

Advances in Biological Prevention and Control of Chicken Salmonellosis: Postprint

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Abstract

Avian salmonellosis poses a serious threat to the global poultry industry, causing enormous economic losses. Enhanced biosecurity control, disease eradication, Salmonella vaccination, and antibiotic prophylaxis and treatment have played important roles in the prevention and control of avian salmonellosis. However, with the emergence of drug-resistant Salmonella strains and the prominent issue of antibiotic residues in poultry products, there is an urgent need for new preventive approaches to replace antibiotics in the prevention of salmonellosis. This article first describes the epidemic strains of Salmonella in chickens and their epidemiological characteristics, as well as the host's immune clearance mechanisms against Salmonella, and then focuses on reviewing recent research progress regarding functional feed additives and feed and water treatment in the prevention and control of Salmonella infection in chickens.

Full Text

Progress on Biological Prevention and Control Strategies in Avian Salmonellosis

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Abstract: Avian salmonellosis poses a serious threat to the global poultry industry, causing tremendous economic losses. While strengthening biosecurity prevention and control, disease eradication, Salmonella vaccination, and antibiotic prophylaxis and treatment have played important roles in controlling chicken salmonellosis, the emergence of antibiotic-resistant Salmonella strains and concerns about antibiotic residues in poultry products have created an urgent need for novel antibiotic alternatives. This review first summarizes the

epidemic Salmonella strains and their epidemiological characteristics, as well as the host immune clearance mechanisms against Salmonella. It then focuses on recent research progress regarding functional feed additives and feed/drinking water treatments for preventing and controlling Salmonella infection in chickens.

Keywords: salmonellosis; chicken; biological control and prevention; feed additives

1.1 Epidemic Salmonella Strains and Characteristics in Chickens

Salmonella are Gram-negative bacteria with blunt ends, lacking spores and generally lacking capsules. Except for *Salmonella pullorum* and *Salmonella gallinarum*, other serotypes possess peritrichous flagella and represent significant foodborne pathogens. Currently, approximately 2,555 Salmonella serotypes have been identified that can cause gastroenteritis in humans and livestock. Salmonella lack host specificity and can infect humans, livestock, and poultry, making salmonellosis a major zoonotic disease. Jackson et al. reported that over 80% of salmonellosis cases in the United States between 1998 and 2008 were directly associated with Salmonella contamination in eggs and chicken meat.

From the perspective of transmission routes in poultry production, Salmonella spread primarily through three pathways: First, infection occurs through contact with contaminated environments, cages, equipment, and drinking water. Second, flocks become infected by consuming contaminated feed, mainly caused by rodents such as mice and flies that pollute the feed. Third, infected breeder chickens can develop systemic and persistent infections after Salmonella invades from the intestine. Salmonella can enter the ovary, or cecal Salmonella can retrograde to the vagina during severe disease, causing oviduct infection. This leads to internal or surface contamination of eggs within the oviduct during oviposition. If egg disinfection is inadequate, Salmonella infection and disease can occur in progeny chicks.

The main pathogenic Salmonella species harming poultry production include *Salmonella pullorum* (SP), *Salmonella enteritidis* (SE), *Salmonella typhimurium* (ST), and *Salmonella gallinarum* (SG). These pathogens cause diseases such as white diarrhea, gastrointestinal inflammation, splenitis, hepatitis, avian typhoid, and oviduct infection, resulting in decreased immune function, reduced growth rate, increased mortality, and contamination of poultry products like eggs and chicken meat that threaten human health.

1.2 Host Immune Clearance Mechanisms Against Salmonella in Chickens

Understanding the immunomodulatory mechanisms following Salmonella infection at the molecular and cellular levels is crucial for developing novel strategies to prevent and control Salmonella colonization and invasion in broilers and

layers. When chickens are infected with *Salmonella*, both innate immunity (primarily heterophils, macrophages, and dendritic cells) and adaptive immunity (mainly cellular and humoral immunity) play vital roles in *Salmonella* recognition and clearance.

During the initial stage of infection, heterophils and macrophages mediate innate immune responses. After *Salmonella* enters the chicken through the digestive tract, it is first recognized by pattern recognition receptors in the cecum, such as Toll-like receptors (TLR)-2, TLR-4, TLR-5, TLR-15, and TLR-21. This activates the nuclear factor-kappa B (NF- κ B) signaling pathway, stimulating increased expression of innate immunity-related pro-inflammatory cytokines and chemokines, including interleukin (IL)-1, IL-6, IL-8, IL-17, IL-18, IL-22, interferon- γ (IFN- γ), tumor necrosis factor-inducible protein, and inducible nitric oxide synthase. Additionally, expression of antimicrobial molecules such as antimicrobial peptides-1 and -2, defensins-1, -2, and -7, lysozyme, complement 3, and mucin-2 is significantly upregulated. Simultaneously, dendritic cells present antigens to T lymphocytes, activating cellular immunity, primarily a Th1-type response that produces CXCLi1, CXCLi2, and IFN- γ . This promotes massive infiltration of heterophils, macrophages, and dendritic cells at the infection site, producing bactericidal substances like nitric oxide and reactive oxygen species that enhance innate immune clearance.

During the later stage of infection (after 14 days), cellular immune responses gradually weaken while humoral immune responses increase, producing large amounts of immunoglobulin (Ig)G and IgA that assist in clearing *Salmonella* from the intestine and visceral organs. Therefore, new prevention and control strategies must enhance host innate and cellular immune functions to improve *Salmonella* clearance efficiency.

Although antibiotics can effectively control *Salmonella* infection in chicken flocks, this practice increases the risk of antibiotic residues in eggs and tissues or the emergence of multidrug-resistant bacteria. Consequently, novel biocontrol methods are urgently needed. Given the complexity of salmonellosis epidemiology in chickens, comprehensive practical solutions must be established based on bacteriological and serological detection results. While environmental sanitation and disinfection play partial roles in controlling *Salmonella* infection and colonization, only combined measures such as functional feed additives, feed heating or disinfection, drinking water treatment, egg disinfection, or vaccination can effectively prevent and control salmonellosis. This review focuses on recent research progress regarding functional feed additives and feed/drinking water treatments for preventing and controlling *Salmonella* infection in chickens.

2.1.1 Probiotics

Direct administration of probiotics or their cultures to livestock and poultry through feed or drinking water represents a potential intervention to reduce

pathogen colonization and invasion in the animal intestine. Probiotics compete with pathogens for intestinal binding sites, preventing pathogen adhesion and colonization; compete for nutrients; secrete antimicrobial substances such as hydrogen peroxide, volatile fatty acids (lactic, acetic, and butyric acids), and specific bacteriocins that inhibit pathogen growth and reduce expression of virulence genes related to pathogen invasiveness; and exert immunostimulatory effects that promote intestinal immune maturation and secretion of antimicrobial substances. These mechanisms create an intestinal environment unfavorable for pathogen survival, substantially reducing colonization and invasion of harmful microorganisms like *Salmonella*, *Clostridium perfringens*, and *Campylobacter*. Numerous experimental and clinical studies have demonstrated that probiotics can accelerate the establishment of normal chicken gut microbiota and restore disrupted microbial balance, not only enhancing host resistance to *Salmonella* infection but also improving poultry production performance.

Van Coillie et al. isolated lactic acid bacteria including *Lactobacillus salivarius*, *L. acidophilus*, *L. reuteri*, *L. plantarum*, and *L. rhamnosus* from the ceca, oviducts, and vaginas of healthy hens, finding they all strongly inhibited *Salmonella*. Sornplang et al. reported that supplementing 1-day-old chicks with *L. salivarius* in feed and drinking water significantly reduced SE infection, primarily by stimulating the immune system—activating innate immunity through heterophil stimulation, enhancing phagocytic activity and index to kill pathogens. However, Andreatti et al. reported that inoculating chicken embryos with *L. salivarius* via air sac did not significantly improve intestinal or liver SE infection within 2 days post-hatching and actually reduced hatchability.

Zhang et al. reported that *L. reuteri* ATCC 55730 produces reuterin, and in vivo trials showed it significantly improved survival rates in SP-infected chickens. Van Coillie et al. also reported that orally inoculating newly hatched chicks with 2×10^8 CFU of *L. reuteri* R-17485 or *L. johnsonii* R-17504 reduced SE numbers in ceca, liver, and spleen by 90% compared to controls six days after challenge (10 CFU per bird). However, other studies found that *L. johnsonii* supplementation did not inhibit SE colonization in poultry.

Other probiotics such as *Enterococcus faecium* and *Bacillus subtilis* also exhibit strong antibacterial capacity. Karaffová et al. reported that *E. faecium* AL41 reduced SE numbers in broiler intestines by regulating intestinal transforming growth factor-4 and IL-17 gene expression and upregulating secretory immunoglobulin A (sIgA) expression. *E. faecium* EF55 also inhibited SE colonization by regulating intestinal mucin expression. Additionally, *B. subtilis* spores can competitively exclude SE, *E. coli*, and *C. perfringens* from young chicken intestines. Vilà et al. reported that dietary supplementation with *Bacillus* spores (100 mg/kg) reduced *Salmonella* positivity rates by 42% in broilers and 25% in layers.

Combined use of multiple probiotics demonstrates synergistic effects and enhanced antibacterial efficacy. Carter et al. reported that combined use of *L. salivarius* 59 and *E. faecium* PNX33 improved poultry production performance,

reduced intestinal acidity, protected intestinal mucosal barrier integrity, and significantly reduced SE colonization and invasion, with superior effects compared to single-strain supplementation. Filho et al. reported that a probiotic product containing four lactic acid bacteria strains (*L. acidophilus*, *L. fermentum*, *L. reuteri*, and *L. salivarius*) administered to 1-day-old SE-susceptible White Leghorn pullets significantly reduced SE infection-induced inflammatory responses by modulating TLR-NF- κ B signaling pathway expression of pro- and anti-inflammatory cytokines, alleviating intestinal tissue damage and reducing SE colonization.

Kerr et al. comprehensively evaluated probiotic products for reducing cecal Salmonella colonization in farm chickens, assessing publication year, experimental design, probiotic characteristics (strain source, composition, concentration, and combination with other additives), administration route and duration, infection characteristics (Salmonella strain type, dose, route, age, frequency, and program), chicken breed, sampling (time, organs, and methods), detection methods, clearance criteria, and reproducibility. Their findings indicated: (1) Numerous commercial probiotic products such as PreemptTM, Aviguard®, FM®-B11, Primalac®, Broilact®, Avian Pac Plus, and competitive exclusion products containing lactic acid bacteria significantly reduced intestinal Salmonella colonization and cecal Salmonella counts when used long-term in diets. (2) Commercial products like Aviguard®, FM®-B11, Primalac®, MSC, Avifree, and probiotic composites with clearly defined strains containing lactic acid bacteria resulted in significantly higher intestinal Salmonella carrier rates compared to products with undefined strains. The authors attributed decreased efficacy to three main factors: (1) initial product design lacking key strains or components for Salmonella inhibition; (2) development of Salmonella resistance during long-term use with unchanged strains; and (3) the four main Salmonella types infecting chickens (SP, SE, ST, and SG) showing differential susceptibility to probiotics.

2.1.2 Prebiotics and Polysaccharides

Prebiotics are indigestible feed components in the anterior digestive tract, primarily oligosaccharides that resist enzymatic and acidic degradation, reaching the hindgut to serve as fermentation substrates for beneficial bacteria like lactobacilli and bifidobacteria, thereby modulating intestinal microbial structure. As potential inhibitors of pathogen colonization, prebiotics primarily exert antibacterial effects through competitive exclusion or formation of antimicrobial metabolites such as lactic acid, propionic acid, and bacteriocins. Common prebiotics include mannan-oligosaccharide (MOS), fructooligosaccharide (FOS), xylooligosaccharide (XOS), and galacto-oligosaccharide (GOS). MOS can adhere to bacterial fimbriae, preventing pathogen adhesion to host intestinal epithelial cells. Pourabedin et al. reported that both MOS and XOS reduced cecal Salmonella counts and enhanced chicken resistance to SE infection by modulating intestinal cytokine expression, microbial community structure, and microbial metabolism. Shang et al. found that dietary supplementation with

0.5% FOS improved intestinal mucosal morphology in SE lipopolysaccharide (LPS)-challenged broilers, enhanced cytokine expression (IL-1, IL-10, and IFN- γ), and increased LPS-specific antibody synthesis, thereby reducing intestinal Salmonella colonization and protecting intestinal health. Hughes et al. observed that 1% GOS supplementation in SE- and ST-challenged chicks reduced Salmonella counts, though differences were not significant at trial completion. However, GOS altered cecal tonsil gene expression and cecal microbiome, indicating its potential as an intervention against Salmonella colonization.

The simultaneous application of prebiotics and probiotics is defined as synbiotics. Totton et al., after reviewing numerous studies on prebiotics reducing cecal Salmonella, found that dietary or water-administered prebiotics could reduce cecal Salmonella counts, but results were highly variable with inconsistent conclusions, showing limited overall reduction and weak effects. Combined use of prebiotics and probiotics demonstrated superior effects compared to prebiotics alone. Other studies also confirmed that synbiotics were more effective than probiotics or prebiotics alone in promoting poultry growth and reducing Salmonella counts.

In addition to typical prebiotics, atypical prebiotic substances with similar physiological functions exist, among which polysaccharides (primarily non-starch polysaccharides) are notable. These also resist enzymatic hydrolysis in the anterior digestive tract and serve as fermentation substrates in the cecum. Brufau et al. reported that β -galactomannan improved intestinal morphology in Salmonella-infected broilers, increased goblet cell numbers and mucin secretion, and enhanced anti-Salmonella capacity, likely through promoting beneficial bacterial growth and increasing mucin expression. Feye et al. found that feeding XPC (a yeast culture product rich in β -glucan and mannan) significantly reduced fecal excretion of multidrug-resistant ST and suppressed expression of invasion-related gene *hilA* and antibiotic resistance genes. Shao et al. reported that dietary supplementation with 0.02% yeast glucan significantly enhanced Salmonella clearance by modulating endogenous antimicrobial peptide expression.

2.1.3 Organic Acids, Nitro Compounds, and Feed Acidifiers

Organic acids have been used as feed additives since the 1960s, though trial results vary considerably depending on formulation composition, dosage, administration duration, target animals, and experimental design. Studies have shown that both short-chain and medium-chain fatty acids can reduce Salmonella colonization in poultry intestines or visceral organs by modulating invasion-related gene expression, though antibacterial efficacy varies with acid concentration and animal model. Cerisuelo et al. reported that dietary supplementation with 1 g/kg sodium butyrate and 50 mg/kg essential oils significantly reduced cecal Salmonella colonization in broilers. In vitro studies confirmed that butyric acid downregulates expression of Salmonella invasion-related genes *hilD* and *hilA*, thereby suppressing Salmonella pathogenicity island I gene expression and

reducing invasiveness and colonization capacity. Machado Junior et al. found that supplementing broiler feed and water with organic acid and oregano extract combinations (0.20% or 0.08%) rendered cecal contents Salmonella-negative 22 days post-SE infection. Evans et al. reported that medium-chain fatty acid supplementation at 3 g/kg in turkey poults significantly reduced cecal Salmonella counts. Van Immerseel et al. demonstrated that dietary supplementation with 3 g/kg caproic acid significantly reduced SE numbers in intestines and visceral organs, with medium-chain fatty acids like caproic acid, caprylic acid, and capric acid decreasing *hilA* gene expression closely associated with Salmonella invasiveness. Kollanoor-Johny et al. reported that dietary caprylic acid supplementation at 0.7% or 1.0% significantly reduced Salmonella counts in small intestine, cecum, cloaca, liver, and spleen, with in vitro studies showing caprylic acid downregulated *hilA* and *hilD* expression, reducing Salmonella invasiveness by 80%. Raeisi et al. found that laurate also significantly inhibited ST growth in vitro. However, some studies showed limited inhibition of intestinal Salmonella by lactic and acetic acids.

Administration method also affects efficacy. Fernández-Rubio et al. reported that feeding plant fat-coated butyrate more effectively reduced Salmonella colonization in crop and intestine, decreased Salmonella translocation to liver, and downregulated invasion-related genes compared to uncoated butyrate, likely due to slow release during digestion, longer retention time, greater delivery to the hindgut, and more sustained antibacterial activity. Beyond downregulating virulence gene expression, organic acids may also alter intestinal pH, osmotic pressure, and bacterial membrane permeability, though the relationship between these changes and antibacterial function requires further investigation.

Nitro compounds also exhibit broad-spectrum antibacterial activity, particularly nitropropanol, which inhibits ST, *Campylobacter*, *E. coli*, and *Listeria* growth. Adhikari et al. reported that dietary supplementation with 100-200 mg/kg nitroethanol or nitropropanol significantly prevented and reduced Salmonella infection in intestinal and visceral organs of laying hens (45 weeks old), modulated inflammatory cytokine expression, and suppressed intestinal inflammation, indicating nitro compounds as potential feed additives for Salmonella control.

Feed acidifiers effectively kill pathogens in contaminated feed, ensuring feed safety. For example, treating feed with 1% formic and propionic acid mixture (80:20) for 48-120 hours significantly reduced Salmonella counts, outperforming single acids, with better efficacy at room temperature (23°C) than at low temperatures (5°C and 1°C). Multiple organic acid mixtures showed significant Salmonella-killing effects in feed, increasing with dosage (1%-7%). Factors affecting acidifier efficacy include temperature, dosage, feed type, humidity, and treatment duration. While higher dosages enhance killing effects, they may destroy heat-labile nutrients like vitamins, reduce palatability, and corrode production equipment, necessitating optimal dosage levels.

2.1.4 Plant Extracts

Plant extract feed additives contain bioactive secondary metabolites including terpenoids, glycosides, polyphenols, essential oils, and alkaloids, exhibiting antimicrobial, antioxidant, immunostimulatory, microbiota-balancing, and intestinal development-promoting functions. Rajani et al. found that pine wood extract supplementation (0.1%, 0.2%, and 0.3%) in ST-challenged broilers significantly reduced ST colonization in ileum, cecum, and liver, with 0.2% showing optimal effects. Upadhyaya et al. reported that dietary trans-cinnamaldehyde (1.0%-1.5%) in laying hens significantly reduced SE numbers in eggshell and yolk, as well as in cecum, liver, and oviduct. In vitro studies showed trans-cinnamaldehyde significantly reduced Salmonella adhesion and invasion of chicken oviduct epithelial cells and decreased Salmonella survival in macrophages. Varmuzova et al. found that dietary turmeric and scutellaria extracts significantly reduced Salmonella counts in cecum, liver, and spleen of SE-infected layers while decreasing expression of inflammatory cytokines (IL-1, IL-8, IL-17, IFN- γ , inducible nitric oxide synthase) and yolk immunoglobulin (IgY).

Plant extracts directly inhibit Salmonella by affecting multiple genes related to invasion, colonization, and cell membrane components. Studies showed that dietary trans-cinnamaldehyde (0.50% and 0.75%) or eugenol (0.75% and 1.00%) significantly reduced cecal Salmonella counts in SE-infected broilers. Trans-cinnamaldehyde did not affect body weight gain or feed intake, while eugenol significantly reduced weight gain. In vitro studies revealed both compounds significantly reduced Salmonella colonization and invasion by downregulating motility genes (*motA*, *flhC*) and invasion genes (*hilA*, *hilD*, *invF*). Additionally, they downregulated flagellar motility, invasion and pathogenicity island I-related genes, cell transport systems, outer membrane proteins, cell metabolism, and biosynthesis pathways in Salmonella PT8, while stimulating transcription of heat shock protein genes (*dnaK*, *dnaJ*, *ibpB*, *ibpA*). Amerah et al. reported that dietary supplementation with essential oil blends (cinnamaldehyde and thymol) combined with xylanase significantly reduced intestinal Salmonella colonization and horizontal transmission compared to essential oils alone.

2.1.5 Bacteriophages

Bacteriophages are natural viruses that infect and replicate within specific bacteria. Based on their destructive capacity, phages are classified as either temperate (integrating their genome with host DNA and replicating without lysing the cell) or lytic (destroying host DNA, replicating, and lysing the cell to release progeny phages). Phages exhibit strong specificity, targeting individual strains below the species level, sometimes only specific strains within a bacterial population. Wong et al. reported that a lytic ST phage (ST1) isolated from chicken feces effectively reduced ST counts in chicken cecum and visceral organs, facilitating Salmonella biocontrol. Adhikari et al. found dietary phage supplementation (0.2%) significantly reduced Salmonella counts and positivity rates

in cecum, liver, and spleen of SE-infected layers. Bardina et al. reported that a three-phage cocktail (UAB_Phi20, AB_Phi78, and UAB_Phi87) significantly reduced Salmonella counts in cecum of ST-infected layers. However, phage application faces significant limitations. Oral administration requires acid resistance to survive passage through the stomach and small intestine while maintaining sufficient concentrations at pathogen colonization sites. Additionally, to avoid adverse effects on commensal microbiota, narrow-spectrum phages targeting specific pathogens must be screened. Further research is needed to resolve these issues for widespread phage application.

2.1.6 IgY

IgY is an immunoglobulin secreted by B lymphocytes in vaccinated laying hens that specifically binds antigens. The specific immunoglobulin accumulates in oocytes when circulating through the ovary, eventually forming IgY during egg development. IgY provides passive immune protection for newborn chicks and serves as a green therapeutic agent for preventing and treating avian digestive diseases. Yang et al. reported that dietary IgY supplementation (0.1%) in chicks increased daily weight gain, immune organ weights, serum immune molecule levels, and intestinal sIgA content, effectively resisting Salmonella infection. Li et al. showed that oral administration of ST-specific IgY in mice alleviated intestinal mucosal inflammation and reduced ST-induced intestinal damage, demonstrating IgY's inhibitory effect on Salmonella. However, challenges including strain selection during IgY production, stability protection, and contamination prevention limit its large-scale application as a functional feed additive.

2.1.7 Other Additives

Other feed additives such as antimicrobial peptides and minerals also prevent Salmonella infection. Kogut et al. reported that oral administration of 12-48 mg/kg BT cationic antimicrobial peptides (produced by Gram-positive cells) stimulated and enhanced early innate immunity in chicks, increasing resistance to SE infection. In another study, Kogut et al. found BT cationic antimicrobial peptides significantly upregulated expression of TLR4, TLR15, TLR21, pro-inflammatory cytokines (IL-1, IL-6, IL-18, IFN), and chemokines (CxCLi2) in SE-infected chicken cecum, enhancing immunity against SE. Additionally, dietary zinc-bearing clinoptilolite inhibited SP colonization in chicken intestines, likely through bacterial and toxin adsorption. Limited research on these additives stems from variable antibacterial efficacy, unclear mechanisms, or low economic returns.

2.2 Feed Treatment

2.2.1 Dry Heat Treatment Contaminated feed represents a major source of Salmonella and *E. coli* introduction in livestock production, with moisture content being critical for Salmonella survival. Dry heat treatment reduces feed moisture, effectively decreasing Salmonella contamination. Jones et al. reported

that dry heat treatment of feed at 80-85°C for 1 minute killed most Salmonella. However, recent research on dry heat treatment is scarce, and this method cannot completely eliminate pathogens. Excessive temperatures may destroy heat-labile nutrients like vitamins and fatty acids, and feed is vulnerable to secondary contamination during transport, limiting treatment effectiveness.

2.2.2 Microbial Fermentation Microbial feed fermentation is a current research focus that combines probiotic addition and feed acidification advantages. During fermentation, nutrients indigestible to the host are broken down into absorbable small molecules, improving feed digestibility. Park et al. reported that dietary supplementation with 0.2% *Lactobacillus*-fermented ginger stem in SG-challenged broilers significantly increased feed intake and body weight while decreasing mortality, serum IgA and IgG levels, and cecal Salmonella colonization. Ashayerizadeh et al. found that feeding broilers rapeseed meal fermented with *L. acidophilus*, *B. subtilis*, and *Aspergillus niger* significantly increased intestinal lactobacilli counts, reduced ST numbers in ileum and cecum, decreased ST invasion of visceral organs, and improved body weight and feed conversion ratio. These results demonstrate the positive role of fermented feed in controlling Salmonella infection.

2.3 Drinking Water Treatment

Microbial water quality in poultry production systems is a critical component and major risk factor for pathogen transmission. Treatment with chlorine preparations, chlorine dioxide, organic acids, peracetic acid, or hydrogen peroxide reduces Salmonella and *E. coli* counts and biofilm formation, with active ingredients exerting antibacterial effects after ingestion. Bourassa et al. found that adding 1 mL/L formic acid to drinking water and 2 g/kg propionic acid to feed reduced cecal ST counts by 25% in challenged broilers. Pathogen biofilms enhance resistance to antibiotics and host immune responses, increasing virulence, and can form in poultry water lines, posing serious health threats. Studies reported that commercial organic acid products and lactic acid inhibited ST biofilm formation.

2.4 Carrier Animal Management

Carrier animals such as rodents and sparrows in farms and feed mills represent important sources of Salmonella contamination for poultry and feed. Regular disinfection and rodent control in chicken houses and feed storage facilities, along with comprehensive carrier animal prevention and management measures, are essential for preventing Salmonella introduction and spread.

3 Summary

In summary, although numerous interventions have been studied for preventing and controlling avian salmonellosis, their practical application shows high

variability, with some demonstrating inferior clearance compared to sensitive antibiotics or incomplete elimination. Combined measures prove more effective than single interventions, though resistance development remains a concern. Therefore, integrated control strategies combining multiple biocontrol methods with biosecurity and improved management practices are necessary to guide safe poultry production.

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