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Mini Review

An overview on some of important sources of natural antioxidants

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Abstract

Oxidation as a reaction in many kinds of foods is a nearly ubiquitous chemical reaction that involves the transfer of electrons from one compound to another, has long been known to have negative effects, especially in physiological contexts. Besides that, antioxidants in food may be defined as any substance which is capable of delaying, retarding or preventing the development of rancidity or other flavour deterioration due to oxidation. Antioxidants may be synthetic or natural. Natural antioxidants (NAO) are generally preferred by consumers. NAO can be found in many sources such as legumes, nuts, oilseeds, cereals, fruits, vegetables, animal products. In this article, sources of antioxidants specifically natural antioxidants are described.

Introduction

Antioxidants apply as inhibitor of the oxidation process (Maestri *et al*., 2006; Mandal *et al*., 2009), even at relatively small concentration and thus have diverse physiological role in the body (Mandal *et al*., 2009). They are important in prevention of plants pollution damage, disease prevention in both plants and animals and play an important role in the body defense system (Ou Huang, 2002; Ahmed and Beigh, 2009).These compounds quench dreaded free radicals and stop oxidation chains *in-vivo* as well, so they have become viewed by many as nature's answer to environmental and physiological stress, aging, atherosclerosis, and cancer (Maestri *et al*., 2006). Consumers believe that foods rich in antioxidants may afford a degree of protection against free radical damage not only in foods, but also in the human body, protecting against cardiovascular diseases, damage of nucleic acids, and other deteriorative processes (Yanishlieva-Maslarova and Heinonen, 2001).

Antioxidants are categorized in two groups of synthetic and natural (Gupta and Sharma, 2006), which most of them are polysubstituted phenolic compounds (Pokorny, 1991). Natural antioxidants are primarily phenolics that may occur in all parts of plants (Asif, 2015), such as fruits, vegetables, nuts, seeds, leaves, roots and barks (Pratt and Hudson, 1990). They scavenge harmful free radicals, which are implicated in the most common cancers and other degenerative diseases including poor brain function (Dillard and German, 2000). Various natural substances were used, but were soon replaced by synthetic chemicals, which are cheaper, more easily available, of consistent quality, and have greater antioxidant activity (Pokorny, 1991). The permitted antioxidants and synergists are restricted to a few compounds: propyl- and dodecylgallate, butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), tert-butyl hydroquinone (TBHQ), ascorbyl palmitate, tocopherols, citric acid and its esters, thiodipropionic acid, lecithin, carotene, and silicone oil (for frying fats) (Yanishlieva-Maslarova and Heinonen, 2001).

A synthetic compound has to meet the following requirements: it should not be toxic; it has to be highly active at low concentrations (0.01–0.02%); it has to concentrate on the surface of the fat or oil phase (Belitz *et al.*, 2009). Due to the non-protein nature, synthetic antioxidant compounds are relatively stable and usually able to penetrate the cells, and thus some of them can be administered orally (Li, 2011).

Some antioxidants are enzymes and proteins and the others are small molecule ones. Foods are important

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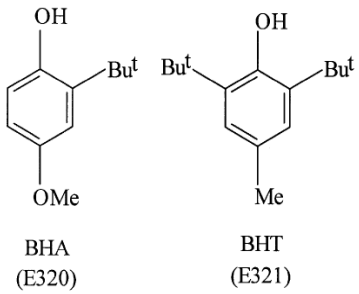

Figure 1. The structures of BHA and BHT

as essential sources of such antioxidants, components and trace elements. The phenolic compounds such as vitamin E and flavonoids are typical antioxidants. In addition, numerous synthetic antioxidants have been developed and some of them have been used in practice as food additives, supplements and drugs. Numerous phenolic compounds have been also synthesized. 2,6-di-tert-butyl-4-methylphenol which is known as BHT is one of the most popular synthetic antioxidants (Yanishlieva-Maslarova and Heinonen, 2001). However, it is generally accepted that natural antioxidants are more potent, efficient and safer than synthetic ones (Tavasalkar *et al*., 2012). BHT and BHA (Figure 1), are the most widely used antioxidants (Lalas and Tsaknis, 2002; Gunstone, 2004). In order to overcome the stability problems of frying oils, synthetic antioxidants, such as BHA, BHT, and TBHQ have been used as food additives. But recent studies have provided evidence for their role as carcinogens (Gohari Ardabili *et al*., 2010). Thus, the search for effective, non-toxic natural compounds with antioxidative activity has been intensified in recent years (Gupta and Sharma, 2006). Furthermore α-tocopherol is the most active form of vitamin E and natural α-tocopherol is more potent than synthetic racemic α-tocopherol primarily. As such, natural antioxidants are more favorably accepted than synthetic antioxidants (Yanishlieva-Maslarova and Heinonen, 2001).

Natural antioxidants are generally preferred by consumers, and may gain legislative approval more easily than synthetic additives do (Yanishlieva-Maslarova and Heinonen, 2001). The fact that a substance is natural and commonly round in food is no guarantee that it is entirely nontoxic. It may have low toxicity, or be carcinogenic or mutagenic. Synthetic antioxidants are tested for such effects, but many natural food components have not yet been tested (Pokorny, 1991).

In natural antioxidant sources, many kinds of compounds can be fined. So in figure 2 you can see some important phenolic compounds and the classifications. As it is shown in figure 2,

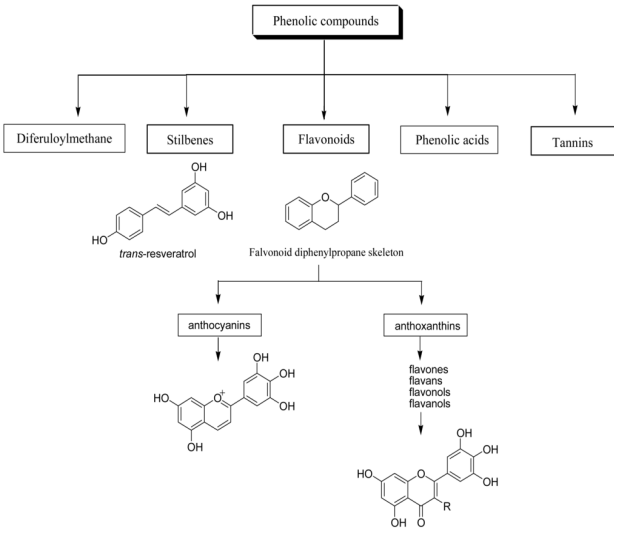

Figure 2. Classification of polyphenols (Han *et al*., 2007)

phenolic compounds are divided in 5 sub-groups (Diferuloylmethane, stilbenes, flavonoids, phenolic acids and tannins). Moreover you can see the flavonoids sub-group is classified to anthocyanins and anthoxanthins.

Natural antioxidant

As mentioned above, natural antioxidants are present in plants, and this is why the basic source of these compounds for humans is plant-derived products. Plant phenolics are multifunctional and can act as reducing agents, free radical terminators, metal chelators and singlet oxygen quenchers (Mathew and Abraham, 2006). Fat soluble vitamins and selenium also occur in food derived from animals (milk and fish lipids, eggs), but in smaller amounts, and depending on the kind of feed consumed (e.g. carotenoids content in milk lipids, eggs). That is why products derived from animals are not significant sources of antioxidants in human diet.

Some common sources of natural antioxidants

It should be mention that the major sources of naturally occurring antioxidants are fruits (Arshiya, 2013), vegetables (Parashar *et al*., 2014), whole grains (Karrar, 2014), green (Thasleema, 2013) and black tea (Perron and Brumaghim, 2009), coffee (Nardini *et al*., 2002), wine (Ghatak *et al*., 2014), beer (Sikora *et al*., 2008), herbs and spices (Alok *et al*., 2014).

Natural antioxidants from legumes, nuts and oilseeds

A variety of studies have reported the antioxidant activities of many legumes, such as yellow and green peas, chickpea, lentils, common beans (pinto, great northern, navy, black, dark red kidney, light red kidney, red Mexican, pink and alubia bean), fava beans, beach bean, and yellow and black soybeans

(Wang *et al*., 2011). Peanuts, peas, and edible beans will be highlighted with a focus on polyphenolics and phenolic acids. Red peanut skins were found to contain 7–9% procyanidins which 50 % of these are low molecular weight phenolic oligomers. The water soluble 2,3-cis-procyanidins were found to be the predominant procyanidins and are characterised by a bond linked with a β (4→8) or β (4→6) arrangement that terminates by a 2,3-trans-flavan-3-ol catechin (Yanishlieva-Maslarova and Heinonen, 2001). Polyphenolics in walnut seed include the monomers ellagic acid, gallic acid and methyl gallate, when present as polymers and bound to sugars are known as hydrolyzable tannins, and comprise the majority of the polyphenolics present. The major lipid-soluble antioxidants found in peanut and in other oilseeds are tocopherols (Maestri *et al*., 2006).

Flaxseed, sunflowers, soybean, cottonseed, and canola antioxidants typify the antioxidants from oilseeds. An important group of antioxidants includes the sterols. These compounds have been shown to prevent thermal oxidative degradation of oils. The antioxidants of confectionery and oil sunflowers include phenolic acids, tocopherols and sterols while purple hulled varieties contain significant concentrations of anthocyanins. Tocopherol homologues are phenolic antioxidants that occur naturally in vegetable oils and provide some protection against oxidation by terminating free radicals (Gohari Ardabili *et al*., 2011). The average tocopherol content in sunflowers is 649 ppm (Przybylski and Mag, 2002) with 94% as α-tocopherol and β-tocopherols each accounting for 3% of the total. The other sterols include campesterol, stigmasterol, Δ^7-stigmasterol, and Δ^5- and Δ^7-avenasterol. The high concentrations of sterols would play a significant role in frying applications as a means of preventing oil polymerization and thermal degradation. In addition, tocopherols serve as hydrogen donating and radical-trapping antioxidants, which benefit fat-based food systems. Soy concentrates and aqueous extracts of soybeans contain isoflavones and phenolic acids as the main antioxidants (Yanishlieva-Maslarova and Heinonen, 2001).

Natural antioxidants from cereals

Cereals are among the most common food components, and can be added to many food products (Yanishlieva-Maslarova and Heinonen, 2001). Among polyphenols enclosed in cereal grains, phenolic acids play important role, and especially ferulic acid is dominating in grains (in wheat and rye, first of all). Beside this compound, vanillic and p-coumaric acids play important role, even though they are present in smaller amounts. In the case of oats, the presence of other polyphenols called avertramidin has been reported, while rutin is the main polyphenol of buckwheat (Vollmannova *et al*., 2013). Furthermore, hand dissection of barley kernels showed that the germ was a significant source of tocopherol and tocotrienols (i.e. Tocols) at 206 mg/kg of the germ and buckwheat contains 387 and 1314 mg/100g flavonoids and 47 and 77 mg/100g rutin in the seeds and hulls, respectively. The antioxidants of corn are unique in the fact that carotenoids make up part of the antioxidants, which is not true in the case of most cereals. It has been reported that carotene and xanthophyll levels of yellow corn are 2.7 and 19.9 ppm, respectively (Sikora *et al.*, 2008). The cereal grains are also a source of catechins; the higher amounts of these compounds were found in seeds of buckwheat, next – in oats and rye, and at least in wheat (Peterson *et al*., 2001; Holasova *et al*., 2002). Moreover rice bran oil is a rich source of antioxidant components. Rice bran oil contains about 0.1–0.14 vitamin E components and 0.9%–2.9% oryzanol (Arab *et al*., 2011). It also contains 608 ppm tocols (343 ppm tocopherols and 265 ppm tocotrienols) and 2847 ppm oryzanols (Yanishlieva-Maslarova and Heinonen, 2001).

Natural antioxidants from fruits and vegetables

Fruits contain several vitamins and mineral salts, and also dietary fiber. The most of fruits are rich source of vitamin C, carotenoids and polyphenolic compounds (Sikora *et al*., 2008; Ellong *et al*., 2015). It has been reported that apples have very strong antioxidant activity, inhibit cancer cell proliferation, decrease lipid oxidation, and lower cholesterol (Andres-Lacueva *et al*., 2010). Potato *(Solanum tuberosum)* is considered as a good source of antioxidants such as ascorbic acid, α-tocopherol and polyphenolic compounds. However, most studies have been focused on the antioxidant activity of phenolic compounds in potato (Yanishlieva-Maslarova and Heinonen, 2001). Over 20 compounds of quercetin and kaempferol were found in cabbage (Sikora *et al.*, 2008).

Furthermore, the antioxidant activity of onion *(Allium cepa)* and onion scales has been studied in lipid oxidation models and in radical scavenging assays. Both yellow and red onions were poor antioxidants towards oxidation of methyl linoleate in contrast to their high antioxidant activity towards oxidation of LDL (Yanishlieva-Maslarova and Heinonen, 2001).

Green tea consists of essential oil, tannin, caffeine, vitamin, and pigment. The pigments of

Table 1. Summary of the most common natural antioxidants and their typical sources (Carr *et al*., 2000; Urquiaga and Leighton, 2000; McGhie and Walton, 2007)

Compound name	Natural source
Ascorbic acid	Most fruits (particularly citrus fruits), some vegetables, tomatoes
Tochopherols	Cereal grains, broccoli, Brussels sprouts, cauliflower, cooking oils (olive, sunflower, safflower), almonds, hazelnuts
Beta-carotene	Vegetables such as kale, red paprika, spinach, parsley, and tomatoes, carrots, sweet potatoes, apricots, papayas
Flavonoids (a type of polyphenol)	Potatoes, tomatoes, lettuce, onions, wheat, Concord grapes, black tea
Anthocyanins (a type of flavonoid)	High content in red wines
Various polyphenols	Teas (mainly green, some rooibos), as well as many red/purple hued fruits or vegetables, such as Concord grapes, red cabbage, blueberries, blackberries, açai berries, etc
Lycopene	Tomatoes, papaya, watermelon, pink grapefruit, guava, the skin of red grapes
CoQ10	Wheat bran

green tea consist of chlorophylls and carotenoids. Chlorophylls are dominant pigments of fresh green tea leaves, but easily degrade, turning into pheophytin and pheophorbide after heating and storing processes. pheophytin has been reported to have antioxidant activity (Kusmita *et al*., 2015).

The main sources of flavonoids are vegetables and fruits (Loprinzi and Mahoney, 2015). For instance, the content of quercetin glycoside in outer leaves of lettuce could be as high as 237 mg/kg fresh weight, and the content of kaempferol glycoside in kale could be 250 mg/kg fresh weight (Yanishlieva-Maslarova and Heinonen, 2001). Pumpkin seed extract has been reported to have anticancer, antimutagenic, and antioxidant activities (Gohari Ardabili *et al.*, 2011). The antioxidant and radical scavenging activities of black pepper *(Piper nigrum)* seeds have been well reported (Khalaf *et al*., 2008). Among vegetables, the best sources of antioxidants are tomatoes, red pepper, Brassica vegetables, onion, garlic and red beet. Red pepper is appreciated mainly because of high content of vitamin C (144 mg/100 g) and cryptoxantin, and tomatoes as a source of lycopene. In red pepper, two derivatives of quercetin, tree – luteolin and one – apigenin were also found (Materska and Perucka, 2005). Lycopene is present in tomatoes peel in amount of 3025 µg/100 g, however, considerably higher amounts, and better absorbed form is supplied by tomatoes preserves, for example ketchup (9900 µg/100 g) (Horbowicz and Saniewski, 2000, Lugasi *et al*., 2003). Moreover, there are some new and unique antioxidants that have been discovered in spinach. NAO is an aqueous spinach-leaf extract that contains derivatives of flavonoids and p-coumaric acid (Shebis *et al*., 2013). At all, in table 1 some common natural antioxidants gathered and also you can find their sources in it.

Conclusions

As it mentioned antioxidant can be considered as a healthy compounds and you can find it in two form of natural and synthetic. Surveys show that the natural antioxidants are safer and have better effects on human. In this article, we talked about some common sources of natural antioxidants (Fruit and vegetables, cereals, legumes, nuts and oilseeds) and show you the antioxidant impact of these sources. Also the kind of antioxidant compound and its classification was mentioned. It can be concluded that using these compounds and products positively influence our health and we should use them in our diet.

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