

Functional food science

Widespread interest in the possibility that selected foods might promote health has resulted in the coining of the generic term “functional food.” The Food and Nutrition Board of the National Academy of Sciences defines a “functional food” as one that encompasses potentially healthful products, including any modified food or food ingredient that may provide a health benefit beyond that of the traditional nutrients it contains (1).

As a working definition, the European view of a function food states that a food can be said to be functional if it contains a component (whether or not a nutrient) that benefits one of a limited number of functions in the body in a way that is relevant to either the state of well-being and health, or the reduction of the risk of a disease (2), or if it has a physiologic effect (3).

Although the term functional food is increasingly recognized as a household word, it has not been embraced totally by the health and scientific communities. Controversies about what is and what is not a functional food remain at the forefront of discussion (4,5). Many believe that the promotion of a food as good or bad is inappropriate and scientifically indefensible. Furthermore, many nutritionists are adamant that only diets can be classified as good or bad, not foods per se (6). It is unlikely that a nonfunctional food exists. Thus, in the broadest context, all foods must be considered functional. Nevertheless, some foods may be particularly beneficial in selectively alerting specific physiologic processes that improve the quality of life or reduce the risk of acquiring a disease. The wholesomeness of any diet depends on the supply of individual food components, interactions among components, and meeting needs dictated by an individual’s genetic background and physiological state.

The suggestion that certain foods or their components might offer some unique health benefit has blurred the distinction between foods and drugs. Classically, a drug is any article intended for use in the diagnosis, cure, mitigation, treatment or prevention of disease. Modification of the Food and Nutrition Board definition to reflect functional rather than health might help to resolve some of these drugs-verses-nutrients concerns. In addition, the promotion of increased consumption of functional foods and their associated bioactive components should be viewed as an approach to optimized nutrition rather than as an endorsement of enhanced consumption of products as part of a marketing strategy. A nutritional program is only as strong as its weakest link. Adding foods/food products to one's diet because of the benefits to health should be considered a step, not a staircase in the right direction. While blueberries contain proanthocyanidins, which can prevent oxidation of LDL cholesterol, prevent cancer, nourish the eyes, and enhance capillary strength, this means little if the rest of the diet is based on pizza and Burger King.

Reasons for public interest

Increased interest in functional foods likely is occurring for 3 reasons: increased health care costs, recent legislation, and scientific discoveries. Expenditures associated with health services, as a percentage of national wealth (the gross national product, or GNP), continue to rise worldwide (7). Health care in the United States accounts for approximately 14 percent of the GNP. Inappropriate dietary habits are viewed by many scientists as contributing to poor health and associated health care costs (8,9). Dietary factors are seen as contributing to the leading causes of death of Americans, including coronary heart disease and certain types of cancers (10). It might be foolhardy to believe that individual foods might be used as magic bullets against diseases, but it would also be unwise to reject evidence that inappropriate dietary

habits can exacerbate unhealthy conditions. A large percentage of healthy Americans are using supplements, with use influenced by several factors, including age, sex and previous medical condition.

Coronary heart disease is the most common cause of death today. It accounts for two-thirds of deaths from heart disease and accounts for 70 percent of all deaths among persons older than 75. Forty-four percent of the mortality and much of the morbidity in the United States can be traced to coronary heart disease (11). The role of diet in this disease is becoming clarified via the scientific method. At an estimated economic cost of \$259 billion, even a small percentage of responders to dietary change could have a substantial impact on health cost. Tucker and Miguel estimated that improving the nutritional status of some persons can be expected to reduce hospital costs (12). Although the benefits of reducing hospital costs should not be underrated, it is likewise important to recognize that preventive nutrition strategies likely will have an even greater impact on health care costs.

Correlations have been reported between dietary habits and 60 percent of cancers in women and more than 49 percent of cancers in men (13, 14). It is likely that several essential and nonessential dietary components influence the risk of developing cancer. Because an estimated 25 percent of Americans ultimately will deal with the complications of cancer; anything that reduces its risk can substantially reduce health care costs.

An estimated 6 percent of the national health expenditure is associated with treatment of obesity (15). Several dietary components may influence energy intake and metabolism, particularly fiber (16). Recent evidence that conjugated linoleic acid (CLA)—a functional food component found primarily in animal tissues and fluids—may alter lipid homeostasis provides the beginning evidence that the potential health benefits of foods are not limited solely to plant

sources (17). Regarding CLA, it is my clinical opinion that it is most effective in morbid obesity and not necessarily applicable toward losing those last 10 pounds.

Three U.S. legislative acts of the 1990s have had a significant effect on the promotion of the concept of functional foods. The first, the Nutrition Labeling and Education Act, passed in 1990 (18), mandated that the Food and Drug Administration (FDA) establish regulations requiring most foods to have a uniform nutrition label while also establishing circumstances under which claims about content and disease prevention could be made about nutrients in foods. The second piece of legislation, the Dietary Supplement Health and Education Act of 1994 (19), defined dietary supplements as any product that contains one or more dietary ingredients such as vitamins, minerals, herbs or other botanicals, amino acids or other ingredients used to supplement the diet. Additionally, it created a mechanism for dealing with safety issues, regulation of health claims and labeling of dietary supplements; established new government entities to review regulations; and encouraged research on dietary supplements. Finally, the FDA Modernization Act of 1997 (20) amended the Federal Food, Drug, and Cosmetic Act by allowing health claims that are not pre-authorized by the FDA if the claims are based on authoritative statements of government agencies such as the National Academy of Sciences or the National Institutes of Health.

Epidemiological and laboratory findings are continuing to provide convincing evidence that increased consumption of fruits and vegetables can significantly modify disease risk. A large number of chemical compounds found in fruits and vegetables appear to be protective (21,22).

A partial list of foods that have been proposed to provide benefits by altering one or more physiologic processes is presented below.

Lipid lowering

Apple, barley, blackberry, blueberry, carrot, eggplant, oats, garlic, ginger, ginseng, mushroom, onion, soybean, tea

Enhanced drug detoxification

Lemon, apple, cranberry, garlic, beet, cucumber, squash, soybean, cabbage, Brussels sprouts, Cauliflower, kale, broccoli, spinach

Anti-inflammatory

Ginseng, licorice, oats, parsley, papaya

Anti-microbial

Cranberry, garlic, onion, green tea

Anti-estrogenic

Anise, fennel, soybean, cabbage

Anti-proliferative

Orange, green tea, garlic, lemon

Nuts, whole grains, fruits and vegetables contain a variety of compounds associated with reduced risk of heart disease, cancer, diabetes, hypertension and a variety of other medical conditions. Widely diverse components in whole grains that may provide protection by influencing the environment of the gastrointestinal tract include dietary fiber and other indigestible components; several types of antioxidants, such as trace minerals and phenolic compounds; and several phytoestrogens that may alter hormonal homeostasis (23,24).

Many types of compounds found in garlic and related foods may be responsible for health benefits attributed to functional foods. Allyl compounds, such as those found in garlic and related foods, have been used in various parts of the world

not only for aroma and flavor but also as anti-microbials, insect repellents, and modifiers of the risks of cancer and heart disease (25).

Other important groups of compounds that contribute to observed protection include carotenoids, which are found in vegetables and fruits; flavonoids, found in fruit, vegetables, nuts and grains; and indoles and cyanates, both found in cruciferous vegetables.

An enormous number of carotenoids are found throughout the plant kingdom. These compounds, many of which do not possess vitamin A activity, can influence numerous biological functions by serving as antioxidants, modulators of cell growth regulation, regulators of gene expression and immunoregulators (26,27).

Indole-3-carbinol is a compound found in brassica family vegetables (most notably broccoli, Brussels sprouts, cabbage and cauliflower) that has been reported to exhibit anti-carcinogenic properties in experimental animals and humans. Recent studies suggest indole-3-carbinol may be a safe, well-tolerated and efficacious treatment for recurrent respiratory papillomatosis (28).

More than 100 sulfur-containing glycosides, known collectively as glucosinolates, occur naturally in cruciferous vegetables. On hydrolysis, they yield thiocyanate, nitrite and isothiocyanates. Isothiocyanates influence a variety of biological reactions and have shown promise in being anticarcinogenic in the research setting (29.)

More than 4,000 flavonoids, which are polyphenolic compounds found ubiquitously in foods of plant origin, have been described and categorized into flavonols, flavones, catechins, flavanones, anthocyanidins and isoflavonoids. Flavonoids potentially have a variety of biological effects, including serving as antioxidants, influencing drug detoxification

mechanisms, and altering cell proliferation (30).

Elucidation of the specific roles and interactions of nutrients and their associations with genetics will assist in the identification of critical times for intervention and lead to sound and accurate dietary guidance that can be tailored to reduce disease risk of individuals. Interactions among nutrients are an area that needs further study. Although interactions among nutrients have been inadequately examined, a few examples of negative and positive interaction exist. Vitamin C has been reported to reduce selenium's effectiveness against chemically induced colon cancer (31). The significance of such interactions may be even more pronounced because selenium has been shown to enhance the ability of garlic to inhibit chemically induced mammary cancer in experimental animals (32). Nonessential and essential nutrients cannot be considered to operate in isolation; rather they work in a dynamic, constantly changing milieu. Greater attention to all components of the diet and elaboration of their interactions should make possible specific and appropriate recommendations tailored to specific subgroups of individuals.

To Process or not to process, that is the question

The processing of foods can influence the availability of nutrients either positively or negatively. Stahl and Sies (33) found that lycopene bioavailability was improved by heating tomato preparations in the presence of oil. Conversely, Ali (34) found that boiling garlic for 15 minutes markedly reduced its ability to inhibit thromboxane B₂ synthesis in rabbit lung. Analogously, recent studies showed that heating garlic in a microwave or convectional oven before peeling can dramatically reduce its ability to alter the bioactivation of a known experimental mammary carcinogen (35). The effect of different processing methods on the biological availability and effectiveness of physiologically active components in various functional foods remains to be determined.

In the final analysis, development of the scientific underpinning of functional foods and their bioactive components as health promoters is emerging as a new frontier for nutritionists and other health professionals. Greater understanding of how diet influences an individual's genetic potential, overall performance and susceptibility to disease can have enormous implications for society. As new discoveries are made in this area, you will read about them here. Currently, the best strategy is to incorporate a wide variety of foods for their essential nutrients and for their potential functional food value in your diet while utilizing supplementation as a support mechanism. While I welcome the functional food revolution with open arms, upon closer examination, I fear that supermarket shelves lined with various highly processed foods will take precedence in the diet because of mere marketing strategies and fancy labeling regarding an isolated compound. Take soluble fiber, for example. It has been shown in clinical research to reduce cholesterol levels. Major grain refiners exploit this fact on their labeling of products containing oats (a grain particularly high in soluble fiber), yet the microprint on the television ads note a 5 percent drop in total cholesterol can be achieved while consuming x amount if oatmeal. I wouldn't praise those calculations at all. Meanwhile, in the clinical setting, I am used to witnessing 60- to 100-point drops in total cholesterol when patients follow an individualized protocol of healthy diet, functional foods and specific supplements. I urge you to look beyond the marketing and focus on your meal planning. Remember, a nutritional program is only as strong as its weakest link.

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