FEATURE

The Functional Food Properties of Figs

Figs are restorative. They increase the strength of young people, preserve the elderly in better health and make them look younger with fewer wrinkles.—Pliny (52-113 AD)

If I should wish a fruit brought to Paradise, it would certainly be a fig.—Mohammed the Prophet

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The importance of “nutraceuticals,” also known as “functional foods,” in the American diet is highlighted by the fact that consumers paid out $9 billion/year for these products (1). The definition of functional foods is still evolving but refers to “foods that, by virtue of physiologically active components, provide benefits beyond basic nutrition and may prevent disease or promote health,” as stated by Clare Hasler, director of the University of Illinois Functional Foods for Health Program. Increasingly, manufacturers are including the names of nonnutritive components on their labels. For example, the labels on green tea list “polyphenols,” and those on tofu list “isoflavones.” The public is becoming more knowledgeable about these nonnutritive ingredients because of the large amount of publicity and articles in the mass media.

Today there is an ever increasing demand for foods that will increase our intake of food components that are perceived to be “protective against disease.” In the future, genetic engineering will allow us to provide a variety of fruit or vegetables that is highly elevated in a certain compound. One example of such research is the work by the USDA and others in the development of a tomato high in lycopene, a carotenoid understood to be an antioxidant and anticancer substance. In some varieties, the concentration of lycopene can be three times that of regular tomatoes. The genes responsible for the synthesis of carotenoids such as lycopene have been isolated. The genes have been inserted in an edible yeast and have produced lycopene and carotenoid at 0.1% dry weight of isolated cells (2).

We are increasingly using foods as preventive agents to decrease our risk of deadly chronic diseases, including cancer and heart disease. The layperson is well aware of the importance of diet to health as a result of the U.S. government’s campaign to increase our consumption of fruits and vegetables to five servings/day. This article is designed to provide information on a relatively unknown but extremely “functional” fruit, namely figs.

General Information

Figs (*Ficus Carica*) are one of the earliest fruits cultivated. Figs were dried and stored for later consumption. There was a fig tree in the Garden of Eden, and the fig is the most mentioned fruit in the Bible. Figs are mentioned in a Babylonian hymnbook dated about 2000 B.C. As early as 2900 B.C., in early Sumerian times, the medical use of figs was already being stressed. Legend has it that the Greek goddess Demeter first revealed to mortals the fruit of autumn, which they called the fig. It was the favorite fruit of Cleopatra, and she ended her life with an asp brought to her in a basket of figs. Every inhabitant of Athens was a “philosykos,” literally translated, “a friend of the fig.” Early Olympic athletes were given figs as a training food and figs were given as laurels to the winners of the first Olympics as a “medal” (3). The Wildlife Conservation Society of New York has recently determined that, in the animal and plant kingdom, the high-calcium content of wild figs makes them a “keystone” fruit, critical to the survival of other plants and animals (4).

Although considered a fruit, the fig is actually a flower inverted into itself. The seeds are the real fruit in figs. They are the only fruit to ripen fully and semidry on the tree. Native to areas from Asiatic Turkey to northern India, figs spread to all the countries around the Mediterranean. Today the United States, Turkey, Greece, and Spain are the primary producers of dried figs. The Spaniards brought figs to the Americas in the early 16th century. The missionary fathers brought them to California where they were planted from San Diego to Sonoma. “Mission Fig” gets its name from this history. The Smyrna fig was imported from Turkey to California in l882. It was given the hybrid name of Calimyrna in honor of the grower’s home.

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California, specifically the San Joaquin Valley, produces 100% of the dried figs grown in the United States. Fig trees reach fruit-bearing age in one to two years and have tremendous longevity. Some trees planted at the beginning of California's commercial fig production are still bearing fruit almost 100 years later. There are four principal varieties of cultivated figs: the amber-colored Calimyrna; the dark, purplish Mission; the small but high-in-sugar Adriatic, and the uniquely white-to-translucent amber Kadota. The Calimyrna and Mission varieties represent almost two-thirds of the commercial production. Dried figs are available in many forms: whole for the consumer and, in industrial products, as paste, concentrate, nuggets, powder, and diced forms. Potassium sorbate is added to dried figs to inhibit yeast fermentation and mold growth. Dried figs are processed to bring their moisture content up from 14–20% to as high as 30%. Compared to other dried fruits such as apricots or apples, color in the Calimryna variety may be stabilized by the addition of low levels of sulfur dioxide (5).

Nutrient Composition of Dried Figs

One serving of figs is 100 g, about 1/4 cup, or about three Calimyrna or four to five Mission figs. Table I lists the nutrient composition of dried figs. Figs are fat free, sodium free and, like other plant foods, cholesterol free. A comparison of the nutrient content of figs with that of other common fruits is given in Table II. Of the common fruits, figs have the highest overall content of minerals, and their calcium content per serving is second to oranges. On a weight basis, figs contain more calcium than any of the fruits listed in Table II. Figs provide more fiber than all of the common fruits. A single serving contains 20% of the daily value of fiber. More than 28% of the fiber is the soluble variety. Soluble fiber has been shown to help control blood sugar and lower blood cholesterol by binding to it in the digestive tract. A recent study has shown that the addition of a soluble-fiber supplement to the diet can aid in weight loss. Pasman studied obese women and found that average energy intake decreased significantly after fiber supplementation while hunger and satiety scores did not change. In a second study of subjects with low-energy intakes, hunger scores were significantly decreased after fiber supplementation. The authors concluded that, by facilitating compliance to a low-energy intake, fiber may be useful in the treatment of obesity (6). Thus, figs and their soluble fiber may be of help with weight reduction, particularly considering the recent finding that over half of Americans, 97 million people, are overweight and 23% are grossly overweight, i.e., obese (7). The upward trend in adult obesity seen in the last 40 years has also been observed in children. Figs, as both a fruit and a snack, are an ideal addition to a child's diet and an adult's because they represent an excellent source of fiber and are naturally sweet.

Nonnutrients in Figs and Benefits in Reducing Risk of Cancer

It has been estimated that up to 70% of the incidences of cancers are related to diet. Major dietary hypotheses relate high fat consumption to breast and colorectal cancers; high alcohol intake to respiratory, gastrointestinal, breast, and liver cancers; and low fiber intake to colorectal cancer. One hundred twenty-eight of 156 epidemiological studies have shown an inverse correlation between the consumption of fruits and vegetables and the incidence of cancer (8). These are summarized in Figure 1. There was a substantial reduction in risk for all cancers among those consuming a large amount of fruits and vegetables. Previously, it was thought that the antioxidant vitamins, vitamin C, E, and β carotene, were responsible for the beneficial effects of fruits and vegetables as shown by epidemiology studies across many cultures. However, recent supplement studies have been disappointing with respect to that hypothesis. For instance, a recent National Cancer Institute study on male smokers was halted because it was found that 5–8 years of vitamin E supplementation had no benefit. β carotene supplementation, in fact, was correlated with a significant increase in the incidence of lung cancer (9). No effect of supplementation with the antioxidants vitamin C, E, or Coenzyme Q10 was found with respect to oxidative DNA damage in smokers (10).

Out of almost 200 epidemiological studies, the relationship between cancer risk and fruit and vegetable intake is exceptionally strong and consistent. People who eat greater amounts of fruits and vegetables have about one-half the risk of getting cancer and have less mortality from cancer. It is the hypothesis of many scientists that the polyphenols in the fruits and vegetables are responsible for the reduced cancer-risk benefits they offer. The polyphenols can act by several mechanisms to prevent cancer, such as carcinogen-blocking activities, antioxidant and free-radical scavenging, and antiproliferation/antiprogression actions (11). In test tube studies, five classes of polyphenols were tested for their ability to inhibit the binding of the potent carcinogen benzopyrene to DNA in liver cells. These compounds were active after being fed to rats and subsequent exposure of the rats' liver cells to the carcinogen (12).

At least 22 studies have been conducted in which cancer has been experimentally induced (usually by means of a chemical carcinogen or irradiation) in animals fed vegetables or fruits. In most of these studies, it has been unequivocally found that the animals experienced fewer tumors, smaller tumors, fewer metastases, less DNA damage, higher levels of enzymes involved in the detoxification of carcinogens, or other outcomes indicative of lower cancer risk (13). For an example, in one study, rats were given a diet with and without a vegetable-fruit mixture. The rats were exposed to a high-fat diet and a chemical carcinogen that induced colorectal cancer. Rats fed high-fat diets developed significantly more tumors than did rats fed low-fat diets, which indicates the underlying importance of a low-fat diet for lowering the risk of cancer. Also, in this study, a lower number of tumors were found in the rats fed vegetables and fruits along with the fat and a carcinogen (14).

Besides their ubiquitous polyphenols**,** figs have other compounds with anticancer activity, specifically benzaldehyde and the coumarins. Benzaldehyde has been used successfully to treat terminal human carcinomas. Of 57 evaluable patients, 19 responded completely and 10 responded with a greater than 50% regression in their cancers when treated with benzaldehyde (15). Treatment of squamous cell carcinomas with benzaldehyde induced the cancer cells to change into keratinized, normal squamous cells.

Coumarins are the major compounds isolated from the volatile extract of figs (16). In fact, the total dry-weight coumarinic content of figs is 0.5% (17). The furanocomarins identified in figs include angelicin, marmesin, psoralen, umbelliferone, and bergapten (17). Coumarins have also been used for the treatment of prostate cancer (18, 19). Among cancers, the incidence of skin cancer is currently growing at the fastest rate. In New Zealand, the age-standardized rates for melanoma have increased 60% compared to the rates in the 1970s, with the greatest proportional increase occurring among younger age groups (20). Psoralens, such as the fig compound angelicin, are currently being investigated for the treatment of skin cancer and have been recommended for clinical trials because they have low skin phototoxicity (21). These compounds produce free radicals and photoadducts of DNA that inhibit proliferation of the cancer cells (22).

Table I. Nutrients Found in Dried Figs (5)

Dietary Component	Amount per 100 g Serving	Daily Value
Total calories	283	—
Calories from fat	4.7	—
Total fat	0.52 g	0%
Saturated fat	0.0 g	0%
Cholesterol	0.0 mg	0%
Sodium	12.26 mg	0%
Potassium	609 mg	7%
Total carbohydrate	66.16 g	9%
Total dietary fiber	12.21 g	
Insoluble	8.74 g	20%
Soluble	3.47 g	
Sugars	49.0 g	—
Protein	3.14 g	—
Vitamin A	9.76 IU	<2%
Vitamin C	0.68 mg	<2%
Calcium	133.0 mg	6%
Iron	3.07 mg	6%

Table II. Comparison of Nutrients Provided in Serving Sizes of Common Fruits (5)

Fruit (g)	Calories	Dietary Fiber (g)	Potassium (g)	Calcium (mg)	Iron (mg)
Apples (154 g, 1 medium)	91	3.0	177	11.0	0.3
Bananas (126 g, 1 medium)	75	1.7	324	4.9	0.3
Dates (40 g, ¼ cup)	113	3.8	240	10.0	0.2
Dried figs (40 g, ¼ cup)	113	4.9	244	53.0	1.2
Grapes (138 g, 1½ cups)	98	0.8	255	15.0	0.4
Oranges (154 g, 1 medium)	72	2.9	279	62.0	0.2
Prunes (40 g, ¼ cup)	109	2.4	290	7.2	0.6
Raisins (40 g, ¼ cup)	126	2.3	306	16.0	1.2
Strawberries (147g, 8 medium)	147	2.2	244	20.6	0.6

Mechanisms Leading to Heart Disease

Elevated lipids such as cholesterol and triglycerides are risk factors for developing heart disease, the number one cause of death in the United States. The public knows that a low-fat diet high in fiber is beneficial with respect to reducing the risk of heart disease. However, another causal mechanism related to metabolism and the transport of lipids needs to be explained. Lipids are water-insoluble nutrients, but they are transported through the body by the blood. This is achieved by the lipids' "packaging" in water-soluble particles of lipoprotein. In these lipoproteins, the amphiphatic lipids (phospholipids and some non-esterified cholesterol) and the receptor protein are on the outside of the particles. The hydrophobic lipids (cholesteryl esters, triglycerides and some non-esterified cholesterol) are protected from water in the interior of the particles.

The four main types of lipoproteins are chylomicrons, very low-density lipoprotein (VLDL), low-density (LDL) and high-density lipoproteins (HDL). Chylomicrons transport triglycerides mainly from the small intestine to the adipose tissue and skeletal muscle, while VLDL transports triglycerides mainly from the liver to the adipose tissue and skeletal muscle. In the circulation, VLDL is converted to LDL. Each LDL particle is about 22 mm in diameter on average and contains in its core about 1,800 oxidizable molecules in the form of cholesteryl esters and triglycerides. There are about 700 molecules of phospholipid on the LDL particle's surface as a monolayer and approximately 600 molecules of non-esterified cholesterol distributed between its core and its surface. LDL's antioxidant defense is contained within the particle and consists of about 20 molecules, mostly the phenolic vitamin E tocopherol with minor amounts of carotenoids and coenzyme Q_{10} (23).

The oxidative theory of atherogenesis was first promulgated in Steinberg's seminal paper in 1989 (24). The hypothesis states that it is not LDL or VLDL that is atherogenic but the oxidized form of these lipoproteins. LDL and VLDL enter the arterial wall from the plasma and are oxidized locally within the wall by oxidizing agents derived from cells, such as macrophages, smooth muscle cells, endothelial cells, and lymphocytes. The oxidized LDL and VLDL are then believed to bind to scavenger receptors on macrophages and internalized rapidly by receptor-mediated endocytosis. The amount of cholesterol from the lipoproteins entering the cells overwhelms the capacity of the macrophages to release it, and the cholesterol accumulates inside the cells and converts them to foam cells, which are the first visible evidence of atherosclerosis. This hypothesis has been substantiated by many different pieces of evidence both in vitro and in vivo (25).

Nonnutrients in Figs and Reduction of the Risk for Heart Disease

There is overwhelming epidemiological evidence of the protective effect of vegetables and fruits against heart disease and, as has been recently found, stroke. A highly significant negative association between the consumption of total fresh fruits and vegetables and ischemic heart disease was reported in the United Kingdom (26) and in the United States (27). A significant negative relationship between fruit and vegetable consumption and stroke in men was recently found in the Dutch Study (28). An additional benefit of fruit and vegetables is their negative association with blood pressure (29), a risk factor for heart disease.

The first indication that flavonoids could function as protection against heart disease came in a study published in the famous 1979 *Lancet* article, which, using data from 17 countries, showed an inverse relationship between coronary artery-disease mortality and wine drinking (30). This led researchers to examine the so-called "French paradox," which describes the apparent contradiction in the data on the French, where a very low incidence of heart disease and mortality, as compared with North Americans, exists alongside the same average serum cholesterol, saturated fat intake, blood pressure, and prevalence of smoking found in countries with high rates of heart disease (31). It was hypothesized that the French's much greater intake of wine was responsible for this effect. Because, in France and the other countries studied, red wine is normally consumed at meals, it was natural to assume that the flavonoids were responsible for this effect, since red wines have a high polyphenol content. Similarly, wine ethanol had the strongest and most consistent negative correlation with coronary heart disease mortality in 21 developed countries (32).

The first epidemiological report indicating that the intake of antioxidant flavonols (as measured in the diet by an HPLC method) reduced the rate of coronary heart disease mortality was released in l993 (33). The five-year study on elderly Dutch men also reported that intakes of tea, onions, and apples were inversely related to coronary heart disease mortality. A study of sixteen male cohorts in seven countries, including the United States, was also published (34). It showed a strong inverse association between flavonol plus flavone intake and mortality from coronary heart disease. The composite diets of 1987 were analyzed and used for the correlation study. In multivariate analysis flavonoids explained 8% of the variance in heart disease rates. In fact, saturated fat and smoking plus flavonoids explained 90% of the variance in heart disease rates, independent of alcohol and antioxidant vitamin intake (34).

A Finnish study with a 26-year follow-up period showed a significant inverse gradient between dietary intake of flavonoids and total and coronary mortality (35). Between the lowest and highest quartile of dietary flavonoids intake, there was a 31% lower risk of total mortality and a 48% lower risk of coronary mortality. For men, there was a 34 and 32% lower risk, respectively. Apple and onion consumption were inversely associated with total and coronary mortality (35). A recently completed epidemiological study of male health professionals in the United States found a modest but nonsignificant inverse association between intake of flavonols and flavones and subsequent coronary mortality rates (36). The risk was 37% lower for those the highest quintile of intake of flavonoids compared with those in the lowest.

In a study of the Dutch, elderly male population, a study of 552 men followed up for 15 years, dietary flavonoids were inversely associated with incidence of stroke, after adjustment for potential confounders in the data, including antioxidant vitamins (37). Black tea consumption was inversely associated with incidence of stroke. The intake of vitamin C and vitamin E was not associated with stroke risk.

Polyphenols in Nuts, Cereals, Fruits, Vegetables, and Beverages

One limitation to these types of studies is that the methodology for determining polyphenol intake generally underestimates the polyphenol content; therefore, this error is carried over to the analyses in these epidemiological studies. Using an acid-hydrolysis and HPLC separation, Hertog measured the total aglycone content of five flavonols and flavones in nine fruits and 28 vegetables (38) and beverages (39). Using this assay method, it was found that the average U.S. diet contains 20 mg/day of these five compounds (36). Thus, only five

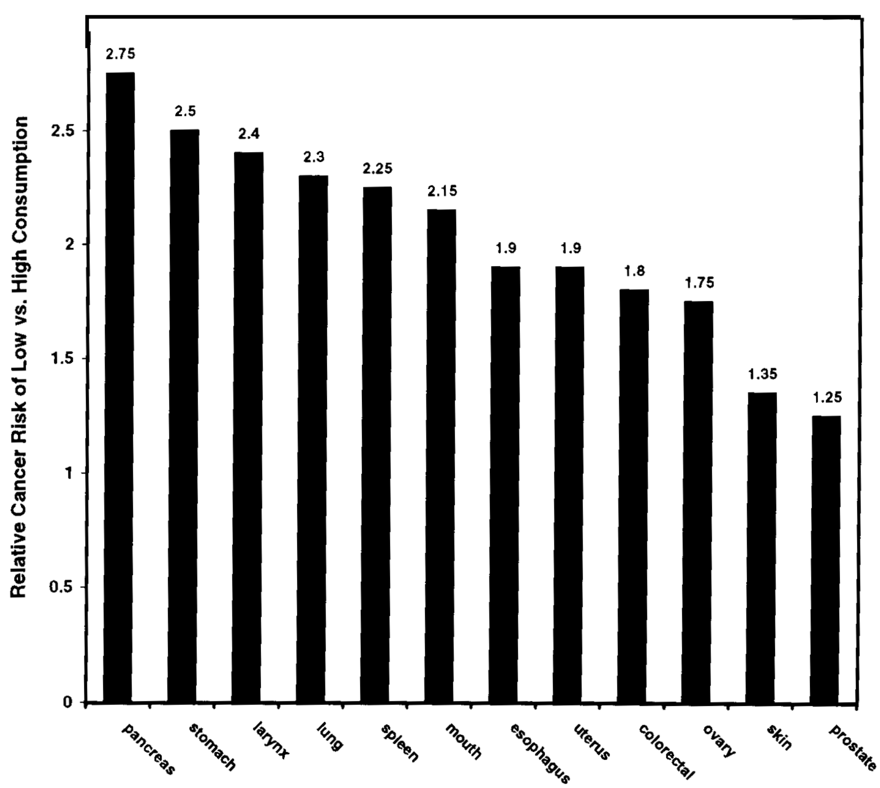


Fig. 1. The protective effect of fruits and vegetables in reducing the risk of cancers: A chart illustrating the increase in mortality from cancer in people consuming the least amount of fruits and vegetables (first quartile) compared to those consuming the most (fourth quartile) (8).

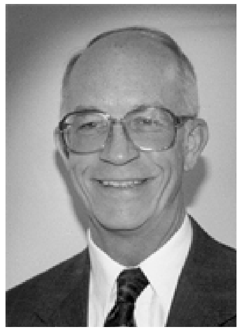
compounds out of the 4,000 known natural substances were used in the epidemiological methodology. Kühnau estimated the intake of polyphenols to be about 1 g/day (40). In our laboratory, the quantity of total polyphenols was measured in dried figs after an acid hydrolysis to liberate the free phenols and polyphenols and followed by reaction with the Folin-Cocialteu reagent, which assays oxidizable polyphenols versus a catechin standard (41). Our vegetable (41) and fig data is included along with published total polyphenols for other foods and beverages in Table III (40, 42).

Using 100 g as a comparison, it is evident on a weight basis that figs contain one of the highest concentrations of polyphenols among the commonly consumed foods and beverages. Only barley, some sorghums, and some beans have the same high levels found in figs. Compared with figs, red wine and tea, two well known and well-publicized sources of polyphenols, are low in phenols. Putting it in perspective, 40 g of figs, the suggested serving size, provide an average of 444 mg of phenols, which is more than the daily per capita consumption of polyphenols from vegetables or 218 mg/day (41).

Table III. Total Polyphenol Content of Common Foods and Beverages (40, 41, 42)

Food/Beverage[a]	Total Polyphenols
Cereals (mg/100 g dm)	
Barley	1,200–1,500
Corn	30.9
Oats	8.7
Rice	8.6
Sorghum	170–10,260
Wheat	22–40
Legumes (mg/100 g fm)	
Kidney bean	948
Pinto bean	856
Snap bean	36
Vegetables (mg/100 g fm)	
Beet	246
Broccoli	108
Corn	147
Garlic	387
Red onion	120
Tomato	39
Fruits (mg/100 g fm)	
Apple	27–298
Blueberry	135–280
Cherry	60–90
Figs	1,090–1,110
Grape	50–490
Grapefruit	50
Orange	50–100
Plum	4–225
Strawberry	38–218
Beverage (mg/200 ml)	
Apple juice	0.4–3.2
Orange juice	37–710
Black tea	150–210
Coffee	267–733
Beer	12–20
White wine	40–60
Red wine	200–800

[a] dm = dry matter, fm = fresh matter



The Author

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Future Directions

The National Cancer Institute and the National Research Council recommend eating at least five servings of fruits and vegetables per day, but only 23% of Americans eat this much (43). A 1991 survey found that the average American's intake of fruit and vegetables was 3.4 servings per day. Between 1991 and l994, the average fruit and vegetable consumption increased from 3.9 to 4.4 servings/day (44). This shows that the American public is beginning to heed the messages about fruits and vegetables and a healthy diet. These recommendations have been made because fruits and vegetables are good sources of vitamins and minerals and are low in fat and high in fiber. An added benefit is the high level of antioxidants present in fruits and vegetables.

Figs are an excellent source of fiber, minerals, and polyphenols. They are low in sodium and have no fat or cholesterol. It remains to be shown in future studies whether the human consumption of figs can lead to a lowering of the risk factors for cancer, such as a decrease in oxidative damage to DNA. With respect to heart disease, do figs produce a decrease in lipids and a decrease in oxidative damage to LDL? One interesting clue is the fact that figs have been found to contain cholesterol-lowering phytosterols, lanosterol, and stigmasterol (45). Only future research will answer these intriguing questions.

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