

Nutritional Quality and Its Importance to Human Health

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Fruits, nuts, and vegetables play a significant role in human nutrition, especially as sources of dietary fiber, minerals, and vitamins—C (ascorbic acid), A, thiamine (B₁), niacin (B₃), pyridoxine (B₆), folacin (also known as folic acid or folate), B₉, and E (Quebedeaux and Bliss 1988, Quebedeaux and Eisa 1990, Craig and Beck 1999, Wargovich 2000). Their contribution as a group is estimated at 91% of vitamin C, 48% of vitamin A, 30% of folacin, 27% of vitamin B₆, 17% of thiamine, and 15% of niacin in the U.S. diet. Fruits and vegetables also supply 16% of magnesium, 19% of iron, and 9% of the calories. Legume vegetables, potatoes, and tree nuts, such as almond, filbert, pecan, pistachio, and walnut, contribute about 5% of the per-capita availability of proteins in the U.S. diet, and their proteins are of high quality as to their content of essential amino acids. Nuts are a good source of essential fatty acids, fiber, vitamin E, and minerals. Other important nutrients supplied by fruits and vegetables include riboflavin (B₂), zinc, calcium, potassium, and phosphorus. Fruits and vegetables remain an important source of nutrients in many parts of the world and offer advantages over dietary supplements because of low cost and wide availability.

Dietary supplements, while advantageous for conditions in which specific nutrients are needed in abundance such as iron deficiency, may be poorly absorbed; and many are derived chemically rather than from natural sources. Climatic conditions, particularly temperature and light intensity, have an especially strong effect on the nutritional quality of fruit and vegetable oxidation (Mozafar 1994). Low temperatures favor synthesis of sugars and vitamin C (glucose being the precursor to ascorbic acid) and at the same time decrease the rate of ascorbic acid oxidation. Maximum β -carotene (vitamin A) content in tomatoes occurs at a temperature range of 15 to 21 °C (59 to 70 °F), but β -carotene content is reduced if temperatures are higher or lower than this range, principally due to the temperature sensitivity of lycopene, the precursor to β -carotene and lutein.

The B vitamins are crop specific when it comes to temperature sensitivity. Warm-season crops (beans, tomatoes, peppers, melons, etc.) produce more B vitamins at high (27 to 30 °C, 81 to 86 °F) than at low (10 to 15 °C, 59 to 70°F) temperatures. Conversely, cool season crops (broccoli, cabbage, spinach, peas, etc.) produce more B vitamins at low than at high temperatures. Light intensity has little effect on the B vitamins; but, as light intensity increases, vitamin C increases and total carotenoids (vitamin A precursors) and chlorophyll decrease (Gross 1991). Higher light intensities produce more sugars, leading to more vitamin C, and also increase plant temperatures, inhibiting β -carotene (vitamin A) production, which protects chlorophyll from photobleaching. Soil type, the rootstock used for fruit trees, mulching, irrigation, fertilization, and other cultural practices influence the water and nutrient supply to the plant, which can affect the composition

and quality attributes (appearance, texture, taste, and aroma) of the harvested plant parts (Goldman et al. 1999). Other environmental factors that affect fruit and vegetable nutritional quality are altitude, soil pH and salinity, production practices (organic versus conventional and greenhouse versus field), ozone, insect injury, and plant diseases.

Maturity at harvest, fruit size, and harvesting method influence the commodity's quality and extent of physical injuries. Delays between harvest and consumption or processing can result in losses of flavor and nutritional quality. The magnitude of these losses increases with exposure to temperature, relative humidity, and/or concentrations of O₂, CO₂, and C₂H₄ outside the ranges that are optimum for each commodity during the entire postharvest handling system (Lee and Kader 2000). Furthermore, processing and cooking methods can greatly affect the nutritional value of fruits and vegetables. For instance, water-soluble vitamins such as vitamin C and folate are lost at high rates when cooking water is discarded, while fat-soluble compounds such as lycopene may be stabilized or enhanced by cooking.

Fruits, nuts, and vegetables in the daily diet have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke, and other chronic diseases (Quebedeaux and Bliss 1988, Quebedeaux and Eisa 1990, Produce for Better Health Foundation 1999, Prior and Cao 2000, Southon 2000, Wargovich 2000, Tomas-Barberan and Espin 2001, Hyson 2002, Goldberg 2003). Some components of fruits and vegetables (phytochemicals) are strong antioxidants and function to modify the metabolic activation and detoxification and disposition of carcinogens or even influence processes that alter the course of the tumor cell (Wargovich 2000). Though antioxidant capacity varies greatly among fruits and vegetables (Prior and Cao 2000, Perkins-Veazie and Collins 2001, Kalt 2002), it is better to consume a variety of commodities rather than limiting consumption to a few with the highest antioxidant capacity. The Dietary Guidelines for Americans, 2010 (USDA and HHS 2010) in part advises filling half your plate with fruits, vegetables, cooked beans, and grains. Such a healthy eating pattern also embodies food safety principles to avoid foodborne illness. In some countries, consumers are encouraged to eat up to 10 servings of fruits and vegetables per day.

There is increasing evidence that consumption of whole foods is better than isolated food components such as dietary supplements and nutraceuticals. For example, increased consumption of carotenoid-rich fruits and vegetables was more effective than carotenoid dietary supplements in increasing LDL oxidation resistance, lowering DNA damage, and inducing higher repair activity in human volunteers who participated in a study conducted in France, Italy, The Netherlands, and Spain (Southon 2000). In another study, adding antioxidant (vitamins A, C, and E) dietary supplements into the diet of cancer treatment patients who were eating a balanced diet of fruits and vegetables negatively affected their radiotherapy and chemotherapy (Seifried et al. 2003). High consumption of tomatoes and tomato products has been linked to reduced carcinogenesis, particularly prostate cancer, and has been thought to be due to the presence of lycopene, which gives red tomatoes their color (Giovannucci 2002). However, use of tomato powder effectively reduced prostate carcinogenesis in rats, while lycopene supplements, considered the primary active ingredient of tomatoes, had no effect (Boileau et al. 2003). Similar comparative studies are needed on other constituents of fruits and vegetables and on the bioavailability of nutrients taken as dietary supplements or as foods that contain these nutrients.

Examples of the phytochemicals in fruits and vegetables that have established or proposed positive effects on human health and their important sources are shown in tables 1 and 2. Some changes in these tables are likely as the results of additional studies on effects of phytochemicals and their bioavailability on human health become available in the next few years. Meanwhile it is important to evaluate the validity and dependability of the results of every study before reaching conclusions for the benefit of consumers.

Table 1. Nutritive constituents of fruits and vegetables that have positive effects on human health and their sources

Constituent	Sources	Established or proposed effects on human wellness
Vitamin C (ascorbic acid)	Broccoli, cabbage, cantaloupe, citrus fruits, guava, kiwifruit, leafy greens, pepper, pineapple, potato, strawberry, tomato, watermelon	Helps prevent scurvy and cardiovascular disease; aids wound healing and immune system
Vitamin A (carotenoids)	Dark-green vegetables (such as collards, spinach, and turnip greens), orange vegetables (such as carrots, pumpkin, and sweet potato), orange-flesh fruits (such as apricot, cantaloupe, mango, nectarine, orange, papaya, peach, persimmon, and pineapple), tomato	Helps prevent night blindness, chronic fatigue, psoriasis, heart disease, stroke, and cataracts
Vitamin K	Nuts, lentils, green onions, crucifers (cabbage, broccoli, brussel sprouts, etc.), leafy greens	Aids synthesis of procoagulant factors; helps prevent osteoporosis
Vitamin E (tocopherols)	Nuts (such as almonds, cashew nuts, filberts, macadamias, pecans, pistachios, peanuts, and walnuts), corn, dry beans, lentils and chickpeas, dark-green leafy vegetables	Helps prevent heart disease, LDL oxidation, cancer, and diabetes; aids immune system
Fiber	Most fresh fruits and vegetables, nuts, cooked dry beans and peas	Helps prevent diabetes and heart disease
Folate (folicin or folic acid)	Dark-green leafy vegetables (such as spinach, mustard greens, butterhead lettuce, broccoli, brussels sprouts, and okra), legumes (cooked dry beans, lentils, chickpeas, and green peas), asparagus	Helps prevent birth defects, cancer, and heart disease; aids nervous system

Calcium	Cooked vegetables (such as beans, greens, okra, and tomatoes), peas, papaya, raisins, orange, almonds, snap beans, pumpkin, cauliflower, rutabaga	Helps prevent osteoporosis; helps lower blood pressure; aids muscles, skeleton, and teeth
Magnesium	Spinach, lentils, okra, potato, banana, nuts, corn, cashews	Helps prevent osteoporosis; aids nervous system, teeth, and immune system
Potassium	Baked potato or sweet potato, banana and plantain, cooked dry beans, cooked greens, dried fruits (such as apricots and prunes), winter (orange) squash, cantaloupe	Helps prevent hypertension (high blood pressure), stroke, and arteriosclerosis

Table 2. Nonnutritive plant constituents that may be beneficial to human health

Constituent	Compound	Sources	Established or proposed effects on human wellness
Phenolic compounds			
Proanthocyanins	Tannins	Apple, grape, cranberry, pomegranate	Help prevent cancer
Anthocyanidins	Cyanidin, malvidin, delphinidin, pelargonidin, peonidin, petunidin	Red, blue, and purple fruits (such as apple, blackberry, blueberry, cranberry, grape, nectarine, peach, plum & prune, pomegranate, raspberry, and strawberry)	Help prevent heart disease, cancer initiation, diabetes, cataracts, and allergies; help lower blood pressure
Flavan-3-ols	Epicatechin, epigallocatechin, catechin, gallocatechin	Apples, apricots, blackberries, plums, raspberries, strawberries	Help prevent platelet aggregation and cancer
Flavanones	Hesperetin, naringenin, eriodictyol	Citrus (oranges, grapefruit, lemons, limes, tangerines, etc.)	Help prevent cancer
Flavones	Luteolin, apigenin	Celery, celery, peppers, rutabaga, spinach, parsley, artichoke, guava, pepper	Help prevent cancer, allergies, and heart disease
Flavonols	Quercetin, kaempferol, myricetin, rutin	Onions, snap beans, broccoli, cranberry, kale, peppers, lettuce	Help prevent heart disease and cancer initiation; are capillary protectants
Phenolic acids	Caffeic acid, chlorogenic acid, coumaric acid, ellagic acid	Blackberry, raspberry, strawberry, apple, peach, plum, cherry	Help prevent cancer; help lower cholesterol
Carotenoids			

Lycopene		Tomato, watermelon, papaya, Brazilian guava, autumn-olive, red grapefruit	Help prevent cancer, heart disease, and male infertility
α -Carotene		Sweet potatoes, apricots, pumpkins, cantaloupes, green beans, lima beans, broccoli, brussel sprouts, cabbage, kale, kiwifruit, lettuce, peas, spinach, prunes, peaches, mango, papaya, squash, carrots	Help prevent/slow tumor growth
β -Carotene		Cantaloupes, carrots, apricots, broccoli, leafy greens (lettuce, swiss chard, etc.), mango, persimmon, red pepper, spinach, sweet potato	Help prevent cancer
Xanthophylls	Lutein, zeaxanthin, β -cryptoxanthin	Sweet corn, spinach, corn, okra, cantaloupe, summer squash, turnip greens	Help prevent macular degeneration
Monoterpenes	Limonene	Citrus (grapefruit, tangerine, etc.)	Help prevent cancer
Sulfur compounds	Glucosinolates, isothiocyanates, indoles, allicin, diallyl isulphide	Broccoli, brussels sprouts, mustard greens, horseradish, garlic, onions, chives, leeks	Help prevent cancer and diabetes; help lower cholesterol and blood pressure

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