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Salicylic acid supplementation for broiler chickens under heat stress

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ABSTRACT

This review highlights some literature data on salicylic acid (SA) supplementation and its effects on heat-stressed broiler chickens. The current review will assess the potential use of supplemented SA and highlight its mode of action to decrease the adverse effects of heat stress on broiler production, including growth performance, animal health, gut microbiota, and heat-shock protein expression in broiler chickens. Dry matter intake, growth rate, and feed conversion ratio were improved for broilers when SA was added to their diet either in powder form or supplemented in their drinking water. It also improves carcass quality in both broiler chicken and Japanese quail. Data from recent literature showed lower blood cholesterol (up to −26.3%) and triglycerides (up to −30.7%) and glucose (up to −16.4%) were found in heat-stressed chickens fed 50–100g/100 kg of SA compared to chickens fed a regular diet. In addition, SA improves the oxidative status of birds by lowering the amount of malondialdehyde in the liver under heat stress. Salicylic acid supplementation also inhibits colonization of harmful microbiota and intestinal pathogens, such as *Salmonella*, *Clostridium perfringens*, *Enterococcus species*, and *Escherichia coli*, in the gut of broilers by enhancing intestinal barrier function and maintaining intestinal microflora balance. Moreover, the review highlights the value of SA as a natural alternative supplement for its anti-inflammatory and antioxidant abilities in animal nutrition to mitigate the negative effects of heat stress and enhance poultry production.

Keywords: Animal health, Broiler chickens, Growth performance, Heat stress, Salicylic acid.

Introduction

Global warming and rising temperatures pose a serious threat to poultry production, including heat stress (HS), a concern for many food safety researchers (Kamboh *et al.*, 2013; Saracila *et al.*, 2021). According to Seifi *et al.* (2018), broiler chickens are under extreme stress when exposed to temperatures higher than 30°. Acute HS is characterized by a brief and sharp rise in temperature, whereas chronic HS is characterized by prolonged exposure to high temperatures (Ma *et al.*, 2015; Akbarian *et al.*, 2016). Due to intense genetic selection for faster growth and higher tissue metabolism, commercial broilers have low heat tolerance (Zhang *et al.*, 2017).

According to the Intergovernmental Panel on Climate Change (2021), global surface temperatures are projected to rise by 1.5°C–2.0°C in the coming decades, with direct consequences for poultry production systems. Recurrent heatwaves are increasingly affecting poultry industries in Asia, the Middle East, and North America, with significant economic and welfare implications (FAO, 2022, Abuajamieh *et al.*, 2025).

More cost-effective methods of mitigating HS in chickens and minimizing losses, including feeding techniques and appropriate broiler nutrition management, are needed to reduce the gap caused by HS in the poultry industry (Ganguly *et al.*, 2018). Conventional antibiotics have been extensively used for a long time as either growth promoters or disease prevention approach (Van Boeckel *et al.*, 2015). Since 2017, many countries, including those in the EU, the USA, and parts of Asia, have enacted strict regulations or outright bans on the use of antibiotics as growth promoters in livestock (EMA, 2019). In addition, the world health organization (WHO, 2017) has issued urgent calls to reduce antibiotic use in food producing animals to curb antimicrobial resistance The actions highlight the global trend of moving toward safer, non-antibiotic alternatives in poultry production.

Chicken meat has recently replaced red meat as a protein source because of its advantageous protein level and well-balanced amino acid profile (Hosseini-Asl *et al.*, 2013). Commercial broiler production has increased to meet increasing human demands due to the facilitation of efficient feeding procedures and genetic selection for quick growth (Higgins *et al.*, 2008). Natural substances should be used as growth promoters instead of antibiotics to increase meat production and

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raise the quality of poultry meat (Lennernäs *et al.*, 1997; Ferronato *et al.*, 2024). Beyond performance outcomes, consumer demand for residue-free meat, sustainable production, and improved animal welfare also drive the shift toward natural alternatives. These drivers strengthen the relevance of exploring natural anti-inflammatory compounds in poultry diets, such as salicylic acid (SA).

Several heat stress mitigation strategies are being extensively used in poultry farms, including management, nutritional, and genetic strategies, such as optimizing housing for ventilation and insulation, providing cool, clean water, and adjusting feeding to higher nutrient density diets (Saeed *et al.*, 2019). Other approaches include increasing stocking density, early thermal conditioning, using heat-resistant genetic lines, and supplementing feeds with vitamins, minerals, or phytochemicals such as lycopene, anthocyanins (Saeed *et al.*, 2019), and acetylsalicylic acid (Alagawany *et al.*, 2017; Phillips *et al.*, 2022) to combat oxidative stress.

Salicylic acid reduces inflammation by blocking prostaglandin and cyclooxygenase formation (Drummond *et al.*, 2013; Phillips *et al.*, 2022). Acetylsalicylic acid and other synthetic salicylates have comparable effects on natural SA (Phillips *et al.*, 2022).

In broiler diets, acetylsalicylic acid has been primarily evaluated to lessen the effects of HS on growth performance (Alagawany *et al.*, 2017; Rokade *et al.*, 2017). However, the dosage used in feed and drinking water impacted the growth performance parameters differently (Ferronato *et al.*, 2024). The administration of SA alone (Aro *et al.*, 2020), or a combination with vitamin C (Talebi and Khademi, 2011; Ferronato *et al.*, 2024), or a combination with NaCl (Aro *et al.*, 2017; Olofin *et al.*, 2024), have been used to mitigate the adverse effect of HS on broiler performance.

Salicylic acid is becoming more popular as a natural feed addition in broiler diets due to the detrimental effects of HS on chickens. This review aims to (1) assess the potential application of SA for reducing heat stress in poultry production, (2) illustrate the mechanisms of action of SA in heat stressed broilers, and (3) present various effects of SA on the growth performance, animal health, and gut microbiota of broiler chickens under HS conditions.

Impact of Heat Stress on Broilers

Heat stress is one of the most critical environmental challenges in poultry production. Physiological homeostasis is disturbed when ambient temperature exceeds the bird's thermoneutral zone, leading to reduced productivity, compromised welfare, and increased mortality (Lara and Rostango, 2013; Olfati *et al.*, 2018; Saeed *et al.*, 2019). Broilers, in particular, are highly susceptible to HS because of their rapid growth, high metabolic rate, and lack of sweat glands (Piestun *et al.*, 2013).

Physiological and metabolite responses

Exposure to high ambient temperature increases the rectal temperature, respiration rate, and panting behaviors as mechanisms to dissipate excess heat (He *et al.*, 2019). These physiological changes are accompanied by elevated oxidative stress and reduced activity of antioxidant enzymes, such as superoxide dismutase and glutathione peroxidase (Bogolyubova *et al.*, 2022). Mitochondrial dysfunction and increased reactive oxygen species (ROS) production further impair energy metabolism and cellular integrity (Akbarian *et al.*, 2016).

Immune function and health

Chronic HS suppresses immune function by reducing lymphocyte proliferation, antibody production, and size of the thymus and bursa (Hirakawa *et al.*, 2020). Increased corticosterone levels promote immunosuppression and inflammation, thereby predisposing birds to infectious diseases. Heat stress also compromises the integrity of the intestinal barrier, allowing endotoxin translocation and systemic inflammation (Zhang *et al.*, 2017; Mahasneh *et al.*, 2024).

Alterations in Gut Microbiota

Heat stress modifies the gut microbial ecosystem by decreasing beneficial bacteria, such as *Lactobacillus* spp. and *Bifidobacterium* spp., and increasing pathogenic species, such as *Clostridium perfringers* and *Escherichia coli* (Nawab *et al.*, 2018; Liu *et al.*, 2020). These alterations disrupt nutrient absorption and gut immune homeostasis, worsening growth retardation.

Effects on the liver and heart function

As a central metabolic organ, the liver is particularly sensitive to thermal load. Heat stress increases the serum levels of hepatic enzymes alanine aminotransferase (ALT), aspartate aminotransferase (AST), and lactate dehydrogenase (LDH), indicating hepatocellular injury (Jastrebski *et al.*, 2017; Saracila *et al.*, 2018a). Similarly, elevated creatine kinase MB (CK-MB) and structural damage in myocardial cells are evidence of cardiac stress (Wu *et al.*, 2015).

Economic and welfare implications

Economically, HS reduces feed efficiency, increases mortality, and impairs carcass yield and meat quality, resulting in substantial financial losses (St-Pierre *et al.*, 2003; Gonzalez-Rivas *et al.*, 2020). For instance, the August 2025 heatwave in Jordan, which lasted for 1 week, when national temperatures reached 49.6°C caused an estimated USD 10 million in livestock-sector losses (unpublished data), highlighting the escalated economic costs of extreme heat events. These losses extend beyond production metrics to include increased energy and water use for cooling systems, lower feed efficiency, and welfare concerns related to dehydration and distress behaviors (FAO, 2022).

Salicylic Acid From Natural Sources

Willow is a well-known source of SA with broader therapeutic uses (Salix spp.; Sharma *et al.*, 2011). Willow has long been used as medicine because of its analgesic and anti-inflammatory properties (Maroon *et al.*, 2010; Capion *et al.*, 2018). Willow is widely used to treat human pain (Uehleke *et al.*, 2013). Salicin, the main component of willow bark, has a more significant concentration of salicylate chemicals (Kammerer *et al.*, 2005), is transformed into SA when taken orally (Mahdi, 2014). Willow branches contain 2,200 mg/kg of SA, whereas willow bark contains up to 3,000 mg/kg of SA (Petrek *et al.*, 2007).

The nutritional qualities, therapeutic benefits, and bioactive phytochemicals of willow have been extensively studied (Islam *et al.*, 2011; Popova and Kaleva, 2015; Ramos *et al.*, 2019). Willow bark contains many phenolic glycosides (Zaugg *et al.*, 1997) and polyphenols, such as flavonoids and tannins (Nahrstedt *et al.*, 2007). According to Khayyal *et al.* (2005), these substances exhibit anti-inflammatory, antipyretic, anti-rheumatic, and hypoglycemic properties. Additionally, the phenolic compounds in willow bark reportedly exhibit antioxidant and antibacterial properties (Pop *et al.*, 2013; Suleiman *et al.*, 2013; Ramos *et al.*, 2019).

The amount of SA in compound feed and its source materials have been established for ruminants and monogastric animals (cattle, pigs, and laying hens; Keszycka *et al.*, 2017; Protasiuk and Olejnik, 2020). Salicylic acid concentrations in the diet varied from less than 0.05 mg/kg to 0.48 mg/kg.

Gligoric *et al.* (2019) and Vlachojannis *et al.* (2009) documented the chemical makeup of willow bark. Nahrstedt *et al.* (2007) found many components of SA, including flavonoids, tannins, and salicin, which are considered the primary active molecules that are converted to SA. During absorption, salicin is converted into various salicylate derivatives (Altınterim, 2013).

The extract from willow bark includes at least 5.0% of the total salicylic derivative expressed as salicin (Saracila *et al.*,2021). Willow extract has anti-inflammatory (Fiebich and Appel, 2003; Fiebich and Chrubasik, 2004), antipyretic (Akao *et al.*, 2002; Khan, 2017), analgesic (Vlachojannis *et al.*, 2009), and antiplatelet activity properties (Altınterim, 2013). The biological activity of willow bark extract can also be attributed to other compounds, such as polyphenols (flavonoids and phenolic acids; Schmid *et al.*, 2001).

Salicylic acid metabolism

Although aspirin (acetylsalicylic acid) is rapidly hydrolyzed to SA *in vivo*, they are chemically distinct compounds. Aspirin is a synthetic acetylated derivative, whereas SA is a naturally occurring plant phenolic. Both drugs share pharmacological properties, such as ant-inflammatory effects, but the aspirin acetyl group confers differences in potency, pharmacokinetics, and safety (Vale, 2016). Note that some birds, such as hens, have slightly different acetylsalicylic acid metabolisms due to the conjugation of SA with ornithine rather than glycine (Baert *et al.*, 2004).

Acetylsalicylic acid is readily hydrolyzed to SA, both enzymatically and non-enzymatically (Fig. 1). Salicylic acid undergoes conjugation reactions that generate the major metabolites salicyluric acid, catalyzed by an Acyl-CoA, N-acyltransferase, and glucuronides (gluc) catalyzed by UDP-glucuronosyltransferase

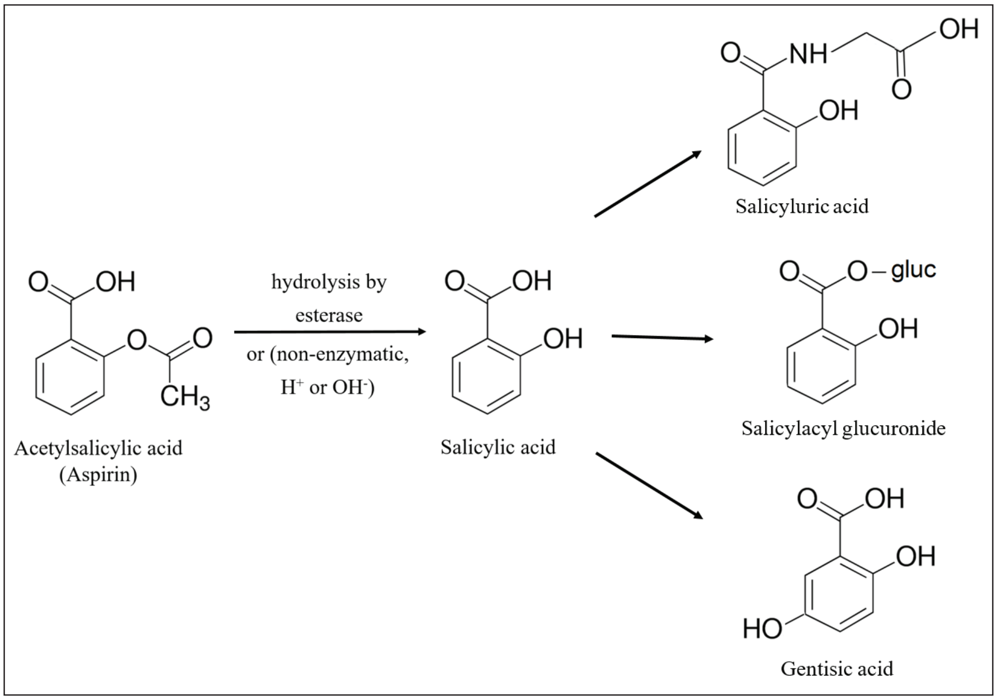

Fig. 1. Metabolic pathway of acetylsalicylic acid.

(Thomas-Brown *et al.*, 2024). The products of SA oxidation have been attributed to non-enzymatic Fenton-type reactions involving 2,3-dihydroxybenzoic acid (2,3-DHBA) and produce gentisic acid (2,5-DHBA, Fig. 1).

Aspirin, also known as acetylsalicylic acid, is a non-steroidal anti-inflammatory medication that prevents prostaglandin synthesis by blocking the cyclooxygenase enzyme. This enzyme creates free radicals and triggers inflammatory reactions (Hilário *et al.*, 2006; Phillips *et al.*, 2022). Acetylsalicylic acid functions as an antioxidant to shield the organism from harm caused by free radicals when it inhibits this enzyme (Alagawany *et al.*, 2017). Furthermore, according to Rokade *et al.* (2017), acetylsalicylic acid improves growth performance and feed utilization by enhancing antioxidant enzymes and immunological function and lowering blood cholesterol and triglycerides in meat and eggs.

Members of the *Salicaceae* family contain over 20 distinct phenolic glycosides, which are glycosylated and esterified derivatives of salicyl alcohol (Van Wyk and Wink, 2017; Landau *et al.*, 2023). Salicin undergoes oxidation in the liver to produce SA after being transformed into saligenin and absorbed into the bloodstream (Van Wyk and Wink, 2017). Goats have also demonstrated that willow consumption has anti-inflammatory effects, as demonstrated by altered milk and blood immune cell populations (Muklada *et al.*, 2020).

According to Kelber *et al.* (2006), SA can suppress monocytes' production of lipopolysaccharide (LPS) and gamma interferon. According to Lee and Sullivan (2001), LPS can trigger several inflammatory pathways, including the up-regulation of TNF-α, one of the most potent pro-inflammatory substances. According to the same researchers, IFN-α may intensify the effects of LPS. Furthermore, it has been observed that the

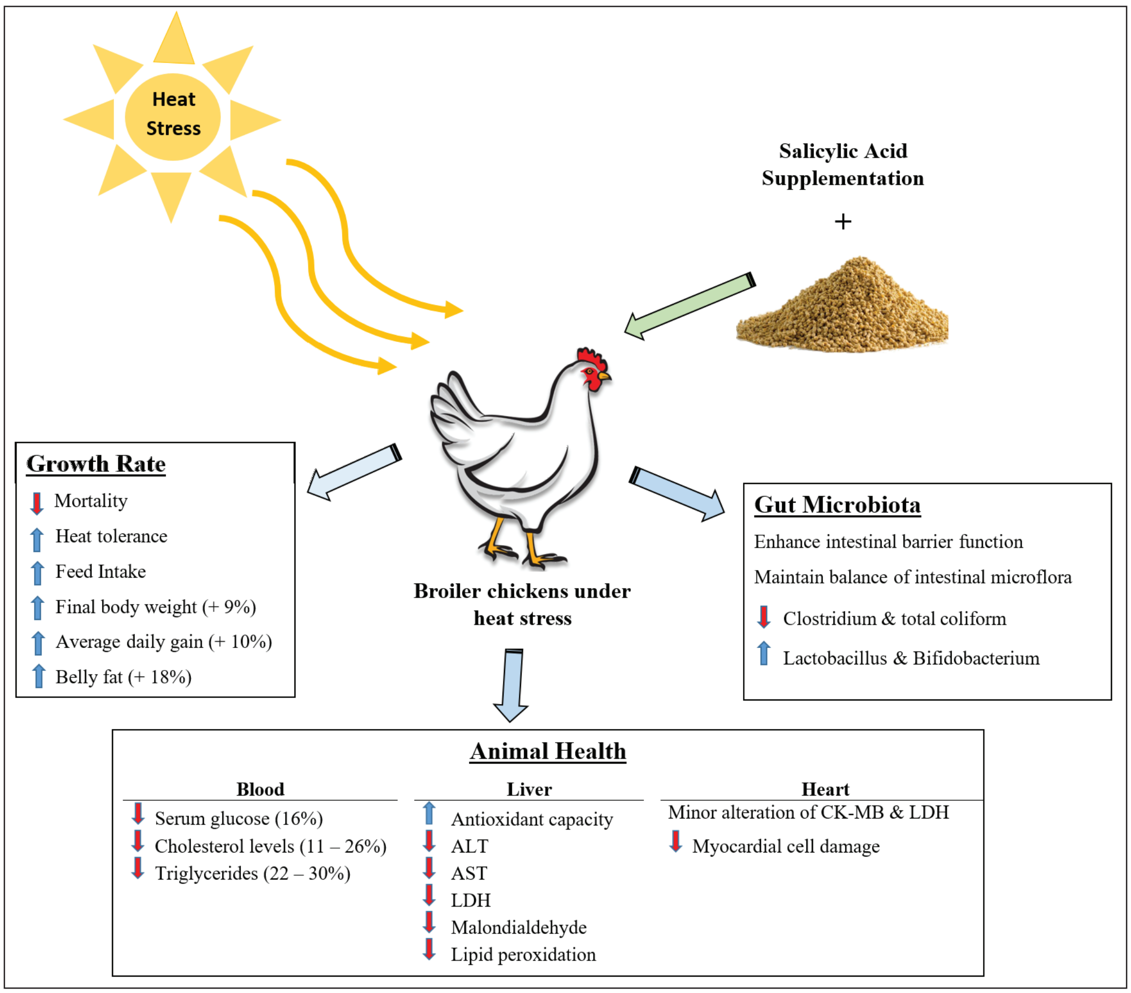

Fig. 2. Effect of salicylic acid supplementation on growth rate, animal health, and gut microbiota of broiler chickens under heat stress. ALT: alanine aminotransferase; AST: aspartate aminotransferase; LDH: lactate dehydrogenase; CK-MB: Creatine kinase–MB.

release of inflammatory mediators, nitrite, and nitric oxidase by monocytes is significantly lower (Kelber *et al.*, 2006). According to Maroon *et al.* (2010), the anti-inflammatory properties of SA are linked to its ability to inhibit pro inflammatory cytokines and cyclooxygenases.

Mode of action

Salicylic acid exerts multiple biological effects relevant to heat stress mitigation. It suppresses prostaglandin synthesis by inhibiting cyclooxygenase (Phillips *et al.*, 2022). It enhances the immune response and decreases corticosterone levels (Rokade *et al.*, 2017). In the gut, SA modulates microbial composition by suppressing pathogens and promoting beneficial bacteria, such as *Lactobacillus* and *Bifidobacterium* (Shi *et al.*, 2019). Moreover, it reduces the expression of heat shock proteins, such as HSP70 (Rokade *et al.*, 2017), improving cellular resilience under heat stress. Together, these mechanisms explain the observed improvements in broiler performance and health under heat stress.

Salicylic Acid Supplementation During Heat Stress

Acetylsalicylic acid, commonly referred to as aspirin, can either improve physiological traits and production performance (Wu *et al.*, 2015; Salah *et al.*, 2019) or mitigate the adverse effects of high temperatures (Roussan *et al.*, 2008) when added as a supplement to the diet or water of heat-stressed broilers. Figure 2 summarize the effect of salicylic acid supplementation on growth rate, animal health, and gut microbiota of broiler chickens under heat stress.

Salicylic acid helps birds cope with heat stress by activating antioxidant defenses (Surai *et al.*, 2019), reducing oxidative damage to cells and membranes (Alagawany *et al.*, 2017; Bogolyubova *et al.*, 2022), upregulating heat shock proteins (Wu *et al.*, 2015), and altering the osmotic balance within cells (Ibrahim and Aziz, 2021).

One of the SA protective mechanisms is the decrease in malondialdehyde (MDA) concentration and electrolyte leakage, which are markers of lipid peroxidation and cell membrane damage under heat stress (Alagawany *et al.*, 2017; Surai *et al.*, 2019; Bogolyubova *et al.*, 2022). Salicylic acid can modulate the activity of enzymes, such as catalase and superoxide dismutase (Surai, 2016; Bogolyubova *et al.*, 2022), which help scavenge and neutralize ROS and stabilize cell membranes (Surai *et al.*, 2019). It also enhances the production of osmoprotectants, such as proline (Alagawany *et al.*, 2017; Ibrahim and Aziz, 2021), which help maintain osmatic balance and cell function under heat stress.

In addition, SA promotes the expression of heat shock protein, particularly HSP27 (Wu *et al.*, 2015; Surai *et al.*, 2019), which helps prevent other proteins from denaturing and aggregating due to heat stress. Wu *et al.* (2015) reported that acetylsalicylic acid treatment reduced myocardial cell injury and efficiently induced HSP27 expression. However, HSP27 expression levels in the hearts of heat stressed chickens in the ASA-HS group and ASA group were continuously induced. The maintained expression levels of HSP27 in both the ASA-HS and HS groups suggest that the effect of ASA treatment lasts for an extended period (Wu *et al.*, 2015). This review provides data on how SA and its derivatives affect broiler chicken growth performance, carcass quality, animal health, gut microbiome, and heat shock protein expression.

Growth rate

According to Ferronato *et al.* (2024), the daily growth performance of broilers improved when acetylsalicylic acid and vitamin C were added to the diet. Their findings demonstrated no appreciable variations in growth performance between dosages when acetylsalicylic acid and vitamin C were used together. Increased feed intake and improved feed efficiency, especially during the finisher period, may be the causes of these gains. However, according to Fathi and Haydari (2016), 80 mg of SA can result in more significant weight gain and an enhanced feed conversion ratio (FCR). Al-Obaidi and Al-Shadeedi (2010) observed similar outcomes for SA when supplemented at a rate of 0.2% of the diet.

Salix babylonica may be a natural substitute for artificial acetylsalicylic acid in broiler diets, according to Al-Fataftah and Abdelqader (2013). They contrasted the effects of synthetic acetylsalicylic acid and the *S. babylonica* leaf extract. According to their findings, Arbor Acres broilers fed a diet supplemented with *S. babylonica* leaf extract (100 ml/day) and those fed a diet containing 0.1% acetylsalicylic acid (100 ml/day) achieved comparable performance parameters under heat stress conditions (35°). Additionally, *S. babylonica* leaf extracts decreased heat-stressed broiler mortality and enhanced heat tolerance, feed intake, body growth, and FCR (Al-Fataftah and Abdelqader, 2013).

Saracila *et al.* (2019) reported that broiler performance was not substantially impacted by the addition of dietary willow bark extract powder (25 and 50 g/kg diet) when broilers were exposed to 32° (14–42 days). The same researchers (Saracila *et al.*, 2018b) reported comparable outcomes after adding 1% extract of white willow bark to the broilers' diet (14–28 days) raised in HS. However, Panaite *et al.* (2020) observed that Cobb 500 broilers (14–42 days old) fed with 0.05) fed 0.05% acetylsalicylic acid had increased final body weight (+9.34%) and average daily gain (+10.76%) than those fed with a lower level of inclusion (0.025%) in thermoneutral conditions. Rohleder, (2008) and Rubio-García *et al.* (2015) reported that the carcass quality of Japanese quails improved in terms of muscle pH and defects when supplemented with acetylsalicylic acid. Furthermore, HS did not affect the proportion of immunological organs (thymus, spleen, and bursa) to body weight when acetylsalicylic acid was used (Ferronato *et al.*, 2024). Acetylsalicylic acid may be able to mitigate intestinal diseases and enhance functional traits because of its potent capacity to block free radicals (Wang *et al.*, 2012).

Sugito *et al.* (2020) showed that no significant effects were found in FCR and carcass weight by the supplementation of acetylsalicylic acid extract (50 and 100 mg/l in drinking water for 7 days in 4 hour/day) under HS (34°) compared to thermoneutral conditions. Furthermore, the same researchers found that only chickens raised in thermo-neutral settings had an 8.42% reduction in abdominal fat when acetylsalicylic acid extract was added to their feed. In broilers under HS, the weight of abdominal fat simultaneously increased by 18.2%. Acetylsalicylic acid counteracts the adverse effects of HS in broilers through its antioxidant activity (Sugito *et al.*, 2020).

Improving the animal health

According to research on heat-stressed broilers, SA supplementation reduces serum glucose and cholesterol levels (Wong *et al.*, 2016). As a stress factor, high temperatures cause neuroendocrine and metabolic changes, leading to increases in blood glucose and cholesterol levels (Altan *et al.*, 2000).

Saracila *et al.* (2019) reported that heat-stressed chickens fed 50 g/100 kg of acetylsalicylic acid powder had noticeably lower blood cholesterol (−26.29%) and triglycerides (−30.65%) than those fed a regular diet. Saracila *et al.* (2018a) compared heat-stressed broiler-fed diet supplementation with a 1% extract of acetylsalicylic acid to those fed a conventional diet, reporting a decrease in serum glucose (−16.35%), cholesterol (−11.25%), and triglycerides (−22.16%).

Broiler liver function was observed to be protected by polyphenol extracts from willow bark under both HS and thermoneutral circumstances (Shi *et al.*, 2019). Furthermore, broilers under HS (32°) fed a diet containing 1% willow bark extract had decreased serum levels of ALT, AST, and LDH than broilers fed a diet without supplements (Saracila *et al.*, 2018a).

Heat stressed broilers fed a diet containing willow bark extract equivalent to approximately 0.05%–0.1% SA activity showed decreased liver MDA levels (Saracila *et al.*, 2018a; 2019). This suggests that acetylsalicylic acid supplementation improves the liver oxidative status of broilers. Zabihi *et al.* (2018) discovered similar outcomes for broilers kept in a thermoneutral environment. Additionally, by lowering the amount of MDA in the broiler liver under HS that was administered nutritional supplementation with acetylsalicylic acid at 0.025% and 0.05% in comparison to the non-supplementing diet, they demonstrated a significant reduction of lipid peroxidation. According to Tan *et al.* (2018), phenols are part of an organism's antioxidant defense, shielding cellular damage from the damaging effects of ROS.

Under HS conditions, the membrane permeability of chicken heart cells increases, releasing several enzymes into the bloodstream. Cardiomyocyte damage-related enzymes, such as CK-MB and lactate dehydrogenase, commonly indicate acute myocardial injury (Chen *et al.*, 2013; Wu *et al.*, 2013). Wu *et al.* (2015) examined pathological lesions and enzyme concentrations linked to cardiomyocyte damage to identify myocardial cell damage in chickens exposed to high temperatures. Aspirin caused a minor alteration in the levels of creatine kinase MB and lactate dehydrogenase, but no morphological changes were observed.

Pretreatment with acetylsalicylic acid decreased myocardial cell damage, which was particularly noticeable in hens subjected to HS without acetylsalicylic acid therapy. There were virtually no indications of cardiac cell damage in HS-treated chickens (Wu *et al.*, 2015). Myocardial cell damage in stressed chickens was reduced following oral acetylsalicylic acid administration compared to animals not given acetylsalicylic acid (Wu *et al.*, 2015).

Fostering Gut Microbiota

The gut microbiota plays a critical role in nutrient utilization, intestinal integrity, and overall performance of poultry. Diet is a major determinant of microbial composition, and feed additives can shift the balance between beneficial and pathogenic bacteria (Iqbal *et al.*, 2020). Salicylic acid and its derivatives may exert growth promoting effects in broilers by inhibiting harmful microorganisms and supporting favorable microbial populations such as *Lactobacillus* and *Bifidobacterium* bacteria (Shi *et al.*, 2019; Rostagno, 2020). Salicylic acid can enhance intestinal barrier function, reduce infection risk, and improve feed conversion ratio by suppressing pathogens, including *Salmonella*, *Clostridium perfringens*, *Enterococcus* species, *Campylobacter*, and *E. coli* (Kogut, 2019). Natural sources of SA, such as willow bark extracts, have relatively low oral bioavailability. As a result, significant fractions may reach the colon, where they are metabolized into bioactive derivatives (Hemeryck, 2017). These interactions can alter microbial signaling pathways and contribute to improved intestinal health (Corêa *et al.*, 2019). Moreover, gut microbes produce metabolites, such as short chain fatty acids, that influence appetite regulation, energy harvest, and growth performance (Byrne *et al.*, 2015; Luo *et al.*, 2018; Liao *et al.*, 2020).

Several studies have indicated that SA supplementation supports a healthier microbial balance by reducing the populations of Coliforms and *Clostridium* species while increasing the number of beneficial lactic acid bacteria. These changes not only improve nutrient absorption and growth outcomes but also contribute to resilience under challenging conditions, including heat stress (Shi *et al.*, 2019; Rostagno, 2020).

Despite its benefits, the potential toxicity of SA must be considered. In poultry, high doses can impair feed intake, reduce growth, and cause metabolic disturbances (Alagawany *et al.*, 2017). Salicylate overdose is associated with gastrointestinal irritation, acidosis, and hepatotoxicity in humans (Vale, 2016).

Table 1. Benefits, limitations, and potential applications of salicylic acid supplementation in Poultry diets.

Salicylic acid supplementation	
Benefits	**References**
- Enhances growth performance, feed utilization, and nutrient digestion	Alagawany *et al.*, (2017); Ferronato *et al.*, (2024)
- Acts as an antioxidant by scavenging reactive oxygen species (ROS) and reducing oxidative stress.	Surai *et al.*, (2019); Bogolyubova *et al.*, (2022)
- Improves thermos-tolerance through regulation of heat shock proteins (HSPs).	Wu *et al.*, (2015); Surai *et al.*, (2019)
- Enhances immune response by modulating pro-inflammatory cytokines.	Sharma *et al.*, (2011); Rokade *et al.*, (2017); Hirakawa *et al.*, (2020)
- Improve egg and meat quality	Rokade *et al.* (2017); Aro *et al.*, (2020)
Limitations	
- Inconsistent efficacy under non-stress conditions	Di Gregorio *et al.*, (2023); Ferronato *et al.*, (2024)
- Optimal dosage and delivery methods are not well standardized	Ferronato *et al.*, (2024)
- Possible toxicity or adverse effects at high concentrations	Vale, (2016); Alagawany *et al.*, (2017)
- Interaction with other dietary supplements not fully understood	Poźniak *et al.*, (2012); Alagawany *et al.*, (2017)
- Lack of large-scale, commercial-condition trials	Di Gregorio *et al.*, (2023)
Potential applications	
- Alternative to antibiotic growth promoters (AGPs)	Di Gregorio *et al.*, (2023)
- Offers non-antibiotic anti-inflammatory effects that may support growth and welfare	Hirakawa *et al.*, (2020)
- Preventive strategy for oxidative stress–related disorders (e.g., reduced fertility, lowered immunity).	Bogolyubova *et al.*, (2022)
- Could be combined with vitamins, minerals, or probiotics for synergistic effects.	Di Gregorio *et al.*, (2023)
- Could be used as feed additive for sheep and goats to mitigate heat stress.	Muklada *et al.*, (2020); Landau *et al.*, (2023)

Thus, careful dose optimization is critical to balance the benefits and risks.
Practical applications indicate that SA and acetylsalicylic acid are most commonly supplemented through feed at 0.02%–0.1% or drinking water at 50–100 mg/l, with beneficial effects reported under heat stress conditions (Al-Fataftah and Abdelqader, 2013; Saracila *et al.*, 2018a). Table 1 summarizes the benefits, limitations, and potential application of SA supplementation in poultry diets.

Conclusion

The broiler industry faces a serious problem caused by heat stress, which is linked to cellular oxidative damage and the inflammatory response. Some plant extracts, such as willow, have been found to contain a variety of bioactive substances, including SA and salicin, with antibacterial, anti-inflammatory, and antioxidant properties.
In this review, we summarized the potential application of SA supplementation as a mitigation approach to decrease the number of oxidative stress biomarkers and pathogenic bacteria and increase the number of lactobacilli in the cecum of heat stressed broilers.
The mechanisms of action of SA in heat stressed broilers were illustrated in this review. Salicylic acid protects broilers from harm caused by free radicals by enhancing antioxidant enzymes and immunological function. In addition, dietary acetylsalicylic acid was valuable in mitigating the adverse effects of heat stress on metabolic parameters, oxidative status, and gut microbiota composition of heat stressed broilers because of its anti-inflammatory and antioxidant qualities. The studies presented in this review show that acetylsalicylic acid supplementation decreases mortality, enhances heat tolerance, and improves growth performance, feed intake, and feed use in heat stressed broilers. However, additional research is needed to

determine the optimal dosage of acetylsalicylic acid supplementation in broiler diets and how it affects other factors such as immunological response, chicken meat safety and quality, and intestinal growth in heat stressed broilers.

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Conflict of interest

All authors declare no conflict of interest.

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Authors' contributions

Rawad Sweidan: Conceptualization, Data Curation, Original Draft Writing, Review and Editing. Mohannad Abuajamieh: Supervision, writing, review, and editing.

Data availability

All data are available by the corresponding author upon reasonable request.

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