

Natural Antioxidants and their Effect on Human Health

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Abstract

Fruit, vegetables and spice antioxidants are recognized for their important role in human health against some diseases for instance cancer and cardiovascular diseases. Phenolic antioxidants, vitamins (C and E), flavonoids, and catechins are among the major naturally bioavailable antioxidants. Natural antioxidants positive impact on human health can be summarized on their potential to act against inflammation, bacteria, aging, oxidative stress and cancer. The evaluation of antioxidants bioavailability in food and medicinal plants are essential to understand the best antioxidant sources and to elevate their use in food, pharmaceuticals and food additives.

1. Introduction

Antioxidants have been proposed to play a significant role as food additives. Antioxidants were described as “any substance that, when present at low concentrations compared to those of an oxidizable substrate, significantly delays or prevents oxidation of that substrate” [1-4]. Antioxidants play an important role in inhibition of plants contamination damage, disease prevention in both plants and animals and play an important function in the body defense system [5-6]. In addition, antioxidants compounds reduce free radicals and break oxidation chains *in vivo* as well [3]. Antioxidants mode of action varies according to species yet, the occurrence of defense system based on

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antioxidants is universal and they exist in both in enzymatic and non-enzymatic systems in the intracellular and extracellular environment [7]. Antioxidants, in living cells, can be categorized into two major groups: synthetic and natural [8]. Table 1 shows classification of antioxidants according to [9].

Table 1. Classification of antioxidants.

<p>A. CLASSIFICATION BASED UPON THEIR NATURE</p> <p>1. Enzymatic antioxidant Superoxide dismutase (SOD), Catalase (CAT), Glutathione peroxidase (GPx), and Glutathione reductase (GR).</p> <p>2. Non-enzymatic antioxidant</p> <p>a) Metabolic antioxidants Reduced glutathione (GSH), lipid acid, L-arginine, coenzyme Q₁₀, melatonin, uric acid, bilirubin, metal-chelating proteins, transferrin, etc</p> <p>b) Nutrient antioxidants Vitamin E, vitamin C, carotenoids, trace metals (selenium, manganese, zinc), flavonoids, omega-3 and omega-6 fatty acids, etc</p> <p>B. CLASSIFICATION BASED UPON SOURCE</p> <p>1. Endogenous Antioxidants Bilirubin, glutathione, lipoic acid, <i>N</i>-acetyl cysteine, NADPH and NADH, ubiquinone (coenzyme Q₁₀), uric acid, enzymes (SOD, CAT, GPx, GR).</p> <p>2. Dietary Antioxidants Vitamin C, Vitamin E, Beta carotene and other carotenoids and oxycarotenoids (lycopene and lutein), polyphenols (flavonoids, flavones, flavonols, and proanthocyanidins</p> <p>3. Metal Binding Proteins Albumin (copper), ceruloplasmin (copper), metallothionein (copper), ferritin (iron), myoglobin (iron), transferrin (iron).</p> <p>C. CLASSIFICATION BASED MECHANISM OF ACTION</p> <p>1. Catalytic systems to neutralise or divert ROS SOD, CAT, GPx</p> <p>2. Binding/inactivation of metal ions prevents production of ROS by Haber–Weiss reaction Ferritin, caeruloplasmin, catechins</p> <p>3. Self suicidal and chain breaking antioxidants scavenge, destroy ROS Vitamin C, vitamin E, uric acid, glutathione, flavonoids</p> <p>4. Quenching ROS, chemical traps/sinks to ‘absorb’ energy Carotenoids, anthocyanidins</p>

Synthetic antioxidants are fairly stable and usually have the potential to break into the cells, and some of them can be administered orally because of their non-protein nature [10]. Synthetic antioxidants are widely used as a substitute to natural antioxidants due to their low cost, availability, stable quality and high antioxidant activity [11]. Butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT), and tert-butyl hydroquinone (t-BHQ) are among common synthetic antioxidants that function against lipid peroxidation [12].

On the other hand, according to a study by [13], natural antioxidants can be present in different parts of higher plants for instance fruits, vegetables, seeds, leaves, roots and barks. Natural antioxidants such as plant phenolics have different functions and it is believed to function as a reducing agent, free radical scavengers, metal chelators and singlet oxygen quenchers [14]. Natural antioxidants such as fat-soluble vitamins, tocopherols, flavonoids, and organic acids are also present in animal food products (milk, fish, eggs and lipids) but their availability depend on type of feed, hence, animal food products are not considered as substantial source of antioxidants in human diet [15].

Several previous epidemiological and scientific studies mentioned the major plant sources of natural antioxidants which are fruits, vegetables, whole grains, green and black tea, herbs and spices [16-24]. Vitamins (C and E), and phenolic compounds are among most studied plant antioxidants [23]. Currently, the interest is on natural compounds such as carotenoids, particularly to Lycopene, b -carotene, lutein, zeaxanthin, and Astaxanthin [25].

2. Antioxidants in Fruits

Abundant nutritional compounds are present in fruits such as vitamins, dietary fiber and mineral salts alongside with carotenoids and polyphenolic compounds [23]. Blackcurrant is a well-recognized fruits as a valuable source of vitamin C (about 120-215 mg/100 g), carotenoids, mainly lutein and b-carotene, phenolic compounds (about 25 mg/g d.m) [26-28].

Strawberry fruits, as well, are also rich with vitamin C (35-104 mg/100 g), phenolic compounds (about 20 mg/g d.m) and high amount of anthocyanins (about 35-40% of total polyphenols content) [29-30].

Grapes and citrus fruits are also a valuable source of antioxidants especially vitamin C and phenolic compounds [31-33]. Blueberries, a well-known fruit worldwide, are rich with vitamin C and carotenoids, and phenolic compounds (amounting to. 30 mg/g dm)

[29, 34]. Apples on the other hand was reported to have strong antioxidant, cancer cell expand reducing, lipid oxidation lowering, and cholesterol decreasing activity [35]. Previous studies reported that almost 80% of polyphenols from apples comprise procyanidins and flavanols [35].

3. Antioxidants in Vegetables

Vegetables are considered one of the most consumed foods worldwide and they represent a main daily diet due to their health aspects to the human body. Antioxidants present in vegetables have an essential part in health protection and disease inhibition [37]. Vitamins C, and E, carotenoids, polyphenols, and other compounds are among valuable antioxidants present in vegetables [38]. Important examples of vegetables that are a valuable source of antioxidants are tomatoes, red pepper, potato, *Brassica* family, legumes and cereals.

Tomatoes, is one of the main cultivated and consumed crops globally, and considered as a valuable source of lycopene, β -carotene, folate, potassium, vitamins (C and E), flavonoids, and phenolics [39-41]. Tomatoes' high levels of lycopene make it an excellent source of antioxidant due to the high stability of lycopene to storage and cooking. Previous studies suggested that the occurrence of cardiovascular disease, and breast, colon, lung, and prostate cancers is correlated with consistent consumption of tomatoes [40, 42, 43]. Tomato also rich with vitamin C, which plays important role in donating electrons for enzymes, and other oxidants, which in turn make it Vitamin C an excellent antioxidant [44].

Red pepper is an excellent source of vitamins (A, C and E), together with neutral phenolic antioxidants and they are significant as a human diet. Antioxidant activity of pepper were found in the pericarp of pepper through two phenolic elements, flavonoids and capsaicinoids [45, 46].

Potato among other vegetables is rich with antioxidants and shows high antioxidant activity. Patatin is the main water-soluble compound that exhibits antioxidant activity accounting for up to 40% of the total soluble protein in potato [47]. In addition, phenolic compounds were found in high levels in potatoes which ranging from 530 $\mu\text{g/g}$ to 1770 $\mu\text{g/g}$ [48, 49]. Potato tubers also rich with ascorbic acid, which is a significant source of vitamin C that may reach to 207.2 mg/kg [50].

Brassica vegetables (such as cabbage, kale, broccoli, and cauliflower) are recognized for the high contents of antioxidant compounds, which make them healthy diet.

Polyphenols, flavonoids, glucosinolates and vitamin C are present in elevated amounts in *Brassica* vegetables [51].

In general, legumes and cereals are not rich with antioxidants but because they represent huge share in diet, they were subjected to various antioxidant value studies. Polyphenols (such as phenolic acids) and, in smaller amounts, p-Coumaric acid play an important role in antioxidant activity [52, 53]. In legumes, catechins can also be found in bean seeds, which contain phenolic acids, quercetin, tannins and anthocyanins, and also flavonoids [54, 55].

4. Antioxidants in Tea

(-)-epigallocatechin-3-gallate (EGCG), (-)-epigallocatechin (EGC), (-)-epicatechin-3-gallate (ECG), and (-)-epicatechin (EC) are among significant polyphenolic compounds exhibit abundantly in green tea [56]. Oppositely, black tea, contains another phenolic compounds such as theaflavins and thearubigins [57].

Table 2. List of natural sources of antioxidants as reported by [24, 58].

Natural antioxidants	Sources
Ascorbic acid	Citrus fruits, tomatoes, vegetables, brown rice, pink and red wine, mango, papaya, sweet potato, watermelon
Catechins	Apples, beans, berries, wine, tea, fruits, chocolate
Anthocyanins	Beets, berries, eggplant, grape fruits, pink and red wine
Beta-carotene	Vegetables, tomatoes, carrots, sweet potatoes, apricots, papayas, squash, acorn, peaches, bell peppers, broccoli, mango
Polyphenols	Tea, fruits, vegetables, red cabbage, blue and black berries
Lycopene	Tomatoes, papaya, watermelon, guava, pink and red grapes.
Tocopherol	Cooking oils (olive, sunflower, safflower and canola), almonds, hazelnuts, whole grains, and wheat germ
Lutein	Corn, egg
Selenium	Carrots, chicken, garlic, onions, oat meal, salmon, tuna, seafood, whole grains, wheat germ

5. Natural Antioxidants Influence on Human Health

Previous researches reported that human health is positively influenced by natural antioxidants. Disorders such as neuro and heart diseases, diabetes and cancer are among the major diseases that antioxidants have the potential to act against [59]. The use on

natural antioxidants been known for decades long before modern medicine and synthetic drugs. The capability to scavenge ROS and eventually, reducing oxidative stress is a well-known biological activity of natural antioxidants. Several evidence implied that natural antioxidants cellular effects might also be facilitated by their interactions with specific proteins essential for intracellular signaling pathways, their influence on epigenetic mechanisms and their modulation of the stomach microbiota [60-61]. [62] study investigated the role of alpha-lipoic acid (ALA), mitochondrial antioxidant operates as a coenzyme for pyruvate dehydrogenase and α -ketoglutarate dehydrogenase on kidney and heart parenchyma in hypertensive rats. Results of the study showed that ALA is highly effective in reducing levels of oxidized proteins.

In a study by [62] regarding DNA damage caused by oxidative stress and the effect of intake of natural antioxidants suggested that DNA stability could be promoted by natural antioxidants during aging. Furthermore, the potential of natural antioxidants to reduce neurodegeneration was also subjected to investigations. [63 and 64] researched the influence of polyphenols from extra-virgin olive oil against neurodegeneration.

Coumarins, another group of phenols that protect neuro system, can be found in medicinal plants such as *Cichorium intybus*, *Artemesia capillaris*, *Ceratostigma willmottianum* and *Citrus limonia*, was subjected to a research by [65]. Pruccoli's paper showed that esculetin (ESC) was the highly efficient in inhibiting and reducing ROS creation in neuronal SH-SY5Y cells.

In addition, Alzheimer's disease (AD), which cause memory loss for millions of people worldwide, was subjected to investigations regarding using natural antioxidants as a bioactive phytochemical compound that could have potential as anti-AD agents. In a study by [66], the effect of *Rosmarinus officinalis* essential oil was investigated and results showed that *Rosmarinus officinalis* essential oil prevented the anxiogenic-like effect of scopolamine based on the dose, and demonstrated a memory-enhancing ability and reduced acetylcholinesterase activity. In another research papers by [67, 68], the role of natural antioxidant in reducing neuro and diabetic diseases were investigated.

Moreover, the antioxidant mechanism that motivate upregulation of enzymes essential for the detox pathways were studied by [69, 70]. Results of these studies demonstrated that natural antioxidant's role in Nrf2 (NF-E2-related factor 2) signaling pathway activation, which regulates the antioxidants defense mechanism and improves the expression of antioxidants and detoxifying enzymes.

Another mitochondrial ubiquinone (CoQ10) antioxidant, which is a lipophilic molecule produced by a benzoquinone head conjugated to a side chain composed by 10 isoprene units, have an essential physiological role by transporting the electron chain and protecting cells against oxidative stress. It was shown that CoQ10 supplementation have the potential to reduce various cutaneous disorders even in low bioavailability [71].

In order to protect children from future hypertension, pregnant mothers are advised to take natural antioxidants supplements. In a study by [72], natural antioxidants function in the prenatal period and in infertility optimization was subjected to investigation. Results suggested a positive effect of antioxidant supplementation on the quality of in vitro embryos, in vitro oocytes maturation and on early development of embryonic.

Spices and cooking herbs containing polyphenolic and other biologically active compounds such as flavonoids, phenolic acids, essential oils, and lignans, made them a valuable supplier of natural antioxidants as stated by several publications [73-75]. In a review by [76], authors reported that antioxidants available naturally in spices have considerably superior biological activities and are actively used in preclinical, experimental and medicinal tests for the medications of diseases suggesting the possibility to develop new spice-based drugs.

6. Conclusion

Numerous studies and researches investigated antioxidants and their value for human health. Among these are natural antioxidants, especially plant-based antioxidants because of their abundance and variety. The use of herbs, spices, and plant constituents goes back to earliest eras in the preparation of traditional food as preservative, aroma, and flavors and are still used until current times. The information available on natural antioxidants opened the door for the treatment of many health disorders such as cancer, heart, and Alzheimer's disease due to their potential to act against inflammation, bacteria, viruses, aging, and cancer. The future embraces unlimited potential with the discovery of new understanding regarding the biology of natural antioxidants and free radicals and turning this understanding into practical applications for a better healthy life.

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