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REVIEW ARTICLE

NUTRACEUTICAL FUNCTIONS OF *BETA*-GLUCANS

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ABSTRACT

Recent studies have shown that naturally occurring substances found in the food of the daily human diet are important for preventing chronic non-communicable diseases. One of them is *beta*-glucan, which is a natural polysaccharide, occurring in plant cell walls, mainly oats, barley and wheat. It is also present in baker's yeast cells, fungal cell walls, and some microorganisms. *Beta*-glucan belongs to one of the dietary fiber fractions, which are attributed a number of beneficial health properties, including the prevention and treatment of certain digestive diseases and supporting the immune system. This compound has biological activity that depends on the size, molecular weight, conformation, frequency of bonds, solubility and changes in structure. *Beta*-glucan reduces cholesterol and glucose concentrations in the blood, which reduces the risk of cardiovascular disease and diabetes. In addition to its effects on lipid levels and glucose metabolism, *beta*-glucan also exhibits antioxidant properties by scavenging reactive oxygen species, thereby reducing the risk of diseases, including atherosclerosis, cardiovascular diseases, neurodegenerative diseases, diabetes, and cancer. Immunostimulatory and antitumor effects have also been reported. The immunostimulatory activity of *beta*-glucan occurs as a result of its attachment to specific receptors present on the immune cell surface. *Beta*-glucan belongs to the group of prebiotics which stimulate the growth and activity of the desired natural intestinal microbiota, while inhibiting the growth of pathogens. It plays an important role in the proper functioning of the gastrointestinal tract and preventing inflammation as well as colon cancer. Such a number of health benefits resulting from the properties of *beta*-glucan may play a key role in improving health and preventing chronic non-communicable diseases, such as diabetes, hypercholesterolemia, obesity, cardiovascular diseases, and cancer.

Key words: *beta-glucans, chronic non-communicable diseases, health properties*

STRESZCZENIE

Badania ostatnich lat dowiodły, iż w codziennej diecie człowieka znajdują się naturalnie występujące składniki żywności o istotnym znaczeniu w zapobieganiu niezakaźnym chorobom przewlekłym. Między innymi jest to *beta*-glukan, który jest naturalnym polisacharydem, występującym w ścianach komórkowych roślin, głównie owsa, jęczmienia i pszenicy. Obecny jest także w komórkach drożdży piekarniczych, ścianach komórkowych grzybów i w niektórych mikroorganizmach. *Beta*-glukan należy do jednej z frakcji błonnika pokarmowego, któremu przypisuje się szereg korzystnych właściwości zdrowotnych, między innymi w prewencji i leczeniu niektórych schorzeń układu pokarmowego oraz wspomaganiu układu odpornościowego. Związek ten wykazuje aktywność biologiczną, która zależy od wielkości masy cząsteczkowej. *Beta*-glukan obniża poziom cholesterolu oraz pozwala utrzymać prawidłowy poziom cukru we krwi, co wiąże się ze zmniejszonym ryzykiem zachorowalności na choroby sercowo-naczyniowe oraz cukrzycę. Oprócz wpływu na poziom lipidów i metabolizm glukozy *beta*-glukan wykazuje także właściwości przeciwutleniające poprzez wychwytywanie reaktywnych form tlenu, zmniejszając tym samym ryzyko wystąpienia, m.in.: chorób układu krążenia, chorób neurodegeneracyjnych, cukrzycy oraz nowotworów. Substancja ta wywiera również efekt immunostymulujący oraz antykancerogenny. Immunostymulujące działanie *beta*-glukanu polega na jego przyłączeniu się do specyficznych receptorów obecnych na powierzchni komórek układu odpornościowego. *Beta*-glukan należy do grupy prebiotyków, stymulujących wzrost i aktywność pożądanej, naturalnej mikrobioty jelitowej, hamując jednocześnie rozwój patogenów. Odgrywa to istotną rolę w prawidłowym funkcjonowaniu przewodu pokarmowego oraz zapobieganiu wystąpienia stanów zapalnych, jak również nowotworów jelita grubego. Wykazane korzyści zdrowotne wynikające z właściwości *beta*-glukanu mogą odgrywać kluczową rolę w poprawie stanu zdrowia oraz przeciwdziałaniu niezakaźnym chorobom przewlekłym, tj. cukrzycy, hipercholesterolemii, otyłości, chorobom sercowo-naczyniowym oraz nowotworom.

Słowa kluczowe: *beta-glukan, niezakaźne choroby przewlekłe, właściwości prozdrowotne*

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INTRODUCTION

Food safety and nutrition along with other lifestyle factors are major determinants of the health of a population. One of the key tasks in terms of food safety is introducing natural ingredients of plant and animal origins as nutraceuticals that play a key role in preventing chronic non-communicable diseases and maintaining good health. Nutraceutical foods and preparations with new biomedical functions and additional physiological activity can become part of a personalized diet. In view of the huge costs incurred for treating the effects of chronic non-communicable diseases, it seems warranted to develop non-invasive methods of dietary prevention and dietotherapy based on natural functional food ingredients obtained using innovative technologies that guarantee their appropriate biopotential [79].

The most serious health risk factors responsible for the highest number of deaths in European countries are high blood pressure, smoking, overweight, and obesity. Excessive body weight means a significantly increased risk of cardiovascular diseases, type 2 diabetes, most types of cancer, and thus the most common causes of morbidity and death in industrialized countries [1, 4, 21, 62]. According to research by the Polish Central Statistical Office (GUS), cardiovascular diseases are responsible for 45% of deaths in Poland and malignant neoplasms for 26% (Figure 1), and these percentages have increased slightly over the last 4 years [22]. Excessive body weight increases the risk of lipid profile disorders, including elevated triglycerides, total cholesterol and LDL – while lowering HDL cholesterol – as well as carbohydrate metabolism disorders, insulin resistance and inflammation, contributing to the development of cardiovascular diseases and type 2 diabetes [16].

An important indicator of the risk of complications of excessive body weight in children and adolescents, just like in adults, is primarily waist circumference, which indicates the presence of visceral fat [69, 81]. It is therefore important to use a well-planned and effective dietary intervention that will reduce weight and improve the health of people with metabolic syndrome.

Numerous epidemiological studies indicate that consuming dietary fiber from whole grains or whole grain products is associated with a reduced risk of type 2 diabetes mellitus (DMT2), cardiovascular disease, cancer and obesity occurrence. Soluble dietary fiber, particularly *bet*a-glucan, which is found mainly in grain cereals, such as barley and oats, as well as *beta*-glucans present in the cell walls of fungi and microorganisms has various beneficial health effects [65].

Due to their properties, *beta*-glucans have a broad spectrum of use, especially in medicine and the pharmaceutical, food, cosmetics and chemical industries, as well as in veterinary medicine, in the production of medicines and feed [86].

CHEMICAL STRUCTURE, SOURCES AND THE PRESENCE OF *BETA*-GLUCANS

Beta-glucans are polysaccharides made of D-glucose molecules connected by β-glycosidic bonds. They belong to one of the dietary fiber fractions, which are attributed a number of health benefits, including the ability to treat certain gastrointestinal diseases and support the immune system [57]. These glucose polymers are a structural component of the cell wall of some pathogenic bacteria (*Pneumocystis carinii*, *Cryptococcus neoformans*, *Aspergillus fumigatus*, *Histoplasma capsulatum*, *Candida albicans*), the *Basidiomycetes* class of fungi, baker's yeast (*Saccharomyces cerevisiae*), and plants, mainly oats, barley and wheat [3, 71]. Some authors found that *beta*-glucans are also present in some vegetables and fruits [77], lichen and algae [57]. Depending on their origin, *beta*-glucans differ in their specific properties, such as solubility, degree of branching, and molecule mass and shape, which have a significant impact on their biological activity [41]. Due to the types of glycosidic bonds present in the *beta*-glucan structure, two isomers can be distinguished: one forming the walls of fungi and yeast, made of β-D-glucopyranose molecules connected by β-1,3- and β-1,6-glycosidic bonds, giving a branched structure [47, 59]; and the other one present in unprocessed grain products in the form of unbranched chains consisting of β-D-glucopyranose monomers connected by β-1,3- and β-1,4-glycosidic bonds [52].

HEALTH BENEFITS OF *BETA*-GLUCANS

The health-promoting properties of *beta*-glucans, which have been confirmed by numerous studies, have been known for several decades. Studies have shown that zymosan, derived from the yeast cell wall, is characterized by high *beta*-glucans content and activates the body's nonspecific immune system response [19, 52]. Based on the accumulated knowledge on *beta*-glucans functions, the fungi-derived lentinan and schizophyllan have been used as drugs in medicine due to their immunostimulatory effect [52]. A diet rich in *beta*-glucans has a positive effect on human health by preventing chronic non-communicable diseases, such as diabetes, hypercholesterolemia, obesity, cardiovascular diseases, and cancer. *Beta*-glucans present in grains (such as oats and barley) have been documented to lower cholesterol and blood glucose (Figure 2) and act as a main factor in preventing obesity and metabolic disorders [14, 29, 75].

The results of both clinical and preclinical studies have confirmed the antioxidant, immunomodulatory, and antitumor properties of *beta*-glucans [11, 40, 46, 86]. In addition, this compound has a prebiotic effect, supporting the growth of beneficial intestinal bacteria [24] (Figure 2).

Hypoglycemic properties

The beneficial effect on glucose metabolism is mainly attributed to *beta*-glucans derived from cereal grains. *Beta*-glucan from grains is not digested in the stomach or intestines after ingestion. It also has a high capacity for binding water and forming sticky gels in the gastrointestinal tract, which results in delayed gastric emptying, slowing down enzymatic breakdown of starch and hindering intestinal absorption of digestible carbohydrates [25]. This mechanism results in a reduction of postprandial glucose in the blood, as well as insulin secretion (Figure 2), which may contribute to a decrease in the incidence of type II diabetes [57].

Moreover, *Pick* et al. [58] showed that consuming oat products may also result in a reduced glycemic response after the next meal, due to the fact that slower rising glycemia is also accompanied by reduced insulin secretion. *Biörklund* et al. [7] observed that oat *beta*-glucan significantly affected the reduction of glycemia and insulinemia compared with barley *beta*-glucan. The effectiveness of *beta*-glucan in lowering blood glucose results not only from the ability to form sticky solutions (the higher the viscosity of the layer, the lower the glucose and lower insulin levels in blood plasma), but also depends on its molecular weight and the concentration used [61]. The results of conducted research proved that the addition of *beta*-glucans from oats with a high molecular weight to food products reduced the level of glycemic response the most [9, 80].

Hypocholesterolemic properties

Grain *beta*-glucans also have a positive effect on lipid metabolism, they reduce blood cholesterol. The hypocholesterolemic effect of *beta*-glucans results from the ability to act as a dietary fiber as well as from the ability to increase the viscosity of food content in the small intestine, which then affects the formation of micelles and their structure and composition [41, 52]. Increased viscosity of the intestinal lumen reduces fat and cholesterol absorption and bile acid binding, increasing their excretion in the feces. Reducing the amount of bile acids results in increased utilization of cholesterol accumulated in the body for bile acid production in the liver. Furthermore, to compensate for reduced bile acid levels, 7α-hydroxylase activity, which is involved in bile acid synthesis, increases [17]. As a result, the cholesterol level in the liver as well as LDL cholesterol concentration in the blood decrease [52]. Due to the properties of *beta*-glucans, lowering the total cholesterol and LDL fraction levels in the blood (Figure 2) may reduce the risk of cardiovascular diseases [78]. *AbuMweis* et al. [2] showed that consuming barley or *beta*-glucans derived from barley leads to a significant reduction in total cholesterol as well as LDL cholesterol. *Ho* et al. [26, 27] also confirmed the lowering of LDL levels by *beta*-glucans derived from barley and oats. *Lange* [41] showed that oat products exert an independent hypocholesterolemic effect, and the consumption of 3 g of *beta*-glucans daily with the diet promotes not only a decrease in total cholesterol by 2% but also LDL by about 5%, which in consequence may contribute to a 10% reduction in the risk of ischemic heart disease occurrence.

Antioxidant properties of *beta*-glucans

Various grains, such as barley, oats, millet and rye, have antioxidant properties by scavenging reactive oxygen species (ROS) (Figure 2), i.e. superoxide anion, hydrogen peroxide, and hydroxyl radicals, which are involved in the occurrence of many diseases [45]. Considering that oxidative stress is considered to be one of the main factors affecting aging of the body and is conducive to the occurrence of atherosclerosis, cardiovascular diseases, brain diseases, diabetes, and cancer, among others, eliminating reactive oxygen species minimizes the possibility of these diseases [39]. *Beta*-glucans from oats and barley have the highest affinity for removing reactive oxygen species [14, 23, 67]. However, *Kofuji* et al. [37] showed that *beta*-glucan extracted from barley has significantly higher antioxidant activity compared with *beta*-glucan from oats and yeast, which indicates that the structure of *beta*-glucans also affects their antioxidant properties. The high antioxidant activity of glucans is probably due to the presence of anomeric hydrogen atoms in their molecules, and the polymeric structure provides additional free radical removal capabilities [63]. Studies on rats revealed that the antioxidant properties of *beta*-glucans after oral administration are due to the prevention of oxidative stress in internal organs such as the liver and kidneys [6, 66]. The results of these studies suggest that *beta*-glucan acts as an antioxidant and protects the body from the adverse effects of free radicals.

Immunomodulatory and antitumor properties

Beta-glucans with immunostimulatory properties were also shown to be beneficial in preventing infectious diseases and gastrointestinal cancer, particularly colorectal cancer [32].

Despite advances in medicine, cancer, which is uncontrolled cell growth, is now classified as a chronic non-communicable disease of the 21st century, which is the leading cause of death after cardiovascular diseases (Figure 1).

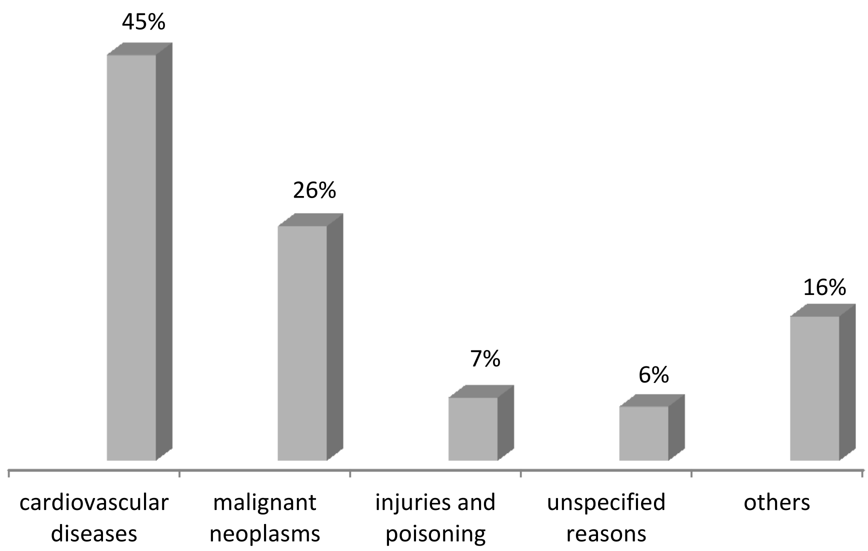

Figure 1. Deaths by cause in Poland in 2013 [22]

Among them, colorectal cancer is diagnosed as the most common malignant gastrointestinal tumor, whose development is a multistage process. Many studies demonstrated the significant role of matrix metalloproteinases (MMPs) and tissue inhibitors of metalloproteinases (TIMPs) in the carcinogenesis of colorectal cancer. Colorectal cancer cells were found to have the ability to synthesize metalloproteinases, including matrix metalloproteinase 9 (MMP-9), a collagen-degrading enzyme of the basement membrane and the extracellular matrix, which plays a significant role in invasive growth, distant metastasis, and tumor angiogenesis [51]. Similar results were obtained in the case of colorectal cancer cell lines, where high activity of MMP-9 was found, which determines the ability of cells to metastasize by degrading the extracellular matrix, among others [43].

Moreover, *Kim* et al. [36] observed that higher expression of this enzyme in colorectal cancer cells resulted in increased tumor aggressiveness and a tendency to infiltrate. *Zeng* et al. [82] also demonstrated higher MMP-2 activity in patients with colorectal cancer compared with normal intestinal mucosa. *Oberg* et al. [54] found higher levels of MMP-9 and TIMP-1 in patients with colorectal cancer compared with healthy individuals, as well as a correlation with the stage of cancer. *Murashige* et al. [50] observed higher levels of TIMP-1 and TIMP-2 mRNA expression along with the progression of colorectal cancer as well as in metastatic lesions in the liver and lymph nodes.

Beta-glucan leads to an increase in the mass of large intestine content, in which carcinogenic compounds (nitrosamines, phenols, cresols, skatoles, indoles, estrogens, secondary bile acids) and toxic metabolites (ammonia, amines) are more dispersed. It also facilitates cleansing the intestines of residual fecal matter and food particles. Thus, the excreted fecal matter does not stagnate. Stagnation promotes the formation of inflammatory foci leading to ulceration and, consequently, tumor foci [20].

The effect of *beta*-glucan is based on two basic mechanisms of action on cancer cells. One of them is indirect action resulting from the immunomodulatory properties that affect the immune system. The indirect action is the stimulation of defense mechanisms, primarily the activation of granulocytes (neutrophils, eosinophils), monocytes, macrophages, and natural killer cells (NK cells) [85]. *Beta*-glucan is an immune stimulator that activates macrophages and cytokines, among others, which are responsible for the body's defense (Figure 2). Macrophages are elements of the immune system that have the unique ability to kill cancer cells and phagocytosis, and are therefore the immune system's first line of defense. The immunostimulatory activity of *beta*-glucan occurs as a result of its attachment to specific membrane receptors on immunologically competent cells, including macrophages, neutrophils, monocytes, NK cells, and dendritic cells, which affects their immune response, including cytokine production and the induction of an oxygen burst [12].

The immunomodulatory effects occur mainly via receptors such as: dectin-1, complement receptor 3 (CR3), and Toll-like receptor 2 (TLR-2). The dectin-1 receptor (innate immune response receptor), which is mainly present on the surface of macrophages and dendritic cells, induces the secretion of pro-inflammatory cytokines by activating tyrosine kinase Syk and nuclear factor-kappa B (NF-κβ) [33, 49, 52]. This receptor works with TLR-2 to activate the pro-inflammatory response by macrophages due to infections caused by mycobacteria [3]. Moreover, it interacts with the TLR-2 receptor to recognize *beta*-glucan and mediates the production of tumor necrosis factor-α (TNF-α). The CR3 receptor, interacting with TLR-2, also mediates TNF-α synthesis by activating transcription factor NF-κβ as well as monocyte chemoattractant protein-1 (MCP-1) production [85] (Figure 2).

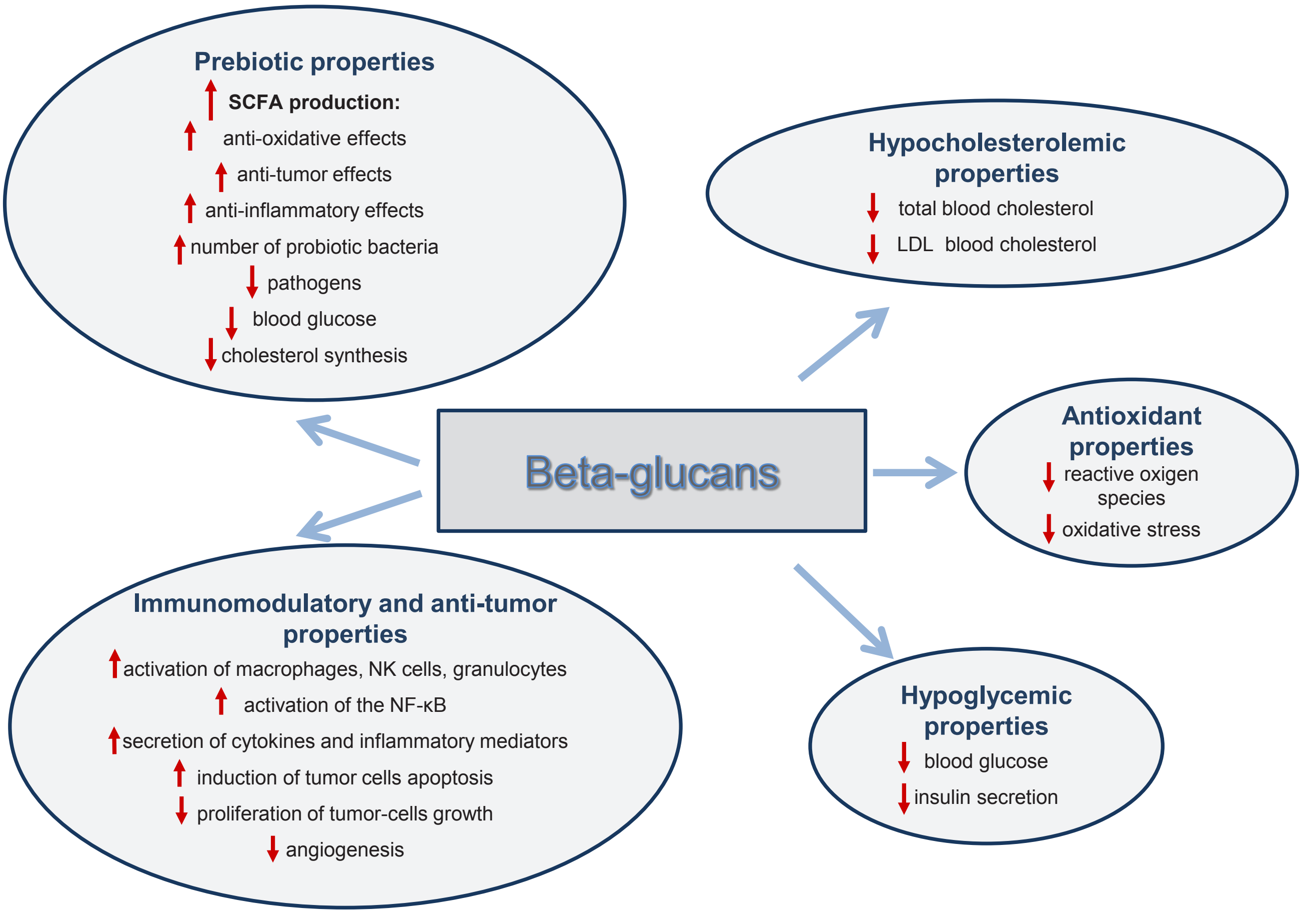

Figure 2. Health benefits of *beta*-glucans [own elaboration]

The CR3 receptor, present mainly on the surface of neutrophils, monocytes, and NK cells, has the ability to recognize the iC3b opsonin, which commonly occurs on the cancer cell surface [3]. Stimulation of phagocytic activity occurs as a result of simultaneous attachment to the CR3 receptor of the complement component iC3b (opsonin) as well as *beta*-glucan, and a lack of any of these components prevents the induction of cytotoxicity [3, 12, 52]. Thus, the antitumor effect of *beta*-glucan associated with the ability to elicit a specific immune response is associated with the activation of the complement system.

The immunostimulatory activity of *beta*-glucan is also based on the macrophage activation mechanism. Due to the presence of specific receptors, such as CR3, TLR-2, dectin-1, macrophages recognize the *beta*-glucan structure, which initiates a cascade of both cellular and humoral immune responses. As a result of *beta*-glucan attachment to macrophage receptors, they are activated, which consists of interconnected processes, such as increased chemotaxis, chemokinesis and degranulation leading to increased expression of adhesion molecules on the macrophage surface. In response to macrophage stimulation, inflammation mediators (interleukins: IL-1, IL-6, IL-8, IL-12, and TNF-α) and pro-inflammatory factors (including: nitric oxide (NO), inducing a cytotoxic effect on cancer cells and pathogens, and hydrogen peroxide (H_2O_2)) are secreted [3] (Figure 2). This leads to pathogen phagocytosis and antibody production.

Beta-glucan, referred to as a Bilogical Response Modifier (BRM), mainly activates the basic cells of the immune system, which are macrophages, the task of which is to absorb and destroy foreign cells in the body, including cancer cells or other pathogens. When crossing the epithelial barrier, a pathogen is phagocytized by macrophages and then digested by lysosomal enzymes released by these cells, which leads to full degradation of the phagocytized material [63]. *Beta*-glucan affects macrophages by intensifying phagocytosis, and by activating transcription factor NF-κβ it increases the production of tumor necrosis factor [34].

The conducted research showed that *beta*-glucan isolated from yeast cell walls of *Saccharomyces cerevisiae*, due to its ability to stimulate the body's immune cells, has antitumor effects, as well as plays the role of an adjuvant in radio- and chemotherapy, thanks to which it supports the action of other preparations used in the treatment of cancer [30, 38]. Furthermore, *Hofer* et al. [28] observed that oral administration of *beta*-glucan from *Saccharomyces cerevisiae* in mice before exposure to radiation induced hemopoiesis as well as secretion of cytokines, such as IL-1, IL-6, TNF-α, thus increasing the chances of survival after irradiation as well as intensifies the phagocytosis of cancer cells. By activating macrophages, *beta*-glucan contributes to the stimulation of the immune system, thus playing a significant role in infectious diseases and cancer, after treatment with immunosuppressive drugs, antibiotic therapy, and radiation, which significantly burden the immune system [63]. Most pathogenic fungi contain *beta*-glucans in the cell wall, which potentially trigger the body's innate immune response [44]. *Beta* glucans derived from the opportunistic pathogens *Pneumocystis carinii* act as strong inducers of macrophage activation by translocation of NF-κB using cell receptors and signaling pathways. They also stimulate the release of inflammation mediators, including TNF-α, IL-1, macrophage inflammatory protein 2 (MIP-2), eicosanoids, and reactive oxygen species [44, 76].

In addition to indirect effects, *beta*-glucans also have a direct effect on cancer cells. It consists of inhibiting cancer cell proliferation by, among others, inhibiting tyrosine kinases, limiting blood vessel development around the tumor and inducing death via apoptosis of cells that have undergone transformation [5, 70, 74, 83] (Figure 2). The mechanism of direct antitumor activity consists of modulating the activity of transcription factor NF-κβ. Excessive activation of this factor was observed in many types of cancer, which consequently intensifies tumor growth by increasing the transcription of genes inducing proliferation, anti-apoptotic activity, and promoting angiogenesis and metastasis [60]. Studies showed that *beta*-glucans inhibit the phosphorylation and degradation of the NF-κβ inhibitor, thus preventing the activation of the transcription factor and then the expression of genes subject to this factor [18, 48, 55, 56].

Beta-glucans isolated from *Pleurotus ostreatus* and *Lentinus edodes* were shown to have antiproliferative and proapoptotic activity against colorectal cancer cells, which indicates a significant antitumor effect [73]. Similar direct antiproliferative activity against colon cancer cell lines was demonstrated for *beta*-glucan obtained from *Pleurotus pulmonarius* [42]. *Beta*-glucan of bacterial origin also inhibits proliferation and induces apoptosis in human colon cancer cells. In addition, *Kim* et al. [35] demonstrated the effect of *beta*-glucan on the expression of apoptotic genes such as Bcl-2 and Bax, as well as caspase-3 activity, which was significantly higher in the case of cells treated with *beta*-glucan compared with the control group [35]. Research conducted by *Shah* et al. [67, 68] showed that grain *beta*-glucans from oats and barley inhibited the proliferation of human colon cancer cell line (Colo-205), human ductal breast epithelial tumor cell line (T47D), and human breast adenocarcinoma cell line (MCF7).

The obtained study results indicate the significant role of *beta*-glucan as a cytotoxic factor in relation to cancer cells, as well as stimulating factor towards the immune system via macrophage activation, among others, which prevents cancer development.

Prebiotic properties

Beta-glucans also have prebiotic properties, which has a beneficial effect on the microflora of the gastrointestinal tract, simultaneously preventing diseases of the large intestine and digestive system. Soluble *beta*-glucans, especially from grains, are fermented by colon microflora, leading to many beneficial health effects. The fermentation of these compounds produces, among others, short-chain fatty acids (SCFA) (Figure 2), such as acetic acid, propionic acid, and butyric acid [10, 31]. SCFAs produced in the colon have an immunomodulatory effect, prevent obesity and colon cell proliferation, thus inhibiting cancer cell growth [52, 64]. In particular, butyric acid has a number of chemotherapeutic effects. By acting as a histone deacetylase inhibitor, it contributes to inhibiting the growth of already degenerated cells and inducing apoptosis in these cells, reducing the risk of developing colon cancer [8, 65].

Due to their antioxidant, antitumor, and anti-inflammatory properties (Figure 2), short-chain fatty acids play an important role in maintaining gastrointestinal and immune system homeostasis [13]. Furthermore, they also have cholesterol-lowering properties [11]. SCFAs are able to regulate glucose and cholesterol metabolism by acting on free fatty acids receptor 2 and 3 (Ffr 2/3). Through these receptors, short-chain fatty acids can increase the concentration of gastrointestinal hormones, such as glucagon-like-peptide 1 (GLP-1) and peptide YY (PYY). PYY induces glucose uptake in skeletal muscles and adipose tissues, while GLP-1 indirectly reduces blood glucose, increasing insulin concentration and reducing glucagon production in the pancreas. Use of propionic acid contributed to the reduction of cholesterol synthesis in rat livers [15, 65] (Figure 2).

By increasing the production of butyric acid and propionic acid, oat *beta*-glucan may also play a significant role in the prevention and treatment of diabetes and cardiovascular diseases [64]. *Beta*-glucans, as a dietary fiber fraction, are an important source of energy, stimulating the growth, activity, and survival of probiotic bacterial strains such as *Lactobacillus* and *Bifidobacterium* while inhibiting the development of pathogenic bacteria (*E.coli*, *Clostridium celatum*, and *Bacterioides*) [24, 72, 84] (Figure 2). This promotes the growth of beneficial intestinal microflora and improves the function of the small intestinal mucosa and colonocytes, thus reducing the risk of nonspecific inflammation and colorectal cancer [53].

CONCLUSIONS

Research conducted in recent years has shown that *beta*-glucans can be helpful in the fight against chronic non-communicable diseases. Due to their hypocholesterolemic and blood sugar lowering properties, they can be used to prevent cardiovascular diseases and diabetes. In addition, *beta*-glucans have immunomodulatory properties, which are due to their ability to bind specific surface receptors on immunologically competent cells, thereby affecting their immune response. They also affect the secretion of cytokines, the expression of inflammation-related genes, phagocytic activity, and the activation of the complement system. They prevent oncogenesis due to their protective effect from genotoxic carcinogens. Therefore, they may play an important role in cancer prevention and treatment. Stimulation of immune system cells is particularly important not only in the case of cancer but also infections, antibiotic therapy, and long-term use of immunosuppressive drugs.

Moreover, some polysaccharides such as *beta*-glucans may act as a prebiotic and stimulate the growth of probiotic bacterial strains in the large intestine and inhibit the growth of pathogenic bacteria. This plays an important role in the proper functioning of the gastrointestinal tract and preventing inflammation as well as colon cancer. The beneficial effects of *beta*-glucans on so many aspects of metabolism have great potential for using this compound as an immunostimulant in the prevention and treatment of many diseases.

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