Chapter

Antioxidants Sources

Marjan Assefi, Kai-Uwe Lewandrowski, Sohila Nankali and Alireza Sharafshah

Abstract

AbstractsNatural antioxidants are abundant in food and medicinal plants. These natural antioxidants, particularly polyphenols and carotenoids, have numerous biological effects, including anti-inflammatory, anti-aging, anti-atherosclerosis, and anticancer properties. To examine potential cancer prevention agent sources and advance their utilization in useful food varieties, drugs, and food added substances, it is fundamental for separate cell reinforcements from food and restorative plants really and assess them suitably. This paper goes into great detail about the green extraction methods of natural antioxidants, the evaluation of antioxidant activity at the chemical and cellular levels, and their primary sources, which are food and medicinal plants.

Keywords: medicinal plants, cellular, prevention, antioxidants, natural, biological effects, anti cancer

1. Introduction

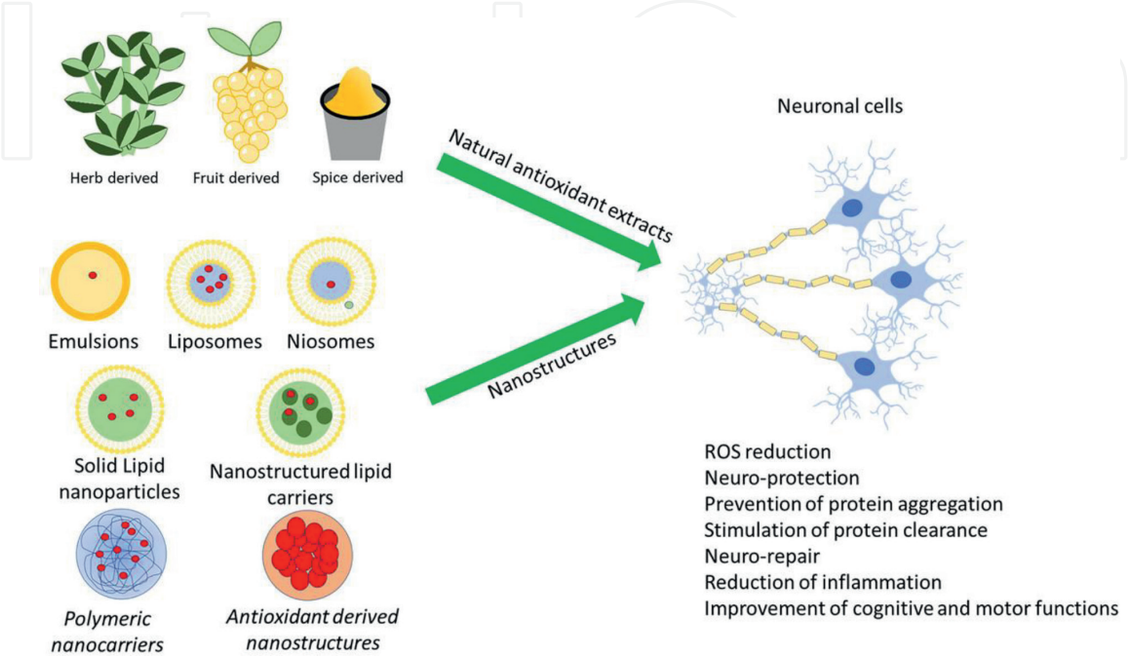
Reactive oxygen species (ROS) and reactive nitrogen species (RNS) like superoxide, hydroxyl, and nitric oxide can damage DNA and oxidize proteins and lipids in cells in a biological system. Typically, the body's cell reinforcement framework can dispose of these extremists, keeping the harmony among oxidation and against oxidation. However, environmental toxins, cigarette smoking, alcohol, radiation, or other forms of exposure can cause excessive ROS and RNS production [1]. These ROS and RNS can cause a variety of chronic and degenerative diseases because they upset the balance between oxidation and antioxidation. The increased intake of exogenous antioxidants would lessen the damage caused by oxidative stress by acting as free radical scavengers, singlet oxygen quenchers, and reducing agents. An oxidative chain reaction would not start or spread as a result of this [2, 3].

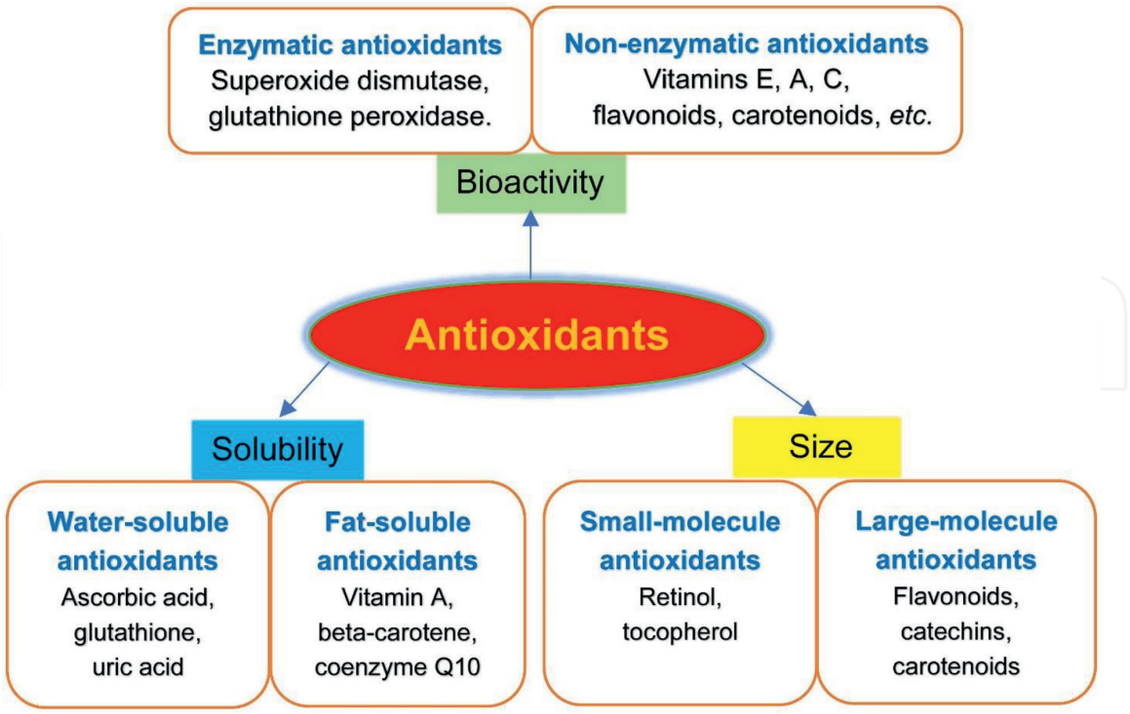
The majority of the exogenous antioxidants come from food and medicinal plants like mushrooms, beverages, flowers, spices, and traditional medicinal herbs. In addition, the industries that process agricultural by-products are potential significant natural antioxidant sources. Polyphenols (phenolic acids, flavonoids, anthocyanins, lignans, and stilbenes), carotenoids (xanthophylls, carotenes), and vitamins (vitamins E and C) are the primary natural antioxidants derived from plant materials. In general, these natural antioxidants, particularly polyphenols and carotenoids, have a wide range of biological effects, including anti-aging, anti-cancer, anti-inflammatory, and antibacterial effects [4].

Food science and nutrition are paying a lot of attention to the effective extraction methods of natural antioxidants, the appropriate evaluation of antioxidant activity, and the fact that their primary sources are food and medicinal plants. Ultrasound-assisted extraction, microwave-assisted extraction, enzyme-assisted extraction, pressurized liquid extraction, supercritical fluid extraction, high hydrostatic pressure extraction, pulsed electric field extraction, and high voltage electrical discharges extraction are just a few green non-conventional methods that have been developed to improve the efficiency with which antioxidant components are extracted from plant materials. Additionally, a variety of evaluation assays, such as the Trolox equivalence antioxidant capacity (TEAC) assay, the ferric ion reducing antioxidant power (FRAP) assay, the oxygen radical absorbance capacity (ORAC) assay, the inhibiting the oxidation of low-density lipoprotein (LDL) assay, the cellular antioxidant activity assay, and others, have been developed to further evaluate the antioxidant capacities of extracts from natural products, particularly those that These tests have been used to rank antioxidant plants and suggest the best foods for antioxidant consumption. The purpose of this review is to provide a summary of the methods used to extract natural antioxidants, methods used to evaluate antioxidant activity, and their primary sources, which are food and medicinal plants [5–7].

The type and concentration of the extraction solvent, the extraction temperature, the extraction time, and the extraction pH are just a few of the extraction factors that have a significant impact on the efficiency of the extraction. Antioxidants have been extracted from food and medicinal plants using a variety of solvents. The chemical nature and polarity of the antioxidant compounds to be extracted determine the solvent selection. The majority of the phenolics, flavanoids, and anthocyanins are antioxidants that dissolve in water. Extraction frequently makes use of polar and medium-polar solvents like water, ethanol, methanol, propanol, acetone, and their aqueous mixtures. Carotenoids are antioxidants that dissolve in lipids. For extraction, common organic solvents like mixtures of hexane with acetone, ethanol, and methanol or ethyl acetate with acetone, ethanol, and methanol have been used [8, 9].

Antioxidants can be extracted from food and medicinal plants using a variety of extraction methods, including conventional and non-conventional methods. The





most common conventional extraction methods are hot water bath, maceration, and Soxhlet extraction. These methods take a long time, use a lot of organic solvents, and have low extraction yields. Additionally, the long heating process in hot water bath and Soxhlet extraction may cause thermolabile compounds to break down [10]. Non-conventional techniques like ultrasound, microwave, pressurized liquid, enzyme hydrolysis, supercritical fluids, high hydrostatic pressure, pulsed electric field, and high voltage electrical discharges have been investigated for the purpose of obtaining antioxidants from plants in a way that is both energy efficient and economically sustainable.

2. Main resources of natural antioxidants

The TEAC assay, which measures antioxidants' capacity to scavenge free radicals, the FRAP assay directly measures antioxidants' reducing capacity, and the total phenols assay by FCR evaluates the phenolic contents of tested samples are the primary sources of natural antioxidants [11–13]. The combination of the TEAC, FRAP, and FCR methods is frequently utilized to evaluate the antioxidant activity in order to carry out in-depth research on various aspects of antioxidants. Numerous food and medicinal plants, such as fruits, vegetables, cereal grains, edible and wild flowers, macro-fungi, medicinal plants, spices, and so on, have been widely estimated to have antioxidant properties. [14] A combination of the results from the FRAP, TEAC, and FCR assays was used to identify the varieties with strong antioxidant properties. In general, these findings demonstrated that diverse categories had a wide range of antioxidant capacities. From 0.11 0.01 to 72.11 2.19 mol Fe(II)/g, 0.84 0.03 to 80.68 2.11 mol Trolox/g, and 11.88 0.11 to 585.52 18.59 mg GAE/100 g, respectively, the FRAP, TEAC, and FCR values of 62 fruits varied. 56 vegetables had FRAP, TEAC, and FCR values ranging from 2.69 to 60.9 mol Fe(II)/g, 6.93 to 33.63 mol Trolox/g, and 4.99 to 23.27 mg GAE/g, respectively. From 5.23 0.23 to 126.19 2.91 mol Fe(II)/g, 0.62 0.14 tso 30.03 1.10 mol trolox/g, and 1.35 0.15 to 9.47 0.48 mg GAE/g, respectively,

the FRAP, TEAC, and FCR values of 24 cereal grains varied. From 0.14 to 1844.85 mol Fe(II)/g, 0.99 to 1544.38 mol Trolox/g, and 0.19 to 101.33 mg GAE/g, respectively, the FRAP, TEAC, and FCR values of 223 medicinal plants varied. Clearly, medicinal plants had significantly higher antioxidant activities and total phenolic content than fruits, vegetables, and cereals among these varieties with strong antioxidant properties [11, 15, 16].

Moreover, the cancer prevention agent exercises of food and restorative plants have additionally been assessed by cell reinforcement action measures in light of various cell types. The 27 vegetables' cellular antioxidant activities ranged from not detected (tomato) to 41.9 6.2 mol of QE/100 g (beet). The 25 fruits' cellular antioxidant activities ranged from 3.15 0.21 mol of QE/100 g (banana) to 292 11 mol of QE/100 g (wild blueberry). In the two examinations, these outcomes showed that CAA values were fundamentally connected with absolute phenolic content. Surarit and others based on HL-60 cells, it was reported that the ethanolic bran extracts of 11 Thai red and purple and two non-pigmented rice varieties performed the following cellular antioxidant activities: non-pigmented rice followed by purple rice in the same order as red rice in terms of phenolic and flavonoid content in these rice extracts [17, 18].

Chemical assays cannot completely capture the sample's in vivo behavior when evaluating its antioxidant capacity. Antioxidants must be evaluated for their efficacy under more biologically relevant conditions. Although more expensive and time-consuming, animal models and human studies are more suitable for evaluation [19]. The cellular antioxidant activity (CAA) assay has been developed to evaluate antioxidant capacities as intermediate testing methods. The Dichlorofluorecin (DCFH) method is a common CAA assay that measures antioxidants' ability to prevent DCFH oxidation. In human hepatocarcinoma HepG2 cells, ABAP-generated peroxyl radicals easily convert DCFH that is trapped within the cells to fluorescent dichlorofluorescein (DCF). Fluorescence could be used to monitor DCF (exc = 485 nm, em = 538 nm). The antioxidant capacity of bioactive components is inversely proportional to the decrease in cellular fluorescence [20–23]. Human red blood cells, human endothelial EA.hy926, human colon cancer Caco-2 cells, human macrophage U937 cells, and mouse macrophage RAW264.7 cells have all been utilized for the CAA assay, with the exception of HepG2 cells. Additionally, a microfluidic cell chip-based CAA assay with arrayed microchannels has been developed to evaluate plant antioxidants. There are 48 distinct parallel array channels and 288 round cell culture micro chambers on the microfluidic chip. With this method, a multimode reader could simultaneously test eight groups of diverse samples at six distinct concentrations.

Tests of antioxidant enzyme expression, inhibition of pro-oxidant enzymes, and activation vs. repression of redox transcription factors are also included in the evaluation of antioxidant activity at the cellular level [15]. These tests are in addition to the ability to scavenge ROS/RNS. Caco-2 cells were used to test the antioxidant properties of the extracts made from five brown seaweeds. Both the activity of the antioxidant enzymes catalase (CAT) and superoxide dismutase (SOD) and the amount of glutathione (GSH) present were evaluated [24]. According to these cellular assays, *Pelvetia canaliculata* could exert its antioxidant capacity in Caco-2 cells primarily by preventing H_2O_2-mediated SOD depletion. In addition, the antioxidant enzyme activities of glutathione peroxidase (GPx) and glutathione reductase (GR) in three Argentine red wines were evaluated. Wine was found to have some protective effects on H_2O_2-exposed cells, which were attributed to the increased activity of the antioxidant enzymes GPx and GR. In addition, phenols (like curcumin) or food extracts (like blueberries) have been used to treat cultured cells, resulting in a suppression of NF-B

activation as an anti-oxidant response. Curcumin treatment reduced NF-B and activator protein-1 activation as well as IL-8 release in alveolar epithelial cells, according to a study. GSH levels and mRNA expression of the glutamylcysteine ligase catalytic subunit were also higher in treated cells than in untreated ones [25–27].

The ability of antioxidants to slow down the oxidation of 2,2′-azobis-2-methylpropanimidamide, dihydrochloride, (AAPH) or 2,2′-azobis(2-amidinopropane) dihydrochloride, dihydrochloride, (ABAP) is measured using the total radical trapping antioxidant potential (TRAP) assay [28–30]. The variation in the rate of the reaction is measured using fluorometry (ex = 495 nm and e When compared to the rate before the antioxidants were added, the reaction's rate of fluorescence decay slows after they were added [31, 32]. The lag phase duration in comparison to Trolox's lag phase serves as the basis for the quantification. The assumption that antioxidants exhibit a lag phase and that the length of the lag phase is positively correlated with antioxidant capacity underpins the use of the lag phase. However, the potential of antioxidants that play a role after the lag phase is completely ignored because not every antioxidant component possesses an obvious lag phase [33–35].

As a more physiologically relevant measure of antioxidant capacity, the inhibition of induced lipid autoxidation has been developed. Free radical initiator (Cu(II) or 2,2′-azobis(2-amidinopropane) dihydrochloride (AAPH)), substrate (linoleic acid or LDL), and antioxidants are typically present in the reaction solution. Cu(II) or AAPH causes linoleic acid autoxidation, or LDL. A UV spectrometer measures conjugated dienes' peroxidation at 234 nm for the lipid components. The reaction begins when a radical initiator is present, and the accumulation of conjugated diene oxides is indicated by an increase in absorbance at 234 nm. The reaction rate slows down after antioxidants are added until the antioxidant is used up. The lag time is measured during the period and used to evaluate antioxidant capacity [36, 37].

The use of a biologically relevant substrate, which makes the results relevant to oxidative reactions in vivo, is this method's main advantage over other in vitro assays. One of the major drawbacks of this method is the variability of the LDL samples, which can vary between donors because LDL is isolated from blood samples. As a result, it is challenging to develop this approach into a high-throughput antioxidant evaluation assay that is consistent and repeatable. The results, on the other hand, would be more reproducible if linoleic acid or its methyl ester was used as an oxidation substrate rather than LDL. However, in the presence of water, linoleic acid would form micelles, and since UV absorbance cannot directly monitor the progression of the reaction in micelles, the method's accuracy may be compromised [38–40].

2.1 Natural sources of polyphenols

Polyphenols, such as phenolic acids, flavonoids, lignans, and stilbenes, are found in a lot of food and medicinal plants. Examples of phenolic acids include cinnamic acid derivatives like p-coumaric, caffeic, and ferulic, as well as benzoic acid derivatives like gallic acid and hydroxybenzoic acids. The hydroxycinnamic acids are more prevalent in edible plants than the hydroxybenzoic acids [41, 42]. The hydroxycinnamic acids are found to be abundant in fruits like blueberries, kiwis, plums, cherries, and apples (0.5–2 g hydroxycinnamic acids/kg fresh wt). While ferulic acid is the most abundant phenolic acid in cereal grains and accounts for approximately 90% of the total polyphenol content of wheat grain, caffeineic acid is the most abundant phenolic acid and accounts for 75–100% of the total hydroxycinnamic acid content in

many fruits. Except for certain red fruits, black radish, and onions, edible plants typically contain very little hydroxybenzoic acid. They are not thought to be particularly nutritious due to their low content [43–45].

The majority of edible fruits and vegetables contain a lot of flavonoids. Flavonols, flavanones, catechins, flavones, anthocyanidins, and isoflavonoids are among its subclasses. Flavonoids come in a variety of forms and concentrations from various food sources. In edible plants, quercetin is typically the most abundant flavonol. Onion is the food with the most quercetin in it. Quercetin levels are relatively low in wine and tea. Kaempferol (broccoli), myricetin (berries), and isorhamnetin (onions) are additional flavonols. Citrus fruits are almost entirely devoid of flavanones. Oranges and mandarins contain the most hesperidin and narirutin flavonoids, while grapefruit contains the most naringin and narirutin flavonoids. Catechins as a rule exist as aglycones or esterified with gallic corrosive. Tea and red wine are the two foods that contain the most catechins [46–48]. Additionally, luteolin and apigenin are the most important flavones. Celery and red pepper are the primary sources for the diet. Anthocyanins like pelargonidin, cyanidin, and delphinidin are what give edible plants like plums, eggplant, and many berries their red, blue, or violet hues [49–51]. The isoflavonoids, for example, isoflavones genistein and daidzein, principally exist in vegetables. Soybean and soy products are the most abundant food source [52, 53].

Linseed, which contains low amounts of matairesinol and secoisolariciresinol (up to 3.7 g/kg dry wt), is the most abundant dietary source of lignans. These same lignans are also found in other algae, leguminous plants like lentils, cereals like wheat and triticale, fruit like pears and prunes, and certain vegetables like garlic, asparagus, and carrots. Resveratrol is a stilbene whose numerous bioactivities have been extensively studied. Resveratrol (0.3–7 mg aglycones/L and 15 mg glycosides/L) is abundant in red wine [54–56].

2.2 Natural sources of carotenoids

Natural pigments called carotenoids include -carotene, lycopene, lutein, and zeaxanthin. All beautiful palatable plants, particularly dim green and yellow-orange verdant, are the great wellsprings of carotenoids [57]. Carotenoids' absorption is primarily dependent on their preparation with oils or fats due to thesir lipid solubility. Among the carotenoids, −carotene is most frequently found in edible plants with the highest provitamin A activity, like acerola, mango, carrot, nuts, and oil palm [58, 59]. A type of red pigment is called lycopene. It almost only exists in the tissues of algae and vegetables. Tomato items like juices, soups, sauces, and ketchup, as well as their handling waste and strip are significant wellsprings of lycopene. The trans isomer accounts for the majority of the lycopene found in tomatoes (between 79 and 91%) [60–62]. The most prevalent xanthophylls found in green and dark leafy vegetables like lettuce, spinach, peas, and broccoli are lutein and zeaxanthin. Zeaxanthin, which accounts for 97.4% of all carotenoids, is also found in the red marine microalga *P. cruentum*.

3. Conclusion

In conclusion, the various nutritional functions and health benefits of antioxidants derived from food and medicinal plants have been the subject of increasing research. Natural antioxidant extraction and antioxidant activity assessment techniques, as well

as their primary sources from food and medicinal plants, are summarized in this review [63–65]. Due to their reduced extraction time, energy consumption, and use of harmful organic solvents, as well as their higher extraction yields for recovering antioxidant compounds from food and medicinal plants, the aforementioned non-conventional methods have the potential to replace or enhance existing extraction methods [66]. Despite this, the majority of them are not suitable for use in industrial settings due to the complicated installation procedures and high cost of the equipment. As a result, finding a balance between cost and energy will be a crucial area of study in the future. The future development trend would be the combination of multiple extraction technologies and the automated potential of these non-conventional extraction technologies to take advantage of the various extraction methods and minimize their disadvantages [67]. The determination of total polyphenolic content by FCR, scavenging free radical ability by TEAC, metal-reducing activity by FRAP, and a kind of cellular-based assay are all suggested for assessing the antioxidant activity of plant materials. Standardizing the operating conditions of the same analysis method and the expression of results is also recommended to make it possible to compare various samples and studies [68–70].

Author details

Marjan Assefi[1*], Kai-Uwe Lewandrowski[2], Sohila Nankali[3] and Alireza Sharafshah[4]

1 University of North Carolina at Greensboro, Greensboro, USA

2 Center for Advanced Spine Care of Southern Arizona, Tucson, USA

3 North Central University, USA

4 University of Isfahan, Isfahan, Iran

*Address all correspondence to: massefi@aggies.ncat.edu

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