Chapter 35

Supplementation of Various Biotics in Poultry Nutrition for Optimizing Well-Being

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ABSTRACT

Global commercial poultry production has core importance for subsistence and the economy. However, antibiotic use has accelerated its expansion, giving rise to concerns regarding drug-resistant bacteria and residues. The growing number of drug-resistant bacteria and the buildup of antibiotic residues in chicken products complicate the treatment of diseases in both humans and animals. Even, the modest dose of antibiotics administrated in poultry leads to residues, which are hazardous to human health. Antibiotics used in livestock and poultry are often defecated intact, building up in the ecosystem and entering the human food system (meat and egg). Consequently, considerable scholarly attention has been devoted to the exploration of antibiotic substitutes, specifically in the context of the European Union's prohibition on antibiotic usage in poultry and animals. In poultry production, probiotics, prebiotics, postbiotics, synbiotics, phytobiotics, organic acids, and bioactive peptides have acquired enormous attention. These alternatives promote feed intake, metabolism, performance, and growth while decreasing disease by regulating the immune system and gut bacteria, reducing infections, and enhancing gut health and antioxidant status. Additionally, feed additives effectively competing with antimicrobial resistance and leave no residues in poultry products. This chapter aims to provide a thorough description of these innovative feed additives, and their impacts on poultry production.

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INTRODUCTION

It is well known that the inappropriate and uncontrolled use of antibiotics is a massive threat to human and animal health. The immediate global steps should need to be taken to redress the adverse effects of the antimicrobial resistance outbreak pandemic (Anderson et al., 2019). The poultry industry, which is expanding as a component of business path of the agricultural and veterinary sectors to cope with the increasing global demand for economical eggs and meat, is reliant on antibiotic growth promoters due to the growth of animal feeds (Rafiq et al., 2022). These antibiotic growth promoters (AGPs) are playing a substantial contribution in international farming or farming technique intensification, since they influence gut health, prevent subclinical infections, and improve feed efficiency. (Cox and Dalloul, 2015). Superbugs or drug-resistant bacteria have spawned as a result of the regular use of sub-therapeutic dosage of antibiotics, genuinely upsetting the natural gut flora and ingenious health hazards while they were transmitted to human receivers through infected chicken products (Castanon, 2007; Ripon et al., 2019). Regulatory organizations like the European Union had begun imposing restrictions on adding AGPs in animal feed as early as 2006 due to this incidence which compelled the sector to germinate for feasible alternatives (Alam and Ferdaushi, 2018). On that note, lots of studies have accomplished some nutritional supports as natural potentialities that can be used in place of it with spirulina, probiotics, prebiotics, phytobiotics, and synbiotics (Abd El-Hady et al., 2022; Rahman et al., 2022; NO and FC, 2023; Rafeeq et al., 2023; Dong et al., 2024). The above alternatives bring the same growth-promoting attributes as AGPs but with the added benefits of innocuity, lack of residuals, and a net positive influence on the gut ecology and animals' general health (Ferdous et al., 2019; Hafeez et al., 2020). Moreover, recent research has indicated how efficient such feed additives as phytogenic are at relieving stress and boosting immunological responses in stress-induced chickens without inflicting the adverse effects of antibiotics (Mehdi et al., 2018). As more data is availed, the method of rearing poultry continues to evolve. The purpose of this chapter was to detail the advantages of the natural feed addition over the AGPs, which can be summarized in significant health promotion and sustainable chicken production. Because of urbanization, growing populations, rising purchasing power of people, the demand for antibiotic free chicken products has been increased, so as a result the production of antibiotic free poultry products is crucial (Erdaw and Beyene, 2022). Challenges persist, especially with conventional poultry farming methods, which are more vulnerable to outbreaks of diseases due to their intensive nature (Graham et al., 2007). These issues are exacerbated by recent US Food and Drug Administration rules that limit the use of certain antibiotics, which have historically been essential to the financial stability of chicken farming. Subtherapeutic antibiotics such as tetracyclines, aminoglycosides, lincosamides, macrolides, penicillin, streptogramins, sulfonamides, and aminoglycosides have been prohibited (Brown et al., 2017; Yang et al., 2019). Organic chicken production prohibits the fertilizers and antibiotics usage, has challenges such as disease outbreaks, slower growth, and higher mortality rates. As a result, organic poultry products are often more expensive and find it challenging to meet the increased demand from customers (Mongeon and Dam, 2021).

In light of the aforementioned challenges, this chapter presents a range of innovative approaches, including the use of several types of feed additives (biotics), which constitute the cutting edge of research in poultry health and nutritional management. These solutions not only address the current issues of antibiotic resistance but also provide a route to improving poultry growth and health in a way that meets customer expectations for safety and sustainability.

Probiotics

The term probiotics was derived from the Greek word's "pro" "in favor" and "biotic which means "life" (Metchnikoff, 1908). Probiotics are live microorganisms which when added to feed at a specific dietary level, stabilize the unbroken microflora of the host and thus stimulate health and well-being of poultry. Yousaf et al. (2022) defined as a live compound that, when taken in sufficient amounts, has a favorable effect on the host's well-being, thereby improving the balance of intestinal microflora. Some of the probiotics used are; *Lactobacillus (L.) acidophilus, L. plantarum, L. bifidus, L. bulgaricus, L. fermentum, L. casei, L. ruminis, L. lactis, L. salivarius, Bifidobacterium bifidum, Bacillus subtilis Enterococcus feacium, Streptococcus feacium, Streptococcus thermophilus, Saccharomyces cerevisiae, Aspergillus oryzae,* and *Candida pintolopesii*. (Sharma et al., 2018; Khomayezi and Adewole, 2022). Probiotics increase the infection resistance. Stimulate the defense system and microbiota balance (Brisbin et al., 2008). Additionally, studies have shown that Lactobacillus strains increase the populations of lactic acid and anaerobic bacteria in the GIT and improve the optimal condition for nutrient absorption by the host (Olnood et al., 2015; Reuben et al., 2021). Probiotics maintain the balance between beneficial and pathogenic bacteria, a critical factor to poultry' gut health and proper development, and inhibit the growth of adverse microorganisms by reducing the intestinal pH due to short chain fatty acid synthesis (Yaqoob et al., 2022). Probiotics also affect the intestines' histomorphology by increasing villus height and villus to crypt ratio, thus increasing the available surface area for nutrient absorption and proper functioning (Huang et al., 2012; Abdel-Rahman et al., 2013; Bai et al., 2013; Afsharmanesh and Sadaghi, 2014). They also contribute to enhancing the intestinal morphology after damage by pollutants, such as deoxynivalenol, especially in laying hen chickens (Awad et al., 2006; Lei et al., 2013). Probiotics play a crucial part in managing enteric pathogens of the likes of *Salmonella spp.* and *E. Coli* O157 through competition for nutrients, the presentation of receptor sites on the intestinal mucosa, and the secretion of antimicrobial compounds (Mehdi et al., 2018; Al-Sagheer et al., 2019; Abd El-Hack et al., 2022). Furthermore, with or without antibiotics, probiotics noticeably improve the immune system of poultry through increasing the formation of antibodies and improving the defense system against diseases such as infectious bursal disease and Newcastle disease virus, which are specifically noticeable in turkeys (Çetin et al., 2005; Haghighi et al., 2006; Khaksefidi and Ghoorchi, 2006; Hussein et al., 2020). *Lactobacillus gallinarum* PL53 lowered the *C.jejuni* and enhanced *Lactobacillus* and *Bifidobacterium* counts in the gut and inreased the weight gain in *C.jejuni* challenged broilers (Khan et al., 2019). In summary, the findings seem to show that probiotics have the potential to significantly boost the immune system, growth performance and health of chickens.

Prebiotic

Prebiotics are indigestible food elements that ferment in the colon, promoting useful bacteria to improve the host's health (Gibson and Roberfroid, 1995). They generally comprise materials like mannan-oligosaccharides, fructooligosaccharides, galacto-oligosaccharides, lactulose, and inulin, which arise naturally from legumes or by various treatments. These compounds are referred as generally recognized as safe (GRAS), as these maintain a microbial equilibrium by providing good bacteria in the gut and inhibiting destructive bacteria (Solis-Cruz et al., 2019). The gut microbiota helps leave out pathogens, digest nutrients, and reinforce the immunological reaction. When used at prescribed dosages, prebiotics for example MOS and FOS have been shown to have a significant impact on GIT health and efficiency by reducing pathogenic bacteria such as *E. coli* and *Clostridium perfringens* and favoring the production of tolerant microorganisms, such as type *Lactobacillus* (Kim et al., 2011; Pourabedin and Zhao, 2015; Slawinska et al., 2019). It has also been reported by Rehman et al., 2020 that the administration of prebiotics or probiotics can lead to better broiler growth performance. Toghyani et al. (2011) reported that the use of prebiotics in a broiler diet improves the characteristics of the carcass. The potential mechanism is similar to the previous one, reduced colonization of the intestinal pathogen, and excretion of more attention to the final utilization of these nutrients. Chen et al. (2005) reported that supplementation of Oligofructose (Raftifeed®OPS) and inulin (Raftifeed®IPE) at the rate of 1% each of the prebiotic in the diet of laying hens increased the egg production and feed efficiency compared to the control group. Prebiotics induce significant changes in the bird's immune system. They increase the synthesis of antibacterial substances – bacteriocins and short-chain fatty acids, which inhibit the intestines' growth and multiplication of bad flora and support improvement of immune cells while stimulating the level of immunoglobulin, which is an essential factor in enhancing the bird's immunological response (Vamanu and Vamanu, 2010; Lopetuso et al., 2019). Prebiotics play a vital role in achieving the ideal gut morphology where it improves the villi length and density resulting in efficient feed utilization and nutrient absorption. According to evidence, "Consistent FOS administration has improved crypt depth as well as lengthened villi; this resulted in nutrient ingestion and overall intestinal health being optimised" (Hanning et al., 2012; Rehman et al., 2007). The obtained results indicate a wide range of prebiotic advantages in poultry nutrition, as shown by intestinal health and the digestive system to the sub-set immune system, and gut morphology. Therefore, the nutrient uptake and bird performance is improved.

Postbiotics and Parabiotics

The concept of metabolic compounds poised through probiotics is postbiotics, and poses a beneficial effect on the host either direct or indirect ways, as initially defined by Tsilingiri et al. (2012). According to the International Scientific Association of Probiotics and Prebiotics (ISAPP) postbiotics are inanimate microbes or their constituents that deliver health advantages (Shelar et al., 2022). Postbiotics cannot multiply or create toxins and are most likely to assure consumers about protection concerns, while hazard of genetic stability or infectivity is substantially decreased than living probiotics. However, it might require further safety evidence such as potential hazardous metabolite release (Sousa et al., 2008; Sanders et al., 2010; Cotter et al., 2013). To maintain an adequate viable count of probiotics at the situation in the present product that varies with storage conditions postbiotics, the postbiotics semen large-scale processing and storage is critical aspect intriguing. Following processing and storage of probiotics, the postbiotics maintains its shelf life by supplying a steady product dose (Nataraj et al., 2020; Salminen et al., 2021). Postbiotics or parabiotics are cell-free supernatants, metabiotics, or cultured and other biological compounds or inactive microbial products with bioactive properties. However, the names are used interchangeably. These are liquid factors from microorganisms such as peptides, short-chain-fatty acids, and enzymes that increase host bioactivity (Patel and Denning, 2013; Aguilar-Toalá et al., 2018). Postbiotics have a complicated composition and soluble factors. The soluble factors and complexes produced by the many microbial strains include biomolecules, vitamins, and acidic and alkaline organic elements with several useful nutritional qualities for livestock (Rai et al., 2019; Rad et al., 2020; Homayouni Rad et al., 2021). The potential of such soluble factors in animal nutrition becomes increasingly attractive, as these products boost immunological responses, promote growth, and facilitates the absorption of diet nutrients (Kareem et al., 2016; Haileselassie et al., 2016; Tiptiri-Kourpeti et al., 2016; Compare et al. 2017). Postbiotics are also recognized utilized to have antibacterial, antioxidant, anti-inflammatory, immunomodulatory, hypocholesterolemic, antitumor, hepatoprotective and growth-stimulant effect (Aguilar-Toalá et al., 2018). Abd El-Ghany et al. (2022), reported that postbiotic lyates applied to hens provided significantly more advantages over controls in relation to the disease profile, growth performance, immunological status, bursa-to-body weight ratio, and reduced coliform population. Humam et al. (2019) revealed that postbiotic from *L. plantarum* group improved gut health, growth performance and overall health. Of the broiler chickens. The above results show that postbiotics in poultry feeding possess benefits advantages. Specifically, they act on the build-up of intestinal structure and enhance nutrient absorption, which consequently positively affects the bird growth performance. Moreover, these promote immunological and gastrointestinal health of the poultry birds.

Synbiotics

A novel approach combining probiotics and prebiotics is known as synbiotics and is being explored with the goal to enhance their beneficial effects in the host. This combination aids in the survival and colonization of microbiological supplements in the gastrointestinal tract by boosting the development and metabolic activity of specific health-promoting bacteria. Referred regarded as "synbiotics," these combinations include of probiotics as well as prebiotics (Gibson and Roberfroid, 1995; Collins and Gibson, 1999). Some of the examples of synbiotics include; *Bifidobacteria*-fructooligosaccharide (FOS), *Lactobacilli*- lactitol, *Lactobacilli*-FOS, *Saccharomyces cerevisiae* -boulardii, *Pediococcus acidilactici*- mannan olidosaccaride (MOS), *Bifidobacteria*-inulin, *Enteroccoccus faecium*-FOS and *Lactobacilli*- inulin (Markowiak and Śliżewska, 2018; Sharma et al., 2018). In the chicken industry, antibiotics are widely used to boost production. However, this has resulted in problems such drug residues in poultry, alteration of the microbial flora, and antibiotic-resistant bacteria. By promoting the growth and activity of beneficial bacteria in the gastrointestinal system, synbiotics—a combination of probiotics and prebiotics—are used to address these issues and boost the efficacy of dietary microbial supplements (Sørum and Sunde, 2001; Gibson and Roberfroid, 1995). Synbiotics appear to significantly enhance chicken performance, according to several research. The growth performance, feed conversion ratio (FCR), and carcass output of broilers were found to dramatically improve when they were given nutritional supplements including synbiotics rather than just probiotics or controls (Awad et al., 2009). Song et al. (2022) discovered that synbiotics containing FOS and L. plantarum improved the digestibility of calcium and phosphorus and increased growth, immunological, and antioxidant indices. These results may point to a potential replacement for antibiotics in the diets of meat-eating birds. A synbiotic of *Enterococcus faecium*-FOS and *Clostridium butyricum*-FOS with marine algae improved the efficiency of yield, mass and shell of egg, egg quality, amino acid digestibility, jejunal structure, and physiological response in layers chickens (Radu-Rusu et al., 2010; Liu et al., 2019; Obianwuna et al., 2023). Studies have shown that synbiotics can enhance the productivity and well-being of chickens, suggesting that they can replace conventional antibiotics used in chicken feeds. Fig. 1 summarizes the beneficial effect of the biotics in poultry birds.

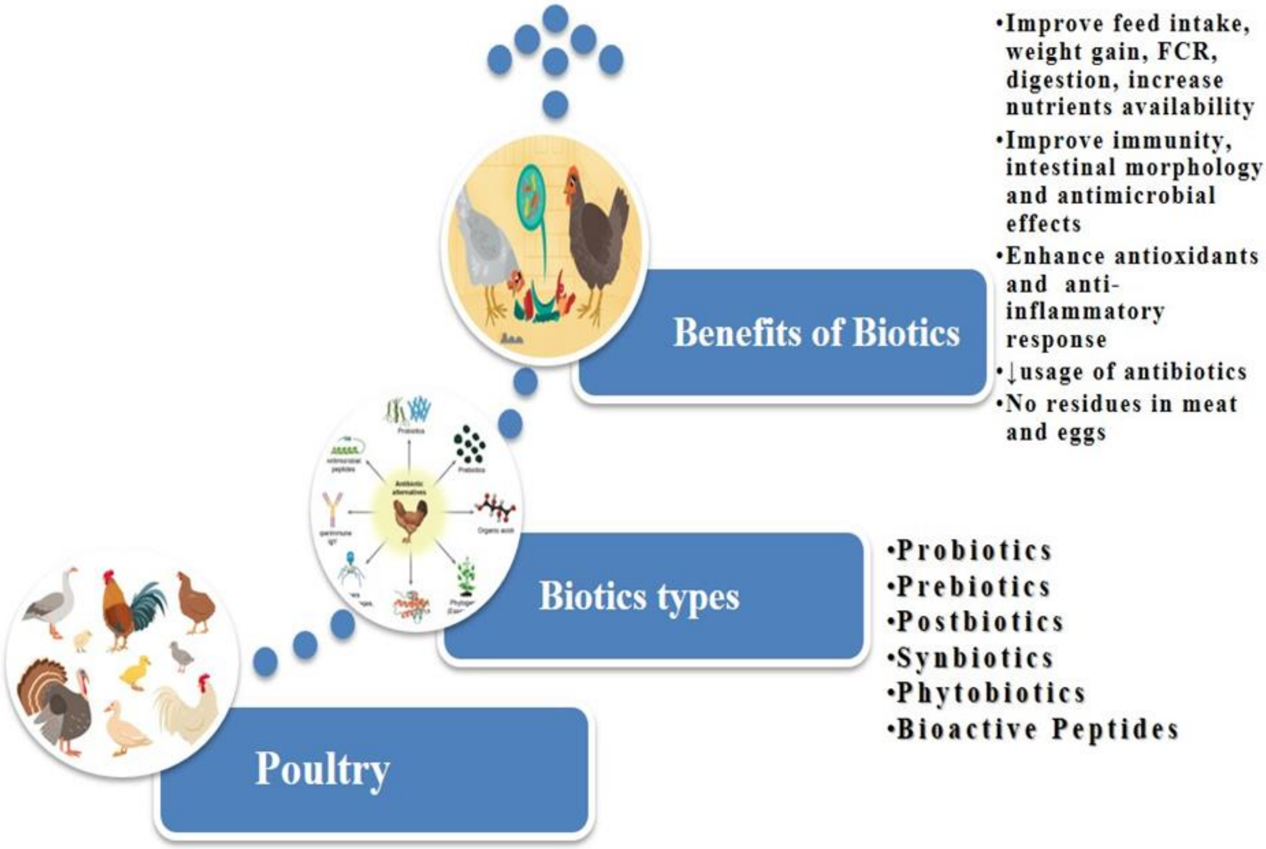

Fig. 1: The beneficial impacts of various biotics in poultry

Phytobiotics

Phytobiotics, also known as phytogenics or botanicals, are natural plant-derived products that are gaining popularity as environmental friendly and nontoxic alternatives to traditional antibiotics in the poultry sector. Phytobiotics, which may confer health benefits on the host include bioactive chemical substances such as phenolics, glycosides, terpenoids, and alkaloids and are derived from one or more sections of plants. The action of these chemicals on poultry as anti-bacterial, anti-coccidial, anti-parasitic, and immunostimulant has been extensively studied (Wang et al., 2008; Shad et al., 2014; Jin et al., 2023). Research on the potential of phytobiotics, prebiotics and probiotics, to improve poultry health and growth has been ongoing since the European Union banned the use of antibiotics as growth promoters in 2006 (Yasodha et al., 2019; Özbudak, 2019; El-Ghany, 2020). Due to the same reasons, these chemicals have been also investigated in several other animal species includingmonogastric species, comprising fish and rabbits, so on (Naiel et al., 2019; Mohammadi Gheisar and Kim, 2018; Alagawany et al., 2018).

Because of their antioxidant properties, phytobiotics may be used when there is heat stress (Chung et al. 2020b). Due to their high concentrations of thymol, carvacrol, and monoterpenes, oregano and thyme have been shown to have beneficial effects on antioxidant enzymes such as glutathione peroxidase and superoxide dismutase, which help regulate lipid metabolism in animals. However, plants such as mint, sage, and rosemary have an indirect antioxidant effect. The content of phenolic compounds, which include hydrolysable tannins, phenolic terpenes, proanthocyanidins, flavonoids, and phenolic acids, as well as the presence of certain vitamins, such as A, C, and E, is considered to provide these antioxidant qualities (Suganya et al., 2016; Filazi and Yurdakok-Dikmen, 2019). Aljumaah et al. (2020) reported that that the use of avilamycin with phytobiotics feed additive can help preserve growth performance of broiler chickens and improve meat quality in broilers challenged with *S. Typhimurium*. The use of phytobiotics together with cinnamon oil has been shown to positively affect growth performance of chickens, which is due to an improved immunological, antioxidant metabolic response and morphometry of the small intestine and an increase in the activity of the beneficial microbiota in the gut.

When chickens have the diet containing the plant with high flavonoids such as Chinese herb and green tea, lipid oxidation is arrested (Suganya et al., 2016). Introducing spices in the diet, such as garlic and onion, results in improving serum lipid profile and increasing liver antioxidant capacity (Khan, 2014; Suganya et al., 2016). Applying of phytobiotics in poultry diet to curb lipid oxidation not only have antioxidants qualities but also boost the host immune system, which makes them more beneficial than those of synthetic antioxidants. It is observed that components such as powdered Ganoderma lucidum mushroom and black cumin seed have been found to increase immune ability against specific pathogens and respond to vaccines at large, particularly at the time of vaccinating (Wang et al., 2002; Ogbe et al., 2008; Al-

Mufarrej, 2014). Moreover, plant extracts have also been reported to increase T cell activity with stimulating immunoglobulin synthesis, increasing humoral immunity and effectiveness antigen presenting cell (Kong et al., 2006; Khaligh et al., 2011; Chung et al., 2020a). The results show that how promisingly the use of phytobiotics is likely to improve the immune system of chickens, antioxidant activity, grow performance and health.

Bioactive Peptides

Bioactive peptides are peptides of short chain and of variable amino acid chain lengths that vary between 2 to 50 which have antihypertensive, antimicrobial and antioxidant properties (Sharma et al., 2011; Sánchez and Vázquez, 2017). The Biopep database contains 1500 bioactive peptides and details their diversity and importance (Singh et al., 2014). These are obtained through enzymatic hydrolysis of proteins from different available sources, which include fish, meat, milk, plant proteins, soybeans, wheat, corn, and many others. Through enzymatic hydrolysis, peptides of different psychoactivities such as biogenic, opioid, immunomodulatory, and others are generated (Barati et al., 2020; Tadesse and Emire, 2020). It is, therefore, possible that the BPs, which are gotten from natural products like sesame, canola and soya beans are added to poultry feeds which makes the intestinal health be enhanced and hence the antibiotics can be replaced (Abdollahi et al., 2017; Osho et al., 2019; Salavati et al., 2020). A subclass of bioactive peptides is the antibacterial peptides (AMPs), which have a spectrum of activity against bacteria. AMPs always kill bacteria by facilitating cell membrane disruption and inflammation. Conventional antibiotics and AMPs function in opposite ways, as the latter build dry envelopes as a method of extinguishing. This BPs attack through barrel stave and toroid pores processes (Trabulo et al., 2010; Li et al., 2021). According to the results of modern research, BPs significantly surpass traditional feed additives, such as mannan-oligosaccharides and antibiotics, in terms of the effectiveness of influence on chicken performance. Thus, the therapeutic potential of these peptides is displayed in the reduction of pathogenic bacteria and the multiplication of needed gut flora (Nakano et al., 2006; Liu et al., 2015; Salavati et al., 2020). The use of BPs as poultry performance enhancers has shown that some peptides can drastically decrease the content of gram-negative bacteria, which has a beneficial effect on nutrient absorption and the health of the intestines in general (Wen and He, 2012).

Moreover, antioxidant peptides reduce the adverse effect of reactive oxygen species. The mechanism of action on amino acids depends on their composition and structure (Stadnik and Kęska, 2015; Esfandi et al., 2019). Peptides produced from rice and soybean proteins boost the body’s defenses by acting on hormones and immune system function (Ngo et al., 2012; Kang et al., 2015). Similarly, peptides have robust anti-inflammatory properties and can both reduce inflammation and increase immune function at the same time. Certain peptides produced from fermented milk yielded outcomes like that of anti-inflammatory medicines (Ialenti et al., 2001; Zhao et al., 2016; Aguilar-Toalá et al., 2017). Cottonseed bioactive peptides added to the broiler diets at a rate of 6 g/kg improved immune responses, growth performance, and serum total antioxidant activity in the absence of antibiotics (Landy et al., 2020). Supplementation of small peptides derived from soybean at the rate of 4.5kg/kg in the laying hens’ diet, enhanced the growth performance, immune system efficiency and antioxidant activity. Moreover, the addition of short peptides improved the intestinal microbiota, barrier integrity, intestinal morphology and overall health of the chickens (Zhao et al., 2022). The findings indicate that bioactive peptides can be used in poultry diet as useful additives and as a therapeutic agent but further research is needed to fully understand their mechanism of action and their benefits for application.

Conclusion

Based on the above findings, it is concluded that different biotics have a positive impact on the growth performance, immune system and antioxidant efficiency, and the gastrointestinal health of chicken birds. Future researchers can use the biotics in all the poultry birds in different proportions and combinations.

Conflict of Interest

The authors declare that there is no conflict of interest.

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