

The potential of beta-glucan as feed additives in broiler chickens: A review

Potensi beta-glucan sebagai pakan aditif ternak unggas: Reviu

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ABSTRACT

Poultry as an industry was continuously growing worldwide and demands for poultry meats were markedly increasing. However, the limited use of antibiotics as treatments and as growth promoters became a serious problem due to the emergence of antibiotic resistance and microbial challenges in commercial poultry farming causing significant economic losses. Therefore, exploring other alternatives such as using feed additives like β-glucans were widely studied and used to meet the demands of the consumers. β-glucans can be found in yeast, fungi, some bacteria, and cereals such as oats, barley, and corn. This review focused on the different functions and effects of β-glucans in poultry. β-glucans were known to have immunomodulation effects by upregulating the cytokines and other immune cells to overcome a disease. Aside from its immunomodulation effects, it can also increase the intestinal villi and crypts. Furthermore, an increase in growth performance was also observed. This evidence is promising but further research is required to properly establish the various functions of β-glucans in poultry as an alternative to antibiotics, anti-inflammatory, and anti-oxidative properties.

ABSTRAK

Unggas sebagai industri yang terus berkembang di seluruh dunia dan permintaan daging unggas meningkat tajam setiap tahunnya. Namun, penggunaan antibiotik yang terbatas sebagai pengobatan dan sebagai pemacu pertumbuhan menjadi masalah serius karena munculnya resistensi antibiotik dan tantangan mikroba dalam peternakan unggas komersial yang menyebabkan kerugian ekonomi yang signifikan. Oleh karena itu, eksplorasi alternatif seperti penggunaan feed additive seperti beta-glukan banyak dipelajari dan digunakan untuk memenuhi permintaan konsumen. Beta-glukan dapat ditemukan dalam ragi, jamur, beberapa bakteri, dan sereal seperti gandum, barley, dan jagung. Ulasan ini berfokus pada berbagai fungsi dan efek beta-glukan pada unggas. Beta-glukan diketahui memiliki efek imunomodulasi dengan meningkatkan regulasi sitokin dan sel imun lainnya untuk mengatasi suatu penyakit. Selain efek imunomodulasi, juga dapat meningkatkan vili usus dan kriptus. Selain itu, peningkatan kinerja pertumbuhan juga diamati. Bukti ini menjanjikan tetapi penelitian lebih lanjut diperlukan untuk menetapkan dengan tepat berbagai fungsi beta-glukan pada unggas sebagai alternatif antibiotik, anti-inflamasi, dan sifat anti-oksidatif.

Kata kunci:

Alternatif antibiotik
β-glukan
Immunomodulation
Promotor
pertumbuhan
Unggas

INTRODUCTION

The intestinal tract of poultry is to struggle with pathogenic bacterial infections from *Escherichia coli*, *Salmonella typhimurium*, and *Clostridium perfringens* (Schwartz & Vetrica, 2021). Antibiotics have been used to prevent

bacterial infection and disease in poultry. However, farmers need to reduce the use of antibiotics due to antibiotic resistance turns out to be a serious problem (Yang et al., 2021). Reducing availability of antibiotics, one of the ways that farmers used to stimulate the immune system of the chicken



and resist microbial infection was feed additives enzyme (Vangroenweghe et al., 2021). Feed additives play a significant role in enhancing the production parameters in the poultry industry. It is commonly used to promote growth and prevent diseases or other health-related issues (Pirgozliev et al., 2019). A good example of feed additives is beta-glucan. It is known for augmenting the immune system by increasing the production of cytokines and activating other cells such as macrophages, natural killer cells, and neutrophils (Moon et al., 2016). Furthermore, β -glucans can significantly increase the antibody titer of the broiler chickens after vaccination (Werf, 2018). Aside from its positive effects on the immune system, β -glucans also have beneficial effects on the gut. It can increase the number of Goblet cells and stimulates cells related to secretory IgA (sIgA) resulting from the increased number of sIgA in the intestinal lumen (Anwar et al., 2017) there is increased pressure on producers to reduce antibiotic use in poultry production. Therefore, it is essential to use alternative substances to cope with microbial challenges in commercial poultry farming. This review will focus on the role of β -glucans originating from yeast cell wall (YCW).

Effects of β -glucans in mammals are widely established in comparison with avians (Petit et al., 2019) the exact receptors and downstream signalling remains to be described for fish. In mammals, Dectin-1 is a member of the C-type lectin receptor (CLR). Recently, various studies eloquently explained the positive effects of β -glucans in poultry such as increased growth (Cho et al., 2013), improved immune status (Omara et al., 2021), and maximized digestive functions of the birds (Ding et al., 2019). Upon knowledge, optimal β -glucan mixtures may be implemented in order to obtain optimal growth performance, exert anti-inflammatory and immunomodulatory activity, and optimized intestinal morphology and histology responses in poultry. This review focuses on the positive effects of β -glucans in the immune system, digestive system, growth parameters, antimicrobial effects, antioxidative, and anti-inflammatory properties in poultry.

DISCUSSION

Definition and Different Preparation of β -glucans

B-glucans are non-starch polysaccharides consisting of D- glucose monomers and connected

by beta glycosidic bonds (El Khoury et al., 2012) there is established evidence on the role of dietary fibers in obesity and metabolic syndrome. Beta glucan (β -glucan. These glycosidic bonds have various specific linkages namely β (1 \rightarrow 3), (1 \rightarrow 4), and/or (1 \rightarrow 6) which can also be branched or unbranched (Kaur et al., 2020) which, when incorporated in food, is renowned for its ability to alter functional characteristics such as viscosity, rheology, texture, and sensory properties of the food product. The functional properties of β -glucans are directly linked to their origin/source, molecular weight, and structural features. The molecular weight and structural/conformational features are in turn influenced by method of extraction and modification of the β -glucan. For example, whereas physical modification techniques influence only the spatial structures, modification by chemical agents, enzyme hydrolysis, mechanical treatment, and irradiation affect both spatial conformation and primary structures of β -glucan. Consequently, β -glucan can be modified (via one or more of the aforementioned techniques. According to (Stier et al., 2014), there are various β -glucans that can be found but it was reported that 1,3/1,6- β -D-glucans can positively stimulate the immune system using their highly branched molecular structure.

Generally, β -glucans can be divided into two major categories namely soluble β -glucans and insoluble β -glucans. Soluble β -glucans can increase intestinal transit time which includes the gel-forming β -glucans (Bashir & Choi, 2017). Soluble beta-glucan was produced through enzymatic hydrolysis (Xin et al., 2022). Insoluble beta-glucan can be found in yeast cell wall can be utilized as functional food based on its excellent immune-enhancing effect (Samuelsen et al., 2014). The use of yeast cell wall-glucan has been limited because it is not soluble in water (Xin et al., 2022).

B-glucans can be commonly found in yeast, fungi, some bacteria, and cereals such as oats and barley (Du et al., 2019). In addition, β -glucans are also present in corn grains (0.1), wheat grains (1.0), sorghum grains (0.1), barley grains (4.1), oat grains (2.8), and rye grains (1.7) in the varying amount in % dry matter (Knudsen, 2014). It was also noted that β -glucans are the major components of the cell wall of yeast, fungi, and some bacteria (Ruiz-Herrera & Ortiz-Castellanos, 2019).

The available preparation of β -glucans that can be used in poultry is mostly in feed powder premix form. The doses and percentages in each diet vary depending on the brands that will be used. In line with this, liquid preparation is also recently becoming popular and widely available such as Celmanax® which is a yeast-derived dietary carbohydrate derived from the cell wall of *Saccharomyces cerevisiae* and contains beta-glucan, mannan-oligosaccharides (MOS) and mannose.

Growth Enhancing Effect of β -glucans

Growth promoters are consistently used due to the increasing demand of humans in animal protein. To compensate, rapidly increasing the growth of the animal was alternatively used to close the gap between the supply and demands. Antibiotic growth promoters (AGP) are one of the commonly used to uplift the growth in chickens, however, a concern of antibiotic residue emerged. Thus, the usage of β -glucans as growth promoter alternative became popular (Fadl et al., 2020).

Effect on different growth parameters

β -glucans as growth promoter has already been established. According to (Ding et al., 2019), the positive effects of β -glucans on body weight were due to the priming of the microflora in the gut thus promoting its development. β -glucans have the ability to decrease intestinal colonization of pathogenic bacteria (improving intestinal health and mucosa integrity) and to reduce competition for nutrients between the host and its microflora allowing more available or higher ileal protein digestibility (Ferket et al., 2002; Gómez et al., 2012)the poultry industry has developed in several areas of nutrition, genetics, engineering, management, and communications to maximizing the efficiency of growth performance (weight for age and feed conversion. Moreover, (ElSawy et al., 2015) stated that due enhanced expression of Growth Hormone Secretagogue Receptor (GHSR) and Insulin-Like Growth Factor 1 Receptor (IGF1R) resulted in a positive increase in body weight The effect on different growth parameters was showed in Table 1.

The modes action of β -glucan improved the performance productivity of chickens. The growth-promoting effect of β -glucan is attributed to their ability to limit the growth of potentially pathogenic bacteria in the digestive tract of

Table 1. The effect β -glucans supplementation on different growth parameters of broiler chickens

Feed additives	Object	Result	Reference
Man-nan-oligosaccharide and β -Glucan	Infected <i>E. coli</i> chickens	increase in body weight, improve the immune response and mitigated pathological lesion	(Fadl et al., 2020)
β -glucan 0.15 g/kg	<i>Eimeria</i> -infected birds	had no negative effects on performance nor did it increase mortality	(Ott, 2015)
0.5 - 2.0 g/kg 1,3-1,6 beta-glucan from yeast	Haidong chicks reared under hypoxic conditions	Improve the growth performances and immunity so can used to reduce and replace the use of antibiotics.	(Ding et al., 2019)
0.15 - 0.2 g/kg yeast β -glucans	Ross 308 broiler chickens	improved growth performance, ileal protein digestibility, and meat yield of broilers	(Ahiwe et al., 2019)
β -glucan 0.6 g/kg	commercial broiler chickens	improve the survival and performance of broilers but no effects on the quality parameters of chicken breast meat.	(Moon et al., 2016)

animals then improving intestinal function and gut health via increase in villus uniformity and integrity (Jahanian & Ashnagar, 2015). In response to immune cell, β -glucan stimulates to release cytokines and chemokines as signaling proteins that stimulate the immunocompetent cells (monocytes, neutrophils, and macrophages) for killing pathogens by phagocytosis, oxidative burst, and cytotoxic killing activities (Hadiuzzaman et al., 2022). Thus, the digestive tract remains healthy, functions more efficiently, and more nutrients are available for absorption

Effect beta-glucan on meat quality

In terms of meat quality, the appearances and texture of poultry meat are the essential characteristics, especially from consumers' point of view. The appearances of the carcass yield, water holding capacity, pH, color, and 2-thiobarbituric acid are similar to chicken with fed by commercial antibiotics. (Moon et al., 2016). The effect on meat quality of broiler chickens by

Table 2. Effect of β-glucans supplementation on meat quality

Feed additives	Object	Result	Reference
β-glucan 1 g/kg	mixed sex Arbor Acres broiler chickens	decreased (P<0.05) the relative weight of abdominal fat by 16.0%	(Z. F. Zhang et al., 2012)
0.1 – 0.2 g/kg β-glucan	Ross 308 male broiler chickens under heat stress condition	elevate meat pH of all birds and decrease cooking loss	(S. Zhang et al., 2020)
β-glucan 1 g/kg	Ross 308 mixed sex broiler chickens	improved the quality of meat due to the significant decrease in drip loss and increase in redness of broiler meat.	(Cho et al., 2013)

adding β-glucans in the diet shown in Table 2. However, limited research can be found in terms of the effects of β-glucans on meat quality and further investigations are needed.

Effect on the gastrointestinal track

In poultry, supplementation of β-glucans protects against a number of economically-important pathogens, such as *Escherichia coli*, *Salmonella enterica*, and *Eimeria* species and improves gut health and increases disease resistance (Anwar et al., 2017; Omara et al., 2021; Shao et al., 2013) 3/1,6-glucan on gut morphology, intestinal epithelial tight junctions, and bacterial translocation of broiler chickens challenged with *Salmonella enterica* serovar Typhimurium. Ninety *Salmonella*-free Arbor Acre male broiler chickens were randomly divided into 3 groups: negative control group (NC. Broilers supplemented with β-glucans have increased humoral and cell-mediated immune responses by improves phagocytic activity, enhances lysozyme and complement levels, and alters tight junction protein expressions (Tian et al., 2016). The effect on gastrointestinal track by adding β-glucans on broilers diet was shown in Table 3.

Immunomodulating effects of beta-glucan

According to (Omara et al., 2021), β-glucans can stimulate both innate and adaptive immunity. β-glucan can modulate the immune system by elevating the production of cytokines and activating other cells such as macrophages, natural killer cells, and neutrophils (Moon et al.,

Table 3. Effect of β-glucans supplementation on the gastrointestinal track

Feed additives	Object	Result	Reference
β-glucans g/kg	0.2 Necrotic enteritis broiler chickens	increased antibody levels against <i>C. perfringens</i> and improved villi height and villi height to crypt depth ratio number of <i>Clostridium perfringens</i> in the birds with necrotic enteritis was reduced and increased number of <i>Lactobacilli</i> spp. and <i>Bifidobacterium</i> spp.	(Tian et al., 2016)
0.1 g/kg β - 1, 3 / 1, 6 - glucan	of <i>Salmonella Typhimurium</i> -infected Arbor Acre male broiler chickens infected	alleviate intestinal mucosal barrier impairment in broiler chickens challenged with <i>Salmonella Typhimurium</i>	(Shao et al., 2013)
100 g/kg β glucan	β Ross 308 chickens	Villi height to crypt depth ratio in the ileum increased	(Karunaratne et al., 2021)
0.5 - 2.0 g/kg 1,3-1,6 β glucan from yeast	Haidong chicks reared under hypoxic conditions	increase in villi height, the elevated number of goblets cells and increased depth in intestinal crypts	(Ding et al., 2019)
0.2 – 0.8 g/kg β glucan	Necrotic enteritis male Ross broiler chickens	decreases intestinal <i>C. perfringens</i> colonization and proliferation and reduces gut lesions scores after oral infection with coccidial oocysts and <i>C. perfringens</i> in broilers	(M'sadeq et al., 2015)

2016). In addition, plasma levels of IgG and IgA can also be elevated resulting in a humoral response (Vlassopoulou et al., 2021). IgA antibodies in the intestines were found to be increased after yeast β -glucans supplementation in chickens infected with *Clostridium perfringens*. As a result, this study proved that yeast β -glucans can stimulate the humoral immunity of chickens with necrotic enteritis (Tian et al., 2016).

IL-2 was also found in yeast cell wall preparation diet provision as reported by (Pascual et al., 2020). IL-2 is important in the production of antibodies by B lymphocytes, and it was also involved in cell-mediated immune response. Moreover, the result of the lymphoid-organ indices was also elevated which conforms to the immunomodulation effect of the β -glucans. Lymphoid organs namely, the bursa of fabricius, thymus, and spleen were all found to be larger in β -glucans supplemented chickens. (Ding et al., 2019) confirmed the same result of the increase in weights of Bursa of fabricius upon supplementation of 0.5 g/kg and 1.0 g/kg of β -glucans in the diet of healthy broiler chicks. However, no increase in the weights of the liver and spleen was observed. The differences in the results of the weight of the organs related to the immune system such as the spleen, thymus, and bursa of fabricius, might be due to the age, breed, and environmental condition. Furthermore, it was reported that β -glucans can significantly elevate the antibody titers of the broiler chickens by 60% to 80% after vaccination against Newcastle disease and Infectious bronchitis (Werf, 2018). β -glucan stimulates the production of precursor cells in bone marrow, resulting in an increased flow of new immunocytes into the various lymphoid organs throughout the body (J. Jacob & Pescatore, 2017)

Anti-microbial Properties of β -glucans

Antibiotic resistance is one of the emerging public health concerns both in the human and animal fields. Thus, the usage of β -glucans as the alternative was significantly becoming popular (Landers et al., 2012). According to (Chamidah et al., 2017), β -glucans are found to have anti-microbial properties against Gram-negative and Gram-positive bacteria. The study use extracted β -glucans from algae and a disc diffusion susceptibility test was performed to analyze the anti-microbial properties of Gram-

positive bacteria such as *Staphylococcus aureus* and *Bacillus subtilis* and Gram-negative bacteria such as *Salmonella typhimurium* and *Escherichia coli*. The results showed that the inhibition ability is significantly higher in Gram-positive bacteria in compare with Gram-negative bacteria. The reason behind this result was differences in the cell wall composition of these bacteria. Gram-positive bacteria consist of peptidoglycans which are known for their rigidity. Furthermore, it was found that a wider diameter of inhibition against Gram-positive and Gram-negative bacteria can be achieved if a higher concentration of β -glucans is present.

Potential as an alternative to antibiotics in the poultry industry

β -glucans as an alternative to antibiotics the in-poultry industry has not yet been deeply examined (Anwar et al., 2017) there is increased pressure on producers to reduce antibiotic use in poultry production. Therefore, it is essential to use alternative substances to cope with microbial challenges in commercial poultry farming. This review will focus on the role of β -glucans originating from yeast cell wall (YCW). Immunocompromised chickens easily allow pathogens such as *Salmonella* spp. which can deliberately infect the animal by targeting the intestines resulting in poor growth. Thus, β -glucans have an important role since it is known for modulating the immune system and it has been found that they can decrease *Salmonella enteric* serovar Enteritidis colonization by protecting the intestinal lining and increasing phagocytosis. It was reported that supplementation of β -glucans increased the villi and density of intestinal crypts (Shao et al., 2013). The same study also revealed that intestinal integrity improved after supplementation. In addition, (Omara et al., 2021) reported that there is a decrease in intestinal lesions found in *Eimeria*-infected chickens after supplementation of β -glucans.

These reported pieces of evidence potentially proved that β -glucans are a promising candidate as an alternative to antibiotics. However, (J. P. Jacob & Pescatore, 2014) reported that β -glucans from barley does not have a positive effect on the poultry performance as opposed to β -glucans from yeast and fungi. The reason behind this is that β -glucans from barley were reported to increase the intestinal viscosity which will result

in decreased activity of enzyme and nutrient digestion as well as its absorption. Furthermore, (Anwar et al., 2017) there is increased pressure on producers to reduce antibiotic use in poultry production. Therefore, it is essential to use alternative substances to cope with microbial challenges in commercial poultry farming. This review will focus on the role of β -glucans originating from yeast cell wall (YCW stated that there is still no evidence regarding directly killing of the pathogenic bacteria using beta-glucan supplementation. To the best of the author's knowledge, there is no previously published study claimed regarding the mechanism.

Antibacterial mode of action against pathogenic bacteria

As mentioned earlier, β -glucans can suppress the colonization of pathogenic bacteria such as *Salmonella* spp. and *Escherichia coli* (Anwar et al., 2017) there is increased pressure on producers to reduce antibiotic use in poultry production. Therefore, it is essential to use alternative substances to cope with microbial challenges in commercial poultry farming. This review will focus on the role of β -glucans originating from yeast cell wall (YCW. Supplementation of β -glucans can increase the number of goblet cells which produced mucin which made the adhesion of the pathogenic bacteria difficult and reduced in number. Aside from this mechanism, increased production of sIgA strengthened the mucosal integrity of the intestine specifically the jejunum (Shao et al., 2013). An increase in sIgA in *Salmonella* challenged chickens was also noted by (Schwartz & Vetvicka, 2021).

On the other hand, (Anwar et al., 2017) there is increased pressure on producers to reduce antibiotic use in poultry production. Therefore, it is essential to use alternative substances to cope with microbial challenges in commercial poultry farming. This review will focus on the role of β -glucans originating from yeast cell wall (YCW expounded that these mechanisms and evidence related to the enhancement of intestinal features and mechanisms (attachment to enteric pathogens or killing them directly) is still unclear and unavailable. Even though dietary supplementation of β -glucans is promising, it still lacks significant evidence and mechanisms to prove that it can really be an alternative to antibiotics. Thus, it can further studies can be

explored to observe its effects and identify the exact mechanism of these enteric pathogens.

Anti-oxidative Properties of β -glucans

According to (Schwartz & Vetvicka, 2021), β -glucans can stimulate bacterial killing and oxidative burst if supplemented in the diet due to the direct interaction of β -glucans and macrophages. The increase in the oxidative burst was also reported by (Ott et al., 2018). Furthermore, (Abd El Tawab et al., 2019) also confirmed that there is an increase in glutathione (GSH) and a decrease in malondialdehyde (MDA) which is suggestive of the anti-oxidative effects of β -glucans in broiler chickens. Additionally, (Moon et al., 2016) stated that β -glucans can lessen the oxidative stress experienced by broiler chickens which will result in good quality meat. However, this claim has not yet been established and needed further studies to confirm.

Anti-inflammatory Properties of β -glucans

In a challenging situation, macrophages can secrete interleukin-18 (IL-18) which stimulates the migration of the inflammatory cells to the affected sites (J. P. Jacob & Pescatore, 2014). A study conducted by (Schwartz & Vetvicka, 2021) suggested that β -glucans can modify the cytokine profile, but it was not notable in an unchallenged setup. It was also revealed that there is a significant decrease of IL-18 in the duodenum of beta-glucan supplemented chicks. Aside from IL-18, interleukin-8 (IL-8) was also observed in this study, and it was reported that on day 7 and day 14 of the dietary experiment, a significant decrease of IL-8 in the intestines may suggest that β -glucans have also the anti-inflammatory effects of β -glucans. Another important cytokine that can be a parameter for anti-inflammatory effects is the interferon- γ (IFN- γ). This cytokine enhances the T-helper cell 1 (Th1) differentiation important in innate immune cell activation and decreased number of IFN- γ was also observed. Thus, it can be a possibility that β -glucans have anti-inflammatory effects.

Effects of β -glucans on Serum Biochemistry and Hematological Values

Blood profile analysis in poultry species supplemented with beta-glucan has a very limited known study. Ding et al. (2019) analyzed the

effect of β -glucans on hematological values such as white blood cells (WBC) count, red blood cells (RBC) count, and the number of lymphocytes. It was discovered that WBCs and lymphocytes significantly increased in chicks treated with β -glucans in comparison with the controlled group. However, no significant result was found in RBCs. In addition, a decrease in cortisol level was noticed in a study conducted by (Vetvicka & Oliveira, 2014), and protective activity of β -glucans in broiler chickens was suggested. These previous reports were in contrast with other studies where hematological values were significantly not influenced by dietary β -glucans in chickens (Cho et al., 2013). Furthermore, an increase in white blood cells, heterophils, lymphocytes, and heterophil-lymphocyte ratio were all observed in a study conducted by (Sadeghi et al., 2013).

WBCs and lymphocyte are responsible for defense against infection and support the repair of damaged tissues in the body. This mechanism is based on the binding ability of pattern recognition receptors (PRRs) expressed on the WBC membrane (notably on macrophages), and pathogen associated molecular patterns (PAMPs), molecular pattern that are exposed on invading pathogens cell membrane. Hence, 1,3-1,6 β -glucan act as PAMPs and once they are bound to PRRs, immune-cells get activated producing a cascade of immune-mediators, with that enhancing the immune system (Ding et al., 2019).

A study was conducted by (Imanpour-jodey et al., 2013) which focus on the effects of β -glucans on the lipid profiles of broiler chickens. The parameters used were serum triglyceride, total cholesterol, and serum high-density lipoprotein (HDL). In the said experiment, it was found that a significant decrease in serum triglyceride in those broiler chickens was supplemented with a 0.08% β -glucan diet. Unfortunately, there is no significant result found on both HDL and total cholesterol levels after beta-glucan supplementation. β -glucan's molecular weight is not a single critical factor for controlling lipid profile. However, study by (Bae et al., 2009), showed that the molecular weight range of β -glucan (around 700,000–800,000 g/mol) appeared to be the most suitable for the improvement of its fat binding capacity. There is an optimum molecular weight range of β -glucan to enhance its fat binding capacity which could be improved by enzymatic hydrolysis.

Future of β -glucans in the Poultry Industry

β -glucans have already become popular mainly because their promising effects on the immune system. It is commonly used in the poultry industry as prebiotics in the form of powder which is added to feeds. Aside from its immune effects, β -glucans have been used in immunotherapy in cancer for humans and some animals including mice (Geller et al., 2019). (de Oliveira et al., 2019) reported the potential of β -glucans as vaccine adjuvants. (Wang et al.,) used sulphated beta glucan as an adjuvant in Newcastle vaccines in chickens and found that there is an increase serum antibodies and cytokines levels (IL-2 and IFN- γ) in compare with non- adjuvant vaccine control group. In addition, increased number of splenic cells were observed in vitro in chickens and concluded that beta glucan is a good candidate for a new type of immune adjuvant.

Many countries have already taken action to reduce the use of antibiotics in poultry feed. Aside from being an adjuvant, β -glucans are also widely studied as an alternative to antibiotic growth promoters. As expounded by (Lindmeier, 2017), the use of antibiotic growth promoters in poultry is prohibited in European Union since 2006. With this, nutrition as an important factor in the growth of birds is widely studied by veterinary nutritionists. Several studies claimed that it can be an alternative to antibiotic growth promoters. A study conducted by (Cho et al., 2013) focused on the effects of β -glucans on the growth of broiler chickens. It was found that there is a marked increase in growth performance in broiler chickens supplemented with a 0.1% yeast cell wall β -glucans diet. (Anwar et al., 2017) there is increased pressure on producers to reduce antibiotic use in poultry production. Therefore, it is essential to use alternative substances to cope with microbial challenges in commercial poultry farming. This review will focus on the role of β -glucans originating from yeast cell wall (YCW) suggested that further experiments should be conducted to know the relationship of β -glucans with the weights of lymphoid organs in terms of growth parameters.

Evidence suggests that β -glucans can act as immunomodulators. However, several studies expounded on its immunomodulation effect and gene expressions and cytokine profiling in association with the immune response effects of β -glucans supplementation during

an active infection are still limited (Ott, 2015). (Omara et al., 2021) observed that there is a significantly enhanced and improved in the immune response genes such as IL-10, IL-17F, interferon (IFN)- γ , inducible nitric oxide synthase (iNOS), and macrophage migration inhibitory factor (MIF) in the thymus at day 14 upon supplementation of 0.1% β -glucans which suggest the immunomodulation effect of β -glucans. Nevertheless, the study still recommends that the timing of cytokine production during an immune response must be further investigated for a better result. It was also mentioned by (de Oliveira et al., 2019) a study using the same β -glucan molecule, administration route and experimental design is needed to compare the effects of β -glucan across vertebrate species. For this end, during 28 days we fed four different vertebrate species: mice, dogs, piglets and chicks, with two β -glucan molecules (BG01 and BG02 that type of experimental designs and route of administration across varying species involving effects of β -glucans can significantly affect the results. In addition, the varying protective effects between branched and unbranched β -glucans as well as the comparison of the effects on its sources needed further studies to properly observe its modulating effect both in challenged and control environments (Ott et al., 2018).

CONCLUSION

β -glucans are non-starch derived from yeast cell walls considered as biological response modifiers which can stimulate the immune system by activating both the innate and humoral immune systems. Furthermore, by adding 0.1 – 2 g/kg β -glucans can increase cytokine levels, stimulates immune cells like macrophages, increase sIgA levels, and alternative growth promoter. In addition, various studies reported that β -glucans can also be an alternative to antibiotics, especially against enteric pathogens such as *Salmonella* spp. and *E. coli*. However, mechanisms such as directly killing the enteric pathogens are still unknown. Thus, further studies are needed to prove that β -glucans can be an alternative to antibiotics, anti-inflammatory, and anti-oxidative properties.

DAFTAR PUSTAKA

Abd El Tawab, A., Elnaggar, O., & Elsisy, A. (2019). The impact of β glucan on the

Immune Response of Broiler Chickens Vaccinated with NDV and AI H9V Vaccines. *Benha Veterinary Medical Journal*, 36(2), 100–108. <https://doi.org/10.21608/bvmj.2019.13775.1021>

Ahiwe, E. U., Omede, A. A., Abdallah, M. E., Chang'a, E. P., Al-Qahtani, M., Gausi, H., Graham, H., & Iji, P. A. (2019). Response of Broiler Chickens to Dietary Supplementation of Enzymatically Hydrolyzed Glucan or Mannan Yeast Products. *Journal of Applied Poultry Research*, 28(4), 892–901. <https://doi.org/10.3382/japr/pfz047>

Anwar, M. I., Muhammad, F., Awais, M. M., & Akhtar, M. (2017). A review of β -glucans as a growth promoter and antibiotic alternative against enteric pathogens in poultry. *World's Poultry Science Journal*, 73(3), 651–661. <https://doi.org/10.1017/S0043933917000241>

Bae, I. Y., Lee, S., Kim, S. M., & Lee, H. G. (2009). Effect of partially hydrolyzed oat β -glucan on the weight gain and lipid profile of mice. *Food Hydrocolloids*, 23(7), 2016–2021. <https://doi.org/10.1016/j.foodhyd.2009.03.016>

Bashir, K. M. I., & Choi, J. S. (2017). Clinical and physiological perspectives of β -glucans: The past, present, and future. *International Journal of Molecular Sciences*, 18(9). <https://doi.org/10.3390/ijms18091906>

Chamidah, A., Hardoko, & Prihanto, A. A. (2017). Antibacterial activities of β -glucan (laminaran) against gram-negative and gram-positive bacteria. *AIP Conference Proceedings*, 1844(May 2017). <https://doi.org/10.1063/1.4983422>

Cho, J. H., Zhang, Z. F., & Kim, I. H. (2013). Effects of single or combined dietary supplementation of β -glucan and kefir on growth performance, blood characteristics and meat quality in broilers. *British Poultry Science*, 54(2), 216–221. <https://doi.org/10.1080/00071668.2013.777691>

de Oliveira, C. A. F., Vetvicka, V., & Zanuzzo, F. S. (2019). β -Glucan successfully stimulated the immune system in different jawed vertebrate species. *Comparative Immunology, Microbiology and Infectious Diseases*, 62(November 2018), 1–6. <https://doi.org/10.1016/j.cimid.2018.11.006>

Ding, B., Zheng, J., Wang, X., Zhang, L., Sun, D., Xing, Q., Pirone, A., & Fronte, B. (2019). Effects of dietary yeast beta-1,3-1,6-glucan on growth performance, intestinal morphology and chosen immunity parameters changes in Haidong chicks. *Asian-Australasian Journal of Animal Sciences*, 32(10), 1558–1564. <https://doi.org/10.5713/ajas.18.0962>

- Du, B., Meenu, M., Liu, H., & Xu, B. (2019). A concise review on the molecular structure and function relationship of β -glucan. *International Journal of Molecular Sciences*, 20(16). <https://doi.org/10.3390/ijms20164032>
- El Khoury, D., Cuda, C., Luhovyy, B. L., & Anderson, G. H. (2012). Beta glucan: Health benefits in obesity and metabolic syndrome. *Journal of Nutrition and Metabolism*, 2012. <https://doi.org/10.1155/2012/851362>
- ElSawy, A., ElMaddawy, Z., & BoGhazel, H. (2015). The Growth Promoting Effect of Beta-glucan in Comparison with Sodium Butyrate in Broiler Chicks. *Alexandria Journal of Veterinary Sciences*, 44(1), 23. <https://doi.org/10.5455/ajvs.163992>
- Fadl, S. E., El-Gammal, G. A., Sakr, O. A., Salah, A. A. B. S., Atia, A. A., Prince, A. M., & Hegazy, A. M. (2020). Impact of dietary Mannan-oligosaccharide and β -Glucan supplementation on growth, histopathology, E-coli colonization and hepatic transcripts of TNF- α and NF- κ B of broiler challenged with E. coli O78. *BMC Veterinary Research*, 16(1), 1–14. <https://doi.org/10.1186/s12917-020-02423-2>
- Ferket, P. R., Parks, C. W., & Grimes, J. L. (2002). Benefits of Dietary Antibiotic and Mannan-oligosaccharide Supplementation for Poultry. *Multi-State Poultry Meeting*, 1–22. <http://www.feedinfo.com/files/multi2002-ferket.pdf>
- Geller, A., Shrestha, R., & Yan, J. (2019). Yeast-derived β -glucan in cancer: Novel uses of a traditional therapeutic. *International Journal of Molecular Sciences*, 20(15), 1–20. <https://doi.org/10.3390/ijms20153618>
- Gómez, S., Angeles, M. L., Mojica, M. C., & Jalukar, S. (2012). Combination of an enzymatically hydrolyzed yeast and yeast culture with a direct-fed microbial in the feeds of broiler chickens. *Asian-Australasian Journal of Animal Sciences*, 25(5), 665–673. <https://doi.org/10.5713/ajas.2011.11316>
- Hadiuzzaman, M., Moniruzzaman, M., Shahjahan, M., Bai, S. C., Min, T., & Hossain, Z. (2022). β -Glucan: Mode of Action and Its Uses in Fish Immunomodulation. *Frontiers in Marine Science*, 9(July), 1–15. <https://doi.org/10.3389/fmars.2022.905986>
- Imanpour-jodey, S., Moghaddaszadeh-ahrabi, S., & Rezapour, A. (2013). *The effects of saccharomyces cerevisiae beta-glucan on blood lipids in broiler chickens* *The effects of saccharomyces cerevisiae beta-glucan on blood lipids in broiler chickens*. 4(September 2014), 134–137.
- Jacob, J. P., & Pescatore, A. J. (2014). Barley β -glucan in poultry diets. *Annals of Translational Medicine*, 2(2). <https://doi.org/10.3978/j.issn.2305-5839.2014.01.02>
- Jacob, J., & Pescatore, A. (2017). Glucans and the poultry immune system. *American Journal of Immunology*, 13(1), 45–49. <https://doi.org/10.3844/ajisp.2017.45.49>
- Jahanian, R., & Ashnagar, M. (2015). Effect of dietary supplementation of mannan-oligosaccharides on performance, blood metabolites, ileal nutrient digestibility, and gut microflora in Escherichia coli-challenged laying hens. *Poultry Science*, 94(9), 2165–2172. <https://doi.org/10.3382/ps/pev180>
- Karunaratne, N. D., Newkirk, R. W., Ames, N. P., van Kessel, A. G., Bedford, M. R., & Classen, H. L. (2021). Effects of exogenous β -glucanase on ileal digesta soluble β -glucan molecular weight, digestive tract characteristics, and performance of coccidiosis vaccinated broiler chickens fed hullless barley-based diets with and without medication. *PLoS ONE*, 16(5 May), 1–30. <https://doi.org/10.1371/journal.pone.0236231>
- Kaur, R., Sharma, M., Ji, D., Xu, M., & Agyei, D. (2020). Structural Features, Modification, and Functionalities of Beta-Glucan. *Fibers*, 1–29.
- Landers, T. F., Cohen, B., Wittum, T. E., & Larson, E. L. (2012). A review of antibiotic use in food animals: Perspective, policy, and potential. *Public Health Reports*, 127(1), 4–22. <https://doi.org/10.1177/003335491212700103>
- Lindmeier, C. (2017). *Stop using antibiotics in healthy animals to prevent the spread of antibiotic resistance*. World Health Organization. <https://www.who.int/news/item/07-11-2017-stop-using-antibiotics-in-healthy-animals-to-prevent-the-spread-of-antibiotic-resistance>
- M'sadeq, S. A., Wu, S. B., Choct, M., Forder, R., & Swick, R. A. (2015). Use of yeast cell wall extract as a tool to reduce the impact of necrotic enteritis in broilers. *Poultry Science*, 94(5), 898–905. <https://doi.org/10.3382/ps/pev035>
- Moon, S. H., Lee, I., Feng, X., Lee, H. Y., Kim, J., & Ahn, D. U. (2016). Effect of dietary beta-glucan on the performance of broilers and the quality of broiler breast meat. *Asian-Australasian Journal of Animal Sciences*, 29(3), 384–389. <https://doi.org/10.5713/ajas.15.0141>
- Omara, I. I., Pender, C. M., White, M. B., & Dalloul, R. A. (2021). The modulating effect of dietary beta-glucan supplementation on expression of immune response genes of broilers

- during a coccidiosis challenge. *Animals*, 11(1), 1–12. <https://doi.org/10.3390/ani11010159>
- Ott, C. P. (2015). *Impact of Dietary Beta-glucan Supplementation on Performance and Immune Response of Broiler Chickens During Challenge*. <https://vtechworks.lib.vt.edu/handle/10919/75170>
- Ott, C. P., Omara, I. I., Persia, M. E., & Dalloul, R. A. (2018). The impact of β -glucans on performance and response of broiler chickens during a coccidiosis challenge. *Poultry Science*, 97(8), 2713–2721. <https://doi.org/10.3382/ps/pey148>
- Pascual, A., Pauletto, M., Giantin, M., Radaelli, G., Ballarin, C., Birolo, M., Zomeño, C., Dacasto, M., Bortoletti, M., Vascellari, M., Xiccato, G., & Trocino, A. (2020). Effect of dietary supplementation with yeast cell wall extracts on performance and gut response in broiler chickens. *Journal of Animal Science and Biotechnology*, 11(1), 1–11. <https://doi.org/10.1186/s40104-020-00448-z>
- Petit, J., Bailey, E. C., Wheeler, R. T., Oliveira, C. A. F. D., Forlenza, M., & Wiegertjes, G. F. (2019). Studies into β -glucan recognition in fish suggests a key role for the C-Type lectin pathway. *Frontiers in Immunology*, 10(FEB). <https://doi.org/10.3389/fimmu.2019.00280>
- Pirgozliev, V., Rose, S. P., & Ivanova, S. (2019). Feed additives in poultry nutrition. *Bulgarian Journal of Agricultural Science*, 25, 8–11.
- Ruiz-Herrera, J., & Ortiz-Castellanos, L. (2019). Cell wall glucans of fungi. A review. *Cell Surface*, 5(November 2018), 100022. <https://doi.org/10.1016/j.tcs.2019.100022>
- Sadeghi, A. A., Mohammadi, A., Shawrang, P., & Aminafshar, M. (2013). Immune responses to dietary inclusion of prebiotic-based mannan-oligosaccharide and β -glucan in broiler chicks challenged with *Salmonella enteritidis*. *Turkish Journal of Veterinary and Animal Sciences*, 37(2), 206–213. <https://doi.org/10.3906/vet-1203-9>
- Samuelsen, A. B. C., Schrezenmeir, J., & Knutsen, S. H. (2014). Effects of orally administered yeast-derived beta-glucans: A review. In *Molecular Nutrition and Food Research* (Vol. 58, Issue 1, pp. 183–193). <https://doi.org/10.1002/mnfr.201300338>
- Schwartz, B., & Vetvicka, V. (2021). Review: β -glucans as effective antibiotic alternatives in poultry. *Molecules*, 26(12), 1–12. <https://doi.org/10.3390/molecules26123560>
- Shao, Y., Guo, Y., & Wang, Z. (2013). β -1,3/1,6-Glucan alleviated intestinal mucosal barrier impairment of broiler chickens challenged with *Salmonella enterica* serovar Typhimurium. *Poultry Science*, 92(7), 1764–1773. <https://doi.org/10.3382/ps.2013-03029>
- Stier, H., Ebbeskotte, V., & Gruenwald, J. (2014). Immune-modulatory effects of dietary Yeast Beta-1,3/1,6-D-glucan. *Nutrition Journal*, 13(1), 1–9. <https://doi.org/10.1186/1475-2891-13-38>
- Tian, X., Shao, Y., Wang, Z., & Guo, Y. (2016). Effects of dietary yeast β -glucans supplementation on growth performance, gut morphology, intestinal *Clostridium perfringens* population and immune response of broiler chickens challenged with necrotic enteritis. *Animal Feed Science and Technology*, 215(2), 144–155. <https://doi.org/10.1016/j.anifeedsci.2016.03.009>
- Vangroenweghe, F., Poulsen, K., & Thas, O. (2021). Supplementation of a β -mannanase enzyme reduces post-weaning diarrhea and antibiotic use in piglets on an alternative diet with additional soybean meal. *Porcine Health Management*, 7(1), 1–12. <https://doi.org/10.1186/s40813-021-00191-5>
- Vetvicka, V., & Oliveira, C. (2014). β (1-3)(1-6)-D-Glucan with Strong Effects on Immune Status in Chicken: Potential Importance for Efficiency of Commercial Farming. *Journal of Nutrition and Health Sciences*, November, 1–7. <https://doi.org/10.15744/2393-9060.1.309>
- Vlassopoulou, M., Yannakoulia, M., Pletsas, V., Zervakis, G. I., & Kyriacou, A. (2021). Effects of fungal beta-glucans on health—a systematic review of randomized controlled trials. *Food and Function*, 12(8), 3366–3380. <https://doi.org/10.1039/d1fo00122a>
- Wang, M., Yang, R., Zhang, L., Meng, X., Fei, C., Zhang, K., Wang, X., Zheng, W., Xiao, S., Zhang, S., Xue, F., & Hu, Y. (2014). Sulfated glucan can improve the immune efficacy of Newcastle disease vaccine in chicken. *International Journal of Biological Macromolecules*, 70, 193–198. <https://doi.org/10.1016/j.ijbiomac.2014.05.048>
- Werf, M. van der. (2018). Benefits of Application of Yeast β -Glucans in Poultry. *Ohly*, 1–3.
- Xin, Y., Ji, H., Cho, E., Roh, K. B., You, J., Park, D., & Jung, E. (2022). Immune-enhancing effect of water-soluble beta-glucan derived from enzymatic hydrolysis of yeast glucan. *Biochemistry and Biophysics Reports*, 30(January), 101256. <https://doi.org/10.1016/j.bbrep.2022.101256>
- Yang, F., Zhang, F., Li, H., Wu, H., Zhao, H., Cheng, X., Ba, Y., Huang, H., Chen, S., & Zhu, J. (2021). Contribution of environmental factors on

the distribution of antibiotic resistance genes in agricultural soil. *European Journal of Soil Biology*, 102(December 2020), 103269. <https://doi.org/10.1016/j.ejsobi.2020.103269>

Zhang, S., Ou, J., Luo, Z., & Kim, I. H. (2020). Effect of dietary β -1,3-glucan supplementation and heat stress on growth performance, nutrient digestibility, meat quality, organ weight, ileum microbiota, and immunity in broilers. *Poultry Science*, 99(10), 4969–4977. <https://doi.org/10.1016/j.psj.2020.06.036>

Zhang, Z. F., Zhou, T. X., Ao, X., & Kim, I. H. (2012). Effects of B-glucan and *Bacillus subtilis* on growth performance, blood profiles, relative organ weight and meat quality in broilers fed maize-soybean meal based diets. *Livestock Science*, 150(1–3), 419–424. <https://doi.org/10.1016/j.livsci.2012.10.003>