

Probiotics as an Alternative to Antibiotics in Poultry

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ABSTRACT

Traditionally, to promote growth and prevent disease, the poultry industry has relied on antibiotics. The extensive use of these drugs has resulted in the appearance of antibiotic-resistant bacteria, which cause a serious health threat. Consequently, probiotics (live beneficial microorganisms) have become progressively vital as a sustainable and actual alternative. Generally, probiotics support intestinal health, stimulate the immune system, and advance nutrient absorption. In fact, probiotics have many benefits, unlike the risks related to the use of antibiotics. Probiotics play an important role in reducing the disease incidence through endorsing a balanced inhibiting the pathogenic bacteria colonization, and intestinal flora. Previous scientific studies have shown that probiotic strains like *Lactobacillus* and *Bacillus* can considerably enhance the feed efficiency, growth, and overall health of poultry. Overall, probiotics represent a promising approach for attracting poultry production by promoting food safety and sustainable agricultural applications, due to increasing support from the agricultural sector and consumer need for antibiotic-free poultry production.

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1. INTRODUCTION

Probiotics are beneficial microorganisms that promote intestinal health, boost the immune system, and improve overall health of poultry. Given the growing concerns about antibiotic resistance, probiotics are being studied as viable alternatives to antibiotics in poultry production. In general, the poultry industry depends on antibiotics to prevent disease and promote growth [1].

On the other hand, a series of health problems can appear in animal husbandry, such as an increase in antibiotic-resistant bacteria due to the overuse of antibiotics. This has led to the discovery of alternatives for upholding poultry health and productivity. Probiotics (live microorganisms) are considered promising alternatives to antibiotics in poultry production because they offer adequate health benefits to the host [2].

Furthermore, probiotics have several advantages over traditional antibiotics, including their ability to improve nutrient absorption, promote gut health, and enhance immune responses in poultry. It is worth mentioning that by boosting balanced gut flora, probiotics can avoid colonization by pathogenic bacteria [3].

Consequently, the incidence of the disease can be reduced without the negative consequences of antibiotic use. Overall, probiotics meet the increasing consumer need for sustainable agriculture and antibiotic-free poultry products. According to recent studies, various probiotic strains can considerably enhance poultry health and production performance [4].

For instance, *Bacillus* and *Lactobacillus* spp. are known to enhance growth, improve feed utilization, and decrease the prevalence of pathogenic bacteria in the gut. These advantages have led to the consideration of probiotics as an attractive choice for poultry producers who want to keep their animals healthy with less antibiotic use [5].

Moreover, scientific evidence has shown that probiotics are effective and safe for poultry production. In many countries, regulatory agencies have defined certain probiotic strains as safe and have allowed their use in animal feed, which has led to their inclusion in poultry farming. In the poultry industry, this regulation, in addition to the positive consumer perceptions of probiotics, makes them a feasible alternative to antibiotics [6].

This study aimed to evaluate the effectiveness of probiotics as sustainable and safe alternatives to antibiotics in poultry production. Specifically, this study sought to examine how different probiotic strains improve gut health, enhance immune function, promote growth performance, and reduce the incidence of pathogenic infections in poultry, thereby contributing to reduced antibiotic use and mitigating the risk of antimicrobial resistance.

2. MECHANISMS OF PROBIOTIC ACTION IN POULTRY

In the poultry industry, probiotics promote gut health, enhance growth, and boost the immune response. The mechanisms by which probiotics exert their effects can be classified as follows.

1. Competitive Exclusion

In the gastrointestinal tract, probiotics compete with pathogenic microorganisms to bind sites and nutrients. Consequently, probiotics avoid colonization and proliferation of dangerous bacteria by occupying these niches [7].

- Mechanism of Action: Probiotics attach to the intestinal epithelium, effectively blocking the attachment of pathogens, such as *Salmonella* and *Escherichia coli*.

2. Production of Antimicrobial Substances

Several probiotic strains produce antimicrobial compounds that inhibit the growth of pathogenic bacteria. These include:

- Bacteriocins: Protein-containing toxins produced by bacteria that can kill or inhibit the growth of similar or closely related strains.
- Organic acids: Probiotics can produce organic acids (e.g., lactic acid and acetic acid) that lower the pH of the intestine, creating an unfavorable environment for pathogens [8].
- Hydrogen Peroxide: Some probiotics produce hydrogen peroxide, which has antimicrobial properties.

3. Immunomodulation

Probiotics can improve the immune response of poultry through several mechanisms:

- Stimulation of immunoglobulin production: Probiotics can stimulate the production of immunoglobulins (such as IgA), which is essential for mucosal immunity.
- Cytokine production: Probiotics can affect the production of cytokines, which are signaling molecules that mediate and regulate immunity and inflammation [9].
- Activation of immune cells: Probiotics can activate various immune cells, including macrophages and T lymphocytes, thereby enhancing the host's overall immune defence capabilities.

4. Enhanced intestinal barrier function

Overall, probiotics play a vital role in the stability of the intestinal barrier, which is vital for preventing pathogens and toxins from entering the bloodstream. In addition,

probiotics promote the production of tight junction proteins that guard the intestinal mucosa.

- Mucins: Probiotics can induce secretion of mucins, which produce a protective mucus layer in the intestine.
- Tight junction proteins: Probiotics can enhance the expression of tight junction proteins that play vital roles in the integrity of the intestinal barrier [10].

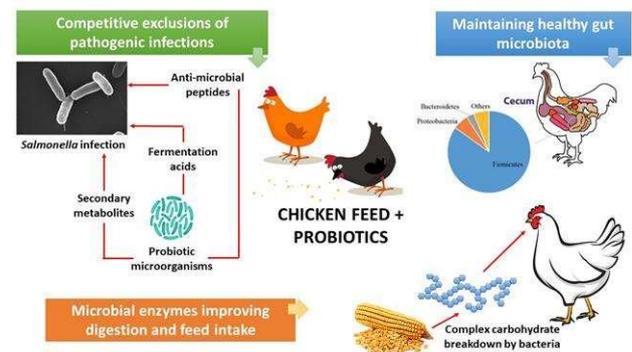


Figure 1. Mechanisms of Probiotics in Poultry Gut Health

Nutrient absorption and metabolism In the poultry industry, probiotics can promote digestion and nutrient absorption by increasing the activity of digestive enzymes and promoting the breakdown of complex carbohydrates, leading to enhanced nutrient utilization.

- Short-chain fatty acids (SCFAs): In general, probiotics can ferment fibers to produce SCFAs, which can function as an energy source for intestinal cells and have anti-inflammatory characteristics.
- Production of vitamins: Certain probiotic strains can produce beneficial vitamins (e.g., B vitamins) for the host [11].

3. PROBIOTIC STRAINS IN ENHANCING POULTRY HEALTH

Studies have shown that the health and performance of poultry can be significantly improved by probiotic strains through a variety of mechanisms. The effectiveness of these strains depends on their ability to improve gut health, increase immune responses, and support overall growth. Specific probiotic strains and their advantages for poultry are described below [12].

1. Lactobacillus

Overview: *Lactobacillus* is one of the most well-known probiotic genera in the poultry industry. Generally, these bacteria are known for their ability to produce lactic acid and ferment carbohydrates, which reduce the pH of the intestine [13].

Benefits:

- Gut Health: *Lactobacillus spp.* It has been found that they support keeping a balanced gut flora through stopping the growth of pathogenic bacteria like *Salmonella*

**Table[1]:** List of Effective Probiotic Strains for Poultry

<i>Lactobacillus acidophilus</i>	Enhances gut health, improves nutrient absorption, and boosts immune response.	<i>Lactobacillus plantarum</i>	Reduces gut pathogens, improves digestion, and supports weight gain.
<i>Lactobacillus casei</i>	Increases resistance to infections and improves gut microbiota balance.	<i>Bifidobacterium bifidum</i>	Supports gut integrity, enhances immune function, and reduces intestinal inflammation.
<i>Enterococcus faecium</i>	Promotes gut microbiota stability and improves feed efficiency.	<i>Bacillus subtilis</i>	Produces enzymes that aid digestion, enhances growth performance, and inhibits harmful bacteria.
<i>Bacillus licheniformis</i>	Boosts immunity, improves feed conversion ratio, and supports gut health.	<i>Saccharomyces cerevisiae</i>	Improves nutrient absorption, enhances growth rate, and supports gut microbial balance.
<i>Pediococcus acidilactici</i>	Increases resistance to heat stress, improves intestinal health, and enhances growth.		

and *E. coli*. This can be accomplished through the competitive elimination and production of antimicrobial substances, such as lactic acid.

- **Growth Performance:** Recent studies have shown that the feed conversion ratio (FCR) and weight gain are enhanced in broilers fed lactobacilli. For instance, a study by Nabizadeh et al. (2019) stated that broilers fed *Lactobacillus acidophilus* had a 12% increase in weight gain compared with a control group [14].

2. Bacillus

Overview: *Bacillus* is a spore-forming bacterium that can withstand harsh environmental conditions and is considered suitable for use in poultry feed.

Advantages:

- **Nutrient absorption:** The absorption and digestibility of nutrients have been observed to improve due to *Bacillus subtilis*, which is important for improved growth performance. Khan et al. (2020) reported that a 15% increase in feed conversion in broilers was achieved by the addition of *Bacillus subtilis*.
- **Control of pathogen:** *Bacillus* spp. A drop in the incidence of gastrointestinal diseases can occur because of the creation of a variety of antimicrobial compounds that can inhibit the growth of pathogens [15].

3. Enterococcus spp.

Overview: *Enterococcus faecium* can be considered another probiotic strain that has been examined for its valuable effects on poultry.

Advantages:

- **Advantages include strengthening the immune system;** recent studies have revealed that *Enterococcus faecium* can stimulate the immune system. This, in turn, leads to an increase in the production of immunoglobulins and improves the resistance to infections. Moreover, García et al. (2021) reported that broilers fed *Enterococcus faecium* had considerably lower rates of respiratory infections.
- **Improved intestinal integrity:** This strain also promotes the production of mucin and tight junction proteins by maintaining intestinal integrity, which is vital for a healthy

intestinal barrier [16].

4. *Saccharomyces cerevisiae*

Overview: *Saccharomyces cerevisiae* is mainly a yeast; however, it can also be combined into probiotic combinations for poultry production.

Benefits:

- **Healthy Eating:** The fermentation of feed in the stomach is observed to increase by *Saccharomyces cerevisiae*, which results in better availability of nutrients and healthier absorption. Khalil et al. (2022) reported that broilers fed this yeast had a 10% increase in average daily weight gain.

- **Reduction of stress:** This probiotic has been associated with a lower stress level in poultry, which can sequentially enhance growth and overall health [17].

Probiotics' benefits in poultry production. Probiotics have received significant attention in the poultry industry because of their plentiful health benefits and ability to improve overall productivity. In fact, the association of probiotics with poultry diets can result in improved intestinal health, increased immune response, enhanced nutrient absorption, and reliance on antibiotics. The following is a brief detailed discussion of these benefits, along with relevant examples.

1. Increased Health of the Gut

In poultry production, one of the main benefits of probiotics is the improvement of gut health. Probiotics enable healthy gut microbiota, which is vital for the efficient absorption and digestion of nutrients. By competing with harmful bacteria for attachment sites and nutrients, probiotics can inhibit the growth of pathogenic microorganisms, such as *Salmonella* and *Escherichia coli* [18].

2. Increased Immune Response

Probiotics have a substantial influence on the immune system of poultry. They stimulate the activity of immune cells, such as macrophages and lymphocytes, and enhance the production of immunoglobulins. Notably, this improved immune response improves poultry's ability to resist infection and decreases the probability of disease, which has been observed to lead to healthier overall health [19].

3. Increased nutrient absorption

As mentioned previously, probiotics can improve nutrient digestion and absorption in poultry. This is achieved by increasing the activity of intestinal digestive enzymes and promoting the fermentation of dietary fiber. These activities result in the production of short-chain fatty acids (SCFAs), which can be used as energy sources for intestinal cells. Increased nutrient availability can lead to increased growth and feed efficiency [20].

4. Reduction of Antibiotic Prescribing

The use of probiotics in poultry production can greatly reduce the need for antibiotics. Probiotics can help prevent diseases that are typically treated with antibiotics, by promoting gut health and improving the immune sys-

tem. This decrease in antibiotic use is primarily related to the increasing concern for antibiotic resistance in both animals and humans [21].

5. Increased Growth Capacity

Several studies have demonstrated that the addition of probiotics to poultry diets can lead to increased growth rates and reduced feed requirements. Probiotics can increase the overall health and well-being of poultry, leading to greater weight gain and more effective feed utilization. This enhancement of growth performance has significant economic benefits for poultry producers [22].

6. Increased Meat Yield

Probiotics have been shown to affect meat quality in the poultry industry. Generally, probiotics can produce healthier birds and superior meat products by promoting gut health and reducing the prevalence of diseases. Some studies have proposed that probiotics can alter the fatty acid composition of poultry meat, which can have a positive effect on its nutritional value [23].

Table[2]: Summary of Probiotic-Induced Improvements in Poultry

Benefit	Description
Improved Growth Performance	Enhances weight gain and feed conversion ratio (FCR).
Disease Prevention	Reduces the risk of necrotic enteritis and other infections.
Enhanced Meat and Egg Quality	Improves meat texture, bone strength, and eggshell quality.
Lower Mortality Rates	Reduces bird losses due to infections and stress.

4. THE ADVANTAGES OF PROBIOTICS OVER ANTIBIOTICS IN POULTRY PRODUCTION.

1. Reduction of Antibiotic Resistance

The development of antibiotic-resistant bacteria is considered one of the major concerns associated with the use of antibiotics in animals. In fact, it has been observed that the misuse and excessive use of antibiotics can result in increased resistance of bacteria, which poses a significant threat to public health. Probiotics are non-antibiotic organisms that contribute to this problem. Overall, producers can reduce the risk of antibiotic resistance in animals using probiotics in poultry production. This is increasingly considered a dangerous issue for both human and animal health [24].

2. Healthy Guts

Probiotics are considered to play an important role in enhancing gut health by promoting healthy gut microbiota. They fight with pathogenic bacteria for attachment sites and nutrients, which stops the development of harmful microorganisms, such as *Salmonella* and *E. coli*. However, antibiotics can interrupt the gut microbiome, resulting in

dysbiosis, which can cause increased susceptibility and negatively affect overall health. Probiotics have a positive effect on the overall health of poultry by upholding healthy gut communities [25].

3. Increased Immune Response

Studies showed that Probiotics can significantly enhance immune function in poultry production by initiating the activity of several immune cells (i.e., macrophages and lymphocytes) and increasing the production of immunoglobulins. On the one hand, the increased immune response improves the poultry's ability to avoid infection and reduces the chances of disease. In contrast, it has been observed that antibiotics have no effect on the immune system and can even negatively influence it by shifting the gut flora, which is vital for a strong immune system [26].

4. Increased nutrient absorption

It is worth mentioning that the processing and absorption of food by poultry can be improved by probiotics. This is because they improve the activity of intestinal digestive enzymes and enable the fermentation of dietary fiber. As a result, this causes the creation of short-chain fatty acids (SCFAs) that are used as an energy source for intestinal cells. This augmented nutrient availability resulted in increased growth and feed efficiency. In contrast, antibiotics can harmfully affect the normal process of digestion and unfavorably affect the absorption of nutrients, resulting in subpar growth [27].

5. Reduction of the Load of Disease-caseinogen

Probiotics can reduce the number of pathogenic bacteria in the gut, resulting in healthier birds and a lower incidence of disease. This is accomplished by competitive exclusion and the formation of substances with antimicrobial properties. Although antibiotics have been observed to be effective in fighting bacteria, they not only fail to specifically mark pathogens but also have a negative effect on the beneficial gut flora. In contrast, it has been observed that probiotics have the ability to inhibit harmful bacteria while promoting beneficial species, and this has been observed to promote gut health while endorsing beneficial species, which has been observed to enhance the health of the gut [28].

6. Sustainability and Consumer Preference

The application of probiotics is in line with sustainable farming approaches owing to the growing popularity of antibiotic-free meat and eggs. This is because probiotics can not only simplify the attainment of these consumer desires, but also maintain animal health and productivity. In many countries, the growing recognition of antibiotic resistance and its significance in human health have resulted in stringent regulations concerning the use of antibiotics. Notably, this has produced a superior reliance on probiotics as a method of poultry production [29].



5. THE INCREASE OF ANTIBIOTIC RESISTANCE IN POULTRY

Due to the extensive use of antibiotics in animal production, the increase in antibiotic resistance in poultry is considered a significant public health concern. Antibiotics are commonly used in poultry production as disease preventers, growth agents, and hosts for infections. However, this usage has led to the selection of antibiotic-resistant bacteria, which are considered an important threat to both humans and animals. Worth mentioning that The World Health Organization has recently recognized antibiotic resistance as one of the top ten global health dangers. This is of great concern because it emphasizes the need for instant action to address this problem [30].

Moreover, recent studies have shown that the factors responsible for the increase in antibiotic resistance in the poultry industry are complex. Among them, the misuse and overuse of antibiotics have been observed to significantly affect the creation of a selective pressure on the population of bacteria, thus allowing resistant strains to flourish and survive. Typically, antibiotics are used at sub-therapeutic concentrations in the poultry industry, which can lead to the development of resistance without eliminating the pathogen. Moreover, the confined space in which poultry are located facilitates the fast transmission of resistant bacteria between flocks. This can exacerbate this issue [31].

In poultry production, it has been observed that the adverse effects of antibiotic resistance are far more extensive than simply on the farm. In general, antibiotic-resistant bacteria can be transferred to humans via the food chain, direct contact with animals, or environmental means. It is worth mentioning that this transmission causes human infections that are difficult to cure owing to the lack of effective antibiotics. Moreover, studies have confirmed that specific strains of antibiotic-resistant Salmonella and Campylobacter, which are usually found in poultry, are associated with human illnesses. Overall, this highlights the public health concerns due to the use of antibiotics in livestock [32].

To control the use of antibiotics in the poultry industry, initiatives have been designed and aimed at decreasing the quantity of antibiotics used. Worth mentioning that Many countries have applied stricter rules regarding the use of antibiotics in animals, especially those that are vital to human health. For example, since 2006, the European Union has prohibited the use of antibiotics to stimulate growth in livestock. These rules have been proposed to prevent and control disease by applying alternative approaches [33]. This includes enhanced biosecurity, vaccine administration, and use of probiotics.

Table[3]: Comparative Analysis: Probiotics vs. Antibiotics

Feature	Probiotics	Antibiotics
Mode of Action	Enhances beneficial gut microbiota	Kills both harmful and beneficial bacteria
Resistance Risk	No risk of antibiotic resistance	Contributes to antibiotic resistance
Consumer Preference	Natural and sustainable	Increasingly restricted
Regulation	Approved as feed additives	Subject to strict regulations

6. CONCLUSION

In conclusion, the use of probiotics in poultry production has several advantages. This includes augmented health of the gut, better nutrient absorption, improved immunity, reduced reliance on antibiotics, improved growth, and improved meat quality. Owing to the excessive use of antibiotics in animal agriculture, the proliferation of antibiotic resistance in poultry is considered a complex problem. The effects of this resistance have spread beyond the poultry industry and are considered a critical threat to public health. Addressing this problem will require a multifaceted approach, such as regulatory acts, enhanced farming approaches, and improved awareness of the value of responsible antibiotic usage in both animal and human medicine.

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