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Beta Glucan and its Unprecedented Role in Human Health

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Introduction

Consumer demands for food production have evolved significantly during the past ten years. Foods are now meant not merely to sate hunger and supply the body with the nutrients it needs, but also to avoid nutrient related illness and to enhance both physical and mental health. In this context, functional foods stand for one of the most intriguing fields of study and invention in the food sector. In the field of food chemistry, Cereals constitute the major part with rice and wheat playing the main role. Among food components, cereal dietary fiber is considered a principal constituent with prebiotic characteristics, acting as a substrate for gut microorganisms and providing health benefits. Coarse cereals are natural sources of beneficial biological components like beta-glucans, polyphenols, and phytosterols, which contribute to probiotic diversity. Reviewing the health benefits of cereals through modulating intestinal flora holds significant value.

Cereal beta-glucan, a type of soluble dietary fiber, holds significant physiological importance because its consumption is directly linked to the reduction of both cholesterol and postprandial glucose levels. The health claims regarding the regulation of blood glucose and cholesterol by cereal beta-glucan have been recognized by regulatory bodies such as the European Food Safety Authority (EFSA) and the U.S. Food and Drug Administration (USFDA). One of the key properties of cereal beta-glucan is its ability to create a highly viscous environment in the intestinal lumen. This viscosity slows down gastric emptying and reduces the absorption of glucose, food lipids, and bile acids. Consequently, cereal beta-glucan plays a crucial role in promoting overall health and well-being through its impact on metabolic processes.

Research has shown that increasing the proportion of coarse cereals in dietary patterns is an effective way to promote probiotic diversity in the intestinal flora, which can further ameliorate multiple chronic diseases. For instance, studies have reported that oat food (Hu, Xing, & Zhen, 2013), barley husks, rye bran (Berger et al., 2014), and lignans (Kaur et al., 2014) can increase the growth of probiotic strains like Bifidobacteria or Lactobacillus. These probiotics exhibit anti-tumor potential and enhance the formation of short-chain fatty acids, such as acetate and butyrate.

Well defined sources

β-glucans are polysaccharides found in various sources, with cereals like oats and barley being major contributors due to their high beta-glucan content. These compounds can also be extracted from grains such as rye and rice, with rice-derived beta-glucans being marketed under the name 'NutrimXe'. Among cereals, Barley and Oats constitute high dietary fibre of around 15.6g/100g and 17.9g/100g respectively. The concentration of beta-glucans varies among different cultivars and plant parts, such as the kernels and bran in barley.

The extraction yield of beta-glucans is influenced by factors like the source, temperature, and pH conditions. For instance, the extraction yield from oats ranges from 50% to 80%, while barley yields between 70% and 80%. Extraction from the yeast *Saccharomyces cerevisiae* can yield up to 87% beta-glucans.

In recent years, edible mushrooms have gained significant research interest as sources of beta-glucans. Notable mushroom sources include *Agaricus brasiliensis, Pleurotus tuberregium, Lentinus edodes, Pleurotus eryngii* and *Pleurotus ostreatus*. These edible fungi are considered good sources of beta-glucans, making them attractive candidates for further investigation and potential applications. The findings suggested a potential link between the consumption of beta-glucans from Pleuran (β-glucan) and improved athletic performance. Specifically, the researchers reported that supplementation with pleuran enhanced the cellular immune response and reduced the occurrence of respiratory tract infections in the athletes studied, indicating that the intake of beta-glucans may contribute to better overall health and potentially enhanced performance. (Liu et al., 2021).

S. No	Sources	β-glucan content (%)
1	Oats	2.5-3.5
2	Barley	3-7
3	Lactic acid bacteria	2-14.5
4	*Paenibacillus polymyxa*	1.08
5	Brewer's yeast	51
6	*Saccharomyces cerevisiae*	36-42
7	*Pleurotus ostreatus*	0.2-0.56
8	*Pleurotus pulmunarius*	0.22-0.5

Table 1: Various sources of beta glucan

β-glucan, a health endorser

β-Glucan is a polysaccharide that serves as a primary structural component of the endosperm and aleurone cell walls in certain grains, such as barley. Its chemical structure consists of an unbranched linear chain composed of glucose monomers linked through β-1,3 and β-1,4 glycosidic bonds in a repeating pattern of g1→3g1→4g and G1→3G1→4G1→4G based on their preferential source. The ratio of β-1,3 to β-1,4 linkages in this polymer is approximately 1:3. The molecular weight of β-glucan from barley typically ranges from 126 to 338 kd. It is a homopolymer, meaning it is made up of a single type of monomer unit, in this case, β-D-glucopyranose residues. The biological efficacy and behavior of β-glucans are contingent upon several key attributes inherent to their molecular architecture. These pivotal factors encompass the precise linear sequence of monomeric units within the polymer backbone, the overall size or mass of the macromolecule, the presence of charged moieties along the polymeric chain, the extent of branching or lack thereof in the structure, the ability of the polymer to dissolve in aqueous environments, and the resistance to flow exhibited by solutions containing these polysaccharides.

β-glucan, a naturally occurring compound found in high concentrations (ranging from 3-8%) in barley, has garnered significant attention as a potential natural additive. Compared to oats, it boasts 3-9 times higher levels of this bioactive component. Unlike artificially synthesized stabilizers, β-glucan in barley possesses a high molecular weight, which can effectively increase the viscosity of solutions at relatively low concentrations. This viscosityenhancing property makes β-glucan a more efficient thickening agent compared to commonly used alternatives like locust bean gum or guar gum, as it can inhibit separation more effectively, even when added in small quantities.

Scientific evidence has demonstrated that β-glucan, possess the ability to modulate various physiological processes, including blood glucose regulation, lipid metabolism, insulin sensitivity, immune system modulation, and exhibiting anti-cancer and anti-microbial activities. Consequently, researchers have directed their efforts towards fortifying food products with barley β-glucan to enhance their nutritional value and impart these beneficial effects.

Role of β-glucan in reducing blood sugar level

There are many evidences suggesting that an increase in the molar weight/ viscosity of beta-glucan can improve the regulation of postprandial glucose levels. This effect is attributed to the formation of a highly viscous gel in the intestine, which entraps digestible saccharides. Due to the resistance of β-glucan to human digestive enzymes, the saccharides embedded within this gel become less accessible. The mechanism behind this phenomenon is threefold. Firstly, the passage of digestive enzymes through the intestine is restricted, reducing their ability to break down the saccharides. Secondly, the mixing of the luminal contents is diminished, hindering the interaction between enzymes and substrates. Thirdly, the transport of glucose to the absorbing surface is slowed down. Additionally, β-glucan has been found to inhibit the metabolism of glucose and the activities of digestive enzymes, such as alpha-glycosidase, during its transit through the digestive system. This further contributes to a reduced glucose response.

Collectively, these effects result in a slower and more gradual introduction of glucose into the bloodstream, leading to lower insulin concentrations. This moderation of glucose absorption and subsequent insulin response is considered beneficial in regulating postprandial glucose levels.

Role of β-glucan in reducing cholesterol level

Investigative studies involving hypercholesterolemic mice have provided valuable insights into the cholesterol-lowering mechanisms of barley β-glucans. When these mice were fed a diet supplemented with 5% β-glucan, compared to the control group, the consumption of β-glucan promoted increased excretion of total lipids and cholesterol through the gastrointestinal tract, leading to a significant reduction in low-density lipoprotein (LDL) cholesterol levels in the blood plasma. Furthermore, it has been shown to enhance the activity of cholesterol 7α-hydroxylase (CYP7A1), an enzyme present in the liver responsible for promoting cholesterol excretion, thereby contributing to the overall cholesterol-lowering effect observed in these studies. The primary studies suggested way that viscous (thick and sticky) fibers help lower cholesterol levels is by trapping bile acids and cholesterol, reducing the absorption and reabsorption of these substances. When less cholesterol and bile acids are absorbed, the levels of these substances in liver cells (hepatocytes) decrease. This triggers an upregulation of LDL receptors in the liver, which remove LDL particles and other lipoproteins containing apolipoprotein B from the bloodstream, thereby lowering the circulating level of LDL cholesterol (LDL-C). The fermentability of dietary fibers may play a smaller, secondary role in the cholesterol-lowering effect of fiber.

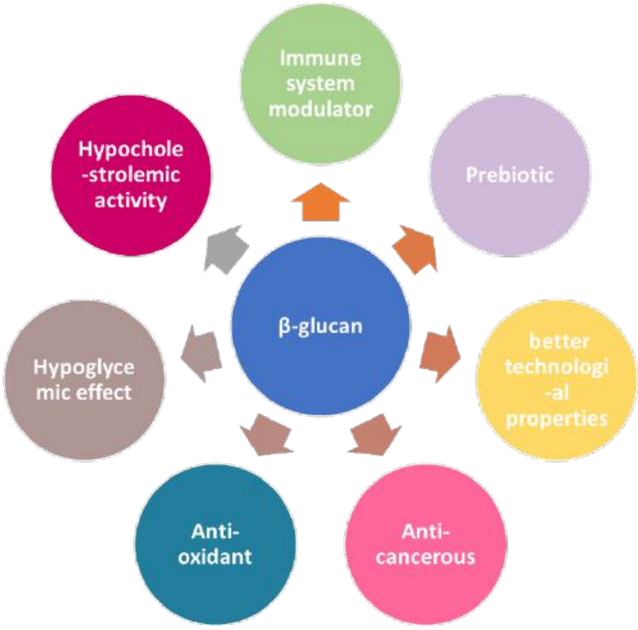
Probiotic effect of β-glucan as a prebiotic

Recent years have witnessed extensive research exploring the health-promoting properties derived from probiotics, prebiotics, and their combined form known as synbiotics. Many studies have utilized the potential of β-glucan as a prebiotic. Dietary patterns play a significant role in shaping the intestinal microecological landscape, exhibiting dynamic shifts in response to variations in eating habits and the intake of nutritional factors. Many investigations have unveiled that beta-glucans derived from oats and barley promote the growth of beneficial gut bacteria, namely Lactobacilli and Bifidobacteria, in a dose-dependent manner. Notably, oats beta-glucan exhibited a more pronounced effect compared to its barley counterpart (Shen et al., 2010). Prolonged adherence to specific dietary routines can profoundly influence the intestinal microbiota, potentially leading to the emergence of novel strains within the host organism (Hehemann et al., 2010). Studies have corroborated that the characteristics of the predominant microorganisms residing in the human gut are closely correlated with the composition and proportions of nutrients present in the overall dietary pattern. Current studies on prebiotics have highlighted their wide-ranging health benefits, including maintaining gut health, preventing colitis, inhibiting cancer, boosting the immune system, reducing cholesterol levels, decreasing the risk of cardiovascular disease, preventing obesity and constipation, restoring the vaginal ecosystem, and promoting the production of bacteriocins. The intricate interplay between diet and gut microbiota underscores the importance of maintaining a balanced and diverse dietary regimen to promote optimal gut health and overall well-being. High-fat and high-sugar diets can lead to an increase in the amounts of Firmicutes and Proteobacteria, along with a reduction in Bacteroidetes and Bifidobacteria in the host's intestine which can also provide diverse polyphenols and fibers that facilitate the growth of probiotics, thereby optimizing the intestinal microecology (Connolly, Lovegrove, & Tuohy, 2010). Generally, a significant portion of the consumed beta-glucans undergoes fermentation in the caecum and colon, yielding short-chain fatty acids such as acetate, propionate, and butyrate. These fatty acids play a crucial role in modulating the function of intestinal epithelial cells (Topping & Clifton, 2001). Emerging research in recent years has shed light on the role of beta-glucan in regulating gut hormones, specifically the pancreatic polypeptide family, glucagon-like peptide (GLP) −1 and GLP-2. This regulation occurs through the production of short-chain fatty acids and the activation of free fatty acid receptors 2 and 3. Consequently, beta-glucan contributes to its protective properties against chronic inflammation, glucose homeostasis, and cancer

Concerted research efforts have been directed toward investigating the effects of probiotics on various chronic diseases, with cardiovascular diseases, particularly atherosclerosis and myocardial infarction, garnering significant attention. The modulation of the gut microbiome through the consumption of coarse cereals and their associated probiotics holds promising implications for promoting overall health and mitigating the risk of chronic ailments.

β-glucan as a manipulating agent

Apart from its role as a health endorsing agent, β-glucans are commonly utilized in liquid food products, such as beverages, sauces, and soups, primarily for their emulsifying and thickening properties rather than as a nutraceutical ingredient. Additionally, it has also found applications in the food industry, such as formulating starter cultures and being incorporated into pet food, fish feed, poultry feed, pig feed, and cattle fee. The baking industry incorporates cereal-derived β-glucans into the formulation of bread and cake products to enhance their physical characteristics and increase the volume and quantity of bread loaves. Furthermore, the incorporation of β-glucans into low-fat ice creams and yogurts has been shown to improve their textural and rheological properties, resulting in a more desirable consistency and mouthfeel.



β-glucan and its varietal roles

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