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Oxidative stress in broiler chicken and its consequences on meat quality

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Abstract

Oxidative stress is inevitable in poultry production, and it affects the physiological, behavioral and biochemical status of growing chicken which ultimately deteriorates meat quality. Appearance, texture, juiciness, tenderness and odor are responsible for the overall meat quality as they are essential perceptible features, which determine the consumer's judgment. Overproduction of free radicals including reactive oxygen species (ROS) disturbs the mitochondrial function in living cells. During high-temperature mitochondrial substrate oxidation and electron transport chain (ETC) activity increases. This increased activity results in excessive production of superoxide that oxidizes protein and lipid contents in muscle tissues. By oxidizing protein and lipid, ROS spoils the nutritive quality of chicken meat. High ambient temperature is one of the major contributing factors that enhance oxidative stress. Poultry feed with anti-oxidant supplementation and innovative processing techniques can help the poultry industry to overcome oxidative stress.

Keywords: Oxidative stress; Reactive oxygen species (ROS); Mitochondria dysfunction; Meat quality

1. Introduction

Poultry meat is the major contributor to global meat production (right after the pig industry); thus, the increasing awareness regarding meat quality among consumers is challenge for poultry industry to produce more healthy and nutritious meat. In commercial poultry farming, oxidative stress has severe implications on meat quality as oxidative reactions occur throughout poultry meat production and processing, from the farm practices to the final customer (Estévez, 2015). Rapid advancement towards genetic improvement in the poultry industry through various genetic selection methods has made the poultry industry much efficient in terms of feed efficiency and growth rate. Simultaneously, poultry birds have become more vulnerable to environmental factors such as heat and oxidative stress (Gonzalez-Rivas et al., 2020), the birds' thermoregulatory system has become more prone to the high ambient temperature that is the potentially discouraging factor for broiler production (Spiers, 2012; Zaboli et al., 2019). Under unfavorable environmental conditions, these genetically modified birds exhibits poor production, they can only perform better in specific environment, as they cannot acclimatize their inner physiological and metabolic conditions with ever-changing global environmental factors. Studies also suggest that birds are more sensitive to oxidative stress and high ambient temperature as compared to other animals (Celi & Gabai, 2015; Estévez, 2015).

Oxidative stress triggers biological malfunctioning, organ damage, poor performance, health issues, and altered meat quality. Oxidative damage in poultry impairs the normal metabolism, which leads to the development of meat abnormalities such as wooden breast and white striping (Estévez, 2015). Compromised anti-oxidant ability in chickens promotes oxidative reactions in meat after the slaughtering of bird. It creates a pro-oxidant environment in muscle tissues, ultimately leading to poor meat quality (Shakeri et al., 2018) by damaging sensory properties and nutritive composition of meat during meat processing by oxidizing numerous feed constituents, lipids and proteins. Lipid oxidation is one of the significant challenge to the poultry meat processing industry because poultry meat is highly

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sensitive to oxidative reactions, and these oxidative reactions are responsible for rancidity in processed poultry products by inducing lipid oxidation (Droval et al., 2012; Min & Ahn, 2005). While protein oxidation negatively affects the functionality and digestibility of proteins and oxidation of pigments such as heme alters the meat color leading to the consumer rejection of the meat (Droval et al., 2012). Furthermore, oxidative stress has severe implications on poultry's health status and production efficiency by disturbing the chicken GIT as GIT is a delicate organ responsible for proper nutrient absorption and digestion. Oxidative reactions potentially damage intestinal epithelia by producing free radicals that ultimately reduce poultry productivity (Gonzalez-Rivas et al., 2020; Lan et al., 2005).

Oxidative stress is the presence of reactive species (RS) in excess amount compared to the anti-oxidant capacity of animal cells (Halliwell & Whiteman, 2004). Out of these reactive species, mostly reactive ("oxygen/chlorine/nitrogen species") species are highly toxic and dangerous for living tissues or cells (Ferreira et al., 2014; Halliwell & Whiteman, 2004). They can alter cellular molecules' functioning and biological structure, including DNA, RNA, lipids, and proteins that cause numerous complications, including metabolic dysfunction, consequently leading to cell death (Cadenas & Davies, 2000; Hansford et al., 1997). These oxidative reactions oxidizes molecules and those oxidized molecules abstract electrons from neighboring molecules triggering a chain of unending reaction causing massive tissue damage in the living organism. Apart from this, OS negatively influences the enzymes' expression, which are involved in crucial processes such as inflammatory reactions, defense mechanism and detoxification process leading to the failure of cell defense mechanism against oxidants. Antioxidants comprise of both non-enzymatic low molecular weight (e.g., vitamin C, GSH, and uric acid) and enzymatic high-molecular-weight [e.g., superoxide dismutase (SOD), glutathione peroxidase (GSH-Px), and arylesterase] complexes. They reduce the rate and development of oxidation and thereby guard cells against oxidative damage (Pamplona & Costantini, 2011). The purpose of this article is to summarize the (1) physiological and metabolic changes in poultry meat under oxidative stress, and (2) potential mitigation strategies against oxidative stress in broiler chickens. Figure (1) describes the predisposing factors responsible for oxidative stress throughout the production and processing of meat along with the consequences of oxidative stress on poultry meat quality.

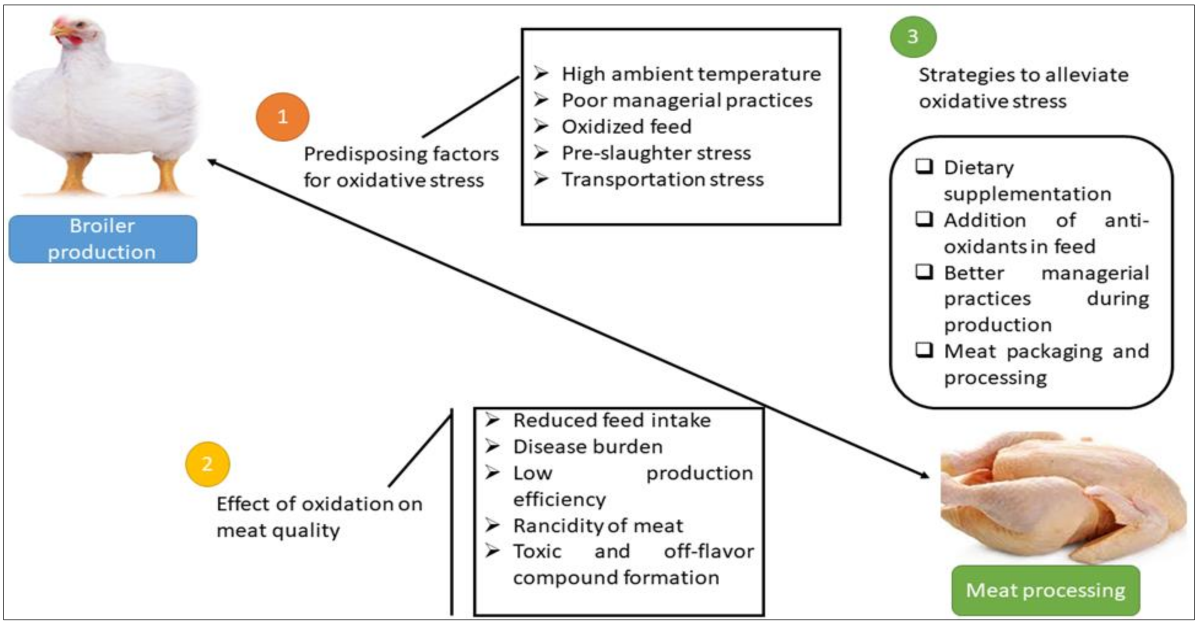

Figure 1 Role of oxidative stress and its predisposing factors in the deterioration of chicken meat quality from meat production to meat processing

2. Oxidative stress

The imbalance among free radicals and anti-oxidant enzymes within living cells or tissues leading to the oxidation of lipids, proteins, and nucleic acid is a fundamental cause of oxidative stress. There are various sources of stress in the commercial farming industry ranging from environmental to nutritional and managerial issues that compromise poultry production performance and health. When the anti-oxidant mechanism within living cells weakens, the production of free radicals increases under physiological oxygen metabolism (Estévez, 2015), these reactive species (ROS, RNS) are needed in cells in small quantities as they also function as signaling molecules during homeostasis. However, excessive production of these species leads to oxidative stress. There is a mechanism in living cells to reduce the number of oxidative species through physiological scavenging. Numerous reactive oxygen species such as superoxide and hydrogen peroxide are produced during oxygen metabolism. The balance must be maintained within cells through the proper ratio between oxidant formation and elimination. In this regard, different scavenging enzymes, including superoxide dismutase (SOD), glutathione peroxidase (GPX), and catalase, carry out the reduction of reactive oxygen species (Lin et al., 2006). SOD catalyzes the superoxide anion of radicals while the catalase enzyme decomposes it into H_2O and O_2, and GPX enzyme reduces lipid hydro-peroxides through glutathione addition (Loyau et al., 2015). On the other hand, reactive nitrogen species (RNS) are produced during nitric oxide synthases metabolism and only expressed in specific intestinal regions. Nitric oxide free radicals help the cell functioning in immune-modulation and neurotransmission, but its overproduction is lethal for intestinal mucosa (Altan et al., 2003).

2.1. Oxidative stress due to high environmental temperature

High environmental temperature is one of the most studied and discussed environmental stressors, which is believed to be a significant challenge to the commercial poultry sector in warm areas of the world. In poultry production, heat stress is mainly associated with reduced feed intake, poor growth, high mortality and compromised meat quality (Hashizawa et al., 2013). High ambient temperature creates pro-oxidant and oxidant imbalance by increasing pro-oxidants' production and triggers oxidative stress (Gonzalez-Rivas et al., 2020; Ahmad Mujahid et al., 2007). Birds kept under heat stress have shown unprecedented changes in the small intestine's microstructure. They displayed reduced crypt depth and villus height of the small intestine that damages the absorptive ability of the small intestine (Marchini et al., 2011). Apart from this, chicken raised under cyclic heat stress have shown epithelial injury, apoptosis, and hyperpermeability, leading to the entry of bacteria from the intestinal region into the blood circulatory system. Heat stress stimulates the chicken hypothalamus, pituitary-adrenal axis, consequent in high blood serum glucocorticoid that successively cuts food intake, weight gain, relative immune organ weight, and natural immunity. This neuro-immune dysfunction further modifies intestinal-immune barriers, permitting infective micro-organisms to migrate through the enteric mucous membrane and generate an inflammatory infiltrate. Inflammation of the intestine causes a reduction in nutrition absorption and consequently hampers weight gain (Zhao et al., 2017).

2.2. High ambient temperature is responsible for mitochondria dysfunction

In living organisms, cellular energy is generated in mitochondria through oxidative phosphorylation. This process of energy production is mainly driven by the well-arranged action of four respiratory enzyme complexes. During this normal physiological process of energy production, almost 1-4% (Costantini, 2019) of oxygen does not convert into water. However, it generates reactive oxygen (superoxide) due to the leakage of electrons during complexes I and III of respiratory chains. Cells are equipped with efficient dismutation pathways; i.e., CuZnSOD acts within the intermembrane area (also present in the cytosol), and MnSOD acts within the matrix to cut back superoxide to hydrogen peroxide (H_2O_2). Within the presence of ferric and cuprous ions, H_2O_2 is often further reduced to the very reactive and dangerous group (OH°; Fenton reaction). In contrast to $O_2°-$ and OH°, H_2O_2 will diffuse into the cytoplasm via membranes, resulting in new molecular reactions removed from the assembly site and then reach new cells and tissues. The transmission to neighbor cells and tissues will occur very quickly through many centimeters of tissue in a fraction of a second (Costantini, 2019). It is believed that underneath traditional physiological conditions, this reactive chemical element species (ROS) generation is not ultimately harmful and is firmly controlled by the anti-oxidant defense mechanisms.

Moreover, a light production of ROS is crucial for correct cell performance through its signal actions. Because of its diffusion capacities and better stability, H_2O_2 is the major ROS acting as a second traveler. During this respect, proof shows that 2-Cys peroxiredoxin (2-Cys PRX; thioredoxin dependent for regeneration) functions as a regulator in dominant basal H_2O_2 levels in cells by its oxidase activity. The primary step within the pathophysiology of HS seems to be a rise in cellular energy demand. A study reported that mitochondrial transportation and β-oxidation of fatty acids were increased when birds were kept under 6 h of acute HS (Ahmad Mujahid et al., 2007). The latter was related to elevated blood levels of nonesterified fatty acids. To fulfill the improved energy demand of cells and mitochondrial biogenesis, the assembly of reducing equivalents and the enzymatic activity of subunits of metabolic process chain complexes are augmented. Underneath physiological conditions, electron transport is tightly coupled to the organic process. This suggests that electrons do not typically flow through the electron transport chain (ETC) to O_2 unless ADP is at the same time phosphorylated to the nucleotide. Throughout this method, the pH scale in muscles decreases because of warm temperature, which boosts pale, soft and exudative meat.

Apart from this, heat stress encourages intracellular phospholipase A2 (PLA2) and arachidonic acid activity in the presence of intracellular Ca^{2+} in broiler (Soares et al., 2003). This enzymatic activity is inducing factor to initiate development of PSE meat by increasing significantly the peroxidation reactions. This higher lipid oxidation and the relative excessive production of arachidonic acid in PSE meat samples corroborated the previous assumption that PLA2 activity was directly related to PSE syndrome occurrence (Soares et al., 2009). To sum it up, high ambient temperature induces pro-oxidant enzymes that act upon phospholipid membranes liberating arachidonic acid and lysophospholipids, which can potentially affect the sarcoplasmic reticulum Ca^{2+} release (Cheah et al., 1986; Cheah & Cheah, 1981). The occurrence of arachidonic acid in substantial amount in PSE meat discloses its potential role in injuring cell membranes. Previous results reveal the importance of phospholipase A2 activity under the elevation of Ca^{2+} to be a triggering factor that initiates intracellular degenerative processes within the skeletal muscle (Soares et al., 2009).

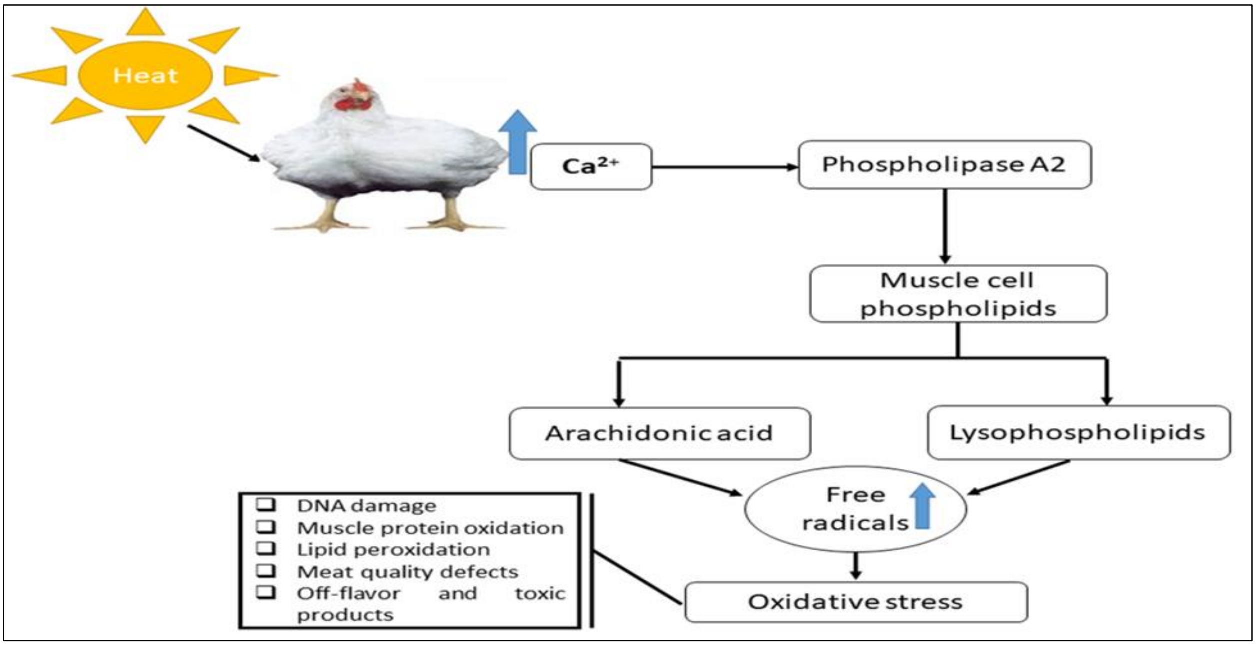

Figure 2 Heat stress disturbs the calcium balance within muscles and enhances the production of free radicals leading to poor meat quality

3. Factors responsible for oxidative stress

3.1. Oxidative stress due to toxins present in feed

In some instances, poultry feed is contaminated with a broad range of adulterants such as dirt, chemicals, micro-organisms, environmental and fungal toxins and is considered to ruin the bird's health and performance. Under normal physiological conditions, the mucosal lining of the intestine and tight junction proteins present among epithelial cells prevents the absorption of those adulterants. Unfortunately, oxidative stress changes this defensive mechanism by altering the normal cellular process in the intestine. Mycotoxins are produced by various fungi commonly known as molds that include aflatoxin, zearalenone, deoxynivalenol, fumonisin, trichothecenes and ochratoxin. The exposure of one of these toxins to intestinal epithelial cells induces oxidative stress. Studies have observed that chronic toxicity caused by mycotoxins severely damages the immunity and intestinal integrity in poultry (Wu et al., 2010). Long-term exposure to these mycotoxins induces the production of reactive oxygen species (ROS), which in turn changes signaling at the cellular level, alters anti-oxidant ability and intestinal integrity. Continuous exposure to toxins makes intestinal epithelium hyperpermeable. All of the mycotoxins intensifies cellular apoptosis and affect poultry health and production. Arsenic is another lethal toxin, extensively present in water, feed, and the environment. It is potentially toxic and causes hostile effects on digestion and absorption of nutrients leading to potential losses in poultry growth. Long-term and extensive arsenic toxicity causes lipid peroxidation, reduces anti-oxidants, and consequently activates apoptosis in the chicken tissues (Zhao et al., 2017). Arsenic toxicity combined with copper traces triggers the swelling and the annihilation of the mucosal lining in the intestine (Wang et al., 2018). The poor ventilation system in poultry houses is responsible for ammonia accumulation in the shed, making air contaminate. Birds cannot breathe comfortably, leading to respiratory distress and oxidative stress, ultimately reducing poultry's production efficiency (Miles et al., 2004). Chronic exposure to ammonia leads to numerous health problems and compromises broilers' welfare (Feng-Xian et al., 2012). The absorption ability of the intestine is solely based on the number and size of villi. Broiler birds under a high concentration of ammonia have short villus height and reduced crypt depth between different small intestine sections. Ammonia has negative implications on immune organ functioning and development in chickens that ultimately compromise nutrient absorption and the immune system (Feng-Xian et al., 2012). Another Study observed that ammonia toxicity enhances creatine kinase activity and lowers serum T-SOD activity, exerting oxidative stress and apoptosis of mucosal structure (Zhang et al., 2015).

3.2. Oxidative stress and gut microbiota

In broiler production, the digestive system, including GIT, has a crucial function as feed efficiency and optimum growth rate are directly related to the digestive system. GIT is mainly comprised of microbiota that includes several micro-organisms such as bacteria, protozoa and fungi; the population of microbiota varies among different segments of GIT (Gabriel et al., 2006). As intestinal epithelium interacts with microbiota, it induces ROS generation, which functions as cellular signaling under normal physiological conditions. Tight junctions among intestinal epithelium act as barriers and save the intestine from oxidation (Ulluwishewa et al., 2011). Studies reported that the interaction of mucosal lining with gut microbiota and their toxins induces oxidative strain. Coccidiosis is one of the leading parasitic diseases of poultry. Eimeria is another pathogenic parasite responsible for oxidative stress and epithelial barrier damage through tight junctions malfunctioning; lipid peroxidation and anti-oxidants, infested birds, exhibit reduced feed consumption, absorption of vitamins and poor growth rate (Naidoo et al., 2008). Environmental burden influences the intestinal epithelial cells and similarly stimulates intestinal bacteria.

4. Broiler chicken production

4.1. Chicken production and meat quality

Broiler meat production has achieved milestones regarding muscle growth and feed efficiency as it has become a cheap source of animal protein. Now, the chicken meat industry's focus is on broiler meat quality as consumer awareness regarding healthy food is growing over time. In the 21st century, well-informed consumers pay more attention to meat's sensory properties such as appearance, texture, juiciness, wateriness, tenderness, odor, and flavor. These are major perceptible meat characteristics that determine overall decisions made by consumers in order to buy meat or meat products (Mir et al., 2017). The measurable features of chicken meat, including water holding capacity, drip loss, cook loss, pH, shelf life, collagen content, protein solubility, cohesiveness, and fat binding ability, are essential for better meat processing make meat products. Poultry feed plays a crucial role in the nutritive value and safety of meat. The amino acid and fatty acid profile of the feed is directly reflected in muscle tissues. Managing poultry production is widely based on meat consumption features (juiciness, tenderness, flavor). After slaughtering the birds, the biochemical changes during the conversion of muscle to meat regulate ultimate meat quality. Postmortem carcass temperature has a profound effect on rigor mortis, and the physicochemical variations observed in PSE muscles are credited to postmortem glycolysis, temperature, and pH (Zaboli et al., 2019).

4.2. Determinants of poultry meat quality

The poultry meat grading system used globally is based on appealing characteristics such as meat consistency, carcass quality, discolorations, missing parts, and skin tears without considering the functional properties of meat which has thwarted the rise of the further processing industry. With increasing health consciousness, consumers are becoming more aware of the nutritional value of the foods they eat. This knowledge, together with the current emphasis on being physically fit and slim trim, has led to an increase in food labels such as Light, Lean, low-fat, reduced-fat, reduced calories, etc. (John et al., 2016). Poultry meat and egg products are natural candidates to meet this emerging demand because of their high nutrient content and relatively low caloric value. Whether or not a poultry product meets the consumer's expectations depends upon the conditions surrounding various stages in the bird's development, from the fertilized egg through production and processing to consumption (Wideman et al., 2016).

The first and foremost determinant of meat quality is its appearance as a customer pays much attention to the appearance to check the freshness and quality of meat (Mir et al., 2017). Tenderness is another desirable meat characteristic that gives a firm texture to poultry meat. It encourages muscle tissue and myofibrillar proteins to hold more water than make meat more tender. The tenderness of meat mostly depends on physical and chemical changes after slaughter when muscle converts into the meat. Oxidative stress usually makes unfavorable changes during this process and reduces the meat firmness (Mir et al., 2017). The meat's flavor is also an important property that buyers use to evaluate poultry meat's overall quality. However, it is difficult to distinguish between taste and odor while eating; both contribute to poultry's flavor. The development of poultry meat flavor is based on sugar and amino acid interactions and lipid and protein oxidation. As discussed earlier, protein and lipid oxidation is responsible for undesirable meat flavor. Other significant determinants of meat quality include water holding capacity, PH value of meat, and most importantly, the nutritional value of meat quality. Unfortunately, oxidative stress severely damages all of these attributes associated with better meat quality (Gonzalez-Rivas et al., 2020).

4.3. How is oxidative stress associated with poultry meat quality?

In living organisms, oxidative reactions are the basis of many biological functioning. However, the imbalance among pro-oxidants and anti-oxidants in living cells causes the overproduction of free radicals like reactive oxygen species (ROS), leading to oxidative damage. In broiler chicken, oxidation mainly damages the meat quality through spoilage and degradation (Cadenas & Davies, 2000; Kohen & Nyska, 2002). Numerous predisposing factors make broiler chickens more vulnerable to oxidative stress, and these factors mainly include high ambient temperature, toxins and different pathological conditions (Estévez, 2015; Fellenberg & Speisky, 2006). While the primary source of oxidative stress in chicken is electron leakage from the respiratory chain in mitochondria during the energy generation process (Mujahid et al., 2007). After slaughter, the chicken meat goes through several oxidative reactions increased by the sudden failure of endogenous anti-oxidant system in living cells. Pro-oxidants' level increases and different biochemical variations happen post-slaughter, such as pH reduction (Estévez, 2015). Some pro-oxidants are naturally present in muscles after the slaughtering that contains transition metals, myoglobin and H_2O_2; these naturally present pro-oxidants boost the ROS production through different mechanisms (Mario Estévez, 2011; B. Min & Ahn, 2005; Soladoye et al., 2015). Oxidation of the proteins in meat is a big challenge to the meat industry. Nitrite present in the muscles is precursor of free radicals like reactive nitrogrn species (RNS) that induce both oxidation and nitration meat proteins. Apart from nitrite, reducing sugars is a crucial role in the production of reactive oxygen species that ultimately damages muscle protein through protein glycol-oxidation (Villaverde et al., 2014). Additionally, numerous physical agents like radiation also trigger unnecessary oxidation in meat, such as photo-oxidation, as they can produce free radicals (Soladoye et al., 2015).

Genetic selection for high growth rates in broiler chicken has made the chicken more susceptible to environmental stressors (Altan et al., 2003; Sihvo et al., 2014). Oxidative stress is among the significant stressors, potentially reducing chicken growth, having severe consequences on the broiler's meat quality. Living tissues have several anti-oxidants to cope with oxidants. If balance among anti-oxidants and oxidants disturbs and oxidants exceed a specific limit within the body, this condition indicates oxidative stress. Most oxidants are produced during cellular metabolism in the mitochondria of living cells. Cellular metabolism is not the only source of oxidants; some external sources, including feed comprised of oxidized lipids and fats, are responsible for producing reactive oxygen species (Cadenas & Davies, 2000). According to (Mujahid et al., 2007), leakage of electrons from the mitochondrial respiratory chain during oxidative phosphorylation is the primary ROS source. High ambient temperature increases ROS production by compromising the functioning of the electron transport chain, which is necessary for energy production in the muscles. Increased ROS liberation is potentially damaging as it aggravates the aging of muscles, protein degradation and inactivates the nuclear proteins, including DNA and RNA (Celi & Gabai, 2015).

4.4. Overproduction of ROS triggered by pre-slaughter stress deteriorates chicken meat quality

In commercial farming, numerous factors are involved in pre-slaughter stress on birds; these stressors ultimately boost the oxidative damage in chicken meat quality. Transportation stress is widely discussed as the stress that enhances serum MDA concentration in blood and is associated with increased mortality. Transportation stress combined with the high ambient temperature in broiler birds cause excessive production of ROS and subsequent higher oxidation ratio that mainly led to the development of pale, soft and exudative (PSE) like meat (Xing et al., 2017). Moreover, using different manipulative techniques in modern farming to change animals' physiological status is also damaging for meat quality as it alters the redox balance of metabolic processes. For example, continuous use of dexamethasone modifies the plasma and skeletal muscle concentration of TBARS that ultimately promotes fatty tissue deposition in skeletal muscles and higher fat in chicken is considered a negative trait in meat quality (Gao et al., 2010). Corticosterone from external sources induced redox imbalance in the skeletal muscle that negatively impacts the oxidative constancy of meat during storage (Cai et al., 2018). A study found that when chicken birds were externally injected with 10% H2O2, an increase was observed in ROS production and drop in anti-oxidant enzyme functioning, which boosted the oxidative stress leading the low PM muscle weight and numerous unwanted changes in meat quality (Cadenas & Davies, 2000).

5. Strategies to alleviate oxidative stress

As discussed earlier, poor digestion and absorption of nutrients generate reactive species that imbalance the redox status of intestinal mucosa and lead to the failure of the anti-oxidant system (Liu et al. 2014). Also, oxidative stress harms the intestinal mucosa, impedes digestive efficiency and absorption of nutrients and adversely influences average animal growth (Yara et al., 2013). Dietary supplementation with nutrients having anti-oxidant properties lessens intestinal free radicals and aids in preserving the intestine's mucosal lining. Therefore, it is indispensable to formulate an economical and proper diet with anti-oxidant agents to alleviate oxidative stress. It has reported that Vitamin E and C supplementation helps the chicken against oxidative stress and boosting the immune functioning of birds (Min et al., 2018). Alpha-lipoic acid, owns both fat and water-soluble, is a powerful anti-oxidant and is the shield against oxidative harms in the poultry GIT (El-Senousey et al., 2018). Numerous studies suggested that vitamin E supplementation in the diet prevents lipid oxidation, and it is beneficial to avoid meat discoloration. Apart from lipid oxidation and discoloration, Vitamin E also discouraged drip loss from chicken meat during a stressful environment. The combination of an-oxidant micro-nutrients including magnesium, zinc, selenium with vitamins can mainly protect meat quality from deterioration induced by oxidative stress (Guo & Dalrymple, 2017; Ismail et al., 2013; Khan et al., 2012; Panda & Cherian, 2014; Skřivan et al., 2012; Young et al., 2003). Methionine and selenium have been reported to show positive results during oxidative stress as they preserve water holding capacity and pigmentation of the meat. Dietary supplementation with polyphenol compounds displays an effective anti-oxidant activity (Gerasopoulos et al., 2015). Equol is also an anti-oxidant compound obtained from the isoflavonoid daidzein, an isoflavone of soybean that can hamper oxidative burden induced by ROS (Liu et al., 2006). Equol guards intestinal epithelium against oxidative stress by enhancing anti-oxidant gene expression, boosting anti-oxidant enzymes' functioning, and improving anti-oxidant ability (Lin et al., 2016).

It has been reported that vitamin E supplementation in the diet prevents lipid oxidation, and it is beneficial to avoid meat discoloration. Apart from lipid oxidation and discoloration, Vitamin E also discouraged drip loss from chicken meat during a stressful environment. The combination of an-oxidant micro-nutrients including magnesium, zinc, selenium with vitamins can mainly protect meat quality from deterioration induced by oxidative stress (Ismail et al., 2013; Khan et al., 2012; Panda & Cherian, 2014; Skřivan et al., 2012). Methionine and selenium have been reported to show positive results during oxidative stress as they preserve water holding capacity and pigmentation of the meat. The inclusion of phenolic compounds in poultry has shown effective combating oxidative stress during poultry meat production and processing. Many plants are rich in phenolic compounds such as apple peel, tea catechins, grape pomace, pea seeds, rosemary leaves and different vegetables. These plants are potent anti-oxidants; their supplementation in diet could improve the digestion in broiler chickens. These are natural sources of anti-oxidants, and studies have suggested that these phytogenic plants are much more potent than synthetic anti-oxidants.

6. Conclusion

The world population is growing every year; an ever-increasing population has put stress on the food production systems. Demand for poultry meat is on the rise, most people like poultry products. At the same time, consumers are becoming conscious about the quality of the food they are eating. The increasing trend of genetic selection in poultry birds for higher yield and better feed efficiency has made birds more susceptible to different physical and chemical stresses. Oxidative stress is one of such stressors that plays an underlying role in developing meat quality defects. Oxidative stress is responsible for the spoilage of meat through lipid and protein oxidation. The potential threat of oxidation to meat quality regarding meat color, water holding capacity, and texture causes quality faults, including white striping (WS), wooden breast (WB), and other significant poultry meat abnormalities. The requirement to lessen the incidence of these problems in the chicken industry with growing awareness about poultry meat as a basis of health urges the research community to develop new techniques to minimize oxidative stress from living birds and processed meat products. Thus, it seems inevitable that studies that investigate deeper into the basics of animal nutrition, genetics, welfare, and the biochemical basis of all these new quality defects are being carried out. Further, more focused studies are required to observe the factors involved in meat quality deeply. That will help us further improve poultry meat quality by reducing the stress factors like oxidative stress.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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