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Health Beneficiary Effects of β-glucan Derived from BARLEY

Ashi Khare, Saumya Singh, Rupali Maheshwari, Mehak Aggarwal, and Smriti Gaur*

Department of Biotechnology, Jaypee Institute of Information Technology, A-10 sec 62, Noida, Uttar Pradesh, India
*E-mail: *smriti.gaur@jiit.ac.in*

Abstract—*Barley derived β-glucan is a polysaccharide, a soluble fiber which is known to be viscous and prebiotic in nature. It consist of 1,3-glycosidic and 1,4-glycosidic backbone with no branching. This barley derived fiber is an important neutraceutical component which is responsible for many health beneficiary effects. β-glucan has two forms , a high molecular weight glucan and a low molecular weight glucan. Oats, mushroom and yeast are also a source of β-glucan but barley's safe historical track records and it being less expensive with new affordable extraction methods provides a good future of barley in commercial field. The objective of this review paper is to shed light on some of the various important health benefits of β-glucan including induced maturation of dendritic cells, antioxidant property, lowering of cholesterol, weight management and alteration of the gut microbiota which in turn reduces the chances of cardiovascular diseases (CVD).*

Keywords*: Barley, β-glucan, Antioxidant, Dendritic cells, Obesity, Cholesterol*

1. INTRODUCTION

Barley has a rich source of nutrients among which β-glucan is the main neutraceutical component. β-glucan is a polysaccharide which is viscous and prebiotic in nature and can also be found in oats, yeast and mushrooms. β-glucans are predominantly found in internal aleurone and sub –aleurone cell walls of oat and barley [1-3]. It has been observed that the highest content of β- glucan is present in Barley 2-20g (65% water-soluble fraction). β-glucan is a soluble fiber of oat and barley but since the humans do not have enzymes to digest it, it is usually fermented in the lower GI tract by the gut microbiota with the help of carbohydrate active enzymes. The gut microbiota helps in conversion of this β-glucan into short chain fatty acids, amino acids and vitamins which have been reported to aid digestion, lowering cholesterol and weight management [4]. It has been observed that β-glucan can enhance or modify the gut friendly bacteria, which in turn helps in reducing the risk of cardiovascular diseases and many other disorders in the host [4]. The extent of fermentation of β-glucan in the GI tract depends on its physicochemical structure. It has been reported in several studies that β-glucan can significantly lower down the cholesterol levels [4-6]. β-glucan also helps in weight management by reducing the digestion time so that the person feels satiated and full and consumes fewer amounts of food and at larger intervals [7]. In a study done on mouse dendritic cells it was shown that the mouse bone marrow cells cultured in presence of β-glucan were stimulated to produce mature dendritic cells from immature mouse dendritic cells and thus β-glucan can also be considered as an immunostimulant which can cause differentiation and maturation of dendritic cells which might further help in prevention or even curing cancer [8]. β-glucan has also been found to show strong anti-oxidant activity as compared to other food polymers which can be used in future as food supplements or for beauty products [9]. The objective of this review paper is to observe the neutraceutical effects of β-glucan from barley in various health related issues. The elaborated effects of β-glucan are discussed as follows.

2. HEALTH BENEFICIARY EFFECTS OF B-GLUCAN

2.1. β-glucan as an antioxidant

Oxidative stress is one of the major causative factors of aging and various diseases such as, cardiovascular diseases, arteriosclerosis, cerebral diseases, diabetes, inflammatory diseases, and cancer [10, 11]. Therefore scavenging of reactive oxygen species (ROS) is important in order to prevent these diseases.

Kyoko et al., reported the antioxidant activity of *β*-glucan. Concentrations of 0.5–2.0 w/v% of *β*-glucans were prepared by dissolving the molecules in ion-exchanged water [9]. To determine the antioxidant activity against hydroxyl radicals in the solution, Radical Catch kit was used which measures the amount of hydroxyl radicals generated by the Fenton reaction with hydrogen peroxide catalyzed by cobalt using luminol luminescence [9] It was observed that *β*-glucan extracted from barley shows the strongest hydroxyl radical scavenging activity as 0.1 w/v% of *β*-glucan scavenged approximately 60% of the hydroxyl radicals in the system [9]. The hydroxyl radical scavenging activity of *β*-glucans extracted under an acidic condition or an alkali condition was slightly higher and it increased gradually with an increase in *β*-glucan

concentration [9]. The *β*-glucans extracted from barley exerts hydroxyl radical scavenging activity across a wide range of molecular sizes [9]. It uses more than 70% *β*-(1,3-1,4)-D-glucan, but also contains other components (i.e., proteins, lipids, saccharides, and dietary fiber) and it was noted that the hydroxyl scavenging activity of *β*-glucan was significantly higher than that of various polymers that are used as food additives [9].

2.2. β-glucan induces maturation of dendritic cells

Dendritic cells (DCs) can be identified as the central immunomodulators in the immune system [12, 13] and therefore chemical agents that can induce strong differentiation/maturation activity in DCs might be useful to preventing or even cure cancer [8,12,13].

Experiments were conducted on Male 6-week-old C57BL/6 mice using various β-glucans with different structures by Tanioka et al,. While conducting experiments with Barley β-glucan (BBG), it was observed that the low molecular weight BBG with an average molecular weight of 2 kDa (BBG-Low) induced DC differentiation/maturation activities [8].

It was observed that the amount of IL-6 produced by sequential treatment of Mouse bone marrow (BM) cells with growth factor GM-CSF and BBG-Low (10 μg/mL) was almost 30 times higher than that obtained by treatment with GM-CSF and BBG [8]. Also the level of IL-6 secreted into the culture medium increased with the increase in amount of BBG-Low and reached a maximum value with a BBG-Low concentration of 10 μg/mL [8]. Beyond this concentration of BBG-Low, the level of IL-6 secreted in the medium remained constant.

It was also noted that the treatment of BM cells with GM-CSF and BBG-Low produced lower levels of TNF-α and IL-12 than treatment with GM-CSF and LPS [8]. Moreover, the expression of characteristic surface molecules of mature DCs like CD80 and MHC II, produced by sequential treatment with GM-CSF and BBG-Low were much higher than those obtained by the sequential treatment with GM-CSF followed by LPS [8]. This indicated that BBG-Low and LPS stimulated immature DCs using different mechanism [8].

A major advantage of using BBG is that barley can be cultivated on a large scale and is cost effective [8]. No side-effects of BBG on humans [14], mice [15], rats [16], or hamsters [17] have been observed. Thus, the results indicate that BBG-Low can be consumed as a dietary supplement for cancer immunotherapy [8].

2.3. Cholesterol lowering effect of barley β-glucan

The β-glucan extracted from barley plays a significant role in lowering the blood cholesterol level. Over the time several studies and clinical trials have suggested β-glucan's cholesterol reducing effects by the means of reverse cholesterol transport and conversion of cholesterol into bile salts. It has been shown in long term feeding studies that having β-glucan as the main component reduces plasma cholesterol in hyper cholesterolemic men [18]. In a study, diet that had high viscous polysaccharide including β-glucan, showed 7.5% reduction of serum cholesterol in hypelipidemic men [19]. β-glucan forms a viscous layer in small intestine which slows down the re-absorption of bile acid (which is made from cholesterol by our body) and it also slows down the dietary uptake of cholesterol. Because of this the body draws circulating cholesterol from the blood plasma to make more bile acids, also the binding of β-glucan to bile acids along with the above mechanism of drawing cholesterol from plasma leads to reduction of cholesterol circulating in blood plasma. In several other studies conducted, the results reported that increasing fiber (β –glucan) intake can lead to reduction in blood total and LDL cholesterol [20]. Some clinical trials were done to study the efficacy of diet that was enriched with barley β-glucan (BBG) extracts . The study was conducted on subjects with moderate cardiovascular disease (CVD) rate and were given two doses (3 & 5g) of both low molecular weight and high molecular weight The main parameter of interest was change in LDL-C concentration. Individuals with diabetes, cancer, secondary hyperlipidaemia or other chronic medical conditions were excluded from the study. Other than this, pregnant and lactating women were also excluded.

A meta analysis of randomized control trials showed the lipid lowering capacity of β glucan [21]. Researchers after exploring nine databases, performed eleven random clinical trials and came to a conclusion that β glucan isolated from barley lowered the total cholesterol level and low density lipoprotein (LDL) concentration by 0.30mmol/l. The study proved that increased concentration of barley products should become a dietary approach to reduce LDL cholesterol concentration.

2.4. *β*-glucan in reducing obesity

One potential way to control obesity is to identify the food which reduces energy uptake by satisfying the need for food in less quantity and better quality. Dietary fiber has a direct effect on the satiety, food uptake rate, and body weight. Many randomized control trials are done with dietary fibers in which some have shown weight reduction [22] while some have not [23]. However, there was seen reduction in weight by a meta analysis which include 22 clinical trials that concluded by proving that 12 g increase in daily fiber intake is done with a 10% reduction in energy intake and a 1.9 kg weight is reduced during an average study duration of 3.8 months[24].

Barley when consumed intact has a property of satiating. It has been noticed that subjects are less hungry before lunch after consumption of barley as compared to wheat and rice [25]. Different producers of barley produced an equivalently higher satiety feeling, up to 180 min in comparison to white wheat bread [26]. It has been reported that biscuits with 5.2% barley *β*-glucan reduce appetite ratings in healthy adolescents [27]. In healthy persons, bread with a 3% of barley *β*-glucan induces a higher reduction in hunger and increase in fullness and

satisfaction as compared to control bread. Also there is meal replacement bars made up of 1.2% of barley *β*-glucan and is taken 2 consecutive days by healthy person doesn't show any result in decreasing energy intake as compared to control bars containing 0.3g barley *β*-glucan[28].

The dietary fiber has physiological property of non digestibility in small intestine [29]. Some of physiological consequences including viscosity in the upper gastrointestinal tract [30], fermentation in the colon [31], and prebiotic effects [32] contribute to increase satiety due to its physiochemical property. The property of higher viscosity in meal delays gastric emptying leading to slow digestion and absorption of nutrients which leads to early sensation of satiety.

The effect of beta glucan (*β*-glucan) depends on many factors. It has been seen in many studies that when *β*-glucan was given in solid or semi solid form then it has higher efficiency in decreasing hunger and increasing satiety than when consumed in liquid form [33]. Molecular weight can vary by different amounts and is the important determinant of solubility.

3. CONCLUSION

The paper reviewed various studies by researchers done on human subjects and mice to understand the effect of β-glucan. It was observed that β-glucan is effective in reducing blood cholesterol, managing weight and obesity, altering gut microbiota to reduce risk of CVD and it has immune stimulant activities which can lead to maturation and differentiation of dendritic cells. It also has a strong anti-oxidative property which helps in overcoming the problem of oxidative stress of the human body. Though β- glucan can be obtained from many sources but barley derived β- glucan or BBG is considered best since it is easier to grow on large scale and is less expensive as compared to mushrooms and other sources. Also over the years it showed a safe historical track and did not show any side or negative effects. β-glucan as an indigestible fiber is catalyzed by the gut microbiota which further helps the human body to maintain metabolism and efficient nutrition. It has also been observed that it forms a viscous layer around the food particle which leads to their slow movement and hence slower rate of digestion which gives the host , the feeling of satiety or fullness, due to which the hosts consumes food after a longer time interval and in lesser amounts. This indirectly helps in weight management and reducing the problem of obesity. The potential of β-glucan in barley could be put to future use as food additives, antioxidants, food supplements, in cosmetics and as antioxidants. Due to barley's easy production and availability and comparatively lesser expenses it can be made a perfect research subject for production of human health beneficiary products. Several researches and studies are going on with the aim of using barley to its maximum potential due to the presence of β- glucan.

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