Chapter 11

Probiotics as an Alternative to Antibiotics in Poultry

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ABSTRACT

The poultry industry is crucial to the economy, providing essential protein sources through chicken meat and eggs. However, it encounters challenges such as stress, health issues, and harsh environmental conditions, leading to significant economic losses. Antibiotics are added in poultry feeds as growth promoters and as an effective approach to lessen the number of detrimental bacteria that harbor the gastrointestinal tract. The antibiotics used in feed can also eradicate beneficial bacteria and the unrestricted use can increase the chances of antibiotic resistance in pathogenic bacteria. So, to resolve this problem, researchers have considered a great interest in promoting remedies to antibiotics. The probiotics are used as a feed supplement to replace the feed antibiotics. The probiotics are commonly used in chicken production. It improves the quality of eggs, meat, bones, and growth performance of birds. The probiotics can alter the intestinal microbes, GIT microbes, and defense system stimulation. The main theme of this chapter is to emphasize on the advantages of feed supplements (probiotics) as an alternative to antibiotics in poultry.

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INTRODUCTION

The poultry industry has a great role in the economy of any country (Shahbaz et al., 2024). Poultry rearing is extensively exposed to numerous problems such as stress, health-related problems, and harsh environmental conditions leading to huge economic losses to the chicken industry (Lutful Kabir, 2009). The chickens were domesticated around 5000 years ago, and people used to consume chicken meat and eggs as a source of protein (Rychlik, 2020). Since the 1940s, poultry feed has been supplemented with antibiotics (*Streptomyces aureofaciens*), which led to growth enhancement and feed additives (Eckert et al., 2010). However, there has been comparatively less emphasis on managing microbial infectious diseases caused by a variety of bacteria such as *Klebsiella, Yersinia, Enterococcus, Proteus, Pseudomonas*, *Salmonella*, *Bacillus*, *Clostridium*, *Mycobacterium*, *Campylobacter*, and *Escherichia Coli*. To mitigate this risk, broiler chicks are typically housed in enclosed facilities (Shurson et al., 2022). Many farmers administer antibiotics mixed in the feed to chicks (Mehdi et al., 2018), a practice that has been prevalent in traditional commercial chicken production for decades. The administration of antibiotics, mainly aims to boost feed utilization, growth rates, and chicken health, thus boosting production and profitability (Lourenco et al., 2019). Chickens serve as a principal food source globally, with antibiotics frequently employed to combat microbial threats. This results in the emergence of antibiotic-resistant genes, which may propagate to other bacteria (Żbikowska et al., 2020).

The essential natural or synthetic compounds known as antimicrobial agents can eliminate or hinder the growth of hazardous bacteria. The control of microorganisms that cause acute or chronic infection is extremely difficult despite antibiotics (Lewis, 2013). The pursuit of discovering novel antibiotics entered a significant phase following Alexander Fleming's discovery of penicillin, which effectively inhibited the growth of *Staphylococcus aureus*. Penicillin marked the advent of genuine antibiotic therapy (Khan, 2017). The tendency of these resistant germs to propagate, either directly or indirectly from one host to the other has resulted in antibiotic resistance (Zhao et al., 2020). The human and animal welfare are affected when antibiotics are used in larger doses or sub-therapeutic doses and it has a detrimental impact on both humans and animals (Grenni et al., 2018). The staphylococci associated with poultry farms have been discovered to be resistant to tetracycline and oxacillin. Distinct *Staphylococcus* species that frequently cause infection in chickens result in septicemia, and pododermatitis, together with evolving resistance to beta-lactam drugs (Pal et al., 2020).

Additionally, *E. coli* has become more resistant to most antibiotics which are frequently used in poultry including tetracycline (Varga et al., 2019). However, the discovery that antibiotic growth promoters contribute to the development of multi-drug-resistant microbes has sparked worries about the health of the world's populations. Antibiotic-resistant genes may have transferred from animals to humans as a result of an upsurge of antibiotic-resistant microbial communities in animals (Olusegun Oyebade et al., 2022). Many European countries have banned antibiotics in the feed of chickens since 2006 (Muhammad et al., 2020). Likewise, in 2015, the US Food and Drug Administration implemented veterinary feed directives, advising restricted use of antibiotics solely for animal treatment purposes (Yaqoob et al., 2022). Antimicrobial drugs for prophylaxis and as growth promoters were declared illicit in Sweden in 1986 and 1988, respectively (Neveling and Dicks, 2021). Similarly, in July 2011, the first Asian country, in which antibiotics growth boosters were banned was South Korea (Muhammad et al., 2019). The ban on the antibiotics used in feed increases the demand for substitutes to prevent loss in animal output. Over the last 20 years, nutritionists who specialized in poultry have observed a significant increase in the application of fatty acids, essential oils, prebiotics, symbiotics, and probiotics.

Additionally, probiotics have been demonstrated to enhance immunological response, GIT anatomy, and biological processes. Consequently, this improves the health and performance of chickens. Feed additives known as probiotics include useful fungi such as (*Aspergillus awamori, A. oryza, and A, noryi*), yeast (*Candida and Saccharomyces*), and beneficial bacteria such as *Bifidobcterium, lactobacillus,* and *streptococci*, all of which have the power to alter intestinal microflora and modulate the immune system (Abdel-Moneim et al., 2021).

Role of Probiotic in Growth Performance

Salmonella is the most common pathogen found in the lower GIT of poultry, especially broilers. Probiotics have evolved as the viable substitutes for growth advancement in most poultry farms after the antibiotic growth promoters were removed from poultry feed. Antibiotic growth promoters cause disturbance in gut microbiota by preventing the GIT pro-inflammatory cytokines from being produced and secreted (Adedokun and Olojede, 2018). The probiotics are non-pathogenic microorganisms in the GIT of broilers that compete with harmful bacteria for nutrition. Additionally, they colonize in the intestines, hindering the growth of hazardous bacteria and boosting the digestive enzymes (galactosidase and amylase) which enhances their growth performance by enhancing the absorption of nutrients (Al-Khalaifah, 2018). Employing a strain of *Lactiplantibacillus plantarum* (LT-113), the vaccinated chicks were found to be shielded against *Salmonella typhimurium* but minimizing intestinal cell production of tight junction genes and gastrointestinal invasion. Salmonella infection eroded the intestinal mucosal barrier in the control group (Wang et al., 2019). Alternatively, oral *Lactobacillus jhonsonii* treatment suppressed the bowel incursion of *Clostridium perfringens* and *Salmonella*. Furthermore, it has been proven that xylanase and multi-strain probiotics boost the bowel's absorption of food-derived energy and the liver's retention of that energy (Olnood et al., 2015).

The probiotics have been phased out for the ability to enhance the development of incorporated chicken outputs since the evaluation of antibiotic growth promoters but hinder the yield and secretion of metabolic regulators by intestinal cells which results in a reduction of intestinal microflora (Jha et al., 2020). Adversely, probiotics can increase growth by modifying the GIT premises and promoting GIT function through the fortification of useful microbes, defense system modification, and pathogenic competitive exclusion. Probiotics supplementation, beneficial microbes confront hazardous microbes for nutrition; and grow in the intestine, which inhibits detrimental microbes and secrete enzymes (beta-galactosidase and alpha-amylase), which accomplice in the assimilation of a nutritious diet and enhances the productivity of animals (Olnood et al., 2015).

Effects of Probiotics on Gut

The well-being and efficiency of the chickens are directly proportional to the GIT environment and microbes. The intestines of poultry are the main harbor of different beneficial microflora which disintegrate complex compounds into simple molecules that are easily digested (Olnood et al., 2015). Different techniques are utilized for the investigation of the beneficial effects of probiotics on GIT microbial activity, composition, and differences, which consist of culture-dependent techniques, genotyping, and *in-vivo* assays. In addition, *in-vivo* administration is the most fruitful and beneficial method for gaining better results. The most significant procedures for measuring the antagonistic potentials of probiotics include the low GIT pH, modification of the defense system, and secretion of organic acid. In addition, the supplementation of diet with probiotics has been researched to increase the GIT microbes by hindering pathogen multiplication and increasing the number of good microbes (Abdel-Moneim et al., 2021). The destruction of intestines by *Eimeria* not only damages epithelium, but also disrupts GIT microbial colonies, enhancing colonization and multiplication of pathogens *Clostridium perfringens*, increasing the chances of secondary diseases, and increasing mortality (Macdonald et al., 2019). The *Eimeria* invasion results in an imbalance in the gut microbial community known as dysbiosis (Ducatelle et al., 2015).

Antibiotic Resistance

Antibiotics have been used to treat infectious diseases in poultry. Since the discovery of antibiotics, poultry feed has been supplemented with antibiotics to enhance the growth of animals. Antibiotics have been crucial in the development of animal husbandry. Poultry farmers use antibiotics to raise chickens in better conditions and prevent different infections in poultry (Boamah and Agyare, 2016). It has been recognized that numerous zoonotic pathogens including *Salmonella, Clostridium sp.*, *Escherichia coli,* and *Campylobacter*, may be found in animal dung (Jones and Martin, 2003). Antibiotics are used in poultry farming however, they kill susceptible strains of bacteria and abandon or enhance variants with traits that are resistant to them. These resistant bacteria proliferate up to a million times per day, promoting resistance by mutation and plasmid mediation (Gould, 2008). Antibiotic resistance is the main outcome of antibiotics being excessively used in the poultry industry (Tiwari et al., 2014).

Probiotics as an Alternative to Antibiotics

The probiotics are defined as feed supplemented with live beneficial microbes (*Bifidobacterium, lactobacillus, and streptococci*), yeast cultures (*Saccharomyces and Candida*), fungi (*Aspergillus awamori, Aspergillus niger, and Aspergillus oryza*). It is crystal clear that probiotics lessen the risk of coccidiosis by enhancing the immune system, intestinal flora balance, and poultry performance (Ahmad et al., 2022). In another study, it was observed that infusing probiotics comprising *Lactobacillus salivarius*, *Enterococcus faecium,* and *Bacillus animalis* into broiler feed decreased the frequency of infections with *Eimeria tenella*, *Eimeria maxima,* and *Eimeria acervulina*. Lowering the lesion score and oocyst numbers in the duodenum, jejunum, and caeca were seen and also modulate the immune system and reduce the shedding oocysts from *E. acervulina*, and *E. tenella*, probiotics such as *Pediococcus* and *Saccharomyces* were added to the feed (Adhikari et al., 2020). In contrast, the administration of *Bacillus subtilis* (orally) significantly decreases the number of *Eimeria tenella* lesions in the caeca (Wang et al., 2019). The results revealed that while probiotic bacteria contend with *Eimeria* for attachment sites in the Gut, they may occupy similar receptors in the epithelium. This analogy prevents *Eimeria* from proliferation and releasing oocysts. However, severe coccidiosis can diminish the potency of probiotics or prebiotics, so more research needs to be evaluated (Adhikari et al., 2020). The biological efficacy of probiotics is becoming more and more verified through research, although employing these microbes for therapeutic purposes should be done with caution (de Melo Pereira et al., 2018).

Technique for Assessing Probiotic's Antibacterial Efficacy against Microbes

The antibacterial activity of probiotics can be assessed using a wide range of *in-vitro* techniques. However, it is viable to figure out whether probiotic cultures and pathogenic strains are directly antagonistic or whether probiotic extracts' antibacterial activity (Sabina, 2016). The microbial antagonist tests on solid media are most applicable when the main goal of the analysis is to identify microorganisms' antagonistic interaction (Balouiri et al., 2016). This technique entails identifying the indicator strain's growth suppression imposed by the test culture. This section provides a detailed examination of the primary techniques that are currently employed in probiotics' antibacterial activity *in-vitro*. Different other techniques are also reported in different research such as the agar well diffusion assay which describes, to figure out whether cell-free supernatants have antagonistic effects performed the agar well diffusion assay. Multiple nutrients are synthesized using selective or differential media. The indicator microbe is injected into the plates. Afterward, each plate with 6-7 mm wells was made in it. The probiotics microorganisms' supernatant is pipetted into the well following centrifugation and dilution in aliquots at different doses. The antibacterial activity is expressed as an inhibition zone or as arbitrary units (AU/ml) following incubation (Parente et al., 1995).

The probiotics that are utilized nowadays are *Lactobacillus acidophilus*, *lactobacillus casei*, *Lactobacillus plantarum*, *Shirota*, *Lactobacillus paracasei*, *Limosilactobacillus reuteri*, *Limosilactobacillus johnsonii*, *Limosilactobacillus. rhamnosus* (Sikorska and Smoragiewicz, 2013). The probiotic supplementation has been demonstrated to deliver advantages in recent years, with outcomes ranging from direct pathogen exclusion to strengthened host immune system performance (Rossoni et al., 2017). The purpose of probiotics is to enhance the host's health. Numerous probiotic-related studies have reported that most of these studies merely demonstrated how probiotics helped the host's intestinal health. Probiotics work by various techniques, including the generation of compounds that hinder gram-negative and gram-positive bacteria, such as hydrogen peroxide and bacteriocins, blocking of adhesion sites, and many more processes (MORAES et al., 2019). The probiotics modulate the immune response in numerous ways, including improving macrophage-mediated non-specific phagocytic activity (Jain et al., 2008). Numerous probiotics are used to alter the pro-anti-inflammatory cytokines (Plaza-Díaz et al., 2017) and have also been reported in different research (Villena et al., 2012). The benefits are antimutagenic (Yu and Li, 2016), anticarcinogenic, and anti-diarrheal (Devaraj et al., 2019). The probiotics are considered to enhance human health such as immunomodulatory effects or competition between bacteria (Piewngam et al., 2019). The antibiotics that are used in daily life possess adverse effects, are expensive, and face resistance (Vítor and Vale, 2011). The idea of a combination of probiotic microbes with traditional medication has been explored. This synergism has several advantages such as quicker healing, less dose of traditional medicine, lowering the side effects, and boosting the rate at which microbial diseases are eliminated.

Future Perspectives

As the poultry industry expands, the need for sustainable and effective antibiotic alternatives will become increasingly important. Future research should aim to optimize the use of probiotics to maximize their benefits in poultry farming. By understanding the specific roles and interactions of various probiotic strains, tailored formulations can be developed to address specific health issues or enhance aspects of poultry growth and productivity. Investigating the synergistic effects of combining probiotics with other natural feed additives, such as prebiotics, essential oils, and organic acids, could lead to more robust and comprehensive strategies for improving poultry health and performance. Raising consumer awareness about the advantages of probiotics in poultry farming and their role in reducing antibiotic resistance can drive demand for poultry products raised with probiotic supplements, encouraging a shift towards more sustainable farming practices. By focusing on these areas, the poultry industry can fully utilize the potential of probiotics to enhance animal health, boost productivity, and ensure food safety, thereby contributing to a more sustainable and resilient global food system.

Conclusion

The poultry industry is vital to the global economy, supplying a substantial portion of protein through chicken meat and eggs. Despite its importance, the sector faces significant challenges such as stress, health issues, and adverse environmental conditions, all of which can lead to considerable economic losses. Probiotics have emerged as a promising alternative to antibiotics in poultry farming. These beneficial microorganisms enhance gut health and the immune system in chickens, improve nutrient absorption, and outcompete harmful bacteria, leading to better overall growth performance. Probiotics such as *Lactobacillus, Bifidobacterium*, and *Saccharomyces* have demonstrated significant potential in reducing diseases like *Salmonella* and *Eimeria* infections in poultry. Furthermore, they help maintain a balanced gut microflora, which is crucial for the effective breakdown and absorption of nutrients. Probiotics can effectively replace antibiotic growth promoters, thereby mitigating the risks associated with antibiotic resistance. They promote the formation of fatty acids, boost the immune system, and improve gut morphology and function. Nonetheless, the effectiveness of probiotics can be influenced by several factors, including the specific strains used and the conditions under which they are administered.

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