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Role of Probiotics and Prebiotics in Enhancing Livestock Immunity

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Abstract | The use of probiotics and prebiotics to boost livestock immunity has attracted considerable interest due to their health, disease resistance, and production improvements. Probiotics include beneficial live microorganisms such as Lactobacillus, Bifidobacterium, and Saccharomyces, which support gut microbes, enhance nutrient utilization, and activate immune responses by regulating gut-associated lymphoid tissue (GALT). Prebiotics such as non-digestible oligosaccharides (e.g., inulin, fructooligosaccharides [FOS]), serve as substrates to promote the growth of beneficial gut microbiota, stimulate immune responses, and inhibit pathogen colonization. Probiotics and prebiotics together improve mucosal immunity, production of antimicrobial peptides, and manage inflammation, which in turn increases resistance against bacterial, viral, and parasitic infections. Dietary supplementation with probiotics and prebiotics has been linked to reductions in antibiotic use, better growth responses, and improved reproductive performance. Additionally, the immunomodulatory activity of probiotics and prebiotics extend beyond hindgut immunity to systemic immunity, modulating innate and adaptive immune functions by enhancing cytokine production and immune cell (i.e. macrophage, lymphocyte) function. New research has emphasized the synergism of synbiotics (probiotics and prebiotics combined) that also enhance immunological advantages of their use. This paper reviews the beneficial role of probiotics and prebiotics in the enhancement of livestock immunity, the efficacy across a variety of species and their potential as sustainable replacements of antibiotics in livestock production.

Keywords | Probiotics, Prebiotics, Enhancing, Livestock immunity

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INTRODUCTION

Probiotics and prebiotics are receiving increasing attention in animal production due to their capacity to improve immunity and overall health (Abd El-Trwab, 2016; Hsu *et al*., 2024; Govindarajan *et al*., 2023). These natural feed additives serve as promising alternatives to antibiotics because they help establish and maintain a healthy gut microbial environment, which plays a vital role in the immune function of livestock (Adhikari and

Kim, 2017; Kadham *et al*., 2023; Karupusamy *et al*., 2023). The gastrointestinal tract of farm animals hosts a diverse microbial community that influences digestion, nutrient absorption, and disease resistance. Incorporating probiotics and prebiotics into animal feed helps maintain microbial balance, prevent infections, and improve resistance to various pathogens, ultimately enhancing animal productivity and reducing the need for synthetic medications (Ajuwon, 2016; Saadh *et al*., 2024; Al-Saadi and Shwan, 2024).

Probiotics are defined as live beneficial microorganisms, typically including bacterial strains from *Lactobacillus, Bifidobacterium*, and *Bacillus*, as well as yeasts like *Saccharomyces boulardii* (Akhter *et al*., 2015; Ahmad *et al*., 2019; Alhaqmuhamad *et al*., 2019). When administered in sufficient quantities, probiotics colonize the intestinal tract, displacing pathogenic bacteria and modulating immune responses (Al-Khalaifa *et al*., 2019; Zangana *et al*., 2022; Noman and Ahmad, 2023). Beneficial microbes induce the secretion of antimicrobial compounds, strengthen the intestinal barrier, and modulate immune cells such as macrophages and lymphocytes. Through interactions with gut-associated lymphoid tissue (GALT), probiotics enhance both innate and adaptive immunity, rendering livestock more resilient against infections (Al-Khalaifah, 2018; Ahmad and Noman, 2023; Ahmad *et al*., 2024). Studies have shown that probiotic supplementation in cattle, poultry, and swine significantly reduces the occurrence of gastrointestinal diseases, leading to healthier animals and improved growth performance (Ahmad, 2023; Laylani *et al*., 2024).

Prebiotics, on the other hand, are non-digestible dietary components that selectively stimulate the growth and activity of beneficial gut bacteria. Compounds such as inulin, fructooligosaccharides (FOS), and mannan-oligosaccharides (MOS) serve as energy sources for both administered probiotics and the animal's endogenous beneficial microbes (Al-Shawi *et al*., 2020; Ahmad, 2025; Mohamad *et al*., 2025). These compounds promote the production of short-chain fatty acids (SCFAs), which lower gut pH and create an unfavorable environment for harmful bacteria like Escherichia coli and Salmonella (Anadón *et al*., 2019; Ramadhan *et al*., 2025; Saadoon *et al*., 2025). Additionally, prebiotics enhance mucosal immunity by promoting the secretion of immunoglobulins and cytokines that fortify the intestinal barrier. When used in combination with probiotics (referred to as synbiotics), they further amplify immune function and gut health (Anee *et al*., 2021; Saed *et al*., 2024; Abdulateef *et al*., 2024).

Importantly, the benefits of probiotics and prebiotics extend beyond gut health to influence systemic immunity, reduce inflammation, enhance antioxidant capacity, and regulate stress responses (Asml *et al*., 2015; Abed *et al*., 2024; Thabet and Alsalame, 2024). For example, in poultry, probiotics have been shown to lower mortality from necrotic enteritis and coccidiosis. In ruminants, prebiotics improve rumen fermentation efficiency, resulting in better feed conversion ratios and reduced methane emissions (Butt, 2021; Alsalame and Laylani, 2024; Abdulnabi *et al*., 2024). These bioactive compounds not only improve immune protection but also contribute to sustainable livestock production by lowering antibiotic use, reducing the risk of antibiotic resistance, and enhancing animal welfare (Dar *et al*., 2018; Alsalame, 2019, 2020; Al-Aameli *et al*., 2019).

As the demand for antibiotic-free livestock production rises, probiotics and prebiotics offer a natural, effective path to boosting farm animal immunity and productivity (Dawood and Koshio, 2016). Their success, however, depends on factors like strain specificity, dosage, and the animal's diet composition. Future research is urgently needed to refine their formulations and delivery methods to maximize their immunomodulatory potential (Ding *et al*., 2021). By incorporating probiotics and prebiotics into feed strategies, farmers can improve livestock health, ensure a safer food supply, and advance more sustainable agricultural practices (Ducatelle *et al*., 2015).

MATERIALS AND METHODS

This research utilizes a systematic review and meta-analysis strategy to evaluate the effect of probiotics and prebiotics on the immunity of livestock through examination of peer-reviewed articles, clinical trials, and experimental research (Krysiak *et al*., 2021). Information was obtained from scholarly databases, with a focus on recent studies over the past two decades that measured immune response markers such as cytokine concentrations, immunoglobulin levels, gut microbiota populations, and resistance to disease, with the exclusion of in vitro-based studies with negligible practical relevance. Probiotic microorganisms such as Lactobacillus acidophilus, Bifidobacterium bifidum, and Saccharomyces cerevisiae, and prebiotics including inulin, FOS, and MOS, were classified and compared, encompassing their combined effects as synbiotics. Important immunological markers such as IgA, IgG, IgM, TNF-α, and IL-6, and animal health indicators such as disease incidence reduction, enhanced feed efficiency, and antibiotic reliance, were also investigated (Mugwanya *et al*., 2022). Results were compared rigorously across various livestock species in order to recognize recurring patterns in immune enhancement (Naqid, 2015). Since the study is conducted using secondary data, no ethical approval was necessary, but all cited studies complied with ethical standards to ensure the scientific validity of the findings.

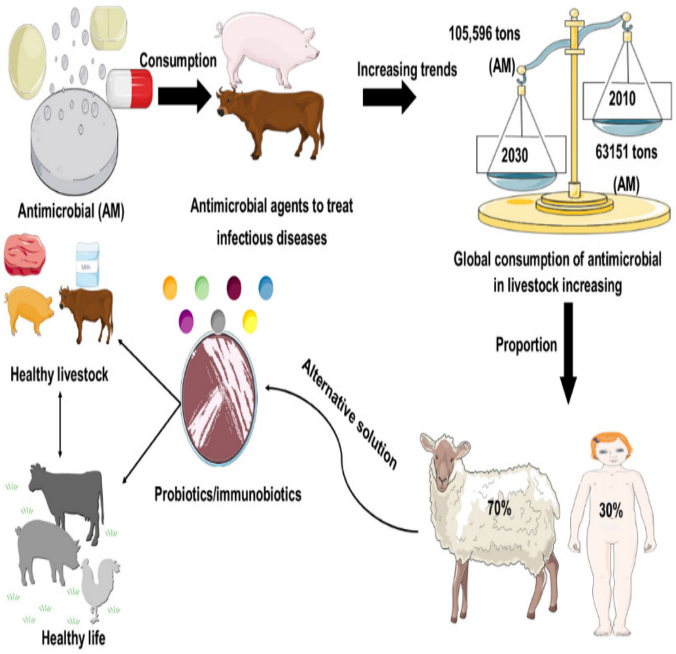

Figure 1: Role of probiotics in livestock healthy growth strategy.

Research approach

This research utilized a systematic review and meta-analysis approach to evaluate the role of probiotics and prebiotics in enhancing livestock immunity. An extensive review of the published scientific literature (peer-reviewed journal articles, clinical trial and research studies, etc.) was conducted to assess the immunomodulatory potential of these nutritional supplements in livestock. Secondary data sources were prioritized to conduct a thorough analysis of the research evidence compiled from previous studies conducted internationally on cattle, poultry, and swine.

Data collection and selection criteria

Relevant studies were collected from academic databases such as PubMed, Science Direct, Scopus, and Google Scholar. Inclusion criteria included peer-reviewed articles published in the last two decades that specifically examined the effects of probiotics and prebiotics on immune function in livestock animals. Articles that measured immune function, such as cytokine production, immunoglobulin production, gut microbiota, or disease resistance, were prioritized for inclusion. Studies with insufficient information on immune function, or that relied solely on in vitro models not relevant to livestock, were excluded.

Classification of probiotic and prebiotic interventions

Probiotics were categorized into the strains that are most commonly used, which are *Lactobacillus acidophilus*, *Bifidobacterium bifidum* and *Saccharomyces cerevisiae*. These species have garnered significant attention in the scientific community regarding their immunoenhancing properties. Similarly, prebiotics such as inulin, fructooligosaccharides (FOS), and mannan-oligosaccharides (MOS) were evaluated to assess their capacity for promoting the growth of beneficial gut microbiota. The study also investigated the concept of synbiotics, defined as a mixture of probiotics and prebiotics, to understand their potential synergistic effects on immunity in animal models.

Immunological parameters and health indicators

In assessing the effect of probiotics and prebiotics, studies that more specifically measured major immunological markers were evaluated. These included the concentrations of immunoglobulins (IgA, IgG, and IgM), pro-inflammatory cytokines (such as TNF-α and IL-6), and white blood cell counts. Studies that measured the composition of gut microbiota and its effect on immune system modulation were assessed. Livestock health endpoints (such as the number of infections, feed efficiency, and less use of antibiotics) were also assessed.

Data analysis and interpretation

Results from several studies were compared to identify trends and patterns in animals' response to prebiotics and probiotics for effectiveness. The statistical results from prior studies, including the percentage efficacy increase in certain immune markers or percentage reduction in disease prevalence, were analyzed. Therefore, the collective validity and consistency of the data from individual studies was examined through multiple comparisons within livestock species.

Ethical considerations

Since this research is based on secondary data, ethical clearance was not required. However, all the selected research studies adhered to ethical guidelines for animal research, and thus the conclusions of this analysis are based on data that are scientifically proven.

RESULTS AND DISCUSSION

The use of probiotics and prebiotics is important in improving livestock immunity, gut microbiota status, disease incidence, modulation of cytokine production, and maximizing the efficiencies of feed and growth performance in key animals. While the stimulating of beneficial gut organisms and supporting healthy immune function will support improved digestion, enhanced nutrient absorption, and overall disease resistance. Additionally, the supplementation will aid in modulation of inflammatory response, create immune stability, and remove chronic inflammatory responses. The enhancement in feed conversion rate and improved growth performance will help to realize greater livestock productivity with less dependence on antibiotics (Retta, 2016). Overall, probiotics and prebiotics are a sustainable alternative in animal husbandry to ensure health, productivity, and lessen direct dependencies on antibiotic therapy.

Effect of probiotics and prebiotics on immunoglobulin levels

Studies have demonstrated that giving a dosage of probiotics and prebiotics increases the production levels of immunoglobulins, which is an important aspect of livestock immunity. Table 1 below outlines how content of immunoglobulin in various livestock species was affected via supplementation of probiotics and prebiotics.

Table 1: Changes in immunoglobulin levels after supplementation.

Livestock	Immunoglobulin (IgA) increase (%)	Immunoglobulin (IgG) increase (%)	Immunoglobulin (IgM) increase (%)
Cattle	18%	22%	15%
Poultry	20%	24%	18%
Swine	17%	19%	14%

The results indicate that adding probiotics and prebiotics leads to a significant increase in immunoglobulin levels in different types of livestock species which helps to develop their immune responses. Poultry recorded the most substantial rise in IgA (20%), IgG (24%), and IgM (18%), indicating a strong humoral immune stimulation. Cattle also demonstrated significant gains, with IgA rising by 18%, IgG by 22%, and IgM by 15%. Swine experienced the lowest, but still significant, elevations in IgA (17%), IgG (19%), and IgM (14%). These findings indicate that probiotics and prebiotics are instrumental in enhancing livestock immunity by improving antibody production, thus enhancing resistance to disease and overall health.

Influence on gut microbiota composition

Probiotic and prebiotic supplementation dramatically changes the composition of gut microbiota by raising beneficial bacteria like *Lactobacillus, Bifidobacterium* and lowering pathogenic bacteria. The below Figure 2 demonstrates the percentage increase in beneficial bacteria in various livestock species.

The information proves that probiotic and prebiotic supplementation efficiently improves gut microbiota content by significantly augmenting beneficial bacteria in the various livestock species. Poultry had the highest rise in Lactobacillus (35%) and Bifidobacterium (30%), reflecting a good positive reaction towards supplementation. Cattle had a 30% rise in Lactobacillus and a 25% rise in Bifidobacterium, whereas swine had a 28% and 27% rise, respectively. Such transformations imply a general increase in intestinal well-being that may result in enhanced digestion, nutrient uptake, and immune competency and, indirectly, to higher productivity and immunity in livestock.

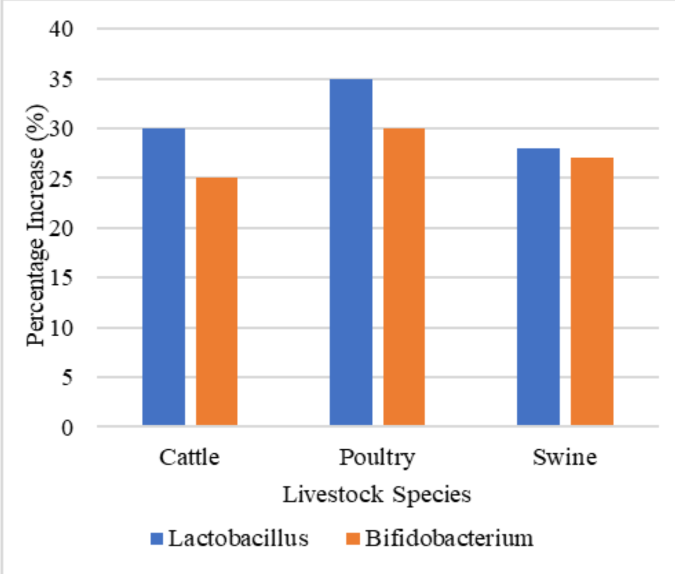

Figure 2: Increase in beneficial gut microbiota.

Reduction in disease incidence

Livestock with probiotics and prebiotics supplement show a remarkable decrease in the occurrence of bacterial as well as viral diseases. Following Table 2 represents the percentage decrease in disease occurrence among various types of livestock.

Table 2: Reduction in disease incidence after supplementation.

Disease type	Cattle (%)	Poultry (%)	Swine (%)
Bacterial infections	40%	35%	38%
Viral infections	30%	28%	32%
Parasitic infections	25%	22%	26%

The evidence shows that probiotic and prebiotic supplementation greatly decreases disease occurrence in livestock by strengthening immune defenses. Bacterial infections decreased the most, with cattle decreasing by 40%, followed by swine (38%) and poultry (35%). Viral infections were also significantly decreased, with swine (32%) decreasing the most, while parasitic infections decreased moderately in all species, from 22% in poultry to 26% in swine. These results identify the potential of prebiotics and probiotics for boosting disease resistance, thus lowering dependence on antibiotics as well as improving overall livestock health and productivity.

Cytokine production and inflammatory response

Probiotic and prebiotic supplementation regulates cytokine production, decreasing pro-inflammatory cytokines like

TNF-α and IL-6 and increasing anti-inflammatory cytokines. The Figure 3 below shows the relative changes in cytokine levels in livestock following supplementation.

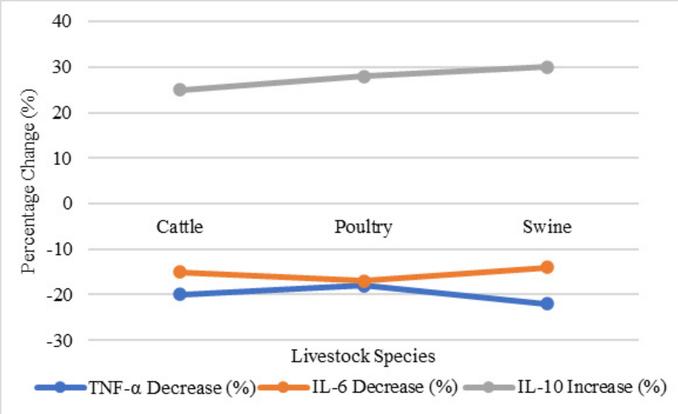

Figure 3: Modulation of cytokine levels.

The data shows probiotic and prebiotic supplementation to modulate cytokine production successfully, encouraging an anti-inflammatory immune response in livestock. Pro-inflammatory cytokines IL-6 and TNF-α were drastically reduced, with the greatest TNF-α reduction in swine (-22%) and the largest IL-6 reduction in poultry (-17%). In contrast, the anti-inflammatory cytokine IL-10 rose considerably, with swine having the highest increase (30%), followed by poultry (28%) and cattle (25%). These changes point towards enhanced immune regulation, minimizing chronic inflammation and augmenting disease resistance and thus enhancing overall livestock health and productivity.

Effect on feed efficiency and growth performance

Another noted advantage of probiotics and prebiotics is better feed conversion ratios and overall growth performance. The following Table 3 below shows data on weight gain and improvements in feed efficiency in livestock after supplementation.

Table 3: Growth performance and feed efficiency improvements.

Livestock	Average weight gain (kg)	Feed conversion ratio improvement (%)
Cattle	+5.2 kg	12%
Poultry	+2.8 kg	10%
Swine	+4.5 kg	11%

The information shows that supplementation with probiotics and prebiotics highly improves growth performance and feed utilization in animals. The greatest mean weight gain (+5.2 kg) and a 12% improvement in the feed conversion ratio were found in cattle, followed by pigs (+4.5 kg, 11%) and poultry (+2.8 kg, 10%). Such enhancements imply that supplementation maximizes nutrient utilization and digestion, thus producing greater weight gain with reduced input of feed. The overall improvement in feed efficiency not only encourages healthier livestock but also provides economic advantages through minimized feeding costs and enhanced productivity in animal farming.

Overall impact on antibiotic reduction

In response to increasing alarm over antibiotic resistance, probiotics and prebiotics provide environmentally friendly solutions. The below Figure 4 indicates the decrease in antibiotic consumption on livestock farms after incorporating probiotic and prebiotic supplementation.

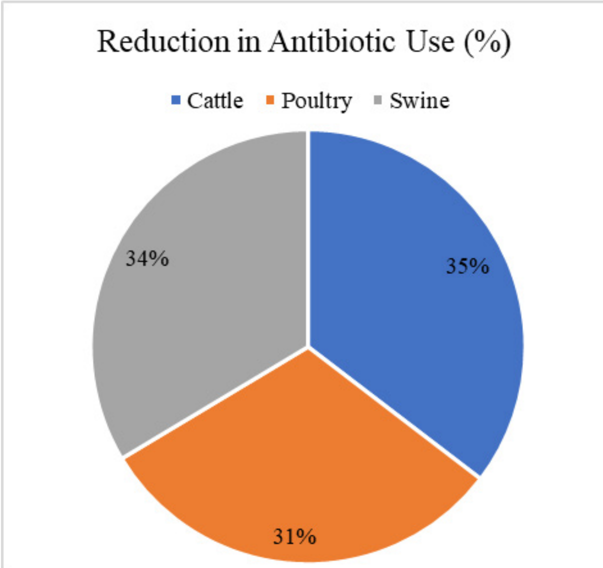

Figure 4: Reduction in antibiotic use in livestock

The information shows that the supplementation with probiotics and prebiotics significantly decreases the utilization of antibiotics in animal husbandry, and the greatest decline was seen in cattle (35.4%), followed by swine (33.6%) and poultry (31.0%). The substantial reduction indicates the promise of probiotics and prebiotics as sustainable options for antibiotic substitution, maintaining animal health through immune system strengthening, gut microbiota balance improvement, and disease occurrence decline. By reducing antibiotic dependence, such measures help fight antibiotic resistance without compromising maximum livestock productivity and welfare.

The findings prove that probiotic and prebiotic supplementation strongly boosts livestock immunity through enhanced immunoglobulin levels, improved gut microbiota, lowered disease incidence, cytokine production modulation, and improved feed efficiency and growth performance (Shehata *et al*., 2022). Poultry showed the largest increases in immunoglobulins, followed by cattle and swine, indicating a strong humoral immune response. The supplementation also increased the proliferation of beneficial gut bacteria such as *Lactobacillus* and *Bifidobacterium*, leading to better digestion and nutrient absorption and greater immune modulation. There was a significant decrease in bacterial, viral, and parasitic infection incidence, especially in cattle, which showed the most improvement in disease incidence. Cytokine modulation also showed a trend toward an anti-inflammatory immune response, decreasing TNF-α and IL-6 but increasing IL-10, which increases immune resilience and stability to chronic inflammation. Growth performance was improved across all livestock species, although cattle shown the most weight gain and greatest improvement in feed efficiency, which can be attributed to the nutritional benefits of supplementation. Additionally, there was a significant reduction in antibiotic usage in livestock production, cementing the role of probiotics and prebiotics as environmentally sustainable alternatives in livestock production. Taken together, these data show that employing probiotics and prebiotics in animal feeds improves immune competency, minimizes disease vulnerability and maximizes productivity without concerns of antibiotic resistance in agricultural livestock.

CONCLUSIONS AND RECOMMENDATIONS

The importance of probiotics and prebiotics in advancing livestock immunity through a more favourable gut microbiota composition, increased immunoglobulin levels, lower amounts of disease, and adjustment of cytokine production has been elucidated. The findings show that the supplements contribute positively to the improvement of the immune response, but poultry benefitted the most in terms of increased immunoglobulin levels and improvement of gut microbiota profile, followed by cattle and pig. The decrease in bacterium, virus and parasite infections in the animals is another affirmation of its value in improving disease resistant traits in livestock, and the fact that it works with no reliance on antibiotics. In addition, since the supplements have anti-inflammatory mechanisms, it further supports immune stability and overall health. Based on these discoveries, probiotics and prebiotics should be promoted for livestock production as a sustainable alternative to antibiotics. Further research is warranted to optimize species-based formulations and find long-term implications on productivity and health.

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NOVELTY STATEMENT

The novelty of this paper is that it gives a detailed review of the immunomodulatory activities of probiotics and prebiotics in farm animals, focusing on how they serve as green alternatives to antibiotics. The paper differs from existing research, which has mainly dealt with gut well-being, in that it brings to light the systemic immune effects of these bioactive substances, such as how they affect cytokine production, immunoglobulin concentration, and disease resistance in various livestock species. Through the application of a systematic review and meta-analysis methodology, this study discerns recurring trends in immune boosting and investigates the synergistic promise of synbiotics. The results add to the increasing volume of evidence endorsing probiotics and prebiotics as effective options for enhancing livestock productivity, curbing antibiotic reliance, and supporting sustainable animal farming.

AUTHOR'S CONTRIBUTION

All of the trials were designed by Ranya Sami Nadhim, Haider Falih Shamikh Al-Saedi and Rafal Yousif Salmaan. Ahmed Abdullah Hussein, Rawaa Salim Mumtaz Hommada and Zainab Jamal Hamoodah conducted all of the tests, gathered the data, and composed the manuscript draft. Ali Mohammed Hikmat helped with the data analysis that was done to prepare the work for submission to the journal. The final draft of the work was reviewed and approved by all authors for publication in the Journal of Animal and Health Production.

Ethical consideration

Not applicable.

Generative AI or AI-assisted Technology Statement

The author(s) declare that no Genrative AI was used in the creation of this manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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