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The Mechanism of Oat β - glucan on Weight Management in Overweight/obese People and Its Application in Functional Foods

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Abstract. Overweight and obesity have become a global public health problem, and the metabolic disorders caused by them have also seriously threatened human health. Oat β - glucan (OBG), as a natural water-soluble dietary fiber, has attracted attention in the weight management of overweight/obese people, but its mechanism of action has not been fully defined, and there is still room for optimization in the development of functional foods. Based on this, this paper will systematically discuss the mechanism of OBG in reducing blood lipids, regulating intestinal flora and other aspects of weight management, as well as its functional application in intestinal health foods, baked foods and meat products. It has been found that OBG can achieve weight loss through lipid metabolism and sugar metabolism, as well as regulating the structure of intestinal flora. At present, OBG has been used in the development of a variety of functional foods, but there are some problems, such as poor taste and poor stability of efficacy. This review provides a theoretical reference for the research mechanism of OBG in the field of weight management, and provides ideas for the optimization, upgrading and market expansion of its functional foods. In the future, it can focus on the research of product formula innovation and efficacy precision.

Keywords: Oat β - glucan, Overweight, Functional Foods

1. Introduction

Overweight and obesity refer to the state where the weight exceeds the health standard, which is usually caused by energy intake greater than consumption, and may cause a variety of health problems. In recent years, the prevalence of obesity in the world has continued to grow rapidly. The world obesity atlas 2025 report predicts that if the current trend remains unchanged, it is estimated that by 2030, nearly 3billion adults worldwide (accounting for 50% of the total number of adults at that time) will be affected by overweight or obesity, and the total number of patients with obesity (BMI ≥ 30 kg/m2) will exceed 1.1 billion [1]. In 2022, about 1 in 8 people in the world will be obese. Obesity can significantly increase the risk of diabetes, cardiovascular disease, some cancers and other chronic diseases, and is an important factor leading to premature death and disease burden [2]. At present, there is no clear and effective treatment drug, mainly to control diet, strengthen exercise and other lifestyle interventions. Therefore, diet plays an important role in the treatment of

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obesity. Functional food refers to food with specific nutritional and health functions, which plays an important role in regulating human physiological functions, promoting health, or reducing disease risk.

Oat β – glucan (OBG), as a water-soluble polysaccharide naturally existing in the cell wall of oat endosperm, has been widely recognized as one of the typical functional food ingredients due to its unique physical and chemical properties and physiological functions. In recent years, β - glucan, as the main soluble dietary fiber in oats, has become a hot research topic at home and abroad. More and more evidence shows that it has a variety of health effects such as weight loss, hypoglycemic and lipid-lowering [3]. However, there is no systematic review and Analysis on the application status of OBG in functional foods and the weight management of overweight/obese people.

Therefore, this paper intends to review the application scenarios of OBG in functional foods, and evaluate its impact on body weight, body fat and metabolic indicators in overweight/obese people, it has important theoretical reference value in the field of functional food development and clinical weight management

2. Basic characteristics of OBG

2.1. Chemical structure and source

OBG mainly exists in the endosperm cell wall and aleurone layer. It is a kind of nonlinear starch polysaccharide. It is comprised of β -1,3 and β -1,4 glycosidic linkage with oat β - D-glucopyranose as monomer [4]. Its fine structure is shown in Figure 1, with β-1,3 linked cellotriose units and celltetrasaccharide units as the main components, and there are alternately linked (1 → 3) and (1 → 4) sequences [5, 6]. In addition, the ratio of trisaccharide to tetrasaccharide in OBG is usually 2:1, which is significantly different from that in barley (3:1) and wheat (4:1). This structural variation also results in differences in some physical properties of β - glucan [7]. Due to its unique physical and chemical properties, natural sources, high safety and natural advantages compared with drugs, and potential in reducing blood glucose, blood lipid and diabetes control, OBG has become a key research object in the field of nutrition and food science.

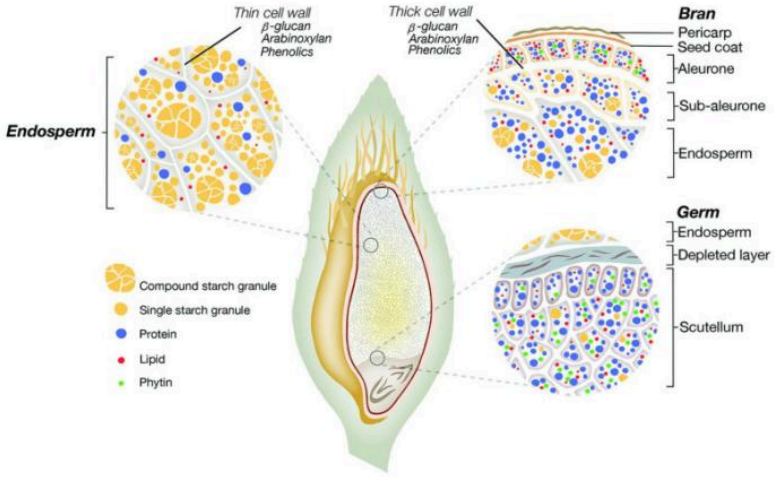


Figure 1. Structural representation of the oat grain presenting different oat tissues and the nutrient distribution [6]

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2.2. Analysis of physical and chemical properties

Huangnali et al. Analyzed the solubility experiment, viscosity characteristic experiment and high temperature treatment experiment of OBG, and concluded that it has the advantages of high water solubility, high viscosity and processing stability [8]. Its high water solubility can make it form a stable colloidal system in water, which can effectively improve the sense of satiety, delay the gastric emptying rate, and its viscosity characteristics make it an ideal food thickener and stabilizer. At the same time, the advantage of processing stability of the product can make it not affected by temperature, pH and other raw materials, and more suitable for a variety of food processing technologies. The above physical and chemical properties make OBG can be used as a natural functional ingredient in weight management products such as meal replacer, low GI functional drinks, energy bars, etc., providing a high-quality raw material basis for the development of scientific, healthy, and sustainable weight management products.

3. Mechanism of weight management

3.1. Direct regulation of lipid metabolism and glucose metabolism

For obese/overweight people, lipid metabolism and glucose metabolism disorders are common manifestations, which are usually manifested as decreased basal metabolic rate, increased insulin resistance, and prone to metabolic diseases such as impaired glucose tolerance and type 2 diabetes. OBG plays an important role in lipid metabolism and glucose metabolism. According to the experimental study of shennanhui on mice with impaired dietary glucose regulation, the insulin resistance index (HOMA - IR) of mice after intervention with OBG was meta analyzed by random effect model. The results showed that compared with the high glucose and high fat model group (MC), the OBG high-dose group and medium dose group could significantly reduce HOMA - IR in mice (SMD=-0.48, 95% CI: -0.87~-0.09, $p<0.05$), and heterogeneity test $I^2=0\%$, indicating that there was no heterogeneity among the included studies; There was no significant difference in HOMA - IR between low-dose groupand low-dose group ($p>0.05$). Subgroup analysis showed that the HOMA - IR of the high and medium dose β - glucan intervention group decreased by 30.3% and 27.3% respectively compared with the model group, and the effect was close to that of the positive control group (reduced by 36.4%). These results confirmed that OBG could effectively improve the insulin resistance induced by high glucose and high fat in mice, and the intervention effect was dose-dependent, and the high and medium dose effects were significant. According to the meta-analysis, the mechanism of OBG may be to increase the activity of glucokinase in the liver by reducing insulin resistance and improving the sensitivity of peripheral tissues to insulin, thereby reducing the release of liver glycogen and improving glucose utilization [9].

3.2. Regulation of intestinal flora structure and diversity

Intestinal flora is a complex collection of microorganisms in the human intestinal tract, which is closely related to digestion, immunity, metabolism and other functions. Through the effective regulation of intestinal flora, metabolism and appetite can be regulated to affect body weight, which is also the indirect mechanism of OBG for weight management. In Chen Xingyun's experiment on high-fat diet mice, it was found that OBG can improve the metabolic disorder induced by high-fat diet by remodeling the structure and function of intestinal flora [10]. Human microbiota - associated (HFA) mice are closer to human intestinal environment due to the large difference between mouse

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flora and human flora. Based on the PCR - DGGE map of the V3 region of 16S rDNA and upgama cluster analysis, the results showed that high-fat diet could significantly shift the composition of intestinal flora in HFA mice, and the community structure was significantly different from that of healthy individuals; At the same time, it can promote the excessive proliferation of harmful bacteria such as Staphylococcus lentus and Clostridium glycolicum, and reduce the diversity of Lactobacillus and Bacteroides. In conclusion, OBG can alleviate high-fat induced blood glucose and lipid abnormalities and liver steatosis by regulating intestinal flora diversity and optimizing community structure, which is an important mechanism for improving metabolic disorders. Therefore, it is a new functional food for obese/overweight patients who tend to eat a high-fat diet.

3.3. Improvement of weight management indicators

Through the above direct and indirect regulation mechanisms, OBG can comprehensively improve the relevant indicators of weight management, which can effectively reduce BMI and body fat rate, and reduce visceral fat accumulation [11]. At the same time, it can regulate glucose and lipid metabolism, reduce blood glucose, total cholesterol and triglycerides, and improve insulin sensitivity. In addition, OBG can enhance satiety, reduce calorie intake, optimize the intestinal flora structure, and improve weight and metabolic health in many ways, so as to achieve stable weight management effect.

4. Application in functional food

OBG is a soluble dietary fiber in oat. Its main functions include regulating blood lipids, controlling blood glucose, enhancing immunity and improving intestinal health. Therefore, it has great development space in the field of functional food.

4.1. Application in intestinal health food

Oat bran powder containing 3.1 g/portion OBG and glucan oat milk products containing up to 3.8% OBG, newly developed in Taiwan, China, combine pea fiber and Isomaltooligosaccharide in product development, so that the products are rich in plant protein, vitamins, minerals, etc., provide comprehensive nutrition for intestinal health, and have the advantages of high fiber, low GI, ketogenic diet, etc., to help maintain intestinal health [8]. Ladjevardi et al. have shown that adding OBG to yogurt can effectively improve the survival number of probiotics, reduce the lipid content of the product, and comprehensively optimize the overall quality of yogurt [12]. This makes the yogurt added with OBG have the effect of regulating the structure of intestinal flora, promoting gastrointestinal peristalsis and maintaining the balance of intestinal flora. According to Mahrous et al., the addition of OBG will not significantly affect the chemical composition of stirred yogurt and concentrated yogurt [13]. Sharafbafi et al. added high molecular weight OBG to milk to prepare low calorie and low cholesterol dairy products [14]. The above related studies show that β - glucan has great potential in the application of intestinal health and weight management. With the increasing demand for weight management, related functional foods have broad application prospects.

4.2. Application in baked foods

Adding OBG to bread and cake can also enhance its physical and chemical properties. Studies have shown that baked foods containing OBG can help slow down the release of glucose, thereby reducing the risk of hyperglycemia [6]. Ekstrom et al. showed that OBG, with its high molecular

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weight, showed good applicability in baking applications, while effectively regulating the blood glucose production response of bread products [15]. This shows that baked foods containing OBG have a significant and stable effect on blood glucose regulation, and can effectively regulate postprandial blood glucose by delaying glucose absorption and reducing food GI. In addition, OBG shows better rheological properties than barley β - glucan and can produce higher quality bread, which may be related to its high viscosity [6]. This property can also be used as a natural thickener in baking fillings, which can improve the viscosity and stability of fillings, improve the taste and flavor, and enrich the palatability of baking products. Therefore, adding OBG to baked foods can not only improve their quality, but also greatly contributed to the application promotion of functional baked foods.

4.3. Application in meat products

In addition to its application in baked goods, OBG also has creative functions in meat products. In the research and development process of functional meat products, adding prebiotics is a commonly used technical means. Relevant studies generally believe that prebiotics can effectively activate the physiological activity of beneficial intestinal flora, and synergize with probiotics to exert anticancer effects [16]. These beneficial ingredients can protect the body by reducing DNA damage of colon cells, inhibiting oncolytic enzyme activity, reducing mutagen binding, and enhancing immune response [17, 18]. The study showed that Sarteshnizi et al. found that OBG could significantly improve the physical properties and sensory quality of sausage, and probiotic sausage could also be prepared by compounding it with resistant starch. The team further pointed out that adding resistant starch and OBG to sausage can improve the water content of the product and make it exhibit antioxidant properties, which is more significant in the formula with low prebiotic fiber addition [19]. The above research results fully show that the combination of OBG and other prebiotic fibers can not only improve the quality and stability of meat products, but also bring additional health benefits to the products.

5. Conclusion

This study systematically reviewed the characteristics, application and weight management of OBG, and summarized its main findings in enhancing satiety, regulating glucose and lipid metabolism, and improving intestinal flora. In terms of enhancing the sense of satiety, OBG swells after entering the digestive tract to delay gastric emptying, reduce energy intake, and help weight management; In regulating glucose and lipid metabolism, it can delay glucose absorption, enhance glucokinase activity and reduce insulin resistance; In terms of improving intestinal flora, it can optimize the structure of flora, enhance the diversity of beneficial bacteria, and inhibit the proliferation of harmful bacteria. The synergy of the three provides an important basis for dietary intervention of metabolic diseases and the development of functional foods. However, there are still some deficiencies in the current research. Because the existing studies are mostly review analyses and lack first-hand experimental data, the dose and molecular mechanism research is not in-depth. And the research is mainly based on the integration of animal models and literature data, lacking the support of human clinical trials. The practical application value of the conclusion needs to be further verified. In the future, it is necessary to further improve the research design and deepen the mechanism exploration. In conclusion, OBG has important value and broad prospects in the field of weight management and functional food, and has great potential in promoting scientific application and industrial development.

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