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Natural Antioxidants: Preservation Roles and Mycotoxicological Safety of Food

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Abstract

Natural antioxidants play a principal role in our life, as in body health, nutrition, food products, and recently in food preservation, it is one of the most effective materials. These components have a potential function for biochemical activities for either the plants, animals, or human tissues. Human foods and animal feeds often suffering from mycotoxins contamination. This action gives rise to oxidative stress in the biological systems. Several articles have been focusing on antioxidant roles avoiding food harmful like pathogens, toxigenic fungi, and mycotoxins. Recently, the investigations pointed out that minor components and phenolic antioxidants were capable of occurring a reduction in mycotoxin contamination. These components were obtained mainly from non-traditional oils in most cases. These oils have distinguished by better antioxidant potency. Antioxidants have the functionality to stop deleterious impacts of free radicals' presence that released in tissues and serum in food processing, antioxidant efficiency to suppress mycotoxin-hazard depends on its structure and its chemical activity In this regard, it could achieve preservation properties and shelf-life extension for the final product. In this review, the role of antioxidants will be discussed in two visions, firstly, the biochemical significance and its role in the body fluids and its protective function. Secondly, this review will cover the antioxidant capacity toward food manufacturing, and the preservation potency, particularly in oil application.

Keywords: Natural antioxidants, toxigenic fungi, mycotoxin, food preservation, free radicals, food additives, oxidative stress, non-traditional oils.

1. Introduction

An antioxidant is a group of molecules or compounds, which can inhibit the oxidation process of different molecules. The oxidation process is a chemical reaction able to produce free radicals (FRs), those guide chain reactions causing cell damages. Antioxidants like ascorbic acid (vitamin C) affect this reaction by doing the disconnect of unwanted reactions [1]. Antioxidant expresses the utilization of substances; it extracted from natural sources and added to food commodities doing protective functions of natural and synthesis material; like industrial chemicals that added to products to prevent oxidation. Antioxidants acting significant functions in the defense of the body system versus reactive oxygen species (ROS). It could be identifying in terms of "the substance, which as of present at low amounts respectably delays or suppress the oxidation process of this material [2]. Otherwise, an antioxidant could be expressed in terms; the substance can delay, stop, or remove oxidative damage to a target material [3].

Antioxidants have appeared as molecules that causing an inhibition for the oxidation process, even at a comparatively small amount, which possesses a diverse physiological function through the body system [4-6]. The natural antioxidant substances mainly extracted from the members of the plant kingdom called natural antioxidant, these constituents have been acting as radical scavengers, assists to convert the FRs resulting in lowering the oxidative reaction of the food materials [7, 8]. An assortment of the FRs-scavenger includes antioxidants is discovered in several food materials such as green tea, citrus fruit, medicinal plants, and varieties of vegetables [9-14]. Antioxidants deem in many cases as the first defense step contra the FR injury [15]. Also, a

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significant step in health maintaining. Balanced vegetables and fruit consumption are the main sources of antioxidants deemed as a familiar step in reducing chronic diseases hazard [16].

Early investigations pointed to a diet rich in antioxidants guarantee positive permanent health benefits [17]. Popularly, citrus fruits have great natural antioxidant values like ascorbic acid. Otherwise, vegetables and fruits that rich in anthocyanin include red grape, blueberry, plum, strawberry, prune, spinach, broccoli,…. etc, have been considered to enclose antioxidants in higher values. Besides that; it is implemented in several food diets [18]. Recently, several experiments report a possibility of suggesting types of fruit-like are the perfect vitamins birthplace as well as phenolic substituents [19, 20]. As the types of antioxidant substances are from different sources related to chemical structure type, the antioxidant family appeared as a great group of members, which belonged to several kingdoms, whereas some of the antioxidant sources are related to animal tissues. Meanwhile, phytochemicals are deeming as non-essential nutrients and their sources mainly are plants. Various phytochemicals exhibited a good ability to act as an antioxidant. In addition, some micronutrients are managed as antioxidants.

2. Antioxidants in food and herbs

Nowadays, commodities like Goji berries, wild blueberries, dark chocolate, pecans, artichoke, elderberries, kidney beans, cranberries, and olive wastes [21] were recorded as rich sources of antioxidants with high oxidative stress values among all types of fruits and vegetables. Non-traditional edible oil sources (like black cumin seed, apricot kernels, wheat germ, grape seeds, and tomato seeds) with a high content of minor constituent (tocopherols, tocotrienols, Phytosterols, phenolic components, ….etc) has strong natural antioxidant properties, as well as, are of great importance for human nutrition [22, 23]. For this reason, many references referring to their food preservative action against lipid oxidation. Notwithstanding, many herbs also recorded to contain potent antioxidants like cloves, oregano, allspice, cinnamon, sage, peppermint, thyme, and lemon balm lead the pack. The fresh and dried varieties of herbs were found to have close values of antioxidants. The research on the determination of antioxidants for the fresh herbs seems as much as the antioxidant that presents in the dried herbs [24].

3. Importance of antioxidants

Antioxidants in most cases have a significant function in most body systems as it was found in several natural sources [2, 24, 25] **(Fig. 1)**.

Antioxidants in different expressions are called little military bodyguards, which protect and defend the body against the systems of metabolism. The FRs are harmful factors be producing in different tissues of the body during various metabolic processes [8, 9, 26]. Numerous components can serve as antioxidants and likely prohibit the dangers of FRs [3, 27, 28].

Generally, antioxidants accomplish include vitamins C and E and β-carotene. Antioxidants could play a major role in the body system, it could be capable to enhance several types of vital metabolites, support kidney function [29, 30]. A study by Pergola et al., supports this result with further evidence for the helpful impacts of antioxidants to protect kidney function [31]. Modern antioxidants that investigated with this research team appeared to be able to improve kidney function in patients with chronic disease up to a percentage of 30 as assessed by Kidney glomerular filtration rate (GFR). These conclusions proffer support ensuring the effective antioxidants in kidney function shielding. In accordance, the study of Bolignano *et al*.,[32] reported the antioxidants functions in delay diabetic and kidney disease progression.

In plants and animals, the formalization of ROS inside the cells as a by-product of metabolism is an unavoidable operation. Models of ROS enclose the hydrogen peroxide, superoxide anion, and hydroxyl radicals [33-35]. The partial reduction of molecular oxygen created the ROS molecules; these deem as deleterious substances for protein, lipid, and DNA molecules. Antioxidants are considered important components in defense against damage caused by several cases of oxidative stress [36-39]. Cells have a senior network of antioxidants to detoxify the intermediates of the ROS. Antioxidants can make prevention or linger down oxidation, in this way, oxidizing itself to susceptible cellular macro-molecules.

Moreover, polyphenols and pigments include anthocyanin and carotenoids developed and supplied further stability. Antioxidants could be hydrophilic or hydrophobic in nature. While, in human systems, hydrophilic antioxidants are the main defense against the harmful FRs in blood plasma, the hydrophobic antioxidants play an important function in cell membranes. The ROS were involved in the mediated oxidative deterioration of macromolecules has been connected to the major causative factors of many diseases, comprehensive cancer diseases [40], atherosclerosis [41], diabetes [42], neurodegeneration [43], and aging [44].
Furthermore, the antioxidants could practice some health functions such as maintain dental health through their activities, make the reduction

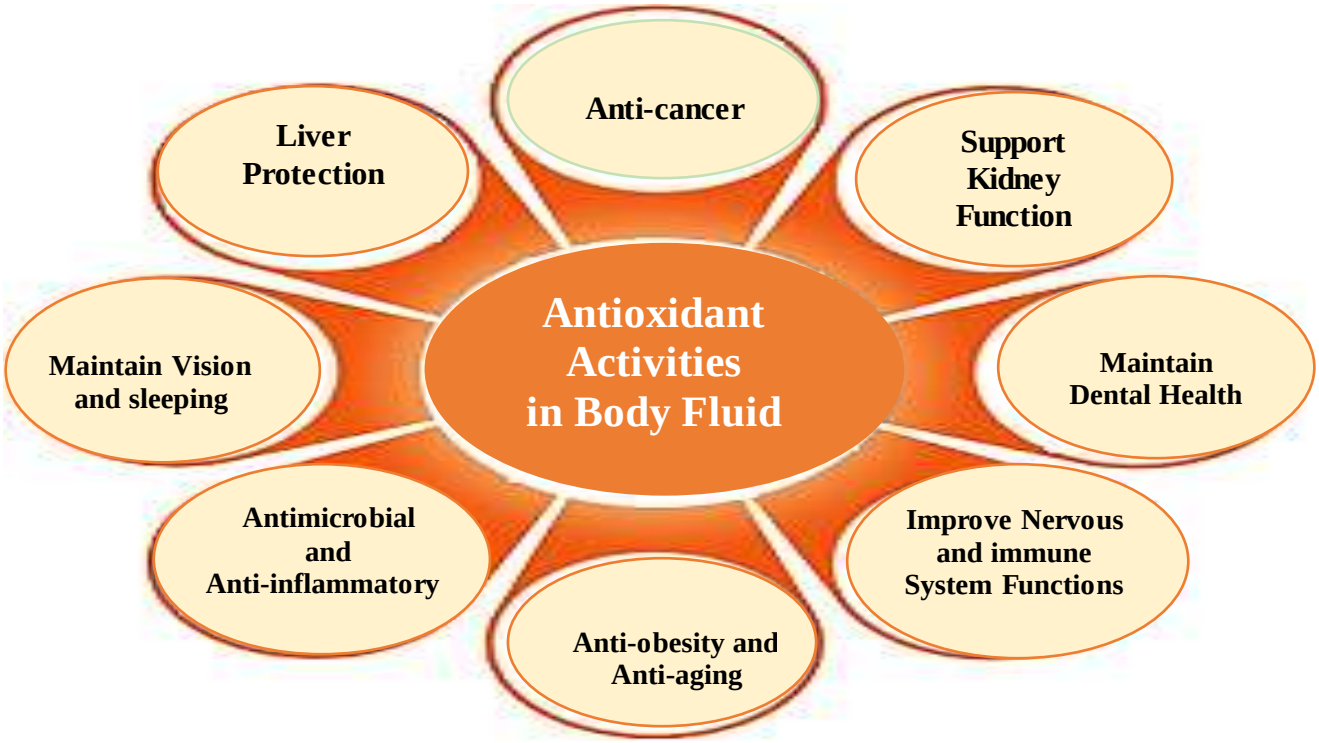

Figure 1: Antioxidants in body fluid and its biochemical functions.

the oxidative stress, reduced the inflammations, that resultant in reducing the severity of periodontitis [45]. However, Wilson *et al.* [26] reported the action of some vitamins as antioxidant molecules, which registered to have a significant role in the health benefits of old persons. These molecules are principally provided by food sources to support the body system.

4. Antioxidants in food technology

Oxidation is a big problem in many types of food products. Antioxidants in many cases applied as food additives to preserve food against oxidation [46]. Antioxidants a functional guard versus food deterioration results from their exposure to sunlight and oxygen [4], which are the significant oxidation agents. Food preservatives include several natural antioxidants, for instance; ascorbyl palmitate, tocopherols, and tocotrienols. However, the synthetic antioxidants are including butylated hydroxyanisole (BHA), propyl gallate, tertiary butyl hydroquinone (TBHQ), butylated hydroxytoluene (BHT), and ethoxyquin. Several antioxidants are naturally presented in several fruits and vegetables; mainly they are polyphenols components like quercetin and epi-gallocatechin. These antioxidants have several health benefits. Oxidation may destroy the DNA fragment causing cancer diseases, change polyunsaturated-fatty acids forms leading to heart attacks [37]. The elevation in antioxidants consumption achieves prevented versus heart and cancer illness.

Natural food-additives are not harmful for the human health; these materials allow consumers to consume tasty, healthy, and safe products. Food manufacturing is only possible due to the application of food preservatives as additives, in that regard, food industries must pursue to utilize ingredients, which have a high level of safety, as well as, regulated by food authorities, besides fulfilling its technological task to support the consumers with the highest possible degrees of quality products [47].

5. Preservatives and antioxidants

All types of food additives are mainly targeted to enhance food properties; it added to food in two parallel directions. Firstly, they added to enhance food sensoria like color, flavor, taste, aroma, and texture [48-50]. Secondly, they added to serve in extended the shelf life of food material through its ability to reduce the microorganisms' growth. Antioxidants play an important role in the second section, which is related to affect microorganism growth [51-53], in this case, it is mainly directed to delay food deterioration and suppress the microbial spoilage of food products. Both, preservatives and antioxidant additives aimed to extend the shelf life of food products, preserving the quality, ameliorate the organoleptic properties, and enhance the nutritional characteristics. It is here essential to understand the differences between the two reasons for the addition of antioxidants (prevent against oxidation and to suppress microbial spoilage).

This will help to clarify which antioxidant should be applied when it should be done, and whose will be more effective. The first distinction among the preservatives and antioxidants is due to its technological function, including their role to prevent the proliferation of undesirable microbes in the final food product [54-56], whilst normally antioxidants applied to save the food from oxidative rancidity. In general, the preservatives, as well, the antioxidants resist the unwanted changes in the product, as the preservatives are mainly suppressed the biological alteration, and the antioxidants are inhibitors of chemical changes besides it probably affects biological hazards.

The second distinction is that preservatives are utilized in products that have more water content, in this case, the microflora like fungi, bacteria, and yeasts, which arise and develop food deterioration [57-59]. Antioxidants are incorporated into products that contain fats, to protect them from lipid oxidation due to the impact of light, heat, or other factors.

6. Biochemical significance of antioxidant

Antioxidants have the functionality to stop the bad impacts of FRs present that released in tissues and serum. Antioxidants have a great role in body fluids; besides they have a protective impact on tissue viability (**Fig. 1**) [60-62]. Environmental pollutants, which are considered the sources of different reactive species (RS) are one of the great hazards faces food materials especially the raw ones.

The RS is a collective term, which encloses oxygen radicals' sides to other ROS. Free radicals are a significant material for the living cycles of organisms, these FRs varied in many active groups such as hydroxyl group (OH), superoxide (O2*), nitric oxide (NO*), and peroxyl radicals. Usually, the expression of the ROS is used to express the FRs and the non-radicals [8, 63]. At the state of antioxidant system defense in the body turned to kowtow, oxidative stress often happens to the cellular ingredients, which encourages inflammatory, alteration, and mutation processes [64]. Otherwise, nutritional habits and the nature of lifestyle could play important roles in contra the exposure to oxidant and injury. Assignment protecting against the hazard of ROS may commonly happen at two stages:

(i) Biochemical safeguard to minimize the level of exposure that impossible to be achieved by individuals living in contaminated regions, or
(ii) Physiological safeguard to erase the antioxidative defense of the organism.

The chemistry of antioxidants and FRs are set up on a balance between both. FRs are reactive compounds that resort to catch electrons from stable biological molecules to entrench themselves [65-67]. As represents in **Fig. 2**, the antioxidants possess various functions and bioactive roles for human health and food preservation.

In unhealthy conditions, the presence of pro-oxidant compounds and/ or various risk factors like stress, extra physical activity also smoking provided an overload of FRs. This operation is known to have levels; 1) initiation where the radicals are produced; then 2) in the propagation the free radicals react with separate molecules; and finally, 3) by the termination, they convert into different products (**Fig. 3**). There are 3 prime groups: reactive sulfur (RS), reactive oxygen (RO), and reactive nitrogen (RN). It was rating according to the difference in terms of radical species. Oxidative stress generated remarkably reactive species and radicals, such as alkyloxy radical, hydroxyl radical, hydrogen peroxide, superoxide, nitrous radical, and atomic oxygen which could be generated both endogenously and exogenously [25, 68]. In standard concentrations, these species have meaningful physiological attributes, particularly, as a mediator for macrophages that select cytotoxic activity contra microorganisms and neoplastic cells. Meanwhile, the nitric oxide can improve concentration; it reacts with superoxide anion without catalyst needs. Finally creating the peroxynitrite radical, which is known to be very dangerous to the body, behaving together with several molecules through diverse mechanisms [22, 23, 69].

An antioxidant can be described as "a substance that, when present at a low concentration associated with those of an oxidizable substrate, significantly prevents or inhibits oxidation of that substrate" [25]. This definition is general and used to describe antioxidants that combat FRs inside the body. All antioxidant types follow one of the seven mechanisms of action, which vary with the type of oxidants:

a) Prohibition the damage of DNA fragments;
b) Incarceration of FRs from the environment;
c) Repression of FRs producing enzymes;
d) Metallic ions chelation;
e) Energizing the endogenous antioxidant enzymes;
f) Obstruction of protein amendment and sugar annihilation and
g) Lipid peroxidation preventing.

These mechanisms explain the chemical behavior of antioxidants in support or suppress some biochemical reactions in the biological system of living-organisms.

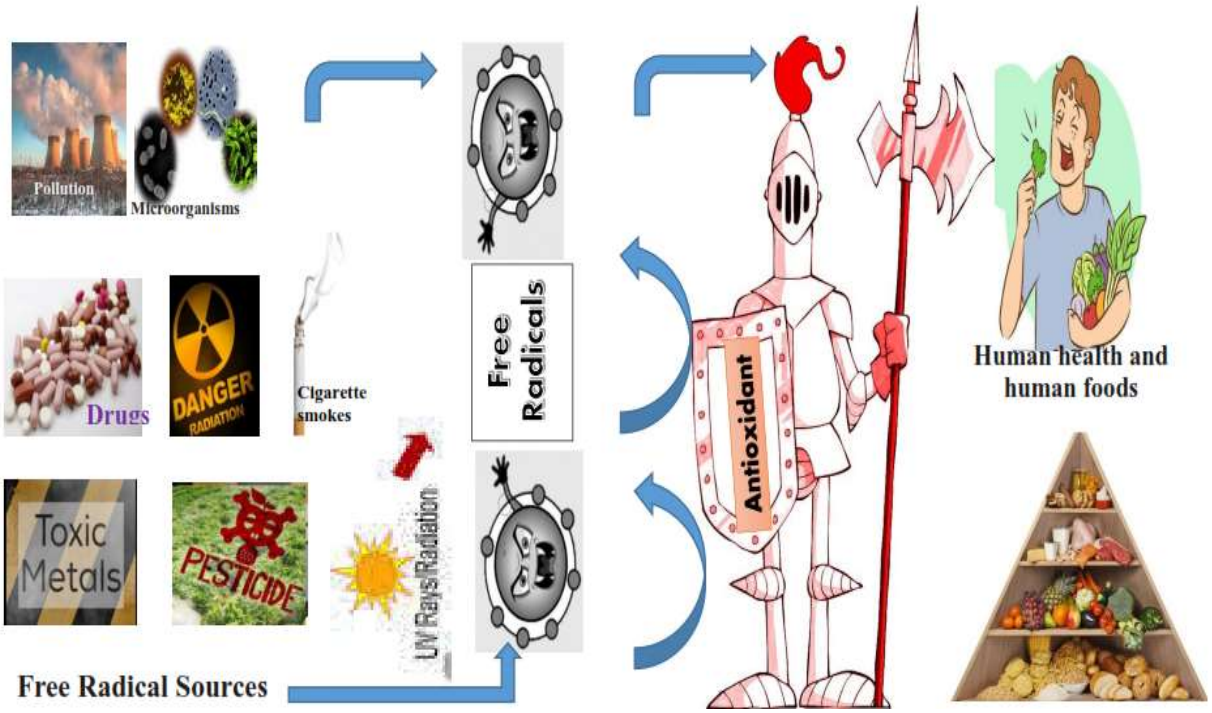

Figure 2: Antioxidant functions in human health and food preservation

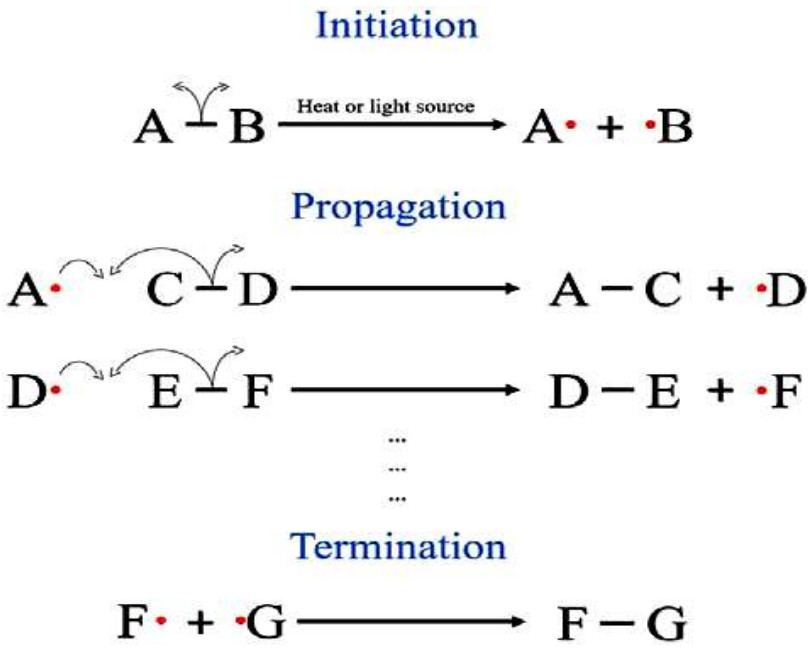

Figure 3: The three steps of radical chain reactions, leading to oxidative stress, which is the excess production of radical species.

7. Industrial applications of antioxidants

Nowadays, synthesized antioxidants manufactured on a mass-production scale in a highly purified form, so it is marketed at a cheap price. However, the introduction of a newly synthesized product requires a comprehensive safety evaluation to achieve regulatory commitments. While this is quite different in the case of natural antioxidants. In the USA, for example, the use of natural antioxidants from plant sources like oregano which is considered generally recognized as safe (GRAS) is directly granted, and no need for extensive safety experimentations. Synthetic antioxidants such as the TBHQ or propyl gallate (PG) have been widely used in fatty foods such as fats and oils which applied in foods like meat products, pastry, nuts, dairy products, seafood, margarine, and bakery products at the range from 0.001 to 0.04% [70, 71]. From ancient and until now, natural products and wild plants have been utilizing as a substantial source of natural antioxidants used in food products. The oily product form of vitamin E (tocopherols) and ascorbic acid considered the famous natural antioxidants commercially applied.

Likewise, plant extracts have accomplished a certain significance (particularly spices extracts included carnosic and rosmarinic acids). Several products from soybean and cereal as well including in food formulas to suppress the oxidation reactions in the food products. The admixture of tocopherols having different concentrations of alpha, gamma- and/or delta-tocopherols (normally dissolved in an edible oil) and synergistic blends consist of tocopherols, ascorbyl palmitate or other antioxidants, synergists like citric acid, lecithin, and carrier. The latest formula usually is a paste, but, sometimes viscous. The pastes must be melted at a temperature of 55 ± 5 ^{0}C in the oil phase of the foodstuff to be preserved [72-74].

7.1. Oil manufacturing and antioxidants applications

Oil is considered as one of the most significant food manufacturing, as the oxidation process is rapidly done for the oil representing chemical changes in the oil. Vegetable oils in their natural form possess constituents that function as natural antioxidants like ascorbic acids, vitamin E, carotenoids, chlorogenic-acids, and flavanoids. Traditional vegetable oil processing comprises many various raw substances, products, and unit operations. The vegetable oil extraction is the first step in processing, followed by the oil refining process which leads to the loss of many important natural minor components that can have negative effects on the physical, chemical, nutritional or sensorial attributes of oils [75, 76]. Concerning virgin oils, which are extracted with cold-press methods, such as olive oil contain many phenolic compounds whose presence affects stability and flavor. The natural antioxidant losses during the oil-refining, handling steps and storage have respectable increasing importance. Generally, retention of maximum levels of natural antioxidants through the application of good manufacturing practices (GMP) is an appropriate target. Accordingly, by following the GMP recommendations, the natural antioxidant (vitamin E; tocopherols and tocotrienols) content of oils is only reduced to 30-40% during refining (neutralization, bleaching, and deodorizing) [Reference]. Regarding the refining techniques of vegetable oil, antioxidants not usually adding to crude oil during the process since it did rich in their original antioxidants (phenolic, tocopherol, and tocotrienol). It should be noted for the removing of natural antioxidant from oils and fats through its refining, this leads to the necessity of antioxidant supplementation during oils and fats manufacturing for raising the quality properties.

The blending of edible oils is the simplest way to modify the fatty acid structure, physicochemical, oxidative potency, and functional characteristics of plant oils without modifying their chemical structure [77, 78]. Many authors reported that the blending of cold press virgin olive oil which possesses a strong antioxidant potency refers to the presence of phenolic compounds, black seed oil, rice bran oil, palm super olein, palm oil, roasted sesame seed oil as a source of natural antioxidant can improve the stability of soft oils [23, 69].

8. Antioxidants: food application and legalizations

Food additives are molecules, which add to foodstuffs to perform particular technological functions, which can preserve food, provide a color, flavor, texturizing, sweet tastes, besides further desired sensory properties in the final product. It was added carefully during food production. Administrative organizations globally legislating compel the law, handling permission, guidance, and regulating the use of food additives. These organizations included the European Food Safety Authority (EFSA), and the, Food and Drugs Administration (FDA). These organizations are evaluating the degree of risks, performed studies, issued reports. Furthermore, other significant organizations include the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the expert committee on food additives, and the Codex Alimentarius are other organizations conjugated with food additives. The EFSA classified food additives into 6 groups, via its appropriate suggested issues in food products. These groups included nutritional additives, preservatives, flavoring, coloring, and texturizing factors. Each food additive connected to a number correlates to its group refers, the groups introduced by the letter "E"; representing European Legalizations. The supplemented quantities from any additive are stringently measured for each

food product. The comprehensive daily consumption requires not exceeding an admissible daily intake (ADI). The ADI is referring to collective quantities of various additives that are daily used while it behaves free of dangerous health influence [29, 30, 32].

9.1. European food safety authority approved food antioxidants

All the food antioxidants that are approved by the European Food Safety Authority, its "E" number, group, name, and the up-to-date corresponding recognized report that details the safety matters and other data about their approval.

9.2. Functional antioxidant groups

In antioxidants subgroups, the bunches of fragments are classified to more simple that perception of the great number of compounds plus the foods, which approved in it. Including the developing interest in natural food additives, some investigators showed the difference between synthetic and natural food additives, but actually, this difference had not been done yet. Hence, the natural and synthetic source of antioxidants is not declared in the official tables, which exhibits the amount and acceptance of performance from each additive in each food type.

9.3. Butylates

Butylates are antioxidants with several uses composed the butylated hydroxy-toluene (BHT – E321), butylated hydroxy-anisole (BHA – E320), and tetra butyl hydroquinone (TBHQ - E319). The TBHQ is a general antioxidant, it is recorded to use according to the ADI not exceeded 0.7 mg/ kg, and principal use with oils, kinds of margarine, meats, and cereals. One of its prime benefits, when associated with another parallel, is the fact it does not miss color when in association to iron, but it reported non-influential in patisserie and bread manufacturers [32, 33]. The BHA is a public synthetic antioxidant of phenolic nature. The BHA aims to check the rancidification of fat in foods, given its low effectiveness on vegetable fat [32, 34, 35]. The BHT is a member of the antioxidants with a butylated group that is generally applied in fatty foods, it does inexpensive to manufacture, utilized in a mixture besides gallates or BHA. The EFSA evaluated consumers' exhibit to BHT and concluded that; it has a low water solubility, also, no hazard of overexposure than ADI value (0.5 mg/Kg body weight) in the food regime [33, 34, 39]. The BHA and BHT have synergic behaviors while they are concurrently inserted inside foodstuffs. At first, the BHA reacts with peroxyl radicals, turned to a radical of BHA phenoxy, which thereafter harnesses BHT to rejuvenate itself previously neutralizing new radicals in food [79].

9.4. Tocopherols

The tocopherols approved by the EFSA include isoforms of tocopherols, γ-, α- and β-tocopherol, as well as a tocopherol-rich extract, being δ-tocopherol the only isoform that is not permitted to be used as a separated additive in food. They are effective against the compounds that cause oxidative stress. The report of tocopherols application in dairy and meat products, fats, and oils. They were added to food targeted preserving the high lipids content as fatty foods, in this respect, they are recognized to be the common potent lipophilic antioxidants. Tocopherols not only reported a highly significant synergistic response in the presence of ascorbic acid but also have interaction with carotenoids, where both are reconstructed by the other co-antioxidant, although regeneration of carotenoids by tocopherols is favored [38, 39].

9. Antioxidant function in avoiding food harmful

Recently, antioxidants reported as preservatives against many food risks. The functionality of antioxidants was referring to their ability to stop harmful food hazards such as bacteria, fungi, and some types of yeasts, as well as their toxins. These results were shown by the application of plant extracts as antioxidant components source [80-82]. As an application of antioxidants in the food sector, several articles were referring to their impact as antimicrobial, antibacterial, antifungal, and anti-mycotic substances [83-85], it was also practiced in fatty foods as mentioned before by Abdel-Razek et al. [86]. However, the antioxidant potency as the effective characterization of olive oil by-products, in that study were determined using different methods of free radical scavenging activities of solutions of the extracts; as 1, 1-diphenyl-2-picryl-hydrazyl (DPPH scavenging activity) and 2, 2′-azino-bis-3-ethyl benzothiazole-6-sulphonic acid (ABTS).

As the results showed; for the extracts of three types of olive industrial by-products, which represented as olive pomace extract, olive leaves extracts, and recovered olive oil from wastes, the values of antioxidant contents of the three materials appeared moderated in their values, however, olive pomace extract showed the highest values either for DPPH and ABTS, also, the IC50 is better in the case of olive pomace extract [86-88]. The authors discuss the impact of antioxidant substances, which were presented in the oil manufacturing waste on different strains of pathogenic bacteria, the results indicate a good impact of these antioxidant substances on the bacterial growth using two effective assays related to the plate diffusion methods, The bacterial strains which were prepared to apply in that article, these bacterial strains were divided into a Gram-positive

strain (Staphylococcus aureus and Bacillus cereus) and a Gram-negative strain (*Campylobacter jejuni and salmonella typhi*).

On the other hand, the phenolic and flavonoids contents of these extracts were also determined, the results indicate a high tenor especially of total phenolic compounds. The highest contents either of polyphenolic substances or flavonoids were recorded in the pomace extract; and in the same line, the results refer to pomace olive extract as the best antibacterial among the three extracts.

Not only the antibacterial effect was the characteristic property, which studied in the aforementioned study, but also the antifungal effect of the application of extracts on fungal growth media was evaluated. Four strains of toxigenic fungi have used the screening of the olive by-products extracts, Data showed a good ability of these materials to inhibit the toxigenic fungal growth of *Aspergillus flavus, Aspergillus ochraceus, Penicillium sp*., and *Fusarium moniliforme* [80].

Otherwise, in a study on some oils and their by-products manufacturing, which had been done by Badr et al., [87], jojoba oil, Jatropha oil, and its industrial wastes were evaluated to determine its antioxidant content. The results showed moderate amounts of antioxidants substances either in the oil itself or at the manufacturing wastes. Again, the ability of these extracts to suppress the pathogenic bacterial strain growth was examined. The results represented a better inhibition zone on the plate diffusions assays for the bacterial growth in the presence of the extracts. The antifungal effect of the extracts was also determined, Data revealed a good inhibition for investigated toxigenic fungi strains.

As a conclusion of these studies, the presence of some antioxidant materials extracted from agricultural wastes and by-products such as polyphenols, flavonoids, and other antioxidant substances can suppress the harmful bacterial growth, minimize the food exposure to several sources of risks, and finally, it could be a significant step to stop the presence of bacterial toxins on final food products through the antioxidant action on microorganism metabolism cycles. Antibacterial, as well as, antifungal characteristics of several food wastes and manufacturing by-products will lead to the use of their extracts as natural food additives, this could provide several benefits from economic to the high-quality properties of the products [89]. It will also be used to extend the shelf life of the product, to avoid the synthetic food additives, as well as to have a product with amazing characteristics produced by just natural components as assisted material through the manufacturing steps.

10. Antioxidant suppress the toxigenic fungi

Natural antioxidants are present in many types of food materials being mainly found in the plant and plant-based materials, it can play different roles, for instance; it could help to avoid the bad alteration of the plant material, extended its resistance to microbial spoilage, as well as, it could help to suppress some un-wanted metabolic pathways [90-92]. On the other hand, the presence of antioxidants means that there are active components that could affect some metabolic pathways of microorganisms, may found in this media; or could contaminate the food material. Antioxidants could play a function of preservative as it could be stopped some biological processes of bacteria or fungi. In some cases, it was reported that, in the presence of antioxidant compounds in the growth media of fungi, it was able to reduce its growth [93-95]

However, the metabolic pathway of these fungi could be influenced during the presence of these active substances, one of the major effects of antioxidant present in the toxigenic fungal growth media is related to its ability to alter the biological process inside the fungi cell resulted in stopped some important products for fungal life [96]. The famous product of toxigenic fungi was the mycotoxin which varied according to the fungal strain. The mycotoxin for fungi is considered a secondary metabolite that important for fungal metabolism, otherwise, mycotoxins are harmful materials for livestock and human. The ability of the antioxidant to suppress these harmful materials found in the fungal growth media was reported [96-98].

11. Mycotoxin and oxidative stress

Oxidative stress (OXst) generates in organisms when the concentration of the ROS passes an antioxidant capacity for cells. The OXst is led to DNA damage, which reinforces lipid peroxidation, protein loss, and cell death [99, 100]. The molecular mechanisms following the toxic consequences of important mycotoxin are organized while the OXst also the FRs generation are associated with the related mycotoxins toxicity.

12. Antioxidant mission to reduce the harmful of mycotoxin in food

Recently, numerous research articles have been focused on how to avoid mycotoxin stress on food commodities, particularly on cereal, fruits, and vegetables [101]. The principle function to lose the mycotoxigenic effect could be reached by suppressing either the fungal growth or mycotoxin excretion, this might be validated through the application of natural components in the growth media of fungi leads to reach these goals. In 2014, Sempere et al.[102]

evaluated the impact of oxidant stress sides to the antioxidants on the ochratoxigenic fungi such as Aspergillus carbonarius. The connection between mycotoxin and oxidative stress synthesis has been less explained in ochratoxins than for any mycotoxin else.

Palumbo et al., [103] evaluated the reducing impact of antioxidants on ochratoxin A production as well as on fungal growth of different Aspergillus fungi that could produce ochratoxins in the growth media. The antimicrobial factor side to the BHA has also been examined as alternates of fungicidal components in Aspergillus sp. controlled in nuts through the storing period. A few types of antioxidant compounds like resveratrol, BHA, and caffeic acid are recorded as an inhibitor of the lipoxygenases. Furthermore, it is recognized that the biosynthesis of lipoxygenase passage yields oxylipins, which trigger signaling mechanisms that activate mycotoxin production. The embroilment of a lipoxygenase in ochratoxin production by Aspergillus ochraceus has been demonstrated by Reverberi et al., [104].

Following the previous works, De Rossi et al.[105] elucidated the ability of resveratrol to control ochratoxins production amount by *Aspergillus carbonarius* fungi during the inhibition process, which is caused by lipoxygenase. This redirected the research ideas to the hypothesis, which supports the antioxidant balance influence ochratoxins synthesis. At the same time, oxidative stress could be an alternate significant agent included in the excitement of the ochratoxin A biosynthesis. In 2017, Shehata et al., [88] studied the aflatoxins reducing from food material using the extracts of agricultural wastes as a source of antioxidants. Three types of these materials (fig pomace, fig immature fruits, and pomegranate husks) were evaluated for their antioxidants potency; results showed their good content of antioxidants materials such as polyphenols and total flavonoids. As it was applied in aflatoxin reduction, it was able to reduce the contamination of aflatoxins amount in which seeds of crop coated by these extracted as a bioactive film. Notwithstanding, the study of Atanasova-Penichon et al., [97], who targeted to evaluate the antioxidant potential in resistance of *Fusarium* fungi and the accumulate of mycotoxin on cereal-based food. The authors were exploring the cereals' minor components; they were referring to the main secondary metabolites in cereals, which had antioxidant potency belong to 3 groups' namely carotenoids, polyphenols, and tocopherols. They also refer to the possibility for the presence of the further combination, consisting of benzoxazinoids and its derivatives, it was lesser manifested in grains but there was a need to do some biological activities. As phenolic compounds deem the principal contributor of total antioxidant capacity in cereal grains, otherwise, the changes in oxidative factors in fungal growth media are probably nominated to intervene with fungal secondary metabolism excretion as a vital biological process and to modify the amount of mycotoxin produced on the fungal growth media. Data revealed more than one evidence that refers to the function of the antioxidant components played an important role to avoid the harmful of the toxigenic hazard of Fusarium moniliforme fungi as well as, they could also have a significant function to suppress mycotoxin excreted by the same type of toxigenic fungi [Reference].

13. Non-traditional oils as a source of antioxidants, possess viability to reduce mycotoxin

Various types of non-traditional vegetable oils are known to have valuable content of antioxidants [23, 106]. These antioxidants were varied in their amounts and their potency [107]. Non-traditional oils are distinguished by the presence of tocopherols, tocotrienols, phenolic antioxidants besides their fatty acid contents [84, 108]. Furthermore, various phenolic compounds sourced from natural vegetative materials exercised stress on the fungal life cycle, includes their metabolites formation [109, 110]. Mycotoxin formation included several biotransformation steps, which stopped in the presence of bioactive molecules [110, 111]. This action was achieved using some plant extracts contains the bioactive sources [112-114] Application of the non-traditional oils for the mycotoxin limitation may vary between their utilization as a source of bioactive components that reduce mycotoxin contamination [84, 108, 115]. Another strategy may occur through the oil application as a carrier or disseminator for the bioactive compound [92, 93]. In that regard, non-traditional types of oil provide a double benefit for safety achievement in food production, including their application in oil manufacturing against mycotoxin contamination.

14. Conclusion

Natural antioxidants are a principal group of bioactive components that exist in many food substances, particularly in plants, fruits, vegetables, and cereals. Natural antioxidant contents, between their sources, varied according to accumulation significance. The accumulation is affected by the growth phase and environmental hazards. Natural antioxidants are considered a principle group of food additives, which their presence achieve various benefits for food products. It plays a significant function to stop the deterioration, mainly against chemically or biological spoilage. Natural antioxidants possess diverse functions in food, as natural preservatives and antimicrobials. As an example, oil production deems significant processes, which include antioxidant additives. The non-traditional oils are a group of limit-commercially types of oils known to be rich by minor

components. These components are possessing bioactive functions to make a capability as a safeguard in food processing. Antioxidant impact, as food preservatives, was recorded to avoid food hazards, such as pathogenic bacteria or toxigenic fungi. It is important for pointing out their role against chemical hazards like mycotoxins. The reducing influence of antioxidants on mycotoxin-secretion, by toxigenic fungal, was listed in several research articles. The application of natural antioxidants against mycotoxin risks provides a high safety degree for food products against risks and harmful parameters.

15. Conflict of interest

The authors declare no conflict of interest.

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الملخص العربى:

مضادات الأكسدة الطبيعية: الدور الوظيفى لحفظ وسلامة الغذاء ضد أخطارالفطريات المنتجة للسموم

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تلعب مضادات الأكسدة الطبيعية دورًا رئيسيًا في حياتنا، كذلك لها دورها الحيوى في صيانة النظام البيولوجى داخل الجسم بالإضافة الى دورها في كل من التغذية والمنتجات الغذائية. ومؤخراً ازداد الاهتمام بمضادات الأكسدة الطبيعية نتيجة لفاعليتها في حفظ الأغذية. وهذه المركبات لها وظيفة مؤثرة على الأنشطة الكيميائية الحيوية سواء للنباتات أو الحيوانات أو الأنسجة البشرية. من الجدير بالذكر أنه غالبًا ما تتعرض بعض الأغذية وأعلاف الحيوانات للتلوث بالفطريات وسمومها. هذا التلوث في معظم الأحوال يؤدي إلى الإجهاد التأكسدي داخل النظم الحيوية. وقد ركزت العديد من المقالات العلمية على الأدوار المضادة للأكسدة وتجنب الضرر الذى قد يصيب بعض الأطعمة بمسببات الأمراض مثل الفطريات السامة أوالسموم الفطرية. وأشارت عديد من الدراسات مؤخرًا إلى أن المكونات الثانوية ومضادات الأكسدة الفينولية كانت قادرة على الحد من التلوث بالسموم الفطرية. عادة ما يتم الحصول على هذه المكونات بشكل رئيسي من الزيوت غير التقليدية (والتي تعد أنواع واعدة من الزيوت غير المتداولة تجارياً على نطاق واسع، مع غنى هذه الأنواع بالمركبات ذات النشاط الحيوى). تميزت هذه الزيوت بفاعلية أفضل ومحتوى متميز لمضادات الأكسدة، والتى لها فاعلية لوقف التأثيرات الضارة للكائنات الحية الدقيقة، حيث يعد توافر الشقوق الحرة في النظم البيولوجية والتي تنطلق في الأنسجة وتعتبر سببا رئيسيا في العديد من الأمراض. وتعتمد كفاءة مضادات الأكسدة لقمع مخاطر السموم الفطرية على تركيبها وشكلها الفراغى ونشاطها الكيميائي، ويمكن أن تحقق خصائص الحفظ وإطالة فترة الصلاحية للمنتج الغذائى. فى هذا البحث المرجعى تم مناقشة دور مضادات الأكسدة الطبيعية من خلال رؤيتين ، أولاً ، الأهمية الكيميائية الحيوية لمضادات الاكسدة ودورها في سوائل الجسم ووظيفتها الوقائية. ثانيًا ، من حيث قدرة مضادات الأكسدة الطبيعية على المساعدة فى حفظ الأغذية المصنعة، وتدعيم فعالية الحفظ ، خاصة عند إضافتها للزيوت الغذائية.