



Barley-

AN ANCIENT GRAIN FOR A MODERN WORLD

By Jennifer Adolphe, PhD, RD, and Kelley Fitzpatrick, M.Sc.



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Health and wellness products have experienced significant growth over the past few decades and many are now considered mainstream. Sales of food products that offer specific health benefits continue to gain momentum, with expectations of 7.5 per cent yearly increases to reach US\$1 trillion by 2018.¹ Several factors have fuelled this growth, including an aging population, high obesity rates, increased prevalence of chronic diseases and a raised public awareness of both healthy and unhealthy foods. As a result, health and wellness is a major factor affecting consumers' purchasing decisions.

Aging Demographics

A significant trend contributing to the need for health-promoting foods is the lengthening of life expectancy, particularly in the developed world, which has changed dramatically in the last 50 years.

In 2011, an estimated five million Canadians were 65 years of age or older, a number that is expected to double to reach 10.4 million seniors by 2036. An estimated one in four Canadians is expected to be 65 years of age or older by 2050.²

In the U.S., people 65 years or older numbered 39.6 million in 2009 and represented 12.9 per cent of the population. By 2030, there will be about 72.1 million older persons accounting for 19 per cent of the population.³

Obesity

According to the World Health Organization (WHO), obesity has nearly doubled worldwide since 1980, to approximately 500 million people, and shows no sign of decreasing.⁴

The Centers for Disease Control and Prevention (CDC) indicated that 35.7 per cent of the U.S. population was obese in 2009–2010.⁵ Obesity is most prevalent in women age 60 and older. The percentage of Canadians who are obese has steadily increased from 22.3 per cent in 2003 to 25.3 per cent in 2011.⁶

Obesity's impact on the health of nations is not immediate. It occurs over a longer time frame, expressing itself through higher incidences of chronic disease such as cardiovascular disease (CVD), diabetes, bone and joint ailments, and other conditions. Obesity-related diseases will continue to increase over time. The CDC reports that 75 per cent of U.S. health-care expenditures are used for treating chronic diseases.⁷

Cardiovascular Disease

Globally, more people die from CVD than from any other cause. An estimated 17.3 million people died from CVD in 2008, representing 30 per cent of all global deaths.

Of these deaths, an estimated 7.3 million were due to coronary heart disease and 6.2 million were due to stroke. WHO projects CVD deaths to rise to 23 million by 2030.⁸

In the United States, CVD accounts for approximately one in three deaths, with more than 2,150 Americans dying daily from CVD.⁹ About half of American adults have one or more chronic health conditions, with heart disease and cancer together accounting for nearly 48 per cent of all deaths.⁷

In Canada, diseases such as heart disease, stroke, cancer and diabetes affect an estimated three out of five individuals over the age of 20.¹⁰ An estimated nine out of 10 Canadians have at least one CVD risk factor, with over 40 per cent of individuals aged 20 to 79 having elevated levels of total cholesterol.¹¹

Diabetes

The number of adults with diabetes worldwide has more than doubled over three decades and is now estimated to be 8.3 per cent, or 371 million people.¹² In Canada, the prevalence of diabetes is projected to reach 3.2 million people in 2016.¹³ Diabetes is predicted to rise from being the 11th leading cause of death worldwide in 2002 to the seventh by 2030; in high-income countries, it is expected to climb to become the fourth leading cause of death.¹³



Diet and Disease

The director-general of WHO has concluded that, “The lives of far too many people in the world are being blighted and cut short by chronic diseases such as heart disease, stroke, cancer, chronic respiratory diseases and diabetes.”¹⁴

WHO recommends the implementation of a comprehensive action plan to promote healthy eating and physical activity, and the realignment of health services to meet the demands of chronic disease prevention and control.¹⁴

Without diet and lifestyle changes, chronic diseases will continue to affect millions globally, leading to lives full of sickness, disability and immobility.

A significant body of research indicates that increasing the intake of certain foods can reduce the risk of many diseases. Eating more whole grains such as barley is one example of a simple change that can contribute to a healthier diet over the long term. Barley is nutrient-dense food rich in dietary fibre that aligns with dietary guidelines from leading health authorities.

Barley: A Naturally Healthy Choice

Barley (*Hordeum vulgare*) is an ancient grain that has been grown and consumed for thousands of years. Barley is Canada’s fourth-largest crop, after wheat, canola and corn.¹⁵ In North America, barley is a major crop used for animal feed as well as for malt for brewing beer. With consumer interest in grains growing, barley is gaining popularity as a tasty, healthy, local food.

Pot and pearl barley are the most common products available. Pot and pearl barley are processed by “pearling,”

which removes the inedible hull and creates a white-coloured, quicker-cooking product. Besides removing the inedible outer hull, the pearling process removes the germ and bran layer and, for this reason, pot and pearl barley are not considered whole grains. They are, however, still high in protein and soluble fibre. The difference between pot and pearl barley is that pearl barley has been pearled more to produce a whiter product.¹⁶

Whole barley that has been de-hulled to remove the inedible hull is also available. De-hulled barley is considered a whole grain because only the inedible hull has been removed. Whole barley takes longer to cook than either pearled or pot barley.¹⁶

Barley flour milled from either pearled barley or whole, de-hulled barley is also available and can be used as a complete or partial substitute for wheat flour in recipes. Barley flakes are also available and can be used as a breakfast cereal or as a substitute for oatmeal in recipes such as cookies.¹⁷

The nutrition profile of some common barley products is shown in Table 1.

Table 1. Nutrition profile of pearled, hulled barley and barley flour*

	Pearled (1/4 cup, 50 g)	Hulled† (1/4 cup, 46 g)	Flour‡ (1/4 cup, 37 g)
Energy	176.0 kcal	162.8 kcal	127.8 kcal
Total fat	0.6 g	1.1 g	0.6 g
Protein	5.0 g	5.7 g	3.9 g
Carbohydrate	38.9 g	33.8 g	27.6 g
Fibre	7.8 g	8.0 g	3.7 g

* Adapted from the U.S. Department of Agriculture¹⁸ † Minimally processed to remove the hull
‡ Made from pearled barley

Whole Grains: A Nutrition Powerhouse!

Whole grains such as barley have been studied clinically for decades and have numerous health benefits supported by solid science.

What is a whole grain?

Whole grains contain all the essential parts and naturally occurring nutrients of the entire grain kernel in their original proportions.

If the grain has been processed (e.g., cracked, crushed, rolled, milled), the product should deliver the same rich balance of nutrients that are found in the original kernel. This means that 100 per cent of the original kernel—all of the bran, germ and endosperm—must be present to qualify as a whole grain.

The outer bran layer of whole grains is composed of non-digestible, insoluble, minimally fermentable carbohydrates.¹⁹ The inner germ and endosperm contain viscous soluble fibres and many other nutrients.¹⁹ In addition to dietary fibre, whole grains are important sources of resistant starch, trace minerals, vitamins, phytoestrogens, and antioxidants that are associated with disease prevention.¹⁹

Barley Components²⁰

HUSK (HULL)

- Fibrous protective coating
- Removed during harvesting or milling

ENDOSPERM

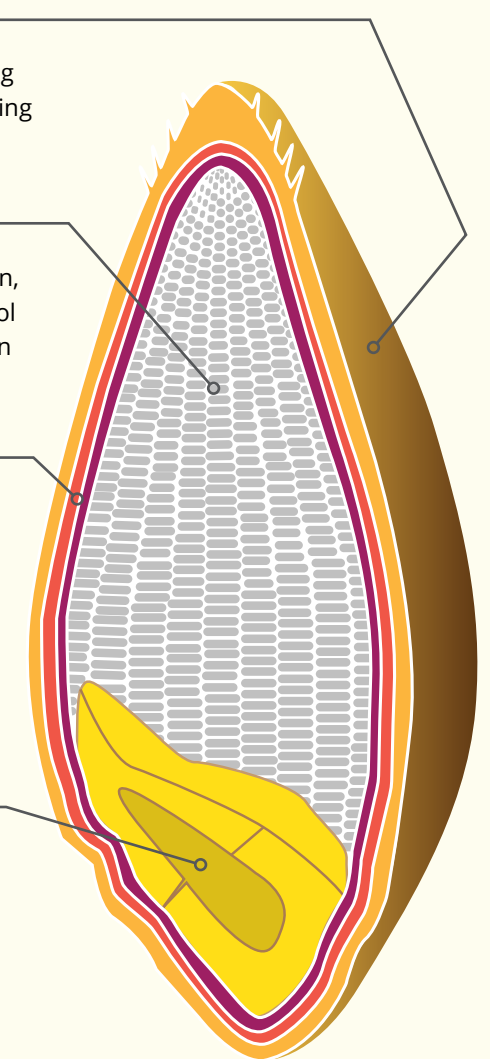
- Contains soluble β -glucan, which reduces cholesterol
- Rich in starch and protein

BRAN AND ALEURONE

- High in dietary fibre and phenolic compounds
- Also contains soluble β -glucan
- Often removed during pearling

GERM

- Rich in lipids (fats) and tocopherols (vitamin E)





The Facts on Fibre

The Institute of Medicine defines dietary fibre as “the non-digestible carbohydrates and lignin that are intrinsic and intact in plants. Functional fibre consists of isolated, non-digestible carbohydrates that have beneficial physiological effects in humans. Total fibre is the sum of dietary fibre and functional fibre.”²⁸

Non-digestible carbohydrates can be further categorized into soluble and insoluble fibres based on their chemical, physical and functional properties. As the names imply, soluble fibres dissolve in water to form viscous gels, whereas insoluble fibres do not dissolve in water.

The Institute of Medicine has set the adequate intake for fibre at 14 grams per 1,000 kilocalories, or about 25 grams per day for women and 38 grams per day for men.²⁸ In spite of the known benefits of fibre, 90 per cent of the U.S. population does not consume enough²⁰ and average intake among Canadians is only about half of the recommendation.²⁹

Barley has the highest fibre content of the food grains (Table 2). Many of the health-promoting properties of whole grains are related to their high fibre content. Dietary fibre intake is inversely associated with risk of chronic disease, including coronary heart disease, stroke, hypertension, diabetes, obesity and metabolic syndrome.³⁰

Table 2. Total dietary fibre content of select grains¹⁸

Whole grain (dry)	Total dietary fibre (g/100 g)
Barley, pearled	15.6
Rye	15.1
Wheat	12.2
Oats	10.6
Buckwheat	10.0
Corn	7.3
Quinoa	7.0
Wild rice	6.2
Brown rice, long grain	3.5

Cardiovascular disease

Cereal fibre is strongly associated with reduced risk of myocardial infarction and stroke, as well as the incidence and rate of death from CVD.²⁰ Increasing consumption of soluble fibres, such as the β -glucan in barley, has clinically significant effects by reducing LDL-cholesterol by five to 10 per cent.³¹

Weight management

Dietary fibre from whole grains may assist with weight loss and/or prevention of weight gain. Since fibre is not enzymatically digested and absorbed, but instead undergoes various degrees of fermentation in the large intestine, it can lower dietary energy density. Soluble fibres, such as the β -glucan and arabinoxylan in barley, contribute to satiety by absorbing large amounts of water and forming gels, thereby increasing stomach distension and slowing gastric emptying. Consuming 20 to 27 grams of dietary fibre daily may help to promote weight loss.³²

Type 2 diabetes

Whole-grain and fibre intake has been shown to be inversely associated with insulin resistance and the risk of developing Type 2 diabetes.²⁴⁻²⁶

Cancer

Diets rich in fibre and whole grains may protect against certain types of cancer, particularly colon cancer. β -glucan has also been reported to possess anti-cancer properties.³³

Gastrointestinal disorders

High-fibre foods are recommended for gastroesophageal reflux disease, duodenal ulcers, inflammatory bowel syndrome, diverticular disease, constipation and hemorrhoids.³⁰ As the largest immune organ in the human body, the gastrointestinal tract is key to overall health, and high fibre intake may enhance immunity.³⁰

Recommendations for whole-grain intake

It is estimated that 99 per cent of the U.S. population does not consume the recommended amount of whole grains (42 to 112 grams per day).²⁰ Whole-grain intake among Canadians is also well below recommended intakes.²¹

Eating Well with Canada's Food Guide recommends consuming at least half of grains as whole grains.²²

The *Dietary Guidelines for Americans* recommend consuming at least half of all grains as whole grains and increasing whole-grain intake by replacing refined grains with whole grains.²³

Whole grains are healthy because they contain:

- Protein for muscle development and tissue repair
- Insoluble and soluble fibres that promote digestive health and lower cholesterol

- Healthy fatty acids, including linoleic acid, oleic acid and α -linolenic acid
- Vitamins and minerals, including B vitamins, vitamin E, calcium, potassium, iron, magnesium and zinc
- Antioxidants that protect against oxidative stress

Whole grains have been shown to reduce the risk of many chronic diseases. Epidemiologic studies demonstrate that a daily intake of approximately three servings of whole grains is associated with a lower body mass index (BMI) and a reduction in central adiposity.¹⁹ Whole-grain and fibre intake has been shown to be inversely associated with insulin resistance and the risk of developing metabolic syndrome and Type 2 diabetes.²⁴⁻²⁶ A meta-analysis found that increasing whole-grain consumption by two servings per day was associated with a 21 per cent decrease in risk of Type 2 diabetes.²⁷

Soluble Fibre

Barley is a rich source of soluble fibre, particularly arabinoxylan and β -glucan.³⁴ Many of the health benefits of barley are attributable to its soluble fibre content, which absorbs water, hydrates, and thus delays gastric emptying, as well as lowers serum cholesterol and moderates postprandial glycaemic response.

Increasing consumption of soluble fibres has clinically significant effects by reducing LDL-cholesterol an estimated five to 10 per cent.³¹ Soluble fibre reduces postprandial lipemia, decreases lipid oxidation, inhibits lipogenic enzymes, and is inversely associated with C-reactive protein concentrations, a marker of inflammation and a risk factor for cardiovascular disease.³⁵

β -glucan increases bile acid excretion by entrapping or binding to the acids and excreting them in the feces.³⁶ Since cholesterol is a substrate for bile acid synthesis, increased excretion results in reduced circulating cholesterol levels.³⁶ Soluble fibre may also lower serum cholesterol levels by acting as a food source for microbial populations, resulting in the production of short-chain fatty acids that inhibit cholesterol synthesis.²⁰

Table 3: Fibre composition (percentage, dry matter basis) of whole-grain barley flours from different varieties

Fibre	CDC McGwire	CDC Fibar	Falcon	Millhouse
β -Glucan	4.3	7.5	3.7	4.1
Soluble fibre	4.7	8.4	3.6	4.0
Insoluble fibre	8.0	7.9	8.2	5.8
Total dietary fibre	12.7	16.3	11.8	9.8

Adapted from Malcolmson et al.¹⁶

Insoluble Fibre

Barley is a rich source of insoluble fibre. Although insoluble fibre does not form gels and has limited fermentability in the colon, it is the type of fibre primarily responsible for promoting bowel regularity by adding bulk.

Constipation is a frequent gastrointestinal complaint and can be especially problematic among the elderly. Fibre consumption can help in the treatment and prevention of constipation.³⁰

Resistant Starch

Resistant starch refers to starch and starch degradation products that are not absorbed in the small intestine because they are resistant to the effects of the alpha-amylase enzyme. Resistant starch is considered to have similar physiological effects and health benefits as fibre because it is not effectively broken down in the gut.³⁴

The amount and degree of resistant starch in a food is affected by many properties including the size, shape and crystallinity of the starch granule; lipid, protein and phosphate content; amount of amylose; and processing.³⁴ Barley is a rich source of resistant starch with the amount ranging from two to 17 per cent, depending on the type of processing.³⁷ For example, flaked barley was found to have more resistant starch than milled (ground) barley.³⁷

Resistant starch has been shown to have numerous health benefits. Although it lacks viscosity like soluble fibre, it is fermented in the colon to short-chain fatty acids. The physiological benefits of resistant starch fermentation include greater production of butyrate, the preferred substrate for colonocytes. Butyrate has the ability to repair damaged DNA in colonocytes and induce death in genetically damaged cells, thus helping to reduce the risk of colon cancer.³⁴ In addition, short-chain fatty acids help to lower the pH of the colon, which limits the proliferation of pathogenic bacteria and reduces the formation of cytotoxic compounds.³⁴

Resistant starch can help to:³⁴

- Prolong satiety to assist with weight management
- Improve blood glucose control
- Inhibit the growth and proliferation of colorectal cancer tumours
- Reduce inflammation



Barley Is a Low-Glycemic-Index Food

Glycemic index was developed to rank carbohydrate-containing foods based on their effect on postprandial glycaemic response. To determine glycemic index, portions of a test food and control food (either white bread or glucose) are fed in amounts that provide equivalent amounts of available carbohydrate. Blood samples are taken at specific time intervals after the food is consumed. The area under the glycaemic response curve is then determined for both the test and control foods. The glycemic index of the test food is calculated as a percentage of the mean glycaemic response to the control food.³⁸

Glycemic load is calculated by multiplying the glycemic index by the carbohydrate content of the food. For people with diabetes, low-glycemic-index foods may provide additional benefit over carbohydrate counting alone.³⁹

Barley has the lowest glycemic index of the food grains and is lower than many other commonly consumed high-carbohydrate foods.

Table 4. Glycemic index of selected foods⁴⁰

Food Item	GI*
Barley	40
Lentils	41
Corn	75
Buckwheat	78
Couscous	93
Rice, brown	94
Bread	100
Millet	101
Potato	117

*Glycemic index determined using white bread as reference food in subjects with normal glucose tolerance



Barley Is a Source of Plant Protein

The amino acid profile of barley is similar to that of other grains.⁴⁴ Though the protein in grains may not stand out as a key nutritional attribute, grains can make an important contribution to overall protein intake, particularly for vegetarians or people trying to consume less animal products. In a world that is striving to feed a rapidly expanding population, choosing more plant-based foods is becoming an increasingly popular strategy among environmentally conscious consumers seeking more sustainable diets.

Complete proteins, also referred to as high-quality proteins, are those that provide all essential amino acids in ratios

required for endogenous protein synthesis. In contrast, an incomplete protein is low in one or more essential amino acids (i.e. limiting amino acid). Animal proteins are complete proteins, whereas most plant proteins are incomplete. In spite of this limitation, essential amino acid requirements can be met exclusively by plant proteins if a variety of plant sources are consumed to meet energy needs.

The limiting amino in barley is lysine, followed by threonine. However, legumes such as beans and lentils provide a complementary protein profile to grains and can be used to balance the intake of essential amino acids. Complementary proteins do not have to be consumed at the same meal and can meet amino acid requirements by being consumed over the course of the day.

Prebiotics: Feeding the Beneficial Bacteria

A complex community of bacteria lives in the human intestine. In fact, there are more bacterial cells in the body than there are human cells. Probiotics are the “good” micro-organisms that provide health benefits when consumed in adequate amounts.

Scientific evidence is mounting regarding the critical role intestinal bacteria play in human health and disease. Prebiotics are non-digestible food components that promote the growth of beneficial gut bacteria (i.e., probiotics) while preventing the invasion of harmful bacteria. Although all prebiotics are a type of fibre, not all fibres meet the criteria to be considered prebiotics.

Prebiotics have been shown to:⁴¹

- Reduce infectious and antibiotic-associated diarrhea
- Provide symptom improvement for people with inflammatory bowel disease
- Protect against colon cancer and cardiovascular disease
- Enhance mineral absorption
- Increase satiety for weight control

Both β -glucan and arabinoxylan fibres in barley show promise as prebiotics.

β -glucan has been found to be highly fermentable by gastrointestinal bacteria. In addition, the hydrolysis products of arabinoxylan have demonstrated prebiotic properties, including promotion of bowel regularity as well as lowering of blood cholesterol, triglyceride and glucose levels.⁴²

Given the high prevalence of obesity in North America, the emerging role that gastrointestinal bacteria may play in weight management is an exciting and rapidly developing area of research. Gut microbiota show promise in the area of energy regulation. Studies in animals in which intestinal micro-organisms have been transplanted between lean and obese animals have shown significant interactions between diet, microbiota and body weight status.⁴³ Though more research is required to unlock how micro-organisms can be used to manage weight, whole-grain, high-fibre foods such as barley are an important part of a diet to support digestive health.



The recommended dietary allowance of high-quality protein for both men and women is 0.8 grams per kilogram of body weight per day.²⁸ The acceptable macronutrient distribution range (AMDR) is “the range of intake for a particular energy source that is associated with reduced risk of chronic disease while providing intakes of essential nutrients.”²⁸ For protein, the AMDR is 10 to 35 per cent.²⁸

Emerging research suggests that protein requirements may be somewhat higher than the levels established by the Institute of Medicine,⁴⁵ although this evidence has not yet prompted a revision of the recommendations.

A dietary plan that includes 25 to 30 grams of high-quality protein per meal may help to maximize muscle protein synthesis. This is a particularly important consideration for elderly populations who are at increased risk for sarcopenia, the degenerative loss of skeletal muscle mass that occurs with aging.⁴⁶

Vitamins and Minerals in Barley

Barley contains many essential vitamins and minerals, including thiamine, niacin, folate, riboflavin, iron, calcium, potassium, phosphorus, magnesium, manganese, zinc and selenium (Table 5). The B complex vitamins in barley play important roles as cofactors in energy metabolism. Grains are a rich source of magnesium, which may contribute to their beneficial effects on insulin sensitivity and diabetes.⁴⁷ Iron, zinc and manganese are cofactors of antioxidant enzymes and have important regulatory and metabolic functions.⁴⁷ Together, the macro- and micronutrient profiles of barley make this grain a nutrition masterpiece.

Table 5. Vitamin and mineral composition of hulled barley*†

Nutrient	Value per 100 g
Minerals	
Calcium (mg)	33
Magnesium (mg)	133
Phosphorus (mg)	264
Sodium (mg)	12
Iron (mg)	3.6
Zinc (mg)	2.77
Copper (mg)	0.498
Manganese (mg)	1.943
Selenium (µg)	37.7
Vitamins	
Thiamine (mg)	0.646
Riboflavin (mg)	0.285
Niacin (mg)	4.604
Pantothenic acid (mg)	0.282
Vitamin B6 (mg)	0.318
Folate (µg)	19
Vitamin B12 (µg)	0
Vitamin C (mg)	0
B-carotene (µg)	13
Lutein + zeaxanthin (µg)	160
Vitamin E (α-tocopherol) (mg)	0.57
Vitamin D (µg)	0
Vitamin K (phylloquinone) (µg)	2.2

*Minimally processed to remove the hull †Adapted from the U.S. Department of Agriculture¹⁸

Antioxidants and Phytochemicals in Barley

Cells are under constant attack from free radicals and reactive oxygen species (highly reactive molecules that cause cellular damage). Oxidative stress occurs when there is an imbalance in the levels of antioxidants and reactive oxygen species. Oxidative stress and inflammation are closely linked and contribute to the development of chronic disease. The body's antioxidant system provides a complex defence mechanism that is supported by the consumption of antioxidant-containing foods such as barley.

Tocopherols and tocotrienols are types of vitamin E compounds, with each class occurring in four forms: α-, β-, γ-, δ-tocopherol and α-, β-, γ-, δ-tocotrienol. Although α-tocopherol is likely the best-known form, all possess antioxidant properties and thus play important physiological roles. Both tocotrienols and tocopherols have been shown to inhibit cholesterol synthesis and possess neuroprotective and anti-carcinogenic properties, though tocotrienols appear to be more effective.^{48,49} Barley is unique among the cereal grains because it contains all eight vitamin E forms.⁴⁴ In addition, barley has more α-tocotrienol than oats, wheat or rye (Table 6).⁴⁹

Table 6: α-Tocotrienol content of select grains

Grain	α-Tocotrienol content (µg/g)
Barley	10.61
Rye	8.69
Wheat	2.83
Oats	1.38

Adapted from Bartłomiej and Baaj⁴⁹

Phenolic compounds are another type of antioxidant found in grains. Diets rich in phenolic compounds are associated with reduced risk of CVD and some cancers.⁴⁸ Nine phenolic acids have been found in barley, with ferulic acid being the most abundant.⁵⁰ Ferulic acid possesses high antioxidant properties, and has anti-inflammatory and tumour-inhibition properties.⁵⁰



Barley is also a dietary source of phytosterols, secondary plant metabolites that help to lower serum cholesterol levels in humans. Ingestion of one to three grams per day of plant sterols is associated with a 10 per cent decrease in serum LDL-cholesterol without altering levels of “good” HDL-cholesterol.⁴⁹ Barley is a natural source of phytosterols, offering 70 to 80 milligrams per 100 grams.⁴⁹

Barley: An Ancient Grain

Barley is an ancient grain that has a long history of use in human nutrition dating as far back as 10,000 BC.⁴⁴ Barley is considered to be one of the founding crops of Old World agriculture.⁵¹ Ancient grains are increasing in popularity among people who want to get back to basics when it comes to their food choices and for those who are looking to consume a more wholesome, nutritious diet.

Some people avoid consuming gluten, so instead they choose ancient grains. However, some ancient grains contain gluten and are not approved for those who are on a medically prescribed gluten-free diet.

Barley and the Gluten-Free Diet

The gluten-free diet was developed to treat patients with celiac disease or non-celiac gluten sensitivity.⁵² Celiac disease is an inherited autoimmune disease that is triggered by the consumption of gluten, a protein found in wheat (including spelt and kamut), barley and rye. When a person with celiac disease ingests gluten, their immune system responds negatively to the presence of the protein, resulting in inflammation and damage to the inner lining of the intestine. This injury reduces the absorption of important nutrients including iron, calcium, folate and vitamin D. The only treatment for celiac disease is a strict gluten-free diet.

Many popular diet and weight-loss plans recommend eliminating certain foods or food components. Recently, some diet plans have suggested that gluten should not be eaten because it is harmful to health and causes obesity. While avoidance of gluten is necessary if a person suffers from celiac disease or non-celiac gluten sensitivity, gluten is not harmful for the rest of the population, nor does it cause obesity. A gluten-free diet does not include barley because barley contains gluten. However, barley is an excellent choice for inclusion in diets where gluten avoidance is not necessary.



It is estimated that up to 30 per cent of U.S. adults have reduced or eliminated gluten from their diets for various reasons.⁵³ Retail sales of gluten-free products have increased by as much as 28 per cent in the last 10 years.⁵³ There is a belief that humans are not meant to eat gluten since it was not part of the diets of our early ancestors. While it is true that gluten-containing crops have only been grown for a few thousand years, most people handle gluten without any problems.⁵⁴ There is little evidence that eliminating gluten improves health in people who have not been diagnosed with celiac disease or non-celiac gluten sensitivity.⁵⁵

Many people choose to consume a gluten-free diet without medical supervision or dietary guidance from a registered dietitian.⁵³ This is not recommended because it may result in poor intake of important nutrients such as fibre, iron and calcium.^{52,56} Adherence to a gluten-free diet is restrictive, difficult to maintain and typically involves higher food costs. It should not be assumed just because a food is gluten-free that it is a healthy option. Gluten-free foods are often high in fat, sugar and salt, and low in fibre, vitamins and minerals.

Autism
Gluten-free diets are promoted in the media for people with autism. One belief is that people with autism have a “leaky gut” that allows gluten protein to be absorbed into the bloodstream to affect the brain and nervous system. Research on the association between gluten and autism is very limited. Some evidence suggests that a gluten-free diet may benefit some people with autism, but the cost and difficulty of eliminating dietary gluten makes the diet almost impossible for most patients.⁵²

Weight control
There is limited research on the association between gluten and obesity. There are, however, numerous studies that suggest that fibre from whole grains helps with weight management.⁵⁷ Soluble fibres, such as the β -glucan in barley, contribute to a feeling of fullness by forming a type of “gel” in the stomach that delays gastric emptying. In addition, whole grains protect against cardiovascular disease by improving blood glucose control, reducing blood pressure and lowering cholesterol.⁵⁸

Although gluten should not be eaten by people with celiac disease or non-celiac gluten sensitivity, the consumption of whole grains such as barley has positive effects on health, and intake should be encouraged for most people.⁵⁸

Health Claims and Food Labelling for Barley Products

The use of government-approved health claims on food labels can help educate and improve the health of consumers as well as provide food manufacturers with a marketing tool for their products.⁵⁹

Canada
In 2012, Health Canada approved the claim that barley-containing foods are a source of fibre shown to help lower cholesterol.⁶⁰ An example of the permitted claim is: “125 ml (1/2 cup) of cooked pearled barley supplies 60 per cent of the daily amount of the fibre shown to help lower cholesterol.”⁶⁰

The “daily amount” referred to in the claim is three grams of barley β -glucan,⁶⁰ and the food must contain at least one gram of β -glucan per serving size. Included in the claim are de-hulled or hulless barley, pearled barley, barley flakes,

grits, meal, flour, bran as well as β -glucan-enriched milling fractions, but it does not include extracted barley β -glucan.⁶⁰

Health Canada permits the following statements in addition to the primary statement:⁶⁰

- Barley fibre helps reduce/lower cholesterol
- High cholesterol is a risk factor for heart disease
- Barley fibre helps reduce/lower cholesterol, (which is) a risk factor for heart disease

Fibre content claims
Health Canada permits nutrient content claims that describe directly or by implication the level of a nutrient or dietary substance in a serving.⁶¹ In Canada, barley products can make “source of fibre” claims if they meet certain conditions.

Pearled and hulled barley provide six grams or more of fibre per reference amount and stated serving size, and are permitted to state that they are a “very high source of fibre,” “very high fibre,” “very high in fibre,” “fibre rich” or “rich in fibre.” Barley flour provides four grams or more of fibre per reference amount and stated serving size; the package label may state “high source of fibre,” “high fibre” or “high in fibre.”

The Daily Value is a set of reference standards established by Health Canada for reporting nutrients in the “nutrition facts” table. The “% Daily Value” is calculated by determining the ratio between the amount of the nutrient in a serving of food and the Daily Value for the nutrient. As a rule of thumb, a “% Daily Value” of less than five per cent means that the food provides a little of the nutrient, whereas a value greater than 15 per cent means the food provides a more substantial amount. Due to inherently high fibre levels, hulled and pearled barley and barley flour all contribute to the Daily Value for this nutrient (Table 7).

United States
The United States Food and Drug Administration approved a health claim for barley in 2006. The claim permits foods containing barley that provide at least 0.75 grams of soluble fibre per serving to state that they may help to reduce the risk of coronary heart disease.⁶²

An example of the claim would be: “Soluble fibre from foods such as barley cereal, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease. A serving of barley cereal supplies one gram of the three grams of soluble fibre from barley necessary per day to have this effect.” The amount of soluble fibre per reference amounts customarily consumed (RACC) must be declared in the nutrition label.

Fibre content claims
In the U.S., if a food contains 20 per cent or more of the Daily Value per RACC, the label may state that the food is “high,” “rich in” or an “excellent source of” a particular nutrient. Such a claim may be made for the fibre content of pearled barley (28 per cent of the Daily Value), hulled barley (32 per cent of the Daily Value) and barley flour (20 per cent of the Daily Value).

Table 7: Dietary fibre content and % Daily Value of barley products*

Barley Product	Dietary Fibre per Serving (g)	% Daily Value
Hulled barley	8	32
Pearled barley	7	28
Barley flour	5	20

*In accordance with both Canada and U.S. labelling regulations



Barley and Food Applications

Both hulled and hullless barley are grown, with the vast majority being the hulled type. Hulled barley requires the removal of the tough, fibrous and largely indigestible hull for food use. The most common method involves the gradual removal of the outer tissues of the kernel by abrasion—a process referred to as pearling. Through this process, the hull is removed along with the germ and some of the bran layer. Hullless barley has a weaker attachment of the hull to the kernel, allowing the hull to be removed during harvesting, thereby eliminating the need to remove the hull prior to processing. This is particularly beneficial in the production of barley flour.

Hullless barley varieties have been developed with different starch characteristics due to altered levels of amylose content. These varieties have different functional properties than varieties with normal starch characteristics.

Additionally, hullless barley varieties with normal and enhanced levels of β -glucans are available, resulting in easier milling to produce whole-grain barley flour for use in foods to meet the barley health claim.

Malcolmson et al.¹⁶ undertook a series of studies to evaluate the performance of whole-grain barley flour in baked goods (pan and pita breads, bagels, tortillas, pizza crusts and crackers) as well as pasta and directly expanded puffs. They also compared the processing, end-product quality and β -glucan content of products made from normal and zero-amylose barley varieties.

The food development studies showed that whole-grain hullless barley flour can be used to formulate high-quality, better-for-you baked products, pasta and extruded snacks and breakfast cereals.

Partial substitution of wheat flour with whole-grain barley flour resulted in the production of high-quality products, although modifications to the formulation and processing conditions were needed. The level of substitution was reported to be dependent on the product being made, but good-quality products are achieved with between 25 and 50 per cent substitution. At these levels, it was possible to meet the barley health claim, although this was dependent on the product being made, the variety of barley used and which government-approved health claim was being considered.

Barley Fits Market Trends

Survey after survey reports that health and wellness are two of the central guiding principles of today's eating culture.⁶³ Consumers globally link processed foods to many health conditions and have become increasingly savvy readers of labels, zeroing in on and avoiding foods that contain preservatives, chemicals and too-long or unpronounceable ingredients. Instead, they seek foods that are fresh, less processed and natural. Barley fits these requirements with its wholesome image. Shoppers tend to have sets of claims they seek in tandem, corresponding with underlying interests and values. Those who seek high fibre, for example, tend to be among those who seek whole grains—again, another plus for barley.

Whole grains and fibre

With consumers actively seeking foods that offer improved nutrition, taste and health benefits, the market for whole grains and fibre is increasing. There is a movement by the food industry to capitalize on market trends and to reformulate products to conform with existing health recommendations and consumer demands. This is particularly apparent in the baked foods and snacks sector.

In its *12 Key Trends in Food, Nutrition & Health 2015* report, New Nutrition Business identifies “good carbs and the steady rise of good grains” as key drivers in food, nutrition and health.⁶⁴ The authors predict that consumers will continue to seek out grains that they perceive as more natural. Another “key trend” identified in the same report, and where barley has a strong fit, is that of the “snackification” of meals.

The *Wall Street Journal* noted that the percentage of Americans who snack at least three times a day has nearly tripled over the last couple decades, from 20 per cent in the 1990s to 56 per cent in 2010. The number was just 10 per cent in the late 1970s.⁶⁵ For an increasing number of consumers, a snack is not an add-on to the traditional three meals a day; snacks are those meals. Data also reveals that, currently, half of all eating occasions are snacks, with 80 per cent taking place at home.⁶⁶

Consumers appear to be aware of dietary recommendations for whole grains and fibre, and are interested in consuming more. Food manufacturers using barley are well poised to fulfil this need.

According to a survey undertaken by the Canadian Foundation for Dietetic Research, baby boomers continue to be a big driver in the demand for whole-grain products as they look to manage their health and improve or maintain their quality of life through nutrition.⁶⁷ Weight management and body image are also key factors that influence food choice.

The same 2013 survey found that 45 per cent of those Canadians striving to improve their diets and health were endeavouring to consume more fibre and whole grains. The most influential factors affecting food choices included “source of fibre” in addition to “food made from whole grains,” for 74 per cent and 71 per cent of this sector, respectively.

The Food Marketing Institute conducts its *Shopping for Health* survey annually to gauge the attitudes of American shoppers to health and nutrition.⁶³ When asked what they were purchasing more of over the period of 2012 to 2013, among the top responses were whole-grain products (43 per cent), multigrain products (42 per cent) and products high in fibre (37 per cent).

According to the 2014 *Food & Health Survey* from the International Food Information Council (IFIC) Foundation, the presence of whole grains in a product is a strong factor in influencing consumer purchases. When asked which of a certain ingredient consumers were trying to consume more of, their top choices were fibre (53 per cent) and whole grains (67 per cent).

Consumer desire for whole grains and fibre is reflected in a growing global market that is projected to reach \$29.5 billion by 2020.⁶⁸ The U.S. represents the largest market globally, while the Asia-Pacific region ranks as the fastest-growing market with a projected compound annual growth rate (CAGR) of 9.2 per cent to 2020. An additional analysis estimated the dietary fibre market to grow from



\$2.3 billion in 2013 to \$4.2 billion by 2019 with a CAGR of 13.1 per cent through 2019.⁶⁹ In terms of revenue in 2013, North America led the market, followed by Europe and the Asia-Pacific region. India, China, Brazil and Argentina are poised to exhibit the fastest-growing trend for dietary fibre consumption.

Data from Mintel's Global New Products Database shows that there were almost 20 times as many new whole-grain product launches in 2010 than in 2000. Bakery products, breakfast cereals and snacks account for a large proportion of new product introductions.

Plant proteins

The use of plant-based proteins is one of the biggest trends in the healthy food sector. Protein-rich foods are important to consumers who perceive health benefits relevant to all family members.⁷⁰ In the *Shopping for Health* 2014 survey, 33 per cent of U.S. shoppers indicated that protein content is an essential criterion when purchasing foods.⁶³

When making decisions about buying packaged food or beverages, 57 per cent of Americans surveyed by IFIC stated that consuming more protein was a critical characteristic in food choice.⁷¹ The primary reasons included: "protein is

an important component for a balanced diet" (76 per cent), "to gain energy" (62 per cent), "to build or maintain muscle strength" (56 per cent) and "for satiety" (51 per cent).

As a result of consumer demands, there has been a notable shift in the food industry away from animal-based proteins toward the use of plant-derived sources that offer similar or superior functional properties. The volume of plant protein ingredients used in food, beverage and dietary supplements was 1.6 million metric tons in 2012 and is expected to increase to 2.3 million metric tons by 2018.⁷²

North America represents the largest market for plant proteins.⁷² Products with a "high-protein" claim experienced an 87 per cent growth rate between 2008 and 2012.⁷³ Europe is also a large consumer of plant protein ingredients, with a predominance of non-genetically modified sources of soy and wheat.

The bread category was a key application area for plant proteins in 2010, representing 13.5 per cent of new introductions, followed by soups (seven per cent). There were also a large number of plant proteins used in prepared pasta (6.4 per cent) and cereals and cereal bars (5.6 per cent).⁷⁴

Although new product launches in Europe with high-protein claims have tripled in the past five years, representing a 260 per cent increase from 2008 to 2013, introductions of food products carrying these claims were three times higher in the U.S.⁷³ Products carrying this claim in the U.S. account for 19 per cent of global new product launches, with India following at nine per cent and the U.K. at seven per cent.⁷⁵

Conclusions

A number of factors support the demand-driven growth of healthy foods, including an aging population as well as an increased prevalence of obesity and chronic disease. Contributing to this trend is rising consumer knowledge and awareness of personal health. The need to improve overall health—and, in particular, heart health—continues to be a primary reason consumers are seeking nutritional food products. Barley, being one of the few ingredients that have government-approved heart-health claims in both the U.S. and Canada, can assist food companies to deliver solution-based nutrition to consumers.

Another key motivation people have to eat healthy is weight management, with food purchase decisions being significantly affected by a desire to lose or maintain weight.

Barley is high in fibre, which is very useful for stimulating satiety in weight-reduction products.

Dietary fibre and whole grains are nutrients of concern in many diets. Boosting the fibre content of foods through the use of certain whole grains or isolated fibres is becoming more common in order to help consumers meet their requirements. Barley as a whole grain has high fibre content and can contribute significant nutritional attributes in many food applications.

With greater efforts being made to develop barley varieties for food use, there will be greater opportunities for food companies to formulate foods with increased β -glucans and soluble fibre levels using barley ingredients.¹⁶

Barley offers a highly nutritious and practical approach to improving consumers' diet and overall health.

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