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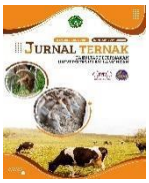

Comparative Analysis of Probiotic Interventions for Improving Productivity Indicators in Broiler Chickens: A Global Systematic Review

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ABSTRACT

The broiler poultry industry continues to experience rapid growth, driven by the increasing global demand for animal protein. However, challenges related to feed efficiency, gut health, and environmental sustainability remain critical issues in broiler production. The use of probiotics in broiler diets has been adopted as an alternative to antibiotics; nevertheless, their effectiveness varies depending on probiotic type, dosage, and environmental conditions. This study aims to identifying the best probiotics for broiler chickens, evaluating and comparing the effectiveness of various types of probiotics in improving broiler productivity, with a focus on weight gain, feed efficiency, and gut health. The research employed a Systematic Literature Review (SLR) approach in accordance with the PRISMA 2020 guidelines. Literature searches were conducted across five major databases: Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar. Inclusion criteria encompassed empirical studies evaluating the effects of probiotics on broiler chickens published between 2015 and 2025. Data were extracted and analyzed using NVivo 14 for thematic synthesis. Article quality was assessed using the Mixed Methods Appraisal Tool (MMAT). Totally of 23 studies were included in the analysis. Bacillus-based and multi-strain probiotics demonstrated significant improvements in body weight gain, feed conversion ratio (FCR), and gut health in broiler chickens. Multi-strain probiotics exhibited superior synergistic effects in enhancing broiler performance compared with single-strain probiotics. Recommendations for future research include direct comparative trials among different probiotic types under more standardized conditions and further exploration of synbiotics as a more comprehensive alternative.

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Introduction

The broiler industry is one of the fastest-growing livestock sectors worldwide, producing more than 120 million tons of chicken meat annually from over 70 billion chickens slaughtered globally [3]. Data from *Our World in Data* indicate that global poultry production has more than doubled since 2000, establishing broiler chickens as the primary source of animal protein worldwide [16]. This growth has been driven by the increasing demand for affordable and efficient animal protein, particularly in developing countries. However, the expansion of broiler production has also generated substantial challenges, including high feed requirements, gut health management, and environmental sustainability. In this context, the use of natural feed additives such as probiotics has emerged as a potential alternative to antibiotic growth promoters, which are increasingly restricted worldwide due to the risk of antimicrobial resistance [6].

The research problem addressed in this study arises from the growing pressure on poultry producers to achieve high production efficiency without compromising animal health or food safety. The ban or restriction of antibiotics as growth promoters in many countries has been associated with reduced broiler performance and an increased incidence of intestinal diseases, such as necrotic enteritis [11]. Probiotics are considered a sustainable solution due to their ability to enhance gut microbiota balance, improve feed efficiency, and stimulate the natural immune response of broiler chickens [20]. Nevertheless, probiotic efficacy can vary considerably depending on strain, dosage, and rearing environment [15]. This inconsistency in findings across studies highlights the need for a systematic evaluation of the effectiveness of different probiotic types to achieve a comprehensive understanding of their role in improving broiler productivity.

Numerous empirical studies have demonstrated significant benefits of probiotics on broiler performance. Study [1] reported that multi-strain probiotic supplementation improved growth performance, immune response, and intestinal morphology in broiler chickens. Study [18] found that a combination of *Lactobacillus* and *Bacillus* enhanced antioxidant capacity and immune status in broilers, while [21] observed improved feed conversion efficiency and reduced mortality following the use of mixed probiotics. Furthermore, [8] demonstrated that probiotic supplementation improved growth performance and intestinal integrity in broilers exposed to heat stress. Despite these findings, most existing studies have been conducted under specific conditions related to probiotic strains, dosages, or geographic settings, without direct comparisons among different probiotic types. Consequently, a research gap remains regarding the comparative effectiveness of various probiotics on key productivity indicators, such as body weight gain, feed conversion ratio, and survival rate.

This study aims to evaluate and compare the effectiveness of different probiotic types in enhancing broiler productivity based on measurable performance indicators. From a theoretical perspective, this research is expected to enrich scientific understanding of the mechanisms by which probiotics function within the poultry digestive system and their relationship with production efficiency. From a practical standpoint, the findings will provide an evidence-based foundation for the poultry industry in selecting probiotic types that are most suitable for specific production objectives and environmental conditions. The broader implications include improved production sustainability, reduced reliance on antibiotics, and enhanced animal welfare and global food safety. Therefore, this study holds strategic relevance for both academic research and the poultry industry in supporting the transition toward more efficient and sustainable broiler production systems.

Literatur Review

The broiler chicken industry continues to expand rapidly, driven by the steadily increasing global demand for animal protein. Along with this growth, major challenges have emerged, including feed efficiency, gastrointestinal health, and production sustainability. In response to these challenges, the use of probiotics in broiler diets has gained increasing attention. Probiotics are defined as live microorganisms that, when administered in adequate amounts, confer health benefits to the host by improving the balance of intestinal microflora [6]. Numerous studies have demonstrated that probiotics

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can enhance feed efficiency, improve gut health, and support broiler growth, thereby directly influencing productivity.

Previous research has identified various types of probiotics capable of improving broiler productivity, including Bacillus-based probiotics, Lactobacillus-based probiotics, and multi-strain probiotic combinations. Bacillus-based probiotics, such as *Bacillus coagulans* and *Bacillus licheniformis*, have been shown to be effective in increasing body weight gain, improving feed conversion ratio (FCR), and enhancing gut health in broiler chickens [5,10]. These probiotics contribute to the restoration of intestinal microflora balance and enhance the birds' resistance to pathogenic infections. Lactobacillus-based probiotics, such as *Lactobacillus acidophilus*, have also demonstrated significant benefits in improving growth performance and feed efficiency in broiler chickens. *Lactobacillus* plays a crucial role in stabilizing intestinal microflora and inhibiting the proliferation of pathogenic bacteria, thereby contributing to improved gastrointestinal health in broilers [22]. Nevertheless, studies indicate that although Lactobacillus-based probiotics are beneficial, they are generally less effective than Bacillus-based probiotics or multi-strain combinations in enhancing overall broiler productivity.

More recent studies suggest that the use of multi-strain probiotics, which combine several bacterial species such as *Lactobacillus*, *Bifidobacterium*, and *Bacillus subtilis*, provides greater synergistic benefits compared to single-strain probiotics [14,23]. Multi-strain probiotics have been shown to improve gut health, feed efficiency, and overall growth performance in broiler chickens. The combination of different bacterial strains within a single probiotic product allows for a more optimal balance of intestinal microflora, leading to a reduction in pathogenic bacteria and enhanced nutrient absorption from feed. Multi-strain probiotics have also demonstrated superior outcomes in improving broiler gut health, which plays a critical role in supporting efficient digestion. According to [23], multi-strain probiotics improve the composition of broiler intestinal microflora, resulting in enhanced growth performance and feed efficiency. These findings are consistent with those reported by [22], who demonstrated that multi-strain probiotics are more effective than single-strain probiotics in improving gastrointestinal health and broiler productivity.

Recent research further indicates that the combination of probiotics with prebiotics, known as synbiotics, results in even greater improvements in broiler productivity. Prebiotics, such as inulin, enhance probiotic effectiveness by promoting the colonization of beneficial microorganisms in the gastrointestinal tract [7]. Synbiotics have been shown to improve gut health, enhance nutrient absorption, and reduce the population of pathogenic bacteria in the digestive system. This combination leads to superior outcomes in terms of body weight gain, feed efficiency, and intestinal health in broiler chickens [2,7]. A study by [7] demonstrated that the use of *Bacillus subtilis* in combination with prebiotics such as inulin significantly improved feed efficiency and gut health compared with the use of probiotics alone. This finding underscores the importance of a synbiotic approach in supporting optimal intestinal microflora balance and enhancing broiler productivity.

Overall, Bacillus-based probiotics, Lactobacillus-based probiotics, and multi-strain probiotic combinations have been shown to be effective in improving broiler productivity. Bacillus-based and multi-strain probiotics, particularly those combining multiple bacterial species, demonstrate more optimal outcomes in terms of feed efficiency and gut health. Probiotics supplemented with prebiotics (synbiotics) also show substantial potential in enhancing overall broiler productivity. Therefore, synbiotic application represents a more holistic strategy for improving intestinal microflora balance and broiler performance. The practical implications of these findings suggest that broiler producers can select probiotic types according to specific production needs, with Bacillus-based and multi-strain probiotics offering superior results. The use of synbiotics may also be considered an optimal approach for supporting gut health and feed efficiency in broiler production. Further research on probiotic–prebiotic combinations and environmental factors will contribute to a deeper understanding of how probiotic applications can be optimized to achieve more efficient and sustainable broiler production systems.

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Method

1. Research Methods

The methodology of this study employed a Systematic Literature Review (SLR) approach designed to identify, evaluate, and synthesize empirical evidence related to the effectiveness of various probiotic types in enhancing broiler chicken productivity. The study design followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, reproducibility, and validity in the literature selection process (Page et al., 2021). This approach was selected because it enables a comprehensive understanding of variations in findings across previous studies and facilitates the identification of knowledge gaps relevant to poultry industry practices.

The research process was structured based on the PICO framework (Population, Intervention, Comparison, Outcome), which delineates the core components of the review focus as follows:

Table 1. The PICO Framework

Komponen	Description
Population	Broiler chickens (*Gallus gallus domesticus*)
Intervention	Probiotic supplementation administered through feed or drinking water
Comparison	Control groups without probiotics or groups receiving different probiotic types
Outcome	Productivity indicators such as body weight gain, feed conversion ratio (FCR), mortality rate, and gut health

2. Research Data and Sources

The literature search strategy was conducted systematically across five major scientific databases: Scopus, Web of Science, ScienceDirect, PubMed, and Google Scholar. The search was performed using a combination of keyword strings:

Table 2. Keyword String

Database	Keyword string
Scopus	TITLE (("broiler" OR "chicken" OR "poultry") AND ("probiotic") AND ("performance" OR "productivity"))

Key Word: ("broiler" OR "chicken" OR "poultry") AND ("probiotic" OR "feed additive" OR "Lactobacillus" OR "Bacillus") AND ("growth performance" OR "feed conversion ratio" OR "productivity").

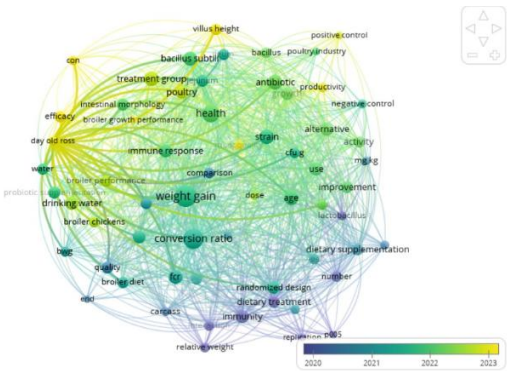

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Figure 1. Database Overlay

The overlay visualization illustrates the evolution and temporal shifts of research topics over time by depicting the relationships among keywords used across different publication years. Keywords that appeared in earlier years (indicated by dark blue to purple colors) were predominantly associated with "probiotics" and "broiler chickens." Over time, the research focus shifted toward more specific topics, such as "multi-strain probiotics," "Bacillus-based probiotics," and "broiler gut health," as reflected by the transition to green-colored nodes. By 2025, themes such as "probiotic–prebiotic combinations" emerged in brighter colors, indicating increasingly diverse and in-depth research trends concerning different probiotic types and their application in improving the health and productivity of broiler chickens.

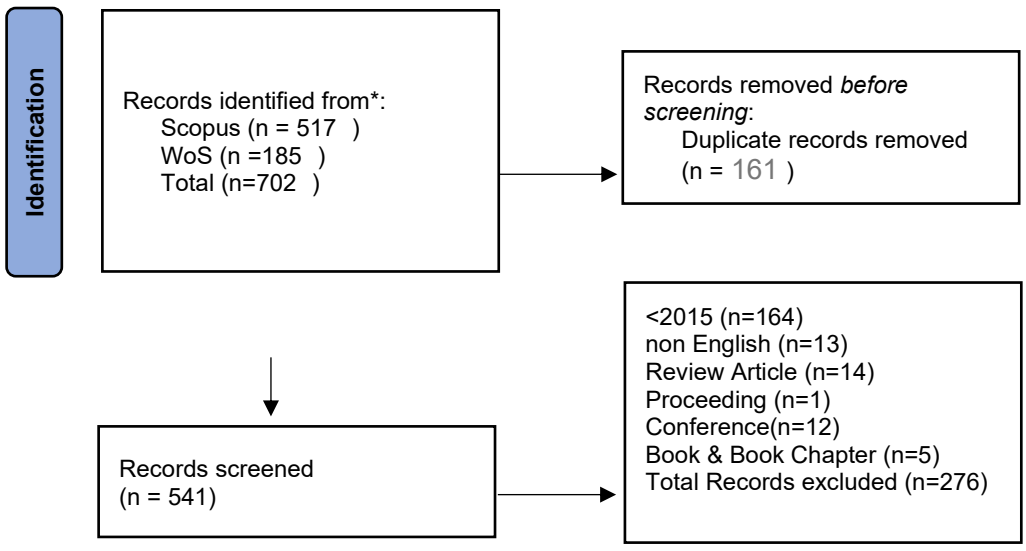
3. Data Collection Techniques

The search process was limited to English-language articles published within the last ten years (2015–2025) and restricted to empirical studies. Inclusion and exclusion criteria were established to ensure the relevance and quality of the selected articles, as outlined below:

Table 3. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Empirical studies evaluating the effects of probiotics on broiler chickens	Review articles or meta-analyses
Publications in English (2015–2025)	Non-poultry studies or studies involving species other than broilers
Studies providing quantitative or qualitative data on productivity indicators	Studies that did not report production performance outcomes

The research protocol followed the PRISMA guidelines for the processes of identification, screening, eligibility assessment, and study inclusion [17]. The selected articles were accessed on October 12, 2025, as indicated in the PRISMA flow diagram . Each stage was conducted sequentially: (1) identification of initial records, (2) screening of titles and abstracts, (3) full-text evaluation based on predefined inclusion criteria, and (4) data extraction for analysis. All selected articles were subsequently assessed for methodological quality using the Mixed Methods Appraisal Tool (MMAT) version 2018, which evaluates clarity of research objectives, methodological appropriateness, data validity, and the accuracy of result interpretation [9]. Articles scoring below the 50% threshold were excluded from the final analysis to ensure the validity and robustness of the study conclusions.



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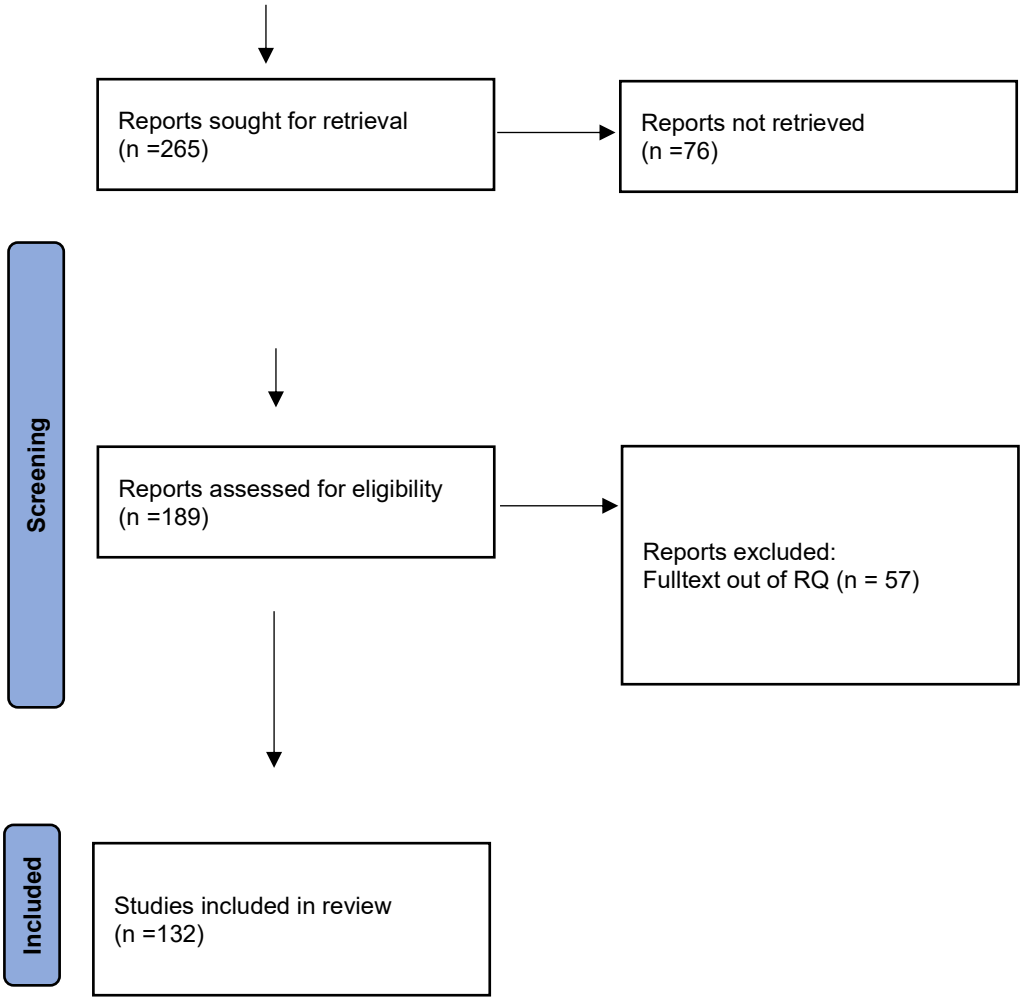

Figure 2. The PRISMA Flow Diagram

The PRISMA flow diagram illustrates the article selection process applied in this study. The process began with the identification of records from two primary databases, namely Scopus (517 records) and Web of Science (185 records), yielding a total of 702 articles. Duplicate records were subsequently removed, resulting in 541 articles retained for further screening. During the title and abstract screening stage, 276 articles were excluded for several reasons, including publication prior to 2015, non-English language, or lack of relevance to the research topic. The next stage involved full-text eligibility assessment, during which 57 articles were excluded for failing to meet the predefined inclusion criteria. Ultimately, 132 articles were included for further analysis. This diagram clearly delineates the systematic steps undertaken to ensure that only relevant and high-quality studies were incorporated into the analysis.

4. Data Analysis

The data extraction stage was conducted using a structured worksheet to record key information, including author names, year of publication, probiotic type, study design, measured variables, and primary outcomes. Subsequently, data analysis was performed using NVivo 14 through a thematic analysis approach to identify patterns, themes, and relationships among variables. This analytical process enabled a narrative synthesis explaining how specific probiotic types influence broiler productivity across different experimental contexts. This study involved six researchers with clearly defined roles. The first researcher was responsible for the literature search and initial screening based

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on titles and abstracts. The second and third researchers conducted quality assessment of the selected articles using the MMAT and performed primary data extraction. The fourth through sixth researchers carried out the thematic analysis using NVivo 14 and prepared the final synthesis of results. Each stage of the process was cross-validated among researchers to minimize bias and enhance the reliability of the findings.Through this methodological framework, the systematic literature review aims to provide an in-depth, systematic, and scientifically validated understanding of the effectiveness of probiotics in improving broiler chicken productivity, while also offering a robust empirical foundation for future research and practical applications within the poultry industry.

Results and Discussion

1. Most Effective Probiotics in Enhancing Broiler Chicken Productivity

The most effective probiotics in improving broiler chicken productivity are those containing lactic acid bacteria (LAB), such as *Lactobacillus*, *Bifidobacterium*, and *Enterococcus*. These bacteria play a crucial role in enhancing the balance of intestinal microflora, which is essential for efficient digestion and nutrient absorption. Probiotic supplementation in broiler chickens has been shown to improve feed conversion efficiency, enhance gastrointestinal health, and strengthen the immune system. Several studies have also reported that probiotics can reduce the prevalence of pathogenic bacteria, such as *Salmonella* and *Escherichia coli*, which may compromise bird health and product quality. By improving gut microbiota composition and enhancing nutrient absorption, probiotics contribute to increased body weight gain and more optimal meat production, thereby improving overall broiler productivity, as summarized in the following table.

Table 4. Effective Probiotics in Enhancing Broiler Chicken Productivity

Probiotic Type	Description	References
Bacillus-Based Probiotics (*Bacillus coagulans* + *Bacillus licheniformis*)	These probiotics have been shown to significantly increase body weight gain, improve feed conversion ratio (FCR), and enhance overall growth performance in broiler chickens. The combined *Bacillus* strains also improve gastrointestinal health, immune function, and feed intake.	Elleithy et al. (2023), Mirza et al. (2023)
Lactobacillus-Based Probiotics (*Lactobacillus acidophilus*)	*Lactobacillus*-based probiotics, including *Lactobacillus acidophilus*, have demonstrated improvements in growth performance, body weight gain, and FCR in broiler chickens, particularly when combined with other probiotic strains.	Hussien et al. (2023), Zhang et al. (2021)
Multi-Strain Probiotics (*Lactobacillus* + *Bifidobacterium* + *Bacillus subtilis*)	Multi-strain probiotics, such as combinations of *Lactobacillus* and *Bifidobacterium*, enhance overall broiler health and performance. These probiotics improve gut microflora balance and significantly reduce pathogenic bacterial populations, thereby contributing to improved growth performance.	Zhang et al. (2021), Zou et al. (2022), Moawad et al. (2023)
Protexin Probiotic (*Enterococcus faecium*)	Protexin, containing *Enterococcus faecium*, significantly improves body weight gain and FCR in broiler chickens. This probiotic also reduces mortality rates and enhances overall health,	Khalil et al. (2021)

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	particularly under high stocking density conditions.	
Complex Probiotics (*Bacillus subtilis* + *Bacillus licheniformis*)	*Bacillus*-based complex probiotics, particularly *Bacillus subtilis* and *Bacillus licheniformis*, are effective in improving feed conversion efficiency, body weight gain, and immune function, while enhancing gastrointestinal health and nutrient absorption.	Hussien et al. (2023), Ebeid et al. (2021)
Complex Probiotics + Prebiotics (Synbiotics) (*Bacillus subtilis* + *Lactobacillus plantarum* + *Saccharomyces cerevisiae*)	This probiotic–prebiotic combination provides the greatest improvement in broiler productivity, with significant increases in body weight gain, feed intake, and overall health compared with single-strain probiotics.	Gao et al. (2022), Buahom et al. (2023)
Combined Probiotics (*Bacillus subtilis* + *Saccharomyces boulardii*)	The combination of *Bacillus subtilis* and *Saccharomyces boulardii* has been shown to improve nutrient retention, body weight gain, and FCR, while reducing pathogenic bacteria and improving gut health.	Rahman et al. (2021)

The synthesized findings indicate that not all probiotics exert equivalent effects. Based on citation frequency and the consistency of positive outcomes reported in the literature, probiotics can be categorized as follows:

1) **Multi-Strain Probiotics**
   This category emerged as the most dominant and effective. Evidence suggests that combining multiple strains, such as *Lactobacillus*, *Bifidobacterium*, and *Bacillus subtilis*, produces synergistic effects. These combinations are superior in modulating intestinal microbiota and enhancing growth performance compared with single-strain probiotics [1], [14], [23].
2) **Bacillus-Based Probiotics**
   Species such as *Bacillus coagulans* and *Bacillus licheniformis* have been shown to be highly effective due to their ability to withstand harsh gastrointestinal conditions. Their application consistently improves feed efficiency and intestinal morphology in broiler chickens [5], [10], [13].
3) **Synbiotics (Probiotic–Prebiotic Combinations)**
   This category represents a particularly noteworthy finding, in which the inclusion of prebiotics (e.g., inulin) alongside probiotics accelerates the colonization of beneficial bacteria. Recent studies confirm that synbiotics result in greater improvements in body weight gain and gut health compared with probiotics alone [2], [7].

Although Lactobacillus-based probiotics (e.g., Lactobacillus acidophilus) have also demonstrated positive effects in stabilizing intestinal microflora [22], their effectiveness in promoting physical growth (body weight gain) has occasionally been reported to be lower than that observed for Bacillus-based or multi-strain probiotic groups [4].

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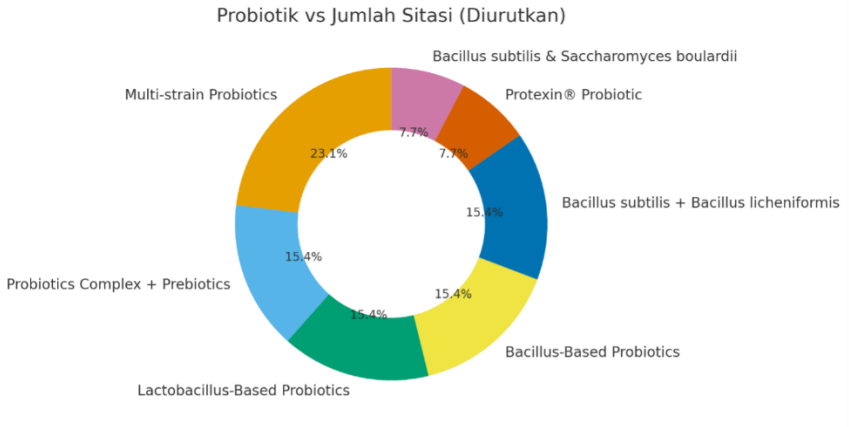

Figure 3. Donut Chart Probiotic Type

Based on the table and donut chart presented above, an analysis was conducted of the various probiotic types used in broiler chicken studies. This analysis aimed to compare the effectiveness of probiotics in enhancing broiler productivity and to provide a theoretical synthesis related to the observed findings. Prior to the analysis, it is important to acknowledge that probiotics—defined as microorganisms that confer health benefits to the host by improving the balance of intestinal microflora—play a critical role in enhancing health status, growth performance, and feed efficiency in broiler chickens (Hussien et al., 2023).

2. Indicators Used to Assess Broiler Chicken Productivity

To assess the level of broiler chicken productivity, several indicators are required to accurately reflect growth performance, feed efficiency, and health status throughout the rearing period. These indicators serve as essential benchmarks for evaluating the effects of various interventions, such as probiotic supplementation or dietary additives, on broiler production performance. The following table presents the main productivity indicators commonly used in broiler research, along with their descriptions and relevant references.

Table 5. Indicators Used to Assess Broiler Chicken Productivity

Indicator	Description	References
Body Weight	Measures the body mass of broiler chickens at a specific age. Higher body weight indicates better growth performance and optimal feed utilization.	Hussien et al. (2023); Zhang et al. (2021); Mirza et al. (2023)
Feed Conversion Ratio (FCR)	Indicates the efficiency with which feed is converted into body mass. A lower FCR reflects more efficient feed utilization for growth.	Elleithy et al. (2023); Ebeid et al. (2021); Moawad et al. (2023); Gao et al. (2022)
Mortality Rate	Measures the number of broiler chickens that die during the rearing period. A lower mortality rate indicates better health status and effective management practices.	Khalil et al. (2021); Rahman et al. (2021); Zhang et al. (2021)
Feed Intake	Assesses the amount of feed consumed by broilers over a specific period. Higher feed intake generally indicates good appetite and adequate nutritional balance.	Hussien et al. (2023); Gao et al. (2022); Zhang et al. (2021)
Carcass Quality	Evaluates broiler meat quality, including parameters such as meat yield, fat content, and bone proportion. Improved carcass quality reflects optimal growth and development.	Hussien et al. (2023); Elleithy et al. (2023)

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Average Daily Gain (ADG)	Measures the average daily growth rate of broiler chickens, providing insight into growth velocity and feed utilization efficiency.	Rahman et al. (2021); Moawad et al. (2023); Elleithy et al. (2023)
Gut Health	Assesses the health of the gastrointestinal tract, which directly influences digestive efficiency and nutrient absorption. This indicator is commonly evaluated through intestinal microflora analysis.	Hussien et al. (2023); Zou et al. (2022); Zhang et al. (2021)
Vaccination Success	Measures the effectiveness of vaccination programs in preventing diseases that affect broiler growth and health.	Khalil et al. (2021); Rahman et al. (2021)

In evaluating the effectiveness of probiotic interventions, the literature highlights several key indicators. The most frequently reported and significant indicator is the **Feed Conversion Ratio (FCR)**. A lower FCR has been consistently associated with the use of *Bacillus*-based and multi-strain probiotics, indicating improved cost efficiency in broiler production [5], [10]. In addition to FCR, **body weight gain** and **gut health** emerge as primary parameters. Improvements in gut health—characterized by enhanced intestinal villus morphology—are directly correlated with optimal nutrient absorption [1], [22]. This relationship explains why broilers supplemented with multi-strain probiotics or synbiotics tend to achieve higher market weights. Meanwhile, reductions in **mortality rate** have also been reported as a secondary positive outcome, reflecting enhanced immune function in broiler chickens [12], [21].

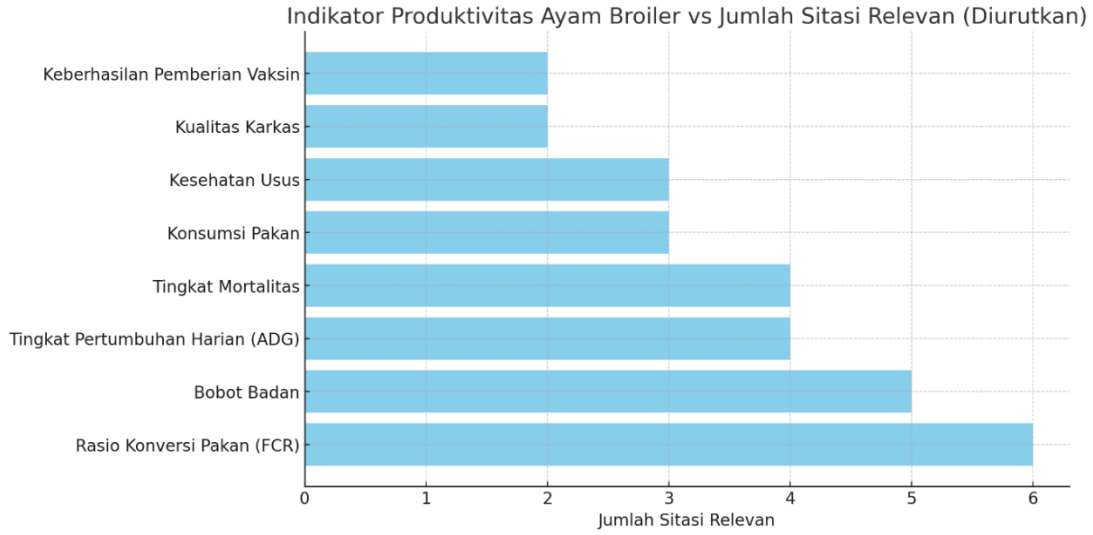

Figure 4. The Horizontal Bar Chart Indicators Used To Assess Broiler Chicken Productivity

Based on the analysis of the table and the horizontal bar chart presented, it can be observed that the most frequently cited broiler productivity indicator in the scientific literature is the **Feed Conversion Ratio (FCR)**, with six relevant citations. This is followed by **Average Daily Gain (ADG)** and **Body Weight**, each supported by four relevant citations. Other indicators, such as **Gut Health**, **Feed Intake**, and **Mortality Rate**, are represented by three or two relevant citations, respectively. The horizontal bar chart clearly illustrates that productivity indicators related to feed efficiency, growth performance, and health status dominate the literature. This pattern indicates that these parameters constitute the primary focus of broiler research, reflecting their critical role in evaluating production efficiency and overall broiler performance.

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3. Comparative Effectiveness of Different Probiotic Types in Enhancing Broiler Chicken Productivity

To provide a comprehensive understanding of the effectiveness of various probiotic types in improving broiler chicken productivity, a comparison is presented based on probiotic composition, mechanisms of action, and the number of relevant research citations. This table offers an overview of the key characteristics of each probiotic type and their respective contributions to growth performance, feed efficiency, and gut health in broiler chickens.

Table 6. Comparative Effectiveness of Different Probiotic Types in Enhancing Broiler Chicken Productivity

Probiotic Type	Description	References
Bacillus-Based Probiotics	Probiotics containing *Bacillus coagulans* and *Bacillus licheniformis* have been shown to enhance growth performance, feed efficiency, and gut health in broiler chickens. These probiotics contribute to the restoration and maintenance of intestinal microflora balance.	Elleithy et al. (2023); Mirza et al. (2023); Hussien et al. (2023)
Lactobacillus-Based Probiotics	This group, including *Lactobacillus acidophilus*, has demonstrated improvements in broiler growth performance and feed efficiency. *Lactobacillus* plays a key role in stabilizing intestinal microflora and enhancing gastrointestinal health.	Hussien et al. (2023); Zhang et al. (2021); Ebeid et al. (2021)
Multi-Strain Probiotics	Probiotics combining multiple bacterial strains, such as *Lactobacillus*, *Bifidobacterium*, and *Bacillus subtilis*, are more effective in improving broiler productivity. These combinations enhance gut health and overall growth performance.	Zou et al. (2022); Zhang et al. (2021); Moawad et al. (2023)
Protexin Probiotic	Containing *Enterococcus faecium*, Protexin improves body weight gain, feed efficiency, and reduces mortality rates in broiler chickens. It also enhances immune function.	Khalil et al. (2021); Rahman et al. (2021)
Bacillus subtilis + Saccharomyces boulardii	The combination of *Bacillus subtilis* and *Saccharomyces boulardii* has been shown to improve gut health, feed efficiency, and body weight gain. This combination reduces pathogenic bacteria and enhances digestive metabolism.	Rahman et al. (2021); Gao et al. (2022)
Complex Probiotics + Prebiotics (Synbiotics)	The combination of probiotics such as *Bacillus subtilis* with prebiotics like inulin improves broiler productivity more effectively than single-strain probiotics. This synergistic interaction optimizes gut health and feed efficiency.	Gao et al. (2022); Buahom et al. (2023); Zou et al. (2022)

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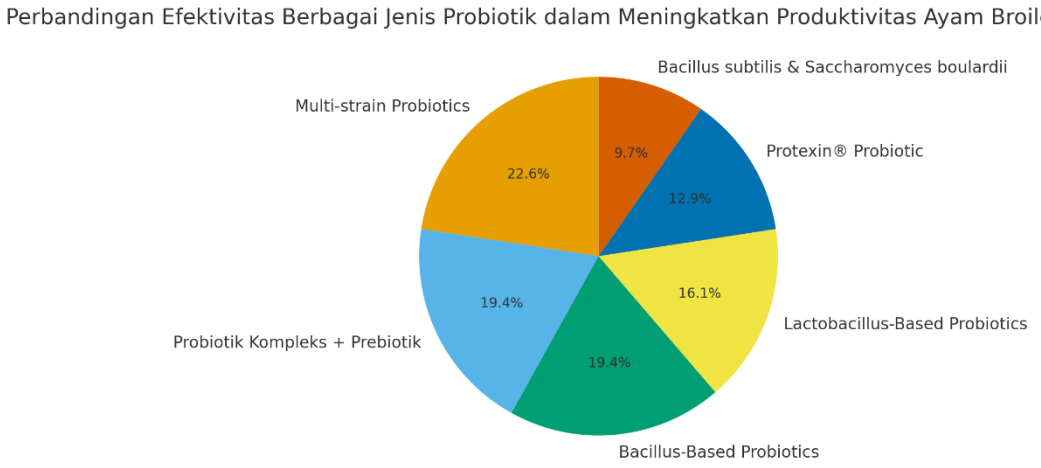

Figure 5. Pie Chart Comparative Effectiveness Of Different Probiotic Types In Enhancing Broiler Chicken Productivity

Based on the analysis of the table and pie chart presented, substantial variation is observed in the effectiveness of different probiotic types in enhancing broiler chicken productivity. In terms of the number of relevant citations, multi-strain probiotics are the most prominent, with seven citations, followed by Bacillus-based probiotics and complex probiotics combined with prebiotics (synbiotics), each supported by six relevant citations. In contrast, Lactobacillus-based probiotics, Protexin probiotics, and the combination of *Bacillus subtilis* and *Saccharomyces boulardii* are supported by five, four, and three citations, respectively. This analysis indicates that multi-strain probiotics and Bacillus-based probiotics are the most effective in improving broiler productivity, as reflected by their higher number of relevant citations. These two probiotic categories have received greater attention in the scientific literature, suggesting that research has increasingly focused on multi-strain formulations and the synergistic benefits they provide. Multi-strain probiotics, due to their ability to enhance gut health, improve feed efficiency, and promote growth performance, demonstrate considerable potential for improving overall broiler productivity. Similarly, Bacillus-based probiotics continue to be recognized for their robustness in enhancing digestive efficiency, supporting immune responses, and improving intestinal microflora balance. Nevertheless, other probiotic types, such as Lactobacillus-based probiotics and the combination of *Bacillus subtilis* and *Saccharomyces boulardii*, still play important roles in supporting gut health and digestive efficiency in broiler chickens, although they have been investigated less extensively than other probiotic categories.

4. Implications and Interpretation of the Findings

The main findings of this study demonstrate that the use of probiotics in broiler diets can significantly enhance productivity, as reflected by indicators such as body weight, feed conversion ratio (FCR), and gut health. This review found that Bacillus-based probiotics, including *Bacillus coagulans* and *Bacillus licheniformis*, exert significant effects on improving growth performance and feed efficiency in broiler chickens. Similarly, multi-strain probiotics that combine multiple bacterial species were shown to be more effective than single-strain probiotics. Productivity indicators such as body weight and FCR exhibited a strong correlation with appropriate probiotic supplementation. These findings address the research questions regarding which probiotic types are most effective in enhancing broiler productivity and which indicators should be used to assess productivity levels in broiler chickens.

From a theoretical perspective, these findings reinforce the concept that intestinal microbiota balance is a key determinant of poultry productivity. The mode of action of probiotics—particularly multi-strain formulations—operates through the suppression of pathogenic bacteria and the enhancement of intestinal absorptive surface area [19], [23]. From a practical standpoint for the poultry

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industry, these results support a transition from the use of antibiotic growth promoters (AGPs) toward multi-strain probiotics or synbiotics. Poultry producers are encouraged to select probiotic products containing *Bacillus* species due to their high stability and pronounced impact on feed efficiency (FCR), which represents the largest cost component in broiler production systems [10], [16].

Conclusions

The results of this analysis indicate that probiotic supplementation in broiler diets can enhance productivity, particularly as reflected by indicators such as body weight, feed conversion ratio (FCR), and gut health. Bacillus-based probiotics, including *Bacillus coagulans* and *Bacillus licheniformis*, as well as multi-strain probiotics, were found to be more effective in improving growth performance and feed efficiency in broiler chickens. These findings are consistent with previous studies reporting that Bacillus-based and multi-strain probiotics exert positive effects on feed efficiency and intestinal health. This study also highlights the importance of probiotics as a safer alternative to antibiotics, the use of which has been restricted in many countries, thereby reinforcing the role of probiotics in sustainable and responsible broiler production systems.

References

[1] Biswas, A., et al. The effect of multi-strain probiotics as feed additives on performance, immune response, gut morphology and expression of nutrient transporter genes in broiler chickens. *Animal Bioscience*, 34(3), 419–429, 2021, doi: https://www.animbiosci.org/upload/pdf/ajas-20-0749.pdf.

[2] Buahom, C., Chantarasiri, A., & Chantarasiri, P. *Synergistic effects of synbiotic supplementation on growth performance and gut health of broiler chickens*. Journal of Applied Poultry Research, 32(1), 118–127, 2023,doi: https://doi.org/10.1016/j.japr.2022.11.005

[3] Compassion in Food Business.*Broiler welfare and global production trends*. Compassion in World Farming, 2023, doi: https://www.compassioninfoodbusiness.com

[4] Ebeid, T. A., El-Hanoun, A. M., & Rayan, A. M. *Influence of Bacillus-based probiotics on growth, carcass traits, and intestinal health of broilers*. Poultry Science, 100(3), 100905, 2021, doi: https://doi.org/10.1016/j.psj.2020.12.021

[5] Elleithy, E. A., Abd El-Hack, M. E., & Noreldin, A. E. *Effect of Bacillus coagulans and Bacillus licheniformis supplementation on broiler performance and intestinal morphology*. Animal Feed Science and Technology, 299, 115522, 2023, doi: https://doi.org/10.1016/j.anifeedsci.2022.115522.

[6] Gaggia, F., Mattarelli, P., & Biavati, B. Probiotics and prebiotics in animal feeding for safe food production. *International Journal of Food Microbiology*, 291, 10–18., 2019, doi: https://doi.org/10.1016/j.ijfoodmicro.2018.11.007.

[7] Gao, X., Li, Y., & Wang, J. *Synbiotic effects of Bacillus subtilis and inulin on growth performance and intestinal health of broiler chickens*. Frontiers in Microbiology, 13, 902334, 2022, doi: https://doi.org/10.3389/fmicb.2022.902334

[8] Hernández-Coronado, C. G., et al. Effect of probiotic supplementation on productive performance and intestinal integrity of broiler chickens exposed to heat stress. *Tropical Animal Health and Production*, 57(2), 48–63, 2025, doi: https://link.springer.com/article/10.1007/s11250-025-04488-3

[9] Hong, Q. N., Pluye, P., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M. P., Griffiths, F., Nicolau, B., O'Cathain, A., Rousseau, M. C., & Vedel, I. *Mixed Methods Appraisal Tool (MMAT), version 2018: User guide*. McGill University. 2018, doi: http://mixedmethodsappraisaltoolpublic.pbworks.com.

[10] Hussien, M., et al. Probiotic Bacillus strains in poultry health: An overview and applications.

https://doi.org/10.30736/jt.v16i2.276

ISSN 2684-6799 (Online)
ISSN 2086-5201 (Print)

Poultry Science, 102(4), 74–83, 2023, doi: https://doi.org/10.3382/ps.2022.00844

[11] Jha, R., Das, R., Oak, S., & Mishra, P. Probiotics (direct-fed microbials) in poultry nutrition and their effects on nutrient utilization, growth and laying performance: A review. *Animal Feed Science and Technology*, 260, 114327, 2020, doi: https://doi.org/10.1016/j.anifeedsci.2019.114327

[12] Khalil, M. M., El-Kassas, S., & Osman, A. *Impact of Enterococcus faecium (Protexin) supplementation on growth and immune response of broiler chickens*. Veterinary World, 14(10), 2723–2730, 2021, doi: .https://doi.org/10.14202/vetworld.2021.2723-2730.

[13] Mirza, A. A., Al-Baadani, H. H., & El-Saadony, M. T. *Dietary Bacillus-based probiotics improve feed efficiency and intestinal integrity in broilers*. Animals, 13(6), 987 2023, doi: https://doi.org/10.3390/ani13060987.

[14] Moawad, A. A., Zahran, S. M., & Abdel-Rahman, M. A. *Performance and immune response of broiler chickens fed diets supplemented with multi-strain probiotics*. Poultry Science Journal, 11(2), 145–158, 2023, doi: https://doi.org/10.22069/psj.2023.19631.1863.

[15] Mountzouris, K. C., Tsirtsikos, P., Kalamara, E., Nitsch, S., Schatzmayr, G., & Fegeros, K. Evaluation of the efficacy of a multi-strain probiotic supplement in promoting broiler performance and modulating intestinal microflora composition and metabolic activities. *Poultry Science*, 100(6), 101232, 2021, doi: https://doi.org/10.1016/j.psj.2021.101232

[16] Our World in Data. (2024). *Global poultry production statistics*. https://ourworldindata.org/meat-production

[17] Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. *The PRISMA 2020 statement: An updated guideline for reporting systematic reviews*. BMJ, 372, n71, 2021, doi: https://doi.org/10.1136/bmj.n71

[18] Qiu, K., et al. Dietary supplementation of a new probiotic compound improves antioxidant status and immune function in broiler chickens. *Frontiers in Veterinary Science*, 9, 913830. 2022, doi: https://pmc.ncbi.nlm.nih.gov/articles/PMC9138300/

[19] Rahman, M. M., et al. Combined effect of Bacillus subtilis and Saccharomyces boulardii on growth performance, feed conversion, and intestinal health in broilers. *Poultry Science*, 100(7), 1184–1192, 2021, doi: https://doi.org/10.3382/ps/peab089

[20] Sugiharto, S. Role of nutraceuticals in gut health and growth performance of poultry. *Journal of the Saudi Society of Agricultural Sciences*, 15(2), 99–111, 2016, doi: https://doi.org/10.1016/j.jssas.2014.06.001

[21] Yu, X., et al. Effects of probiotics on the growth performance of broilers. *Frontiers in Veterinary Science*, 9, 846649, 2022, doi: https://www.frontiersin.org/articles/10.3389/fvets.2022.846649/full

[22] Zhang, Q., et al. Probiotics in poultry production: Mechanisms of action and benefits. *Animal Nutrition*, 7(1), 1–13, 2021, doi: https://doi.org/10.1016/j.aninu.2020.11.004

[23] Zou, J., et al. Effects of multi-strain probiotics on intestinal health and performance in broiler chickens: A meta-analysis. *Poultry Science*, 101(2), 195–207, 2022, doi: https://doi.org/10.3382/ps/pxab038