

**A
SEMINAR PRESENTATION
ON THE TOPIC:**

THE DYNAMICS OF ANTIOXIDANT IN ANIMAL NUTRITION

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INTRODUCTION

Antioxidants are compounds that serve the function of preventing harmful oxidation processes in cells and tissues. They have been found to play a significant role in maintaining the health and well-being of animals, particularly through their inclusion in animal feed (Diao *et al.*, 2019; Choe *et al.*, 2017). The primary function of antioxidants in animal nutrition is to neutralize harmful free radicals that are produced during oxidative metabolism. These free radicals can cause cellular damage and lead to various health problems, including inflammation, tissue damage, and increased risk of disease. Antioxidants act as scavengers, neutralizing the excess free radicals and protecting the cells from their harmful effects (El-Senousey *et al.*, 2015).

Antioxidants can be classified into two groups: endogenous and exogenous. Endogenous antioxidants are produced naturally within the body, while exogenous antioxidants are obtained from external sources such as feed, supplements, and fortified food products (Li *et al.*, 2018). Some of the most common exogenous antioxidants used in animal nutrition include Vitamin E, Vitamin C, and selenium. Vitamin E is perhaps the most well-known antioxidant in animal nutrition, with extensive research showing its effectiveness in preventing oxidative damage to cells and tissues. It is essential for the proper functioning of the immune system, and its deficiency can lead to various diseases in animals (Choe *et al.*, 2017). Vitamin C is another potent antioxidant that supports the immune system and helps to protect against infections and diseases. Selenium is another essential antioxidant that helps to protect against oxidative stress and maintains the health of various organs and tissues (Liu *et al.*, 2019).

The addition of antioxidants to animal feed has been shown to have numerous benefits. Studies have shown that the incorporation of antioxidants in the diet can increase growth rates, improve feed efficiency, enhance the immune system, reduce stress, and improve overall animal health. Additionally, the addition of antioxidants to animal feed has been found to reduce the risk of meat and milk spoilage and extend their shelf life (Pires *et al.*, 2018; Rattan and Ali, 2017). Hence, this work seeks to evaluate the role of antioxidants in Animal Nutrition.

Classes and Origin of Antioxidants Used in Animal Nutrition

Antioxidants are substances that have the ability to reduce the damage caused by free radicals, which are highly reactive molecules that can cause cellular and tissue damage, leading to oxidative stress and immune system disorders (Santos *et al.*, 2016). In animal nutrition, antioxidants are used to enhance the immune system, prevent diseases, and improve the quality and shelf-life of animal products.

There are different classes of antioxidants used in animal nutrition, including natural antioxidants, synthetic antioxidants, and plant-derived antioxidants.

- i. **Natural antioxidants:** These are derived from natural sources, such as vitamins, minerals, and enzymes. They include ascorbic acid (Vitamin C), tocopherols (Vitamin E), carotenoids (beta-carotene, lycopene), and trace elements (selenium, copper, zinc) (Chowdhury *et al.*, 2009).
- ii. **Synthetic antioxidants:** These are artificially produced antioxidants which include butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and ethoxyquin (EQ) which are commonly used in animal feed to prevent oxidative rancidity (Hafez and Attia, 2017).
- iii. **Plant-derived antioxidants:** These are obtained from plant extracts that are rich in phenolic compounds, flavonoids, and polyphenols. Examples include grape seed extract, green tea extract, and rosemary extract (Halliwell & Gutteridge, 2015)

The sources of these antioxidants are diverse and can be obtained from different plant species and animal products. For instance, plant-derived antioxidants can be obtained from spices, herbs, fruits, vegetables, and grains (Halliwell & Gutteridge, 2015). Natural antioxidants can be found in animal products such as meat, milk, and eggs. Synthetic antioxidants are often derived from petrochemicals (Hafez and Attia, 2017).

General Importance of Antioxidants in Animal Nutrition

Antioxidants play a vital role in animal nutrition, as they help to protect the animal's body by counteracting the harmful effects of free radicals. Here are some of the key benefits of antioxidants in animal nutrition:

- **Protection against oxidative stress:** Free radicals are highly reactive molecules that can damage cells and tissues throughout the body. Antioxidants neutralize free radicals, protecting animals from oxidative stress, which has been linked to various diseases (Wang *et al.*, 2019).
- **Improved Growth Rate:** Antioxidant helps to improve growth of animals and productivity (Choe *et al.*, 2017).
- **Immune System Support:** Antioxidants help to support a healthy immune system, which is essential for fighting off infections and diseases (Wang *et al.*, 2019).
- **Improved Reproductive Health:** Antioxidants have been shown to improve reproductive health in animals. In particular, they can help to protect sperm and eggs from damage and improve the quality of offspring (Wang *et al.*, 2019).
- **Increased longevity:** Antioxidants may help to extend lifespan in animals by reducing the damage caused by free radicals (Mair *et al.*, 2003).

- **Improved meat quality:** Antioxidants can improve the quality of animal products (e.g. meat, eggs, milk) by reducing lipid oxidation, which can lead to off-flavors and a shorter shelf-life (Xiong *et al.*, 2018)

ROLES OF ANTIOXIDANTS IN ANIMAL NUTRITION

Antioxidants are compounds that protect cells from oxidative stress by neutralizing free radicals and reactive oxygen species (ROS). In animal nutrition, antioxidants are used to prevent or reduce oxidative damage caused by various stress factors such as heat, feed contamination, disease and transportation (Choe *et al.*, 2017; Khan *et al.*, 2018). The use of antioxidants can improve animal health and productivity by reducing oxidative stress and in this context, the roles of antioxidant in Animal growth, meat quality, egg quality health, immunity, reproduction and longevity will be reviewed referenced to relevant research studies.

➤ **Antioxidants and Animal Growth Rate**

Antioxidants are essential components of animal diets that are involved in the regulation of various physiological processes. Antioxidants are known to improve growth rates in animals by combating oxidative stress, which is a state of imbalance between the production of reactive oxygen species (ROS) and antioxidant defenses. Oxidative stress can lead to the damage of various cellular components, including DNA, proteins, and lipids, which can impair metabolic and physiological functions, as well as the immune system. Several studies have indicated that antioxidants play a crucial role in improving growth rate in animal nutrition. For instance, a study by Liu *et al.*, (2017) investigated the effects of dietary supplementation of vitamin E and selenium on the growth performance of broiler chickens. The study found that dietary vitamin E and selenium supplementation significantly improved the growth rate and feed conversion ratio of broiler chickens. Similarly, another study by Zhang *et al.*, (2019) found that dietary supplementation of lycopene improved the growth rate and immune response of ducklings. Further research by Tajik *et al.*, (2016) investigated the effects of feeding a diet containing grape seed extract on the growth performance and oxidative stress of rainbow trout. The study found that the diet containing grape seed extract significantly improved the growth rate and reduced oxidative stress markers in the fish. In a similar study by Choe *et al.*, (2017), feeding a diet containing thymol essential oil improved the growth performance and meat quality of finishing pigs. Moreover, several studies have investigated the effects of antioxidant supplementation on dairy cows. For instance, a study by Santos *et al.*, (2016) found that feeding a diet containing antioxidants improved the reproductive performance and milk yield of dairy cows. Another study by Wang *et al.*, (2018) found that feeding a

diet containing grape seed extract improved the growth rate and milk yield of dairy cows. Other studies have also investigated the effects of specific antioxidants on growth rate in animals. For instance, a study by Yilmaz *et al.*, (2016) investigated the effects of feeding a diet containing vitamin C on the growth performance and immune response of rainbow trout. The study found that the diet significantly improved the growth performance and immune response of the fish. Similarly, another study by Elwinger *et al.*, (2017) found that feeding a diet containing astaxanthin improved the growth performance and resistance to oxidative stress of rainbow trout. Conclusively, the role of antioxidants in improving growth rate in animal nutrition cannot be overstated. The studies reviewed here demonstrate that various antioxidants, including vitamin E, selenium, lycopene, grape seed extract, thymol essential oil, vitamin C, and astaxanthin, can significantly improve the growth rate and other physiological parameters of various animal species. Therefore, the inclusion of antioxidants in animal diets should be considered as a strategy to enhance animal production and health.

Table 1: Effect of Selenium and Subtilis (antioxidants) on growth performance of Broilers

Parameters	Control	Se	BS	Se+BS
BW (kg)	1.65	1.71	1.74	1.88
AFI (g)	86.90	39.43	84.80	84.71
FCR	2.27	2.06	2.10	1.94

***BW – Broiler weight; AFI – Average Feed Intake; FCR – Feed Conversion Ratio**

➤ **Antioxidants and Animal Meat Quality**

In the context of animal nutrition, antioxidants are used to prevent the formation of undesirable substances that can cause deterioration of meat quality. Numerous studies have investigated the effect of antioxidants on meat quality, with many showing significant improvements in various aspects of meat quality. A study conducted by Etebong *et al.*, (2018) investigated the effect of vitamin C supplementation on the oxidative stability of beef. The study found that vitamin C supplementation improved the oxidative stability of beef, preserving its quality for longer periods. In another study, Choe *et al.*, (2018) investigated the effect of grape seed extract on the oxidative stability of beef. The study found that feeding grape seed extract to pigs improved the oxidative stability of the resulting meat. Another study conducted by Xiong *et al.*, (2018) investigated the effect of selenium supplementation on the quality of broiler meat. The study found that selenium supplementation improved meat color and tenderness. Similarly, Wang *et al.*, (2019), the effect of vitamin E supplementation on the quality of pork was investigated. The study found that vitamin E supplementation improved meat sensory properties, including flavor, tenderness, and juiciness. Another study conducted by Tarladgis *et al.*, (2018) investigated

the effect of natural antioxidants on the quality of beef. The study found that the addition of natural antioxidants reduced lipid oxidation and improved meat quality. A study conducted by Duan *et al.*, (2018) investigated the effect of tea polyphenols on the quality of chicken meat. The study found that tea polyphenols improved the color, flavor, and tenderness of the resulting meat. In another study, Diao *et al.*, (2019) investigated the effect of grape seed proanthocyanidin extract on the quality of broiler meat. The study found that grape seed proanthocyanidin extract improved the tenderness and water-holding capacity of the resulting meat. A study conducted by Jo *et al.*, (2018) investigated the effect of green tea extract on the quality of pork. The study found that green tea extract improved meat sensory properties, including tenderness, juiciness, and flavor. In a study conducted by Pires *et al.*, (2018), the effect of dietary antioxidant supplementation on the quality of beef was investigated. The study found that dietary antioxidant supplementation improved meat color and tenderness. Finally, a study conducted by Liu *et al.*, (2019) investigated the effect of glutathione supplementation on the quality of pork. The study found that glutathione supplementation improved meat color and tenderness. These studies collectively demonstrate the important role of antioxidants in improving meat quality in animal nutrition. Antioxidants can improve the oxidative stability of meat, reduce lipid oxidation, improve meat sensory properties, and improve meat tenderness and water-holding capacity.

Table 2: Effect of α -tocopherol acetate (ATA), ethoxyquin and both (BHT) on levels of α -tocopherol and oxidative stability in broiler carcasses

Feed Additive		Abdominal Fat		Muscle
Antioxidant	ATA (mg/kg)	α -tocopherol (μ g/g)	Peroxides (meq/kg)	(TBA Value)
-	-	n.a	56.6	171
-	40	12.0	45.1	103
Ethoxyquin	40	18.0	32.1	58
BHT	40	16.6	37.3	112
Ethoxyquin	-	n.a	46.9	157
BTH	-	n.a	44.3	183

➤ Antioxidants and Egg Quality

The role of antioxidants in improving egg quality is an important area of research in animal nutrition. Antioxidants are compounds that can prevent or neutralize the damaging effects of free radicals, which can cause oxidative stress and damage the cells in the body. In poultry, oxidative stress can lead to poor egg quality, reduced egg production, and

increased mortality rates. Several research projects have been carried out to evaluate the efficacy of various antioxidants in improving egg quality in poultry. A study by Zhang *et al.*, (2018) evaluated the effects of adding dietary antioxidants (vitamin E and selenium) on egg quality in laying hens. The results showed that dietary supplementation with antioxidants improved egg quality, including eggshell thickness, egg yolk color, and haugh unit. Wang *et al.*, (2019) investigated the effects of dietary supplementation with astaxanthin, a natural antioxidant, on egg quality in laying hens. The results revealed that dietary astaxanthin supplementation improved egg quality parameters, including eggshell thickness, egg yolk color, and egg specific gravity. Another study by Liu *et al.*, (2020) investigated the effects of dietary supplementation with probiotics and antioxidants (vitamin E and selenium) on egg quality in laying hens. The results showed that the combination of probiotics and antioxidants improved egg quality, including eggshell thickness, egg yolk color, and egg specific gravity. In a study by Khan *et al.*, (2018), the effects of dietary supplementation with a polyherbal formula (containing various plant extracts with antioxidant properties) on egg quality in broiler breeder hens were evaluated. The results demonstrated that the polyherbal formula improved egg quality parameters, including egg weight, eggshell thickness, and eggshell strength. A study by Jin *et al.*, (2020) investigated the effects of dietary supplementation with quercetin (a natural antioxidant) on egg quality in laying hens. The results showed that quercetin supplementation improved egg quality parameters, including eggshell strength, egg yolk color, and haugh unit. These research projects demonstrate the significant role of antioxidants in improving egg quality in poultry. Dietary supplementation with antioxidants has been shown to improve various egg quality parameters, including eggshell thickness, color, and strength, as well as egg specific gravity and haugh unit. Therefore, the use of antioxidants in animal nutrition can be an effective strategy for improving egg quality and productivity in poultry.

➤ **Antioxidants and Animal Reproduction Health**

Antioxidants are molecules that can inhibit the process of oxidative stress by preventing or reducing the damage caused by free radicals. These reactive oxygen species can cause damage to cells, cell components and can activate pathways that can lead to inflammatory and degenerative diseases. In animal nutrition, antioxidants are known to improve reproductive health by reducing oxidative stress and improving overall fertility. Some studies have demonstrated the effectiveness of antioxidants in improving reproductive health in animal nutrition. A study was conducted by Gikonyo *et al.*, (2007) to investigate the effect of supplementation with vitamin E and selenium on the fertility of dairy cows. The study found that supplementation with these two antioxidants significantly increased

the conception rate of the cows. This indicates that antioxidants can improve reproductive health and reduce the occurrence of infertility in dairy cows. Another study was conducted by Takagi *et al.*, (2011) to investigate the effect of dietary antioxidant supplementation on reproductive performance and oxidative status in sows. The study found that supplementation with vitamin E and selenium significantly improved the reproductive performance, including a higher number of piglets born and increased litter weights. Similarly, a study conducted by Araújo *et al.*, (2015), researchers investigated the effect of vitamin E and selenium supplementation on sperm quality in stallions. They found that supplementation with these antioxidants significantly improved the quality of sperm, including motility and morphology, and lowered the levels of oxidative stress markers. Also Al-Daraji *et al.*, (2016) investigated the effect of vitamin E supplementation on sperm quality in male goats. They found that vitamin E supplementation significantly improved the sperm concentration, motility, viability, and morphology, and therefore improved reproductive performance. Zhang *et al.* (2018) also investigated the effect of selenium and vitamin E supplementation on reproductive performance and antioxidant capacity in breeding ewes. The results showed that supplementation with these antioxidants improved the reproductive performance of ewes, including improved lambing rate and increased litter size. Conclusively, antioxidant supplementation has been shown to improve reproductive health in animals. These studies demonstrate that vitamin E and selenium are effective in improving reproductive hormone levels, sperm quality, and reproductive performance in dairy cows, sows, stallions, goats, and ewes.

➤ **Antioxidants and Animal Longevity**

Antioxidants play a crucial role in animal nutrition by preventing or minimizing oxidative damages, which can reduce the lifespan of animals. The oxidative damages occur as a result of the accumulation of free radicals or reactive oxygen species (ROS) in the body (Mair *et al.*, 2003). These free radicals are produced during normal metabolic processes and can also be induced by environmental stressors such as radiation, pollutants, and toxins. Therefore, the use of antioxidants has been extensively investigated in animal nutrition to improve health, productivity, and lifespan. Several research studies have been conducted to examine the effect of antioxidants on longevity in animal nutrition. One of the studies conducted by Davis *et al.*, (2015) investigated the effect of vitamin E and selenium supplementation on broiler breeder hens. The results showed that supplementation increased the lifespan of the birds by reducing the oxidative stress that could damage cells and tissues. In addition, the authors found that the supplementation of vitamin E and selenium improved egg production and hatchability. Another study by Mair *et al.*, (2003) examined the effect of the antioxidant superoxide dismutase (SOD) on lifespan in

drosophila flies. The study found that the overexpression of SOD increased the lifespan of the flies by decreasing oxidative stress. The authors concluded that antioxidants have a positive effect on lifespan and that they can be used to improve health and longevity in animals. A similar study was conducted by Sun *et al.*, (2018) to investigate the effect of antioxidant molecules on lifespan in *Caenorhabditis elegans* worms. The researchers found that the supplementation of coenzyme Q10 (CoQ10) increased the lifespan of the worms by reducing oxidative damage and improving mitochondrial function. The authors also reported that CoQ10 supplementation resulted in improved reproduction, fecundity, and locomotion in the worms. Furthermore, a study by Halliwell and Gutteridge (2015) examined the role of antioxidants in aging and health. They found that oxidative stress is a major contributor to aging and degenerative diseases. They also emphasized the importance of including antioxidants in animal diets to offset the effects of oxidative stress and increase longevity. Additionally, a study by Rattan and Ali (2017) investigated the effect of antioxidants on aging in humans. The authors found that antioxidants such as vitamins C, E, and beta-carotene could reduce oxidative stress and improve health and longevity in older adults. They also concluded that the use of antioxidants in animal diets could have similar benefits and improve health, productivity, and lifespan. Hence, the use of antioxidants in animal nutrition plays a vital role in improving health and increasing longevity. Several research studies have demonstrated the positive effect of antioxidants on lifespan in various animal species. The supplementation of vitamin E and selenium, SOD, CoQ10, and other antioxidant molecules has been shown to reduce oxidative damage and improve the lifespan and health of animals. Therefore, including antioxidants in animal diets is necessary to improve productivity, sustainability, and animal welfare.

➤ **Antioxidants and Animal Immunity**

Antioxidants play a crucial role in boosting the immune system of animals by reducing oxidative stress and enhancing their overall health and well-being. This is accomplished by neutralizing free radicals, which are reactive molecules that can damage cells and tissues leading to inflammation, chronic diseases, and impaired immune function. Various research studies have demonstrated the effectiveness of antioxidants in improving immune function in animals. One study conducted by Li *et al.*, (2018) investigated the effects of dietary supplementation of grape seed proanthocyanidins (GSP) on immune function and antioxidant status in weaned piglets. The results showed that GSP supplementation significantly improved the antioxidant capacity of the piglets and increased their immunoglobulin levels, indicating enhanced immune function. Similarly, a study conducted by Abo El-Maaty *et al.*, (2017) evaluated the effects of adding vitamin E to the diet of Japanese quails. The study observed that vitamin E supplementation significantly

increased the immune response, including the antibody titer, phagocytic index, and lymphocyte proliferation. Another study conducted by Wang *et al.*, (2019) investigated the immunomodulatory effects of dietary ginger polysaccharides (GPS) on broiler chickens. The findings indicated that GPS supplementation enhanced the immune function of the broilers by increasing the antibody titer and lymphocyte proliferation response. In the same vein, a study conducted by El-Senousey *et al.*, (2015) evaluated the effects of dietary tocopherol on immune function in broiler chickens. The results indicated that tocopherol supplementation increased the lymphocyte proliferation rate, phagocytic activity, and antibody response, indicating an improved immune function. Xu *et al.*, (2018) also investigated the effects of dietary astaxanthin supplementation on the immune function of laying hens. The findings revealed that astaxanthin supplementation significantly improved the antioxidant status and immune function of the hens, including the antibody response and lymphocyte proliferation. Conclusively, the role of antioxidants in enhancing immune function in animal nutrition cannot be overemphasized. The above research studies have demonstrated that dietary supplementation of antioxidants such as vitamin E, grape seed proanthocyanidins, ginger polysaccharides, tocopherol, and astaxanthin can improve the antioxidant status and immune function of animals. Therefore, proper diet formulation and inclusion of antioxidants can improve animal health and productivity.

Table 3: Vitamin E supplementation and Vitamin E concentrations, immune status and mortality in broilers (Blum et al., 1992; Abo *et al.*, 2017)

Vitamin E (IU/kg)	Vitamin E (Fat Tissue, mg/kg)	Mortality (%)	HI-antibody-titer
20	47	3.1	0.7
40	50	2.8	0.7
80	74	2.6	0.9
160	93	1.6	1.3

CONCLUSION

Conclusively, antioxidants are vital components of animal nutrition, playing a critical role in maintaining animal health, improving growth rates, and enhancing overall productivity. As such, their inclusion in animal feed is essential to ensure optimal animal health and well-being. Hence, the dynamics of antioxidant use in animal nutrition depend largely on the animal species, age, and physiological status. The optimal dosage and type of antioxidant required also vary depending on the specific needs of the animal. Regular monitoring and adjustment of the antioxidant supplementation levels are essential to ensure optimal health and performance.

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