CFW FEATURE

Whole-Grain Barley for Today's Health and Wellness Needs

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The updated 2005 USDA *Dietary Guidelines for Americans* (4) recommends increased consumption of whole grains as part of a health-promoting diet. Research indicates that consumption of a diet rich in whole-grain foods can help reduce the risk of coronary heart disease, type II diabetes, and certain cancers and provide other health benefits as well. Incorporation of whole-grain barley as part of a balanced diet offers a variety of benefits.

Prowashonupana (Sustagrain, ConAgra Foods), a waxy, hulless barley variety with a unique macronutrient composition, was developed during the late 1970s through a conventional barley breeding program at Montana State University. Higher in fiber and protein and lower in starch than many common cereal grains, Prowashonupana barley can be used by product developers to formulate products with improved health benefits and a variety of health claims. The variety's name is an acronym that represents its grain characteristics and lineage: PRO: high protein (high lysine); WA: waxy starch; SHO: short awned; NU: nude (hulless); and PANA: derived from the parent barley Compana.

Composition, Functionality, and Product Applications

Composition. The carbohydrate distribution in Prowashonupana barley is at least 30% dietary fiber and ≤30% starch, which is 2–3 times the amount of fiber and about half the amount of starch compared with other common cereal grains. Approximately half of the dietary fiber is β-glucan. The macronutrient composition of Prowashonupana is compared with standard barley and oats in Table I. This high-lysine (>4 g/100 g of protein) barley variety also delivers other whole-grain nutrients, including healthy lipids, vitamins, minerals, tocotrienols, and other phytonutrients. The total antioxidant capacity of Prowashonupana is 4,600 μmol TE/100 g, which compares favorably with the total antioxidant capacity of fruits and vegetables such as cultivated blueberries (6,220 μmol TE), strawberries (3,557 μmol TE), raisins (3,037 μmol TE), and spinach (2,640 μmol TE) (17).

Andersson and coworkers (1) used microscopic and chemical analyses to compare the structure, macronutrient distribution, and macronutrient content of Prowashonupana to another waxy, hulless barley variety. They found that Prowashonupana barley kernels and starchy endosperm cells were both irregular in shape. Its starchy endosperm cells were also smaller, contained fewer starch granules, and had thicker cell walls. Microscopic examination indicated that Prowashonupana also contained more protein. Chemical analyses confirmed the microscopic observations.

Ingredient Functionality and Product Applications. Prowashonupana barley can be processed into standard dry milled products, including whole kernel, steel cut, flake, and flour. Because it is hulless, it can be classified as a whole grain in all processed forms.

Prowashonupana barley can be used to enhance the flavor, texture, appearance, and nutritional composition of a variety of product applications, including hot cereals, cookies, crackers, breads, tortillas, granola bars, fruit-filled cereal bars, extruded snacks, and pastas. Its functional flexibility allows it to be used in foods that span across meal occasions, including muffins and ready-to-eat cereals for breakfast; soup, vegetarian patties, and pizza for lunch or dinner; crackers and extruded chips for snacks; and cookies and toppings for dessert. Additionally, the higher fiber content, lower starch carbohydrate profile, and increased protein content of Prowashonupana work well in instant beverage mixes, nutritional bars, capsules, and wafers targeted for diet and weight-loss products, meal replacements, and fiber supplements.

Benefits of Whole-Grain Barley

Adequate intake of whole grains has been linked with reduced risk of coronary heart disease, type II diabetes, certain cancers, and weight maintenance. The 2005 USDA *Dietary Guidelines for Americans* (4) recommends consumption of at least three servings of whole-grain foods per day, preferably by substituting whole grains for refined grains. At least half of the daily grain intake should be from whole grains.

Blood Sugar Management. In several published studies (10,13,15) and a pilot study (A. Grandjean and K. Reimers, *unpublished data*), Prowashonupana barley was shown to lower the postprandial blood glucose response in human subjects when incorporated in a variety of product applications, including hot cereals, bars, breads, and beverages. The studies were conducted according to standard in vivo glycemic testing protocols. Foster-Powell and coworkers (10) determined that a range of products types containing different Prowashonupana barley forms and inclusion levels qualified as low glycemic index (GI) foods (GI < 55 compared with glucose reference) (Table II).

In other studies, consumption of Prowashonupana barley hot cereal resulted in lowered glucose and insulin responses compared with oat hot cereal (2,16). Behall and coworkers (2) fed Prowashonupana barley and oat hot cereals to 10 nondiabetic, overweight women at dosages of 1 g of carbohydrate per kilogram of body weight (two-thirds of the carbohydrate was from the grain source). The grains were each tested in flake and flour forms. Glucose area under the curve (AUC) was reduced 59–65% by the barley and 28–36% by the oats compared with the glucose control. The effect of particle size on glycemic response was not significant. Insulin AUC was significantly reduced by the barley (44–56%) compared with glucose. Rendell and coworkers (16) fed equal calorie portions of Prowashonupana barley flakes, oat flakes, and a commercial meal replacement beverage to nondiabetic (n = 16) and type II diabetic (n = 18), overweight subjects. Consumption of the barley resulted in significantly lower postprandial glucose and insulin responses compared with the oats and liquid meal replacement beverage.

Inclusion of Prowashonupana barley (15–20%, flour basis) has been shown to significantly lower the glycemic response induced by grain-based foods. Rao and

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Singh (15) reported that addition of Prowashonupana (Sustagrain) at 15–20% in whole-wheat atta resulted in low-GI chapatis. Compared with the control whole-wheat chapati, consumption of one low-GI chapati per day for 2 months significantly lowered glycosylated hemoglobin and postprandial blood glucose in type II diabetic subjects (n = 20 per treatment).

Consumption of a low-GI meal also may improve glucose tolerance at the next meal. According to Liljeberg and coworkers (12), inclusion of Prowashonupana barley as part of a low-GI breakfast delayed between-meal fasting, increased satiety, and improved glucose tolerance at the lunch meal.

Weight Management. Whole-grain intake has been positively correlated with body weight maintenance (4). Consumption of whole-grain foods may help with weight maintenance by increasing satiation (regulation of energy intake per meal) and satiety (return of hunger after a meal). Whole-grain foods are less energy dense compared with refined grain foods, which may lower caloric intake. The soluble fiber in whole grains such as barley and oats may help increase satiety by delaying gastric emptying and slowing nutrient absorption in the small intestine.

Lifschitz and coworkers (11) compared the metabolism of Prowashonupana to a standard barley variety. Ten healthy subjects consumed 35-g portions of ^{13}C-enriched Prowashonupana or standard barley pilaf. Breath carbon dioxide and hydrogen outputs were measured at baseline and at regular intervals for 450 min after consumption as indicators of oxidation and malabsorption, respectively. Prowashonupana was significantly less absorbed than the standard barley.

In a pilot study conducted by Grandjean and Reimers (*unpublished data*), 420-cal portions of a Prowashonupana (Sustagrain) barley granola bar and a commercial chewy granola bar were fed to six healthy female subjects after an overnight fast. The granola bar breakfasts were fed in random order, with at least 1 week of separation between tests. Each subject served as their own control. Subjects consumed 100 fewer calories from an ad libitum lunch buffet after consumption of the barley bar breakfast compared with the commercial chewy granola bar breakfast.

Digestive Health and Function. Fiber intake is important for digestive health and function. Fiber amount and type and ratio of soluble to insoluble fiber all play a role in gastric emptying, absorption of nutrients in the small intestine, laxation attributes and process, and the balance of beneficial intestinal flora. Adequate intake of fiber from whole grains also may reduce the risk of gastrointestinal cancers (4). The average fiber intake in the United States is 14 g/day,

Table I. Average nutrient composition of hulless barley, oats, and barley variety Prowashonupana (Prowash)[a]

Nutrient (%)	Hulless Barley	Oats	Prowash Barley
Protein	13	15	20
Fat	3	6	7
Starch	60	59	21–30
TDF[b]	13	10	30
β-Glucan	5	5	15

[a] Adapted from Rendell and coworkers (16).
[b] Total dietary fiber.

Table II. Glycemic index values of Prowashonupana barley-based foods[a]

Product (Entry No.)	Glycemic Index (Glucose = 100)
Smoothie, raspberry (soy-milk base) (25)	33 ± 9
Muesli bread (72)	54 ± 6
Hot cereal, apple cinnamon (189)	37 ± 6
Hot cereal, unflavored (190)	25 ± 5
Snack bar, apple cinnamon (565)	40 ± 8
Snack bar, peanut butter and chocolate chip (565)	37 ± 6

[a] Data from Foster-Powell and coworkers (10).

which is approximately half the 25 g/day recommended for a 2,000-cal diet.

Rich in dietary fiber compared with other common cereal grains, a 40-g serving of Prowashonupana barley provides 12 g of dietary fiber, which is nearly half (48%) the recommended daily value. The increased fiber content provided by Prowashonupana allows product developers to make fiber nutrient content claims across a range of whole-grain inclusion levels. For example, inclusion of just 25% of this barley in a pasta application allows an excellent source of fiber claim.

Diets containing whole-grain flour from Prowashonupana barley, wheat, oats, and rye and a cellulose-based diet were compared in a 4-week study with rats. The grains made up 50% of nutritionally balanced diets and were designed to provide a range of fiber levels and variety of soluble/insoluble fiber ratios. The barley-containing diet resulted in higher fecal volume and density and lower weight gain compared with the other grains (14).

Heart Health. Studies have shown that whole-grain intake is associated with reduced risk of coronary heart disease. Evidence suggests that eating three or more servings of whole-grain foods per day results in a 20–30% reduction in coronary heart disease risk (4). This protective effect is likely due to several components in the whole-grain matrix, including fiber, lignans, tocotrienols, phytosterols, flavonoids, and other phytonutrients.

Consumption of adequate amounts of soluble fiber from oats (3 g/day) has been shown to reduce cholesterol. Products that contain at least 0.75 g of oat soluble fiber and meet other claim criteria can be labeled with an FDA approved heart health claim (21 CFR 101.81 [9]). A similar health claim for barley-based foods that contain at least 0.75 g of soluble fiber and meet other claim criteria was recently approved by the FDA (Docket No. 2004P-0512 [8]).

Other FDA approved heart health claims for foods formulated with whole grains include whole-grain food claims that require a product to contain 51% whole grain by weight and meet other claim criteria (Docket No. 99P-2209 [5]; Docket No. 03Q-0547 [6]). Grain, fruit, and vegetable foods that contain at least 0.6 g of soluble fiber per reference amount customarily consumed and meet other claim criteria also are eligible for another FDA approved heart health claim (21 CFR 101.77 [7]). The soluble fiber content of Prowashonupana barley is about 3 times higher than that of oats (a 40-g serving of Prowashonupana barley provides 6 g of β-glucan). This higher soluble fiber content provides product developers with flexibility across a broader inclusion range in formulating products for which heart health claims can be made.

Whole-grain barley may also help reduce cholesterol and plasma triglyceride levels. Bourdon and coworkers (3) measured plasma triglycerides and cholesterol following the consumption of test meals containing barley-enriched pasta. Prowashonupana was included in one of the barley test meals. Both of the barley test meals appeared to stimulate reverse cholesterol transport.

T. P. Carr (*unpublished data*) compared the effects of Prowashonupana barley-based versus oat-based diets on cholesterol metabolism in hamsters. Barley was fed at both equal weight and equal β-glucan levels compared with the oat diet. Cholesterol absorption efficiency was significantly reduced with both barley diets. There was a decrease in total and LDL cholesterol with the high barley diet, although the results were not statistically significant. HDL cholesterol levels were maintained in all three diets.

Conclusions

Research has linked the consumption of a diet rich in whole-grain foods with a reduced risk of coronary heart disease, type II diabetes, and certain cancers, as well as weight maintenance and digestive health benefits. Whole-grain barley incorporated as part of a balanced diet delivers healthy lipids, vitamins, minerals, antioxidants, and other phytonutrients. Because it is hulless, Prowashonupana can be classified as a whole grain in all processed forms. It is higher in fiber and protein and lower in starch than many common cereal grains, providing unique health benefits and allowing health claims for a variety of products.

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