



## $\beta$ -Glucan and its Health Benefits: A Review

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### Abstract

The  $\beta$ -glucans are the polymers of glucose present in the cells walls of fungi and cereals. They are the major compositions of several nutritional diets such as barley, oats and mushrooms. Earlier report suggested that  $\beta$ -glucans have anticancer, antidiabetic, anti-inflammatory and immune-modulating effects. The importance of  $\beta$ -glucans in food processing industries such as yogurt, bread and pasta have been well known to everyone. Recent research suggested that gut microbiota plays a significant role and vastly studied for its intermediate role in regulating health. Several reports have suggested that  $\beta$ -glucans has a significant impact on the gut microbiota which plays a major role in human health. The review focusses on clinical trials as well as various health benefits of  $\beta$ -glucans on humans.

**Keywords:**  $\beta$ -glucans; Bacteria; Fungi; Yeast

### Introduction

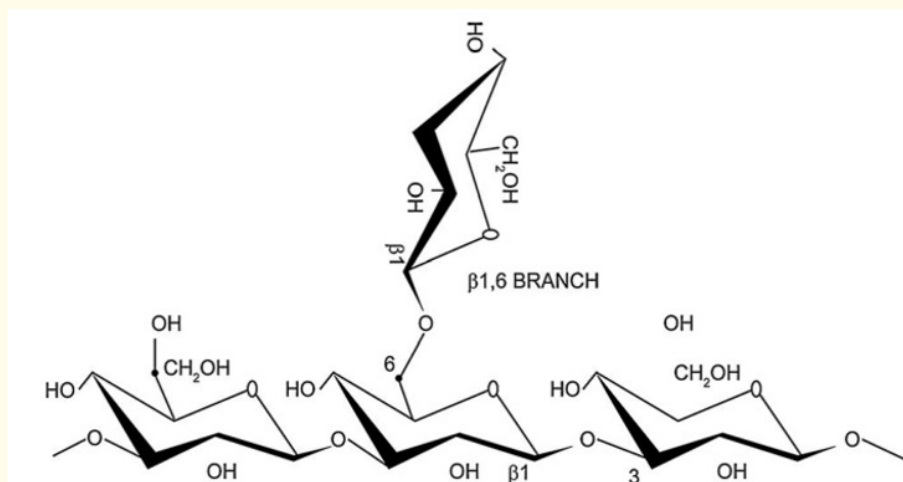
$\beta$ -glucans are a group of naturally dietary fibers, found a high level in the cell wall of certain microorganisms including bacteria, fungi, yeast and in the endospermic and aleuronic walls of the cereal grains such as oats, barley, rye and millets.  $\beta$ -glucan is a strongly hydrophilic non-starchy polysaccharide, generally divided into soluble and insoluble  $\beta$ -glucans, based on physiological properties. Insoluble  $\beta$ -glucans fibers consist of  $\beta$ -(1,3/1,4)-D-linked glucose units, whereas soluble viscous  $\beta$ -glucans fibers consist of  $\beta$ -(1,3/1,6)-D-linkage glucose [1]. Other names for  $\beta$ -glucans include:  $\beta$ -glycans,  $\beta$ -1,3-glucan, and  $\beta$ -1,3/1,6-glycan.  $\beta$ -glucans are taken as herbal medicines associated with various prebiotic effects and beneficial health outcomes such as reduction in glycemic index and serum cholesterol; control of diabetes, cardiovascular diseases, cancer, and hypertension; immune-enhancing properties; antimicrobial (antibacterial, antiviral) properties; and wound healing activities [2].

Probiotics have a long history of safe consumption and can regulate intestinal microflora balance. They offer a range of health benefits, including preventing necrotizing enterocolitis, reducing crying in infants with colic and improving the quality of life for IBS patients<sup>2</sup>.  $\beta$ -glucans have been shown to be a carbon source

for some probiotic microorganisms, influencing their growth rate and lactic acid production in the intestinal environment [3]. The US Food and Drug Administration has included  $\beta$ -glucans in natural compounds that affect the immune response and recommends that regular intake of 3g of  $\beta$ -glucan from cereal sources, such as oats or barley, along with a low cholesterol diet, helps in reducing the risk of heart-related disease [4].

### Structure of $\beta$ -Glucan

$\beta$ -glucans are chains of  $\beta$ -D-glucose monomer units, linked together by several different types of glycosidic linkages at different positions. The most common forms of  $\beta$ -glucans are those comprising of D-glucose units with  $\beta$ -1,3 links. Structure of  $\beta$ -glucan can either be branched or unbranched<sup>5</sup>.  $\beta$ -glucans, derived from cereal, are mixtures of  $\beta$  (1 $\rightarrow$ 3) and  $\beta$  (1 $\rightarrow$ 4) glycosidic linkages without any  $\beta$  (1 $\rightarrow$ 6) bonds. Yeast  $\beta$ -glucans (e.g., *Saccharomyces cerevisiae*) are mixtures of linear  $\beta$  (1 $\rightarrow$ 3) backbones with 30-residue straight chains and connected through long branches attached via  $\beta$  (1 $\rightarrow$ 6) linkages whereas Fungal  $\beta$ -glucan are made of straight  $\beta$  (1 $\rightarrow$ 3) glucan with short-branched chains connected through  $\beta$  (1 $\rightarrow$ 6).  $\beta$ -glucans from bacteria (e.g., *Agrobacterium bio-baris*) have straight and unbranched  $\beta$  (1 $\rightarrow$ 3)-D-glucan backbones [4].



**Figure 1:** Structure of β-glucan (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5618555/#B11-ijms-18-01906>).

### How does β-glucan work?

β-glucan itself is not digested as it is a viscous fiber and it forms a gel in digestive tract. As a result, delay in carbohydrate absorption, slowing the delivery of glucose into the bloodstream. This thick gel grabs cholesterol as it slowly moves through the digestive system to prevent absorption, and then eliminates it from your body [6]. When β-glucan is taken by mouth, it might lower blood cholesterol by preventing the absorption of cholesterol from food in the stomach and intestines, When given by injection, β-glucans might stimulate the immune system by increasing chemicals which prevent infections [7].

### Foods sources of β-Glucan

β-Glucans are a type of soluble dietary fibers, found naturally in cereal grains, yeast, and certain mushrooms and sold as a supplement. Among Cereals, barley (2-20g, 65% is water-soluble fraction) and oats (3-8g, 82% is water-soluble fraction) have the highest content of β-Glucan. Other Cereals also contain β-Glucan but in much lower amounts like sorghum (1.1-6.2g), rye (1.3-2.7g), maize (0.8-1.7g), triticale (0.3-1.2g), wheat (0.5-1.0g), durum wheat (0.5-0.6g), and rice (0.13g) [4]. Other sources of β-Glucan include yeasts, such as *Saccharomyces cerevisiae*, various species of mushrooms, such as Reishi, Maitake and Shiitake, and seaweeds, such as *Laminaria* sp [8]. Canada is a major producer of both oats and barley, producing 2297.6 and 7605.3 thousand metric tons of oats and barley, respectively, in 2010/2011. In 2007, Canada was the 5<sup>th</sup> leading producer of barley and 2<sup>nd</sup> leading producer of oats worldwide [7].

### Health benefits of β-Glucan

A β-glucan rich diet has potential effects on human health by preventing chronic non-communicable diseases, such as diabetes, hypercholesterolemia, obesity, cardiovascular diseases and cancer

[9]. These highly viscous β-glucans fibers have proven health benefits including lowering blood cholesterol and blood lipid profiles as well as maintaining body weight. β-glucans are potent immunomodulators with effects on both innate and adaptive immunity and thereby have beneficial effects in fighting infectious diseases, such as bacterial, viral, fungal, and parasitic diseases. In several countries including the United States of America, Canada, Finland, Sweden, China, Japan, and Korea, β-glucans are allowed as potent immunological activators and found to be the most effective soluble fiber with strong anticancer, insulin resistance, anti-hypertension, and anti-obesity effects [1].

Here's the extensive study findings on the possible health benefits of beta-glucan:

**Cholesterol:** Elevated total and low-density lipoprotein (LDL) cholesterol levels are considered as major risk factors for cardiovascular disease. β-glucans rich foods like oatmeal, is responsible for significantly lowering low-density lipoprotein (LDL or "bad") cholesterol and reduce heart disease risk. A health claim that "Oat β-glucan, a soluble dietary fiber, definitively helps for reducing plasma cholesterol levels and risk of heart disease" approved by the United States Food and Drug Administration (FDA) in 1997. Similarly, a cholesterol-lowering health claim for oat β-glucan was allowed by the United Kingdom Joint Health Claims Initiative (JHCI) in 2004. The original conclusions made by FDA and JHCL show that intake of oat β-glucan at daily doses of at least 3 g may reduce plasma total and low-density lipoprotein (LDL) cholesterol levels by 5-10% in normocholesterolemic or hypercholesterolemic subjects. Studies described herein have shown that, on average, oat consumption is associated with 5% and 7% reductions in total and LDL cholesterol levels, respectively. Significant scientific agreement continues to support a relationship between oat β-glucan and blood cholesterol levels, with newer data being consistent with earlier conclusions made by the FDA and JHCI [10].

- **Dosage:** At least 3 grams of β-glucan daily, is found to be reduced total cholesterol and LDL cholesterol. But it doesn't impact on HDL cholesterol levels, which is also a good thing for heart health [11].
- **Diabetes:** Diabetes mellitus (Diabetes) is a chronic disease, which is caused due to high blood glucose level (hyperglycemia). According to World Health Organization (WHO) statistics, about 171 million people from worldwide are suffering from diabetes in 2000 and this number would be more than doubled by 2030. Management of Diabetes includes: control of blood glucose level and lipids and reduction of hypertension. β-glucan have potentially beneficial in the treatment of diabetes and associated cardiovascular disease. The foods containing β-glucan have been used for clinical trial in the treatment of diabetes. The intake of natural dietary fiber β-glucan has been shown to reduce all the risk factors, that will provide benefit to the treatment of diabetes and associated complications. Research also suggests that β-glucan may help in managing diabetes by controlling blood sugar levels, lowering cholesterol, and keeping blood pressure in check. β-glucan supplementation can help to lower blood sugar and improve insulin sensitivity [12].
- **Cancer:** Research indicates that β-glucan may stimulate immune cells to produce anti-cancer compounds called cytokines, which regulate inflammation and help the immune system fight diseases such as cancer. According to a 2013 review published in *Anti-Cancer Agents in Medicinal Chemistry*, most cancer research on β-glucan has been conducted in test tubes and mice, with few trials conducted in humans. Human trials have been reported as a positive impact on patient survival and quality of life. Japan approved a mushroom-derived β-glucan for use with chemotherapy to treat gastric cancer and colorectal cancer, and to prolong remission among patients with small-cell lung cancer according to a 2012 study published in the journal *Surgery*. As per a 2009 review published in the *Journal of Hematology and Oncology*, β-glucans may boost the immune system in patients with late-stage cancers [13].

#### Possible side effects

Although β-glucans are likely safe, but still there are some concerns associated with the consumption of β-glucan. As it lowers the blood sugar, it's a benefit in some cases but it can be dangerous to the people with hypoglycemia. People should take lower dose of β-glucan, who generally eat low fiber diet. If it's taken in larger than normal dose, it may cause gastric distress, bloating, gas [14]. A recommended amount of β-glucans intake through dietary choices may not cause side effects, but consumption of a β-glucan supplement carries potential side effects and risks.

Possible side effects of taking a β-glucan supplement orally include:

- Diarrhea
- Nausea
- Vomiting

Possible side effects of taking β-glucan intravenously include:

- Back and joint pain
- Fever and chills
- Excessive urination
- Diarrhea
- Changes in blood pressure
- Skin rashes
- Swollen lymph nodes

So, before taking β-glucan, definitely consult your physician first to make sure it is ok for you to use these products [13].

#### Clinical trials of β-Glucan

As Glucan Therapy achieved remarkable success in pre-clinical animal models, many efforts have been made to determine therapeutic efficacy in human patients. No human adverse effects have been reported for the consumption of a diet, rich in β-glucan from oats or barley flour or their extracts. Glucans, derived from the Shiitake mushroom (lentinan) and from *Coriolus versicolor* (Polysaccharide-K) have been licensed as successful drugs in Japan since 1983. Currently 177 β-glucan clinical trials are summarized by the American database ClinicalTrials.gov, mostly in cancer, gastrointestinal tract therapy, lowering cholesterol and improvements of immune reactions. This database mostly covers the trials, which is either performed in the USA or at least involving US companies. There is another clinical trial study, Maitake (mushroom-derived glucan), can progress to acute myelogenous leukemia in myelodysplastic syndromes [15]. In Clinical Trials, β-glucans have been orally administered in capsules, in food and as part of vaccines as adjuvants. Oral administration is as active as the injected dose, as shown by the study. For intervention purposes, most studies were aimed at oral administration of β-glucan (derived from cereal) for metabolic diseases [5].

#### β-Glucan as food supplement

β-glucans are part of a biologically active natural molecules group, and it can be taken orally as a food supplement or as part of a daily diet and are considered safe to use [1]. β-glucans have gained strong attention, among different types of fibers, due to their well-documented immunomodulatory activities, which involve anti-infectious immunity, anti-cancer immunity and all aspects of cellular and humoral defense reactions and able to decrease cholesterol

levels. Therefore β-glucans can be considered as one of the best types of soluble fiber for dietary supplementation [16].

### Conclusion

β-glucan is an exciting new area of research for many scientists, as it may improve many systems of the body, from the heart to the digestive system [17]. β-glucans are nutraceuticals having documented health benefits and industrial applications and also occupy a prominent position among immunomodulators. β-glucan, a source of numerous health benefits [12] are effective for lowering cholesterol, diabetes, cancer and used to boost the immunity of people, whose body defense has been weakened by conditions like chronic fatigue syndrome, or physical and emotional stress by the treatments such as radiation or chemotherapy [4].

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