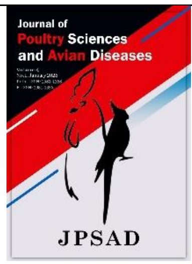
Journal of Poultry Sciences and Avian Diseases

Journal homepage: www.jpsad.com



The Role of Aspirin and Its Derivatives in Enhancing Broiler Health and Performance: A Comprehensive Review

Yadollah Badakhshan[1*], Arsalan Barazandeh[1], Morteza Mokhtari[1]

[1] Department of Animal Science, Faculty of Agriculture, University of Jiroft, Jiroft, Iran

*** Corresponding author email address**: y.badakhshan@ujiroft.ac.ir

Article Info

Article type:
Review Article

How to cite this article:
Badakhshan, Y., Barazandeh, A., & Mokhtari, M. (2026). The Role of Aspirin and Its Derivatives in Enhancing Broiler Health and Performance: A Comprehensive Review. *Journal of Poultry Sciences and Avian Diseases*, *4*(2), 1-12.
http://dx.doi.org/10.61838/kman.jpsad.157

ABSTRACT

Following restrictions on antibiotic growth promoters (AGPs) in many regions due to their link to the development of microbial resistance. The recent ban on antibiotics in poultry has underscored the urgent need for alternative methods to enhance growth performance in chickens. Various innovative strategies are being explored to address this challenge. Aspirin, chemically known as acetylsalicylic acid, has attracted attention in poultry nutrition, particularly in broiler diets. Its potential benefits include enhancing growth performance, improving feed efficiency, and possibly providing anti-inflammatory effects. This review synthesizes findings from 64 studies conducted between 2015 and 2025 on the effects of aspirin use across many animal species, particularly in broiler diets, focusing on growth and development, carcass traits, and health criteria. The literature indicates that the addition of Aspirin to drinking water at concentrations exceeding 200 mg/L was associated with reduced performance and adverse histology in several studies. Conversely, including up to 100 mg/kg of Aspirin in the diet has been demonstrated in several studies to improve performance and decrease the population of Escherichia coli. These effects are especially pronounced under stressful conditions commonly faced in broiler production, such as high stocking densities and heat stress. This review underscores the health advantages and potential uses of Aspirin and its derivatives in broiler nutrition.

Keywords: *Aspirin, Acetylsalicylic acid (ASA), Diet, Performance, Broiler, Supplement*

Article history:
Received 04 September 2025
Revised 04 October 2025
Accepted 07 January 2026
Published online 01 February 2026

1 Introduction

Antibiotics have been prohibited in livestock production due to their relation to the development of microbial resistance. While antibiotics are effective in suppressing the growth of harmful microbes, they also negatively impact beneficial microbes (Capita & Alonso-Calleja, 2013; Vidovic & Vidovic, 2020). Metals, prebiotics, symbiotics, probiotics, herbal additives, acidifiers, and various enzyme mixes support the growth of beneficial microbes, while their by-products help suppress harmful microbes (Zamojska et al., 2021). The ban on antibiotic growth promoters (AGPs) has resolutely highlighted the need for alternative strategies to boost poultry growth, including metals, prebiotics, symbiotics, probiotics, herbal additives, acidifiers, and enzyme mixes (Bueno et al., 2023).

Inflammation is a biological process that occurs in all body organs in response to various stimuli, potentially disrupting normal growth and development. This disruption may manifest as morbidity, loss of appetite, and the onset of fever. Anti-inflammatory medications can help maintain homeostasis and serve a preventive role against these disturbances. Two main types of anti-inflammatory drugs are steroid-based medications and non-steroidal anti-inflammatory drugs (NSAIDs), which differ in their chemical structure and mechanisms of action (Kaur & Singh, 2022).

Aspirin, also known as acetylsalicylic acid (ASA), is a commonly used non-steroidal anti-inflammatory drug (NSAID) that has been extensively studied in various rodent species, including rats, mice, and rabbits. These investigations focus on its pharmacological properties, potential therapeutic benefits, and associated risks. Research has shown that aspirin derivatives have the potential to decrease the size of myocardial infarcts and enhance ventricular function following ischemic events (Rossoni et al., 2001). Low-dose Aspirin has been shown to inhibit NF-κB activation, thereby reducing inflammation in older rats. Likely Studies show that this anti-inflammatory action is facilitated by the reduction of reactive species and the activity of cyclooxygenase-2 (COX-2), both of which are linked to NF-κB activation. Specifically, administering low-dose Aspirin to 24-month-old Fischer 344 rats led to a significant decrease in levels of pro-inflammatory markers, including COX-2, inducible nitric oxide synthase (iNOS), and various adhesion molecules regulated by NF-κB pathways. This reduction is achieved by inhibiting IκBα phosphorylation and degradation, a protein that typically prevents NF-κB from entering the nucleus and activating genes associated with inflammation (Jung et al., 2006).

Aspirin has been shown to reduce the severity of experimental autoimmune encephalomyelitis (EAE) in mice by enhancing the stability of regulatory T cells via interleukin-11 (IL-11). Studies show that low doses of Aspirin effectively mitigate the symptoms of EAE, a model for multiple sclerosis (MS), by reducing inflammation and demyelination associated with the condition (Mondal et al., 2018). Low-dose Aspirin can significantly reduce the risk of colorectal cancer recurrence (Zhao et al., 2020). Research indicates that low-dose Aspirin can help maintain endothelial function in aging organisms by enhancing endothelium-dependent vasodilation, which tends to decline with age (Bulckaen et al., 2008). In a study with rabbits fed a cholesterol-rich diet, Aspirin treatment led to a notable decrease in atherosclerotic plaque formation and in inflammatory markers, particularly COX-2 and macrophage levels, compared with the untreated control group. This indicates that the anti-atherosclerotic properties of Aspirin are closely associated with its capacity to inhibit COX-2 expression, which, in turn, diminishes inflammation associated with atherosclerosis (Guo et al., 2006). The findings in a rabbit model suggest that Aspirin's ability to enhance apoptosis while reducing necrosis could be beneficial in treating lymphatic metastases (Batista et al., 2012). The pairing of Aspirin and clopidogrel has demonstrated a marked increase in antithrombotic effects in experimental studies involving rabbits. Evidence suggests that clopidogrel, which selectively blocks ADP receptors, experiences enhanced antithrombotic activity when used alongside Aspirin, resulting in better outcomes across various experimental scenarios (Herbert et al., 1998). One major issue associated with aspirin use is its potential to lead to gastrointestinal bleeding. Research involving rodents has shed light on the mechanisms contributing to this adverse effect. Specifically, high doses of Aspirin administered during pregnancy in rats resulted in congenital defects such as ventricular septal defects and midline anomalies, alongside significant gastric damage characterized by elevated ulcer scores and oxidative stress (Cook et al., 2003). Harmful effects of high aspirin doses were also reported in mice and rabbits (Dong et al., 2022; Zhang et al., 2022). Rats are more sensitive to hemorrhagic and developmental effects, whereas mice show fewer signs of hemorrhage (Takahashi & Hiraga, 1985). Research indicates that Aspirin may have significant effects on renal function under specific conditions. Notably, administration of 30 mg/kg of Aspirin has been associated with glomerular atrophy and the formation of renal cysts in male rats. This finding highlights the potential for Aspirin to induce adverse renal changes, particularly at higher doses, as studies have shown that Aspirin's impact on kidney function is dose-dependent. For instance, doses exceeding 80 mg can lead to marked deterioration in renal function, which is clinically relevant for patients with existing health issues (Al-Abdaly et al., 2021). Oral administration of 100 mg/kg of Aspirin notably improved diabetic cystopathy in male rats. This treatment was part of a study where diabetic rats exhibited significant bladder complications, characterized by inflammation and structural damage. After a 10-week regimen of Aspirin, the treated rats showed reduced bladder inflammation and fibrosis, alongside a decrease in blood glucose levels (Du et al., 2023).

Aspirin and its derivatives are emerging as potential growth enhancers in the poultry sector. The pharmacokinetics of acetylsalicylic acid (ASA) and sodium salicylate (SS) were evaluated after a single oral or intravenous (IV) dose in broilers. In avian medicine, ASA and SS are widely used for their established analgesic and anti-inflammatory effects. The mean residence time in broiler blood and the total elimination half-life were reported to be 3-6 hours for oral administration and approximately 3 hours for IV administration of Aspirin, with a peak serum value of 96 µg/ml. This data suggests that Aspirin is cleared from the bloodstream of broilers quickly (Poźniak et al., 2013). Residues of ASA in the liver and muscles of laying hens decreased to below 10 µg/kg body weight within eight hours after the administration of 10 mg/L ASA in drinking water. This indicates a rapid elimination of ASA from the body, with no significant accumulation in the liver or muscles (Protasiuk & Olejnik, 2020). These benefits make Aspirin a promising alternative to antibiotic growth promoters, particularly in addressing stress-related challenges in poultry production. The most frequently utilized forms of Aspirin include sodium salicylate (SS) and acetylsalicylic acid (ASA), Aspirin helps alleviate the negative effects of heat stress and high stocking densities by reducing oxidative stress and inflammation, which are common challenges in poultry production, As a non-steroidal anti-inflammatory drug (NSAID), Aspirin reduces inflammation, helping to maintain homeostasis and prevent disruptions in growth and development caused by stress or disease (Ferronato et al., 2024; Tavakoli et al., 2022). Reports suggest that salicylates are effective in mitigating the adverse effects of heat stress and high stocking densities in broiler production (T. D. Panaite et al., 2020; Saracila et al., 2023). Aspirin enhances antioxidant enzyme activity, protecting tissues from oxidative damage and improving overall health and performance (Fathi et al., 2016).

By considering all the above, we decided to review the results of acetylsalicylic acid and its compound administration on antioxidant capacity, inflammation, body organs, and performance of broiler (Table and Figure 1)

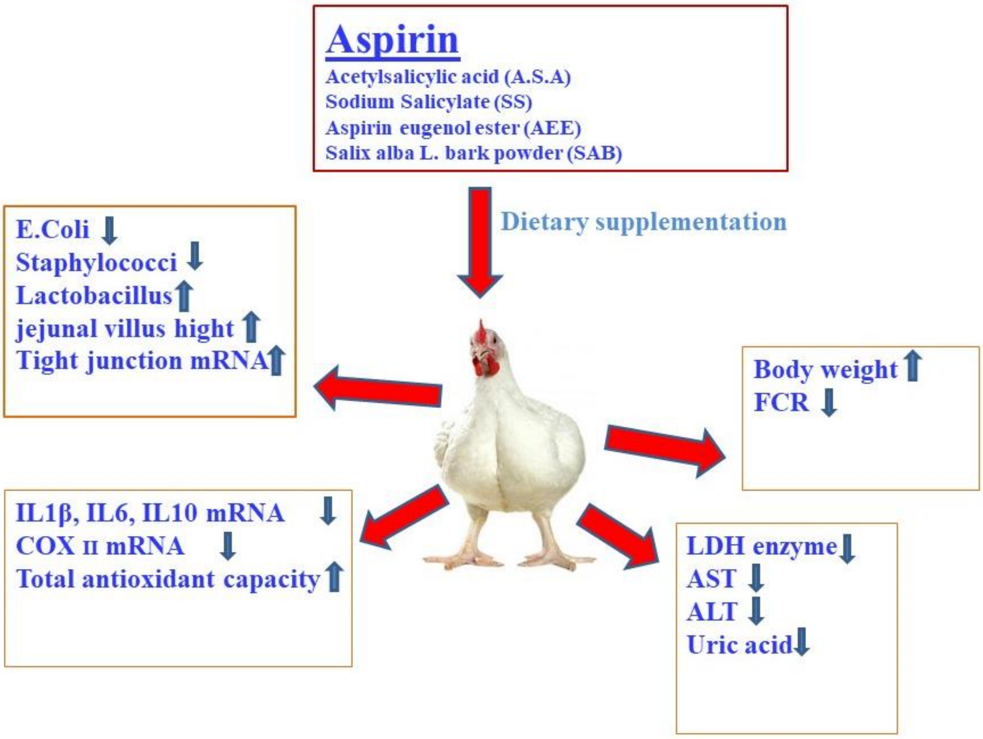


Figure 1. Aspirin and its derivatives from salicin

Table 1. Effects of different forms of Aspirin in broiler nutrition

Forms	Poultry type	Design, numbers, doses, and treatments	Results	Literature reference
Sodium salicylate (SS)	Cobb 500	For 42days, broilers were treated with (0, 2.5, 5, 10 mg/Kg diet), 12 birds in each group.	10 mg sodium salicylate increased body weight by 5.8% and reduced the Feed conversion rate. There were no significant changes in the hematological and biochemical parameters of different groups. 10 mg SS significantly reduced the levels of LDH, GGT enzymes, and uric acid linearly.	(Almeida et al., 2022)
Acetylsalicylic acid (ASA) and sodium salicylate (SS)	Ross 308	Broilers aged 28 days were gavaged with 0, 200, 400 mg/Kg body weight for 14 days.	ASA and SS reduced body weight, increased the kidney and liver to body weight ratio, and lesions on the small intestine, particularly at a dose of 400mg	(Poźniak et al., 2012)
Acetylsalicylic acid (ASA)	Broiler	Broilers aged 15 days were treated by heat stress and 0.05% ASA in the diet for 27 days.	ASA did not change BW, FCR, biochemical, and hematological parameters, but it significantly reduced the AST level compared to the control group.	(Saker et al., 2020)
Aspirin	Ross 308	Aspirin is added to the diet at 0, 50, and 100 mg/Kg for 42 days.	100 mg/kg of Aspirin induced the highest feed intake and weight gain and the best feed conversion ratio compared to the other treatments. Aspirin reduced the abdominal fat, pancreas, proventriculus, ventriculus, Jejunum, colon, and cecum weight.	(Tavakoli et al., 2022)
Aspirin	Ross 308	Aspirin is added to the diet at 0, 50, and 100 mg/Kg for 42 days.	Aspirin treatment reduced blood AST and ALP levels, and reduced the thymus and bursa of Fabricius weight.	(Tavakoli et al., 2022)
Aspirin	Broiler	Broilers aged 15 days were treated with 0.025, 0.05, and 0.075% ASA in the diet for 14 days.	ASA increased body weight and feed intake, reduced FCR, particularly in 0.05 % inclusion.	(Dabai et al., 2021)
Salix alba L. bark powder (SAB)	Cobb 500	Broiler aged 14 days treated with 0.025, 0.05% SAB in diet for 28 days.	SAB increased body weight but did not change FCR. It reduced AST and ALT levels, liver TBARS, and harmful bacteria in the large intestine (*E. coli*, Staphylococci), while elevating liver total antioxidant capacity and Glutathione capacity.	(T. Panaite et al., 2020)
Sodium salicylate (SS)	Cobb 500	Broiler treated with Bacitracin and SS (0,10, 30, 90 mg/kg) for 42 days	Bacitracin and SS similarly decreased AST and ALT globulin levels and increased total protein levels compared to the control group in a linear manner.	(Di Gregorio et al., 2023)
acetylsalicylic acid (ASA)	Cobb 500	ASA was added to the diet (0, 50, 100 mg/Kg) for 42 days	ASA increased feed intake and reduced FCR compared to the control group. But creatine kinase and lactate dehydrogenase were significantly elevated in the 100mg treatment, reducing the bursa of fabricius, cecum, and harmful bacteria (*E. coli*, staphylococci)	(Ferronato et al., 2024)
Aspirin Eugenol Ester (AEE)	Arbor Acres	0.01% AEE in their diet, lonely or with LPS (immunostressor)	AEE increased the body weight, average daily gain, and average daily feed intake, as well as decreasing the feed conversion ratio of immune-stressed broilers, and protected against oxidative damage in immune-stressed broiler livers by elevating the total antioxidant capacity. superoxide dismutase activity, and glutathione, decreased MDA, $PGF_2\alpha$, and IL1β gene expression	(Zhong et al., 2024)
Salicylic Acid (SA)	Lohmann Brown aged 60 weeks	0.2% SA is added to the diet or water as a different treatment for animals from 60 to 75 weeks of age.	Treatments did not changed The percentage of moisture, protein, fat, carbohydrates, and ash in each of the whites and yolks was similar to that of the control	(Al-Tamimy et al., 2022)

			group, indicating that egg quality was comparable.	
Aspirin eugenol ester (AEE)	Arbor Acres	0.01%AEE in diet fed 42days under high density and normal stocking rate	High stocking rate elevated MDA, COX2 gene expression, decreased total antioxidant capacity, intestinal villus height, tight junction gene, and AEE addition reversed the above-mentioned effects and increased intestinal integrity and body weight	(Zhong et al., 2024)
Salix alba		SA was added to the diet (0, 25, 50 mg/Kg), and the broiler was exposed to heat stress from 14 days old.	SA addition reduced MDA and protein carbonyls, reduced harmful microflora of the intestine, increased TAC and glutathione in the liver,	(Saracila et al., 2023)
Acetylsalicylic acid (ASA)		ASA was added to drinking water from the 14th day of the rearing period (0, 300, 600, 1200 mg/L)	ASA doses of 600 and 1200mg/L increased serum ALT, AST, and creatinine, urea, total protein level, and destroyed liver, kidney, and intestinal villi	(Muneeb et al., 2022)
Aspirin eugenol ester (AEE)	Arbor Acres	0.1g/Kg AEE added to the diet of chicken treated with LPS	AEE improved the ileal morphology and increased the ratio of villus height in LPS-induced immune stress in chickens reduced TNF, IL-1, and IL-6 in the ileum tissue.	(Zhang et al., 2024)

2 Materials and Methods

This review involved a systematic search of scientific databases, including PubMed, Scopus, and Web of Science, targeting studies published from 2015 to 2025. The search strategy utilized keywords such as "aspirin," "acetylsalicylic acid," "broiler," "poultry," "anti-inflammatory," and "growth performance," along with relevant synonyms. Inclusion criteria focused on original research and experimental investigations addressing the impacts of Aspirin and its derivatives on growth metrics, performance outcomes, antioxidant status, inflammation, and organ health in broilers and similar animal models. Studies excluded were non-English articles and reviews.

Extracted data from eligible studies encompassed aspirin dosage (expressed as mg/kg or mg/L), administration routes (dietary, drinking water, or oral gavage), treatment duration, and experimental conditions (such as heat stress, stocking density, or disease models), alongside primary outcomes related to growth performance, biochemical markers, and histopathological assessments.

3 Sources of Salicylic acid

Salicylate is among the earliest known pain relievers, with its use traced back to 400 B.C. Hippocrates utilized the leaves and bark of the willow tree, which contain salicin, to alleviate pain and reduce fever. Over time, acetylsalicylic acid, commonly known as Aspirin, has emerged as one of the most widely used medications globally (Figure 2). Salicylate serves as an analgesic and antipyretic agent by exhibiting anti-inflammatory properties. Salicin acts as a precursor in the production of Aspirin and salicylic acid, both of which possess significant anti-inflammatory effects (Tawfeek et al., 2021).

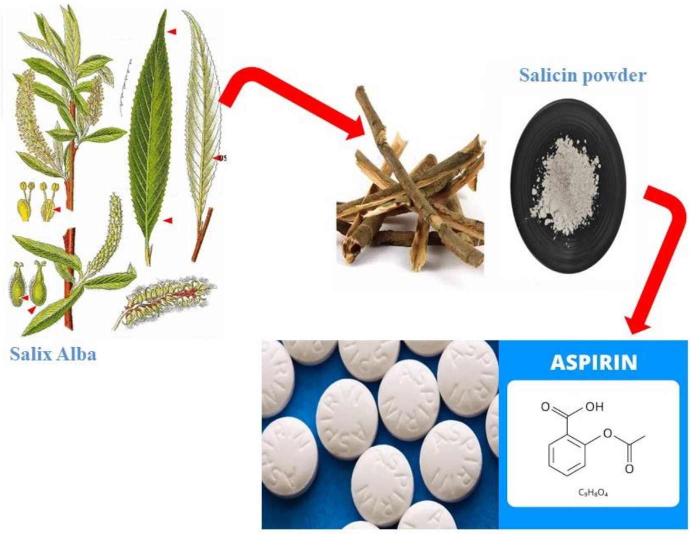


Figure 2. Physiological, antioxidant, and performance effects of Aspirin and its derivatives on broilers.

3.1 Anti-inflammatory and Antioxidant effects

Arachidonic acid (AA) is closely linked to inflammation and serves as a primary mediator of pro-inflammatory responses. The administration of Aspirin Eugenol Ester (AEE) reduced the expression levels of IL-1β, IL-6, IL-8, and TNF-α in both in vivo and in vitro studies using a mouse model. Additionally, AEE decreased AA and prostaglandin D2 levels in the livers of these mice (Liu et al., 2023). It is well established that AEE can reduce H_2O_2-induced mitochondrial dysfunction, decrease reactive oxygen species (ROS) production, and lower apoptosis rates by boosting the expression of Bcl-2 and Nrf2 in a rodent model (M.-Z. Huang et al., 2019; M. Z. Huang et al., 2019). In poultry research, incorporating 0.05% Salix alba bark powder into the diet may effectively mitigate oxidative stress in broiler livers and enhance gut microbiota. The bark powder notably decreased levels of thiobarbituric-reactive substances and protein oxidation while boosting total antioxidant capacity in the livers of broiler chickens (T. Panaite et al., 2020).

In this context, AEE decreased inflammation by lowering the production of prostaglandin-F_2α and reducing the expression of prostaglandin-endoperoxide synthase 2 (PTGS2) and interleukin-1 beta (IL-1β) in the liver of broiler chickens (Zhong et al., 2024). Pre-treatment with Aspirin notably reduced liver damage in lipopolysaccharide-treated mice by lowering levels of inflammatory markers, including C-reactive protein, interleukin-1β, and tumor necrosis factor-alpha (Saitoh et al., 2024). The findings of this study suggest that Aspirin may serve as a protective agent for the liver by diminishing the impact of systemic inflammation on liver function. AEE is a newly developed pharmaceutical compound derived by esterifying Aspirin and eugenol, effectively combining the beneficial properties of both. This compound has attracted considerable interest due to its wide range of biological effects, which include anti-inflammatory, antioxidant, antithrombotic, and anti-atherosclerotic activities. Specifically, a concentration of 0.01% AEE has been shown to safeguard against oxidative damage in the livers of broiler chickens subjected to lipopolysaccharide (LPS) stress by boosting superoxide dismutase activity, total antioxidant capacity, and the levels of glutaredoxin two and glutathione S-transferase alpha 3 (GSTA3) (Zhong et al., 2024). Research has shown that ASA significantly affects hepatic oxidative stress in broiler production under high stocking rates by enhancing the levels of antioxidant enzymes in the liver (Zhong et al., 2024). Broilers that were given Salix alba L. bark powder (SAB) at concentrations of 0, 0.025, and 0.05% exhibited significantly reduced levels of malondialdehyde and glutathione in their livers, along with a greater total antioxidant capacity in comparison to the control group (T. D. Panaite et al., 2020).

Chickens treated with LPS exhibited a notable increase in the mRNA levels of inflammatory factors such as interleukin-6 (IL-6), cyclooxygenase-2 (COX-2), interleukin-10 (IL-10), tumor necrosis factor-α (TNF-α), interleukin-1β (IL-1β), and prostaglandin E Synthesase-1 (mPGES-1) in the ileum. However, these levels were significantly reduced with AEE supplementation (Zhang et al., 2024).

Broilers subjected to heat stress exhibited elevated levels of malondialdehyde and protein carbonyls in their liver. The inclusion of Salix alba powder in their diet at levels of 0, 25, and 50 mg/kg resulted in a linear increase in glutathione and total antioxidant capacity, while simultaneously reducing the levels of malondialdehyde and protein carbonyls (T. D. Panaite et al., 2020).

Lipopolysaccharides (LPS) trigger acute inflammation in the livers of broiler chickens. In this context, administration of AEE (an extract) has been shown to mitigate inflammation by lowering prostaglandin-$F_2α$ production and reducing the expression levels of prostaglandin endoperoxide synthase and interleukin-1 beta (IL-1β) (Zhong et al., 2024). While the antioxidant capacity and activity of the liver have not been evaluated at high doses of a ASA (300, 600 and 1200 mg/L) or sodium salicylate (SS) (200 and 400 mg/L) in the drinking water of broilers, there is a clear disruption in the liver's antioxidant function associated with elevated levels of aspirin administration, as indicated by the increased liver size and related serum enzymes (Muneeb et al., 2022; Poźniak et al., 2012).

3.2 Antimicrobial effect

Several studies have reported antimicrobial and microbiota-modulating effects in certain contexts (Zimmermann & Curtis, 2017). Researchers found that adding Aspirin eugenol ester (AEE) at 0.01% in the feed effectively mitigates immune stress in broiler chickens (Zhong et al., 2024). A high stocking rate led to changes in intestinal microbial composition, including decreases in bacteria such as Bacteroides and Faecalibacterium. The study found that incorporating AEE into the diet at high stocking densities helps decrease the population of Enterococcus faecalis while promoting the growth of beneficial bacteria such as Bifidobacterium and Lactobacillus (Zhang et al., 2024; Zhong et al., 2024). AEE enhanced beneficial bacteria in the microbial population of broilers' gut in high-density production, aligning it more closely with that of the control group. A prior study indicated that including dietary salicin extracted from *Salix alba* at levels of 0, 25, and 50 mg/kg enhanced disease resistance by reducing populations of staphylococci and *E. coli* while increasing the numbers of *Lactobacilli* in the gut microbial population of broilers exposed to heat stress (T. D. Panaite et al., 2020; Saracila et al., 2023). When *Helicobacter pylori* is treated with Aspirin (ASA) and other COX inhibitors, its sensitivity to antibiotics such as amoxicillin, clarithromycin, and metronidazole increases (Wang et al., 2002). It is suggested that one of the fundamental processes involves inhibiting the transcription factor nuclear factor-kappa B, which plays a crucial role in the inducible expression of various cellular and microbial genes related to inflammation, such as interleukin-1 (IL-1), IL-6, and adhesion molecules.

Additionally, another mechanism involves the activation of p38 mitogen-activated protein kinase and mitogen-activated protein kinase/extracellular signal-regulated kinase (Kopp & Ghosh, 1994; Mazur et al., 2007; Ríos-Ibarra et al., 2014). In this context, administering Aspirin to mice decreased the levels of *Alistipes finegoldii* and *Bacteroides fragilis*, both of which are regarded as pathogenic. At the same time, there was an increase in the beneficial genera *Bifidobacterium* and *Lactobacillus* in their fecal samples (Zhao et al., 2020). A diet supplemented with AEE in rats demonstrated several restorative effects on microbiota imbalances caused by a high-fat diet. This included a decrease in the Firmicutes phylum and an increase in *Euryarchaeota*. Notably, there was a significant rise in *Bifidobacterium* levels and a reduction in *Turicibacter* within the AEE group (Ma et al., 2018). In line with this, stress has been found to elevate Enterococcus faecalis populations while reducing levels of beneficial bacteria such as *Lactobacillus* and *Bifidobacterium* in broiler chickens. This shift in the gut microbiota balance may adversely affect intestinal health and increase vulnerability to disease under stressful rearing conditions (Wu et al., 2019).

Research on antibiotic resistance genes in the gut microbiome of fish found that treating them with Aspirin alongside antibiotics reduced the number of antibiotic resistance genes. This suggests that using Aspirin in combination with antibiotics may help mitigate antibiotic resistance (Guo et al., 2024). Broilers subjected to an experimental challenge with *Clostridium perfringens*, as part of a model to induce subclinical necrotic enteritis, exhibited exacerbated intestinal lesions when treated with 0.025% acetylsalicylic acid (ASA) (Lorenzoni et al., 2019). In contrast, chickens fed a diet containing 0.12 g/kg of Aspirin were protected against body weight loss, ileal inflammation, and intestinal cell apoptosis caused by necrotic enteritis, as it reduced the inflammatory response (Wang et al., 2019). In this context, TNF plays a crucial role in the development of necrotic enteritis, and plant-derived polyphenols have been proposed as effective alternative anti-TNF agents due to their capacity to inhibit TNF-induced inflammatory pathways both in vitro and in vivo (Singh et al., 2016). These findings suggest Aspirin may modulate inflammatory or apoptotic pathways; however, poultry efficacy and safety are dose, route, and model-dependent diets instead of antibiotics is its capability to inhibit cell death signaling pathways Aspirin's diverse effects on various diseases from its capacity to engage multiple molecular targets, which in turn activates various cellular signaling pathways, including those involved in apoptosis and inflammation. This interaction leads to significant biological responses that contribute to its therapeutic benefits across different conditions.

3.3 Effect on Body organs

Several studies have highlighted histological effects of Aspirin supplementation in diets or drinking water across various organs, including the liver, kidneys, and intestines. Notably, higher cytotoxicity has been observed at doses exceeding 400 mg/L in drinking water. An experiment involving long-term administration of acetylsalicylic acid at concentrations of 300, 600, and 1200 mg/L revealed that elevated doses led to hepatorenal toxicity. Specifically, broilers treated with 600 and 1200 mg/L exhibited elevated relative weights of the kidneys, heart, intestines, spleen, thymus, and bursa compared with the control group. In contrast, no significant lesions were noted at the 300 mg/L dosage. However, at 1200 mg/L, hepatocytes displayed swelling, compressed nuclei, and vacuolated surfaces (Muneeb et al., 2022). In a related study, administering 0, 200, and 400 mg/L of acetylsalicylic acid (ASA) or sodium salicylate (SS) in drinking water over an extended period led to histological findings of liver parenchymal destruction in subjects in the ASA 400 and SS 400 treatment groups.

Additionally, while gastrointestinal tract lesions were noted, they were mild and did not depend on dosage; some individuals treated with salicylate exhibited mild inflammatory wounds in the colon and crop (Poźniak et al., 2012). A high stocking density in broiler production resulted in significant variations in the morphology of the villi in broilers. The inclusion of 0.01% Aspirin eugenol ester (AEE) markedly increased jejunal villus height. This enhancement was clearly associated with an increase in the expression of zonula occludens genes, with notable elevations in the mRNA levels of ZO-1 and claudin-1 (Zhong et al., 2024). These genes are important in determining the permeability traits of tight junctions. In an experiment, dietary sodium salicylate at doses of 0, 2.5, 5, and 10 mg/kg resulted in no significant damage to the large or small intestine of broilers after 42 days. Consequently, the author concluded that histopathological examinations confirmed that daily administration of sodium salicylate at 2.5 to 10 mg/kg over 42 days did not cause any harmful changes in the tissues of the intestines, liver, or kidneys (Almeida et al., 2022). The involvement of heat shock proteins in cell survival has been documented. In this context, administering Aspirin orally at 1 mg/kg [URL] to 30-day-old broilers 2 hours before exposure to heat stress resulted in a significant increase in heat shock protein expression in the kidneys and hearts compared with the control group exposed to heat (Tang et al., 2018; Wu, Zhang, Xu, et al., 2016).

3.4 Performance improvement, growth, and feed efficiency effect

Supplementing with SS at 10 mg/kg throughout the production period significantly improved chicken growth. Additionally, chickens fed diets supplemented with Aspirin had better feed conversion ratios (FCR) than those on a standard diet (Almeida et al., 2022). In addition, including 50 or 100 mg/Kg aspirin in the diet increased body weight and decreased feed conversion ratio (FCR) compared with the control group (Tavakoli et al., 2022). Adding 0.05% to the diet of 15-day-old broilers over a 27-day production period yielded outcomes similar to those observed with 0.05% (Dabai et al., 2021). However, a concentration of 400 mg/L (as opposed to 200 mg/L) in drinking water induced a decline in body weight and an increase in feed conversion ratio (FCR) (Poźniak et al., 2012). In addition, 0.05% ASA to the diet produced results comparable to those of the control group (Saker et al., 2020). A recent study found that adding ASA to the diets of growing broilers significantly improved final body weight, feed intake, and average daily gain, especially under stressful conditions such as heat stress and a high risk of ascites (Balog et al., 2000; Salah et al., 2019; Sandoghchian Shotorbani et al., 2008; Wu, Zhang, Lu, et al., 2016). In this context, improvements in broiler performance under high latitudes or under heat stress have been reported. The studies mentioned above indicated that ASA improved broiler growth performance when administered at a dosage of less than 200 mg/Kg feed or 200 mg/L water.

3.5 Blood biochemistry and metabolic effect

Hematological criteria are widely utilized to evaluate the health status, stress levels, welfare, and disease conditions in chickens. Additionally, hematobiochemical parameters provide insights into chicken health by highlighting abnormalities that may arise from the use of immunostimulants. The results of the hematological, biochemical, and histopathological studies indicate that daily dietary SS doses of 2.5-10 mg/kg for 42 days did not negatively affect blood levels of ALT, AST, LDH, uric acid, or creatinine in broilers (Di Gregorio et al., 2023). The levels of glucose, cholesterol, and triglycerides in the serum were reduced in broilers that received treatment with willow bark extract (Saracila et al., 2018). Aspirin has the potential to improve hyperlipidemia induced by a high-fat diet, with studies indicating that doses of AEE (50 mg/kg and 160 mg/kg) can reduce total cholesterol and triglycerides in rodent models on a standard diet. Furthermore, administering AEE at a dose of 54 mg/kg over 5 weeks can restore normal blood lipid levels in rats with hyperlipidemia (Karam et al., 2015; Li et al., 2012). A high-fat diet in rats led to significant increases in blood levels of ALT, AST, bilirubin, and urea; however, AEE notably decreased these levels (Ma et al., 2018). The inclusion of acetylsalicylic acid (ASA) in the diet of quails has been shown to yield results similar to those for the AST enzyme under heat-stress (El-Kholy et al., 2018). ASA supplementation reduced serum ALT and AST levels in heat-stressed broilers, indicating no signs of liver damage in these groups (Puron et al., 1994; Salah et al., 2019). In this context, adding 62.5 mg/L of Aspirin (ASA) to the drinking water of broiler chickens exposed to heat stress from day 35 of production reduced malondialdehyde (MDA) levels in their breast muscles, a key factor contributing to food spoilage (Roussan et al., 2008). At the 0.20% aspirin supplementation level, the incidence of ascites showed a trend toward significance compared with the control group, particularly in birds raised in a hypobaric chamber. The control group exhibited significant hypertrophy in both the liver and the heart, along with elevated hematocrit levels, which were notably higher than those observed in the aspirin-treated group (Balog et al., 2000). Research has indicated that dietary supplementation with sodium salicylate significantly improved hematological parameters in chickens (Almeida et al., 2022). They also demonstrated a significant reduction in LDH, GGT, and uric acid levels, with no changes observed in the white or red blood cell counts across all treatments. Previous research has indicated that high single doses of Aspirin administered via gavage and concentrations of ≥600–1200 mg/L in drinking water have been associated with hepatic and renal stress. In contrast, lower doses administered through feed (expressed as mg/kg) generally demonstrate neutral or beneficial effects(Poźniak et al., 2012). The addition of 300, 600, and 1200 mg/L to drinking water over 28 days resulted in increased serum levels of ALT, AST, creatinine, urea, and total protein at the ASA doses of 600 and 1200 mg/L (Muneeb et al., 2022). Conversely, the dietary supplementation of aspirin eugenol ester, SS, and Salix alba L. bark powder (SAB) has the potential to significantly improve the hematological parameters in chickens (Di Gregorio et al., 2023; T. Panaite et al., 2020; Zhang et al., 2024; Zhong et al., 2024).

4 Conclusion

Aspirin and some of its derivatives have been reported to possess antioxidant, anti-inflammatory, and antimicrobial properties under certain conditions. The extent of these effects can vary depending on the compound and context, making them valuable in applied animal science. These compounds can be safe within defined dietary ranges; higher drinking-water doses have been associated with hepatic and renal stress. Affordability varies by formulation. Recent research recommended focusing on the application of Aspirin to enhance its use in animal science. Such advancements could play a crucial role in supporting antibiotic-reduction strategies for the poultry industry, particularly under the challenging conditions of high stocking rates, heat stress, and summer thermal challenges in broiler production.

Acknowledgements

The authors would like to express their appreciation to the University of Jiroft that supported this study under the grant No: 2812-03-2.

AI Use Statement

Artificial intelligence tools were not used for data analysis or interpretation. AI assistance was limited to language editing and formatting during manuscript preparation.

Conflict of Interest

We declare that no conflict of interest.

Author Contributions

All authors significantly contributed to this study.

Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Ethical Considerations

This study is a narrative/systematic review of published literature on the use of ASA in rodent and poultry diets. No animals were used, and no new in vivo experiments were conducted. Therefore, ethics approval was not required.

Funding

This research was funded by a grant (7508007-6-51) from the University of Tehran Research Council.

References

Al-Abdaly, Y., Saeed, M., & Al-Hashemi, H. (2021). Effect of methotrexate and aspirin interaction and its relationship to oxidative stress in rats.

Al-Tamimy, S. M. A., Abbas Malik, N., & Taleb Dhiab, A. (2022). The Effect of Adding Tartaric Acid and Salicylic Acid on the Chemical Composition of Eggs Produced from Lohman Chickens. *Archives of Razi Institute*, *77*(6), 2353. [DOI].

Almeida, E., Górniak, S., Di Gregorio, M., Araújo, C., Andréo-Filho, N., Momo, C., & Hueza, I. (2022). Safety and growth-promoting potential of repeated administration of sodium salicylate to broilers. *Animal-Open Space*, *1*(1), 100026. [DOI].

Balog, J. M., Huff, G. R., Rath, N. C., & Huff, W. E. (2000). Effect of Dietary Aspirin on Ascites in Broilers Raised in a Hypobaric Chamber1. *Poultry Science*, *79*(8), 1101-1105. [PMID: 10947177] [DOI].

Batista, R. P., Denadai, R., & Saad-Hossne, R. (2012). Effects of aspirin on mesenteric lymph nodes of rabbits as basis for its use on lymph nodes metastases. *Acta Cirúrgica Brasileira*, *27*(11), 795-801. [PMID: 23117612] [DOI].

Bueno, I., Ricke, I., Hwang, H., Smith, E., Nault, A., Johnson, T. J., & Singer, R. S. (2023). Efficacy of antibiotic and non-antibiotic interventions in preventing and treating necrotic enteritis in broiler chickens: A Systematic Review. *Avian diseases*, *67*(1), 20-32. [PMID: 37140108] [DOI].

Bulckaen, H., Prévost, G., Boulanger, E., Robitaille, G., Roquet, V., Gaxatte, C., Garçon, G., Corman, B., Gosset, P., Shirali, P., Creusy, C., & Puisieux, F. (2008). Low-dose aspirin prevents age-related endothelial dysfunction in a mouse model of physiological aging. *American Journal of Physiology-Heart and Circulatory Physiology*, *294*(4), H1562-H1570. [PMID: 18223195] [DOI].

Capita, R., & Alonso-Calleja, C. (2013). Antibiotic-resistant bacteria: a challenge for the food industry. *Critical reviews in food science and nutrition*, *53*(1), 11-48. [PMID: 23035919] [DOI].

Cook, J. C., Jacobson, C. F., Gao, F., Tassinari, M. S., Hurtt, M. E., & DeSesso, J. M. (2003). Analysis of the nonsteroidal anti-inflammatory drug literature for potential developmental toxicity in rats and rabbits. *Birth Defects Research Part B: Developmental and Reproductive Toxicology*, *68*(1), 5-26. [PMID: 12852480] [DOI].

Dabai, S., Bello, S., & Dabai, J. (2021). Growth performance and carcass characteristics of finisher broiler chickens served carrot leaf extract as a supplementary source of vitamins and minerals. *Nigerian Journal of Animal Science*, *23*(1), 144-149. [URL].

Di Gregorio, M. C., de Almeida, E. R. M., Momo, C., da Silva Araújo, C. S., Hueza, I. M., Andréo-Filho, N., Raspantini, L. E. R., Gotardo, A. T., & Górniak, S. L. (2023). Sodium Salicylate as Feed Additive in Broilers: Absence of Toxicopathological Findings. *Animals*, *13*(9), 1430. [PMID: 37174467] [PMCID: PMC10177601] [DOI].

Dong, Z., Yang, L., Jiao, J., Jiang, Y., Li, H., Yin, G., Yang, P., & Sun, L. (2022). Aspirin in combination with gastrodin protects cardiac function and mitigates gastric mucosal injury in response to myocardial ischemia/reperfusion. *Frontiers in Pharmacology*, *13*, 995102. [PMID: 36238560] [PMCID: PMC9553090] [DOI].

Du, H., Xu, F., Liu, J., Zhang, J., Qin, Y., Xu, Y., & Li, N. (2023). Long-term aspirin administration suppresses inflammation in diabetic cystopathy. *Aging (Albany NY)*, *15*(17), 9128-9143. [PMID: 37702622] [PMCID: PMC10522387] [DOI].

El-Kholy, M. S., El-Hindawy, M. M., Alagawany, M., Abd El-Hack, M. E., & El-Sayed, S. A. A. (2018). Use of acetylsalicylic acid as an allostatic modulator in the diets of growing Japanese quails exposed to heat stress. *Journal of thermal biology*, *74*, 6-13. [PMID: 29801651] [DOI].

Fathi, M., Haydari, M., & Tanha, T. (2016). Influence of dietary aspirin on growth performance, antioxidant status, and mortality due to ascites in broiler chickens. [DOI].

Ferronato, G., Tavakoli, M., Bouyeh, M., Seidavi, A., Suárez Ramírez, L., & Prandini, A. (2024). Effects of combinations of dietary vitamin C and acetylsalicylic acid on growth performance, carcass traits and, serum and immune response parameters in broilers. *Animals*, *14*(4), 649. [PMID: 38396617] [PMCID: PMC10886125] [DOI].

Guo, X., Zhao, W., Yin, D., Mei, Z., Wang, F., Tiedje, J., Ling, S., Hu, S., & Xu, T. (2024). Aspirin altered antibiotic resistance genes response to sulfonamide in the gut microbiome of zebrafish. *Environmental Pollution*, *359*, 124566. [PMID: 39025292] [DOI].

Guo, Y., Wang, Q.-z., Tang, B.-s., Zuo, Y.-f., Li, F.-m., Jiang, X., Wang, L., & Ma, K.-f. (2006). Effects of aspirin on atherosclerosis and the cyclooxygenase-2 expression in atherosclerotic rabbits. *Chinese Medical Journal*, *119*(21), 1808-1814. [PMID: 17097036] [DOI].

Herbert, J.-M., Dol, F., Bernat, A., Falotico, R., Lalé, A., & Savi, P. (1998). The antiaggregating and antithrombotic activity of clopidogrel is potentiated by aspirin in several experimental models in the rabbit. *Thrombosis and haemostasis*, *80*(09), 512-518. [PMID: 9759636] [DOI].

Huang, M.-Z., Yang, Y.-J., Liu, X.-W., Qin, Z., & Li, J.-Y. (2019). Aspirin Eugenol Ester Reduces H2O2-Induced Oxidative Stress of HUVECs via Mitochondria-Lysosome Axis. *Oxidative Medicine and Cellular Longevity*, *2019*(1), 8098135. [PMID: 30706438] [PMCID: PMC6433644] [DOI].

Huang, M. Z., Yang, Y. J., Liu, X. W., Qin, Z., & Li, J. Y. (2019). Aspirin eugenol ester attenuates oxidative injury of vascular endothelial cells by regulating NOS and Nrf2 signalling pathways. *British Journal of Pharmacology*, *176*(7), 906-918. [PMID: 31583045] [PMCID: PMC6754946] [DOI].

Jung, K. J., Kim, J. Y., Zou, Y., Kim, Y. J., Yu, B. P., & Chung, H. Y. (2006). Effect of short-term, low dose aspirin supplementation on the activation of pro-inflammatory NF-κB in aged rats. *Mechanisms of Ageing and Development*, *127*(3), 223-230. [PMID: 16310244] [DOI].

Karam, I., Ma, N., Liu, X.-W., Li, S.-H., Kong, X.-J., Li, J.-Y., & Yang, Y.-J. (2015). Regulation effect of Aspirin Eugenol Ester on blood lipids in Wistar rats with hyperlipidemia. *BMC Veterinary Research*, *11*, 1-7. [PMID: 26289078] [PMCID: PMC4546030] [DOI].

Kaur, B., & Singh, P. (2022). Inflammation: Biochemistry, cellular targets, anti-inflammatory agents and challenges with special emphasis on cyclooxygenase-2. *Bioorganic Chemistry*, *121*, 105663. [PMID: 35180488] [DOI].

Kopp, E., & Ghosh, S. (1994). Inhibition of NF-κB by sodium salicylate and aspirin. *Science*, *265*(5174), 956-959. [PMID: 8052854] [DOI].

Li, J., Yu, Y., Yang, Y., Liu, X., Zhang, J., Li, B., Zhou, X., Niu, J., Wei, X., & Liu, Z. (2012). A 15-day oral dose toxicity study of aspirin eugenol ester in Wistar rats. *Food and Chemical Toxicology*, *50*(6), 1980-1985. [PMID: 22516304] [DOI].

Liu, X., Tao, Q., Shen, Y., Liu, X., Yang, Y., Ma, N., & Li, J. (2023). Aspirin eugenol ester ameliorates LPS-induced inflammatory responses in RAW264. 7 cells and mice. *Frontiers in Pharmacology*, *14*, 1220780. [PMID: 37705535] [PMCID: PMC10495573] [DOI].

Lorenzoni, A., Rojas-Núñez, I., & Moore, A. (2019). Effect of aspirin on the intestinal response to a necrotic enteritis challenge. *Avian diseases*, *63*(4), 686-692. [PMID: 31865684] [DOI].

Ma, N., Liu, X.-W., Kong, X.-J., Li, S.-H., Jiao, Z.-H., Qin, Z., Yang, Y.-J., & Li, J.-Y. (2018). Aspirin eugenol ester regulates cecal contents metabolomic profile and microbiota in an animal model of hyperlipidemia. *BMC Veterinary Research*, *14*(1), 1-15. [PMID: 30563510] [PMCID: PMC6299661] [DOI].

Mazur, I., Wurzer, W. J., Ehrhardt, C., Pleschka, S., Puthavathana, P., Silberzahn, T., Wolff, T., Planz, O., & Ludwig, S. (2007). Acetylsalicylic acid (ASA) blocks influenza virus propagation via its NF-κB-inhibiting activity. *Cellular microbiology*, *9*(7), 1683-1694. [PMID: 17324159] [DOI].

Mondal, S., Jana, M., Dasarathi, S., Roy, A., & Pahan, K. (2018). Aspirin ameliorates experimental autoimmune encephalomyelitis through interleukin-11–mediated protection of regulatory T cells. *Science Signaling*, *11*(558), eaar8278. [PMID: 30482850] [PMCID: PMC6325078] [DOI].

Muneeb, M., Javed, M. T., Sarfaraz, T., Ayub, A., Israr, F., Anwar, S., Abdeen, Z. U., Hina, I., Raza, A., & Afzal, Z. (2022). Effects of different acetylsalicylic acid doses on body organs, histopathology, and serum biochemical parameters in broiler birds. *Brazilian Journal of Veterinary Research and Animal Science*, *59*, e176998-e176998. [DOI].

Panaite, T., Saracila, M., Papuc, C., Predescu, C., & Soica, C. (2020). Influence of dietary supplementation of Salix alba bark on performance, oxidative stress parameters in liver and gut microflora of broilers. Animals 2020; 10: 958. *Animals (Basel)*, *10*(6). [PMID: 32486449] [PMCID: PMC7341264] [DOI].

Panaite, T. D., Saracila, M., Papuc, C. P., Predescu, C. N., & Soica, C. (2020). Influence of Dietary Supplementation of Salix alba Bark on Performance, Oxidative Stress Parameters in Liver and Gut Microflora of Broilers. *Animals*, *10*(6), 958. [PMID: 32486449] [PMCID: PMC7341264] [DOI].

Poźniak, B., Świtała, M., Bobrek, K., Graczyk, S., & Dzimira, S. (2012). Adverse effects associated with high-dose acetylsalicylic acid and sodium salicylate treatment in broilers. *British poultry science*, *53*(6), 777-783. [PMID: 23398422] [DOI].

Poźniak, B., Świtała, M., Jaworski, K., Okoniewski, P., & Niewiński, P. (2013). Comparative pharmacokinetics of acetylsalicylic acid and sodium salicylate in chickens and turkeys. *Br Poult Sci*, *54*(4), 538-544. [PMID: 23906222] [DOI].

Protasiuk, E., & Olejnik, M. (2020). Residues of salicylic acid and its metabolites in hen plasma, tissues and eggs as a result of animal treatment and consumption of naturally occurring salicylates. *Food Additives & Contaminants: Part A*, *37*(6), 946-954. [PMID: 32240053] [DOI].

Puron, D., Santamaria, R., & Segura, J. C. (1994). Effects of Sodium Bicarbonate, Acetylsalicylic, and Ascorbic Acid on Broiler Performance in a Tropical Environment. *Journal of Applied Poultry Research*, *3*(2), 141-145. [DOI].

Ríos-Ibarra, C. P., Lozano-Sepulveda, S., Muñoz-Espinosa, L., Rincón-Sánchez, A. R., Cordova-Fletes, C., & Rivas-Estilla, A. M. G. (2014). Downregulation of inducible nitric oxide synthase (iNOS) expression is implicated in the antiviral activity of acetylsalicylic acid in HCV-expressing cells. *Archives of virology*, *159*(12), 3321-3328. [PMID: 25106115] [DOI].

Rossoni, G., Manfredi, B., Colonna, V. D. G., Bernareggi, M., & Berti, F. (2001). The Nitroderivative of Aspirin, NCX 4016, Reduces Infarct Size Caused by Myocardial Ischemia-Reperfusion in the Anesthetized Rat. *The Journal of Pharmacology and Experimental Therapeutics*, *297*(1), 380-387. [PMID: 11259566] [DOI].

Roussan, D. A., Khwaldeh, G. Y., Haddad, R. R., Shaheen, I. A., Salameh, G., & Al Rifai, R. (2008). Effect of Ascorbic Acid, Acetylsalicylic Acid, Sodium Bicarbonate, and Potassium Chloride Supplementation in Water on the Performance of Broiler Chickens Exposed to Heat Stress1. *Journal of Applied Poultry Research*, *17*(1), 141-144. [DOI].

Saitoh, H., Sakaguchi, M., Miruno, F., Muramatsu, N., Ito, N., Tadokoro, K., Kawakami, K., & Nakadate, K. (2024). Histopathological Analysis of Lipopolysaccharide-Induced Liver Inflammation and Thrombus Formation in Mice: The Protective Effects of Aspirin. *Current Issues in Molecular Biology*, *46*(12), 14291-14303. [PMID: 39727984] [PMCID: PMC11674652] [DOI].

Saker, O. A., El-Dakroury, M. F., Al-Sokary, E. T., Risk, W. F., & Abass, M. E. (2020). Ameliorative Effect of Dietary Acetylsalicylic Acid and Sodium Bicarbonate Supplementation on Growth and Health Status of broiler chicks exposed to heat-stress. *Alexandria Journal of Veterinary Sciences*, *64*(1). [DOI].

Salah, A. S., Mahmoud, M. A., Ahmed-Farid, O. A., & El-Tarabany, M. S. (2019). Effects of dietary curcumin and acetylsalicylic acid supplements on performance, muscle amino acid and fatty acid profiles, antioxidant biomarkers and blood chemistry of heat-stressed broiler chickens. *Journal of thermal biology*, *84*, 259-265. [PMID: 31466762] [DOI].

Sandoghchian Shotorbani, M. R., Sandooghchian, S., & Sandoghchian, B. (2008). Effect of prostaglandins and anti prostaglandins (NSAID) on ascites in broilers. *Journal of Biotechnology*, *136*, S260. [DOI].

Saracila, M., Panaite, T. D., Predescu, N. C., Untea, A. E., & Vlaicu, P. A. (2023). Effect of dietary salicin standardized extract from salix alba bark on oxidative stress biomarkers and intestinal microflora of broiler chickens exposed to heat stress. *Agriculture*, *13*(3), 698. [DOI].

Saracila, M., Panaite, T. D., Vlaicu, P. A., Tabuc, C., Palade, M. L., Gavris, T., & Criste, R. D. (2018). Dietary Willow Bark Extract for Broilers Reared Under Heat Stress. *Bulletin of the University of Agricultural Sciences & Veterinary Medicine Cluj-Napoca. Animal Science & Biotechnologies*, *75*(2). [DOI].

Singh, D. P., Borse, S. P., & Nivsarkar, M. (2016). Clinical importance of nonsteroidal anti-inflammatory drug enteropathy: the relevance of tumor necrosis factor as a promising target. *Translational Research*, *175*, 76-91. [PMID: 27083387] [DOI].

Takahashi, O., & Hiraga, K. (1985). Differences in the Haemorrhagic Toxicity of Aspirin between Rats and Mice. *Acta Pharmacologica et Toxicologica*, *56*(1), 6-13. [PMID: 3872009] [DOI].

Tang, S., Zhou, S., Yin, B., Xu, J., Di, L., Zhang, J., & Bao, E. (2018). Heat stress-induced renal damage in poultry and the protective effects of HSP60 and HSP47. *Cell Stress and Chaperones*, *23*(5), 1033-1040. [PMID: 29779133] [PMCID: PMC6111100] [DOI].

Tavakoli, M., Bouyeh, M., & Seidavi, A. (2022). Influences of dietary aspirin supplementation on growth performance, carcass characteristics and gastrointestinal organs of broilers. *Journal of the Hellenic Veterinary Medical Society*, *73*(4), 5061-5066. [DOI].

Tawfeek, N., Mahmoud, M. F., Hamdan, D. I., Sobeh, M., Farrag, N., Wink, M., & El-Shazly, A. M. (2021). Phytochemistry, pharmacology and medicinal uses of plants of the genus Salix: An updated review. *Frontiers in Pharmacology*, *12*, 593856. [PMID: 33643045] [PMCID: PMC7908037] [DOI].

Vidovic, N., & Vidovic, S. (2020). Antimicrobial Resistance and Food Animals: Influence of Livestock Environment on the Emergence and Dissemination of Antimicrobial Resistance. *Antibiotics*, *9*(2), 52. [PMID: 32023977] [PMCID: PMC7168261] [DOI].

Wang, H., Latorre, J. D., Bansal, M., Abraha, M., Al-Rubaye, B., Tellez-Isaias, G., Hargis, B., & Sun, X. (2019). Microbial metabolite deoxycholic acid controls Clostridium perfringens-induced chicken necrotic enteritis through attenuating inflammatory cyclooxygenase signaling. *Scientific reports*, *9*(1), 14541. [PMID: 31601882] [PMCID: PMC6787040] [DOI].

Wang, W. H., HU, F. L., CY WONG, B., Berg, D. E., & LAM, S. K. (2002). Inhibitory effects of aspirin and indometacin on the growth of Helicobacter pylori in vitro. *Chinese Journal of Digestive Diseases*, *3*(4), 172-177. [DOI].

Wu, D., Zhang, M., Lu, Y., Tang, S., Kemper, N., Hartung, J., & Bao, E. (2016). Aspirin-induced heat stress resistance in chicken myocardial cells can be suppressed by BAPTA-AM in vitro. *Cell Stress and Chaperones*, *21*(5), 817-827. [PMID: 27262845] [PMCID: PMC5003798] [DOI].

Wu, D., Zhang, M., Xu, J., Song, E., Lv, Y., Tang, S., Zhang, X., Kemper, N., Hartung, J., & Bao, E. (2016). In vitro evaluation of aspirin-induced HspB1 against heat stress damage in chicken myocardial cells. *Cell Stress and Chaperones*, *21*(3), 405-413. [PMID: 26910344] [PMCID: PMC4837179] [DOI].

Wu, Y., Wang, Y., Yin, D., Wu, W., Sun, X., Zhang, Y., Guo, X., Chen, J., & Yuan, J. (2019). Effect of supplementation of nicotinamide and sodium butyrate on the growth performance, liver mitochondrial function and gut microbiota of broilers at high stocking density [10.1039/C9FO00904C]. *Food & Function*, *10*(11), 7081-7090. [PMID: 31670358] [DOI].

Zamojska, D., Nowak, A., Nowak, I., & Macierzyńska-Piotrowska, E. (2021). Probiotics and postbiotics as substitutes of antibiotics in farm animals: A review. *Animals*, *11*(12), 3431. [PMID: 34944208] [PMCID: PMC8697875] [DOI].

Zhang, H., Zhang, Y., Bai, D., Zhong, J., Hu, X., Zhang, R., Zhen, W., Ito, K., Zhang, B., Yang, Y., Li, J., & Ma, Y. (2024). Effect of dietary aspirin eugenol ester on the growth performance, antioxidant capacity, intestinal inflammation, and cecal microbiota of broilers under high stocking density. *Poultry Science*, *103*(7), 103825. [PMID: 38772090] [PMCID: PMC11131080] [DOI].

Zhang, M., Xia, F., Xia, S., Zhou, W., Zhang, Y., Han, X., Zhao, K., Feng, L., Dong, R., & Tian, D. (2022). NSAID-associated small intestinal injury: an overview from animal model development to pathogenesis, treatment, and prevention. *Frontiers in Pharmacology*, *13*, 818877. [PMID: 35222032] [PMCID: PMC8864225] [DOI].

Zhao, R., Coker, O. O., Wu, J., Zhou, Y., Zhao, L., Nakatsu, G., Bian, X., Wei, H., Chan, A. W. H., Sung, J. J. Y., Chan, F. K. L., El-Omar, E., & Yu, J. (2020). Aspirin Reduces Colorectal Tumor Development in Mice and Gut Microbes Reduce its Bioavailability and Chemopreventive Effects. *Gastroenterology*, *159*(3), 969-983.e964. [PMID: 32387495] [DOI].

Zhong, J., Zhen, W., Bai, D., Hu, X., Zhang, H., Zhang, R., Ito, K., Zhang, Y., Zhang, B., & Ma, Y. (2024). Effects of aspirin eugenol Ester on liver oxidative damage and energy metabolism in immune-stressed broilers. *Antioxidants*, *13*(3), 341. [PMID: 38539874] [PMCID: PMC10967847] [DOI].

Zimmermann, P., & Curtis, N. (2017). Antimicrobial effects of antipyretics. *Antimicrobial Agents and Chemotherapy*, *61*(4), 10.1128/aac. 02268-02216. [PMID: 28137805] [PMCID: PMC5365702] [DOI].