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Review paper

Review study on the oxidative stress and antibiotic use risks in broiler chickens: role of plant extracts

Frahtia Ahlem, Derouiche Samir*

Department of Cellular and Molecular Biology, Faculty of Natural Sciences and Life, University of El-Oued, El-Oued 39000, Algeria
Laboratory of Biodiversity and Application of Biotechnology in the Agricultural Field, Faculty of Natural Sciences and Life, University of El-Oued, El-Oued 39000, Algeria

*Corresponding author: dersamebio@gmail.com
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ABSTRACT

Context: In poultry production, oxidative stress is unavoidable and impacts the physiological, behavioral, and biochemical conditions of developing chickens, ultimately lowering the quality of their meat. ***Objectives:*** This literature review aims to draw attention to how oxidative stress affects poultry production and gastrointestinal function, specifically how it affects growth performance, immunological responses, and reproductive results. ***Methods:*** The data were collected by searching Science Direct, Google Scholar, PubMed, Scopus, Springer and National Center for Biotechnology Information. We used several keywords in searching terms like poultry and Broiler chickens. ***Results:*** This review highlights the complex processes that underlie Oxidative stress and explains how a number of variables, such as environmental stresses, genetic predispositions, and dietary components, might make reactive oxygen species production worse. Furthermore, the effects of oxidative stress on poultry's physiological systems and production performance are investigated. Antibiotics are employed in broiler production for curative applications, prophylactic measures, and as agents for growth promotion. Antibiotic residues in broiler meat pose serious health risks to consumers, including toxicity, allergic reactions, and the development of microbes resistant to antibiotics. Exogenous vitamin, antioxidant, and plant extract supplements scavenge reactive oxygen species and help reduce oxidative stress in the gastrointestinal tract. ***Conclusion:*** Potential directions for future study on using these pathways to treat oxidative stress-related illnesses in poultry are explored.

Keywords: antibiotic, antioxidants, broiler chickens, GIT, oxidative stress

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INTRODUCTION

The broiler sector is instrumental in ensuring food security and generating income, especially within developing nations. Nonetheless, it encounters economic obstacles, including competition from imported goods and the necessity for cohesive policies that promote sustainable methodologies (Queenan et al., 2021; Lekhisa and Muroyiwa 2024). Broiler chickens are primarily raised for meat production due to their soft, tender meat, low-fat content, and short production cycle. Globally, broilers play a significant role in enhancing food security, providing a reliable protein source, and contributing to employment opportunities in the agricultural sector. Their rapid growth and efficient feed conversion make them a valuable food animal, supporting both local economies and global food demands (Kryger et al., 2010).

The poultry industry in Algeria plays a pivotal role in the nation's agriculture, providing substantial quantities of meat and eggs. In 2021, poultry, specifically chickens, represented the principal livestock category in Algeria. During that period, the population of chickens within the nation exceeded 137 million individuals (Statistica, 2024). In the corresponding year, the country attained a ranking of 45th in terms of production, yielding a total of 298 thousand metric tons (Report Linker, 2024).

The elevated prevalence of diseases, notably Newcastle disease and coccidiosis, exerts a considerable influence on poultry health and productivity, resulting in significant economic detriment (Alloui et al., 2015; Rahmani et al., 2024). Poultry agricultural enterprises are significantly impacted by thermal stress resulting from escalating temperatures, which can detrimentally influence the metabolic responses of chickens, especially during summer (Mouss et al., 2024). The sector is predominantly dependent on externally sourced feed, which represents a significant economic liability, as 80% of feed components are procured from foreign suppliers (Alloui et al., 2013).

Broiler breast musculature comprises roughly 21-23% protein and 1.90-1.97% lipid content, whereas the thigh musculature contains 19.03-19.93% protein and 4.70-6.05% lipid content (Kralik and Kralik 2017). Moreover, broiler meat serves as a substantial source of vital minerals including phosphorus, magnesium, iron, copper, and manganese, with the pectoral muscles contributing significantly to the nutrient reference values associated with these minerals (Goluch et al., 2023). It is also a significant source of essential amino acids, such as lysine, methionine, and threonine, which play a vital role in promoting human health (Radu-Rusu et al., 2010). In terms of fatty acid composition, the muscular tissue of the thigh exhibits a greater concentration of omega-3 fatty acids in comparison to the breast muscular tissue, which is characterized by a more dietary profile. Furthermore, the cholesterol concentration in thigh muscles is elevated, attaining levels of 82-83 mg per 100 g (Radu-Rusu et al., 2010).

While broiler meat serves as a valuable nutritional resource, its inherent nutritional attributes may be affected by a multitude of variables, encompassing the formulation of feed and the methodologies employed in rearing practices. The incorporation of targeted feed additives and alterations in dietary composition can augment the nutritional characteristics of broiler meat, thereby rendering it significantly more advantageous for human ingestion (Choi et al., 2023). An extremely dynamic and complicated organ, the GIT is essential for both immunological response

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and nutrient absorption. Nutrient absorption occurs through the intestinal mucosa, which is made up of connective tissues, epithelial cells, and other cell populations. The intestinal epithelia serve as a selective barrier between the GIT's tissues and luminal environment, and they are constantly exposed to a wide range of potentially hazardous substances. A redox imbalance is caused by a number of stresses, including dietary toxin and pathogenic pathogens that cause the production of free radicals within cells (Derouiche et al., 2013).

METHODS

The data were collected by searching Science Direct, Google Scholar, PubMed, Scopus, Springer and National Center for Biotechnology Information (NCBI). The keywords used as search terms were "poultry", "Broiler chickens", "oxidative stress", "antibiotic", "plant extract anti-oxidant", "nutritional resource", "Vaccination", "poultry meat quality".

VACCINATION PROGRAMS

Vaccination constitutes a fundamental element in the prophylaxis of diseases within broiler production. A multitude of vaccination protocols are utilized to address prevalent avian diseases. Table 1 provides a simplified vaccination program offered by LAPROVET (Nirala et al., 2018), which is a French veterinary laboratory, involved in the development of livestock sectors in Africa.

Table 1. Broilers' vaccination program.

Age	Treatment/ Vaccination	Mode of Administration
Day 1	Primo vaccine Newcastle Disease (ND) Infectious bronchitis (IB)	Beak dipping or nebulization
Day 1-3	Anti-stress	Drinking water
Day 4-6	Hepatoprotective	Drinking water
Day 7	Primo vaccine Gumboro	Drinking water
Day 7-10	Vitamin complex	Drinking water
Day 14	Gumboro vaccine booster	Drinking water
Day 14-16	Hepatoprotective	Drinking water
Day 17	Newcastle vaccine booster	Nebulization or drinking water
Day 17-18	Vitamin complex	Drinking water
Day 19	Infectious bronchitis vaccine	Nebulization or drinking water
Day 19-20	Vitamin complex	Drinking water
Day 21	Gumboro vaccine booster	Drinking water
Day 21-23	Minerals and trace elements	Drinking water
Day 24-26	Anticoccidial	Drinking water
Day 30	Newcastle booster vaccine	Nebulization or drinking water

ANTIBIOTIC USES AND RISKS

The rearing of chickens is facilitated through the consistent application of antibiotics, which serve not only to prevent and treat diseases but also to enhance bodily growth. The excessive and improper utilization of antibiotics in livestock is exacerbating the

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escalating concern of antibiotic resistance (Haque et al., 2020). Antibiotics represent a critical category of compounds in veterinary pharmacology that are crucial to both animal dietary requirements and the management of livestock production. The administration of antibiotics for addressing bacterial infections is, to a considerable extent, indispensable (Arsène et al., 2022). Antibiotics are employed in broiler production for curative applications, prophylactic measures, and as agents for growth promotion. Their efficacy in augmenting growth is attributable to the enhancement of feed conversion efficiency and the mitigation of disease prevalence, which consequently elevates economic returns (Alabi et al., 2024).

The occurrence of antibiotic residues in broiler meat presents significant health hazards to consumers, encompassing allergic responses, toxicity, and the emergence of antibiotic-resistant bacterial strains. Furthermore, these residues have the potential to interfere with the soil microbial community upon their excretion into the environment (Arsène et al., 2022; Nirala et al., 2018). The application of antibiotics in the context of broiler production is currently subject to critical examination owing to the potential emergence of drug-resistant bacterial strains. A paradigm shift towards antibiotic-free production is occurring, propelled by consumer preferences and public health considerations. Nonetheless, this transition poses significant challenges in ensuring both food safety and the welfare of chickens in the absence of antibiotic usage (Haque et al., 2020).

POULTRY OXIDATIVE DAMAGE

Oxidative stress (OS) is characterized by an imbalance between pro-oxidants and antioxidants that favors the pro-oxidants (Derouiche et al., 2017). OS arises when there are more reactive species (RS) than animal cells can use as antioxidants (Derouiche et al., 2020). The body continuously generates reactive oxygen species (ROS) as a byproduct of normal metabolism (Derouiche et al., 2022). These substances are extremely reactive and have the ability to change a wide range of important macromolecules in biology. These occurrences cause OS and oxidative damage, which result in the emergence of different metabolic dysfunctions (Derouiche and Kechrid 2013). Oxidative damage to poultry causes abnormalities in the meat, such as white striping and wooden breasts, by interfering with normal metabolism. After being killed, chickens with lower antioxidant capacities are more prone to have oxidative responses in their meat (Chen et al., 2022). By oxidizing proteins and lipids during the meat processing process, it damages the meat's nutritional value and sensory appeal and creates a pro-oxidant environment in muscle tissues, which ultimately leads to low-quality meat (Domínguez et al., 2021). Moreover, OS impairs the gastrointestinal tract, a delicate organ required for proper digestion and nutrient absorption, which in turn reduces poultry productivity. Free radicals produced by oxidative reactions can harm intestinal epithelia, which further impairs chicken health and productivity (Cao et al., 2021).

SOURCE OF OXIDATIVE STRESS IN POULTRY

One of the most difficult environmental stressors related to poultry production is the high temperature. Because heat stress results in a redox imbalance favoring prooxidants over antioxidants, it is a significant cause of systemic oxidative stress

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(Wasti et al., 2020). Changes in feed intake, poor growth performance, immunosuppression, hypoxia, and high mortality have all been linked to heat stress. Additionally, heat stress lowers the quality of chicken meat (Mishra and Jha, 2019). A variety of environmental toxins, as well as bacterial and fungal toxins, are frequently present in poultry diets and feed ingredients, and they are known to have an impact on gut health. Toxin absorption from the paracellular space is inhibited by the intestinal luminal epithelial cells and the tight junction proteins that separate two neighboring epithelial cells. In addition to changing cellular functions, oxidative stress also modifies the function of the intestinal barrier (Zmrhal et al., 2023).

There are many minerals that cause poisoning in chickens, such as arsenic, which is found in food, water, and the environment in large quantities. It is extremely poisonous and has negative effects on nutritional absorption and digestion, which may hinder the growth of chickens. One of the main causes of the air pollution in the inadequately ventilated chicken barn is ammonia. Elevated ammonia levels change feed efficiency and reduce body weight and development rate (Aljohani, 2023).

Protozoa, fungus, and bacteria make up the majority of the GIT microbiota. The microbiota population changes throughout the compartment, peaking at the GIT's distal segments (20). In reaction to commensal bacteria, intestinal epithelial cells produce ROS, a second messenger that takes part in cellular signaling (Matijašić et al., 2020). According to studies, oxidative stress is caused by the mucosa's interaction with microorganisms or their toxins. Intestinal epithelial cells are impacted by environmental heat stress, which also increases intestinal bacteria and bacterial LPS. LPS is known to cause damage and apoptosis in a variety of cell types (Ghulam-Mohyuddin et al., 2022).

VIRUS-INDUCED OXIDATIVE STRESS

Viruses affect the redox equilibrium by increasing the synthesis of oxidants such superoxide and NO and inhibiting the synthesis of CAT, SOD, and GPx. Since immune cells need these enzymes in greater quantities than other cells, a weaker immune response results from decreased synthesis and activity of these enzymes (Akyildiz and Denli 2016). Granulocytes and macrophages produce more ROS during viral infections, which has antibacterial properties against a variety of diseases. Numerous opportunistic infections, including as Salmonella, Staphylococcus aureus, Serratia marcescens, and Aspergillus species, are brought on by a failure to produce ROS (Arunachalam et al., 2023). Lipid peroxidation, protein oxidation, and DNA oxidation are all examples of the direct antibacterial activity. Autophagy, apoptosis, and inhibition of the mammalian target of rapamycin are some of the pathways that ROS initiates in response to viral infection in order to eradicate or spread viral infections (Herb and Schramm, 2021). Additionally, ROS disrupt T cell polarization, adaptive immunological responses, and innate immune cells' presentation of antigens. However, studies also confirm ROS's immunosuppressive effects, which may aid in viral infection and evolution (Bassoy et al., 2021).

OXIDATIVE STRESS AND POULTRY MEAT QUALITY

Oxidation mostly results in meat deterioration and spoiling in broiler chicken. High ambient temperatures, pollutants, and various pathological states are among the many

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predisposing factors that increase the susceptibility of broiler chickens to oxidative stress (Cartoni-Mancinelli et al., 2023). However, during the energy-generating process, electron leakage from the respiratory chain in the mitochondria is the main cause of oxidative stress in chickens (Kowalczyk et al., 2021). The abrupt failure of the natural antioxidant system in living cells causes the chicken meat to undergo a number of oxidative reactions after slaughter. Following slaughter, pro-oxidant levels rise and many biochemical changes, including pH decrease, take place. Following slaughter, muscles containing transition metals, myoglobin, and H2O2 naturally contain certain pro-oxidants. These pro-oxidants increase the formation of ROS through a variety of methods (Surai et al., 2019). One major issue facing the meat business is the oxidation of the proteins in meat. Muscle nitrite serves as a precursor to free radicals such as reactive nitrogen species (RNS), which cause proteins meat oxidize and nitrate (Wang et al., 2022). In addition to nitrite, reducing sugars plays a critical part in the generation of reactive oxygen species, which in turn causes protein glycol-oxidation, which destroys muscle protein. Furthermore, because they can create free radicals, a variety of physical factors, such as radiation, also cause needless oxidation in meat, including photo-oxidation (Ponnampalam et al., 2022).

MITIGATION OF OXIDATIVE STRESS

Consuming antioxidant-rich foods lowers intestine free radicals and supports intestinal mucosal health (Riaz-Rajoka et al., 2021). According to a number of studies, oxidative stress puts birds at risk for a number of diseases and welfare issues. As a result, developing an economical plan to reduce oxidative stress is crucial (Afzal et al., 2023). Vitamin C and E supplements enhance immunological function and antioxidant capacity (Chetehouna et al., 2024a). Alpha lipoic acid is a strong antioxidant that is soluble in both fat and water and protects the intestines of poultry from oxidative damage. Combining vitamins with antioxidant micronutrients like magnesium, zinc, and selenium can primarily shield meat quality from oxidative stress-induced degradation (Chetehouna et al., 2024b). Because they maintain the meat's ability to retain water and its color, methionine and selenium have been shown to have beneficial effects during oxidative stress (Ponnampalam et al., 2022).

ROLE OF ANTIOXIDANT OF PLANT EXTRACTS

Plant extracts have a wide range of activities and their active secondary plant metabolites typically belong to the classes of isoprene derivatives and flavonoids (Frahtia et al., 2024; Islam et al., 2024). They have a wide range of activities. A great number of plant extracts contain chemical compounds exhibiting antioxidant, antimicrobial, anti-inflammatory, anticoccidial and anthelmintic properties (Chetehouna et al., 2024c).Incorporating phenolic compounds into poultry has demonstrated efficacy in mitigating oxidative stress during the production and processing of poultry meat. Apple peel, tea catechins, grape pomace, pea seeds, rosemary leaves, and various vegetables are among the many plants that are high in phenolic compounds (Mahfuz et al., 2021). Because these plants are strong antioxidants, broiler chickens' digestion may be enhanced by include them in their diet. These phytogenic plants are natural sources of antioxidants, and research

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indicates that they are far more effective than artificial antioxidants (Basiouni et al., 2023).

When used as feed supplements, plant extracts or oils primarily improve the gastrointestinal microbiota environment by reducing the number of possible pathogens and increasing the small intestine's ability for digestion (Colella et al., 2023). Studies have shown that dietary plant extracts have a significant impact on stimulating the endocrine system and the metabolism of intermediary nutrients (table). Herbal extracts or their active ingredients may have positive effects on animal nutrition by increasing hunger and feed intake and enhancing the release of endogenous digestive enzymes (Alem 2024). On the other hand, there are many studies that prove the beneficial effect of plant extracts with a very low risk of toxicity, which proves the biological effectiveness of plants with safe use of plant extracts (Asrar et al., 2023). However, we must ensure that the plant is not toxic by means of an acute toxicity test before any use of the plant extracts, as confirmed by the study of Hashemi et al., 2008 which indicated that Acute toxicity study indicated that water suspensions of herbal aqueous extract are not toxic when administered by the oral route to experimental birds at 2000 mg kg-1 b.wt.

Table 2. Effects of dietary plant extracts used as feed additives on poultry performance (Alem, 2024).

Active Compounds	**Plant**	**Family**	**Parts**	**Function**
Eugenol	Clove (*Syzygium aromaticum*)	Myrtaceae	Flower	Appetizer, digestion stimulant, antiseptic
Cinnamaldehyde	Cinnamon (*Cinnamomum zeylanicum*)	Lauraceae	Leaf	Appetizer, digestive stimulant, antiseptic
Linalol	Coriander (*Coriandrum sativum*)	Apiaceae	Leaf, seed	Appetite enhancer, digestive stimulant
Anethol	Anise (*Pimpinella anisum*)	Apiaceae	Fruit	Digestive stimulant, galactagogue
Phthalides	Celery (*Apium graveolens*)	Apiaceae	Fruit, leaf	Appetizer, digestive stimulant
Capsaicin	Capsicum (*Capsicum annuum*)	Solanaceae	Fruit	Reduce pain and swelling
Zingerone	Ginger (*Zingiber officinale*)	Zingiberaceae	Rhizome	Appetizer, antioxidant, stress reducer
Allicin	Garlic (*Allium sativum*)	Amaryllidaceae	Bulb	Enhance gut activity, promote growth in livestock and poultry
Cineol	Rosemary (*Rosmarinus officinalis*)	Lamiaceae	Leaf	Anti-bacterial, anti-microbial, neurological protection
Thymol			Whole plant	Pharmaceutical application, antimicrobial, antioxidant, anti-carcinogenic, anti-inflammatory, immune-stimulant

CONCLUSION

Environmental factors, such as thermal stress, pathogenic causes, and dietary factors all contribute to oxidative stress in the poultry GIT. The growth and productivity of

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broilers, as well as the quality of the meat they produce, are adversely affected by these pressures. One of the stressors that contribute to the development of meat quality problems is oxidative stress. Meat spoils due to oxidative stress, which causes lipid and protein oxidation. White striping, wooden breast, and other notable irregularities in poultry meat are caused by the possible threat of oxidation to meat quality with regard to color, texture, and water-holding ability. Nowadays, a variety of antioxidants, such as exogenous vitamins, antioxidants, and plant extracts, are applied singly or in combination to protect chickens from oxidative stress. To reduce oxidative stress in broiler chickens, more research is needed to examine the effects of antioxidants in various combinations. Accordingly, and from the above, it is necessary to benefit from some of the warnings that we have listed in this review in order to raise poultry anywhere in the world on sound, healthy rules and a balanced diet away from causes of oxidative stress and all the influences and obstacles that may lead to diseases or unhealthy poultry meat.

DECLARATION OF CONFLICT OF INTEREST

No conflict of interest to declare.

DECLARATION OF HONOUR

We declare in our honor that our results are not fake and made up.

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