Bay State Milling
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HealthSense™
High Fiber Wheat Flour

Fiber from the Farm: HealthSense™ Flour

HealthSense™ Flour enters the market to support public health initiatives.

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Figure 1: White pan bread made using 100% HealthSense™ high fiber wheat flour.

Fiber for the People

Modern dietary practices that promote high intakes of refined carbohydrates and lack dietary fiber pose a large risk for consumers because of the essential role dietary fiber plays in maintaining and improving metabolic and cardiovascular health (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2015). Dietary fiber is a nutrient that many consumers hear of from medical professionals and see on the nutrition facts panels, but it had never been formally defined by the United States Food and Drug Administration until May of 2016. The new definition declared that in order for a non-digestible carbohydrate component to be declared dietary fiber, it must exist in a food product unaltered from its origin; a definition that coined the term "intrinsic and intact dietary fiber" (Food and Drug Administration, 2016). The public health need for food products with more intrinsic and intact dietary fiber is undeniable. While the FDA recently changed the recommended daily value from 25 to 28 grams per day, it has been reported that the average American consumes approximately 16 grams of fiber per day (Food and Drug Administration, 2016 ... Rose, DeMeo, Keshavarzian, & Hamaker, 2007). While consumers have many options for increasing their fiber intake, few products offer the no-compromise approach that consumers look for when choosing healthy products. According to the 2017 Food and Health Survey conducted by the International Food Information Council, approximately 90% of the consumers surveyed agree that ingredients such as fiber are considered healthy ("2017 Food & Health Survey"). Other studies have shown that at least 60% of the American consumers surveyed wanted to increase their fiber consumption ("Fiber: The Key to Brightening Your Golden Years"). HealthSense™ flour was developed to support the public health initiative of increasing dietary fiber consumption by providing consumers with the opportunity to consume their favorite products made with refined carbohydrates, without depriving their bodies of dietary fiber.

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Fiber from Food

While scientists and health care professionals previously classified all non-digestible carbohydrate components of food as dietary fiber, modern research techniques have allowed scientists to discover that there are many types of fibers in food products. Most dietary fibers are grouped into the traditional classifications of water-soluble and water-insoluble. Water-soluble fiber can dissolve in and absorb water in the body, thus allowing for the passage of soft stools (Wursch & Pi-Sunyer, 1997). Water-soluble fibers can play a key role in the prevention of chronic diseases like cardiovascular disease and type 2 diabetes because of its role in decreasing blood cholesterol, regulating blood glucose and insulin levels, and weight maintenance (Saltzman et al., 2001 ... Wursch & Pi-Sunyer, 1997 ... Howarth, Saltzman, & Roberts, 2001). In contrast, water-insoluble fibers play a key role in the prevention of bowel disorders because they can quickly pass through the body, helping to alleviate constipation and promote bowel regularity (Rose et al., 2007).

One kind of alternative fiber is resistant starch; a relatively new term used to describe starch molecules that are not digested by enzymes that reside in the human body for a variety of reasons. There are several types of resistant starch that can be found in foods:

Type 1	*Found in whole grains and seeds. Resistant to enzymatic degradation because it is trapped around hearty food matrixes like bran and germ layers (Englyst & Cummings, 1987).*
Type 2	*Found in high amylose grains. Contains tightly packed, un-gelatinized starch molecules that are inaccessible to digestive enzymes (Englyst & Cummings, 1986).*
Type 3	*Composed of retrograded starch molecules that form a tight, crystalline structure that cannot be broken down by digestive enzymes (Englyst & Cummings, 1987).*
Type 4	*Chemically modified starch designed to resist digestion and be functional for food manufacturers (Han & BeMiller, 2007).*

Table 1: Definition of Resistant Starches 1-4.

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Fiber from the Farm, Not the Factory - High Amylose Wheat

A common grain processing technique is milling wheat kernels into "white" flour, which calls for grinding down the starchy endosperm and removing the fiber-rich bran and germ layer. Refined wheat flour is a common source of carbohydrates in the Western Diet due to its mild taste and desirable texture in processed foods. The resulting conundrum faced by consumers is a strong preference and high consumption pattern of foods containing an ingredient that is nearly devoid of dietary fiber.

Various government and health organizations have tried to promote higher dietary fiber intake by recommending that consumers make at least half of the grains consumed in their diet whole grains; however, most still fail to make the switch due to the negative sensory perceptions, or lack of affordability of whole grain foods. Innovations such as high amylose wheat provide an affordable solution to the dietary fiber gap because the starch synthesis within the grain is nutritionally superior and unique to this specific wheat variety. The endosperm and resulting refined flour from high amylose wheat contain up to ten times more dietary fiber when compared to common refined wheat flour.

The starch in the endosperm of common wheat typically contains 25% amylose (a linear starch molecule) and 75% amylopectin (a highly branched starch molecule) loosely entwined with each other. This structure allows for digestive enzymes to engage with the starch molecules and break them down for use as an energy source for the body. The starch in the endosperm of high amylose wheat contains nearly three times the amount of amylose compared to common wheat, resulting in a starch matrix that is highly compacted and thus lacks availability to digestive enzymes. As a result, the starch is considered a non-digestible carbohydrate, which brings it into the realm of dietary fiber.

Because resistant starch is not degraded by digestive enzymes in the small intestine, it enters the large intestine where it is consumed by the resident bacteria in a process called fermentation.

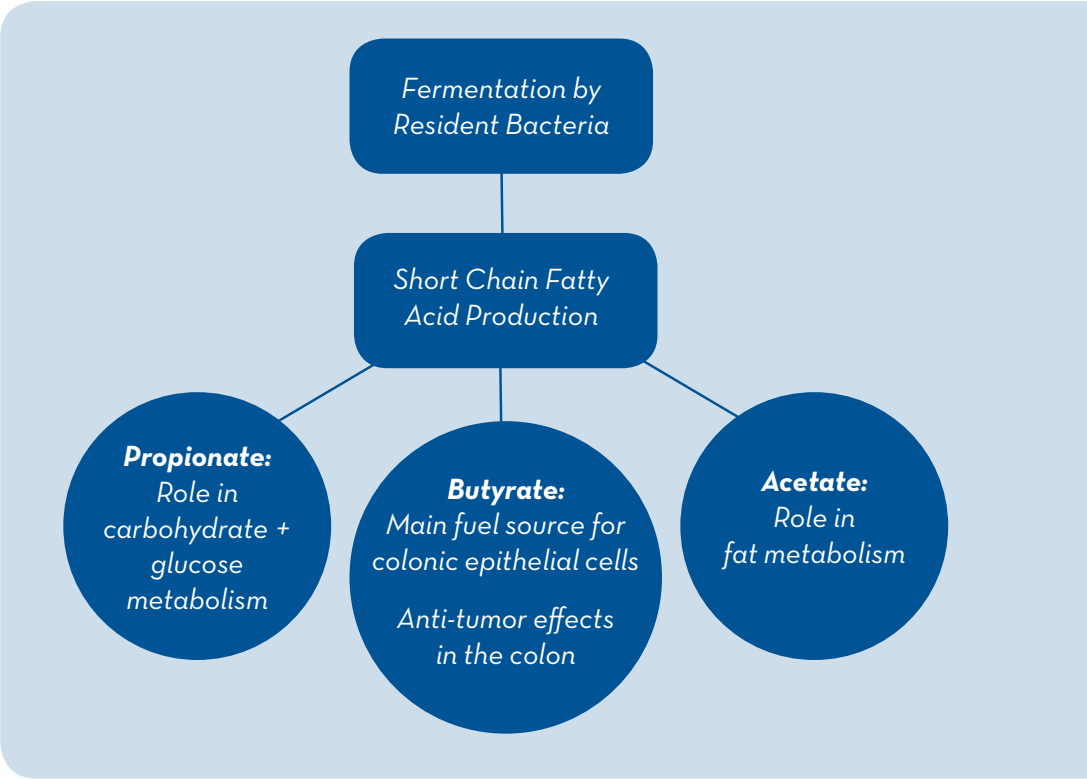

Figure 2: Fermentation mechanisms and their influence on metabolism.
(Han et al., 2014 ... Wolever, Spadafora, & Eshuis, 1991 ... Siavoshian et al., 2000)

Development of HealthSense™ Flour from High Amylose Wheat

HealthSense™ flour is wheat flour reimagined. It consistently delivers a minimum of 25% total dietary fiber in a refined wheat flour, compared to less than 3% in refined common wheat flour . It was developed to allow food manufacturers to easily replace their common refined wheat flour with more nutritious, yet fully functional, flour. Unlike the majority of isolated fibers that exist in processed food, HealthSense™ flour contains 100% intact and intrinsic dietary fiber, which allows for the delivery of other beneficial nutrients that are naturally occurring within the food matrix. This is an important distinction in the definition of dietary fiber by the FDA.

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Rheology and Functionality of HealthSense™ Flour

It is very common for food processors to measure standard quality and rheological parameters to give insight into how an ingredient will function during processing. The most common quality and rheological tests used for wheat flour include:

Flour Analysis Test	Insight Gained	Directional Difference, HealthSense™ vs. Common Wheat Flour for Pan Bread
Total Dietary Fiber in Flour	Fiber content of raw material	↑
Total Dietary Fiber in White Bread	Fiber content delivered to consumer	↑
Moisture	Shelf life and ingredient interactions	=
Ash (14% moisture basis)	Purity of refined wheat flour	↑
Protein (14% moisture basis)	Strength and quality of the flour	=
Loaf Volume	End use quality	=
Farinograph (AACC's Constant Dough Method)	Dough development characteristics and absorption	
Absorption	Dough hydration characteristics	↑
Stability*	Strength of the flour	↓
MTI*	Strength of the flour	↑

*Table 2: Directional rheological differences between refined common wheat flour and HealthSense™ flour. *Results based on farinograph tests using initial release of HealthSense™ high fiber wheat flour.*

The HealthSense™ flour depicted in Table 2 was formulated to meet the needs for commercial white pan bread manufacturers and can be adjusted to meet the needs for other formulators that require higher or lower protein content. The data presented in Table 2 displays directional differences between refined common wheat flour and HealthSense™ flour for absorption, stability, and mixing tolerance index. Despite these rheological differences, studies done at Bay State Milling's Rothwell GrainEssentials Center have shown that HealthSense™ flour is fully functional in various applications.

Figure 3: White pan bread made using 100% HealthSense™ high fiber wheat flour.

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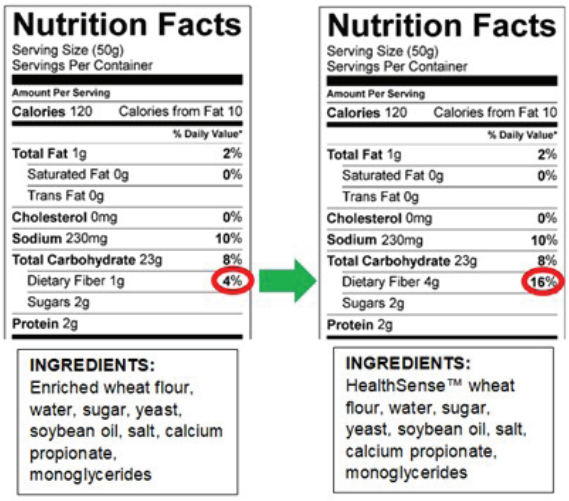

Figure 4: Nutrition Facts panels for bread made with refined common wheat flour vs. bread made with HealthSense™ flour.

Fiber testing methods

While there are numerous methods approved by scientific organizations for dietary fiber measurements, the benefits and limitations must always be evaluated before selecting the most appropriate analysis for a food product.

AOAC Method #	What is measured	Benefits	Limitations	Measures Fiber in HealthSense™ Flour
985.29 (Prosky)	*High molecular weight dietary fiber*	*Cost*	• Underestimates RS1, RS2, and RS3. • Overestimates RS4	X
991.43 (Lee)	*Insoluble dietary fiber and dietary fiber soluble in water and insoluble in ethanol*	*Cost*	• Underestimates RS1, RS2, and RS3. • Overestimates RS4	X
2009.01 (McCleary)	*High molecular weight dietary fiber and dietary fiber soluble in water + ethanol*	*More accurate RS measurements*	• Slightly underestimates RS2 and RS4. • Lengthy incubation time that does not have physiological relevance	✓

Table 3: Methods to measure Total Dietary Fiber and its constituents (Megazyme, 2017).

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HealthSense™ Flour in Applications

While HealthSense™ flour has been designed to be a one-for-one replacement for refined common wheat flour, there are still minor adjustments that bread manufacturers may need to make, just like with any new ingredient substitution.

Processing Characteristic	Changes with HealthSense™ Flour
Absorption	↑
Mix time	↓
Dough Handling: Extensibility	↑

Table 4: Processing changes commonly experienced when using HealthSense™ Flour in pan bread applications.

Sensory evaluations conducted at Bay State Milling have shown that bread made with HealthSense™ flour and bread made with refined common wheat flour have some notable differences, but are overall comparable. Sensory panelists found that bread made with HealthSense™ flour was sweeter and had more fermented yeast in the flavor when compared to breads made with refined common wheat flour. Panelists also noted that bread made with HealthSense™ flour had less cohesion in the mouth and was more mouth drying when compared to the control. The panel concluded that the degree of difference between the two breads was low enough that the average consumer may not find a discernible difference[1].

HealthSense™ has also been tested in a number of applications besides white pan bread, such as tortillas, pasta, and snacks. It is a revolutionary way to deliver fiber, a nutrient of public health concern, in the foods consumers love most, without compromising on taste. To learn more about HealthSense™ and collaboration with Bay State Milling, please contact us at baystatemilling.com.

[1] *Degree of difference scale and methods as described by "The Best Approach Inc." consulting firm (Fossum, 2017).*

Figure 5: White pan bread made using 100% HealthSense™ high fiber wheat flour.

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