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Functional Foods Fact Sheet: Antioxidants

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Background

Plant foods, such as fruits, vegetables, and whole grains contain many components that are beneficial to human health. Research supports that some of these foods, as part of an overall healthful diet, have the potential to delay the onset of many age-related diseases. These observations have led to continuing research aimed at identifying specific bioactive components in foods, such as antioxidants, which may be responsible for improving and maintaining health.

Antioxidants are present in foods as vitamins, minerals, carotenoids, and polyphenols, among others. Many antioxidants are often identified in food by their distinctive colors—the deep red of cherries and of tomatoes; the orange of carrots; the yellow of corn, mangos, and saffron; and the blue-purple of blueberries, blackberries, and grapes. The most well-known components of food with antioxidant activities are vitamins A, C, and E; β -carotene; the mineral selenium; and more recently, the compound lycopene.

Health Effects

The research continues to grow regarding the knowledge of antioxidants as healthful components of food. Oxidation, or the loss of an electron, can sometimes produce reactive substances known as free radicals that can cause oxidative stress or damage to the cells. Antioxidants, by their very nature, are capable of stabilizing free radicals before they can react and cause harm, in much the same way that a buffer stabilizes an acid to maintain a normal pH. Because oxidation is a naturally occurring process within the body, a balance with antioxidants must exist to maintain health.

Research

While the body has its defenses against oxidative stress, these defenses are thought to become less effective with aging as oxidative stress becomes greater.¹ Research suggests there is involvement of the resulting free radicals in a number of degenerative diseases

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associated with aging, such as cancer, cardiovascular disease, cognitive impairment, Alzheimer's disease, immune dysfunction, cataracts, and macular degeneration.²⁻⁹ Certain conditions, such as chronic diseases and aging, can tip the balance in favor of free radical formation, which can contribute to ill effects on health.

Consumption of antioxidants is thought to provide protection against oxidative damage and contribute positive health benefits. For example, the carotenoids lutein and zeaxanthin engage in antioxidant activities that have been shown to increase macular pigment density in the eye. Whether this will prevent or reverse the progression of macular degeneration remains to be determined.¹⁰ An increasing body of evidence suggests beneficial effects of the antioxidants present in grapes, cocoa, blueberries, and teas on cardiovascular health, Alzheimer's disease, and even reduction of the risk of some cancers.¹¹⁻¹⁵

Until recently, it appeared that antioxidants were almost a panacea for continued good health. It is only as more research has probed the mechanisms of antioxidant action that a far more complex story continues to be unraveled. Although recent research has attempted to establish a causal link between indicators of oxidative stress and chronic disease, none has yet been validated. A new area of research, led by the study of the human genome, suggests that the interplay of human genetics and diet may play a role in the development of chronic diseases. This science, while still in its infancy, seeks to provide an understanding of how common dietary nutrients such as antioxidants can affect health through gene-nutrient interactions.¹⁶

There still remains a lack of direct experimental evidence from randomized trials that antioxidants are beneficial to health, which has led to different recommendations for different populations. For example, the use of supplemental β -carotene has been identified as a contributing factor to increased risk of lung cancer in smokers.¹⁷ However, because the risk has not been indicated in non-smokers, these studies suggest that a precaution regarding the use of supplemental β -carotene is not warranted for non-smokers. If supplementation is desired, the use of a daily multivitamin-mineral supplement containing antioxidants has been recommended for the general public as the best advice at this time.¹⁸

A recent review of current literature suggests that fruits and vegetables in combination have synergistic effects on antioxidant activities leading to greater reduction in risk of chronic disease, specifically for cancer and heart disease.¹⁹ For some time, health organizations have recognized the beneficial roles fruits and vegetables play in the reduced risk of disease and developed communication programs to encourage consumers to eat more antioxidant-rich fruits and vegetables. The American Heart Association recommends healthy adults "Eat a variety of fruits and vegetables. Choose 5 or more servings per day."²⁰ The American Cancer Society recommends to "Eat 5 or more servings of fruits and vegetables each day."²¹ The World Cancer Research Fund and the American Institute for Cancer Research 1997 Report *Food, Nutrition and the Prevention of Cancer: A Global Perspective* states, "Evidence of dietary protection against cancer is strongest and most consistent for diets high in vegetables and fruits."²² The potential for antioxidant-rich fruits and vegetables to help improve the health of Americans led the National Cancer Institute (NCI) to start the, "5-A-Day for Better Health" campaign to promote consumption of these foods.²³

Given the high degree of scientific consensus about consumption of a diet that is high in fruits and vegetables—particularly those which contain dietary fiber and vitamins A and C; the Food and Drug Administration (FDA) released a health claim for fruits and vegetables in relation to cancer. Food packages that meet FDA criteria may now carry the claim "Diets low in fat and high in fruits and vegetables may reduce the risk of some cancers."²⁴ In addition the FDA, in cooperation with NCI, released a dietary guidance message for consumers, "Diets rich in fruits and vegetables may reduce the risk of some types of cancer and other chronic diseases."²⁵ Most recently the *Dietary Guidelines for Americans* stated, "Increased intakes of fruits, vegetables, whole grains and fat-free or low-fat milk and milk products are likely to have important health benefits for most Americans."²⁶

Antioxidant research continues to grow and emerge as new beneficial components of food are discovered. Reinforced by current



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research, the message remains that antioxidants obtained from food sources, including fruits, vegetables and whole grains, are potentially active in disease risk reduction and can be beneficial to human health.²⁷

Examples of Functional Components*		
Class/Components	Source*	Potential Benefit
Carotenoids		
Beta-carotene	carrots, various fruits	neutralizes free radicals which may damage cells; bolsters cellular antioxidant defenses
Lutein, Zeaxanthin	kale, collards, spinach, corn, eggs, citrus	may contribute to maintenance of healthy vision
Lycopene	tomatoes and processed tomato products	may contribute to maintenance of prostate health
Flavonoids		
Anthocyanidins	berries, cherries, red grapes	bolster cellular antioxidant defenses; may contribute to maintenance of brain function
Flavanols—Catechins, Epicatechins, Procyanidins	tea, cocoa, chocolate, apples, grapes	may contribute to maintenance of heart health
Flavanones	citrus foods	neutralize free radicals which may damage cells; bolster cellular antioxidant defenses
Flavonols	onions, apples, tea, broccoli	neutralize free radicals which may damage cells; bolster cellular antioxidant defenses

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Proanthocyanidins	cranberries, cocoa, apples, strawberries, grapes, wine, peanuts, cinnamon	may contribute to maintenance of urinary tract health and heart health
<i>Isothiocyanates</i>		
Sulforaphane	cauliflower, broccoli, Brussels sprouts, cabbage, kale, horseradish	may enhance detoxification of undesirable compounds and bolster cellular antioxidant defenses
<i>Phenols</i>		
Caffeic acid, Ferulic acid	apples, pears, citrus fruits, some vegetables	may bolster cellular antioxidant defenses; may contribute to maintenance of healthy vision and heart health
<i>Sulfides/Thiols</i>		
Diallyl sulfide, Allyl methyl trisulfide	garlic, onions, leeks, scallions	may enhance detoxification of undesirable compounds; may contribute to maintenance of heart health and healthy immune function
Dithiolthiones	cruciferous vegetables— broccoli, cabbage, bok choy, collards	contribute to maintenance of healthy immune function
<i>Whole Grains</i>		
Whole grains	cereal grains	may reduce risk of coronary heart disease and cancer; may contribute to reduced risk of diabetes
<p><i>Chart adapted from International Food Information Council Foundation: Media Guide on Food Safety and Nutrition: 2004-2006.</i></p> <p><i>*Not a representation of all sources</i></p>		

For more information on additional beneficial components of food, visit [Background on Functional Foods](#).

Examples of Antioxidant Vitamins and Minerals			
Vitamins	Daily Reference Intakes*	Antioxidant Activity	Sources
Vitamin A	300-900 µg/d	Protects cells from free radicals	Liver, dairy products, fish
Vitamin C	15-90 mg/d	Protects cells from free radicals	Bell peppers, citrus fruits
Vitamin E	6-15 mg/d	Protects cells from free radicals, helps with immune function and DNA repair	Oils, fortified cereals, sunflower seeds, mixed nuts
Selenium	20-55 µg/d	Helps prevent cellular damage from free radicals	Brazil nuts, meats, tuna, plant foods

Chart adapted from Food and Nutrition Board Institute of Medicine DRI reports and National Institutes of Health Office of Dietary Supplements

**DRI's provided are a range for Americans ages 2-70.*

For information on Daily Reference Intakes for specific populations click here: <http://www.iom.edu>

The Bottom Line

Most research indicates that there are overall health benefits from antioxidant-rich foods consumed in the diet. The results of clinical trials with antioxidant supplements have yet to provide conclusive indication of health benefits. Current recommendations by the U.S. government and health organizations are to consume a varied diet with at least five servings of fruits and vegetables per day and 6-11 servings of grains per day, with at least three of those being whole grains.

Other Resources:

- American Cancer Society www.cancer.org
- American Dietetic Association www.eatright.org
- American Heart Association www.americanheart.org
- American Institute for Cancer Research www.aicr.org
- The Dietary Guidelines for Americans www.healthierus.gov/dietaryguidelines
- Food and Drug Administration www.fda.gov
- Institute of Food Technologists www.ift.org
- Institute of Medicine Food and Nutrition Board www.iom.edu
- National Cancer Institute www.cancer.gov
- National Institutes of Health Office of Dietary Supplements www.ods.od.nih.gov
- United States Department of Agriculture www.usda.gov and www.mypyramid.gov

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