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Different Antioxidants in Fruits and Vegetables for Human Health

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ABSTRACT

Antioxidants are nutrients in food that protect cells from damage from free radicals. Fruits and vegetables are the rich sources of antioxidants which help to prevent cardiovascular disease and some chronic and degenerative diseases associated with oxidative damage. Reactive oxygen species (ROS) are accumulated in cell because of imbalance in production. ROS can cause severe damage to cell which sometimes leads to the death of the cell. Antioxidants which present in different fruits and vegetables have capacity to fight against these ROS. They improve immune function and lower the risk for infection, cardiovascular disease, and cancer. The colours of fruits and vegetables are clues about the types of nutrients they provide. To get a variety of nutrients, eat a variety of colours. Fruits and vegetables contain antioxidants like Vitamin A, Vitamin C, Vitamin E, Anthocyanins, β-carotene, Catechins, Ellagic acid, Lutein, Lycopene, Resveratrol. Antioxidants are substance which can defend the human body from free radicals and reactive oxygen species (ROS) induced chronic diseases.vegetables are rich source of antioxidant. Functionally, it scavenges the free radical formed during the oxidative stress. This free radical damages the cell and their constituents. Consequently, it leads to chronic heart disease and ageing related problem. To reduce the health related problem, crop like cauliflower should consumed in appropriate manner in daily dietary food.

Key words: *Antioxidants, Nutrients, Reactive oxygen, Lutein, Lycopene.*

INTRODUCTION

Imbalance in the production of reactive oxygen species causes negative cellular alterations is known as oxidative damage, which is caused by several molecules[14]. ROS are partially reduced forms of oxygen such as singlet oxygen, hydrogen peroxide (H_2O_2), superoxide ($O_2^{-\bullet}$) or hydroxyl radical ($OH^{\bullet}$) [5]. ROS inhibit water channel and transporter proteins; enhance lipid peroxidation; alters membrane fluidity, stability and structure; inhibit membrane dependent processes such as electron flow in chloroplast and mitochondria; damage nucleic acids and proteins. From a biological perspective, an antioxidant is considered as any compound able to oppose cellular oxidation. Antioxidants are nutrients in food that protect cells from damage from free radicals.

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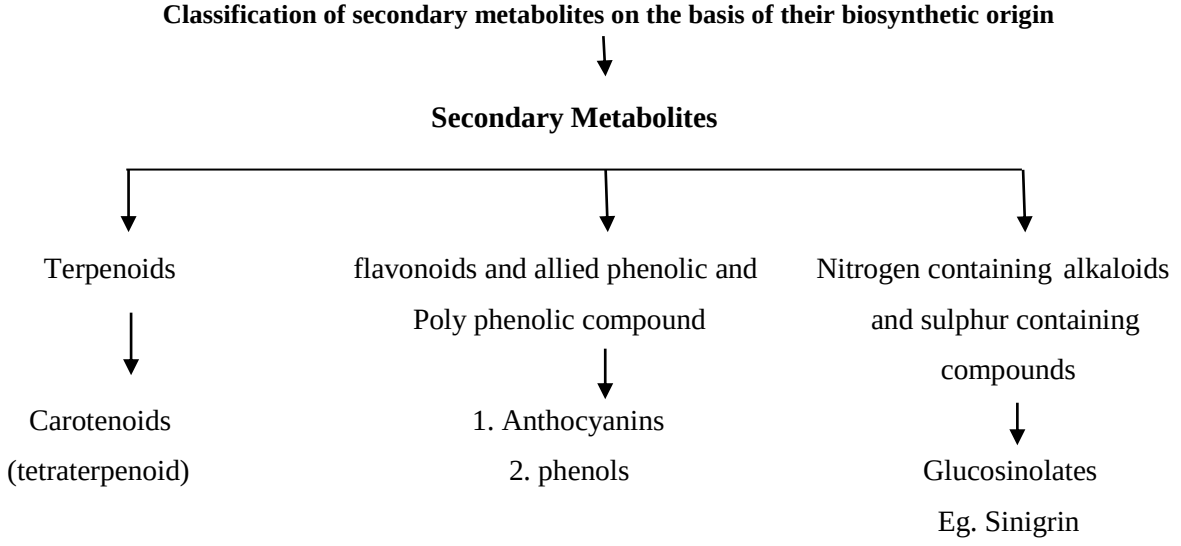
Fruits and vegetables are the rich sources of antioxidants which help to prevent cardiovascular disease and some chronic and degenerative diseases associated with oxidative damage[3]. Nothing new to introduce world famous vegetable named cauliflower (Brassica oleracea var botrytis). Apart from rich source of mineral and vitamins, cauliflower is famous for its phytochemicals compound namely carotenoids, phenols, flavonoids, and glucosinolates[2,18]. Not only in India, cauliflower is an important vegetable grown all over the world and has a wide variety of uses directly as a vegetable or as an ingredient in salads, soups, and so forth. The Free radical (FR) reaction occurs in human body and food systems. In the form of reactive oxygen species (ROS) and nitrogen species, the free radicals are formed. Free radicals are the integral part of normal physiological process. However, when the concentration becomes higher than the normal, the condition becomes critical leading to injury and death may occur. The over production of FR occurs due to oxidative stress brought about by an imbalance of the bodily antioxidant defense system or free radical formation.

Antioxidants are substance which can defend the human body from free radicals and reactive oxygen species (ROS) induced chronic diseases. Antioxidants are classified into two groups such as enzymatic and non-enzymatic[20]. Enzymatic antioxidants comprise superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase, produced endogenously in human systems and under normal conditions they are defense against the free radicals and ROS. Though, antioxidant enzymes are weakened against radicals during the severe disease conditions. Therefore, the external sources of dietary antioxidants are required to strengthen the human defense system. Polyphenols, carotenoids, vitamins and minerals are Non enzymatic antioxidants found rich in fruits and vegetables. Dietary antioxidants are believed to be the effective nutrients in the prevention of oxidative stress related diseases[10]. The oxidative stress occurs when the generation of reactive oxygen species (ROS) in a system exceeds the system's ability to neutralize and eliminate them. The ROS can lead to damage of cellular lipids, proteins or DNA, impairing their normal body function[6]. Brassica crops have been related to the reduction of the risk ofchronic diseases including cardiovascular diseases and cancer[7]. Antioxidants are present in all plant organs and include ascorbic acid, carotenoids, vitamin E and phenolic compounds, among others[13] (Fig. 1).



The 30-40% of cancers is directly connected to improper diet and related factors (Czapski, 2009). Epidemiological studies showed positive association between ingestion of fruits and vegetables and reducedmortality from cancers, heart disease and other degenerative diseases. The major antioxidants available in cauliflower are vitamins C and E, carotenoids, and phenolic compounds, especially flavonoids.

Classification of antioxidant

Water soluble antioxidant

1. Vitamin C
2. Phenolic compounds

Lipid soluble antioxidant

1. Carotenoid
2. And vitamin E

Ascorbic acid

Vitamin C is water-soluble antioxidant. It acts as an enzyme cofactor, a radical scavenger, and as a donor/acceptor in electron transport at the plasma membrane. Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate α-tocopherol.

Flavonoids (Phenolic compound)

Flavonoids are a group of polyphenoic compound, present in most plant tissue and often in vacuoles. They are present in high concentrations in the epidermis of leaves and fruits and have important and varied roles as secondary metabolites, being involved in processes like UV protection, pigmentation, stimulation of nitrogen-fixing nodules and disease resistance. The antioxidant ability of flavonoids and phenolic acids is related to the number and position of hydroxyl groups in the molecule. It produced in the plant via the shikimic acid pathway. Quercetin, Kaempferol, Isorhamnetin, Cyanidin are the main flavonoid found in cauliflower.

Carotenoids

Carotenoids are color compound, lipid soluble antioxidant, present in small quantity in cauliflower. Carotenoids (carotenes and xanthophyll) are red, orange and yellow pigment found in all cole crops. Due to conjugated double bonds carotenoid have both radical scavengers and quenchers of singlet oxygen activity. Lutein and b-carotene are the dominant carotenoids in cruciferous vegetables.

Vitamin E

In addition to carotenoids, Vitamin E also belongs to lipid soluble antioxidant whose effect is mainly due to α-tocopherol in brassica vegetable with the exception cauliflower having predominant of ϒ-tocopherol. The predominant reaction responsible for tocopherol antioxidant activity is hydrogen atom donation, where a tocopheroxyl radical is formed. It helped in protection to coronary heart disease

Glucosinolates

Glucosinolates are sulphur containing secondary metabolites, which is hydrophilic, anionic, non-volatile as well as non-toxic substance. It is synthesized on the pod wall of cauliflower[12] from amino acid (methionine) and sugar. Upon the hydrolysis it gives characteristic flavor to cauliflower. Glucosinolates are act as an antioxidant. It enhances DNA repair, serve to prevent carcinogenesis in animal by regulating the cell cycle and stimulating apoptosis. However, it have beneficial effect on animal health, an enlargement of thyroid has been found leads to goiter, a drawback of high consumption of glucosinolates in human.

Table – Antioxidant and their content in Vagitables

Antioxidant	Content	References
Vitamin C	40-80 mg/100g edible portion	Podsedek 2007
Flavonoid	267.21 mg/100 gon dry weight basis	Ahmed and Ali 2013
Carotenoids (β)	0.07–0.08 mg/100 g edible portion	Podsedek 2007
Vitamin E	0.35 mg/100 g edible portion	Podsedek 2007
Glucosinolate	5.26-8.26 µmol/g dry matter	Kapusta-Duch *et al.* 2016

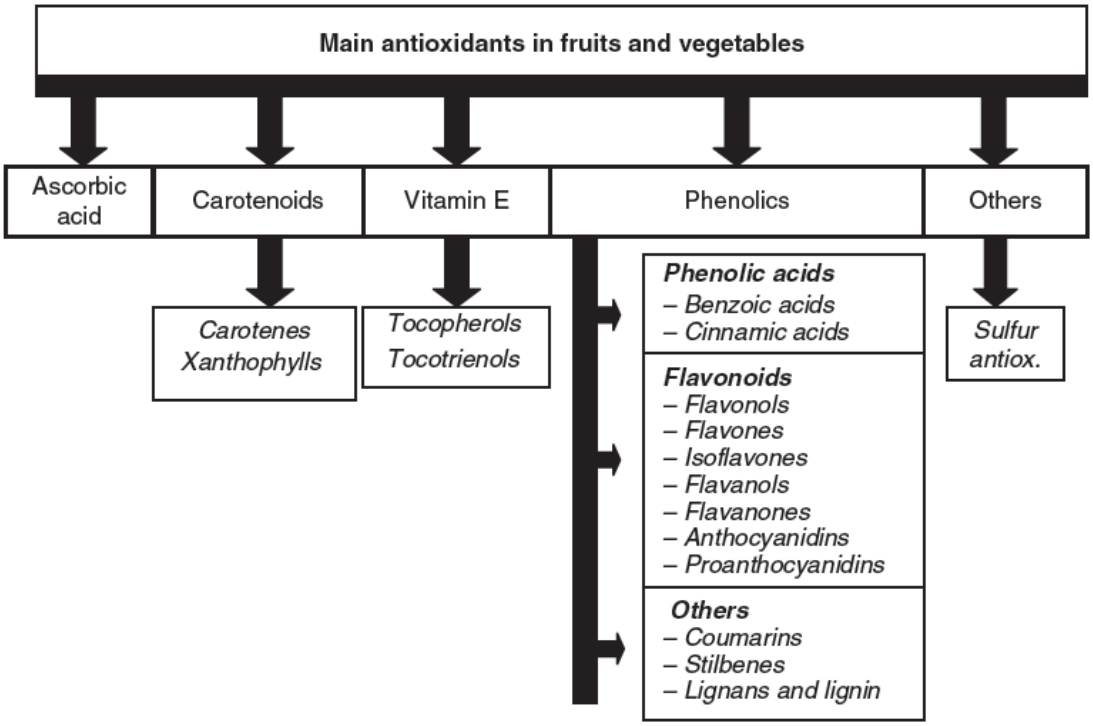


Fig. 2: Classification of different antioxidants present in fruits and vegetables

Eating a diet that includes a variety of fresh, deeply coloured fruits and vegetables, such as broccoli, spinach, tomatoes, sweet peppers, carrots, mangoes, kiwi, berries and cantaloupe and nuts, is the safest and most effective way to boost your antioxidant supply and reap the health benefits these substances may convey.

1. Ascorbic acid

Ascorbic acid (AsA) and its first oxidation product dehydroascorbic acid considered as vitamin C. AsA is a water soluble carbohydrate-derived compound showing antioxidant and acidic properties due to the presence of a 2,3-enediol moiety. Humans and a few other species are not able to synthesize AsA. Plants synthesize AsA which is one of the most important compounds for human nutrition present in fruits and vegetables. The role of AsA in disease prevention has been associated with its capacity to neutralize ROS.

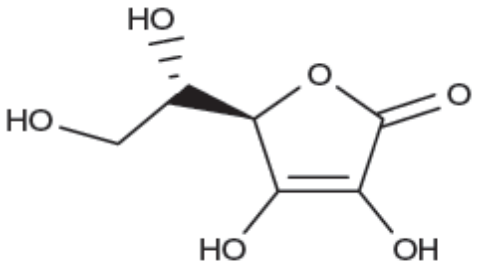


Fig. 2: Structure of Ascorbic acid, a major antioxidant in fruits and vegetables

2. Carotenoids

Fruits and vegetables are the main sources of carotenoids in the diet[15]. The presence of conjugated double bonds in carotenoids has a main role in determining their antioxidant properties[17]. In the last few years, carotenoids have received great attention due to their antioxidant properties and potential to prevent some diseases. α-carotene, β-carotene, lycopene, lutein, violaxanthin and zeaxanthin are different carotenoids. Vegetables (carrot, pumpkin, squashes) and fruits (mango, papaya, citrus, apricot and watermelon) are the rich source of carotenoids. Cancers of the mouth,

pharynx, esophagus, stomach, colon and rectum can be prevented by lycopene and lutein may help decrease your risk of macular degeneration.

3. Tocopherols and tocotrienols

These include the fat-soluble compounds grouped as vitamin E, characterized by a high antioxidant capacity. They can be in eight different forms because of the number and position of methyl group in aromatic ring. Vitamin E deficiency results in stunted growth. In general, vitamin E levels are more abundant in oily seeds, olives, nuts, peanuts, avocados and almonds. Even though the levels of tocopherol in broccoli and leafy vegetables are lower than in fat-rich products, they are good sources compared to other fruits and vegetables. Vitamin E is highly susceptible to oxidation during storage and processing. It may helps to prevent the oxidation of LDL or "bad" cholesterol which contributes to plaque build-up in the arteries.

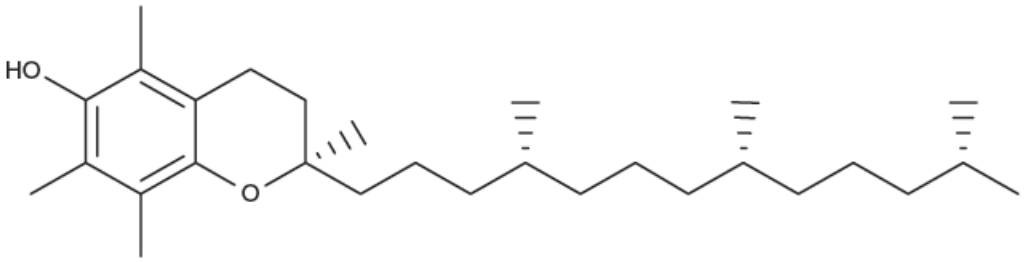


Fig. 3: Structure of tocopherol

4. Phenolic compounds

This group encompasses a great diversity of compounds derived from the aromatic amino acids phenylalanine and tyrosine. They are generally present in low concentrations, but in certain cases, such as in blueberry, they can reach levels of more than 0.1%. In general, they also accumulate in the peel more than in the pulp of fruits. The general characteristic of the compounds within this group is to have aromatic rings with variable degrees of hydroxylation[14]. Phenolic compounds are easily oxidized to quinones. A large number of phenolic compounds have been identified in plants[19]. They have been subdivided into different subclasses, such as phenolic acids, flavonoids and other compounds (e.g. lignans, stilbenes, tannins, coumarins and lignin).

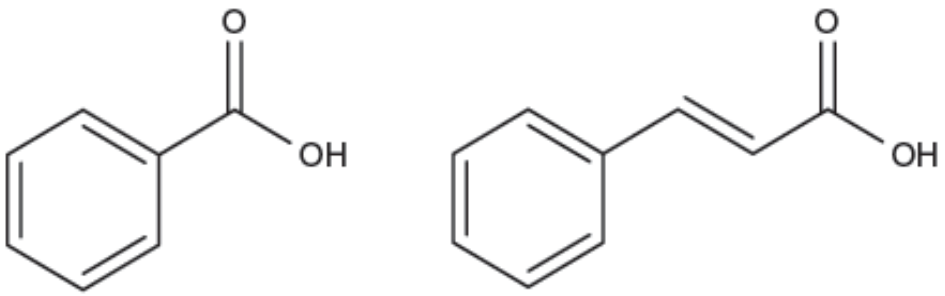


Fig. 4: Structure of benzoic acid (left) and cinnamic acid (right), precursors of the two main classes of phenolic acids present in fruits and vegetables

Phenolic acids

Phenolic acids include derivatives of benzoic and cinnamic acid. The most common benzoic acid derivatives are *p* -hydroxybenzoic, vanillic, syringic and gallic acid, while common cinnamic acid derivatives include *p*-coumaric, caffeic, ferulic and sinapic acid. Caffeic acid is the most abundant phenolic acid in several fruits such as berries[14]. The contribution of each of the phenolic compounds to the antioxidant capacity depends on their structure. For instance, the number of hydroxyls present in the molecule can increase the antioxidant capacity.

Flavonoids

Flavonoids represent a large group of phenolic compounds with two aromatic rings in their structure that are associated together by a 3C-oxygenated heterocycle. Phenolic compounds are usually present as glycosides, which reduce their activity against free radicals and increase their solubility. At the cellular level, they are compartmentalized in the vacuoles[16]. There are different classes of flavonoids such as: **a)** flavones and flavanols; **b)** flavanones, flavanols; **c)** isoflavones; **d)** pro-anthocyanidins; and **e)** anthocyanidins.

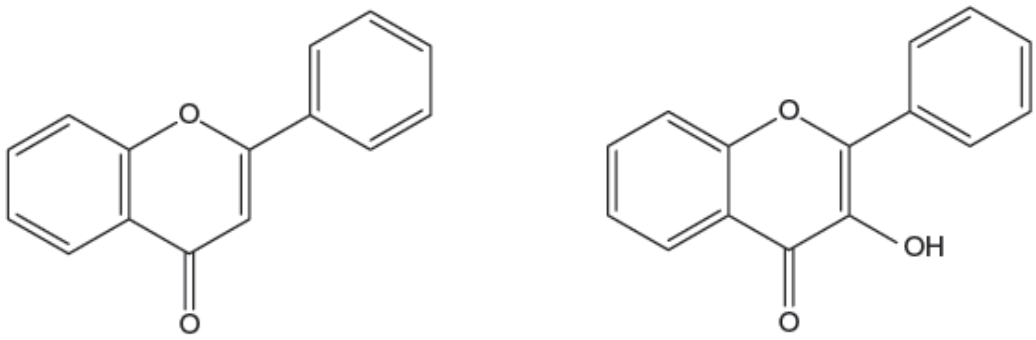


Fig. 5: General structure of flavones (left) and flavonols (right)

a. Flavones and flavonols: Onions are rich in these compounds. Blueberries also have high levels, especially in the peel, because synthesis is stimulated by exposure to light. Celery is a good source of flavones. Flavones are also present in citrus, but they are associated mainly with the fruit peel.

b. Flavanones and flavanols: Orange juice is a source of the fl avanone glycoside hesperidin. The flavanols catechin and epicatechin are common in grapes[16].

c. Isoflavones: Isoflavones are phytoestrogens present in legumes. The three most commonly found isoflavones are genistein, glycitein and daidzein.

d. Pro-anthocyanidins: Proanthocyanidins are oligomeric flavonoids. They are common in the peel and seeds of grapes[9]. Other sources of these compounds include apple, almond and blueberry.

e. Anthocyanidins: Anthocyanidins are pigments giving several fruits their characteristic red or purple colors, although in some conditions they can be uncolored. Besides being pigments, anthocyanidins have great relevance due to their contribution to the antioxidant capacity of fruits and vegetables. There are six anthocyanidins more common in fruits and vegetables: pelargonidin, cyanidin, delphynidin, peonidyn, petunydin and malvidin.

Summary

Fruits and vegetables contain antioxidants like vitamins (A, C, E), Anthocyanins, β-carotene, Catechins, Ellagic acid, Lutein, Lycopene, Resveratrol. These antioxidants improve immune response and protect against infections. Vitamins play an important role as cofactor in various enzymes. Antioxidants have a capacity to degrade free radicals and prevent the cell from damaging effect of free radicals. Apart from the taste is concern, Vegetables have been reported rich source of antioxidant. It keeps the cardiac as well as ageing problem away. It will make people healthy and strong. So it is important to consume vegetables in daily dietary food.

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