Antioxidants and Health

Introduction

See the table that compares the ORAC strength of different foods, vitamins and supplements as antioxidants. The more familiar antioxidants include vitamins E and Vit. C; the carotenoids (such as beta-carotene); selenium; and flavonoids (anthocyanidins, polyphenols, quercetin). All of these are readily supplied by a varied and well-balanced diet. Probably lesser known are the antioxidants produced by the body itself. These include glutathione, alpha-lipoic acid, and coenzyme Q_{10}.

In addition, some supplements, such as zinc, copper, and selenium, are necessary to actually strengthen the body's own antioxidant protection system.

Antioxidants absorb oxygen radicals

Humans and other living creatures have a highly complicated antioxidant defense system composed of enzymes and vitamins. Antioxidants are classed as phytochemicals (phyto = plant) and are Mother Nature's protection from assaults by free radicals. The term "free radicals" refers to unstable oxygen molecules that damage our body's cellular walls, damaging DNA (genetic material), proteins and fats and so causing ageing. Free radicals are highly reactive molecules that are produced in the body as a by-product of metabolism in cells. Degenerative human diseases have been recognised as being a consequence of free radical damage (Swatsitang *et al*, 2000). The buildup of free radicals leads to a condition termed oxidative stress.

Antioxidants are compounds that neutralise the damaging effects of oxidation. Research indicates that antioxidants help prevent the development of heart and lung diseases, some cancers, cataract formation and the effects of ageing. According to

Oxidation in foods and biological systems occurs via free radical reactions. Foods or ingredients that h ave the ability to remove (scavenge) the free radicals stabilize the foods or biological system, and their ability to scavenge is measured as the Oxygen Radical Absorbance Capacity (ORAC).The antioxidant activity of foods is determined using a method designed to give maximum extraction of the antioxidant capacity of the sample. The stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical gives a strong absorption maximum at

Chan *et al* (1997), oxidative stress can compromise the body's immune response, heighten the inflammatory response, increase the incidence of CD4 cell apoptosis (a type of programmed cell death) and has been implicated in HIV-related muscle wasting and weight loss, dementia and neuropathy.

517 nm and is purple in color. The color turns from purple to yellow when the odd electron of DPPH radical becomes paired with hydrogen from a free radical scavenging antioxidant forming the reduced DPPH-H. The resulting decolorization is stoichiometric with respect to the number of electrons captured. The reference standard, Trolox [(S)-(-)-6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid], and the sample are extracted and reacted with the methanol-water DPPH solution for four hours at 35°C and the absorbance changes are measured at 517 nm. The quantity of sample necessary to react with one half of the DPPH is expressed in terms of the relative amount of Trolox reacted. Antioxidant activity of a sample is expressed in terms of micromole equivalents of Trolox (TE) per 100 grams of sample, i.e. Trolox units per 100 gm or TE/100g. (medlabs).

Antioxidants are found naturally in the body and a variety of foods – especially fruits and vegetables. Oxidation is cellular damage caused by free radicals. Our bodies have a built-in "defence system" of antioxidants that serve to prevent damage from free radicals. The main source of these antioxidants is fruits and vegetables that we recognise as food, the heritage of our pre-agricultural lifestyles. These foods provide antioxidant nutrients such as vitamins A, C, E and selenium.

Various measures of antioxidant capacity have been developed (Milner, 2000). Of these the relative ORAC efficacy (FL Units) appears to be more widely quoted. The oxygen radical absorbance capacity (ORAC) is a test tube analysis that measures the total antioxidant power of foods and other chemical substances, usually per 100 grams. The USDA recommends an intake of 3000 to 5000 ORAC units/ day. Research shows that the average person generates about 5000 ORAC units of free radicals each day, but only obtains about 1250 ORAC units of antioxidants through the diet. ORAC (Oxygen Radical Absorbance Capacity) units quoted on this site are per 100 grams.

Fast acting antioxidants, such as ascorbic acid, phenolic acids completely inhibit free radical propagation. Slow acting antioxidants consist of the tocopherols, polyphenols, flavonoids, and certain proteins and lipids, that are found in the blood stream (serum).These serum antioxidants are largely made up of the following, protein-thiols, vitamin C, Vitamin E, Uric acid, bilirubin, carotenoids, vitamin A, lipids and some unknown factors (Genox Corp., 2003)

No two antioxidants are exactly alike. Some are fat-soluble, some are water-soluble,

some are soluble in both water and fat. Some antioxidants concentrate in the liver, while others protect the eyes or heart. You should therefore work on having a variety of antioxidants in your diet.

Ageing

Doctor Percival (1998), in an article on **antioxidants** in "*Clinical nutrition insights*", observed that the "damage to cells caused by free radicals is believed to play a central role in the **ageing process** and in **disease progression**. **Antioxidants** are our first line of defence against free radical damage, and are critical for maintaining optimum health and well-being. The need for antioxidants becomes even more critical with increased exposure to free radicals. Pollution, cigarette smoke, drugs, illness, stress, and even exercise can increase free radical exposure." Because many environmental factors contribute to what he terms, "oxidative stress", the assessment of individual susceptibility becomes important. He continues, "Many experts believe that the Recommended Dietary Allowance (RDA) for specific antioxidants may be inadequate and, in some instances, the need may be several times the RDA. As part of a **healthy lifestyle** and a well-balanced, wholesome diet, antioxidant supplementation is now being recognised as an important means of improving free radical protection."

This view is supported by other scientists such as in the 1993 publication by Ames, Shigenaga, and Hagen who observe that "Metabolism, like other aspects of life, involves trade-offs. Oxidant by-products of normal metabolism cause extensive damage to DNA, protein, and lipid. We argue that this damage (the same as that produced by radiation) is a major contributor to ageing and to degenerative diseases of ageing such as cancer, cardiovascular disease, immune-system decline, brain dysfunction, and cataracts. Antioxidant defences against this damage include ascorbate, tocopherol, and carotenoids. Dietary fruits and vegetables are the principal source of ascorbate and carotenoids and are one source of tocopherol. Low dietary intake of fruits and vegetables doubles the risk of most types of cancer as compared to high intake and also markedly increases the risk of heart disease and cataracts. Since only 9% of Americans eat the recommended five servings of fruits and vegetables per day, the opportunity for improving health by improving diet is great."

Another view proposed by Gregg (1988) amounts to a slightly different perspective on

antioxidants, "If we focus on the dominant chemical process in our body based on simple quantity, the energy supply process of metabolism, the true beneficial effect of antioxidants is not the selective elimination of damaging free radicals, but rather the enhancement of metabolism. This will increase the rate of consumption of oxygen, lowering the local oxidation potential, making oxidative damage less likely. As a natural unavoidable consequence, it will increase cellular energy, which can be used for everything including the prevention or repair of damage. Concerning cellular damage, it is very likely that the increased availability of cellular energy is considerably more important than the reduction of oxidation potential (oxidative free radicals)."

Free radicals

Free radicals are potentially damaging molecules released in the body through normal metabolic processes and are capable of attacking the healthy cells of the body, causing them to lose their structure and function - to age. Free radicals are electrically charged molecules and so react with other substances in order to neutralise themselves - a process called **oxidation**. In this process, a chain reaction is initiated as another free radical is formed, leading to thousands of free radical reactions within seconds of the initial reaction. Antioxidants act to stabilise or deactivate free radicals before they attack cells and so are essential for maintaining optimal cellular and systemic health and well-being. Free radicals are also called reactive oxygen species (ROS), a term that encompasses all highly reactive, oxygen-containing molecules. Dr. Percival (1998) says, "They can react with membrane lipids, nucleic acids, proteins and enzymes, and other small molecules, resulting in cellular damage."

These free radicals or ROS are formed via three normal and natural body processes. Our ancestors diet was natural and fresh enough to supply plentiful antioxidants to counter the formation of free radicals. Free radicals are formed via:

1. **Normal aerobic metabolic processes.**
2. **White blood cell (phagocytes) defensive mechanisms, by which bacteria and viruses are killed, and by which foreign proteins (antigens) are denatured.**
3. **The natural detoxification of toxic substances (such as nicotine in cigarette smoke) -**
   termed xenobiotic metabolism.

Common examples of oxidation in everyday life include the rusting of metal, the browning of fruit and the rancidity of oils.

Disease

Free radicals damage to cells (oxidative stress) is now believed to contribute significantly to ageing and to degenerative ageing diseases such as cancer, cardiovascular disease, cataracts, immune system decline, and brain dysfunction. Free radicals activity has been implicated in at least 50 diseases (Percival, 1998). Antioxidants reduce free radical formation. Our modern lifestyles may limit the availability of antioxidants, allowing free radicals to cause cumulative and debilitating damage to our cells.

Some of the diseases attributed to oxidative stress include, Alzheimer's Disease, Macular Degeneration, Autoimmune Disease Multiple Sclerosis, Cancer Muscular Dystrophy, Cardiovascular Disease Pancreatitis, Cataractogenesis Parkinson's Disease, Diabetes Rheumatoid Arthritis, Iron Overload Segmental Progeria Disorders and Ischemic-Reperfusion Injury (Genox Corp, 2003).

Different antioxidants are effective against different diseases, so the science of antioxidant treatment will become quite complex. The Genox Corporation (2003) states that 150 epidemiological studies show an inverse correlation between blood serum levels of carotenoids, tocopherols and retinol and the incidence of various cancers and other human diseases.

Modern lifestyles

Our 21st century technological and industrial way of life contributes significantly to an increase in the body's oxidant load. Dr Percival lists a number of things that increase our oxidant load:

- **Vigourous exercise, accelerating cellular metabolism;**
- **Chronic inflammation, infections, and other illnesses;**
- **Exposure to allergens and the presence of "leaky gut" syndrome; and**
- **Exposure to drugs or toxins such as cigarette smoke, pollution, pesticides, and insecticides.**

- **The absorption of these important trace minerals required by antioxidant enzymes may decrease with ageing.**
- **Intensive agricultural methods have also resulted in significant depletion of valuable trace minerals from our soils and the foods grown in them.**

Oliveri (2003) reports that one study found that the average American eats only two servings of vegetables daily, not three to five as recommended, and only one serving of fruit instead of the recommended two to four servings each day. She reports that the Framingham heart study found that eating three additional servings daily of fruits and vegetables daily could reduce overall stroke rates by 22% and risk of bleeding stroke by 51%. Eating 5 to 9 servings of fruits and vegetables daily increases the phytochemicals and antioxidants in your diet.

Antioxidant compounds

Antioxidant components include:

- **Ascorbic acid (vitamin C), Vitamin A (tocopherols), (retinol and carotenoids), tocotrienols (vitamin E), carotenoids;**
- **Low molecular weight compounds such as glutathione and lipoic acid. Glutathione is an important water-soluble antioxidant, synthesised from the amino acids glycine, glutamate, and cysteine.**
- **Antioxidant enzymes such as superoxide dismutase (SOD), glutathione peroxidase, and glutathione reductase, that catalyse free radical quenching reactions.**
- **Antioxidant enzymes that metabolise oxidative toxic intermediates require micronutrient or trace element cofactors such as selenium, iron, copper, zinc, and manganese for optimum catalytic activity.**
- **Metal binding proteins, such as ferritin, lactoferrin, albumin, and ceruloplasmin that sequester free iron and copper ions, capable of catalysing oxidative reactions.**
- **Numerous other antioxidant phytonutrients present in a wide variety of plant foods.**
- **Polyphenols include bioflavonoids, organic acids and phenolic acids, and most of the antioxidant activity in foods is attributed to its polyphenol content.**

Polyphenol testing by Brunswick Labs (Aug. 22, 2002) compared phenolic content of High Desert Bee Pollen to fruits such as blackberries, peaches and apples. The bee pollen posted a total polyphenol content of 15.05 mg/g; the next highest measurement was 5.575 mg/g for cranberries. The group of compounds, aspalathox, a rooibos tea concentrate has an ORAC value of 375000 ORAC units/100 grams (3.5 oz) making it an excellent antioxidant, rich in polyphenols, compounds known to possess potent antioxidant activity.The two types of polyphenols found in Aspalathox are the flavanoids and phenolic acids.

As an example, lipid peroxides are neutralised by beta carotene, vitamin E, ubiquinone, flavonoids and glutathione peroxidase. Free radicals based on hydrogen peroxide are neutralised by vitamin C, glutathione, beta carotene, vitamin E, CoQ10, flavonoids and lipoic acid.

Vitamin C, vitamin E, and beta carotene are currently the best understood and widely known dietary antioxidants. Another group of dietary antioxidant substances are plant-derived substances collectively termed "phytonutrients," or "phytochemicals". About 3,000 plant-derived flavonoid substances have been described. In humans, flavonoids have antioxidant effects serving as anti-inflammatory, antiallergenic, anti-viral, anti-aging, and anti-carcinogenic activity compounds. In addition to an antioxidant effect, Dr. Percival notes that "flavonoid compounds may exert protection against heart disease through the inhibition of cyclooxygenase and lipoxygenase activities in platelets and macrophages."

Most antioxidant combinations contain a standard ingredient base, namely vitamin C, vitamin E, beta-carotene, and the mineral selenium. After that, there is a great deal of variation. Some combinations include newly discovered antioxidants, such as proanthocyanidins (flavonoids found in grape seed extract, pine bark, and red wine), N-acetyl-cysteine (NAC), alpha-lipoic acid, coenzyme Q_{10}, and zinc. Others feature potent herbal antioxidants such as ginkgo biloba or green tea.

The word **nutraceutical** refers to foods or parts of foods that provide medical or health benefits, including the prevention and/or treatment of disease. Some examples of relationships between nutraceuticals and health benefits include the importance of calcium in preventing osteoporosis, folate in the prevention of neural tube defects in infants and

the role of decreasing dietary fat and increasing fibre in the prevention of colon cancer. Phytochemicals and antioxidants are two specific types of nutraceuticals (Oliveri, 2003).

Some ORAC values of foods are in Table 1 on the ORAC page.

Chinese medicine, yin and yang and antioxidants

Traditional Chinese herbs, identified as Yin-tonic herbs, have strong antioxidant activities and high ORAC values ranging from 433 to 1939 umol Trolox equivalent (TE)/g. Good antioxidant herbs are *Rhizoma coptidis* (Huanglian), *Radix scutellariae* (Huangqın), and *Radix et rhizoma rhei* (Dahuang) (Ou et al., 2003). Their ORAC values are comparable to or even higher than pure vitamin C (2000 mol TE/g) and E (1162 umol TE/g). The Yang-tonic herbs are not strong antioxidants.

Natural herbal balance against oxidative stress

Modern living has increased the challenges to our antioxidant defence system. The term "oxidative stress" has been coined to represent a shift towards the pro-oxidants in the pro-oxidant/antioxidant balance. This is caused by an increase in oxidative metabolism. This oxidative stress at the cellular level is caused by many factors, including exposure to alcohol, medications, trauma, cold, infections, poor diet, toxins, radiation, or strenuous physical activity. This is why very fit athletes are more prone to get "flus" and "colds" - their training regime has increased their oxidative stress. Protection against these processes requires antioxidant substances derived directly or indirectly from the diet. An inadequate diet - modern fast foods - lacking antioxidant nutrients may not allow one's full antioxidant potential, so increasing overall oxidative stress. Dr. Percival (1998) and the Genex Corporation (2003) list the following diseases as associated with **oxidative stress.**

The human body utilise an integrated antioxidant system where different natural antioxidants complement each other. The reducing potential of each antioxidant within the whole defence system is enhanced when a full complement of antioxidants is available. As such, the best source of antioxidants is a natural source with a balanced mix of available antioxidants.

Other antioxidant sources

The antioxidant capacity of different foods and compounds is measured as the Oxygen Radical Absorbance Capacity (ORAC) test.

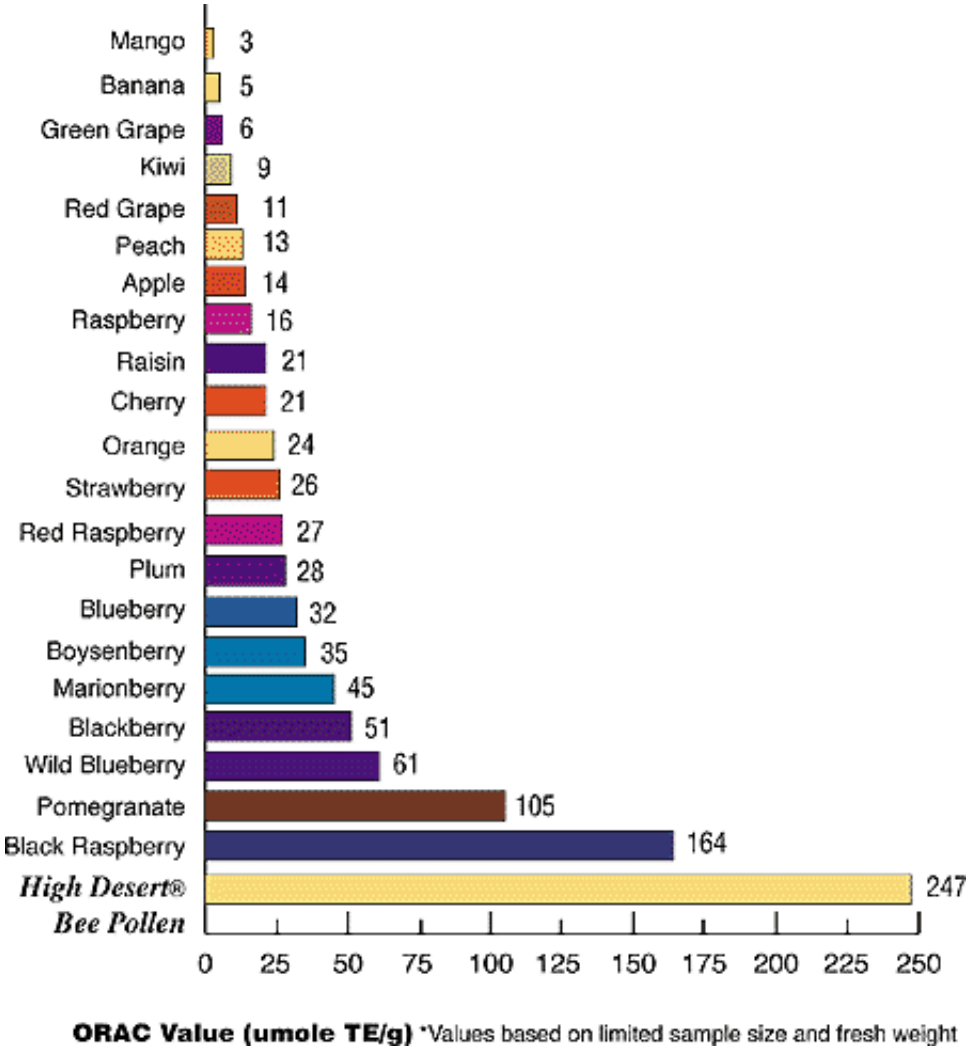

Chart from http://www.hsrmagazine.com/articles/2c1specialty2.html Vitamin C has a relative ORAC efficacy of 0.95, while Black Tea has a value of 17267, Raspberry Juice, 54034 and grape juice 31441 (Milner, 2002).

Antioxidant Books