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The antioxidant effect of certain fruit and vegetables: A review

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Abstract

There are innumerable fruits and vegetables which are consumed for their nutrients or for their medicinal purposes. In recent times these fruits and vegetables have been shown to possess valuable antioxidants of great nutritional and therapeutic values. Antioxidants are an inhibitor of the process of oxidation, even at relatively small concentration and thus have diverse physiological role in the body. Antioxidants can eliminate free radicals and other reactive oxygen and nitrogen species, and these reactive species contribute to most chronic diseases. Dietary plants contain variable chemical families and amounts of antioxidants. Vegetables provide the body, an added source of antioxidants to fight against free radicals. Without the necessary intake of healthy vegetables, free radicals can spread and eventually lead to various types of cancer. This review discusses about antioxidant effect of fruit and vegetables.

Keywords: Antioxidant effect, phenolic compounds, fruit, vegetables

Introduction

In January 2020, the world faced an outbreak of coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV 2). Evidence of high human-to-human transmissibility of SARS-CoV-2 has made social isolation the best preventive measure to avoid the spread of COVID-19. This pandemic is substantially affecting lifestyles, healthcare systems, and national and global economies. Social isolation is often an unpleasant experience that may have negative effects on mental health.

It has been suggested that, until quarantine ends, self-isolation is likely to cause psychological and emotional symptoms, 3 changes in mood and altered sleep or eating patterns^[4], worsening of chronic health conditions, weight gain, and increased use of alcohol, tobacco, or illegal drugs. Optimal nutrition is one of the main determinants of health that can improve well-being and mitigate the harmful health consequences associated with social distancing by helping to prevent or control most chronic diseases (eg, diabetes, hypertension, and excess bodyweight/obesity); aid in the regulation of sleep and mood; and prevent fatigue^[5, 6]. Nutritional modulation of the immune system is also important across the age spectrum. During early childhood, breastfeeding can provide protection against infections and respiratory diseases, as breast milk contains antibodies, enzymes, and hormones that can offer health benefits^[7]. In older adults, the group at most risk for COVID-19, changes in dietary habits lead to significant alterations in immunity and inflammation, termed immunosenescence and inflammaging.⁸ Some nutrients, such as omega-3 polyunsaturated fatty acids and probiotics, have been linked to anti-inflammatory responses and enhanced resistance to upper respiratory tract infection.

Now days, role of fruits and Vegetables are important sources of various vitamins, minerals, and fibres for humans. However, they differ in many aspects, including the contents of vitamins, minerals, and fibres as well as their antioxidant capacity. It is well known that fruits are rich in various antioxidants, including ascorbic acid, carotenoids, and phenolics. Some studies demonstrate that the antioxidants contained in certain fruits and Vegetables are bio available (Parashar *et al.*, 2008). Therefore, these fruits and vegetables can be considered as an ideal source of natural antioxidants. It is credible to speculate that increasing consumption of these fruits intentionally will increase the intake of natural antioxidants, which may provide an alternative in the intervention of the aging process by protecting against oxidative damage.

Various fruits may provide protection differently against oxidative stress since they are different in antioxidant capacity.

We hypothesize that fruits with high antioxidant capacity are more effective than those with low antioxidant capacity in reducing oxidative damage associated with the aging process. Fruits are rich in antioxidants that help in lowering incidence of degenerative diseases such as cancer, arthritis, arteriosclerosis, heart disease, inflammation, brain dysfunction and acceleration of the ageing process. Antioxidants are substances which when present at low concentration are able to prevent or delay oxidative damage of lipids, proteins and nucleic acids by reactive oxygen species. These reactive oxygen species mainly are reactive free radicals such as superoxide, hydroxyl, peroxy, alkoxy and non-radicals such as hydrogen peroxide, hypochlorous. They scavenge radicals by inhibiting initiation and breaking chain propagation or suppressing formation of free radicals by binding to the metal ions, reducing hydrogen peroxide, and quenching superoxide and singlet oxygen [1].

The most abundant antioxidants in fruits are polyphenols, Vitamin C, Vitamins A, B and E whereas, carotenoids are present to a lesser extent in some fruits. These polyphenols, most of which are flavonoids, are present mainly in ester and glycoside forms [2]. The three major groups: vitamins, especially vitamin C; phenolics; and carotenoids, especially β -carotene is responsible for the defensive effect of antioxidants in fruits and vegetables. Vitamin C and phenolics are known as hydrophilic antioxidants, and carotenoids are known as lipophilic antioxidants. A number of researches have been made in the antioxidant capacity of fruits.

Guava

It is one of the most gregarious of fruit trees, the guava, *Psidium guajava* L belongs to the myrtle family (Myrtaceae). Almost universally known by its common English name or its equivalent in other languages the guava fruit, usually 4 to 12 centimetres (1.6 to 4.7in) long, are round or oval depending on the species. The outer skin may be rough, usually with a bitter taste, or soft and sweet. Guava is usually green before maturity, but becomes yellow, maroon, or green when ripe. The fruit generally have a pronounced and typical fragrance, similar to lemon rind but less sharp. Guava pulp may be sweet or sour, varying between off-white ("white" guavas) to deep pink ("red" guavas), with the seeds in the central pulp of variable number and hardness, depending on species. Guava is a rich source of minerals like iron, calcium, and phosphorus and has many vitamins like ascorbic acid, pantothenic acid, vitamin A, carotenoids such as β -carotene and lycopene, and niacin. Single common guava (*P. guajava*) fruit contains about four times the amount of vitamin C as an orange [3]. The fruit has also been shown to contain saponin combined with oleanolic acid. Morin-3-O- α -L-lyxopyranoside and morin-3-O- α -L-arabopyranoside and flavonoids, phenolic compounds such as ellagic acid, anthocyanin, guaijavarin, and quercetin are also reported [3].

Chemical analysis of guava plant extract has revealed the presence of anti-microbial compounds like tannins, phenol triterpenes, flavonoids, guajivolic acid, guajavanoic acid, linolenic acid, linoleic acid, guavacoumaric acid, galaturonic acid, asphaltic acid, benzaldehyde, essential oils, saponins, carotenoid, cectin, fibre, fatty acids and a high content of vitamins C and A in its fruit [4]. The hydrophilic and lipophilic antioxidant properties of guava fruits were reported by Thaipong [5]. It was concluded from their

investigation that both white and pink flesh guavas fruits had high hydrophilic antioxidant activity and compounds for phenolic and vitamin C pointed that regular consumption of guava might be beneficial to health. The hydrophilic antioxidant activity, the major activity, had high correlations with both total phenolic and vitamin C thus showing that the use of the total phenolic or vitamin C content to determine antioxidant activity level in guava fruit was executable.

Phenolic and vitamin C are the better contributors to the antioxidant activity of guava fruits, compared to the contribution of carotenoids. The guava possesses primary antioxidant potential. These primary antioxidants scavenge radicals to inhibit chain initiation and break chain propagation which is attributed to its high total phenolic compounds. Thus the guava fruit can be harnessed either its protective or preventive roles against diseases arising from oxidative stress.

Papaya

The papaya, scientific name *Carica papaya* belongs to the genus *Carica* in the myrtle family (Caricaceae). The papaya is a native plant of Central America but is widespread throughout tropical Africa. It develops from syncarpous superior ovary with parietal placentation. It is most commonly known as pawpaw. This highly nutritious papaya fruit has been reported to provide 26 calories, 92.1 g H₂O, 1.0 g protein, 0.1 g fat, 6.2 g total carbohydrate, 0.9 g fibre and 0.6 g ash. USDA National Nutrient database recorded an orange-fleshed papaya (per 100 g) contained 39 calories, 88.8 g H₂O, 0.61 g protein, 0.14 g fat, 9.81 g total carbohydrate, 1.8 g fibre, 0.61 g ash. Additionally, Oyoyede [7] tested the chemical profile of unripe pulp of *carica papaya* and reported that the papaya fruit was very rich in carbohydrate (42.28% starch, 15.15% sugar) but low levels of fat. The fruit also contains increased levels of vitamin C (51.2 mg/100g), vitamin A precursors including β -carotene (232.3 μ g/100g), and β -cryptoxanthin (594.3 μ g/100g), as well as magnesium (19.2-32.7 mg/100g), which has been reported by Wall [8]. The fruit also contains papain which is a major component of papaya latex and is widely applied for meat tenderisation. In recent years, papain and other endopeptidases have been proven to have several medical benefits, such as defibrinating wounds and treatment of oedemas [9].

Tropical papaya is used to treat paediatric burns due to its proteolytic enzymes. Exception of papain, other endopeptidases, such as leukopapain and chymopapain, is also able to facilitate wound cleaning, promoting growth and improving the quality of the scar. The variations in the papaya fruit are due to various cultivars. Though *C. papaya* is an edible and flavourful fruit, it is also used for its medicinal benefits like treatment for numerous maladies, ranging from gastrointestinal disorders to asthma and sexually transmitted diseases. Often, the plant is boiled along with herbal adjuvants in order to expel worms [10]. The leaves have also been used in infusions to treat internal parasites [11]. Along with its use as an antihelminthic, the whole fruit of *C. papaya* has also been boiled and used as an infusion in order to treat stomach ulcers. In Madagascar, a tea made of from *C. papaya* leaves has also been used in order to treat gastric ulcers as well as general gastric discomfort [12]. In the Congolese region of Africa, a decoction made of the ripe seeds is said to be a very effective treatment of dysentery [13].

C. papaya is also effective in treatment of malaria. Along with the leaves of *Azadirachta indica*, *C. papaya* has been used as a steam treatment for malaria [11]. The fruit has also been used as a popular hepatoprotective agent. In cases of jaundice and hepatitis, immature fruit is either eaten or used in a decoction [10]. Most studies reported that papaya fruits and its leaves had high antioxidant capacity due to their high contents of vitamin B (in leaves), vitamin C, E (in fruits), and carotenoids [6, 13, 14].

Watermelon

Watermelon (*Citrullus lanatus*) is a vine-like flowering plant native to southern Africa. The watermelon fruit usually considered a type of melon has a smooth exterior rind (green, yellow and sometimes white) and a juicy, sweet interior flesh usually deep red to pink but sometimes orange, yellow and even green if not ripe. Water melon rinds are also edible but are mostly avoided due their unpleasant flavour.

Water melon is a good source of amino acid citrulline, vitamin A, vitamin C, the antioxidant lycopene, Beta carotene and potassium. Cucurbitacin has diuretic and purgative properties. The fruit has but few medicinal uses. Bitter forms are used in Senegal as a drastic purge and are considered poisonous [16]. Some other ethno-medicinal uses of the fruit include diuretic, purgative, remedy for urinary conditions suggestive of gravel and stone in the bladder, gonorrhoea and leucorrhoea in women [17, 18]. Lycopene and citrulline have been shown to be present in this fruit and are helpful in preventing some chronic diseases [19]. The amount of lycopene in watermelon is highly variable, but is generally more than that of tomato. Citrulline is present in all parts of the fruit [20]. Lycopene was found to be relatively stable in fresh cut watermelon, and could increase slightly in whole fruit held at room temperature [21]. Seedless watermelon generally has more lycopene than seeded types, and lycopene present in red fleshed fruit, with small amounts in orange fleshed watermelon, and none in yellow fleshed types. Lycopene has been extensively studied for its antioxidant and cancer-preventing properties. Lycopene has been repeatedly studied in humans and found to be protective against a growing list of cancers; these cancers now include prostate cancer, breast cancer, endometrial cancer, lung cancer and colorectal cancers [22, 23].

The antioxidant function of lycopene helps to protect cells and other structures in the body from oxygen damage. Protection of DNA (our genetic material) inside of white blood cells has also been shown to be an antioxidant role of lycopene [24]. The amino acid citrulline in watermelon is a known stimulator of nitric oxide. Nitric oxide is known to relax and expand blood vessels much like the erectile dysfunction drug Viagra and may increase libido [25]. The health benefit of watermelon fruit is associated with its powerful antioxidant properties as found in vitamin A, lycopene and beta carotene which help to neutralize free radicals hence can be use in the prevention of diseases associated with oxidative stress such as diabetes, asthma, atherosclerosis.

Pomegranate

The Pomegranate, botanical name *Punica granatum*, is a fruit-bearing deciduous shrub or small tree growing between 5–8 meters (16–26 ft) tall. The pomegranate is widely considered to have originated in the vicinity of Iran and has

been cultivated since ancient times [29]. Today, it is widely cultivated throughout the Mediterranean region of southern Europe, the Middle East and Caucasus region, northern Africa and tropical Africa, the Indian subcontinent and the drier parts of southeast Asia [29]. The pomegranate can be made into juice or the seeds can be consumed as food. One pomegranate fruit contains around 40% of an adult's recommended daily requirement of vitamin C and is high in polyphenol compounds which have been suggested to be involved in many diseases. Pomegranate has also been used as an antihelminthic and antidiarrheal agent.

The *Punica granatum* leaves are opposite or sub-opposite, glossy, narrow oblong, entire, 3–7 cm long and 2 cm broad. The flowers are bright red, 3 cm in diameter, with four to five petals (often more on cultivated plants). Pomegranates are widely acknowledged for their antioxidant properties which are more than other fruits items. Among them are blueberry, cranberry, and red wine and green tea which is recommended by doctors to all of their patients.

The pomegranate plant contains alkaloids, mannite, ellagic acid, and gallic acid, and the bark and rind contain various tannins having properties such as being water soluble. The polyphenols in pomegranate are assumed to provide the anti-oxidant activity and protect low-density lipoprotein (LDL) against cell-mediated oxidation directly by interaction with the lipoprotein and indirectly by accumulation in arterial macrophages hence have antiatherosclerotic activity. The inner and outer rinds of the fruit contain more polyphenols than the seeds and juice. In addition, pomegranate juice may cause antihypertensive effects by decreasing angiotensin-converting enzyme (ACE) activity. Atherosclerosis has been proven to retard due to the antioxidants the pomegranate juice provides.

Tomato

Tomatoes, one of the most produced and consumed vegetables worldwide, are a rich source of lycopene, β -carotene, folate, potassium, vitamin C (ascorbic acid), chlorogenic acid, flavonoids, rutin, plastoquinones, phenolics, tocopherol (vitamin E) and xanthophylls [28-32]. Vitamin C is considered an excellent antioxidant because it donates electrons for enzymes, or other compounds that are oxidants. Tomatoes are relatively low in beta-carotene, but high in lycopene, an active antioxidant agent with no vitamin A activity [33].

Lycopene is an interesting antioxidant because it is fairly stable to storage and cooking, and thus, is present in the cooked tomatoes that are consumed frequently, and account in part for the lower heart disease and cancer risk [28]. In addition, many epidemiological studies have suggested that the regular consumption of tomatoes may lead to a decreased incidence cardiovascular disease incidence [34, 35], and reduced risk of breast, colon, lung, and prostate cancers [31].

Chilli and Sweet Pepper

Pepper is an important source of nutrients in the human diet, and an excellent source of vitamins A, C and E, as well as neutral and acidic phenolic antioxidants important in plant defense responses [36, 37]. Two fractions of phenolics, flavonoids (with phenolic acids) and capsaicinoids isolated from the pericarp of pepper fruit showed antioxidant activity [38].

Levels of these compounds can vary by genotype and maturity, and are influenced by growing conditions and losses after processing. Generally, the concentration of carotenoids, ascorbic acid, flavonoids, phenolic acids, and other chemical constituent increases as the peppers reach maturity, whereas the level of lutein declines [37]. Provitamin A increases as colour develops in most cultivars, except for yellow varieties, and brown peppers have the highest provitamin A activity compared to other coloured peppers [39]. Coloured pepper varieties seem to be good sources of antioxidant, with the high carotenoid content found in mature stages [40].

Potato

Ascorbic acid contained in potato tubers attracts attention, as a significant source of vitamin C in human nutrition. Marabel variety of potato has the highest ascorbic content (207.2 mg/kg), and exceeded other seven varieties by 15-49% [41]. Ascorbic acid concentrations varied between 11 and 30 mg per 100 g fresh weight in North American varieties and breeding lines of potato [42].

Bulb and Root Crops

Aerial parts (leaves and stem) of radish (*Raphanus sativus*), which are usually discarded, possesses potent antioxidant and radical scavenging activity, as measured by standard antioxidant assays. HPLC identification of polyphenolics indicated the presence of catechin, protocatechuic acid, syringic acid, vanillic acid, ferulic acid, sinapic acid, o-coumaric acid, myricetin and quercetin in leaves and stem. Leaves and stem of radish had total polyphenolic content of 86.16 and 78.77 mg/g dry extract, respectively. Often under-utilized part of this vegetable thus possesses considerable amount of polyphenolics. Hence, it should be regarded as a potential source of natural antioxidants, and could be effectively employed as an ingredient in health, or in functional food [43].

Carrots are high in fibers, carotenoids, vitamins C and E, and phenolics such as coumaric, chlorogenic and caffeic acids [44]. Water-soluble anthocyanin obtained from the carrot also possesses antioxidant properties. Drinking carrot juice may protect the cardiovascular system by increasing total antioxidant status, and by decreasing lipid peroxidation [45]. Water soluble antioxidant capacities of carrot juices can be increased by thermal treatment and maintained by high pressure treatment [46].

In addition, bulb crops such as onion and garlic contain antioxidants that provide additional nutritional elements in areas where such foods are consumed frequently, such as Eastern Europe, the Mediterranean region, and in parts of the western world [27]. Among the frequently consumed raw vegetables, the highest level of the antioxidant activity were found in the red onion, followed by white onion=yellow onion>garlic, in that order [47].

Cruciferous Vegetables

Vegetables belonging to the *Brassicaceae* (*Cruciferae*) family are rich in polyphenols, flavonoids and glucosinolates, and their hydrolysis products, which have antibacterial, antioxidant and anticancer properties [48]. Brassica vegetables provide a large group of glucosinolates, which according to Plumb *et al.* [49] possess rather low antioxidant activity, but the products of their hydrolysis can protect against cancer.

Generally, among Brassica vegetables, white cabbage is the poorest source of vitamin C. Red pigmentation of red cabbage is caused by anthocyanins, which belong to flavonoids. Total carotenoid contents of Brussels sprouts, broccoli, red cabbage and white cabbage are 6.1, 1.6, 0.43 and 0.26 mg/100 g, respectively. Lutein and β -carotene are the dominant carotenoids in cruciferous vegetables. Brassica vegetables also contain cryptoxanthin, neoxanthin and violaxanthin, but cryptoxanthin is present only in broccoli (0.024 mg/100 g) [50]. A study on the variation in the antioxidant potential of green cabbage grown under nutritional soil supplements derived from agricultural and food processing sources found that the application of nutritional soil supplements results in increase in the antioxidant activity [51].

Green Leafy Vegetables

Green leafy vegetables are rich sources of antioxidant vitamins [52]. The ascorbic acid, total carotene, β -carotene and total phenolic content of the green leafy vegetables, *viz.* *Amaranthus* sp., *Centella asiatica*, *Murraya koenigii* and *Trigonella foenum graecum*, ranges from 15.18-101.36, 34.78-64.51, 4.23-8.84 and 150.0-387.50 mg/100 g, respectively, with antioxidant activity highest in *Murraya koenigii*, and least in *Centella asiatica* [53].

Lettuce has an effective antioxidant and other health-promoting properties. Among various types of lettuce commonly grown, leaf-type is most abundant in health-promoting phytochemicals [54]. Lettuce cultivar 'Red Sails', which has loose red foliage, is generally higher in total phenolic concentration and antioxidant capacity. 'Red Sails' also contains higher amount of major phenolic compound, chlorogenic acid [55].

Drumstick

Drumstick (*Moringa oleifera*) is used in Indian traditional medicine for a wide range of ailments. Both mature and tender leaves of *Moringa oleifera* have potent antioxidant activity against free radicals, to prevent oxidative damage to major biomolecules, and afford significant protection against oxidative damage [57].

Leguminous Vegetables

The antioxidant properties of cowpea (*Vigna unguiculata*) and African yam bean (*Sphenostylis sternocarpa*) were assessed with regard to their Vitamin C, total phenol and phytate content, as well as antioxidant activity, as typified by their reducing power and free radical scavenging ability. The Cowpea and African yam bean could be considered as a functional food due to their relatively higher antioxidant activity (free radical scavenging ability and redox potential), attributable to total phenol content [58].

Vegetables like daikon sprout, spinach and onion show high antioxidant activity against different reactive oxygen species and reactive nitrogen species, while broccoli, cabbage and Chinese cabbage show high antioxidant activity against hypochlorite ion [59]. Raw and fresh vegetables exhibit most consistent protection against cancer, with over 85% of studies finding an inverse association. Findings are consistent for lettuce, leafy green and cruciferous vegetables, allium, tomatoes and carrots, with about 70% of studies reporting a protective role against cancer. More than 60% of studies on other vegetables and fruits found a protective effect against total cancer risk. Only about 40%

of studies found some protection by legumes and potatoes^[60, 61]. β -carotene, vitamin E and calcium shows a significant inverse relation with breast cancer risk^[60].

Conclusion

Antioxidants are the essential source that we have to take with our fruits. Though some foods have more nutrients, Fruits and vegetables are the best source of antioxidants. The antioxidant activity can be depending on several factors such as maturity stage, climate, species etc. Therefore, there is a high potential for the use of fruits and vegetables as a health promoting and disease preventing source. The general recommendation is to consume a diet based predominantly on fresh foods such as fruits, vegetables, whole grains, low-fat dairy sources, and healthy fats (olive oil and fish oil) and to limit intakes of sugary drinks and processed foods high in calories and salt. Dietary supplements (i.e, vitamins C and D, zinc, and selenium) should be administered to individuals with, or at risk of, respiratory viral infections or in whom deficiency is detected.

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