resistant starch Actistar RT	54.84	86	284	2,434.095	0.914

Table III. Designed experiment

Run	Design	Block	Sugar (%)	Shortening (%)	Rice flour (%)	Resistant starch (%)	Flour/ (flour + starch)* 100	Moisture (g)	Spread (mm)	Height (mm)	Hardness (g)	Fracturability (mm)
1	2	1	32	18	21	29	42.0	54.84	375	68	7,898.78	1.211
2	6	1	32	9	45	14	76.3	54.84	304	71	10,547.93	1.260
3	9	1	27	13	14	46	23.3	99.64	317	86	514.55	2.008
4	8	1	22	8	25	45	35.7	139.64	284	72	1,242.21	3.999
5	7	1	27	18	45	10	81.8	54.84	295	59	6,838.39	1.473
6	4	1	22	18	17	43	28.3	54.84	275	58	1,113.96	0.996
7	15	1	24	8	46	22	67.6	74.84	282	65	2,539.66	1.679
8	5	1	22	13	39	26	60.0	54.84	281	59	3,851.68	1.048
9	3	1	28	8	27	37	42.2	54.84	283	78	2,205.13	0.807
10	13	1	32	8	14	46	23.3	54.84	294	98	2,657.55	0.972
11	14	1	32	18	33	17	66.0	54.84	369	66	5,773.33	1.101
12	16	1	22	11	34	33	50.7	54.84	282	65	1,803.64	0.660
13	1	1	32	8	34	26	56.7	54.84	306	86	4,423.03	1.704
14	11	1	22	18	17	43	28.3	54.84	280	61	771.43	0.600
15	10	1	32	8	14	46	23.3	54.84	292	96	2,392.30	0.965
16	12	1	27	13	14	46	23.3	54.84	287	70	1,626.84	0.708

mula. Table III summarizes the designed experiment. The experiment was flawed with respect to cookie spread; there was either no spread (<300 mm) or a lot of spread (>350 mm) and therefore spread could not be modeled using statistical analysis. Runs 1 and 11 in Table III had good spread. They were also close to the pastry flour control with respect to hardness and fracturability. Both were at the high levels of sugar and shortening.

The knowledge from our model experiments was applied to more typical cookie formulas. This in combination with our product development know-how led to the development of crunchy gluten-free cookies and soft-baked cookies. Formulas for typical crunchy and soft-baked cookies are listed in Table IV. Degree of soft-baked cookie quality can be tailored by adjusting glycerol level. These are great cookies, and they are gluten-free. Finally, one gluten-free cookie base mix was formulated to enable efficient manufacturing of all of the cookies.

Batter-based Products

The fundamentals of batter formulation do not change when formulating a gluten-free batter-based product. The final volume of the product and the fineness of the crumb are still dependent on the amount of air incorporated during mixing, the amount of gas generated by the leavening system, the ability of the batter to retain the gas, and the setting of the crumb in the expanded state during the bake. The size of the gas cells is still important in defining the fineness of the crumb in the finished product. Wheat flour has been a component of batter formulations since the beginning of baking, and, hence, modern formulations that have evolved are all based on its effect on viscosity and emulsification, and, hence, structure setting gas retention. Replacing it to yield a gluten-free system can be accomplished, but a systematic approach considering the fundamental processes that define batter baking is by far the most efficient.

The obvious choice to replace flour in a batter is a combination of starch to aid in setting the structure and an ingredient that provides viscosity at room temperature. Wheat starch can be used in gluten-free formulas if the contaminating gluten level and amount of starch in the formula allow the final product to comply with gluten-free requirements (i.e., <20 ppm). A more conservative approach would be to use starch from a cereal or tuber that did not invoke the celiac response. Corn, tapioca, potato, and rice starch are examples. Common ingredients that can build viscosity include modified starches and hydrocolloids such as gums. An objective should be to reproduce the viscosity profile through the bake that most closely resembles that of the target flour-containing batter system. Gluten also plays a role as an emulsifier and, when removed, emulsification also needs to be restored to original levels.

Standard measurements of density to determine the amount of air incorporated during mixing and viscosity are useful tools in formulating gluten-free batters. Since viscosity during the entire bake is important, instruments such as the Rapid Visco Analyzer (RVA, AACC Intl. Method 22-08) or the amylograph (AACC Intl. Method 22-10) are often employed. The electrical resistance oven, an especially useful tool for measuring viscosity during baking, is described by Shelke et al. (7). Of course, final product assessments are the most important measurements of all and they are often specific to the product. An example would be the cake scoring, symmetry, volume, and uniformity procedures described in AACC Intl. Methods 10-90 and 10-91.

Bread

As is obvious from Figure 4, wheat flour, and specifically gluten, possesses unique properties required to bake a quality loaf of bread. The wheat-flour-containing bread in this figure was made with a very simple white bread formula. The other loaves represent substitutions of alternate flour with wheat flour followed by absorption changes to adjust dough rheology as close to the wheat dough as possible. The proteins in these alternate flours are very close to wheat genetically and still they are inadequate. Wheat gluten is unique among the common cereal proteins. Formulating high quality gluten-free bread is a considerable challenge.

Table IV. Typical crunchy and soft-baked cookie formulas

Ingredients	%
Crunchy peanut butter cookie	
Baking soda	0.47
Corn syrup	4.93
Mono- and diglycerides	1.89
Peanut butter creamy	5.68
Resistant starch	5.68
Salt	0.40
Shortening	20.46
Sugar	22.74
Vanilla extract	0.38
White rice flour	32.63
Whole liquid egg	4.74
Total	100
Soft-baked chocolate chip cookie	
Ammonium bicarbonate	0.35
Baking powder	0.27
Chocolate chips	7.80
Dextrose	3.55
Glycerol	1.77
High fructose corn syrup	13.84
Mono- and diglycerides	1.77
Resistant starch	5.32
Salt	0.37
Shortening	19.16
Starch[a]	0.18
Sugar	10.29
Vanilla extract	0.35
White rice flour	30.54
Whole liquid egg	4.43
Total	100

[a] Cargill Hiform 72348.

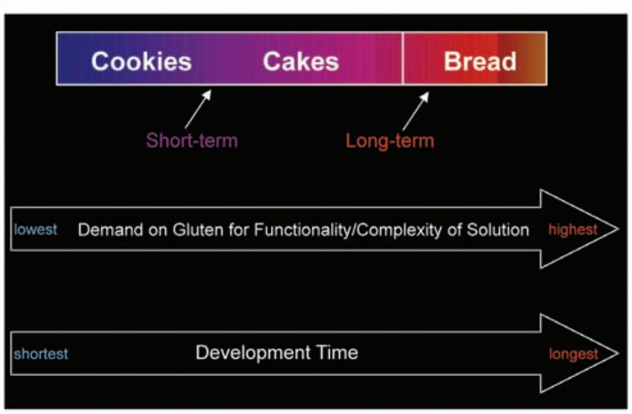

Fig. 3. Demand on gluten functionality vs. product development time.

Fig. 4. Wheat gluten is a unique set of cereal proteins.

Considering gluten's functionality through the bread making process provides gluten-free formulation insight. When the basic ingredients of bread dough (i.e., flour, water, salt, and yeast) are combined and mixed, the salt dissolves, the yeast hydrates and begins to assimilate sugars, and the outer layers of the flour particles are successively hydrated and sloughed off. As mixing continues, a three-dimensional, viscoelastic network is established that entrains air and provides cohesiveness to the dough mass. In the proofing step, air cells expand and the viscoelastic network inhibits the diffusion of the leavening gasses through the dough. During baking the gas cells expand, cell walls get thinner, and the gluten network dehydrates and strain hardens. Eventually it becomes brittle, breaks, and the cells interconnect and the gas phase of the bread is continuous. Upon cooling the elastic nature of the gluten network is retained providing the chewy texture inherent in quality breads.

Consequently a gluten replacement would have to be "wetable" to disperse and interact with other dough components such as starch. Unless a gluten-free formula is to be manufactured on equipment not standard to dough processing, providing cohesiveness is also a requirement. Formation of a three-dimensional gas retaining network that can dehydrate and strain harden would certainly be necessary to produce gluten-free bread with reasonable volume and crumb structure. Finally, the elastic nature gluten provides in the final bread would have to be present.

It becomes very apparent, very early, to anyone formulating gluten-free baked bread that a single ingredient that will replace gluten does not exist. The common approach is to assemble a mixture of starches, hydrocolloids, fibers, and dairy ingredients to replace all the functionalities described above. As previously discussed, the quality of the commercial offerings resulting from this approach are not at parity with wheat-containing bread. Even if parity was achieved, the gluten-free bread formulated would likely be a specific "specialty" bread and the solution would not be broadly applicable to all gluten-free bread formulations.

An alternate and certainly longer-term approach is to develop an ingredient system that replaces all of the gluten functionalities described above. If this system can be developed it would apply to formulation of all breads from simple baguettes to the most complicated specialty breads. At a minimum, evaluating ingredients outside the toolbox of standard bakery ingredients will be required to develop it. More likely it will be necessary to develop a system containing some entirely new baking ingredients. If achieved, however, the quality of all types of gluten-free bread would be elevated by the incorporation of this new gluten-free baking ingredient system.

Summary

Wheat is unique. That is the paradigm that cereal scientists have been taught for decades. For people with gluten intolerances, however, it is important that we challenge this paradigm and find exceptions. It is important that we identify or create ingredients that can mimic the properties of gluten and formulate high quality, nutritious baked products with them. When we are successful we will be formulating baked products with some new and possibly very versatile ingredients. They may have applications far beyond the gluten-free market. We will then be operating in a new paradigm and whenever a new paradigm is adopted, opportunities abound. These are exciting times.

References

1. ACNielsen 52 wks ending 10/6/07. The Nielsen Company, NY, 2007.
2. Alaedini, A., and Green, P. H. R. Narrative review: Celiac disease. Ann. Intern. Med. 142:289-298, 2005.
3. Associated Press. Gluten-free market goes mainstream. Associated Press, New York, July 27, 2005.
4. Innova. Innova Food and Beverage Database (Innova) 2007. Innova Market Insights, The Netherlands, 2007.
5. Kupper, C. Dietary guidelines and implementation for celiac disease. Gastroenterology. 128:S121-S127, 2005.
6. Market Research Group. Gluten-free foods and beverages in the U.S. Published online at www.packagedfacts.com/Food-Allergy-Products-1042244/. Packaged Facts, A Division of Market Research Group, LLC, Rockville, MD, July 1, 2006.
7. Shelke, K., Faubion, J., and Hoseney, R. C. The dynamics of cake baking studied by a combination of viscometry and electrical resistance oven heating. Cereal Chem. 67(6):575, 1990.
8. Thompson, T., Dennis, M., Higgins, L. A., Lee, A. R., and Sharrett, M. K. Gluten-free diet survey: Are Americans with coeliac disease consuming recommended amounts of fibre, iron, calcium and grain foods? J. Hum. Nutr. Diet. 18:163-169, 2005.

Jodi Engleson is a principal food technologist working in Cargill's bakery technology area to create opportunities for customers and for Cargill. During her six-year tenure, Jodi has enjoyed all the passion that brought her into the field of cereal and food science. She is an inventor on eight patent applications. She joined Cargill after earning her Ph.D. in food science from the University of Minnesota Food Science and Nutrition Department in 2001. As a graduate research assistant, she worked in collaboration with plant breeders and industrial partners to establish protocols to identify primary structural and functional contributors to quality in grains. Jodi earned bachelors degrees in food science and chemical engineering from the University of Minnesota in 1998. Her college work sparked an interest in complex systems and the use of multidisciplinary approaches to understand them. Jodi is the 2009 AACC Intl. Annual Meeting technical program chair. She plans to pursue scuba diving this spring. Jodi can be reached at Jodi_Engleson@cargill.com.

Bill Atwell enjoys scuba and is currently employed by Cargill as the technical leader of the bakery category. Recently he had a back operation and the next time you see him he may appear noticeably taller. Atwell is an adjunct professor in the Department of Food Science and Nutrition at the University of Minnesota. As an active member of AACC International, he has served as president, director, Carbohydrate Division chair, Northwest Section chair, and Foundation Board chair. A special passion is mentoring and Atwell has organized and continues to coordinate mentoring programs for Cargill, the University of Minnesota, and AACC Intl. Bill can be reached at Bill_Atwell@cargill.com.