

ANTIOXIDANTS IN SELECTED FOODS AND BEVERAGES AND THEIR ROLE IN PREVENTION OF DISEASES

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ABSTRACT

The accumulation of free radicals plays a well-documented role in the pathogenesis of many chronic diseases. Antioxidants are the agents that are capable to react with free radicals, neutralize their reactive potential by quenching, and thus reduce the ability of free radicals to damage DNA and other cellular structures. Antioxidants are responsible for maintenance of oxidative balance of the cells. In order to maintain health, it is useful to ensure efficient intake of specific antioxidants from food. The authors present and highlight the selected food groups and beverages with high antioxidant values, their health benefits and the effect of processing on the bioavailability of these nutrients.

KEY WORDS: antioxidants, free radicals, fruits and vegetables, beverages, recommendations

ABBREVIATIONS

BMI	Body Mass Index
FAO	Food and Agriculture Organization of the United Nations
LDL	Low-density Lipoprotein
UV	Ultraviolet
WHO	World Health Organization

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INTRODUCTION

In 1957, the research scientist Denham Harmon proposed the free radical theory of aging. His theory proposed that the consequence of aging was the result of “attacks” upon our body tissues by radicals due to oxidative stresses. These oxidative stresses, the result of pollution, cigarette smoke, UV rays from the sun, and (even worse) normal metabolism caused disease and aging (Milbury and Richer, 2008).

Free radicals are highly reactive elements that are produced naturally in all cells and have their physiological relevance. Free radicals can damage various cell structures, including DNA in their nuclei, due to their nature. Antioxidants are any agents that are capable to react with free radicals, neutralize their reactive potential by quenching, and thus reduce their ability to damage DNA and other cellular structures. Antioxidants are responsible for maintenance of oxidative balance of the cells. Oxidative stress occurs when the cells are exposed to excessive amounts of free radicals, either by their overproduction, or in excessive exposure to environmental toxins. Systematic operation of a large number of free radicals in the body results in a cascade of processes, which can damage cell structures, and among a lot of other threats, there is an increased risk of cancer development. In experimental conditions, antioxidants can hinder free radicals from damaging the cell structures, and hence they are able to reduce the risk of cancer. Despite the undeniable achievements in the study of the role of oxidative stress in carcinogenesis and the role of antioxidants in anti-cancer prevention, current results cannot yet be considered final and further targeted research will be necessary. Nevertheless, eating of food rich in antioxidants can be considered legitimate (Poráčová et al., 2016; Minárik and Kimáková, 2016).

The concept of total antioxidant capacity represents the sum of all substances and antioxidant effects that are in plasma. Several methods can be applied to measure total antioxidant capacity (Štípek et al., 2000; Racek, 2003; Ďuračková, 2010; 2014).

ANTIOXIDANTS IN FOOD

Free radicals arise in the human body for various reasons. They have positive effects with adverse external and internal influences if their number increases in the body. They are involved in many chronic diseases including cardiovascular, cancer, respiratory and other diseases. Our organism has a protective system against free radicals, which is based on antioxidants. However, the body produces antioxidants in a limited amount. Therefore, it is important to supplement antioxidants from food in their natural form or to use the synthetic products (vitamin C, vitamin E, selenium, coenzyme Q and other) (Štípek et al., 2000; Racek, 2003; Ďuračková, 2010; 2014; Kimáková and Pavlík, 2017).

It is rational to prefer natural resources not only because of their higher efficiency, but also because high intake of synthetic antioxidants can cause a number of side effects, even oxidative stress. Nutrition with higher levels of antioxidants has a beneficial effect on health. Radical change in the consumption of the main sources of natural antioxidants (fruits, vegetables, vegetable oil, cereals, nuts, legumes, mushrooms and so on) is beneficial. Lifestyle change and environment recovery provides one of the possible solutions to reduce high mortality rates for cardiovascular and malignant diseases and (Kimáková and Pavlík, 2017).

WHO experts have developed a material on healthy nutrition, leading to the prevention of chronic diseases (WHO/FAO, 2005; WHO, 2015). In the next part, we present the selected kinds of food and beverages with high antioxidant values, their health benefits and the effect of processing on the bioavailability of these nutrients.

Ginkgo biloba

The largest plantations of *Ginkgo biloba* can be found in the USA. Leaves from *Ginkgo biloba* are used to produce an extract that is one of the best-selling in the world. They are filled with active substances, mainly flavonoids, terpenoids, organic acids, phenolic substances and others. In China, *Ginkgo*'s healing effects have been used since ancient times. They applied it mainly to improve blood circulation, pulmonary and dermatological diseases (Šuchová, 2009).

Ginkgo can help cognitive performance and memory. The medical benefits of *Ginkgo biloba* extract are attributed primarily to two groups of active constituents: the ginkgo flavone glycosides and the terpene lactones. Glycosides usually represent 22 - 27% of the extracted extract. Active substances help expand the blood vessels, improve the blood circulation of the lower and upper limbs and destroy free radicals. The protective effects of *Ginkgo biloba* extract to central nervous system have been demonstrated (Mechírová and Domoráková, 2002; Ursell, 2004; Domoráková et al., 2006; Slíva and Minárik, 2009).

Common sea buckthorn (Hippophae rhamnoides L.)

Common sea buckthorn is a hardy shrub that grows up to a height of between two meters and four meters. People from China, Mongolia, and Greece used it to treat lung, gastrointestinal and other diseases. It helps to get rid of mucus, inflammation, regulates blood circulation, heals mucous membranes, helps with throat pain and heals digestive system. Its fruits are eaten fresh or worked up to different products. Orange-red colouration of fruits depends on the content of carotenoids. The vitamin E content occupies the first place among all the fruit plants. It is prepared from the raccoon ointment, tea and oil. The crustacean oil acts antioxidant and it reduces the free radicals content (Jablonský and Bajer, 2007).

Common sea buckthorn is used mainly due to the high content of vitamin C (Slíva and Minárik, 2009). The high content of provitamin A makes the common sea buckthorn an excellent remedy for all vitamin A deficiency diseases. Berries are used to make juice, marmalade, wine and jams (Červená and Červený, 1994).

Mushrooms

The antioxidant properties of wild mushrooms have been extensively studied and many antioxidant compounds extracted from these sources have been identified, such as phenolic compounds, tocopherols, ascorbic acid, and carotenoids. Wild mushrooms might be used directly in diet and promote health, taking advantage of the additive and synergistic effects of all the bioactive compounds present. The antioxidant potential of beta-glucans is based on an increase in SOD activity or glutathione peroxidase in the liver (Ferreira et al., 2009; Slíva and Minárik, 2009).

Pleurotus ostreatus contains carbohydrates, proteins, essential amino acids, vitamins (B1, B2, B3, B5, B7, C) and minerals (Ca, Fe, Mg, P, K, Se, Na, Zn). It is significant that it contains β -D-glucan polysaccharide. Shiitake mushroom (*Lentinus edodes*) is an edible mushroom native to East Asia, which is cultivated and consumed in many Asian countries. It is considered a medicinal mushroom which has stimulating and reinforcing properties that strengthens the immune system and acts against cancer (Sekretár et al., 2003; Červený and Červená, 1994).

Coffee, cocoa and chocolate

Caffeine is a purine alkaloid contained in a variety of plants - coffee, tea or guaranin. It is known that caffeine has psycho-stimulatory properties, diuretic effect, increases hydrochloric acid formation, dilates the bronchi and stimulates cardiac activity (Slíva and Minárik, 2009).

Studies in many countries have now shown that coffee is actually the major individual source of dietary antioxidants (exceeding wine, tea, chocolate, and individual fruits and vegetables),

and in-vitro studies have also shown that some coffee constituents can induce the expression of carcinogen detoxifying enzymes. The preponderance of scientific evidence suggests that moderate coffee consumption (3–5 cups/day) may be associated with reduced risk of certain disease conditions (Clemens and Coughlin, 2007).

Cocoa contains a number of flavonoids that have beneficial cardiovascular health effects. Consumption of cocoa with a high content of flavonoids is associated with an acute increase in circulating nitrous oxide, blood vessel enlargement and increased microcirculation. Long-term consumption of high-flavonoid cocoa is associated with cardiovascular health benefits. Hot chocolate containing at least 75% cocoa is a rich source of antioxidants. In milk chocolate, milk ingredients reduce the total cocoa content and increase the level of saturated fat, negating the potential benefits of cocoa for the heart. Some studies have found short-term benefits in LDL cholesterol levels after dark chocolate consumption (Keen et al., 2005).

Fruits and vegetables

Epidemiological studies have established a positive correlation between the intake of fruits and vegetables and prevention of diseases like atherosclerosis, cancer, diabetes, arthritis and also ageing. The most thoroughly investigated dietary components in fruits and vegetables acting as antioxidants are fibres, polyphenols, flavonoids, conjugated isomers of linoleic acid, D-limonene, epigallocatechin gallate, soya protein, isoflavanones, vitamins A, B, C, E, tocopherols, calcium, selenium, chlorophyllin, alipharin, sulphides, catechin, tetrahydrocurecumin, seasaminol, glutathione, uric acid, indoles, thiocyanates and protease inhibitors (Kaur and Kapoor, 2001). Bioflavonoids and polyphenolic substances found in fruits have a major contribution to the antioxidant capacity of their juices. The most effective is the dark fruit, especially Aronia melanocarpa (Racek, 2003; Poráčová et al., 2016).

Green and black tea

Tea is the second most consumed drink in the world after water. Green tea is a ‘non-fermented’ tea, and contains more catechins than black tea or oolong tea. Catechins are in vitro and in vivo strong antioxidants. In addition, certain minerals and vitamins increase the antioxidant potential of this type of tea. Since ancient times, green tea has been considered by the traditional Chinese medicine as a healthful beverage. Recent human studies suggest that green tea may contribute to a reduction in the risk of cardiovascular disease and some forms of cancer, as well as to the promotion of oral health and other physiological functions such as anti-hypertensive effect, body weight control, antibacterial and antiviral activity, solar ultraviolet protection, bone mineral density increase, anti-fibrotic properties, and neuroprotective power (Cabrera et al., 2006).

Tea is one of the most commonly consumed beverages in the world and is rich in polyphenolic compounds collectively known as the tea flavonoids. Tea flavonoids possess antioxidant properties in vitro and have been proposed as key protective dietary components, reducing risk of coronary heart disease and some cancers (Langley-Evans, 2000).

Tea includes tannins, flavonoids, catechins, enzymes, teens, caffeine, minerals, vitamins B1, B2, B6, B9, A, C, P. They support the immune system and increase the resistance to infections. The cup of tea contains approximately 140 mg of flavonoids. Tea flavonoids have a high antioxidant activity, so in many studies the antioxidant strength of tea is compared with fruit and vegetables. It has been found that daily consumption of three cups of tea has the same antioxidant effects as daily consumption of six apples. Another study showed that one or two cups of tea have the same effect as five pieces of fruit or vegetables or 400 mg of vitamin C. The significant anti-cancer effect of green tea has been confirmed in animals and humans (Slíva and Minárik, 2009; Kimáková et al., 2012, Ďuračková, 2010; 2014).

Red wine

Epidemiological studies suggest that the consumption of wine, particularly of red wine, reduces the incidence of mortality and morbidity from coronary heart disease. This has given rise to what is now popularly termed the “French paradox”. The cardioprotective effect has been attributed to antioxidants present in the polyphenol fraction of red wine. Grapes contain a variety of antioxidants, including resveratrol, catechin, epicatechin and proanthocyanidins. Of these, resveratrol is present mainly in grape skin while proanthocyanidin is present in the seeds (Das et al., 1999; Kimáková et al., 2012).

Red wine contains polyphenol resveratrol. This antioxidant protects the organism from the effects of free radicals. Resveratrol has anti-inflammatory and anticancer effects. It works against stiffening of arteries and other blood vessels. It is found in red grapes, blackberries and raspberries. Red wine contains 1,000 - 4,000 mg phenols per litre while white wine contains 200 - 500 mg phenols per litre. (Racek, 2003; Mojžiš and Mojžišová, 2007; Mikuš and Pružinec, 2007).

Polyphenol flavonoids counteract oxidative stress, protect against the toxic effects of pure alcohol, and together with alcohol improve the spectrum of blood lipids. However, it is most important to consume the wine with a limit of maximum two cups a day, and especially after a meal (Novotný et al., 2009).

Virgin olive oil, olives

Epidemiological studies suggest that a Mediterranean diet (which is rich in virgin olive oil) decreases the risk of cardiovascular disease. The Mediterranean diet, rich in virgin olive oil, improves the major risk factors for cardiovascular disease, such as the lipoprotein profile, blood pressure, glucose metabolism and antithrombotic profile. Endothelial function, inflammation and oxidative stress are also positively modulated. Some of these effects are attributed to minor components of virgin olive oil. Therefore, the definition of the Mediterranean diet should include virgin olive oil. Microconstituents from virgin olive oil are bioavailable in humans and have shown antioxidant properties and capacity to improve endothelial function. Furthermore, they are also able to modify the haemostasis, showing antithrombotic properties. In countries where the population consumes typical Mediterranean diet, such as Spain, Greece and Italy, where virgin olive oil is the principal source of fat, cancer incidence rates are lower than in northern European countries (Perez-Jimenez, 2005).

Polyphenols from olives have potent antioxidant activities; 50% of the phenolic compounds contained in olives and virgin olive oil are hydroxytyrosol and derivatives thereof. Hydroxytyrosol is the major olive polyphenol consumed and well absorbed in humans. It is considered to have the highest antioxidant potency compared to the other olive polyphenols. Review of the human intervention studies showed that olive polyphenols decreased the levels of oxidized-LDL in plasma and positively affected several biomarkers of oxidative damage (Raederstorff, 2009). One tablespoon of olive oil corresponds to the cholesterol from two eggs which are eaten. Antioxidants in olive oil can help reduce aging. The protective effect of virgin olive oil can be most important in the first decades of life, which suggests that the dietetic benefit of virgin olive oil intake should be initiated before puberty, and maintained through life (Perez-Jimenez, 2005; Považanová, 2007).

TABLE I.

Twelve steps to healthy eating

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- Eat a nutritious diet based on a variety of foods originating mainly from plants, rather than animals.
- Eat bread, whole grains, pasta, rice or potatoes several times a day.
- Eat a variety of vegetables and fruits, preferably fresh and local, several times a day (at least 400 g per day).
- Maintain body weight between the recommended limits (a BMI of 18.5 – 25) by completing moderate to vigorous levels of physical activity, preferably daily.
- Control fat intake (not more than 30% of daily energy) and replace most of the saturated fats with unsaturated fats.
- Replace fatty meat and meat products with beans, legumes, lentils, fish, poultry or lean meat.
- Use milk and dairy products (kefir, sour milk, yoghurt and cheese) that are low in both fat and salt.
- Select foods that are low in sugar, and eat free sugars sparingly, limiting the frequency of sugary drinks and sweets.
- Choose a low-salt diet. Total salt intake should not be more than one teaspoon (5g) per day, including the salt in bread and processed, cured and preserved foods. (Salt iodization should be universal where iodine deficiency is a problem)
- WHO does not set particular limits for alcohol consumption because the evidence shows that the ideal solution for health is not to drink at all, therefore less is better.
- Prepare food in a safe and hygienic way. Steam, bake, boil or microwave to help reduce the amount of added fat.
- Promote exclusive breastfeeding up to 6 months, and the introduction of safe and adequate complementary foods from the age of about 6 months. Promote the continuation of breastfeeding during the first 2 years of life (WHO/FAO, 2005, WHO, 2015).
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DISCUSSION AND CONCLUSION

A diet rich in natural antioxidants can influence the increase of reactive antioxidant potential of the organism and therefore minimize the risk of developing chronic diseases. The organism obtains exogenous antioxidants from food, for example, vitamin C and vitamin E and also compounds of polyphenolic structure synthesized in plants, including flavonoids. Individual antioxidants in the form of dietary supplements are more potent and bioavailable than they are in food matrices, and they do not exhibit the synergistic effects with other compounds found within natural food sources. The supplements most likely do not possess all the physiologically active components needed to be truly effective in preventing disease incidence and progression (Milbury and Richer, 2008; Ďuračková, 2010; 2014).

To ensure a healthy lifestyle, WHO recommends eating lots of fruits and vegetables, reducing fat, sugar and salt intake and exercising. Based on height and weight, people can check their BMI to see if they are overweight. WHO provides a series of publications to promote and support healthy lifestyles (WHO/FAO, 2005; WHO, 2015). Twelve steps to healthy eating can be seen in *Table I*. There is evidence of antioxidants role of defending the body against the oxidative stress. Fruits, vegetables, cereal and legumes, tea, coffee, wine, chocolate as well as herbs and spices are the rich sources of antioxidants.

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