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STUDY ON THE EFFECTS OF THE NATURAL ANTIOXIDANTS ADDED TO FOOD OF ANIMAL ORIGIN: PROPERTIES AND HEALTH BENEFITS

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Abstract

Natural antioxidants added to products of animal origin are substances that help slow down the oxidation process, thereby protecting food from spoilage and prolonging its shelf life. They are commonly used in the food industry to maintain product quality and safety. The most widely used natural antioxidants are vitamins C and E, selenium, polyphenols, omega-3 fatty acids, and carotenoids. Vitamin C (ascorbic acid) plays a role in the bioavailability of iron in the body and supports immune function, along with the beta-carotenoids: lutein and zeaxanthin (precursors of vitamin A). Beta-carotenoids are also implicated in ocular function. Vitamin E (tocopherol) helps reduce lipid oxidation and may lower the incidence of cardiovascular disease. Polyphenols reduce oxidative stress, as do omega-3 fatty acids. The incorporation of these antioxidants in animal products not only enhances their stability but also offers significant health benefits by reducing oxidative stress and promoting overall wellness.

Key words*: health benefits, natural antioxidants, products of animal origin, oxidation process, vitamins.*

INTRODUCTION

Natural antioxidants have become a focal point in the food industry due to their dual role in extending product shelf life and promoting consumer health. Antioxidants are vital not only for preserving food quality but also for their significant benefits to human health (Lee & Im, 2021). They play a critical role in neutralizing free radicals, thereby mitigating oxidative stress, which is linked to the development of various chronic diseases, such as cardiovascular diseases, diabetes, cancer, and neurodegenerative disorders. Oxidative degradation in food of animal origin is a significant issue, impacting its nutritional value, sensory properties, and shelf life. Lipid oxidation, in particular, results in the formation of harmful secondary products such as aldehydes, which affect both food safety and human health (Corino & Rossi, 2021).

To mitigate this, natural antioxidants derived from plants, microorganisms, or other natural sources have gained attention as viable alternatives to synthetic antioxidants like butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA). These compounds, while effective, have raised health concerns due to their potential toxicity. Natural antioxidants, including polyphenols, carotenoids, vitamins (e.g., vitamin C and E), and other bioactive compounds, offer dual benefits: they inhibit oxidative degradation in food and provide health-promoting effects when consumed (Velasco & Williams, 2011). Compounds from natural sources used as antioxidant agents in foods include phenolic acids, flavonoids, tocopherols, and carotenoids. They inhibit oxidation by acting as reductants, chelating agents, and free radical scavengers with strong H-donating capacity (Shahidi, 2000).

The most widely used natural antioxidants are vitamins C and E, selenium, polyphenols, omega-3 fatty acids, and carotenoids. The main sources of natural antioxidants include cereals, oilseeds, plants of the *Lamiaceae* family, coffee and tea, legumes, tree nuts, berries and fruits (Figure 1) (Karakaya et al., 2011).

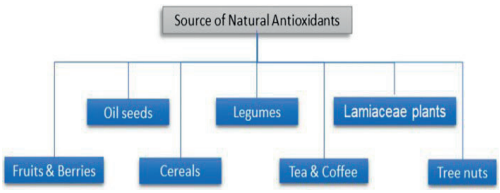

Figure 1. The figure presents a hierarchical diagram showing the main sources of natural antioxidants

MATERIALS AND METHODS

In this research, a structured review of the scientific literature was conducted, with the objective of highlighting the importance of adding natural antioxidants to products of animal origin. A total of 21 bibliographic sources were consulted, selected based on clearly defined criteria to ensure the relevance and timeliness of the information.

Studies published between 1992 and 2024 were considered, in order to include both foundational research and the most recent scientific developments in the field.

Databases used to identify relevant literature included: *PubMed*, *ScienceDirect* and *Google Scholar*.

Key words used in the search process included: *meat preservation*, *food quality*, *plant extracts*, *health benefits, natural antioxidants, products of animal origin, oxidation process, vitamins*.

The selection criteria included scientific articles published in journals, written in English. Works focused on the use of natural antioxidants in animal-origin products. Articles presenting relevant experimental data on food quality, oxidative stability, or shelf-life extension.

RESULTS AND DISCUSSIONS

Natural antioxidants are biologically active substances obtained from sources such as plants, microorganisms, fungi, or animal tissues. These compounds play a vital role in mitigating or preventing oxidative damage caused by free radicals and reactive oxygen species (ROS), which are generated through various physiological processes in the body (Shahidi, 2000).

In food systems, natural antioxidants help extend shelf life by inhibiting lipid peroxidation and other oxidative reactions, thereby maintaining the product's flavour, colour, and nutritional quality (Jayasena & Jo, 2014).

Antioxidants form a critical part of the body's defense mechanism against oxidative stress. They are categorized based on their origin: enzymatic (endogenous) antioxidants are naturally produced within the body, such as enzymes like superoxide dismutase, catalase, and glutathione peroxidase and nonenzymatic (exogenous) antioxidants are obtained through diet, including vitamins (C and E), carotenoids, polyphenols, and other phytochemicals found in fruits, vegetables, nuts, and herbs (Figure 2.) (Brewer, 2011).

Together, endogenous and exogenous antioxidants, work synergistically to maintain cellular health and protect against oxidative stress-related diseases such as cardiovascular disorders, cancer, and neurodegenerative conditions (Kumar et al., 2015; Oswell et al., 2018).

The main mechanisms of action include free radical scavenging (neutralization of free radicals by donating hydrogen atoms or electrons that stabilize reactive species and prevent oxidative chain reactions that can damage lipids, proteins, and DNA), metal chelation (chelating pro-oxidative metal ions such as iron and copper, which helps reduce their catalytic activity in the generation of reactive oxygen species (ROS), thereby slowing oxidation), and breaking autoxidation chains (acting as chain breakers by stabilizing lipid peroxyl radicals, thus stopping further lipid peroxidation and being beneficial for the preservation of fats and oils in food products) (Krinsky, 1992; Halliwell, 2024).

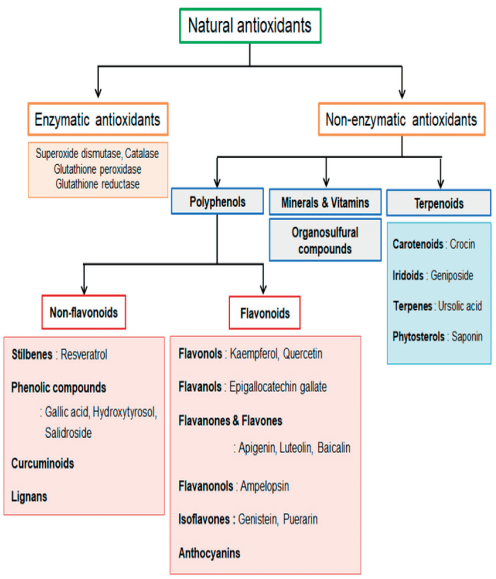

Figure 2. Classification of natural antioxidants

Phenolic antioxidants are an essential class of natural compounds with significant roles in both

food preservation and health. They are particularly effective in inhibiting the formation of free radicals and interrupting the propagation of autoxidation reactions, processes that are central to oxidative damage in biological and food systems (Shah, 2014).

In the context of food processing, methods such as thermal treatments, irradiation, fermentation, or drying significantly influence the stability of these compounds. The instability of polyphenols, driven by their polyhydroxy structure, often leads to degradation and unwanted reactions with other food components. Environmental factors such as pH, temperature, light, oxygen, enzymes, and metal ions play a crucial role in this dynamic. Thermal degradation of certain polyphenols, such as quercetin and rutin, has been extensively studied, revealing structural changes that can alter their bioactivity compared to their native form. Therefore, to harness the functional effects of polyphenols in processed foods, a thorough understanding of their stability is essential, along with the application of technologies that protect their integrity (Zhang, Wang & Xiao, 2022).

Fat-Soluble Vitamin E (α-Tocopherol) is one of the most effective lipid-soluble antioxidants, integrating into cell membranes and food matrices to prevent lipid peroxidation. It reacts with lipid peroxyl radicals to form stable compounds thereby protecting unsaturated fatty acids and enhancing the oxidative stability of oils and fats (Oswell et al., 2018).

Water-Soluble Vitamin C (L-Ascorbic Acid) is highly effective in aqueous environments, scavenging ROS and regenerating oxidized forms of other antioxidants, such as vitamin E. Its synergistic action enhances the overall antioxidant capacity in complex matrices like food emulsions (Lourenço S.C., Moldão-Martins & Alves, 2019).

Flavonoids such as quercetin, catechin, naringenin, and kaempferol are bioactive compounds predominantly found in fruits, tea, and vegetables. These compounds exhibit potent antioxidant and anti-inflammatory properties. For example, catechins, abundant in green tea, play a significant role in enhancing its health-promoting effects, including oxidative stability, by scavenging free radicals and inhibiting lipid peroxidation (Velasco & Williams, 2011).

Volatile oils such as eugenol (from clove), carvacrol (from oregano), thymol (from thyme), and menthol (from mint) exhibit strong antioxidant and antimicrobial properties. These bioactive compounds are widely utilized for their dual functionality in enhancing flavour and ensuring the preservation of food products by inhibiting microbial growth and delaying oxidative spoilage (Lourenço S.C., Moldão-Martins & Alves, 2019).

Plant pigments such as anthocyanins and anthocyanidins, which are responsible for the red, blue, and purple colours of many fruits, employ two primary antioxidative mechanisms. First, they neutralize free radicals by donating hydrogen atoms, effectively stabilizing reactive species. Second, they chelate pro-oxidative metals like iron and copper, reducing their catalytic role in oxidative reactions. These dual actions contribute significantly to slowing oxidation processes in biological and food systems (Figure 3.) (Shah, 2014; Katiyar & Mukhtar, 2018).

Oxidation leads to the formation of compounds responsible for rancidity, reduced nutritional value, and increased health risks due to the accumulation of toxic byproducts (Brewer, 2011).

Meat fat, particularly the unsaturated fatty acids, is highly susceptible to oxidation, with poultry meats exhibiting a greater degree of susceptibility compared to beef or pork (Karakay et al., 2011).

The addition of natural antioxidants to meat products helps reduce or prevent the formation of these harmful oxidation products. This not only preserves the nutritional quality of the meat but also enhances its health benefits and extends its shelf life by limiting the creation of harmful chemical toxins. Traditionally, synthetic compounds have been employed to delay oxidation reactions (Fernandes et al., 2018).

However, increasing consumer demand for healthier, more natural alternatives has driven extensive research into identifying and utilizing natural bioactive compounds with antioxidant properties (Karakaya et al., 2011).

The addition of natural antioxidants to food provides several health benefits that support overall well-being, primarily by counteracting oxidative stress, which plays a key role in the development of various chronic diseases (Aminzare et al., 2019).

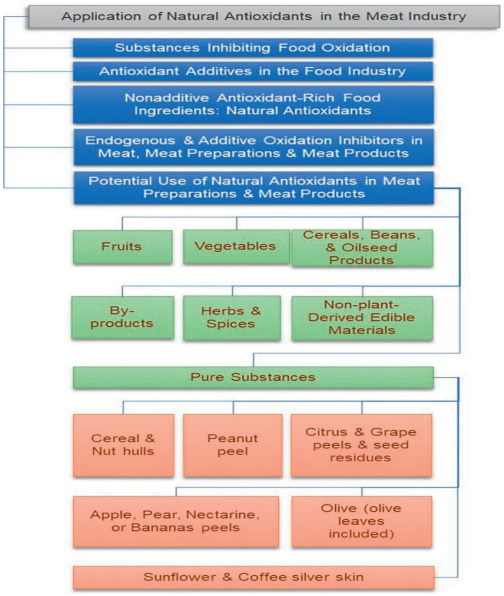

Figure 3. The applications of natural antioxidants in the meat industry

Natural antioxidants significantly improve health status and also enhance the quality of food products (Table 1) (Corino & Rossi, 2021; Pinilla-González et al., 2024).

Reduced risk of chronic diseases

Natural antioxidants, including polyphenols, vitamins C and E, and carotenoids, play an important role in neutralizing free radicals in the body. By doing so, they help mitigate oxidative damage to cells, which is a key contributor to the development of various chronic diseases such as cardiovascular disease, diabetes, cancer, and neurodegenerative conditions like Alzheimer's disease. Research has consistently shown that diets rich in antioxidants can lower the risk of these diseases by enhancing cellular health, improving antioxidant defence mechanisms, and reducing inflammation, which is often a precursor to disease progression (Sies, 2015; Katiyar & Mukhtar, 2018).

Anti-inflammatory effects

Numerous natural antioxidants, such as flavonoids, phenolic acids, and specific vitamins, exhibit strong anti-inflammatory properties. These bioactive compounds can regulate inflammatory pathways in the body, effectively reducing chronic inflammation. This is particularly important as persistent inflammation is a known risk factor for developing conditions like arthritis, diabetes, and cardiovascular diseases. By mitigating these inflammatory responses, natural antioxidants contribute to maintaining overall health and preventing the onset of inflammation-driven disorders (Lee & Im, 2021).

Table 1. Sources and benefits of natural antioxidants

Natural Antioxidant	Sources	Main Benefits
Vitamin E (α-tocopherol)	Avocado, plant oils	Improves oxidative stability of meat, delays lipid oxidation, enhances shelf life, improves animal health.
Vitamin C (ascorbic acid)	Fruits (citrus, berries)	Reduces oxidative stress, improves immune function, supports collagen synthesis.
Carotenoids (e.g., lutein)	Avocado, carrots, spinach	Maintains eye health, supports immune system, improves meat color and stability.
Polyphenols (e.g., catechins, resveratrol, quercetin)	Green tea, grape pomace, oregano, berries	Enhance antioxidant capacity, reduce lipid peroxidation in meat, improve meat quality and shelf life, support cardiovascular health.
Flavonoids (e.g., quercetin, kaempferol)	Oregano, tea, Lamiaceae plants	Reduce inflammation, improve oxidative stability in animal products, support vascular health.
Essential oils (e.g., carvacrol, thymol, rosmarinic acid)	Oregano, *Lippia* spp.	Lower lipid oxidation in meat, improve sensory attributes, act as natural preservatives.

Improved immune function

Antioxidants such as vitamin C, zinc, and selenium play a vital role in enhancing immune function by safeguarding immune cells against oxidative damage. These nutrients help stabilize free radicals and reduce oxidative stress, thereby preserving the integrity and efficiency of immune cells. This protection boosts the body's

resistance to infections and supports faster recovery during illnesses. Moreover, they contribute to the modulation of immune responses, aiding in the prevention of chronic inflammation and immune dysfunction (López-Pedrouso et al., 2022).

Skin health and anti-aging

Dietary antioxidants, particularly those found in fruits, vegetables, and plant-derived oils, play a significant role in promoting skin health. These bioactive compounds protect the skin from oxidative stress induced by environmental factors such as UV radiation, which contributes to premature aging signs, including wrinkles, sagging, and hyperpigmentation (Tsiplakou et al., 2021). Key antioxidants such as vitamin E, vitamin C, and carotenoids like lycopene and beta-carotene have demonstrated the ability to mitigate oxidative damage, support collagen synthesis, and enhance skin's overall appearance. Their combined actions help maintain skin elasticity, hydration, and a youthful appearance while reducing the risk of photodamage (Nimse & Pal, 2015; Oswell et al., 2018).

Weight management and metabolic health

Certain antioxidants, particularly those abundant in berries, green tea, and citrus fruits, may support weight management through their effects on metabolism and fat oxidation.

These compounds, such as catechins, flavonoids, and vitamin C, enhance thermogenesis and lipid metabolism, promoting the utilization of fat as an energy source.

Additionally, they help stabilize blood glucose levels by improving insulin sensitivity and reducing postprandial glucose spikes, which is particularly advantageous for individuals at risk of obesity and type 2 diabetes.

Regular consumption of these antioxidant-rich foods contributes to metabolic health and helps prevent conditions associated with dysregulated glucose and lipid metabolism (Lourenço S.C., Moldão-Martins & Alves, 2019).

Protection against environmental toxins

Antioxidants, particularly those present in herbs such as rosemary and turmeric, play a crucial role in the body's detoxification processes by neutralizing toxins and harmful chemicals. These bioactive compounds enhance the functionality of detoxifying organs, particularly the liver, by reducing oxidative stress and supporting enzymatic systems responsible for the breakdown and elimination of xenobiotics. Furthermore, antioxidants like polyphenols, curcumin, and carnosic acid protect cells from damage induced by pollutants and environmental toxins, thereby mitigating their harmful effects on health. Regular consumption of antioxidant-rich herbs contributes to improved detoxification efficiency and overall resilience against environmental stressors (Jiang & Xiong, 2016; Tsiplakou et al., 2021).

The use of natural antioxidants in meat and meat products represents a promising approach to improving food quality, extending shelf life, and meeting consumer demand for healthier, more sustainable food options. While challenges exist in terms of cost, effectiveness, and regulatory hurdles, ongoing research and innovation continue to expand the potential of these natural preservatives (Aminzare et al., 2019).

CONCLUSIONS

Natural antioxidants are essential both for extending the shelf life of food products and for their health benefits to consumers, reducing oxidative stress linked to chronic diseases.

In animal-based foods, antioxidants prevent oxidative degradation, protecting nutritional values and sensory characteristics such as flavour and colour.

Antioxidants neutralize free radicals, chelate pro-oxidative metals, and interrupt autoxidation chain reactions, protecting lipids, proteins, and DNA from oxidative damage.

Adding natural antioxidants to meat products reduces the formation of toxic compounds, enhancing food safety, improving nutritional value, and prolonging shelf life.

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