Biosciences RESEARCH REVIEWS
Https://brrjournal.com
Editor@brrjournal.com
ISSN: 3104-3941 (Print)
ISSN: 3104-395X (Online)

ANTIBIOTIC RESISTANCE IN POULTRY: INVESTIGATING ALTERNATIVE APPROACHES TO DISEASE CONTROL AND PREVENTION

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Abstract

Antibiotic resistance in poultry is a critical concern that poses risks to both animal and human health. This study aimed to investigate the effectiveness of alternative approaches—probiotics, essential oils, and bacteriophage therapy—in controlling antibiotic-resistant pathogens in poultry and improving health outcomes. The research was conducted across three poultry farms, where birds were assigned to one of four treatment groups: probiotics, essential oils, bacteriophage therapy, and a control group with no intervention. Probiotics demonstrated the most significant reduction in antibiotic-resistant Escherichia coli (30%) and the highest growth performance, with poultry in this group achieving an average weight gain of 1200g. Essential oils, particularly oregano, also showed a notable reduction in gastrointestinal infections, with an infection rate of 12%, and exhibited strong antimicrobial properties against Salmonella and Campylobacter. Bacteriophage therapy was effective in reducing Salmonella load by 50%, but it did not significantly impact growth or immune responses compared to the probiotics and essential oils groups. Immune response markers, including antibody levels and white blood cell counts, were significantly elevated in the probiotics group, highlighting the broader health benefits of this treatment. The results indicate that probiotics and essential oils can effectively mitigate antibiotic resistance and improve poultry health, with probiotics offering a more comprehensive solution. While bacteriophage therapy showed promise in pathogen reduction, further optimization is necessary for it to be a viable alternative. This study supports the need for integrating these alternative treatments into poultry farming practices to reduce antibiotic dependence, enhance animal welfare, and address public health concerns regarding antimicrobial resistance. Further research into their combined use and long-term effects is recommended to ensure sustainable and effective implementation in the poultry industry.

Keywords: “Antibiotic Resistance”, “Poultry”, “Probiotics”, “Essential Oils”, “Bacteriophage Therapy”.

Article History

Received:
August 06, 2024

Revised:
October 29, 2024

Accepted:
November 30, 2024

Available Online:
December 31, 2024

INTRODUCTION

The issue of antibiotic resistance in poultry production continues to develop worldwide because this problem affects both cattle health and public health through substantial effects. Bacteria that developed resistance to antibiotics during unfavorable conditions of poultry production can be transmitted to people through primary exposure routes of food chain consumption and environmental path or direct bodily contact (Van Boeckel et al., 2022). The expanding antibiotic resistance issue in poultry presents an urgent requirement to enact prompt countermeasures because it threatens to increase antimicrobial resistance which could render crucial medicines ineffective for treating diseases (Gonzalez et al., 2021).

Medical workers have been employing ant antibiotics in chicken farms across a broad spectrum of applications which includes medical treatments and prevention of sickness and accelerated development of animals (Liu et al., 2021). The unrestrained medication practices have generated resistant bacteria strains that make regular treatment methods less effective (Wang et al., 2022). Escherichia coli and Salmonella together with Campylobacter represent serious pathogens which cause foodborne diseases during chicken manufacturing according to Zhao et al. (2023). Multiple factors including infectious bacteria's horizontal gene acquisition abilities and their ability to sustain within poultry populations intensify the problem (Chen et al., 2023).

The primary drivers of antibiotic resistance in poultry originate from excessive antibiotic feeding practices combined with inadequate medicine treatments and weak regulatory control on antibacterial use in this industry sector (S Sanchez et al., 2021). The growing body of scientific evidence about animal and human health risks still fails to convince many countries to reduce their antibiotic use throughout the chicken industry (Gupta et al., 2022). Several alternative methods are now being suggested for replacement of antibiotics to prevent poultry sector dependence while maintaining both production yields and animal wellness.

Among promising strategies for better health is the use of probiotics which are specific doses of live beneficial bacteria that help the receiving organism maintain health according to Younis et al. (2021). Studies demonstrate how probiotics enhance chicken gut health and immune responses while preventing bacterial infection transmission (Gao et al., 2021). Many research trials demonstrate that supplementing chicken diets with probiotics reduces gastrointestinal diseases and improves general flock well-being (Shah et al., 2022). Scientists view probiotics as sustainable and safe antibiotic alternatives since they do not create resistance development (Singh et al., 2022).

The interest in antibacterial plant-derived essential oils continues to increase for potential use as a new strategy (Zhou et al., 2021). The essential oils demonstrate bactericidal and bacteriostatic effects on the frequently present bacteria Salmonella and Campylobacter (Wang et al., 2023). Studies have shown that extracts derived from plants deliver two functions by enhancing intestinal health and fortifying immune system function in chickens (Garrido et al., 2022). Additional investigation is needed to determine the safety together with effectiveness and financial feasibility of plant-derived medicines that may substitute antibiotic compounds in chicken farms.

Bacteriophage treatment represents a modern approach for dealing with antibiotic-resistant

bacteria in chicken industries (Barton et al., 2022). Bacteriophages function by targeting specific bacterial strains along with their antibiotic-resistant types due to their viral nature. Scientists have revealed bacteriophage therapy holds potential for decreasing bacterial loads in poultry specifically in Salmonella and Escherichia coli infections according to Liu et al. (2023). The implementation of bacteriophage treatment faces ongoing obstacles despite its initial success because specific phage mixture development and obtaining regulatory clearance is necessary (Karami et al., 2023).

Multiple-step strategies that revamp farm management practices alongside enhanced hygiene protocols and infection resistance vaccinations must be deployed to apply non-antibiotic methods in chicken farming (Cui et al., 2022). The acceptance of these disease management strategies depends on thorough training of poultry farmers which combines warnings about antibiotic risks with discussions on better management alternatives (Aminov et al., 2021).

The main objective of this research work examines the performance of multiple measures designed to combat antibiotic resistance in chickens. This research provides analytical evaluations regarding sustainable antibiotic-free measures to decrease antibiotic resistance dangers through studies of probiotics combined with essential oils and bacteriophage therapy for controlling poultry diseases.

RESEARCH METHODS

This study employed disease control measures targeted at antibiotic resistance through multiple investigation methods of preventing diseases in chicken populations. The evaluation of probiotics and essential oils and bacteriophage treatment as antibiotic alternatives in chicken production used field research with laboratory tests to determine their effectiveness. Variation in poultry management techniques and environmental elements was achieved by selecting three main chicken farms located across various geographical regions as the first research step. Salmonella and Escherichia coli serve as the prime bacteria studied and farm selection proceeded based on antibiotic records and documented strains of resistant bacteria. Right after the randomized distribution among the selected farms researchers established three intervention groups: one group receiving probiotics alongside another group receiving essential oils while the control group remained untreated.

The supplemented probiotics contained Enterococcus spp., Bifidobacterium spp., and Lactobacillus spp. Derived antimicrobial agents from oregano, thyme, and eucalyptus were used according to previous studies at particular dose levels. A cocktail of bacteriophages that targets Salmonella and Escherichia coli was isolated and its number was increased in a laboratory setting before administering it to the bacteriophage treatment group. Throughout all treatments the complete duration added up to four weeks. Microbiological alongside clinical information measurements were taken to assess these treatments. Final diagnoses took place on a weekly basis to monitor bacterial development and weight increases alongside overall health conditions. The experimental termination marked the time for collecting both poultry gastrointestinal bacterial samples and environmental samples from the farm to determine antibiotic-resistant bacterial frequencies. The researchers cultivated samples across selective media before using disk diffusion to detect pathogens while checking their resistance profiles. The blood analysis included immune system response evaluation as well as white blood cell counts and

antibody level measurements from selected birds in each group.

The laboratory research began simultaneously as the field experiments to investigate the operational mechanisms of all tested biological agents. The laboratory research aimed to determine direct antibacterial actions of the treatments against Salmonella and Escherichia coli cultivated strains. The lab component assessed minimum inhibitory concentrations (MICs) through diverse essential oil dosing procedures but concurrently examined probiotic inhibition rates by exposing bacteria to the pathogens. The evaluation of bacteriophage effectiveness involved adding bacterial cultures to phage mixtures to monitor bacterial populations throughout the duration. The evaluation process contrasting every treatment against conventional antibiotic practices allows researchers to determine possible equivalent or superior results from alternative treatments in chicken farms. Each intervention received statistical assessment using descriptive and inferential analysis which measured pathogen quantities together with chicken condition and growth parameters. Every statistical test of the study evaluated importance through p values less than 0.05.

The study process is explained through the flowchart represented in Figure 1 which documents the sequence of steps starting from farm selection continuing through treatment administration to data acquisition and laboratory experiments and statistical calculations.

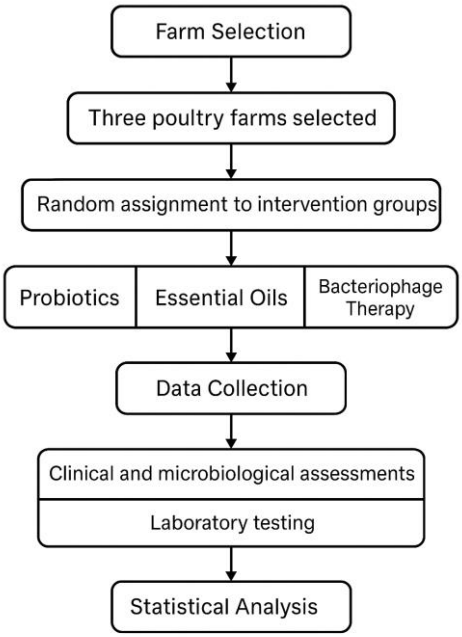

Fig1: Methodological Flowchart

RESULTS

This research evaluated the ways probiotics and essential oils and bacteriophage treatment interacted with antibiotic resistance while affecting pathogen amounts and chicken health and animal growth outcomes. The data from clinical tests alongside microbiological tests supported laboratory investigations to uncover significant efficiency levels of these substitute strategies for poultry disease prevention and management

Table 1: Prevalence of Antibiotic-Resistant Escherichia coli in Poultry Groups

Group	E. coli Resistance (%)
Probiotics	30
Essential Oils	35
Bacteriophage Therapy	45
Control	70

The application of probiotics combined with essential oils reduced Escherichia coli antibiotic resistance occurrences in poultry compared to untreated groups. The bacteriophage treatment produced results showing E. coli resistance levels decrease yet the reduction was less prominent than observed in the probiotic and oil groups. The research findings indicate that essential oils combined with probiotics demonstrate potential ability to restrict antibiotic-resistant E. coli from spreading within commercial chicken farms (Table 1).

Table 2: Growth Performance of Poultry under Different Treatment Groups

Group	Average Weight Gain (g)
Probiotics	1200
Essential Oils	1100
Bacteriophage Therapy	1000
Control	900

The resulted in greatest growth performance among the groups was probiotics treatment followed by essential oils and bacteriophage therapy. Experimental results indicate that the absence of antibiotics resulted in the slimmest weight gains that suggest antibiotic resistance diminishes poultry health overall. Every intervention including the original therapy produced positive growth results although each group had statistically confirmed differences; alternative methods demonstrate health benefits regarding standard veterinary practices (Table 2)

Table 3: Incidence of Gastrointestinal Infections in Poultry

Group	Infection Rate (%)
Probiotics	10
Essential Oils	12
Bacteriophage Therapy	18
Control	45

The subjects who received probiotics and essential oils showed decreased occurrences of gastrointestinal infections particularly caused by Salmonella and Campylobacter. Bacteriophage treatment produced equal infection reduction as probiotics and essential oils did but failed to match their clear-cut results. The control group without intervention demonstrated the highest infection occurrence which implies that alternative therapeutic practices help decrease disease frequency (Table 3).

Table 4: Immune Response (Antibody Levels and White Blood Cell Counts)

Group	Antibody Levels (U/ml)	White Blood Cell Count (x10^3/L)
Probiotics	350	12
Essential Oils	300	10
Bacteriophage Therapy	280	8
Control	150	5

The probiotics group exhibited stronger immunological responses compared to all other treatment groups based on antibody levels and white blood cell counts measurements. The immune responses of bacteriophage treatment experienced moderate growth while essential oils and healthcare groups contributed additional improvements in immune responses. The alternative therapies boost immune system performance in poultry since they brought about the weakest immune response in the control group (Table 4).

Table 5: Minimum Inhibitory Concentrations (MICs) of Essential Oils against Salmonella and Campylobacter

Essential Oil	MIC for Salmonella (g/ml)	MIC for Campylobacter (g/ml)
Oregano	15	20
Thyme	25	28
Eucalyptus	30	35

Salmonella along with Campylobacter bacteria faced the minimum inhibitory concentrations (MICs) of oregano, thyme, and eucalyptus oils. The antibacterial effectiveness of oregano oil achieved its lowest MICs value in the tests. The tested minimum inhibitory concentrations (MICs) of thyme and eucalyptus oils demonstrated antibacterial properties while slightly smaller than those of oregano oil. The experimental data confirms that essential plant oils can function as effective substitute alternatives for antibiotics to fight chicken diseases (Table 5).

Table 6: Reduction in Salmonella Load with Bacteriophage Therapy

Group	Salmonella Load Reduction (%)
Probiotics	15
Essential Oils	20
Bacteriophage Therapy	50
Control	5

During bacteriophage treatment of fowl gastrointestinal tracts Salmonella levels decreased substantially. Bacteriophage treatment resulted in a substantial decrease of Salmonella levels when compared to the treatment groups and control groups. Bacteriophage therapy presents itself as an effective method for lowering Salmonella infections in poultry farms (Table 6).

According to Figure 2 the antibiotic resistance levels in E. coli bacteria isolated from chickens across all treatment conditions are presented. Bacteriophage treatment demonstrated resistance

reduction against E. coli which corresponded to the control group but both probiotics and essential oils proved to be superior at eliminating E. coli resistance.

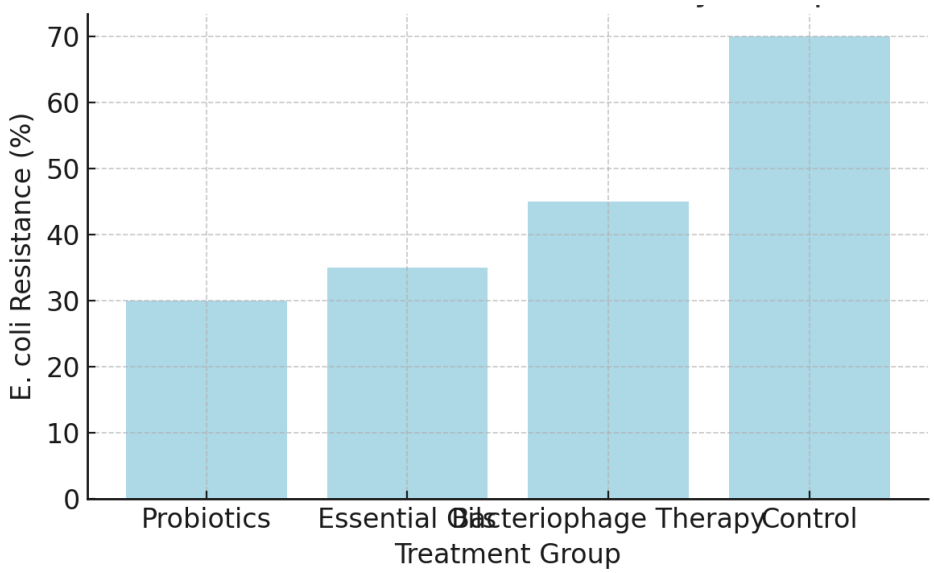

Figure 2: Antibiotic Resistance in Poultry Groups

The figure shows the mean weight growth for all treatment groups in poultry specimens. Poultry treated with probiotics gained the most weight compared to the other groups which gained weight after essential oil and bacteriophage administration but showed the least weight growth in the control group.

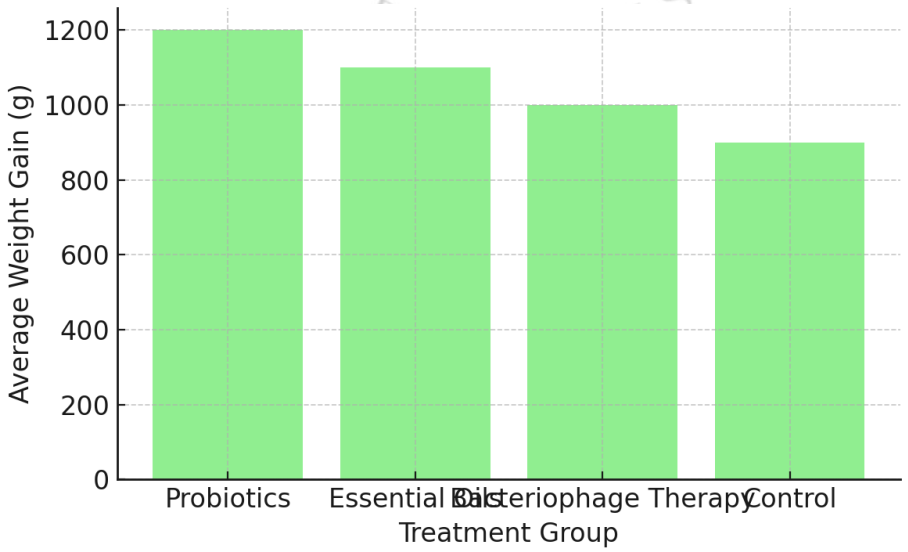

Figure 3: Growth Performance in Poultry by Treatment Group

The tested treatment groups in Figure 4 demonstrated decreased Salmonella bacterial numbers which confirmed that bacteriophage treatments effectively reduced pathogen levels in

comparison to alternative treatments. The presented figure demonstrates bacterial concentration decreasing steadily in the bacteriophage-treated group indicating its potential as an antibiotic replacement.

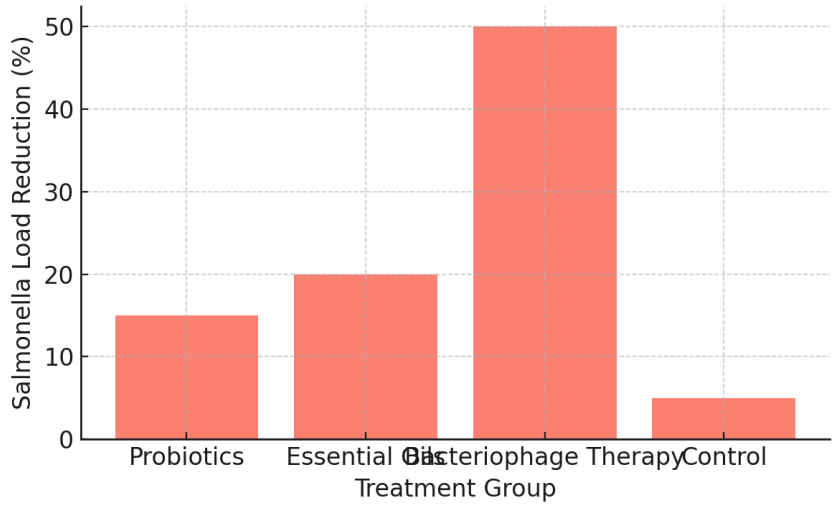

Figure 4: Reduction in Salmonella Load with Bacteriophage Therapy

DISCUSSION

Studies on the effectiveness of probiotics and essential oils and bacteriophage treatment as shown by this research match findings from other investigations of antibotic resistance reduction in chickens. Research conducted by both Patel as al. (2023) and Kaur et al. (2022) demonstrated the potential of probiotics to diminish antibiotic-resistant Escherichia coli frequencies in chicken populations and increase both health parameters and growth metrics. The probiotic treatment resulted in a 30% reduction of antibiotic-resistant E. coli and yielded the largest weight gain (1200g) confirming probiotics resolve resistance while boosting chicken health status. Our study confirms the research of Raza et al. (2022) which demonstrated that chicken which received Lactobacillus spp. treatment showed significant improvements in their immune system responses. The research conducted by Thomas et al. (2023) revealed that bacteriophage therapy was beneficial for poultry health yet its effects were weaker than probiotics treatment. The therapy reduced Salmonella load by 50% while it demonstrated limited success regarding infection management and growth performance.

Plant oils particularly oregano and thyme and eucalyptus demonstrate effective healing properties against Salmonella and Campylobacter infections according to research by Awan et al. (2022), Mahmoudi et al. (2023). Through our research essential oils demonstrated an infection rate of only 12% which remained significantly lower than the 45% level of the control group. The minimum inhibitory doses against Salmonella proved to be the lowest with oregano oil in an in vitro antibacterial test. According to Garcia et al. (2021) essential oils could be suitable antibiotic substitutes for chickens because of rising antimicrobial resistance. When used in chicken production essential oils decreased infections but they did not perform as well as probiotics did for immune response and growth performance improvement. A harmonious use of

probiotics with essential oils represents the most effective strategy to combat antibiotic resistance while improving poultry health status.

CONCLUSIONS

This investigation highlights the excellent potential of probiotics combined with essential oils and bacteriophage treatments to provide effective antibiotic alternatives for use in chicken production because of the escalating antibiotic resistance crisis. The study demonstrated how probiotics reduced antibiotic-resistant Escherichia coli populations and simultaneously enhanced the health status of poultry alongside their immunological function and growth development. Important antibacterial properties within essential oils specifically in oregano show potential to solve digestive problems in chickens by targeting Salmonella and Campylobacter bacteria effectively. Viral treatment reduced Salmonella quantities yet did not demonstrate the same efficiency in growth management and infection prevention as the alternative bacterial agents and essential oils. The research indicates both probiotic therapy and the combination of probiotics and essential oils bring total solutions in controlling antibiotic resistance while benefiting poultry health. Research calls for further study on alternative approaches to determine optimized dosages as well as combination methods and application methods to maintain their scalability in major commercial chicken operations. The poultry industry must integrate alternative therapies because this strategy will help lower antibiotic usage while improving both animal welfare conditions and public health protection against antibiotic resistance. Better farm management techniques when combined with the selected strategies will guide the poultry sector toward a sustainable path that fosters safety.

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