



The Role of Probiotics as Alternatives to Antibiotic Growth Promoters in Enhancing Poultry Performance

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Abstract | Research has been conducted on the utilization of probiotics as an alternative to antibiotic growth promoters (AGPs), particularly following the ban on AGP use in the world as well as by Indonesian authorities due to concerns about antibiotic resistance. This review article aims to assess the application of probiotics in the poultry industry. The use of probiotics in poultry has been shown to enhance production efficiency. Incorporating probiotics in chickens can improve feed nutrient assimilation, ration intake, meat protein content, and weight gain while reducing the feed conversion ratio. Probiotics commonly include bacteria and fungi. Notable microorganisms in this category are Lactic Acid Bacteria (LAB) such as *Lactobacillus* spp. and *Bifidobacterium* spp., as well as fungi like *Saccharomyces* spp., *Rhizopus* spp., and *Mucor* spp. These microbes specifically target the gastrointestinal tract. The metabolic mechanisms of probiotics differ from those of antibiotics. While antibiotics destroy both pathogenic and non-pathogenic bacteria in the digestive tract and can leave residues in tissues, probiotics enhance digestive health. They adhere to and form colonies on the intestinal epithelium, thereby minimizing the attachment and replication of pathogenic bacteria. In conclusion, probiotic microorganisms produce enzymes such as lipase, amylase, and protease, which facilitate digestion and improve metabolic processes and nutrient absorption. Additionally, probiotics secrete bacteriocins that can eliminate pathogenic bacteria, promoting a balanced microflora in the intestinal tract. This balance is crucial for strengthening poultry immunity, enhancing efficient nutrient absorption, and improving overall production efficacy.

Keywords | Probiotics, AGP, Bacteriocins, Production, Poultry

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INTRODUCTION

Human life relies on animal food, particularly meat, which serves as a balanced source of protein due to its amino acid composition that closely matches human needs. Animal protein is essential for human health, and the amino acids found in meat are more easily digestible, allowing for better utilization in the body's cells (Lofgren, 2013). With the rapid growth of the global population, the demand for animal protein continues to rise (Ban and

Guan, 2021). Chicken, being readily available, fast-growing, and more affordable than beef, is among the most widely consumed livestock products (Kralik et al., 2018). To meet the increasing demand for animal protein, broilers are the preferred choice due to their efficient feed conversion and optimal growth rates. This efficiency drives the poultry industry to focus on broiler production (Almajiri et al., 2023).

In Indonesia, antibiotics have been used in animal feed

since 1946 to enhance digestibility, growth, and overall livestock health. However, the use of antibiotics as growth promoters has raised concerns about antibiotic resistance (Untari et al., 2021). In response, the Indonesian government enacted Law No. 18/2009 and Law No. 41 of 2014, prohibiting antibiotic growth promoters (AGPs) in animal husbandry. These regulations also restrict the use of hormone-mixed feeds and certain additives. Furthermore, ministry of agriculture (MOA) regulation No. 14/permentan/PK.035/5/2017 classifies antibiotics as veterinary drugs (Untari et al., 2021). The issuance of MOA No. 22/2017 further strengthens the ban on AGPs, requiring manufacturers to certify that their feed formulas do not include antibiotic growth promoters. The overuse of AGPs has led to the emergence of antibiotic-resistant pathogens, posing significant public health risks (Duan et al., 2023).

The growing awareness of antibiotic resistance, coupled with bans on antibiotic use and an increasing demand for organic poultry meat, has prompted consumers to seek antibiotic-free meat, often willing to pay a premium for it. Consequently, research has been directed toward finding alternatives to AGPs (Gadde et al., 2017). Key objectives in this research include identifying ideal microflora for poultry health and performance and developing feeds that promote beneficial microflora growth (Park et al., 2013). One promising alternative is the use of probiotic bacteria as feed additives (Japutra et al., 2021).

Lactic acid bacteria (LAB), a type of probiotic, inhibit pathogenic bacteria by fermenting sugars and producing lactic acid as the primary end product (Manafi, 2015). Probiotics are microorganisms that, when consumed in adequate amounts, confer health benefits (Ayivi et al., 2020). As feed additives, probiotics enhance livestock health by modifying the gut microbiota, promoting the growth of beneficial bacteria (Makala, 2021). They present a viable alternative to AGPs in the poultry industry, enhancing performance and gut health without contributing to antibiotic resistance.

Probiotics can detoxify harmful substances, potentially improving the digestibility of organic and dry matter. They also produce enzymes that enhance nutrient absorption in the digestive tract of chickens (Chang et al., 2022). The inclusion of probiotics in feed can increase amino acid availability, as the nutritional value of the diet and a well-functioning digestive system are closely linked to the quantity of meat protein produced (Asif et al., 2023).

Evidence suggests that probiotics can enhance broiler performance. Studies indicate that adding probiotics to feed can reduce pathogenic bacteria in the small intestine and improve digestive efficiency by promoting villi in the in-

testinal mucosa (Makala, 2021). The addition of probiotics has been shown to increase β -glucanase enzyme production throughout the chicken's small intestine, aiding in substrate breakdown and enhancing nutrient absorption. Probiotics also reduce digesta viscosity (Chang et al., 2022). Incorporating bacterial cultures into broiler feed can improve nutrient utilization and accelerate the production of digestive enzymes (Latif et al., 2023). For example, using 2.5 grams/kg of probiotics in broiler rations has been found to improve performance and feed efficiency, resulting in increased body weight and reduced feed conversion ratios (Makala, 2021). Additionally, probiotics in feeds containing 10% crude fiber can enhance feed intake, body weight gain, and reduce feed conversion ratios (Bhogoju and Nahashon, 2022).

The aim of this article review is to explore the use of probiotics as a substitute for antibiotic growth promoters in poultry production.

METHOD AND SCOPE OF STUDY

This review article employs a literature study method, sourcing information from scientific articles published in journals between 2014 and 2024, covering the last decade. The analysis involves a comprehensive literature review focusing on the role of probiotics in animal husbandry, the relevant microorganisms, the mechanisms of action of probiotics, and the distinctions between probiotics and antibiotics as AGPs. Specifically, this study concentrates on the use of probiotics as alternatives to AGPs in poultry feed.

PROBIOTICS IN ANIMAL HUSBANDRY

Probiotics offer an innovative alternative to antibiotics. These live microorganisms provide beneficial effects on consumer health (Zhao et al., 2023). Effective probiotics possess several key characteristics, including the ability to be produced at an industrial scale, stability and a long shelf life, adaptability to field conditions, and the capacity to survive and colonize the gut, all of which benefit broiler farmers (Ha et al., 2016). Probiotic bacteria predominantly belong to the LAB group, such as *Lactobacillus* and *Bifidobacterium*. These bacteria play a crucial role in maintaining the digestive ecosystem and enhancing the host's immune system (Sirisopapong et al., 2023).

Probiotics help restore the balance of microflora in the digestive tract. They colonize the mucosal surface, creating an environment that inhibits pathogenic bacteria from adhering, which promotes effective feed digestion and enhances the conversion of feed into meat (Bhogoju & Nahashon, 2022). In ruminants, probiotics improve nutrient absorption, enhance livestock health, reduce lambing intervals, and accelerate growth. For calves, probiotics lead to decreased mortality rates and provide protection against cer-

tain pathogenic diseases, ultimately increasing meat production (Izuddin et al., 2020; Al-Shawi et al., 2020).

In poultry, probiotics contribute to overall health by stimulating specific intestinal cells (Arquette et al., 2018). Probiotics such as *Lactobacillus casei*, *Lactobacillus acidophilus*, and *Lactobacillus plantarum* colonize the small intestine, restoring microbial balance by suppressing pathogenic bacteria (Sirisopapong et al., 2023). They function by colonizing and competing for nutrients, vying for attachment to the intestinal wall, and inhibiting the growth of harmful microbes (Echegaray et al., 2023).

MICROORGANISMS IN PROBIOTICS

Probiotics are beneficial microorganisms that, when administered in appropriate amounts, support the health of the recipient (Shao et al., 2023). Lactic acid bacteria are the primary source of probiotics used in animal feeds, offering numerous health benefits for the host, including modulation of gut microbiota, immunomodulation, anti-inflammatory effects, and antimicrobial properties (Sirisopapong et al., 2023). Common types of bacteria used to produce probiotics include *Lactobacillus*, *Bacillus subtilis*, and *Bacillus* species, which can be incorporated into drinking water (Bhagoju & Nahashon, 2022).

Phuoc (2017) reported that *Bacillus* species, including *Bacillus subtilis* and other *Bacillus* strains, are widely utilized to develop probiotics for chickens. These strains, such as *Bacillus subtilis* BR2CL and *Bacillus* sp. BT3CL, can serve as alternatives to AGPs and are effective in feed silage production. Their use can enhance poultry productivity and feed quality, with ongoing research aimed at optimizing their efficacy (Sirisopapong et al., 2023). Additionally, characterizing the normal microflora present in the digestive tracts of native chickens and selecting suitable bacteria for probiotic development has been a focus of study. In vivo and in vitro results indicate that probiotic microbes can reduce populations of *Escherichia coli* and *Salmonella* species (Park et al., 2013).

Research on fungi as probiotics has also gained traction. Local probiotic products containing complete microbial cultures, such as *Saccharomyces*, *Rhizopus*, and *Mucor* species, can be used as dietary supplements. *Saccharomyces* species, rich in vitamins, enzymes, and essential nutrients like carbohydrates and proteins, serve as effective probiotics. Additionally, mannan-oligosaccharides (MOS) found in the cell walls of *Saccharomyces* can bind mycotoxins (Munoz et al., 2010). *Rhizopus* species, classified as heterofermentative, utilize the phosphoketolase pathway for glucose metabolism, while *Mucor* species produce amylolytic enzymes that aid in the digestion of feed starch (Karimi & Zamani, 2013).

Bacillus species enhance digestibility by secreting enzymes such as protease, lipase, and amylase (Quintero-Garcia et al., 2023). Probiotics also help reduce ammonia levels in livestock, as they can decrease urease activity, an enzyme that converts urea into ammonia, thereby minimizing ammonia formation—a substance that can be toxic to poultry (Makala, 2021).

Singh et al. (2014) investigated the effects of combining the yeast *Saccharomyces cerevisiae* with vitamins E and C, finding that this combination boosted the immune system of poultry. The use of probiotics has also been shown to improve egg quality and production (Li et al., 1997; Kazue et al., 2012; Park et al., 2013). Feeding *Bacillus* species improved intestinal anatomy and egg quality. Specifically, incorporating *Bacillus* species up to 3% in layer diets positively influenced consumption and conversion rates, yielding favorable economic benefits by reducing feed conversion costs (Asif et al., 2023).

MECHANISM OF ACTION OF PROBIOTICS

Probiotics work in several ways. They compete for food substances, find places to attach to the gut wall, and block microbes that are directly defeated. Gut microbial balance is achieved when the good microbes suppress the bad ones (Fuller, 2002).

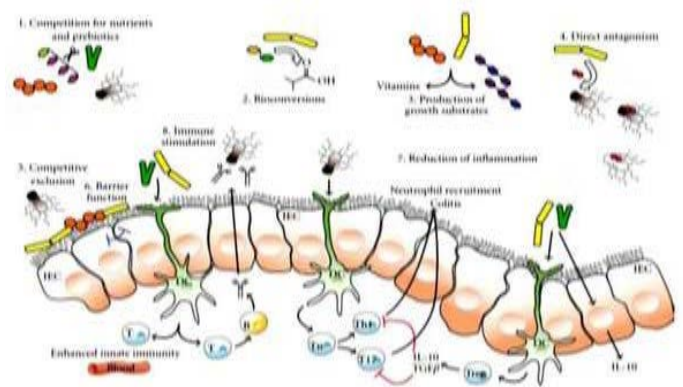


Figure 1: Mechanism of action of probiotics. (Source: Fuller 1992)

Probiotics perform five key functions in the gastrointestinal tract which were shown in Figure 1 (Fuller, 1992): 1) competing for food substances, 2) bioconverting hydrolyzed sugars into fermentation products with inhibitory properties, 3) producing growth substrates such as vitamins or exopolysaccharides (EPS) for the growth of other bacteria, 4) attacking antagonistic or unfavorable bacteria through their bacteriocin properties, and 5) facilitating competitive exclusion by binding to bacteria. Klaim (2006) found that probiotics also enhance the immune system by stimulating specific gut cells.

In the poultry industry, probiotics have garnered signifi-

cant attention as a potential alternative to the prophylactic use of antibiotics. They function by attaching to or colonizing the digestive tract. For successful attachment and colonization, probiotics must differentiate themselves from the adapted and resident bacteria in the host's intestinal tract. This distinction is crucial for probiotics to survive in the digestive tract and attach to intestinal cells. Once colonization occurs, probiotics can positively influence the host animal's immune system, leading to improved nutrient absorption and enhanced immunity. By attaching to intestinal cells, probiotics help prevent pathogenic bacteria from adhering to the villi of the small intestine (Bhogaju & Nahashon, 2022). This reduces the available sites for harmful microbes such as *Escherichia coli* and *Salmonella typhimurium* to attach.

Several probiotics can bind to human intestinal cells, including *Lactobacillus casei*, *Lactobacillus acidophilus*, *Lactobacillus plantarum*, and various bifidobacteria (Roobab et al., 2020). Probiotics combat foodborne pathogens and produce antimicrobial substances, competing with pathogenic bacteria for substrates and disrupting their growth. This competition is essential for the proper development of microbial colonies during colonization. Prebiotics, which are coarse fiber foodstuffs, serve as substrates for probiotics. Many probiotics produce enzymes that aid in substrate digestion; for example, *Lactobacillus* species produce lactic acid and cellulase enzymes (Bedu-Ferrari et al., 2022). These enzymes help break down crude fiber, which is often difficult for the poultry digestive tract to digest. Since current animal feed ingredients frequently derive from industrial or agricultural waste, which typically contains high crude fiber content, probiotics that produce cellulase can significantly improve feed quality (Chuang et al., 2021).

The enzymatic breakdown of crude fiber promotes tissue growth and weight gain. Probiotics also release antimicrobial compounds called bacteriocins, such as Lactacin B and Acidolin, which inhibit the growth of pathogenic organisms (Sirisopapong et al., 2023). Additionally, probiotics stimulate the production of antimicrobial substances like defensins in the intestinal epithelium, modulating the host's immune response (Gupta & Garg, 2015).

Probiotics enhance the animal's immune system and improve mucosal health by regulating various aspects of the host's immune system. They reduce toxin secretion and inhibit the growth of pathogenic microbes in the digestive tract, thereby strengthening the host's immunity and decreasing the presence of harmful microorganisms. This results in increased disease resistance and overall improved animal health (Navarro et al., 2018). Furthermore, probiotics can decrease urease production, an enzyme that hydrolyzes urea into ammonia. Reducing ammonia formation is beneficial since high ammonia levels can lead to respiratory

toxicity in poultry (Khan, 2013).

EFFECT OF PROBIOTICS ON POULTRY PERFORMANCE

The use of probiotics has been shown to enhance poultry performance in several studies (Li et al., 1997). Probiotics improve feed intake and digestion in poultry, and research indicates they can modulate bacterial metabolism, leading to increased growth and productivity (Li et al., 1997). One study found that adding citric acid at levels up to 1.0% improved feed efficiency. Specifically, with a ration protein level of 18%, acidified chickens consumed less feed than the control group while maintaining similar live weights (Khan, 2013).

In poultry farming, the application of probiotics has a significant positive impact on animal performance and health. By promoting a balanced gut microflora, probiotics enhance digestion and nutrient absorption, contributing to better growth rates and improved feed conversion efficiency. Additionally, probiotics strengthen the immune system, reduce the risk of pathogenic bacterial infections, and help birds cope with environmental and management stressors. Therefore, the use of probiotics not only boosts poultry production but also lowers medical costs and enhances overall welfare in the livestock industry (Khan & Naz, 2013).

DIFFERENCES IN FUNCTION OF ANTIBIOTICS AND PROBIOTICS AS AGP

Probiotics primarily function by reducing the number of pathogenic bacteria in the digestive tract. These beneficial bacteria colonize the villi of the small intestinal mucosa, diminishing pathogenic bacteria and facilitating the hydrolysis and absorption of feed substances. This enhanced absorption accelerates the conversion of nutrients into meat, ensuring an efficient feed-to-meat transformation process and optimizing livestock growth (Ma et al., 2023). Probiotics have been shown to improve feed conversion rates, promote growth, and reduce mortality in livestock.

In contrast, the use of AGPs has been linked to several negative effects on livestock health and production outcomes. Concerns include the presence of antibiotic residues in tissues, the development of resistance among pathogenic bacteria, and the potential for antibiotic resistance in consumers, which can contribute to degenerative diseases. As a result, many countries have enacted bans on the use of antibiotics in livestock due to these adverse impacts (Manyi-Loh et al., 2018).

Probiotics support the poultry digestive tract in several ways, including the elimination of toxins produced by pathogenic bacteria, the inhibition of pathogenic bacterial growth, the modulation of enzyme activity in the small in-

testine, and the enhancement of livestock growth and performance (Khan, 2013). When added to feed, probiotics colonize the intestines and foster a beneficial microbial environment, leading to increased feed intake, improved feed efficiency, enhanced growth, and reduced mortality rates in poultry (Khan, 2013). Thus, probiotics play a crucial role in achieving a healthy chicken digestive tract and are essential for optimizing poultry production. They can serve as effective substitutes for antibiotics in poultry rations (Kabir, 2009).

Traditionally, poultry have been administered antibiotics in the form of AGPs to enhance growth. While antibiotics kill pathogenic microorganisms in the gut, they also create an environment where beneficial microorganisms can flourish. However, the long-term use of antibiotics for livestock growth can lead to bacterial resistance and antibiotic residues in animal products (Manafi, 2015). This poses a serious concern for human health, as antibiotic-resistant bacteria can cause infections that are difficult or impossible to treat (Salim et al., 2018).

Replacing antibiotics with probiotics in chicken feed helps boost productivity while minimizing health risks. Probiotics combat pathogenic bacteria in the gut, allowing non-pathogenic and beneficial bacteria to thrive. These beneficial bacteria can alter the intestinal environment, particularly by lowering the pH to create a more acidic atmosphere. They enhance gastrointestinal immunity by producing bacteriocins and short-chain organic acids such as lactate, acetate, and propionate (Harzallah & Belhadj, 2013). Bacteriocins inhibit the proliferation of pathogenic microbes, allowing non-pathogenic microbes to establish themselves on the intestinal epithelium. Probiotics derived from beneficial endogenous microbes can firmly attach to the intestinal mucosa, effectively blocking pathogenic microbes and enhancing the chicken's immune system while improving nutrient absorption (Yaqoob et al., 2022).

EFFECTS OF VARIOUS PROBIOTIC STRAINS ON POULTRY HEALTH AND PRODUCTION

Table 1 highlights specific probiotic strains, their mechanisms of action, and the benefits they confer to poultry performance. It is well illuminated from the studies included in this table that probiotic supplementation has been increasingly recognized for its beneficial effects on poultry performance, primarily by enhancing gut health and promoting efficient nutrient absorption. Among the commonly used probiotics, *Lactobacillus acidophilus* has been widely studied for its ability to compete with pathogenic bacteria in the gut and produce antimicrobial substances such as bacteriocins. These actions help improve body weight gain and enhance feed efficiency while reducing mortality rates in poultry. Roobab et al. (2020) demonstrated that birds

supplemented with *Lactobacillus acidophilus* exhibited improved growth performance, likely due to reduced pathogen loads and an enhanced gut environment.

Similarly, *Lactobacillus plantarum* plays a significant role in producing lactic acid, which aids in nutrient absorption and promotes better gut health. Bhogoj and Nahashon (2022) observed that poultry fed with *Lactobacillus plantarum* experienced better weight gain, improved gut morphology, and a reduced incidence of intestinal diseases. This strain's ability to produce lactic acid lowers gut pH, creating an unfavorable environment for pathogens and fostering a more efficient digestive process.

In addition to *Lactobacillus* species, *Bifidobacterium bifidum* effectively colonizes the gut, competing for nutrients with pathogenic bacteria. This competitive exclusion enhances the immune system of poultry, reducing gastrointestinal infections and improving overall health. Roobab et al. (2020) highlighted that supplementation with *Bifidobacterium bifidum* resulted in a stronger immune response, leading to better disease resistance.

Fungal probiotics like *Saccharomyces cerevisiae* have also shown positive impacts on poultry performance. Bedu-Ferrari et al. (2022) and Navarro et al. (2018) reported that the inclusion of *Saccharomyces cerevisiae* in poultry diets resulted in increased growth rates, enhanced gut morphology, and improved feed conversion ratios. The immune-modulating properties of this yeast contribute to a healthier gut environment, supporting better nutrient absorption and overall performance.

Another commonly used probiotic strain, *Lactobacillus casei*, has been associated with improved nutrient absorption and the inhibition of pathogenic bacterial growth. This strain produces short-chain fatty acids (SCFAs) like acetate and lactate, which nourish the gut epithelium and create a protective barrier against pathogens. Sirisopapong et al. (2023) found that poultry supplemented with *Lactobacillus casei* had enhanced growth performance and reduced pathogenic bacterial loads in the gut.

Furthermore, *Bifidobacterium longum* is known for its ability to inhibit harmful bacteria and reduce gut inflammation. Khan (2013) observed that supplementation with *Bifidobacterium longum* led to improved weight gain and reduced ammonia production, which is beneficial for poultry housed in confined environments. This strain's ability to decrease ammonia production by inhibiting urease activity helps maintain a healthier respiratory environment for poultry.

Lastly, fungal probiotics such as *Rhizopus* and *Mucor* spe

Table 1: Summary of Probiotic Strains and Their Effects on Poultry health and Production

Probiotic Strain	Mechanism of Action	Effects on Poultry Performance	Reference
<i>Lactobacillus acidophilus</i>	Competes with pathogens, produces bacteriocins	Improved growth, enhanced feed efficiency, reduced mortality	Roobab <i>et al.</i> (2020)
<i>Lactobacillus plantarum</i>	Produces lactic acid, enhances nutrient absorption	Better weight gain, improved gut health	Bhogoju & Nahashon (2022)
<i>Bifidobacterium bifidum</i>	Competes for nutrients, colonizes gut	Boosted immune system, reduced incidence of gastrointestinal infections	Roobab <i>et al.</i> (2020)
<i>Saccharomyces cerevisiae</i>	Stimulates immune system, modulates gut flora	Increased growth rates, enhanced gut morphology, improved FCR	Bedu-Ferrari <i>et al.</i> (2022); Navarro <i>et al.</i> (2018)
<i>Lactobacillus casei</i>	Produces short-chain fatty acids, competes with pathogens	Enhanced nutrient absorption, reduced pathogenic bacteria growth	Sirisopapong <i>et al.</i> (2023)
<i>Bifidobacterium longum</i>	Inhibits harmful bacteria, reduces gut inflammation	Improved weight gain, reduced ammonia production, better feed efficiency	Khan (2013)
<i>Rhizopus sp.</i>	Enhances enzymatic breakdown of fibers	Improved digestion, enhanced growth	Chuang <i>et al.</i> (2021)
<i>Mucor sp.</i>	Produces enzymes like cellulase, improves crude fiber breakdown	Increased body weight gain, reduced mortality	Khan & Naz (2013)

cies play a pivotal role in fiber degradation, particularly in poultry diets with high crude fiber content. Chuang *et al.* (2021) reported that these fungal probiotics enhance the enzymatic breakdown of fibers, leading to better digestion and nutrient absorption. *Mucor* species also produce cellulase enzymes that break down crude fiber, contributing to improved body weight gain and reduced mortality in poultry (Khan & Naz, 2013).

These findings collectively suggest that probiotics, through various mechanisms of action, significantly improve poultry performance by enhancing gut health, promoting nutrient absorption, and boosting the immune system. Consequently, probiotics represent a promising alternative to antibiotics in poultry production, offering both performance and health benefits without the risks of antibiotic resistance or residues in animal products.

COMPARISON OF ANTIBIOTICS AND PROBIOTICS AS GROWTH PROMOTERS IN POULTRY

The Table 2 clearly differentiates the impacts of antibiotics and probiotics used as growth promoters in poultry, covering key performance indicators like growth, feed intake, immune response, and safety.

The use of growth promoters in poultry production is essential for optimizing performance, with antibiotics traditionally playing a dominant role. However, concerns about antibiotic resistance and potential negative impacts of antibiotic residues on human health have spurred interest in probiotics as safer, sustainable alternatives. Both approaches offer unique advantages and challenges, reflected in var-

ious performance metrics such as growth, feed conversion, immune modulation, and sustainability.

Antibiotics have been widely used to enhance poultry growth by eliminating pathogenic bacteria in the digestive tract, allowing beneficial microbes to thrive. This reduction in harmful bacteria promotes better nutrient absorption, leading to improved weight gain and feed efficiency. However, research by Wu *et al.* (2022) indicates that while antibiotics boost short-term growth, they may contribute to long-term health issues in poultry, including gut dysbiosis and increased mortality rates due to antibiotic-resistant bacteria.

In contrast, probiotics offer similar growth performance benefits while providing additional long-term health advantages without the risks associated with antibiotic use. Probiotics, such as *Lactobacillus* and *Bifidobacterium* strains, enhance nutrient absorption and improve feed conversion ratios by colonizing the gut and outcompeting pathogenic microbes. Silva *et al.* (2011) demonstrated that poultry supplemented with probiotics had lower feed intake but achieved comparable or better growth rates than those fed with antibiotics, suggesting that probiotics optimize feed utilization, contributing to better efficiency even with reduced consumption.

A significant advantage of probiotics is their role in immune modulation. While antibiotics have limited effects on immune responses, probiotics enhance immune function and increase resistance to infections. Navarro *et al.* (2018) reported that probiotics boost the host's immune

Table 2: Comparison of Antibiotics and Probiotics as Growth Promoters in Poultry

Parameter	Antibiotics (AGPs)	Probiotics	Reference
Growth Performance	Improved: Significant improvement in weight gain and feed efficiency.	Comparable to antibiotics in achieving growth; shows long-term health benefits.	Wu et al. (2022); Khan (2013)
Feed Intake	Higher: Typically linked with increased feed conversion ratio (FCR).	Lower feed intake was observed, particularly in new litter conditions.	Silva et al. (2011)
Feed Conversion	No significant effect: effect in some studies, possibly species-dependent.	Mixed results, some studies reported improved FCR with probiotics due to better nutrient absorption and gut health.	Wu et al. (2022); Silva et al. (2011)
Immune and Antioxidant Capacities	Average effect: Limited direct effects on immune modulation.	Enhanced immune response, antioxidant capacity, and overall resilience to infections.	Wu et al. (2022); Navarro <i>et al.</i> (2018)
Intestinal Health	Average effect: Intestinal morphology with possible dysbiosis risk.	Improved intestinal morphology and diversity. Enhanced immune response, antioxidant capacity, and overall resilience to infections.	Bhogoju & Nahashon (2022)
Antibiotic Resistance	Risk of developing antibiotic-resistant bacteria over time.	No risk of resistance; promotes beneficial bacteria growth and balance in the gut microbiome.	Wu et al. (2022); Manyi-Loh <i>et al.</i> (2018)
Sustainability and Safety	Concerns over residual antibiotics in meat, potential health risks to humans.	Generally regarded as safe; no residue concerns in animal products	Wu et al. (2022); Khan & Naz (2013)

system by promoting the production of antimicrobial substances like bacteriocins and short-chain organic acids, helping to reduce pathogenic bacterial loads in the gut and improve overall resilience to diseases.

Another crucial consideration is the effect on intestinal health. Antibiotics can disrupt gut microbiota, leading to dysbiosis, which negatively impacts intestinal morphology and function. Conversely, probiotics improve gut health by maintaining microbial balance and enhancing the structure of the intestinal lining. [Bhogoju and Nahashon \(2022\)](#) found that probiotic supplementation improved gut morphology and nutrient absorption, resulting in better growth and feed efficiency.

The issue of antibiotic resistance underscores the need for probiotics as a safer alternative. Continuous antibiotic use in poultry can lead to the development of resistant bacterial strains, posing health risks to both animals and humans. [Manyi-Loh et al. \(2018\)](#) highlighted that antibiotic-resistant bacteria could be transferred to humans through poultry products, raising significant public health concerns. In contrast, probiotics do not contribute to antibiotic resistance and promote the growth of beneficial bacteria in the gut, making them a more sustainable option for poultry production.

Lastly, probiotics offer clear advantages in sustainability and food safety. The widespread use of antibiotics raises concerns about residual antibiotics in meat, which can af-

fect human health. [Wu et al. \(2022\)](#) emphasized that probiotics are generally regarded as safe and leave no residues in animal products, making them a better option for ensuring the safety and quality of poultry products for human consumption.

In summary, while antibiotics have historically been effective in promoting poultry growth, their associated risks, such as antibiotic resistance and potential health hazards, have led to a shift toward probiotics. Probiotics not only improve growth performance and feed efficiency but also enhance immune function and intestinal health, offering a more sustainable and safer alternative in poultry production.

PERFORMANCE METRICS OF POULTRY WITH PROBIOTIC SUPPLEMENTATION

[Table 3](#) summarizes the effects of probiotics on key performance metrics such as body weight gain, feed conversion ratio (FCR), mortality rate, and carcass percentage, compared to control groups that did not receive probiotic supplementation.

Probiotic supplementation in poultry has shown significant improvements across various performance metrics, including body weight gain, feed conversion ratio, mortality rates, carcass percentage, feed intake, immune response, and ammonia production. These enhancements are attributed to the multiple mechanisms by which probiotics optimize gut health, improve nutrient absorption, and mod

Table 3: Performance Metrics of Poultry with Probiotic Supplementation

Variables	Probiotic Effect	Control Group	Study/Reference
Body Weight Gain (BWG)	Significant improvement in body weight gain	Lower body weight gain	Khan (2013); Bhogoju & Nahashon (2022)
Feed Conversion Ratio (FCR)	Reduced FCR due to better nutrient absorption	Higher FCR	Silva et al. (2011); Wu et al. (2022)
Mortality Rate	Lower mortality rate, improved disease resistance	Higher mortality rate	Khan & Naz (2013); Navarro et al. (2018)
Carcass Percentage	Increased carcass percentage, indicating better meat yield	Lower carcass percentage	Bedu-Ferrari et al. (2022)
Feed Intake	Lower feed intake with optimized nutrient utilization	Higher feed intake	Silva et al. (2011); Chuang et al. (2021)
Immune Response	Enhanced immune system, better resistance to pathogens	Weaker immune response	Roobab et al. (2020); Sirisopapong et al. (2023)
Ammonia Production	Reduced ammonia production due to inhibition of urease activity	Higher ammonia production	Khan (2013)

ulate the immune system. One of the most notable effects of probiotics in poultry is the significant improvement in body weight gain. Strains such as *Lactobacillus* and *Bifidobacterium* enhance nutrient absorption by maintaining a healthier gut environment. Khan (2013) and Bhogoju & Nahashon (2022) reported that birds receiving probiotic supplementation consistently exhibited higher body weight gain compared to control groups. This improvement is likely due to probiotics' ability to compete with pathogens, improve gut morphology, and stimulate the production of digestive enzymes, all contributing to more efficient nutrient utilization.

The FCR is another critical performance metric significantly improved by probiotic supplementation. Probiotics optimize digestion and nutrient absorption, leading to a reduction in the amount of feed required for weight gain. Studies by Silva et al. (2011) and Wu et al. (2022) have demonstrated that birds supplemented with probiotics had lower FCR compared to control groups. This improvement translates to better economic efficiency in poultry production, as less feed is needed to achieve the desired weight.

Probiotics also positively impact mortality rates. By enhancing immune function and gastrointestinal health, probiotics reduce the incidence of disease, thereby lowering mortality rates in poultry flocks. Research by Khan & Naz (2013) and Navarro et al. (2018) highlighted that probiotic supplementation significantly reduced mortality rates, leading to healthier and more resilient poultry.

Additionally, probiotics have been shown to increase carcass percentage, a key indicator of meat yield in poultry. Enhanced nutrient absorption and improved gut health contribute to more efficient growth and muscle development, resulting in a higher carcass percentage. Bedu et al. (2022) found that birds receiving probiotics exhibited

higher carcass percentages compared to control groups, underscoring the beneficial effects of probiotics on meat production.

Interestingly, feed intake tends to be lower in probiotic-supplemented birds, yet their performance is often comparable to or superior to that of birds with higher feed intake. This is primarily because probiotics enhance nutrient absorption and utilization efficiency, enabling birds to gain weight and grow effectively despite consuming less feed. Silva et al. (2011) and Chuang et al. (2021) observed that birds on probiotic-supplemented diets consumed less feed but exhibited improved performance metrics, highlighting the efficiency gains associated with probiotics.

Probiotics also significantly enhance the immune response in poultry. By stimulating the production of antimicrobial substances, such as bacteriocins and short-chain fatty acids, probiotics help reduce pathogenic loads in the gut and bolster the birds' immune systems. Research by Roobab et al. (2020) and Sirisopapong et al. (2023) documented that birds supplemented with probiotics exhibited stronger immune responses and were better equipped to resist infections compared to control groups.

Furthermore, probiotic supplementation has been linked to a reduction in ammonia production in poultry. High ammonia levels in poultry houses can lead to respiratory problems and other health issues. Probiotics, particularly those that reduce urease activity, contribute to lowering ammonia production in the gut. Khan (2013) demonstrated that birds receiving probiotics had reduced ammonia levels in their environment, which in turn improved their overall health and performance.

In summary, probiotic supplementation offers substantial benefits for improving performance metrics in poul-

try production. By enhancing body weight gain, reducing feed conversion ratio, lowering mortality rates, increasing carcass percentage, optimizing feed intake, boosting immune response, and reducing ammonia production, probiotics represent a highly effective alternative to traditional growth promoters in poultry.

CONCLUSION

Lactic acid bacteria (LAB) such as *Lactobacillus* spp. and *Bifidobacterium* spp., along with fungi like *Saccharomyces* spp., *Rhizopus* spp., and *Mucor* spp., are among the most commonly used probiotic organisms to enhance broiler productivity. Unlike antibiotics, which can kill both pathogenic and non-pathogenic digestive microbes and leave residues in animal tissues, probiotics promote poultry performance without causing any harmful residues, making them safer for human consumption. Probiotics work by attaching to and multiplying in the digestive tract, where they compete with pathogenic microbes for resources. They produce antimicrobial substances that inhibit the growth of harmful bacteria while simultaneously boosting the immune system of chickens. This multifaceted approach allows probiotics to effectively improve gut health and overall poultry performance, making them a viable alternative to antibiotics in broiler rations.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest with anyone.

NOVELTY STATEMENT

This study aimed to evaluate the effectiveness of Lactic Acid Bacteria (LAB) probiotics as a substitute for Antibiotic Growth Promoters (AGP) in poultry production. With increasing regulations prohibiting the use of AGPs in chicken farming, there is a pressing need for alternative strategies to enhance production while ensuring animal health and safety. The research focused on assessing how LAB probiotics can improve growth performance, gut health, and immune function in chickens, thereby providing a sustainable solution to the challenges posed by the ban on AGPs.

AUTHOR CONTRIBUTIONS

RA and DAC wrote the manuscript, WPL, SH, and AM supervised the study and edited the final version of the manuscript. All authors contributed to the revision of the manuscript, intellectual content, and approved the manuscript for publication.

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