

Antioxidants and its uses

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Antioxidants are substances used to preserve food by retarding deterioration, rancidity or discoloration caused due to oxidation. Antioxidants neutralize the free radicals in the body and prevent oxidation reaction. Damage that leads to chronic diseases is cumulative, usually occurring over decades. That's why it is important that antioxidants requirements be met on a daily basis to slow this cumulative damage that builds up over the course of lifetime. Insufficient antioxidants in the body leads to excessive free radicals causing oxidative stress and lead to development of serious diseases and memory loss. The human body makes its own antioxidant to neutralize free radicals but in our present environment free radicals far exceed the antioxidant produced in the bodies so there is a need to use the natural and synthetic antioxidants in our diet but in low and effective concentrations. And in addition they also can be used as natural preservatives, colouring agents and therapeutic compounds which help to increase shelf life and maintain the organoleptic properties, vitamin content and the eye – appeal of foods.

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INTRODUCTION

An antioxidant is a molecule capable of slowing or preventing the oxidation of other molecules. Oxidation is a chemical reaction that transfers electrons from a substance to an oxidizing agent. Oxidation reaction can produce free radicals, which start chain reactions that damage cells. Antioxidants terminate this chain reaction by removing free radicals intermediates and inhibit other oxidation reactions by being oxidized themselves. The term antioxidant originally was used to refer specifically to a chemical that prevented the consumption of oxygen. Early research on the role of antioxidants in biology focused on their use in preventing the oxidation of unsaturated fats, which is the cause of rancidity. Antioxidants are classified into two broad divisions, depending on whether they are soluble in water (hydrophilic) or in lipids

(hydrophobic).

Antioxidants function by interfering with the chain reaction. If the number of free radicals can be kept low enough, oxidation will not occur, all have strange relationship with oxygen. Oxygen is needed to breathe, while oxygen is essential for all metabolic processes in the body. This stress is responsible for many de-generative conditions in our body e.g. ageing. An antioxidant should not have any harmful physiological effect and should not impart an objectionable flavour, odour or colour to the food in which it is present. It should be effective in low concentrations (0.01-0.02%) and be fat soluble. Gum Gallic was the first anti-oxidant approved for stabilization of animal fats, specially lard. Antioxidants have been center of much media attention in recent years due to the ability to stabilize reactive potentially harmful free radicals in the body. Free radicals are the cause of many diseases from cancer to colds. Free radicals damage a person's DNA and this damage can be prevented and sometimes reversed with healing properties of antioxidants.

What are oxidants?

Oxidant chemicals also called free radicals are produced during normal aerobic cell respiration. They also occur when

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phagocytes, the cell that fight infections, destroy cells infected with bacteria or viruses, with burst of nitric oxides, superoxide's and hypo chloride, when fatty acids are digested and certain enzymes are activated to fight toxins. These free radicals damage the DNA that makes up our genes. The oxidants play an important role in the ageing process as ageing appears to be a good part due to the oxidants produced as by-products of normal metabolism.

What are antioxidants?

Antioxidants are substances used to preserve food by retarding deterioration, rancidity or discolouration caused due to oxidation. Antioxidants act against oxidants to minimize the damage made by them. Antioxidants in fruits and vegetables play a big role in minimizing cell damage by combining with and neutralizing free radicals broadly, antioxidants are the substances that when present in low concentrations compared to those of an oxidizable substrate significantly delays or prevent oxidation of that substrate. The oxidizable substrates include almost everything found in foods and living tissues including proteins, lipids, CHO's and DNA.

Antioxidants are also defined as substances used to preserve food by retarding deterioration, rancidity or discolouration due to oxidation. The most common antioxidants are vitamin C, vitamin E, beta-carotene, vitamin B₂, Vitamin B₁, lutein and co-enzyme q10. Further, on the basis of chemical point of view, antioxidants are substances that prevents or slow down oxidation reactions. Since there are different oxidative reactions from oxidation of iron to rust, to transformation of lipids to peroxides, there is no single substance that is universal antioxidant.

Antioxidant neutralizes the free radicals in the body. Let's take an example of an apple sliced half. Take a piece of lemon and squeeze its juice on one half of apple and leave other half exposed to air. You will notice that the half portion with lemon will retain its freshness and colour for a longer time as compared to exposed portion; here the lemon acts as as antioxidant, preventing it from turning brown (oxidizing).

The type of compound that can function effectively as an antioxidant, a molecule must:

React with free radicals more rapidly than the free radicals react with lipid, the products of reaction with free radicals must not be pro-oxidant and the molecule must be lipid soluble.

Antioxidants- must in our diet:

Insufficient antioxidants in the body lead to excessive free radicals causing oxidative stress. This imbalance can lead to the development of serious diseases; accelerate the ageing process and memory loss. The human body makes its own antioxidants to neutralize free radicals and prevent any serious damage. Earlier, the amount of antioxidants the body produced was sufficient to act with free radicals produced but in our

present environment, free radicals far exceed the antioxidant produced in the body. This creates a great deal of oxidative stress on the body and organs. Oxygen is the key to human survival as it is also responsible for maximum damage to the human body as 'free radicals' (Fig. 1). Free radicals are also produced through environmental pollution, cigarette smoke, car exhaust fumes, cooking, heating, burning, air and water pollution, pesticides, herbicides, refineries exhaust and alcohol etc. Antioxidant will not delay ageing in healthy older people but it does help to minimize damage made by several diseases especially associated with old age *e.g.* cancer, neurological diseases, complications of diabetes etc. Thus, it is not sufficient to just take antioxidants but physical exercise and a healthy life style play a great role in dealing with ageing. It is also important to limit the consumption of red meat and saturated fats.

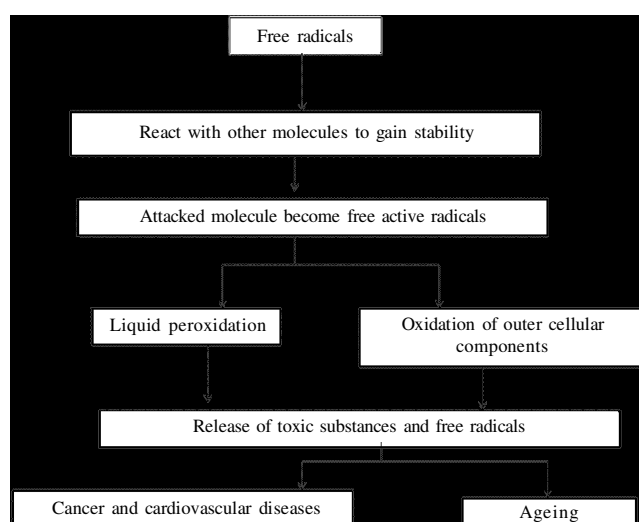


Fig. 1. Mechanism of free radical reaction in body

The starting point is a diet high in consumption of fruits and vegetables. An excellent source of natural food antioxidants, some supplements are very helpful. Supplements of vitamin E and vitamin C should be a major component of everyone's nutritional programme. Coenzyme q10, pycnogenol and grape seed extract are additional supplements. A dietary programme of food rich in antioxidants and supplements is best when started early and continued throughout life span (Fig. 2). In addition to antioxidants and supplements, some approaches to reducing free radicals production and damage in the body are obvious. Stop smoking or never begin and stay away from passive smoke, minimize exposure to smoke and air pollution. Protect skin from UV light by using skin blocking lotions, the body produces antioxidants as well as they are available through fruits and vegetables.

Requirement of antioxidants:

In India, under nutrition is a very major problem and it is

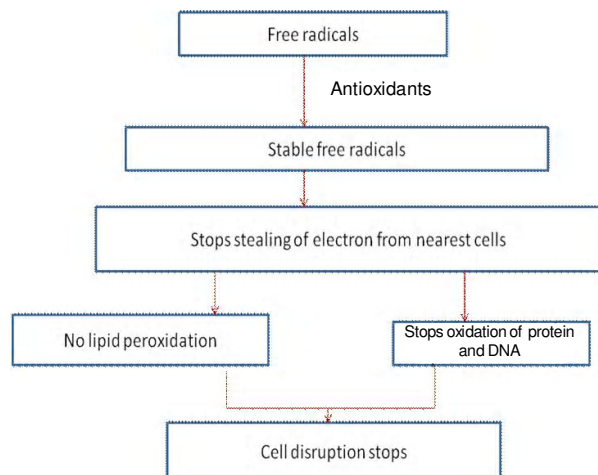


Fig. 2. Mechanism of free radical inhibition by antioxidants

the responsibility of the entire family to see that elders eat at least two fruits and three vegetables a day. This will provide sufficient quantity of antioxidants.

Types of antioxidants:

There are two types of antioxidants, *i.e.*, natural and synthetic.

Natural antioxidants:

The potent sources of natural antioxidants are spices and herbs. Spices have been used for hundreds of years not only for flavoring purposes but also for their food preservation ability. The antioxidants of herbs and spices like red chillies, cinnamon, sage, turmeric, clove, nutmeg and dry ginger retard rancidity of oils. Dark and brightly colored fruits and vegetables such as carrot, tomatoes, peppers and spinach have a higher concentration of antioxidants. The best natural source of antioxidants available to us are fresh fruits, leafy green vegetables, carrots, citrus, oil from soy bean and sunflower, papaya, mangoes and pumpkins.

Many antioxidants are supplied through the diet and most of these come from fruits and vegetables. Some antioxidants are produced by the body, while certain nutrients are found in fruits and vegetables. A number of vitamins including vitamins A, C and E, beta carotenes have antioxidant functions. Vitamin B however does not necessarily act as antioxidants by themselves but are important cofactors in a number of antioxidant actions. The vitamins like compounds, coenzyme Q10 and alpha-lipoic acid are also powerful antioxidants.

Advantages of natural antioxidants:

- They are readily acceptable by consumer.
- They are considered to be safe; furthermore, no safety

tests are required by legislation.

- If it is a component of a food that is “Generally Recognised As Safe (GRAS)”.

Properties of natural antioxidants:

- Should not cause off flavours or colours.
- Must be lipid soluble.
- Must be non toxic.
- Should have carry through properties.
- Must be cost effective.
- Powerful scavenger of free radicals as superoxide, hydrogen peroxide, hypochloride, peroxy radical and single oxygen.
- Protects membranes against peroxidative damage by peroxy radical in aqueous phase.
- Protects against endogenous oxidative DNA damage in human sperm and could increase risk of genetic defects.

Sources of antioxidants:

Vitamin C, beta-carotenes and vitamin E are rich sources of antioxidants. A balanced diet rich in these vitamins are an ideal source of natural antioxidants. During normal body functioning and oxygen utilization, a process called “oxidation” occurs as a result of chemical and enzymatic reactions in the cells. As a result of this process, harmful substances called “free radicals” form. These free radicals can cause chain reactions that damage cells and may play a role in the development of several chronic diseases including cancer and heart disease. Research results have been overwhelming regarding the dangers of these free radicals. Vitamins C, E, and beta-carotene, found in fruits and vegetables, are the best known antioxidants. But there also are several other antioxidants that occur naturally in foods and beverages. “Flavonoids” are one such type found in foods and beverages such as garlic, black and green tea, apples, and onions. A diet rich in fruits and vegetables and low in fat is strongly associated with reduced risk for cancer and heart disease. Supplements such as vitamin E, vitamin C and Co enzyme 10 can be used though unsupervised overuse can actually cause harm or interact with other medications.

Antioxidants are found in varying amounts in foods such as vegetables, fruits, grain cereals, legumes and nuts. Some antioxidants such as lycopene and ascorbic acid can be destroyed by long-term storage or prolonged cooking. Other antioxidant compounds are more stable, such as the polyphenolic antioxidants in foods such as whole-wheat cereals and tea. In general, processed foods contain less antioxidant than fresh and uncooked foods, since the preparation processes may expose the food and oxygen. Some antioxidants are made in the body and are not absorbed from the intestine. One example is glutathione, which is made from amino acids.

Ascorbic acid (Vitamin C):

Ascorbic acid or 'vitamin C' is a monosaccharide antioxidant found in both animals and plants. As it cannot be synthesized in humans and must be obtained from the diet. Ascorbic acid is a reducing agent and can reduce and thereby neutralize reactive oxygen species such as hydrogen peroxide. 60mg. per day (100 mg. for smokers) of vitamin C, though most nutritionists recommend at least 500 mg/day (Table 1).

Food sources:

All types of citrus fruits, kiwi, papaya, strawberry and leafy vegetables, broccoli, cabbage, tomatoes, green and red peppers etc.

Other benefits of ascorbic acid addition:

- When secondary processed products such as fruit drinks or soft drinks are made from fruit juices or purees, additional ascorbic acid is often added during the mixing process to restore nutrient losses that might have occurred during processing.
- Ascorbic acid is added to soft drinks and fruit beverages to prevent oxidative flavour deterioration.
- Adding extra ascorbic acid to bottled and canned beverages reduces the oxygen in the head spaces of the containers to prevent future oxidation of the product.
- Precautions should be taken when adding ascorbic acid as a nutrient to processed fruit products.
- Use stainless steel or plastic manufacturing equipment.
- Remove as much oxygen as possible from equipment and containers.
- Use flash heat sterilization and/ or add the ascorbic acid as close to the end of thermal processing as possible.

Tocopherols and tocotrienols (vitamin E):

Vitamin E is the collective name for a set of eight related tocopherols and tocotrienols, which are fat- soluble vitamins with antioxidant properties. Of these, α -tocopherol has been most studied as it has the highest bioavailability, with the body preferentially absorbing and metabolizing this form. Vitamin E is the antioxidant that prevents cancer-promoting chemicals from accumulating in the body. 30 units of vitamin E though 400-600 units is recommended for proper effect. It is a hard to find sufficient quantities of vitamin E from diet alone.

Table 1. List of antioxidants and their quantity requirement in our daily life

Name of antioxidant	Quantity required
Vitamin E, Tocopherols	100-3200 IU/day
Vitamin C, Ascorbic acid	500-1000 mgm/day
Carotenoids, B- carotene	10-50 mgm/day
Selenium	100-300 mgm/day
Zinc	15-25 mgm/day
Amount of antioxidant rich food	600 gms/day

Food sources:

A good source is almonds. Major food sources are vegetable oils (sunflower oil, 48.7mg/100g), nuts (hazelnut, 21mg/100g), almonds (20mg/100g), whole grain breads and cereals (Table 1).

Carotenoids (β -carotene):

This has been called "nature's most potent naturally occurring antioxidant" Recent research suggests beta-carotene may work best in concert with other antioxidants.

Food sources:

Carrots, broccoli, squash, cantaloupe, spinach, other deep yellow and orange fruits and vegetables, as well as green leafy vegetables. The stronger the colour, the higher the carotenoid content. So, a colourful platter of bright red, orange, yellow and green vegetables is not only pleasing to look at – It's also good for you.

Flavonoids:

Flavonoids are capable of scavenging peroxy, alkyl, superoxide, nitric oxide radicals in aqueous and inorganic environments. Scavenging property is due to the fact that H atom from aromatic OH group can be denoted to a free radical and the aromatic compound can support an unpoured electron due to delocalisation around the 'electron system'. Found in whole lot of vegetables and fruits, onions, beets, citrus fruits and berries contain flavonoids. Green tea is a good source.

Selenium:

This mineral is among a group of key minerals, including zinc, copper, iron and manganese, which assists antioxidants by helping to produce enzymes needed to quench free radicals. Occurring naturally in many foods and beverages, these compounds may exert antioxidant effects alone or in combination with other antioxidants. Requirement is 70 mg/day. A healthy diet with plenty of colourful vegetables can provide you with cancer fighting and heart disease preventing antioxidants, and if diet does not provide them, there are supplements you can get.

Food sources:

Cashews, meat, oysters, salmon, tuna, black/green teas, apples, onions, citrus, fruits, carrots, broccoli, cabbage, soy products, parsley, tomatoes, eggplant, peppers, berries and whole grain are excellent sources.

Synthetic antioxidants:

A number of spices and other plant products contain phenolic compounds that may have significant antioxidant properties and have been shown to inhibit oxidation in certain food systems. The phenolic compounds present such as

Eugenol, Carnosol, Rosmanol, Rosmariquinone, Sesamol, oats etc. (Table 2).

Table 2. List of antioxidants compound and their availability in foods

Name of antioxidant	Quantity required
Vitamins C (ascorbic acid)	Fruits and vegetables
Vitamin E, (Tocopherols, tocotrienols)	Vegetable oils
Polyphenolic antioxidants (resveratrol, flavonoids)	Tea, coffee, soy, fruit, olive oil, chocolate, oregano and red wine
Carotenoids (lycopene, carotenes)	Fruits and vegetables

Butylated hydroxyl anisole (BHA):

Butylated hydroxy anisole is a mixture of two isomers referred to as a 'hindered phenol' because of the proximity of the tertiary butyl group to the hydroxyl group. This may hinder the effectiveness in vegetable oils, but increase the carry through' potency for which BHA is known. BHA is more effective in suppressing oxidation occurring in animal fats than in vegetable oils. It is useful in protecting flavour and colour of essential oils. Uses: In lard, shortenings, vegetable oils, cereals, package liners, potato products, dry soups, chewing gum, etc. Usually used in combination with other primary antioxidants.

Propyl gallate(PG):

It is a synthetic antioxidant which has gained widespread usage since its approval by FDA in 1947. Three hydroxyl groups make it very reactive. Lower solubility. Tends to chelate trace minerals such as iron and form colored complexes. PG is useful in inhibiting oxidation in oils and animal fats, meat products, spices and snacks. Uses: In lard, shortening, vegetable oils, cereals, animal feeds, etc. Usually used in combination with BHA or BHT.

Butylated hydroxyl toluene (BHT) :

Butylated toluene is also a 'sterically hindered' phenol, susceptible to loss through volatilization in high temperature applications. Uses: In lard, shortening, vegetable oils, cereals, package liners, animal feeds, etc. used alone in combination with BHA or PG citric acid.

Tertiary butyl hydroquinone (TBHQ):

Tertiary-butyl hydroquinone is an extremely potent antioxidant. It had been used extensively in non-food applications prior to gaining approval in food. TBHQ protects the oils against oxidation and like BHT and BHA, it provides carry through protection to finished fried products. Reduces food spoilage, increases profit, ensures fresher tasting food and customer satisfaction. It is most cost effective in edible oils and fats; reduced costs. Uses: frying oils(soybean, sunflower, canola, palm, cotton, groundnut, corn and safflower

oil), fats(shortening, ghee, lard and tallow), margarine, salad dressings, baked foods, snack foods, pre-prepared foods, dairy powders and citrus and essential oils.

Combination of antioxidants:

Antioxidants are usually used in combination to take advantage of their differing properties. For example, BHA combined with PG and citric acid. The propyl gallate provides a high level of initial protection while the BHA has good carry through properties.

Reasons for combinations:

To take advantage of different properties, allow for better control and accuracy providing synergistic effects. Combinations may provide more complete distribution in some foods more convenient to handle.

Benefits of antioxidants:

All antioxidants have a chemical element referred to as a 'redox' potential, which is the measurement of their ability to be oxidized. They are by this action also classified as "reducing agents" which are needed to quickly block the chain reaction caused by free radicals before cell damage can result.

Acne: It can help to boost the immune system and clear the blood.

Ageing skin: To help protect the cell integrity as well as the supportive collagen tissue.

Alcohol: Consumption of alcohol causes a host of toxins in the body and antioxidants are useful in the detoxification process.

Allergies: Certain antioxidants help with the control of the histamine release mechanism, which may be of use for allergies.

Angina, heart and arterial disease: by helping to protect blood vessels from fatty deposits, they may help the veins maintain their elasticity.

Arthritis and joint pain: Helps to relieve localized oxidative stress and also promote healthy joint cells.

Bowel inflammation: Since free radicals contribute to this problem, the addition of antioxidants may be helpful.

Cancer: Although antioxidants may not cure cancer, much research has been done and is still continuing, regarding the role of antioxidants in the prevention and alleviation of cancer.

Fatigue: Useful in releasing oxidized fatty deposits, and in doing so, boosting energy production.

Injuries: Help prevent oxidation processes from hampering recovery.

Male infertility: Excessive free radicals destroy genetic material and sperm counts may be lower than normal, which could lead to infertility.

Memory loss: Promotes the growth of tissue and helps prevent DNA destruction; they are also indicated to assist

with memory loss.

Rheumatism: As with arthritis, antioxidants are involved in relieving localized oxidative stress and also promote healthy joint cells.

Stamina: Antioxidants help to reduce the build-up of peroxide from the body; an increase in stamina should be experienced when they are abundant in the body.

Stress: General stress levels, as well as specific female stress during pregnancy, menopause or when taking oral contraceptives, as well as stress felt by adolescents while growing up, can benefit from extra antioxidants.

Wounds: The oxidation processes can hamper wound healing and since antioxidants will help control this, better healing would be promoted and the immune system boosted in general, which will help to prevent infections.

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