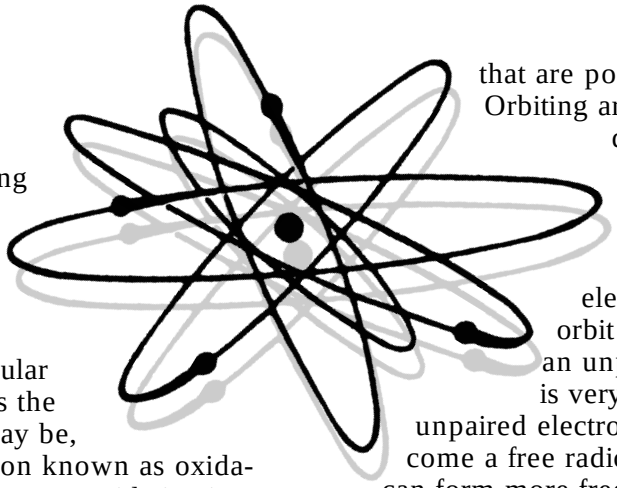
ALABAMA A&M AND AUBURN UNIVERSITIES

ALABAMA COOPERATIVE Extension SYSTEM

HE-778

Antioxidants and Health



Over the last 20 years scientists have been able to demonstrate a common link among the various chronic diseases that currently plague people in the United States. For example, conditions such as cancer, Alzheimer's disease, rheumatoid arthritis, cardiovascular disease, and cataracts as well as the actual aging process itself all may be, in part, caused by a phenomenon known as oxidative or free radical damage. The term oxidative is used because oxygen is frequently involved.

Antioxidants, on the other hand, are chemical compounds that can prevent, stop, or reduce oxidative damage. It is the balance between the free radicals that are produced and the amount of antioxidants available to prevent or reduce the free radicals that actually determines the amount of tissue damage. The balance between free radicals and antioxidants will determine the amount of oxidative stress a person is undergoing. Decreasing free radical production, increasing dietary antioxidant intake, or both can reduce oxidative stress. The worst case scenario would be a person who is producing a large number of free radicals but who has a very low antioxidant status. This would create a large oxidative stress and could, over time, produce significant damage to the person's body tissues.

Outlined in this publication are descriptions of what free radicals are, how they cause oxidative damage, and how they are produced in the body. Also included are descriptions of various types of antioxidants and how they work as well as information on using supplements as a source of antioxidants versus obtaining antioxidants in foods.

Free Radicals and Oxidative Damage

What are free radicals? They can best be described as follows. Normally, atoms have a central area called a nucleus. The nucleus contains protons that are positively charged particles. Orbiting around the nucleus at various distances are negatively charged electrons. These electrons usually orbit in pairs creating a stable atom. However, when one electron is removed from an orbit or one electron is added, an unpaired state is created. This is very unstable for the atom. The unpaired electron causes the atom to become a free radical that, if left unchecked, can form more free radicals in a chain reaction. Eventually, this can cause damage to surrounding cells and tissues. Free radicals can damage the fat and protein parts of the body. This damage has been linked to the development of cardiovascular disease as well as cataracts. Free radicals also damage a cell's DNA, which may lead to the development of cancer or be a contributor to the aging process.

The oxygen molecule, while an essential chemical of life, easily produces free radicals in the body resulting in oxidative damage. Oxygen in our bodies, therefore, is a two-edged sword, both helping and hurting us.

Damaging free radicals can be produced in our bodies both from normal body processes and from sources that originate outside of the body. Some sources of free radicals that originate inside the body are the following:

- As a normal by-product of respiration and energy production. We all need to breathe and produce energy to work our muscles, fuel our brains, etc. However, a side effect of these processes is the production of free radicals.
- As part of our normal immune function. Several of our body's immune cells actually produce free radicals to kill invading bacteria. As long as this is well controlled, we have no problems. However, when these processes are out of control, as occurs with some autoimmune diseases, some of the free radicals that are produced may actually harm our cells.

• As by-products of normal enzyme or chemical reactions. Free radicals can be produced as part of the breakdown of adrenaline, in the processing of certain fat compounds, and in iron metabolism. Generally, we have little control over the free radicals that are produced from sources originating within our bodies.

A number of factors that originate outside of the body also can cause free radical formation once they enter or make contact with the body. Some examples of these sources of free radical producers are found in Table 1. Among them is cigarette smoke, a big producer of free radicals in the body. Other ways to reduce oxidative or free radical damage to the body, besides increasing antioxidant intake, are to avoid smoking, avoid overexposure to the sun, and avoid living in areas where the air is polluted. Obviously, we do have some control over these factors.

Antioxidants

Because of the constant exposure to free radicals, both plants and animals have developed numerous antioxidant compounds and systems to protect themselves. Antioxidants generally function in two ways. The antioxidants can be preventative, actually preventing free radicals from forming. The antioxidants also can be chain breaking, stopping the free radical chain reaction once it has started. Antioxidants used in the body also can be classified according to their chemical make-up. These antioxidants are outlined below.

Vitamins, Minerals, Vitamin-Like Compounds. This group of antioxidants includes such well-known antioxidant nutrients as vitamin C and vitamin E as well as minerals like selenium. Other antioxidant compounds in this group include the vitamin-like compounds, coenzyme Q and glutathione. Some of these compounds work in the water-soluble areas of the body (vitamin C, glutathione) while others work in the fatty parts of cells and tissues (vitamin E, coenzyme Q). Vitamins C and E and the mineral selenium are essential nutrients that must be provided in the diet.

Table 1. Sources of Free Radicals*

Cigarette smoke
X-rays
Chemicals, such as pesticides
Sunburn (UV light)
Air pollution (ozone, smog)
Radiation
Some drugs
Physical trauma (injury or infection)

*Minimizing exposure to these items will reduce free radical production in the body.

Glutathione and coenzyme Q can be obtained in the diet, but also can be made in the body from other chemical compounds.

Enzymes. Several antioxidant enzymes are made by various cells in the body. The three most important antioxidant enzymes are superoxide dismutase (SOD), catalase, and glutathione peroxidase. These enzymes are made in the body in response to the presence of certain free radicals. Thus, if a body is under higher oxidative stress and is producing more free radicals, more of the three antioxidant enzymes will be made to counterbalance the stress. Unfortunately, the antioxidant enzymes alone are not sufficient to take care of all free radicals that are produced. This is why there is a need to obtain various other antioxidants in the diet. Some commercial companies will sell antioxidant enzymes as dietary supplements. However, these enzyme supplements are not effective because enzymes are proteins and are digested in the stomach and small intestine. Any dietary antioxidant enzymes that are consumed will be digested and broken down into smaller fragments before they enter the body. These fragments do not get rid of free radicals. Antioxidant enzymes are only effective when made within the body.

Antioxidant Phytochemicals. Another important group of dietary antioxidant compounds has been discovered in the last several years. These compounds are found in plant foods and have been given the name phytochemical antioxidants (phyto meaning "from plants"). Hundreds of these phytochemical antioxidants have been discovered. The discovery of these compounds has been a strong driving force in the effort by various public agencies to increase fruit and vegetable consumption (i.e., the emphasis to "Eat at least five fruit and vegetable servings a day.") Some of the well-defined phytochemical antioxidants are listed in Table 2. Because there are so many different phytochemicals and because each one may act differently in the body, it is very important that these compounds be obtained from a diet that contains a

Table 2. Some Phytochemical Antioxidants

Phytochemical Antioxidant	Food Source
Beta-carotene	Carrots, Sweet Potatoes, Cantaloupe
Lycopene	Tomatoes, Tomato Products
Lutein	Spinach, Broccoli, Green Peas
Epigallocatechin gallate (EGCG)	Green and Black Teas
Polyphenols (flavonoids and other compounds)	Red Wine, Soy Products, Peas, Onions, Apples, Red Grapes, Orange Juice, Cranberries, Strawberries

variety of fruits, vegetables, and whole grains. It is impossible to obtain all of the phytochemical antioxidants through supplementation.

While scientists have not been able to identify all the different phytochemical antioxidants in a fruit or vegetable, a method has been developed that can estimate the overall antioxidant potential of the plant food. This process gives a number that is known as the oxygen radical absorbency capacity (ORAC) of the fruit or vegetable. Plants with higher ORAC numbers have a greater antioxidant potential. For example, prunes have been shown to have a very high ORAC (antioxidant) number. ORAC numbers of some fruits and vegetables are shown in Table 3.

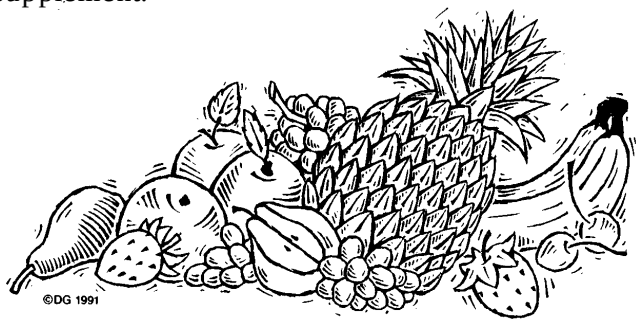
Table 3. ORAC (Antioxidant) Units of Selected Fruits and Vegetables

Food Source	ORAC units/100 grams (3.5 oz)
Fruits	
Prunes	5,770
Raisins	2,830
Blueberries	2,400
Strawberries	1,540
Plums	949
Oranges	750
Red grapes	739
Vegetables	
Spinach	1,770
Brussels sprouts	980
Broccoli	880
Beets	840
Onions	450
Corn	400
Eggplant	390

Supplements Versus Diet

Numerous antioxidant supplements are currently on the market. However, with perhaps one exception, antioxidant compounds can be easily obtained from dietary sources. Because so much still needs to be learned about antioxidants, the wise person should concentrate on obtaining antioxidants through various dietary food sources. Following are recommended levels of some antioxidants as well as some examples of good dietary sources.

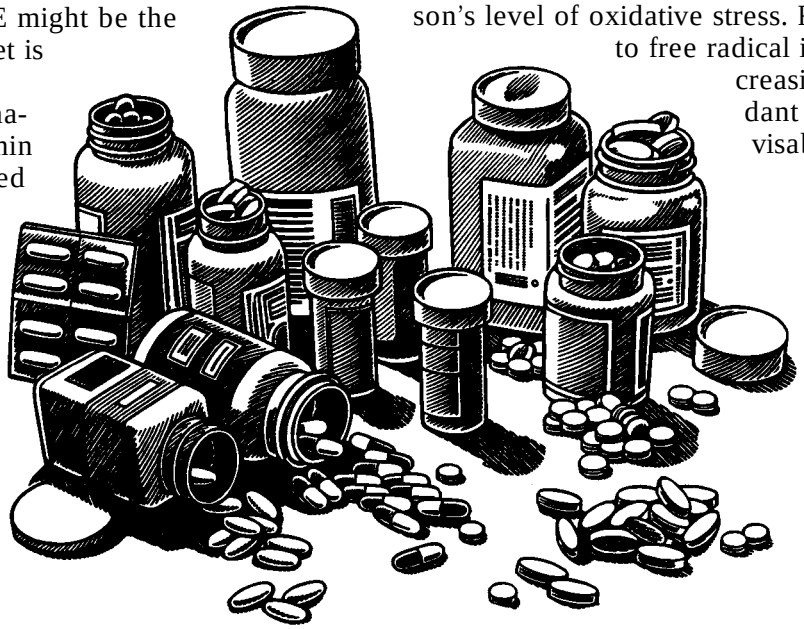
Vitamin C. Current antioxidant intake recommendations for vitamin C range from 200 to 1000 milligrams each day. While 1000 milligrams a day is a little difficult to obtain totally from the diet, intakes of 200 to 500 milligrams can easily be obtained in the diet. For example, 1 cup of orange juice, ½ cup of broccoli, ½ cup of strawberries, 1 baked potato, and 3 slices of tomato would provide 220 to 240 milligrams of vitamin C. Of course, these foods also provide other phytochemical antioxidants that give them an advantage over a vitamin C supplement.



Beta-carotene. Current recommendations suggest an intake of beta-carotene of 10 to 30 milligrams each day. This range can easily be obtained in the diet. One carrot, ½ cup of spinach, and ¼ of a cantaloupe would provide approximately 11 milligrams of beta-carotene. While many studies looking at beta-carotene intake from the diet have shown positive effects on health, supplements of beta-carotene have actually been shown to worsen health in smokers with lung cancer. Again, the food source seems better than the supplement.

Phytochemicals. There are hundreds of different phytochemical antioxidants so individual recommendations for these compounds are not offered. However, recommendations have been made for the total ORAC units that should be consumed each day. Individuals should consume enough fruits, vegetables, and whole grains to reach an ORAC-unit total of 3,000 to 5,000 each day. This can easily be done in the diet. A ¼-cup serving of raisins, a ½-cup serving of blueberries, and a ½-cup serving of spinach will provide approximately 5,000 to 5,100 ORAC units. Eating five fruit and vegetable servings each day would consistently meet the total ORAC recommendation.

Vitamin E. Vitamin E might be the one exception to the "diet is better" recommendation. Obtaining 10 to 15 international units (IUs) of vitamin E a day, the recommended dietary allowance, is not hard. However, most vitamin E antioxidant recommendations suggest that people consume 100 to 400 IUs of the vitamin each day. This amount of vitamin E cannot easily be obtained in the diet; therefore, supplementation may be appropriate.



In summary, the body uses a number of different antioxidants to protect itself from free radical damage. Obtaining most of these antioxidants through supplementation is not feasible. Eating adequate amounts of a variety of fruits, vegetables, and whole grains is the best approach to establishing good antioxidant status. Furthermore, reducing exposure to the various sources of oxidative damage (cigarette smoking, sun exposure, etc.) reduces the need for more antioxidants. Remember that it actually is the balance between free radical production and antioxidant status that determines a person's level of oxidative stress. Reducing exposure to free radical initiators and increasing dietary antioxidant intake are both advisable procedures.

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