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Antioxidant activity of vitamins against free radicals

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Abstract

Antioxidants are one of the most powerful protectors of our long- term health, they act to protect our bodies from damage effect that results from chemicals and free radicals which humans may get through normal daily activities such as breathing or by environmental contaminants like cigarette smoke or pollution. We make this review to focus on the antioxidant activity of vitamins that we can get from food to protect our body systems against these harmful bodies

Keywords: antioxidants, vitamin, free radical, reactive oxygen species

1. Introduction

1.1 Free radicals

Free radicals are atoms or groups of atoms with an odd (unpaired) number of electrons and can be formed when oxygen interacts with certain molecules. Once formed these highly reactive radicals can start a chain reaction, like dominoes.

These free radicals are parts of groups of molecules called reactive oxygen species (ROS), reactive nitrogen species (RNS) and reactive sulphur species (RSS). Vajragupta et al., [2004]. For example:

- ROS include:
  - As superoxide anion ($O_2 \bullet^-$).
  - Perhydroxyl radical ($HO_2 \bullet$).
  - Hydroxyl radical ($\cdot OH$).
  - Nitric oxide.
  - Other species such as hydrogen peroxide (H_2O_2), singlet oxygen (1O2), hypochlorous acid (HOCl) and peroxynitrite ($ONOO^-$).
- RNS are derived from nitric oxide through the reaction with $O_2 \bullet$ to form $ONOO^-$.
- RSS are easily formed from thiols by reaction with ROS. Giles et al., [2002].

1.2 Formation and decomposition

The reduction of molecular oxygen (O_2) produces superoxide ($^\bullet O_2^-$) as show in figure (1), and is the precursor of most other reactive oxygen species

$$O_2 + e^- \rightarrow {}^\bullet O_2^-$$

Dismutation of superoxide produces hydrogen peroxide (H_2O_2):

$$2\,H^+ + {}^\bullet O{-}2 + {}^\bullet O{-}2 \rightarrow H_2O_2 + O_2$$

Hydrogen peroxide in turn may be partially reduced to hydroxyl radical ($^\bullet OH$) or fully reduced to water: Turrens et al., [2003]

$$H_2O_2 + e^- \rightarrow HO^- + {}^\bullet OH$$
$$2\,H^+ + 2\,e^- + H_2O_2 \rightarrow 2\,H_2O$$

But not always ROS is harmful; ROS have important functions to perform in the cell, examples: Devasagayam et al., [2004]

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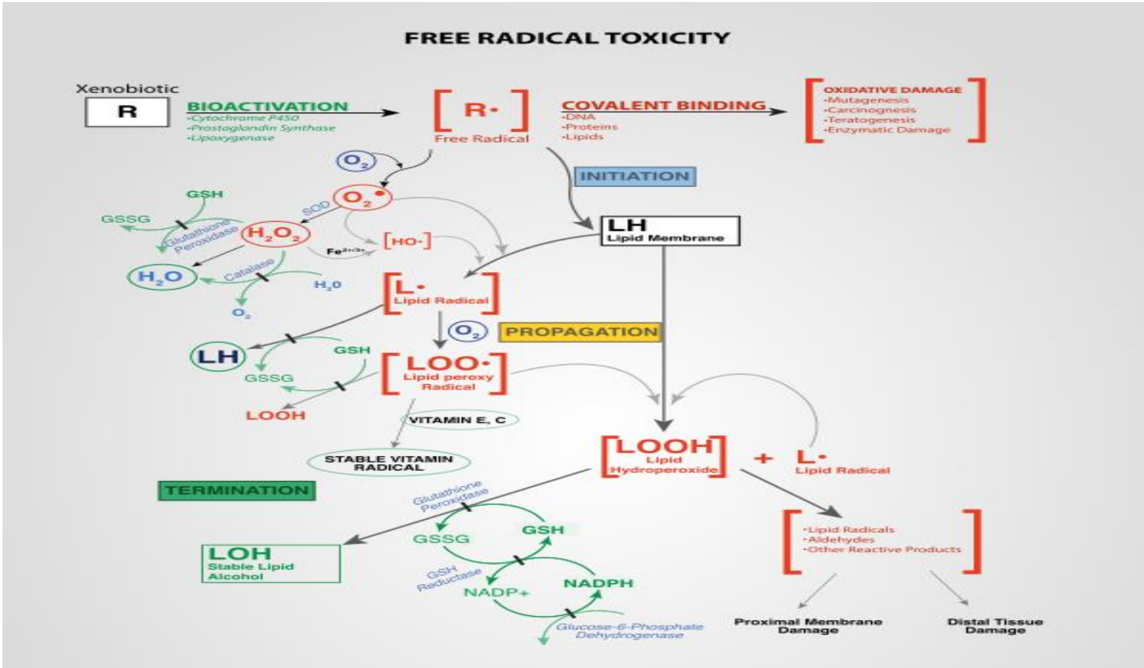


Figure 1: Free radical mechanisms in tissue injury

- The cells of the thyroid gland must make hydrogen peroxide in order to attach iodine atoms to thyroglobulin in the synthesis of thyroxin.
- Macrophages and neutrophils must generate ROS in order to kill some types of bacteria that they engulf by phagocytosis.
- Subunits of the enzyme NADPH oxidase assemble in the lysosome membrane forming the active enzyme.
- It catalyzes the synthesis of the superoxide anion.

$$NADPH - 2\,e^{-} + 2O_2 \longrightarrow NADP^{+} + H^{+} + 2\,{\cdot}O_2^{-}$$

This activity produces a large increase in oxygen consumption, called the "respiratory burst".

- Neutrophils (but not macrophages) also kill off engulfed pathogens by using the enzyme myeloperoxidase which catalyzes the reaction of hydrogen peroxide (made from superoxide anions) with chloride ions to produce the strongly antiseptic hypochlorite ion (OCl^{-}).

$$H_2O_2 + Cl^{-} \longrightarrow HOCl \text{ (hypochlorous acid)} + OH^{-}$$

$$HOCl \longrightarrow H^{+} + OCl^{-}$$

But, excessive amounts of ROS can have deleterious effects on many molecules including protein, lipid, RNA and DNA since they are very small and highly reactive.
In order to prevent or reduce the ROS induced oxidative damage, the human body and other organisms have developed an antioxidant defense system that includes enzymatic, metal chelating and free radical scavenging activities to neutralize these radicals after they have formed. In addition, intake of dietary antioxidants may help to maintain an adequate antioxidant status in the body. Geier et al., [2009].

1.3 Antioxidant

Antioxidant is a molecule capable of inhibiting the oxidation of other molecules. Oxidation is a chemical reaction involving the loss of electrons or an increase in oxidation state. Oxidation reactions can produce free radicals. Sies et al.,[1997]
Although oxidation reactions are crucial for life, they can also be damaging; plants and animals maintain complex systems of multiple types of antioxidants, such as glutathione, vitamin C, vitamin A, and vitamin E as well as enzymes such as catalase, superoxide dismutase and various peroxidases. Roshan et al., [2004]. Insufficient levels of antioxidants, or inhibition of the antioxidant enzymes, cause oxidative stress and may damage or kill cells. Halliwell et al. [1995].

1.3.1 Type of antioxidant

Antioxidants are classified into: Sies et al.,[1997]

1.3.1.1 Hydrophilic

They are soluble in water which is react with oxidants in the cell cytosol and the blood plasma, like: Uric acid , Ascorbic acid (vitamin C), Glutathione and Lipoic acid.

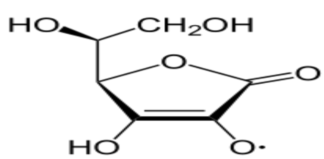
1.3.1.2 Lipophilic

They are soluble in lipids which protect cell membranes from lipid peroxidation, like: Carotenes, α-Tocopherol (vitamin E), Ubiquinol (coenzyme Q) and melatonine.

1.3.2 Antioxidant vitamin

1.3.2.1 Ascorbic acid (vitamin C)

Vitamin C is a monosaccharide oxidation-reduction (redox) catalyst found in both animals and plants. Ascorbic acid is a redox catalyst which can reduce, and thereby neutralize, reactive oxygen species such as hydrogen peroxide. Sarmad et al.,[2017] , In addition to its direct antioxidant effects, ascorbic acid is also a substrate for the redox enzyme ascorbate peroxidase, a function that is particularly important in stress resistance in plants . Baillie et al., [2009]. It typically reacts with oxidants of the reactive oxygen species, such as the hydroxyl radical. Such radicals are damaging to animals and plants at the molecular level due to their possible interaction with nucleic acids, proteins, and lipids. Garry et al., [2009]



Semidehydroascorbate

The net reaction is:

$RO\bullet + C_6H_7O_6^- \rightarrow RO- + C_6H_7O_6^\bullet \rightarrow \rightarrow ROH + C_6H_6O_6$

The oxidized forms of ascorbate are relatively unreactive and do not cause cellular damage. However, being a good electron donor, excess ascorbate in the presence of free metal ions can not only promote but also initiate free radical reactions, thus making it a potentially dangerous pro-oxidative compound in certain metabolic contexts.

1.3.2.2 Vitamin A

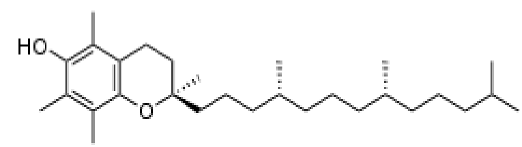
One of the Vitamin A benefits is that it acts as an antioxidant. But it’s not exactly Vitamin A that’s acting as the antioxidant ,it is Carotenes (i.e. beta carotene, alpha carotene) are the precursor of Vitamin A and are found in plant sources And the human body has 2 functions for carotenes which can turn it into Vitamin A or turn it into an antioxidant. Tanumihardjo et al., [2009].

About 40% of carotenes are converted to Vitamin A while 60% functions as powerful antioxidants and this is good because your body will turn carotenes to Vitamin A only if your body needs it. The rest will circulate through your blood as antioxidants. This is helpful because there are some issues with Vitamin A overdose and toxicity. And there are many types of carotenes that act as great antioxidants (i.e. alpha & beta carotene, lycopene). Carotenes specifically fight off the singlet oxygen free radical. Fennema et al., [2008].

1.3.2.3 Vitamin E

Vitamin E refers to a group of compounds that include both tocopherols and tocotrienols. Naturally occurring vitamin E exists in eight chemical forms (alpha-, beta-, gamma-, and delta-tocopherol and alpha-, beta-, gamma-, and delta-tocotrienol) that have varying levels of biological activity . Packer et al., [2001]

Vitamin E is found naturally in some foods, added to others, and available as a dietary supplement. It is the collective name for a group of fat-soluble compounds with distinctive antioxidant activities. Packer et al., [2001]



The α-tocopherol form of vitamin E

As an antioxidant, vitamin E acts as a peroxyl radical scavenger, disabling the production of damaging free radicals in tissues, by reacting with them to form a tocopheryl radical, which will then be reduced by a hydrogen donor (like vitamin C) and thus return to its reduced state. Borgstahl et al., [1992].

1.3.2.4 Vitamin K

Vitamin K is a fat-soluble compound that plays an essential role in the physiology of mammals. Its primary function pertains to the blood-clotting process. It may be a key anti-aging vitamin. It may prevent both heart disease and osteoporosis. And it's a stronger antioxidant than vitamin E or coenzyme Q10. Vitamin K may be the future of treating certain kinds of cancer. And it may have something to do with Alzheimer's disease. Micronutrient information center, [2014].

1.3.2.5 Vitamin D

Vitamin D, which includes Vitamin D 3 (cholecalciferol) and Vitamin D 2 (ergocalciferol), is a lipid soluble vitamin, Vitamin D has been called the “miracle vitamin” by many health experts due to mounting discoveries of its significance in promoting health and fighting numerous diseases, including cancer, heart disease, and diabetes.

Vitamin D possesses antioxidant properties and also strengthens the role of existing antioxidants in the body. For instance, demonstrated that calcitriol acts similarly to traditional antioxidant nutrients by inhibiting an enzyme called inducible nitric oxide synthase (iNOS), which is overactive in patients with Alzheimer's and Parkinson's disease. Garcion et al., [1997].

2. Conclusion

Body produces some antioxidants, get them in certain foods and vitamins, Common antioxidants include.

- Vitamin A: is in milk, butter, eggs, and liver.
- Vitamin C: is in most fruits and vegetables. Eat fruits such as berries, oranges, kiwis, cantaloupes, and papayas. Eat vegetables such as broccoli, bell peppers, tomatoes, cauliflower, Brussels sprouts, and kale.
- Vitamin E: is in some nuts and seeds. For example, almonds, sunflower seeds, hazelnuts, and peanuts. You can find it in green leafy vegetables such as spinach and kale. You also can find it in soybean, sunflower, corn, and canola oils.
- Beta-carotene: is in brightly colored fruits and vegetables. Eat fruits such as peaches, apricots, papayas, mangoes, and cantaloupes. Eat vegetables such as carrots, peas, broccoli, squash, and sweet potatoes. It also is in some leafy green vegetables such as beet greens, spinach, and kale.
- Lycopene: is in pink and red fruits and vegetables. This includes pink grapefruits, watermelon, apricots, and tomatoes.
- Selenium: is in pasta, bread, and grains, including corn, wheat, and rice.

References

Ahmed H., Raghda S., and Emad Y., Potential applications of antioxidants - A Review, International Journal of Research in Engineering and Innovation 1(6): 78-82(2017).

Baillie J., Thompson A., Irving J., Bates M., Sutherland A., and Macnee W., Oral antioxidant supplementation does not prevent acute mountain sickness: double blind randomized placebo-controlled trial, Qjm. (5); 341–348(2009).

Borgstahl G., Parge H., Hickey M., Beyer W., Hallewell R., and Tainer J., The structure of human mitochondrial manganese superoxide dismutase reveals a novel tetrameric interface of two 4-helix bundles. Cell. 71 (1); 107–108(1992).

Devasagayam T., Tilak J., Boloor K., Sane K., Ghaskadbi S., and Lele R., Free Radicals and Antioxidants in Human Health: Current Status and Future Prospects. Journal of Association of Physicians of India; (52): 796,(2004).

Fennema O., Fennema's Food Chemistry. CRC Press Taylor & Francis. 454–455(2008).

Garcion E., 1, 25-Dihydroxyvitamin D3 inhibits the expression of inducible nitric oxide synthase in rat central nervous system during experimental allergic encephalomyelitis, Molecular brain research 45(2);255–267(1997).

Garry R., and Freya Q., Ascorbate (Vitamin C), its Antioxidant Chemistry App. letter in Free Radical & Radiation biology Program, (2011).

Geier D., Kern J., and Garver C., A prospective study of transsulfuration biomarkers in autistic disorders. Neurochem Res; (34): 386–393, (2009).

Giles G., and Jacob C., Reactive sulfur species: an emerging concept in oxidative stress. Biol. Chem.; (383): 375–388, (2002).

Halliwell B. and Gutteridge J., The Definition and Measurement of Antioxidants in Biological Systems. Free Radical Biology and Medicine,(1); 125-126, (1995).

Halliwell B., the antioxidant paradox, Lancet (355): 1179-1180(2000).

Micronutrient information center, linus Pauling institute, Oregon state university, Corvallis, OR, July 2014.

Packer L., Weber S., and Rimbach G., Molecular aspects of alpha-tocotrienol antioxidant action and cell signalling, The Journal of Nutrition. 131 (2); 369S–373S (2001).

Roshan Z., Syed T., Nawab A., Khattak G., and Muhammad T. studies on in vitro surface sterilization and antioxidants on guava shoot tips and nodal explants. Pakistan journal of biotechnology; (2): 12-16 (2004).

Sarmad G., Zena K., and Nada F.,study of cumin antibacterial and antioxidant activity of alcoholic and aqueous extracts, Pakistan Journal of Biotechnol. (2); 227 -231 (2017).

Sies H., Oxidative stress: oxidants and antioxidants. Experimental Physiology; (2): 291–295, (1997).

Tanumihardjo S., Vitamin A: biomarkers of nutrition for development, The American Journal of Clinical Nutrition. 94 (2): 658S–665S (2011).

Turrens J., Mitochondrial formation or reactive oxygen species. Journal Physiol;(552): 335 -344,(2003).

Vajragupta O., Boonchoong P., and Berliner L., evaluation of hydroxyl radical scavenging ability, superoxide dismutase activity and stability towards hydrolysis. Free Radic Res. journal Manganese complexes of curcumin analogues; (38): 303–314, (2004).