

Beta-Glucan: Health Benefits and Product Applications



**Innovating to Meet Nutrition,
Health, and Wellness Needs Every Day**

PromOat® Beta Glucan

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- Research indicates that diets higher in fibre are associated with improved health and reduced risk of certain diseases
- Oat beta-glucan is a viscous, soluble fibre that can help maintain healthy blood cholesterol and blood glucose levels as well as support gastrointestinal health and assist in weight management
- Despite the fact that many consumers say that they are making efforts to consume diets high in dietary fibre, current fibre intakes remain below recommendations
- Tate & Lyle's PromOat® Beta Glucan is a great example of an ingredient that manufacturers can use in the development of new and innovative products that may promote health while helping to meet the population's dietary fibre needs

Fibre types and health benefits

Decades of research indicate that diets higher in fibre are associated with reduced risks for heart disease and diabetes^{1,2} as well as improved gut health and digestion²; however, average intakes remain well below the currently recommended amounts^{1,3}. With fibre intakes low across global populations, there is potential for long-term public health implications^{1,3}.

Dietary fibres are nondigestible carbohydrates in the diet that, when consumed, pass through the small intestine into the large intestine where they may be partially or completely fermented by colonic microbiota². There are several varieties of dietary fibre, and each type provides specific health benefits; thus, it is recommended that individuals consume fibre from multiple sources. Fibres can be soluble or insoluble in water as well as viscous or nonviscous. Viscous soluble fibres, including oat beta-glucan, are the only fibres that have been shown to lower cholesterol⁴. Research studies have demonstrated that increasing soluble fibre intake by 5-10 g/day can reduce LDL cholesterol by 5%⁵. For greater LDL cholesterol reductions, the Therapeutic Lifestyle Changes (TLC) diet recommends soluble fibre intakes up to 25 g/day⁴. Considering that most individuals habitually consume less than

25 grams of fibre per day in total⁶⁻¹², methods to increase soluble fibre intake are needed.

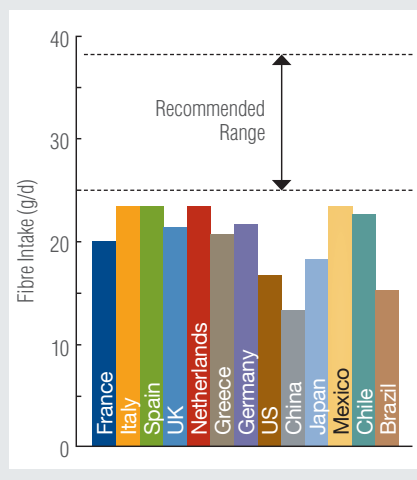
Tate & Lyle's PromOat® Beta Glucan is a viscous soluble fibre made from non-genetically modified (non-GM) Swedish oats that can be added to foods and beverages to promote healthy cholesterol levels while increasing dietary fibre intake. Clinical studies have demonstrated additional health benefits associated with oat beta-glucan intake, such as maintaining health blood glucose levels, supporting gastrointestinal health, and assisting with weight management.

Dietary fibre gap: Intakes vs. recommendations

Most dietary fibre recommendations for adults call for intakes ranging from 25-38 g/day depending on country-specific guidelines^{2,7}. The World Health Organization (WHO) suggests worldwide recommendations of 25 g/day⁷. Figure 1 notes a wide range of fibre intakes across various countries against the recommended range for consumption⁶⁻¹². In the United States (US), for most age and gender groups, less than 5% meet the dietary recommendations for fibre¹³ despite consistent messaging to the public to increase dietary fibre intake. In the United Kingdom (UK), only 13% of women and 28% of men meet dietary fibre recommendations¹².

Data indicate that consumers believe fibre is important to health and that they recognize the lack of fibre in their diets¹⁴, yet closing the fibre intake gap has not been easy, as many diets continue to lack adequate servings of fruits, vegetables, whole grains, and fibre-fortified foods. Recent innovations are making it easier for food manufacturers to fortify their products to help boost fibre content and close this intake gap. An abundance of research continues to demonstrate that fibres added to foods provide similar benefits as "intact" fibres inherent in whole foods.

Figure 1
Adult fibre intakes by country⁶⁻¹²





Fibre Innovation for Health

Benefits

Oat beta-glucan has been tested by a number of independent researchers to demonstrate its physiological health benefits. The following are some highlights of the research on the health benefits of oat beta-glucan:

- Promotes heart health by lowering blood cholesterol levels¹⁶⁻²⁰
- Supports healthy blood glucose levels by eliciting a lower glycaemic response²¹⁻²³
- Well tolerated and may support a healthy gut by producing short-chain fatty acids²⁴⁻²⁶
- May assist with weight management through calorie and fat reduction in foods and promotion of satiety²⁷⁻²⁹

Fibre innovation

While traditional sources of fibre like whole grains, fruits, and vegetables should be encouraged, fibres added to foods are also important contributors to dietary fibre intakes. Dietary fibres that are either extracted or synthesized nondigestible carbohydrates and have beneficial physiologic effects in humans are now available on the market; the US Institute of Medicine refers to these as functional fibres². Fibres such as these are useful in developing products that have exceptional taste and appeal to the consumer while offering the same health benefits as fibres that are intact and naturally occurring in fruits, vegetables, and grains. Adding even small amounts of fibre to foods traditionally low in dietary fibre, resulting in amounts as low as 2.5-5.0 g/serving, could help individuals meet their fibre requirements without exceeding calorie needs¹⁵.

PromOat[®] Beta Glucan is an example of a versatile functional fibre ingredient produced by Tate & Lyle and currently used in foods and beverages in North America, Europe, and Asia as a potential solution to increase fibre intake without sacrificing taste, texture, or enjoyment. Total daily intakes of beta-glucan as low as 3.0-4.0 g/day have been shown to

promote health through maintenance of healthy blood cholesterol and blood glucose levels while helping to meet daily recommended fibre needs^{19,20}.

Characterization of PromOat[®] Beta Glucan

Beta-glucans from oats and barley are polysaccharides of linear, mixed linkage (1,3), (1,4)-beta-D-glucans. PromOat[®] Beta Glucan is concentrated beta-glucan derived from non-GM, Swedish oats, produced by a chemical-free, aqueous, enzymatic process. The final product is a fine, cream-colored powder with a caloric value of 3.2 kcal/g of ingredient. PromOat[®] Beta Glucan is a source of 35% oat soluble beta-glucan fibre by weight and contains small amounts of carbohydrate and protein; fat content is negligible (Table 1).

Oat beta-glucans from different sources can have a wide range of molecular weights, as processing conditions affect the final product. PromOat[®] Beta Glucan has a high molecular weight similar to native oat beta-glucan. The high molecular weight makes PromOat[®] Beta Glucan highly viscous. Many health benefits associated with oat beta-glucan are

Table 1

Nutritional content of PromOat[®] Beta Glucan^a

	PromOat [®] Beta Glucan
Energy ^b	315 kcal or 1319 kJ
Total fat	0.5 g
Saturated fat	< 0.1 g
Carbohydrate	56 g
Fibre (beta-glucan) ^c	35 g
Sugars	< 0.5 g
Protein	4 g
Sodium	< 25 mg

^a Values per 100 g on a dry weight basis.

^b Determined by calculation using 2 kcal/g for the soluble fibre portion. When using 4 kcal/g for the soluble fibre portion, the calculated calorie value is 385 kcal.

^c Typical range: 34-36 g; minimum: 33 g.

attributed to viscosity that increases with molecular weight^{19,23,30}.

PromOat[®] Beta Glucan has strong water-binding and emulsifying properties. It thickens and stabilizes emulsions, creating a smooth texture and creamy mouth feel in reduced-fat products. This ingredient can also lengthen the shelf life of food products due to improved moisture management, and it is acid- and heat-stable, which allows for easy integration into many food and beverage products.



Fibre Innovation for Health

Supports healthy blood cholesterol

In 2012, the World Health Organization (WHO) reported that coronary heart disease (CHD) was the leading cause of mortality, resulting in 7.6 million deaths worldwide³¹. It is well established that reducing blood cholesterol reduces the risk of CHD, and the US National Cholesterol Education Program (NCEP)* estimates that each 1% reduction in LDL cholesterol reduces the risk of heart disease by 1-2%⁵. Several clinical studies have demonstrated that increasing intake of viscous soluble fibres like beta-glucan can effectively reduce LDL and total cholesterol. Three meta-analyses have summarized nearly 50 randomized controlled trials including 1,780 normo- and hypercholesterolaemic subjects completed between 1985 to 2007^{16,17,32}. Overall, the data suggest that 3 g/day of beta-glucan can lower LDL cholesterol by 3-5% and total cholesterol by 2-4%^{16,17,32}. This may result in a reduction in heart disease by 3-10%, with the greatest reductions occurring in those with higher starting cholesterol levels¹⁶. Additionally, the physicochemical properties of beta-glucans can impact the efficacy in lowering cholesterol. Oat beta-glucans with high molecular weight and solubility used at high concentrations are thought to be more viscous in the small intestine. This increased viscosity may reduce reabsorption of bile acids and increase the synthesis of new bile acids from cholesterol, thus reducing circulating LDL concentrations²⁰.

In weighing the totality of the evidence, the European Food Safety Authority (EFSA) issued a positive opinion for the ability of oat beta-glucans to lower blood cholesterol and reduce the risk of cardiovascular disease²⁰. Several countries allow health claims or functional claims for beta-glucan and heart health/cholesterol reduction. The claims are based on a daily consumption of 3 g beta-glucan, which in most cases can be divided among three to four servings of foods.

Even the most recent studies continue to support the findings that oat beta-glucan may promote the reduction of blood cholesterol. For example, Queenan et al. demonstrated that 6 g/day of oat beta-glucan significantly reduced LDL cholesterol in those with elevated cholesterol compared to



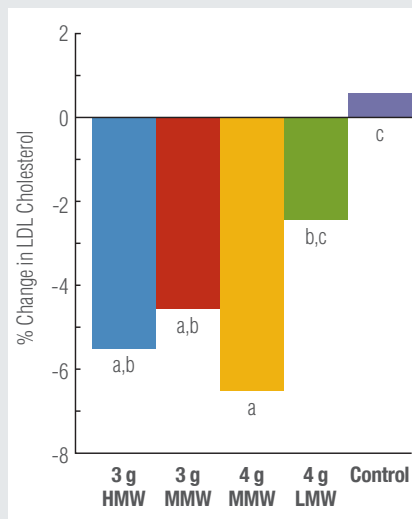
a control¹⁸. Further, Wolever et al. demonstrated that both oat beta-glucan dose and molecular weight are critical in cholesterol lowering¹⁹. In this study, 3 g/day of a high molecular weight and 3 g/day and 4 g/day of a medium molecular weight oat beta-glucan significantly reduced LDL cholesterol compared to a wheat fibre control (Figure 2)¹⁹. PromOat® Beta Glucan is a high molecular weight beta-glucan.

Favorable blood glucose and insulin response

The impact of oat beta-glucan on blood glucose and insulin responses has also been studied extensively over the past few decades. In 2011, EFSA determined that a cause and effect relationship has been established between the consumption of beta-glucans (from both oat and barley sources) and a reduction of postprandial glycaemic responses²¹. Their conclusion was based off of six key clinical trials that consistently demonstrated 'an effect of oat and barley beta-glucans in decreasing postprandial glycaemic responses, without disproportionately increasing postprandial insulinaemic responses, at doses of at least 4 g per 30 g of available carbohydrates²¹'. Further, EFSA determined that the mechanism by which beta-glucans lower blood glucose has been well established²¹. Beta-glucans increase the viscosity of the meal bolus, thereby reducing the interaction between food and digestive enzymes in the stomach, delaying gastric emptying, and reducing absorption of glucose^{21,22,33-35}. Because viscosity plays a large role in reducing blood glucose and insulin responses, differences in physicochemical properties of beta-glucans, such as molecular weight, may impact the magnitude of the effect.

Figure 2

Reduction in LDL cholesterol following four weeks of oat beta-glucan consumption¹⁹



Treatment groups with different letters are significantly different (P<0.05)

HMW = High molecular weight
MMW = Medium molecular weight
LMW = Low molecular weight

*A program managed by the US National Institute of Health.



A recent review by Tosh concluded that the EFSA recommendation of including 4 g of beta-glucan per 30 g available carbohydrate may be too restrictive²². A total of 34 studies with 119 treatments including both oat and barley beta-glucan were included in this review. These studies were controlled, randomized, blinded, crossover, or parallel in design and included information on available carbohydrate dose, beta-glucan dose, and postprandial blood glucose response. Data were combined for oat and barley products as average reductions in area under the curve (AUC) for glycaemic response were not significantly different. Tosh found that glycaemic response was more strongly related to beta-glucan dose than the ratio of beta-glucan to available carbohydrate in processed foods. Including at least 4 g beta-glucan per ~30-80 g of available carbohydrate should significantly reduce postprandial glycaemic response²².

Studies published after these reviews continue to provide evidence that beta-glucan can reduce postprandial glycaemic response and that the physicochemical properties of the beta-glucan consumed may impact the magnitude of the results. For example, Kwong et al. demonstrated that at a dose of 4 g, a high molecular weight, high viscosity beta-glucan was more effective at attenuating peak blood glucose rise than a low molecular weight, lower viscosity beta-glucan²³. PromOat® Beta Glucan is a high molecular weight beta-glucan.

Weight management

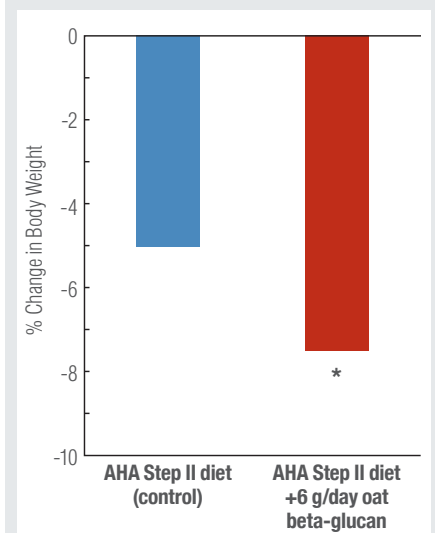
PromOat® Beta Glucan may help support weight management through enabling fat and calorie reduction in food formulations. Intake of beta-glucan may also promote satiety and/or reduced energy intake at a subsequent meal. For example, Beck et al.^{27,28} observed that subjective satiety ratings significantly increased with an oat beta-glucan dose as low as 2.2 g and that appetite suppressant hormones cholecystokinin (CCK) and plasma peptide YY (PYY) were significantly increased in a dose-dependent manner when evaluating 0 g (control), 2.2 g, 3.8 g, and 5.5 g of beta-glucan for part or all of the study population. Energy intake at a subsequent meal was also reduced in subjects who consumed the highest dose of beta-glucan compared to the control. Although these energy intake results did not reach statistical significance, the absolute difference was greater than 400 kJ (~95 kcal) in a single meal, which is clinically relevant as it could equate to a 0.4 kg (0.9 lb) weight loss monthly if maintained²⁸.

Chronic studies provide a better indication of the long-term effects of oat beta-glucan on satiety and weight management. In a randomized, controlled, parallel-group study of an oat-derived beta-glucan extract, thirty-eight overweight men consumed the TLC/Step II diet** for eight weeks and bread with 6 g of beta-glucan or a whole wheat bread control²⁹. The two breads were equivalent in energy, protein, fat, and carbohydrate, and energy intakes between the groups were similar overall. Both body weight and body mass index (BMI) were reduced by 7.5% in the oat beta-glucan group and 4.9% in the control group, resulting in a statistically significant difference between the two groups (Figure 3)²⁹.

While additional studies are needed, this emerging evidence suggests that oat beta-glucan may support weight management efforts through increased satiety, changes in satiety hormones, and reduced calorie intake.



Figure 3
Reduction in body weight after 6 g/day oat beta-glucan for eight weeks²⁹



*Significant difference compared to control (P<0.002)

** The TLC/Step II diet is recommended by the US NCEP and the American Heart Association for individuals with elevated blood cholesterol. The diet is reduced in fat, saturated fat, and cholesterol compared to a typical western diet.

Fibre Innovation for Health

Promotes GI health

Resists digestion and is fermented in the gut

Oat beta-glucan contains a mixture of β (1-3) and β (1-4) glucosidic linkages that reduce the digestibility of this ingredient³⁶⁻³⁹. Undigested beta-glucan serves as a valuable substrate for fermentation by colonic bacteria, leading to the production of the short chain fatty acids (SCFA) propionate, butyrate, and acetate. In vitro studies demonstrate that significantly greater production of butyrate occurs with fermentation of beta-glucan compared to inulin²⁴, FOS, psyllium, and corn arabinoxylan²⁵. Increasing butyrate is desirable as it is the main energy source for colonocytes and has demonstrated anti-inflammatory and anticarcinogenic properties^{40,41}. Propionate production was also enhanced in these studies^{24,25}, which may be beneficial due to links between this SCFA and satiety as well as inhibition of cholesterol synthesis^{41,42}. Fermentation of

oat beta-glucan has also been demonstrated in rats. Over a six week period, faecal pH was reduced and SCFA concentrations were increased in rats fed oat beta-glucan. Additionally, ammonia levels, β -glucuronidase activity, and azoreductase activity were reduced, suggesting that consumption of oat beta-glucan may reduce the concentration of toxic compounds in the colon²⁶. Compared to many other fibres, the fermentation of oat beta-glucan is delayed, which may further promote colonic health by enhancing production of beneficial SCFA in the distal colon where toxic compounds from protein digestion are created and the majority of colon cancer lesions are seen^{18,25,43}, however, additional research is needed.

Good digestive tolerance

The majority of studies investigating the various health benefits of oat beta-glucan have been completed without reports of gastrointestinal disturbances. Oat beta-glucan is a well tolerated soluble fibre.

Use of PromOat® Beta Glucan in foods and beverages

PromOat® Beta Glucan can be used in a wide variety of foods and beverages including cereals, baked goods, soups, sauces, salad dressings, dips, smoothies, fruit juices, and sports drinks. Its contribution to the product's overall fibre would be included in the fibre listing on the nutrition information panel for food. Depending upon the recipe, usage level, and local regulations, products containing PromOat® Beta Glucan may be labelled as gluten-free*.

Current fibre intakes are very low among US adults, at about one-half of the US daily fibre recommendation of 25-38 g/day for women and men^{2,44}. In other nations⁷, average fibre intakes also fall well below recommended intakes. Diets high in fibre have been associated with lower risk of heart disease and improved blood glucose control while also supporting digestive health and laxation and aiding in weight management^{45,46}.

Consumption of foods and beverages made with PromOat® Beta Glucan can help close the fibre intake gap and may help to reduce calorie and fat intake. PromOat® Beta Glucan is well tolerated, and research suggests that it supports healthy cholesterol and blood glucose levels, may promote gastrointestinal health, and may help consumers maintain a healthy body weight.



To learn more about PromOat® Beta Glucan please visit www.promoat.com.

* Labelling and claims may vary by country. Customers are advised to consult their own regulatory experts to determine appropriate labelling and claims for their products.

Innovating to Meet Nutrition, Health, and Wellness Needs Every Day

Nutrition professionals opportunity to educate consumers

Despite the fact that many consumers say that they are making efforts to consume diets high in dietary fibre and that they review labels for dietary fibre content when purchasing products, current fibre intakes remain low^{7,14}. This has long-term implications for public health related to risk of coronary heart disease, stroke, hypertension, certain gastrointestinal disorders, obesity, and the continuum of metabolic dysfunctions including prediabetes and type 2 diabetes^{1,47}. According to a 2014 food and health survey of US consumers by the International Food Information Council, 53% of individuals stated that they are trying to consume more dietary fibre¹⁴. Nutrition professionals can help to move consumers toward the goal of increasing fibre intake with education on benefits and sources of dietary fibre as consumers desire to make dietary changes.

Conclusions

While individuals should increase their consumption of dietary fibre from sources such as beans and peas, other vegetables, fruits, and whole grains¹, the incorporation of added fibre like PromOat[®] Beta Glucan into foods as part of a well-balanced diet can help individuals meet their recommended fibre intakes without exceeding their calorie needs. As a gently processed, high molecular weight, neutral tasting beta-glucan, Tate & Lyle's PromOat[®] Beta Glucan is uniquely positioned to be an ingredient that food manufacturers can use in the development of new and innovative products to meet the population's fibre needs and provide health benefits, including maintenance of healthy blood cholesterol and blood glucose, supporting gastrointestinal health, and potentially supporting weight management.

A commitment to innovation

Tate & Lyle, a global leader in wellness innovation, is committed to delivering innovative ingredients that can be incorporated into great-tasting foods to help consumers meet their nutrition, health, and wellness needs every day. That is because Tate & Lyle invests heavily in innovation and research and in developing ingredients that can be incorporated into a wide variety of great-tasting food and beverage solutions. Teams of food and nutrition scientists are continuously innovating, researching, and testing ingredients that will meet current and future health and nutrition needs.

At the same time, Tate & Lyle has a robust market research program designed to provide the necessary insights on consumer preferences around the world. The research program allows Tate & Lyle to customize its offerings and provide tailor-made solutions in local and regional markets.

Better-for-you ingredients for health and wellness

In response to global public health efforts calling for people to reduce calories and sodium and increase fibre intakes, Tate & Lyle offers a number of novel ingredient solutions that meet these needs.



Tate & Lyle's global Commercial and Food Innovation Center, Hoffman Estates, Illinois, USA

To learn more about Tate & Lyle ingredients and innovation as well as health benefits and relevant research, please visit www.foodnutritionknowledge.info and www.tateandlyle.com.

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