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# A-Z Guide to Food as Medicine

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Diane Kraft  
Ara DerMarderosian



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## Foreword

There is a growing consumer interest in health and the role that nutrition can play in promoting health and preventing nutrition-related chronic diseases. This heightened interest in nutrition has been accompanied by many questions about what specifically can be done with nutrition to promote health and prevent disease. There is a growing interest in phytochemicals because of the ongoing research demonstrating their many health benefits. Phytochemicals are present in plant foods such as fruits, vegetables, beans, grains, nuts, seeds, soy products, as well as liquid vegetable oils. Thousands of phytochemicals have been identified; common classes include antioxidants, flavonoids, flavanols, flavanones, isoflavones, catechins, epicatechins, anthocyanins, anthocyanidins, proanthocyanidins, isothiocyanates, carotenoids, allyl sulfides, polyphenols, and phenolic acids, among others. The list of phytochemicals may be overwhelming to grasp. Given their plethora and their myriad biological actions, there is a need for an authoritative resource that provides important basic information about many individual foods and phytochemicals. Having all of this information compiled in *The A–Z Guide to Food as Medicine* will be of benefit to readers in understanding the current evidence base for individual phytochemicals. This guide is an important resource because it presents concise and key science-based information that can be quickly and easily accessed. It can also be used as a filter for “junk science,” which clutters many information resources and causes a lot of confusion among the public. The guide is formatted to define the food, spice, bioactive compound, or topic of interest; its origin, including how it is used; a summary of the scientific findings, including references; the bioactive dose, when known; and safety information, when applicable. This guide presents germane information concisely in one place. This is of benefit to readers who wish to follow good nutrition practices that are based on sound science. Readers will find that the guide is “go to” resource when trying to sort fact from fiction in response to the burgeoning nutrition misinformation that is everywhere. Key topics of interest include nutrients, bioactive components, specific foods, spices, and other topics of interest. Readers will value the extensive list of topics covered and the concise information

presented for each one. *The A–Z Guide to Food as Medicine* will serve as an expedient resource for quickly accessing fact-based information about foods and phytochemicals in a manner that obviates the need to spend unnecessary time hunting down reputable information in the literature and other sources. I highly recommend *The A–Z Guide to Food as Medicine* as a valuable, “quick-access” resource for obtaining sound, science-based information that can be used to implement dietary practices that benefit health.

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## *Preface*

Traditional use of foods as medicine has been practiced worldwide since ancient times. In the third century BC, Hippocrates said, “Let food be thy medicine.” In the centuries that followed, records show that foods and plant materials were the basis of early medicines in practically every country. In contrast to folkloric use of foods as medicine, when an apple a day was recommended to keep the doctor away but for unknown reasons, modern science has isolated immune-enhancing constituents in apples and recommends the number of servings (a bioactive dose) of fruits one needs daily for health to prevent certain diseases<sup>1</sup> and makes practical recommendations to eat not only white-fleshed fruits but also to consume as many different colors of fruits as possible to ingest as wide an array as possible of nutrients and phytochemicals associated with health and disease prevention.

Phytochemicals, literally “plant chemicals,” are produced by the plant for survivability, that is, as protection against pathogens and pests,<sup>2</sup> and they also provide health benefits when consumed.

For example, glucosinolates in brassica family vegetables are both plant-protective<sup>3</sup> and have been shown to exert anticancer properties when consumed.<sup>4</sup> Phytochemicals are also responsible for the characteristic colors, flavors, aromas, and textures of plant foods.

The beneficial pharmacological properties of foods, nutrients, and phytochemicals are highlighted in this guide.

Whole food, with few exceptions, is preferable as a source of nutrients and phytochemicals. Phytochemicals, similar to nutrients, are best utilized by the body when provided as part of the whole food matrix, rather than as individual entities. This is due to the numerous symbiotic elements contained within foods that work in concert with one another, both enhancing the beneficial elements and diluting the less desirable elements.<sup>3</sup>

The actions of phytochemicals in the diet are characterized by Dillard and German as follows:

1. Substrates (fuels) for biochemical reactions
2. Cofactors of enzymatic reactions

3. Inhibitors of enzymatic reactions
4. Absorbents/sequestrants that bind to and eliminate undesirable constituents in the intestine
5. Ligands (substances that bind to another molecule to form a complex) that agonize or antagonize cell surface or intracellular receptors
6. Scavengers of reactive or toxic chemicals
7. Compounds that enhance the absorption and/or stability of essential nutrients
8. Selective growth factors for beneficial gastrointestinal bacteria
9. Fermentation substrates for beneficial oral, gastric, or intestinal bacteria
10. Selective inhibitors of deleterious intestinal bacteria

This guide is a dictionary of foods and bioactive ingredients found in foods. The authors included fruits, vegetables, and other natural foods identified in the scientific literature as having been studied for a physiological effect. Individual entries (foods, nutrients, and phytochemicals) are organized alphabetically so information can be easily accessed. Only naturally occurring foods and food constituents are addressed while dietary supplements are not, because their physiological effects may be due to dose, whereas, our focus was on natural physiological effects of foods and food constituents. Only enteral, and not topical uses of foods, nutrients, and phytochemicals are addressed.

Each entry provides

- The food or food constituent name, definition, and common use.
- Scientific findings for its beneficial effects or lack thereof.
- A bioactive dose, if known, that is, if supported by scientific consensus; for example, the quantities of food groups that one should eat daily that are consistent with health are known and are presented as a “bioactive dose.” Likewise, the quantities of nutrients that one should consume daily, in the foods they select, are known, and the recommended dietary allowance (RDA) or adequate intake (AI) of nutrients is presented as a “bioactive dose.” In many cases, data about the physiological effects of a phytochemical are limited to laboratory research, suggesting the research on that particular food component is preliminary. The reader is aware that *in vitro* and animal studies do not prove *in vivo* biological activity. By including such preliminary data, the guide is informing the reader that a phytochemical is in its infancy in terms of research. Rarely have foods or their constituents been adequately tested in well-designed, adequately powered clinical trials. When a clinical trial’s bioactive dose has been reported, the guide attempts to include it in the scientific findings section, but for the majority of foods and phytochemicals



presented herein, typically a bioactive dose is not known and “bio-active dose: not known” is stated.

- Safety data, such as the tolerable upper level of intake (UL), for nutrients are stated. Safety concerns for certain groups or individuals have been captured when they were identified in the scientific literature whether or not studies in scientific findings address these groups. For example, there may have been no studies conducted in pregnant women and no studies on pregnant women will appear in the scientific findings sections, but when pregnancy precautions have been published and could be identified in the scientific literature, the safety section will state that safe use has not been established during pregnancy.

All foods are generally recognized as safe (GRAS) by the U.S. Food and Drug Administration, and many food constituents, for example, limonene and vanillin, also have GRAS status. Generally, the statement “Presumed safe when consumed in normal dietary quantities by non-allergic individuals” is stated in the safety section for the majority of foods, nutrients, and phytochemicals, followed by safety concerns for certain groups or individuals.

### *Important advice and notes*

With regard to using information in this guide, it is important to keep the caveats of good science and common sense in mind:

1. Most common foods are known to be safe when properly prepared and consumed in normal amounts. However, some can interact with prescription drugs and some should not be consumed when certain diseases or conditions exist. Some foods must also be avoided in cases of food intolerance, sensitivity, or allergy.
2. Phytochemicals and food constituents that are medicinal in nature in small quantities may be deleterious to health in large quantities.
3. All data provided in this guide are intended for reference and to enhance knowledge of foods and food constituents.

**Diane Kraft and Ara DerMarderosian**

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Photo by Michael Taro Andersen

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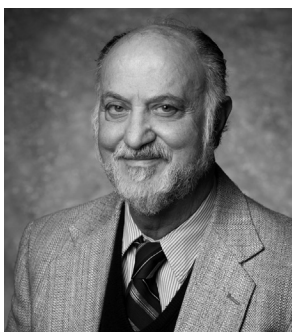


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logical, and toxicological aspects of natural products, through the eighth (2015) edition. He is the herbal and dietary supplement chapter author for several editions of *The Merck Manual*, and has spoken on nutrition and pharmacognosy topics to medical professionals for several decades.



## *Açaí berry (Euterpe oleracea)*



Acai fruit. (Image from diogoppr/Shutterstock.)

### *definition*

Dark purple fruit of the açaí palm native to South America. Commonly sold as juice or juice drink.

### *scientific findings*

An *in vitro* study found that acai juice polyphenols exhibited antioxidant properties and inhibited LDL (low-density lipoprotein) oxidation but found “no consistent clinical evidence of antioxidant potency” of acai compared to other beverages, such as red wine.<sup>1</sup> In rats fed a hypercholesterolemic diet, acai supplementation improved antioxidant status and reduced non-high-density lipoprotein (HDL) cholesterol.<sup>2</sup> In a small crossover clinical trial of healthy human volunteers (n = 12), acai juice and pulp, dosed at 7 mL/kg of body weight, raised plasma antioxidant capacity but did not affect other markers of antioxidant activity such as antioxidant capacity of urine.<sup>3</sup> A small nonblinded, non-placebo-controlled trial of healthy overweight adults (n = 10) showed that consuming 100 g of acai pulp for 1 month improved insulin, total cholesterol, and postprandial plasma glucose.<sup>4</sup>

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*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. There is insufficient safety data available to evaluate the use of acai during pregnancy or lactation.<sup>5</sup>

*Alfalfa (Medicago sativa)**definition*

Herb which is made into tea and used medicinally; the seeds and sprouts are also consumed.<sup>6</sup> Alfalfa sprouts are used fresh in salads, on sandwiches, or juiced. *M. sativa* contains saponins, flavonoids, phytoestrogens, alkaloids, phytosterols, and terpenes.<sup>7</sup> In traditional medicine, *M. sativa* has been used to treat atherosclerosis, heart disease, stroke, cancer, diabetes, and menopausal symptoms.<sup>7</sup>

*scientific findings*

In laboratory research, the *M. sativa* plant has exhibited neuroprotective, hypocholesterolemic, antioxidant, antiulcer, antimicrobial, hypolipidemic, and estrogenic properties.<sup>7</sup> In a clinical trial (n = 15 hypercholesterolemic subjects), eating 40 g of alfalfa seeds three times daily with meals for 8 weeks reduced elevated total and LDL cholesterol,<sup>8</sup> due to saponins' inhibition of the absorption of cholesterol or bile in the gut,<sup>8</sup> an effect that also was demonstrated in two laboratory studies.<sup>9,10</sup>

*bioactive dose*

For high cholesterol, a typical oral dose of 5–10 g of the alfalfa herb steeped, strained, and drunk as tea three times daily has been used.<sup>6</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Alfalfa seeds and sprouts have the potential for bacterial contamination and should be avoided by children, older adults, and immune-compromised individuals.<sup>11</sup> Chronic ingestion of alfalfa seeds has been associated with pancytopenia and drug-induced lupus-like effects.<sup>5</sup> Alfalfa constituents may exert estrogenic effects and therefore



may be unsafe during pregnancy and lactation when used in amounts greater than those found in foods.<sup>5</sup> When the alfalfa herb is prepared and used as a tea as described in Bioactive Dose, it is considered to be possibly safe for use by adults, but excessive or long-term use is not recommended.<sup>5</sup>

## Allium vegetables



Spring onion, onion, and garlic. (Image from jopelka/Shutterstock.)

### definition

Bulbous culinary herbs of the Alliaceae family that include approximately 500 species such as onion (*Allium cepa*), shallot (*Allium ascalonicum*), garlic (*Allium sativum*), green onion (*Allium macrostemon*), leek (*Allium porrum*), scallion (*Allium tartaricum*), and others. Commonly used raw or cooked for their flavor and pungent odor due to organosulfur compounds such as allyl derivatives.<sup>12</sup> Allium vegetables are rich in flavonoids.<sup>13</sup> They have been used for medicinal purposes throughout recorded history.

### scientific findings

In laboratory studies, allyl derivatives inhibited carcinogenesis in the stomach, esophagus, colon, mammary gland, and lung of experimental animals<sup>14</sup> and improved immune function, reduced blood glucose, and conferred radioprotection and protection against microbial infection.<sup>15</sup> Clinical trials to investigate anticancer effects of allium vegetables and their constituents are lacking,<sup>15</sup> but epidemiological studies have provided preliminary evidence of allium vegetables' anticancer effects in certain types of cancer. For example, a population-based case-control study (n = 238 case subjects with confirmed prostate cancer and 471 control subjects) found that men who consumed the highest amount of allium

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vegetables (>10.0 g/day which is approximately one tablespoon<sup>16</sup>) had a statistically significant lower risk of prostate cancer than those who consumed the least.<sup>17</sup> Allium vegetable intake of  $\geq 1$  portion per week compared with low or no consumption was associated with a reduced risk of myocardial infarction in a case-control study (n = 760 patients with a first episode of nonfatal acute myocardial infarction and 682 controls).<sup>18</sup> High allium vegetable consumption was associated with a reduced risk of gastric cancer in a meta-analysis of 19 case-control and two cohort studies (n = 543,220).<sup>19</sup> In a multicenter case-control study, a comparison of dietary data from 454 endometrial cancer cases and 908 controls found “a moderate protective role of allium vegetables on the risk of endometrial cancer.”<sup>20</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Allspice (Pimenta dioica)*

### *definition*

Dried fruit of a Caribbean tree<sup>21</sup> that is ground into a reddish-brown powder and consumed as a spice. Allspice is used in Caribbean cooking as jerk seasoning; in Indian chutneys, biryani, and meat and poultry dishes; in Middle Eastern cooking; and is a standard ingredient in pumpkin pie. *P. dioica* contains numerous phytochemicals including phenolics, vanillin, eugenol, and terpenoids.<sup>22</sup> In traditional medicine, allspice has been used to treat hypertension, inflammation, pain, diarrhea, fever, cold, pneumonia, and bacterial infection.<sup>22</sup>

### *scientific findings*

Laboratory studies have shown allspice to have antioxidant properties.<sup>23,24</sup> A review of allspice found its glycosides and polyphenols exerted antibacterial, hypotensive, antineuralgic, and analgesic properties in laboratory studies; in addition, *in vitro* and *in vivo* studies showed it to have anti-prostate-cancer and anti-breast-cancer properties, as well as to exhibit “selective antiproliferative and antitumor properties on human cancer cells and their animal models.”<sup>21</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. There is insufficient reliable information available about the safety of allspice used in amounts greater than are normally found in food, especially during pregnancy and lactation.<sup>5</sup>

*Almond (Prunus dulcis)**definition*

Tree nut, also known as sweet almond, that is consumed raw, roasted, pureed as almond butter, in candy and baked products, and made into milk. In addition to protein and fiber, almonds are a source of  $\alpha$ -tocopherol, manganese, magnesium, copper, phosphorus, riboflavin,<sup>25</sup> phytosterols, and polyphenolic compounds such as proanthocyanidins and lignans.<sup>26</sup> Almost 50% of almond weight is fat,<sup>25</sup> most of which is monounsaturated.<sup>27</sup>

*scientific findings*

When consumed as part of a low saturated fat diet, low cholesterol diet, 2.5–3.5 oz (70–100 g) of almonds reduced total cholesterol by 4%–11% and LDL cholesterol by 7%–12%, according to the results of five small human studies, two of which also found a 1.7%–3.5% increase in HDL cholesterol.<sup>28</sup> Perhaps due to their high content of bioavailable  $\alpha$ -tocopherol, almond-supplemented diets may reduce LDL-cholesterol oxidation.<sup>25</sup> Despite nuts' general reputation for being high-calorie, two randomized, controlled trials found that a low-calorie diet that included almonds did not increase body weight. In one of the studies ( $n = 123$ ), overweight and obese individuals were randomly assigned to consume either an almond-supplemented low-calorie diet or a nut-free low-calorie diet. At 18 months, both groups experienced clinically significant and comparable weight loss.<sup>29</sup> In the second study ( $n = 65$ ), subjects were randomized to a liquid formula-based weight-loss diet supplemented with almonds, or a liquid-formula-based-weight-loss diet supplemented with complex carbohydrates. At 24 weeks, greater reductions in weight were seen in the almond-supplemented group.<sup>30</sup> Both studies found improvements in blood lipids in almond-supplemented groups compared to control groups.<sup>29,30</sup> In a third, non-placebo-controlled study ( $n = 20$ ), healthy women added almonds to their diet for 10 weeks, followed by a 3-week

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washout period, followed by their usual diet without almonds for another 10 weeks. The study found that “10 weeks of daily almond consumption did not cause a change in body weight,” which was attributed to “compensation for the energy contained in the almonds through reduced food intake from other sources.”<sup>31</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Anise (Pimpinella anisum)*

### *definition*

Umbelliferous (umbrella-shaped) mint family plant whose volatile oils, including anethole, contribute to its licorice-like flavor and aroma.<sup>5,32</sup> Anise seeds are used as a spice and to flavor liquors. Anise has been used in folk medicine to treat nausea and ulcer.<sup>33</sup> Though anise seeds are commonly consumed after meals to freshen breath and to induce burping, no published reports were found to substantiate its mechanism of action to induce burping, which is thought to occur because a constituent in anise reduces the surface tension of the stomach contents, resulting in gas bubble coalescence and release.

### *scientific findings*

An *in vitro* study demonstrated anti-*Helicobacter pylori* activity in an extract made from the seeds of *P. anisum*.<sup>34</sup> *P. anisum* has demonstrated antimicrobial, antifungal, antiviral, antioxidant, immunostimulant, muscle relaxant, analgesic, and anticonvulsant activity and reduced morphine dependence in laboratory studies.<sup>35,36</sup> Umbelliferous vegetables are considered to be among the foods and herbs having the highest anticancer activity.<sup>37</sup>

### *bioactive dose*

Not known. An oral dose of one tablespoon of the tea taken several times a day has been used for antifatulence.<sup>5</sup> The tea is prepared by steeping 1–2 teaspoons of the crushed seed for 10–15 min and then straining.<sup>5</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Anthocyanins**definition*

Purple or red plant food pigments that serve as antioxidants, found in foods such as berries, black currant, blueberry, cherry, cranberry, eggplant, lingonberry, mulberry, lettuce, and strawberry.<sup>38</sup> Chemically classified as polyphenolic compounds, examples of anthocyanins include cyanidin, malvidin, and petunidin.<sup>41</sup> Used in folk medicine to treat liver dysfunction, hypertension, vision disorders, microbial infections, diarrhea, and other disorders.<sup>39</sup>

*scientific findings*

In laboratory research, anthocyanins demonstrated estrogenic activity that altered development of hormone-dependent disease symptoms; increased cytokine production, thus regulating immune response; reduced capillary permeability and fragility and strengthened membranes; exerted anti-inflammatory, antidiabetic, and antimicrobial properties; and demonstrated anticancer and antiproliferative capabilities.<sup>39–43</sup> A comprehensive review of eight prospective, controlled interventional and observational studies (n = 390,769 participants) found no evidence to suggest that high anthocyanin intake is inversely associated with colorectal adenomas.<sup>44</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Antioxidant**definition*

Phytochemical that can prevent, inhibit, or repair damage caused by oxidative stress. Antioxidants may interfere with oxidation by inactivating a prooxidant compound, scavenging free radicals, acting as chelators to deactivate metal catalysts, repair oxidative damage, or stimulate the

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activity of antioxidant enzymes.<sup>45,46</sup> All plant foods are sources of antioxidants, which include carotenoids; vitamin C, vitamin E, and selenium; isothiocyanates; and phenolic compounds (flavonoids, stilbenes, phenolic acids, and lignans).<sup>46</sup>

### *scientific findings*

Epidemiological data suggest that intake of foods rich in vitamin E, vitamin C, and  $\beta$ -carotene is associated with a decreased risk for coronary heart disease.<sup>47</sup> Studies support a beneficial effect of food-derived  $\beta$ -carotene, vitamin C, vitamin E, lutein, and zeaxanthin in delayed progression of advanced age-related macular degeneration; while other studies have reported inconclusive findings.<sup>47</sup> The U.S. Department of Agriculture has developed a rating scale to measure the antioxidant content of plant foods called the oxygen radical absorbance capacity.<sup>48</sup> A measure of antioxidant capacity of the diet called dietary total antioxidant capacity has been shown to be inversely associated with risks of developing common chronic diseases, and was found to be a good predictor of dietary and plasma antioxidant status in a sample of healthy, young adult men and women (n = 60 nonsmoking adults aged 16–25).<sup>49</sup>

### *bioactive dose*

Not known and/or varies by antioxidant (see: Bioactive Dose for Selenium, Vitamin C, and Vitamin E—each has an RDA [recommended dietary allowance]. Note  $\beta$ -carotene has no RDA).

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Varies by antioxidant (see: Safety for Selenium, Vitamin C, and Vitamin E—each has a UL [tolerable upper intake level]).  $\beta$ -carotene has no UL.

## *Apple (Domestica sylvestris)*

### *definition*

Popular fresh fruit of which there are thousands of varieties. Apples are also consumed dehydrated, dried, baked, as juice or cider, as applesauce, and in baked desserts. Apple pulp is high in the soluble fiber pectin.<sup>50</sup> Apple skins are a source of insoluble fiber and phytochemicals such as phloretin and the flavonoid quercetin.<sup>51</sup> Applesauce has been traditionally

used to treat diarrhea as part of the BRAT (bananas–rice–applesauce–toast/tea) diet.<sup>52</sup>

### *scientific findings*

Pectin may reduce diarrhea by stimulating epithelial growth in the colon.<sup>53</sup> Soluble fibers slow upper gastrointestinal transit time and alleviate diarrhea; on the other hand, the soluble fiber in apples increases fecal water content to promote water retention in stools, while insoluble fibers provide bulk, both actions of which promote laxation. Soluble fibers promote the excretion of cholesterol and bile acids, thereby helping to reduce serum cholesterol. Total and LDL cholesterol were reduced in a randomized, double-blind, placebo-controlled study (n = 71 healthy, moderately obese adults) in subjects ingesting 600 mg of apple polyphenols for 12 weeks, an effect not seen in the placebo group.<sup>54</sup> In a 1-year clinical trial (n = 160 postmenopausal women), consumption of 75 g dried apple (about two medium-sized apples) was found to significantly reduce atherogenic cholesterol levels in the third month.<sup>55</sup> A nonrandomized trial of healthy subjects (n = 23) found that apples, but not apple juice, significantly reduced total and LDL cholesterol.<sup>56</sup> Epidemiologic studies suggest an inverse relationship between apple consumption and colon cancer risk<sup>57</sup> and that regular consumption of one or more apples a day may reduce the risk for lung and colon cancer.<sup>58</sup> According to a review, “Exposure to apples and apple products has been associated with beneficial effects on risk, markers, and etiology of cancer, cardiovascular disease, asthma, and Alzheimer’s disease” and preliminary data suggest an association of apples with improved cognitive outcomes related to normal aging, diabetes, weight management, bone health, pulmonary function, and gastrointestinal health.<sup>59</sup> A prospective, population-based cohort study (n = 20,069 men and women aged 20–65 years free of cardiovascular diseases at baseline) found that high intake of white-fleshed fruits may protect against stroke. Each 25-g/day increase in white fruit and vegetable consumption was associated with a 9% lower risk of stroke.<sup>60</sup> In a laboratory analysis, apple extracts showed strong antioxidant activity despite low total phenolic contents.<sup>61</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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*Apricot (Prunus armeniaca)**definition*

Stone fruit member of the Rosaceae family that is consumed fresh, dried, canned, in jams and preserves, and as nectar. Apricots are good sources of  $\beta$ -carotene<sup>62</sup> and contain potassium, soluble and insoluble fiber,<sup>63</sup> and flavonoids.<sup>64</sup> In folk medicine, apricots have been used to treat hemorrhage, infertility, eye inflammation, and spasm.<sup>65</sup>

*scientific findings*

Apricots bound bile acids in an *in vitro* study.<sup>66</sup> Intestinal binding of bile acids by dietary soluble fiber reduces serum cholesterol levels in humans.

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Artichoke (Cynara scolymus)*

Artichoke. (Image from Binh Thanh Bui/Shutterstock.)



### *definition*

Herb that is a good source of fiber (7 g per 1 medium artichoke) and a source of folate, calcium, and potassium<sup>67</sup> in addition to caffeic acid and flavonoids.<sup>68</sup> Technically, the base of the flower petals (referred to as “leaves”) are edible, and they are held in place by a core (artichoke “heart”), which is the main edible portion of the artichoke. Fresh artichokes can be steamed or braised, or, when purchased canned (either packed in salt water or with oil and other flavorings, such as vinegar), used as a salad vegetable.

### *scientific findings*

A meta-analysis of three randomized, placebo-controlled clinical trials (n = 262 patients with hypercholesterolemia) concluded that artichoke leaf extract may have cholesterol-lowering potential.<sup>69</sup> In one trial, the total cholesterol level in participants receiving artichoke decreased from 7.16 (0.62) to 6.86 (0.68) mmol/L after 12 weeks and increased from 6.90 (0.49) to 7.04 (0.61) mmol/L in patients receiving placebo, the total difference being statistically significant.<sup>69</sup> A second trial found artichoke leaf extract reduced total cholesterol levels from 7.74 to 6.31 mmol/L, whereas the placebo reduced cholesterol from 7.69 to 7.03 mmol/L.<sup>69</sup> A third trial showed that artichoke leaf extract significantly reduced blood cholesterol compared with placebo in a subgroup of patients with baseline total cholesterol levels of more than 230 mg/dL.<sup>69</sup> In a 6-week, double-blind, randomized controlled trial (n = 247 patients with functional dyspepsia), a dose of 640 mg of artichoke leaf extract reduced dyspepsia compared to placebo.<sup>70</sup> In a randomized, crossover design study (n = 8 healthy subjects and n = 19 subjects with metabolic syndrome), glucose, insulin, and homocysteine levels were measured postprandially every 4 h after a meal containing boiled wild artichoke, white bread, refined olive oil, and lemon juice, and a control meal that did not contain the boiled artichoke. The boiled artichoke meal, compared with the control meal, reduced postprandial serum glucose and insulin response in normal subjects and had no effect in patients with metabolic syndrome or in homocysteine levels in either group.<sup>71</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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*Arugula (Eruca sativa)**definition*

Also called rocket or roquette. Aromatic Brassicacea salad green. It may be finely chopped and combined with garlic, parmesan cheese, and other ingredients to make pesto. A good source of vitamin K<sup>72</sup> and glucosinolates.<sup>73</sup> *E. sativa* seed extract has been used to treat skin disorders in traditional Middle Eastern medicine.<sup>74</sup> Arugula seeds are used to grow microgreens used in salads and as a garnish.

*scientific findings*

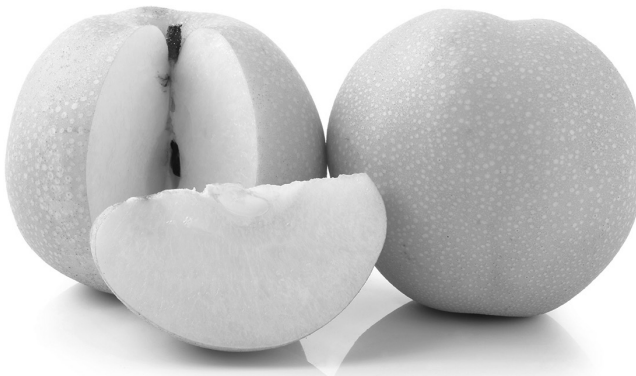
Arugula (*E. sativa* cv. *Sky*) extract exhibited antioxidant properties *in vitro* in human colon cancer cells.<sup>75</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Asian pear (Pyrus pyrifolia)*

Asian pear. (Image from MRS.Siwaporn/Shutterstock.)

*definition*

Crisp-fleshed, juicy pear, sometimes called an Asian apple pear or Japanese pear. It resembles a yellow apple with rough, sandpaper-like skin, and it

tastes like a watered-down apple.<sup>76</sup> A source of flavonoids, it contains 4 g of fiber per medium fruit.<sup>77</sup>

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### *scientific findings*

In laboratory research, *P. pyrifolia* cv. *Shingo* (Korean pear), a specific variety or cultivar of Asian pear, stimulated two key alcohol-metabolizing enzymes involved in alcohol detoxification.<sup>78</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Asparagus (Asparagus officinalis L.)*

### *definition*

Green shoot vegetable (the spears are “shoots”) that is commonly eaten cooked by broiling or steaming. Asparagus is a good source of vitamin K and folate<sup>79</sup> and contains numerous phytochemicals including flavonoids<sup>80</sup> and saponins.<sup>81</sup> The mineral content (copper, iron, zinc, manganese, calcium, magnesium, sodium, potassium, and phosphorous) is higher in green asparagus than in other varieties, and nutrients are generally richest in the tips of the spears. Asparagus has been used in traditional medicine as a diuretic<sup>82</sup> and a contraceptive.<sup>80</sup>

### *scientific findings*

In laboratory studies, asparagus has exhibited antifungal, antiviral, and antitumor properties attributed to steroidal saponins.<sup>81</sup> In an 8-week animal study, an asparagus extract reduced total and LDL cholesterol and raised HDL cholesterol in mice fed a high-fat diet to induce hyperlipidemia; in addition, antioxidative effects and normalization of animals' liver function tests were attributed to the asparagus extract.<sup>83</sup> The *Asparagus racemosus* species of asparagus, commonly used in the manufacture of dietary supplements of asparagus<sup>84</sup> exhibited diuretic properties in an experimental study of laboratory animals that compared asparagus to furosemide, a diuretic medication.<sup>82</sup>

## A

*bioactive dose*

Not known. *A. racemosus* has been used medicinally as a tea prepared by steeping 40–60 g of the cut rhizome or root in 150 mL of boiling water for 5–10 min and then straining.<sup>5</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Should not be consumed in quantities greater than are normally eaten in the diet during pregnancy, due to its history of use as a contraceptive, or during lactation, due to insufficient reliable information about the safety of asparagus consumed in amounts greater than those found in food during breast feeding.<sup>5</sup> Eating asparagus caused urticaria, dysphagia, dyspnea, anaphylaxis, and skin lesions in sensitized individuals.<sup>5</sup>

*Astaxanthin**definition*

Naturally occurring antioxidant that imparts the characteristic pink pigment to shrimp, lobster, and salmon in the wild and added as a colorant to farm-raised crustaceans and salmon.<sup>85</sup> A 200-g portion of salmon contains approximately 1–7 mg of astaxanthin is rarely found in plant foods.<sup>86</sup>

*scientific findings*

In laboratory studies, astaxanthin reduced oxidative stress and inflammation, enhanced immune response, exhibited cardioprotective properties, and inhibited cancer cell growth.<sup>86</sup> An 8-week, randomized, double-blind, placebo-controlled study (n = 14 young healthy women), dietary astaxanthin supplementation decreased deoxyribonucleic acid (DNA) damage biomarkers and enhanced immune response.<sup>85</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Avocado (*Persea americana*)

### definition

Fruit commonly consumed raw in salads and sushi and as the main ingredient in guacamole. Avocado is an excellent source of folate, is high in monounsaturated fat, and is a source of lutein, zeaxanthin, and an especially rich source of the  $\beta$ -sitosterol, supplying 114 mg per cup of commercial variety avocado and 175 mg per cup of California avocado.<sup>88–91</sup> Due to its high fat content, avocado is considered to be a high-calorie fruit.

### scientific findings

The oils in avocado may theoretically promote absorption of fat-soluble vitamins that are consumed in the same meal. Consuming 200 g/day of avocado as part of a low-calorie diet did not compromise weight loss when subjects ( $n = 61$ , mean BMI [body mass index] of 32) substituted it for 30 g of mixed dietary fat.<sup>92</sup> In a controlled clinical trial ( $n = 15$  normolipemic and 30 hypercholesterolemic subjects), all subjects received an avocado-enriched diet. The avocado-enriched diet reduced total cholesterol after 7 days in normolipemic subjects and significantly reduced total cholesterol in hyperlipemic subjects.<sup>93</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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## *Banana (Musa paradisiaca)*

### *definition*

Among the most commonly eaten fresh fruits, banana is a good source of pectin, potassium, vitamin C, and vitamin B6, and contains serotonin and 2-pentanone.<sup>1-4</sup> Bananas are routinely recommended to patients to maintain or restore blood potassium levels because one large (8–9" long) banana supplies approximately 500 mg of potassium.<sup>2</sup> Bananas have a low glycemic index.<sup>5</sup> They have been traditionally recommended for diarrhea management as part of the pediatric BRAT (bananas–rice–applesauce–toast) diet.<sup>6</sup>

### *scientific findings*

Green bananas and pectin significantly reduced diarrhea in a small, double-blind clinical trial (n = 62 boys aged 5–12 months with persistent diarrhea [ $\geq 14$  days]) randomly assigned to receive, for seven days, either a rice-based diet (n = 21); a rice-based diet with 250 g/L of cooked green banana (n = 22); or a rice-based diet with 4 g/kg of pectin (n = 19). Diarrhea significantly improved in the banana- and pectin-supplemented group compared to the rice-only group.<sup>7</sup> Possible mechanisms for bananas to maintain normal stool consistency include that pectin may stimulate epithelial growth in the colon to reduce diarrhea<sup>8</sup> and/or that soluble fiber slows gastrointestinal (GI) transit time, increasing the likelihood of nutrient absorption. Banana pulp had a cholesterol-lowering effect in rats, which was attributed to both its soluble and insoluble fibers.<sup>9</sup> An experimental study found that 2-pentanone inhibited biomarkers of colon cancer in human colon cancer cells.<sup>4</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. A case of acute pancreatitis possibly resulting from banana allergy has been reported.<sup>10</sup> Excessive eating of bananas (up to 20 bananas/day), with no other foods for 2 years by a case subject with anorexia nervosa, resulted in hyperdopaminemia, defined as whole blood dopamine exceeding the normal range of 0.5–6.2 ng/mL.<sup>11</sup>

## *Basil, sweet (Ocimum basilicum)*

### *definition*

Mint family herb that contains phenolics and terpenoids, such as stigmasterol and  $\beta$ -sitosterol.<sup>12</sup> When consumed in a significant quantity rather than in small quantities as a culinary herb, for example in a 1/4-cup portion as pesto (a paste made with sweet basil, garlic, parmesan cheese, and walnuts used to coat cooked pasta), sweet basil provides a significant amount of vitamin K.<sup>13</sup> Sweet basil is used fresh or dried in flavoring many foods. Thai basil is a different variety of sweet basil, which has pointed (not rounded) leaves and is dark green in color with purple pigments, especially on its stems, whereas, sweet basil is uniformly grass-green in color. Although sweet basil is grown domestically, Thai basil is native to Southeast Asian cooking and is commonly sold in Asian markets.

### *scientific findings*

In laboratory studies, sweet basil cultivars exhibited antioxidant and free radical scavenging activity attributed to its phenolic components.<sup>14–16</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed by nonallergic individuals in normal dietary quantities.

## *Beer*

### *definition*

Alcoholic beverage made from fermenting a grain, such as barley, and adding hops, also a grain, to impart the characteristic bitter flavor.

Twelve ounces of regular (5% alcohol) beer provides approximately 350 cal, 13–14 g of alcohol (ethanol), 10 g of carbohydrate, negligible amounts of vitamins, such as niacin (1% DV [daily value]), potassium (3% DV), manganese (2% DV), and selenium (3% DV),<sup>17–19</sup> and polyphenols, which beer has less of than wine.<sup>20</sup> Beer consumption dates to at least 5000–7000 BC when wet grains combined with yeast in the air causing fermentation.

### *scientific findings*

Polyphenols, such as xanthohumol, and phytochemical metabolites in beer have exhibited anti-inflammatory, antithrombotic, antiatherogenic, antioxidant, anticarcinogenic, estrogenic, and antiviral properties in experimental research (*in vitro*, cell culture, enzyme assay).<sup>20</sup> A meta-analysis of 26 studies examining beer and vascular risk found evidence of an inverse association between light-to-moderate beer consumption and vascular risk.<sup>21</sup> A systematic review of more than 35 observational studies examining the effect of beer on body weight found insufficient scientific evidence to assess whether beer intake at moderate levels (<500 mL/day or less than two 12-oz beers) is associated with general or abdominal obesity, but concluded that “higher intake, may be positively associated with abdominal obesity.”<sup>22</sup> Beer’s probiotic effects are due, in part, to the yeast used to make beer, *Saccharomyces cerevisiae*. *S. cerevisiae* reduced abdominal pain in irritable bowel syndrome (IBS) in a small, randomized, controlled, clinical trial 9 (n = 179 adults with irritable bowel syndrome).<sup>23</sup>

### *bioactive dose*

“Moderate consumption” has been defined as no more than one drink (12 oz of regular beer) per day for women and no more than two drinks (24 oz of regular beer) per day for men.<sup>18</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Heavy beer drinking ( $\geq 2$  drinks/day) was associated with increased risk of colorectal cancer in a meta-analysis that included 12 case control and nine cohort studies, while light or moderate beer drinking was not.<sup>24</sup> The findings of a meta-analysis of 17 case-control and six cohort studies suggest that high consumption of beer (and other alcoholic beverages) was associated with an increased lung cancer risk.<sup>25</sup>

## Beet (*Beta vulgaris*)

### B



Beet. (Image from yamix/Shutterstock.)

### *definition*

Also known as red beet or sugar beet. Root vegetable that is a good source of folate and potassium, a fair, but not good source of iron, and a source of anthocyanin, betaine, phenolics, flavonoids, and terpenoids.<sup>26</sup> Its above-ground portion, the beet greens, are rich in fiber, magnesium, and vitamin K. Fresh beets are roasted, baked, or boiled; canned beets are a common salad bar vegetable and may be pickled and served cold; and when very thinly sliced may be consumed raw as a salad ingredient. Beet greens are typically sautéed.

### *scientific findings*

*B. vulgaris* exhibited antioxidant properties in a laboratory analysis.<sup>27</sup> Pre-exercise beet juice in athletes postponed fatigue and increased endurance and enhanced low- and high-intensity aerobic performance but did not reduce muscular fatigue during 30 s of intense anaerobic exercise.<sup>28</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Approximately 10% or more of people may experience beeturia, pink or red urine, following the ingestion of beets, which may be associated with iron deficiency.<sup>29,30</sup>



## $\beta$ -carotene

### *definition*

Vitamin A precursor present in rich amounts in yellow- and orange-fleshed fruits and vegetables, certain red fruits and vegetables, and dark green vegetables. Good sources include carrots, pumpkin, and spinach. Cooking a fruit or vegetable may enhance its  $\beta$ -carotene bioavailability.<sup>31</sup>

### *scientific findings*

Laboratory studies suggest  $\beta$ -carotene functions as an antioxidant.<sup>32</sup> Observational epidemiological studies suggest an association between higher dietary levels of fruits and vegetables containing  $\beta$ -carotene and a lower risk of lung cancer.<sup>33</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. No UL has been established for  $\beta$ -carotene and “no adverse effects except for carotenoderma have been reported from consumption of food  $\beta$ -carotene.”<sup>32</sup> Carotenoderma, the yellow discoloration of the skin, is thought to be harmless when it occurs due to the intake of food carotenoids.<sup>32</sup>

## $\beta$ -glucan

### *definition*

Bioactive polysaccharide found naturally in foods that contain yeast, fungi, including mushrooms, certain bacteria, seaweeds,<sup>34</sup> and grains such as oats.  $\beta$ -glucans in cereals are soluble fibers.

### *scientific findings*

Regular consumption of  $\beta$ -glucans contributes to maintenance of normal blood cholesterol concentrations.<sup>35</sup> Yeast-derived  $\beta$ -glucans dosed at 7.5 g twice daily, significantly reduced total cholesterol concentrations by 6%–8% in patients with hypercholesterolemia after 7–8 weeks of treatment.<sup>36</sup> In a meta-analysis, ingesting  $\beta$ -glucans derived from barley in doses of 3–10 g/day significantly reduced total and LDL cholesterol over 4–6 weeks of treatment without significantly affecting HDL cholesterol.<sup>36</sup> Adding  $\beta$ -glucans, as during food enrichment, may adversely affect  $\beta$ -glucan structure or solubility, decreasing its ability to reduce cholesterol levels<sup>36</sup>: A barley product highly enriched with  $\beta$ -glucans (75% by weight) exhibited altered ability to significantly reduce total cholesterol.<sup>36</sup>

There is insufficient reliable information available about the effectiveness of  $\beta$ -glucans for uses other than cholesterol lowering.<sup>36</sup>

**B***bioactive dose*

Consumption of  $>3$  g of  $\beta$ -glucans daily from oats or barley may be associated with the maintenance of normal blood cholesterol levels in adults who have normal or mild elevations of their total cholesterol levels.<sup>35</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. There is some evidence that 15 g/day of yeast-derived  $\beta$ -glucans can be used safely for up to 8 weeks.<sup>36</sup>

*Bitter orange (*Citrus aurantium*)*

Bitter orange. (Image from Laitr Keiows/Shutterstock.)

*definition*

Also known as Seville orange or sour orange. Orange that resembles a navel orange, but is too sour to be popular for eating in the United States.<sup>37</sup> Used to make marmalade, relishes, candy, and condiments.<sup>38</sup> Bitter orange has been used in traditional medicine for nausea, indigestion, and constipation; current folk or traditional uses of bitter orange are for heartburn, loss of appetite, nasal congestion, and weight loss, and is also applied to the skin to treat fungal infections such as ringworm and athlete's foot.<sup>39</sup>

*scientific findings*

There is little evidence to support the use of bitter orange for any physiological effect or health condition.<sup>39</sup> Bitter orange peel extract is used in place of ephedra in many herbal weight-loss products.<sup>39</sup> Though studies have evaluated bitter orange extract in supplemental form in combination with other weight-targeted ingredients (and results have been inconclusive),<sup>36</sup> the use of bitter orange as a food in weight reduction has not been evaluated.<sup>38</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. According to a review, *C. aurantium* contains 6',7'-dihydroxybergamottin and bergapten, both of which inhibit cytochrome P450-3A, and would be expected to increase serum levels of many drugs.<sup>38</sup> Bitter orange contains the chemical synephrine (oxedrine),<sup>38</sup> which is similar to the main chemical in ephedra, an FDA (Food and Drug Administration)-banned substance that causes high blood pressure and is linked to heart attack and stroke.<sup>40</sup>

*Blackcurrant (Ribes nigrum)**definition*

Also spelled blackcurrant. High-vitamin C berry that is a significant source of anthocyanins. Used to make liqueurs.

*scientific findings*

The effect of blackcurrant anthocyanins on progression of glaucoma was evaluated in a placebo-controlled, double-blind trial (n = 38 glaucoma subjects) in which subjects taking eye drops were randomized to receive either oral blackcurrant anthocyanins (n = 19) or a placebo (n = 19) for 2 years. In the blackcurrant anthocyanins group, an insignificant improvement in ocular blood flow, but not intraocular pressure, was observed, whereas no effect occurred in the placebo group.<sup>40</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Black pepper (Piper nigrum)**definition*

Ground, dried fruit of the *P. nigrum* vine that is among the most-used culinary seasonings. Usually consumed in such minute quantities that its nutrient contribution is nominal; however, one teaspoon of black ground pepper supplies 1% DV for calcium and 5% DV for vitamin K.<sup>41</sup> Contains the phytochemical piperine.<sup>42</sup>

*scientific findings*

In laboratory studies, black pepper exhibited antioxidant and free-radical-scavenging properties.<sup>42,43</sup> Piperine displayed beneficial, protective effects against inflammation and alveolar bone loss, supported bone microstructures, and prevented collagen fiber degradation in an experimental periodontitis study.<sup>44</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Blueberry (Vaccinium corymbosum,  
Vaccinium angustifolium)**definition*

Common sweet berry that is eaten fresh, frozen, dried, as a preserve, and as a constituent of mixed juice beverages. Blueberries contain vitamin A, vitamin C, potassium, thiamin, riboflavin, vitamin B6, and folate, and are a rich source of fiber,<sup>45</sup> in addition to tannin and flavonoids, such as anthocyanins and procyanidins.<sup>46</sup>

*scientific findings*

There is inadequate scientific research to evaluate the effectiveness of blueberry in any physiologic affect or health condition.<sup>45</sup> Blueberries have

higher total antioxidant capacity relative to other fruits due to their anthocyanin and procyanidin constituents; however, berry anthocyanins have been found to have a low bioavailability.<sup>47</sup> An *in vitro* study found that despite their low bioavailability, blueberries were a potent *in vivo* antioxidant at very low concentrations.<sup>48</sup> One portion of blueberries (300 g) improved cell antioxidant defense against DNA damage in a small, randomized crossover design study (n = 10 young healthy men).<sup>48</sup> According to a review, anthocyanins from blueberry extract were able to cross the blood–brain barrier in a rat study that found brain anthocyanins to be positively associated with learning performance, though factors other than anthocyanins could also have contributed to the neurocognitive effects seen in the study.<sup>45</sup> While many fruits may increase bladder irritation in interstitial cystitis, blueberries are among a handful of fruits that reportedly do not.<sup>49</sup>

#### *bioactive dose*

Not known.

#### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

### *Bok choy (Brassica campestris)*



Bok choy. (Image from SOMMAI/Shutterstock.)

## B

*definition*

Also called pak choi. Hardy, green and white leaf vegetable usually prepared by stir-frying or sauteing. Bok choi is a source of calcium, vitamin K, potassium, and vitamin C,<sup>50</sup> in addition to isothiocyanates and indoles.<sup>51</sup>

*scientific findings*

See *Brassica vegetables*.

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Boron**definition*

Trace mineral found in avocado, peanut butter, peanuts, prune and grape juice, chocolate products, wine, pecans, and raisin bran cereal.<sup>52</sup>

*scientific findings*

Little data are available on the biologic functions of boron<sup>52</sup> beyond that it plays a role in metabolic processes related to bone.<sup>53</sup> Diets high in boron provide approximately 3.25 mg boron per 2000 kcal/day; diets low in boron provides 0.25 mg boron per 2000 kcal/day.<sup>36</sup>

*bioactive dose*

No RDA has been established for boron.

*safety*

A tolerable upper limit of 20 mg has been established.<sup>52</sup>

*Brassica vegetables (Brassica oleracea)*

B



Brassica vegetables. (Image from Serg64/Shutterstock.)

*definition*

Also called cruciferous or mustard family vegetables. Genus consisting of many common species, such as broccoli, cauliflower, Brussels sprouts, cabbage, kale, and others, that contain compounds known to have antioxidant effects, such as glucosinolates, flavonoids, and vitamin C<sup>54,55</sup> and have been widely studied for anticancer effects.

*scientific findings*

High consumption of brassica vegetables may be associated with decreased risk of cancers of the lung, stomach, colon, and rectum, according to a review of six cohort studies and 74 case-control studies evaluating brassica consumption and cancer risk; importantly, though, this research did not separate out whether vegetables generally could be responsible for the effect versus specifically brassica vegetables.<sup>56</sup> Epidemiological research suggests that eating about 1.75 cups of cruciferous vegetables decreases the risk of developing bladder cancer by about 30% in men and women.<sup>36</sup> Some epidemiological research suggests that consumption of brassica vegetables is associated with a reduced risk of prostate cancer; however, other epidemiological research has found no association.<sup>36</sup> Sulforaphane and indole-3-carbinol, types of glucosinolates, have been shown in laboratory research to regulate genes that prevent cancer cell proliferation and viability.<sup>57</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. A case-control study (n = 293 cases of thyroid cancer and 354 population controls) in Melanesian women found that consumption of an average of one serving (50–80 g) of cruciferous vegetables daily was associated with thyroid cancer among women with low iodine intake (<96 µg/day).<sup>58</sup> Raw brassica (cruciferous) vegetables contain goitrogens that interfere with iodine utilization, thereby affecting the functionality of the thyroid, which depends on iodine to make thyroid hormones, however, cooking destroys goitrogens.<sup>59</sup>

*Brazil nut (*Bertholletia excelsa*)*

Brazil nut. (Image from Jessmine/Shutterstock.)

*definition*

Crescent-shaped oily white nut that is large in comparison to other nuts, weighing approximately 5 g, and is sourced from a tree native to the Amazon rainforest.<sup>60</sup> Typically eaten raw, straight out of the shell, Brazil nuts are a particularly rich source of the mineral selenium, supplying 290 µg of selenium per 1 nut<sup>61</sup>—more than 3 × the selenium daily reference value of 70 µg. Though they are high in fat (most of which is polyunsaturated and monounsaturated), providing 3 g of fat per nut and 30 cal, Brazil nuts also supply magnesium, copper, manganese, vitamin E, and thiamin.<sup>62,63</sup>



*scientific findings*

Brazil nuts have been used to correct selenium deficiency.<sup>64</sup> In a small, nonrandomized human trial (n = 37 obese, selenium-deficient women with hypercholesterolemia), one Brazil nut daily for 8 weeks corrected selenium deficiency and significantly improved HDL cholesterol levels.<sup>61</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Broccoli (Brassica oleracea* L. var. *italica*)*definition*

Hardy green vegetable whose thick, edible stalks and flowering heads (florets) are eaten raw or cooked. A good source of fiber, magnesium, potassium, vitamin C, folate, and carotenoids, it is also a good source of calcium: a broccoli stalk with floret (150 g) supplies 70 mg (7% DV) of calcium.<sup>65</sup> Phytochemical components include glucosinolates, phenolic acids, and flavonoids.<sup>66</sup>

*scientific findings*

More than 50% of the calcium in broccoli is absorbed compared to approximately 30% absorption of the calcium in dairy products.<sup>67</sup> Glucosinolate in broccoli was shown to be antimicrobial against *Staphylococcus aureus* in a laboratory study.<sup>68</sup> Epidemiological research suggests that consumption of broccoli is associated with a modestly reduced risk of breast cancer in premenopausal women but not in postmenopausal women.<sup>36</sup> Epidemiological research suggests consumption of broccoli might be associated with a reduced risk of colorectal and stomach cancer.<sup>69</sup> A laboratory study found that broccoli soluble fiber prevented *Escherichia coli* translocation in Crohn's disease cells, which may have implications in preventing Crohn's disease by limiting access of harmful bacteria to vulnerable intestinal cells.<sup>69</sup>

*bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Recent laboratory studies indicate that broccoli extracts and/or glucosinolate-derived degradation products might have undesirable genotoxic effects, the relevance of which to human health is not yet known.<sup>70</sup>

## *Brussels sprouts (Brassica oleracea* *var. gemmifera* DC.)

### *definition*

Brassicaceae vegetable that resembles a greenish-yellow miniature cabbage. It can be cooked by steaming, sautéing, roasting, or broiling after being coated with olive oil, and is a source of vitamin K, lutein, zeaxanthin and the antioxidant glutathione.<sup>71,72</sup>

### *scientific findings*

Rats induced to develop mammary cancer that were fed a 20% brussels sprout diet had a 13% incidence of tumor, whereas, those fed a casein-cornstarch diet had a 77% incidence of tumor. Tumors regressed in rats switched from the casein-cornstarch diet to the brussels sprouts diet after 6 weeks; but in the 10th week of the study, 100% of rats developed tumors. Rats fed the 20% brussels sprout diet during tumor initiation exhibited a 67% incidence of fibroadenomas, whereas rats fed the casein-cornstarch diet during initiation, but switched later to the brussels sprouts diet, showed over a 90% incidence of adenocarcinomas.<sup>73</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# C

## *Cabbage (Brassica oleracea var. capitata)*



Napa cabbage. (Image from Kellis/Shutterstock.)

### *definition*

Firm-leaved *Brassica* vegetable that may be consumed raw, cooked, or pickled and fermented to make sauerkraut (white or red cabbage) or kimchee (napa cabbage). Both white cabbage (pale green in color) and red cabbage (magenta and white in color) are good sources of vitamin C and vitamin K, and all members of the *Brassica* genus contain glucosinolates and antioxidants; additionally, red cabbage is a good source of vitamin A.<sup>1,2</sup> In traditional medicine, cabbage juice has been used to treat peptic ulcer.<sup>3,4</sup>

### *scientific findings*

C An experimental study found that cabbage juice extract significantly inhibited gastric ulcer formation in different animal models due to its ability to stimulate the synthesis of mucus, increase pH, and decrease hydrogen ions in the stomach.<sup>4</sup> Brassinin in cabbage exerted chemopreventive properties during the initiation and promotion phases of carcinogenesis in a laboratory study.<sup>5</sup> In a case-control study (n = 697 newly diagnosed bladder cancer cases compared to n = 708 healthy controls matched to cases by age, gender, and ethnicity), median isothiocyanate (ITC) intake from cabbage family vegetables containing ITCs was lower in bladder cancer cases compared to healthy controls. Median ITC intake was statistically significantly lower in bladder cancer cases (1.41½-cup servings of cabbage family vegetables) than in healthy controls (who consumed 1.76½-cup servings of cabbage family vegetables). Controls' intake was significant for including cole slaw (from green and red cabbage) and sauerkraut.<sup>6</sup>

### *bioactive dose*

Not known. For gastric pain and hyperacidity, a dose of 1 teaspoon of cabbage juice 3 times daily before meals has been used.<sup>7</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Goitrogens in raw cabbage can interfere with iodine utilization and thyroid function<sup>8</sup>; cooking cabbage destroys goitrogens.<sup>9</sup>

## *Caffeine*

### *definition*

One of the most commonly ingested alkaloids worldwide,<sup>10</sup> tastes bitter and is a nervous system stimulant and diuretic. Over 60 different plants contain natural caffeine, including coffee beans, tea, kola nuts (used to flavor cola), and cacao pods (used to make chocolate products). Caffeine is also produced synthetically for use in foods and drugs.<sup>11</sup> The average adult ingests 200 mg/day.<sup>11</sup> Caffeine content in 8 ounces of common beverages include coffee, 95–200 mg (with darker roasts containing less caffeine than lighter roasts because caffeine is lost during roasting in a process called sublimation<sup>7</sup>); black tea, 40–120 mg; and green tea, 15–60 mg.<sup>7</sup>

*scientific findings*

Caffeine ingestion improves mental alertness and prevents fatigue.<sup>7</sup> Taking caffeine orally in combination with analgesics is effective for treating simple headache and migraine headache.<sup>7</sup> Caffeine is an ergogenic aid.

*bioactive dose*

A dose of 250 mg has been used for headache; 150–600 mg has been used for fatigue; 2–10 mg/kg or more has been used for athletic performance.<sup>7</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Caffeine can blunt appetite and cause headache, dizziness, nervousness, irritability, trouble sleeping, and dependence. Tolerance varies by individual, but amounts greater than 250–300 mg/day have been associated with tachyarrhythmias, sleep disturbances, and other side effects.<sup>7</sup> Amounts less than 200 mg/day have not been associated with clinically important adverse fetal effects and are generally recognized to be safe during pregnancy, but pregnant women should address caffeine use with their physician.<sup>11</sup> Consumption of caffeine in amounts over 200 mg/day is associated with increased risk of miscarriage.<sup>7</sup> Breast milk concentrations of caffeine are thought to be approximately 50% of maternal serum concentrations, and caffeine consumption in large amounts is possibly unsafe during lactation as caffeine can cause sleep disturbances, irritability, and increased bowel activity in breast-fed infants exposed to caffeine.<sup>7</sup> Large amounts of caffeine may cause or worsen fibrocystic breast disease.<sup>12</sup>

*Calcium**definition*

Major mineral element of skeleton and teeth, present in the body in quantities of 1100–1200 g, that is also necessary for nerve transmission, muscle contraction, blood clotting, blood pressure maintenance, and other functions.<sup>13</sup> Good sources of calcium include dairy products; certain dark green leafy vegetables, such as bok choy, broccoli, kale, and watercress; tofu made with calcium sulfate; canned fish containing edible bones, such as sardines; almonds and pistachios; and calcium-fortified beverages such as orange juice, almond milk, rice milk, and soy milk. Efficiency of calcium absorption decreases as people age.<sup>13</sup>

### *scientific findings*

C Adequate calcium intake is associated with optimal bone development and bone mineral density. Some studies have found that consuming the recommended amount of calcium can reduce the risk of developing hypertension.<sup>14</sup> “Many clinical trials and observational studies show that intake of dietary calcium modestly reduces blood pressure in patients with or without hypertension, usually around 1–2 mmHg,” and further, “calcium may be more effective at lowering blood pressure in certain people, such as those who are salt-sensitive and those with low baseline dietary calcium intake”<sup>7</sup>; however, the evidence does not support a strong relationship between increased calcium intake and blood pressure reduction in healthy and hypertensive adults.<sup>15</sup> “Obesity often coexists with low calcium intake and vitamin D,” but current evidence from randomized clinical trials do not support that calcium and vitamin D accelerates weight or fat loss in obesity.<sup>16</sup>

### *bioactive dose*

The RDA for calcium is 1000 mg for 19–50 year-old adults.

### *safety*

The UL for calcium is 2500 mg, an amount that would require dietary intake of more than eight 8-oz. servings of milk. High calcium intake may interfere with the absorption of minerals and is associated with hypercalcemia and milk-alkali syndrome. Doses >1000–1300 mg/day for adults have also been associated with an increased risk of myocardial infarction.<sup>7</sup> High calcium intake suppresses vitamin D activity.<sup>17</sup> High intake of calcium from supplements, but not foods, is associated with the development of kidney stones.<sup>14</sup> To prospectively examine whether calcium intake influenced risk of prostate cancer, the Health Professionals Follow Up Study (n = 47,781 men) followed subjects free of cancer at baseline in 1986 through 1994. Consumption of calcium was related to higher risk of total, advanced, and metastatic prostate cancer, especially at intakes exceeding 2000 mg/day.<sup>17</sup>

## *Cantaloupe (Cucumis melo)*

### *definition*

Orange-fleshed melon consumed fresh; a good source of fiber and vitamins A, C, and E<sup>18</sup>; cantaloupe also supplies nonprovitamin A carotenoids, phenolics, and terpenoids.<sup>19</sup>

*scientific findings*

Cantaloupe extract reduced diabetes-induced renal oxidative stress, a precursor of diabetic nephropathy, in mice.<sup>20</sup> A case-control study (n = 438 Chinese women age matched to n = 438 controls) that examined dietary intake and breast cancer risk found that consumption of the “watermelon/papaya/cantaloupe” fruit group was significantly inversely associated with breast cancer risk; further, other constituents of cantaloupe, including vitamins C and E and fiber were inversely associated with breast cancer risk.<sup>21</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Canthaxanthin**definition*

Type of xanthophyll carotenoid closely related chemically to  $\beta$ -carotene<sup>22</sup> and presumed to be a human antioxidant. Found naturally in plant and animal foods such as mushrooms<sup>23</sup> and trout<sup>24</sup> and added to foods such as farmed salmon as a colorant.<sup>25</sup> In addition, canthaxanthin has come to be used widely as a drug, food, and cosmetic colorant.<sup>26</sup>

*scientific findings*

Canthaxanthin scavenged free radicals in a laboratory study.<sup>27</sup> A cross-sectional study (n = 235 women) investigating the comparative plasma levels of dietary antioxidants, including canthaxanthin, in a target group of women (n = 95 women with cervical intraepithelial neoplasia or cervical cancer) versus in a control group (n = 40) found that plasma canthaxanthin was found to be lower in women with cervical cancer and cervical intraepithelial neoplasia versus the control group.<sup>28</sup>

*bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. An experimental study found that canthaxanthin may be associated with the formation of undesirable crystals in the macula lutea membranes of the retina,<sup>26</sup> a condition termed canthaxanthin retinopathy, while other carotenoids have not been reported to cause this phenomenon.<sup>22</sup> An acceptable daily intake of 0.00–0.03 mg/kg body weight has been established for canthaxanthin.<sup>29</sup> Canthaxanthin is likely safe when used orally in amounts commonly found naturally in foods, but likely unsafe when used in amounts higher than those commonly found naturally in foods.<sup>7</sup>

### *Caper (Capparis spinosa)*



Caper. (Image from Africa Studio/Shutterstock.)

### *definition*

Unopened flower bud of the *Capparis spinosa* shrub that is pickled and used as a pungent, salty condiment eaten in small quantities due to its strong flavor. Capers contain numerous phytochemicals, including phenolics, tocopherols, sterols, alkaloids, glucosinolates, and fatty acids.<sup>30</sup> Traditionally used as a diuretic, astringent, and antidiabetic, antihyperlipidemic, and antirheumatic agent.<sup>30</sup>

### *scientific findings*

There is inadequate scientific evidence to support traditional uses of capers. Laboratory studies have demonstrated its antioxidant and

anti-inflammatory effects.<sup>31,32</sup> In an experimental study, caper extract demonstrated potent lipid-lowering properties in diabetic rats.<sup>33</sup>

#### *bioactive dose*

Not known.

#### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

### *Capsaicin*

#### *definition*

Vanilloid compound<sup>34</sup> that is the active ingredient in *Capsicum frutescens* (see Pepper, chili). Contact causes irritation and burning sensation. Known for its thermogenic properties,<sup>35</sup> capsaicin causes sweating, followed by a cooling of body temperature through the evaporation of sweat. Its name may derive from the Greek *kapto*, meaning “to bite,” or the Latin *capsa*, meaning box, referring to the fact that the pepper pod is hollow.<sup>36</sup>

#### *scientific findings*

In a small, placebo-controlled study (n = 11 heartburn sufferers) designed to evaluate capsaicin's effects on gastrointestinal parameters related to heartburn, subjects were given a meal followed by a placebo, and, on another occasion, a meal followed by a 5-mg capsaicin capsule. Capsaicin significantly decreased time to peak heartburn onset (120 min vs. 247 min).<sup>37</sup> In an experimental study, capsaicin improved endothelial cell function *in vitro*, which the authors hypothesized may have implications for cardiovascular health.<sup>38</sup> Epidemiological data revealed that the consumption of foods containing capsaicin was associated with a lower prevalence of obesity,<sup>39</sup> and capsaicin is being investigated for its role in weight management due to its mildly thermogenic properties.<sup>39,40</sup> While capsaicin is used topically in medicines, no studies were found to justify its topical use when sourced from food, and therefore, topical use of capsaicin is not addressed.

#### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Capsaicin is known to cause an extreme burning sensation.

### *Carambola (Averrhoa carambola)*



Carambola. (Image from EM Arts/Shutterstock.)

### *definition*

Also called star fruit. Yellow, star-shaped fruit of the Oxalidaceae family that is popular in Asian cultures, and contains 3 g of fiber, 40 mg of vitamin C, and approximately 140 mg of potassium per cup,<sup>41</sup> in addition to polyphenolic antioxidants.<sup>42</sup>

### *scientific findings*

Insoluble fibers in star fruit experimentally adsorbed glucose, retarded glucose diffusion, postponed the release of glucose from starch, and inhibited the activity of  $\alpha$ -amylase *in vitro*, mechanisms that may be hypoglycemic in human beings.<sup>43</sup>

### *bioactive dose*

Not known.



*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Carambola is associated with considerable adverse effects, including neurotoxicity and nephrotoxicity, and should not be used by uremic patients.<sup>44</sup>

*Caraway (Carum carvi)**definition*

Aromatic herb whose crescent-shaped seed is commonly used to make rye bread and distilled to produce an essential oil used to flavor cheese, sausage, and other products. Source of the phytochemicals quercetin and limonene.<sup>45</sup> Herbal products formulated for abdominal discomfort and pain frequently contain caraway oil. Caraway contains the monoterpene carvone; foods containing carvone have a history of use as carminatives.<sup>45</sup>

*scientific findings*

Caraway essential oils inhibited colon carcinogenesis in rats.<sup>46</sup> Carvone exhibited antinociceptive (analgesic) and anti-inflammatory activities in a laboratory study.<sup>47</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Pregnant women should avoid medicinal use of caraway oil because it may stimulate menstruation.<sup>7</sup>

*Carnitine**definition*

Also called L-carnitine (the form found in food that is the active form in the body found in skeletal and cardiac muscle). Dietary sources of carnitine include meats, especially red meats; dairy products; breads; and vegetables.<sup>48</sup> The average adult consumes 60–180 mg of carnitine per day, while those eating a vegan diet take in 10–12 mg a day.<sup>48</sup> Healthy

C people do not need to consume carnitine from food because it is made *in vivo* from lysine and methionine via the liver and kidney in quantities that are probably sufficient to meet daily requirements<sup>49</sup> (such nutrients are considered to be “nonessential” dietary compounds). Body levels of carnitine can be low in certain disease states; for example, some preterm infants, who cannot synthesize sufficient carnitine, require carnitine supplementation.<sup>48</sup>

### *scientific findings*

Carnitine transports long-chain fatty acids into the mitochondria for oxidation and energy production and transports waste compounds out of the mitochondria.<sup>48</sup> There is scientific agreement on carnitine supplementation for carnitine deficiency.<sup>48</sup> Primary carnitine deficiency is a genetic condition that prevents the body from using certain fats for energy, signs and symptoms of which typically appear during infancy or early childhood and can include encephalopathy, cardiomyopathy, confusion, vomiting, muscle weakness, and hypoglycemia.<sup>48</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Carnosol*

### *definition*

Phytochemical found in common herbs, such as rosemary, sage, parsley, and oregano.<sup>50</sup>

### *scientific findings*

Carnosol exhibited antioxidant,<sup>51</sup> anti-inflammatory, and chemoprotective properties in laboratory studies.<sup>52</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Carotenoids**definition*

Subclass of terpenoids that includes two distinct types of molecules, the carotenes and the xanthophylls. More than 600 types of naturally occurring carotenoids have been identified, of which approximately 50 have provitamin A activity.<sup>53</sup> Carotenoid sources include fruits, vegetables, and oils.<sup>54</sup>

*scientific findings*

Numerous observational studies have found that people who ingest more carotenoids in their diets have a reduced risk of several chronic diseases, including cancer, cardiovascular disease, age-related macular degeneration, and cataract.<sup>53</sup> Major public health benefits could be achieved by increasing consumption of carotenoid-rich foods, the primary source of which is fruits and vegetables.<sup>55</sup>

*safety*

No UL has been established for carotenoids and no adverse effects except for carotenoderma, the yellow discoloration of the skin, is thought to occur from ingesting excessive amounts of dietary  $\beta$ -carotene. Carotenoderma is harmless when it occurs due to the intake of food sources of carotenoids.<sup>56</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Carrot (*Daucus carota* L.)

### *definition*

Typically orange root vegetable widely recognized for its role in vision because its provitamin A carotenoids maintain the cornea and make rhodopsin. It is a good source of insoluble fiber,<sup>57</sup> and different cultivars contain different phytochemicals, for example, purple carrots are rich in anthocyanins.<sup>55</sup> Commonly eaten fresh and as part of processed foods, carrots are among the 10 most economically important vegetable crops grown worldwide.<sup>58</sup>

### *scientific findings*

*Daucus carota* exhibited anticancer and antioxidant activities in laboratory research.<sup>58</sup> In an experimental study, its oil suppressed proliferation and induced apoptosis of human colon adenocarcinoma cells.<sup>58</sup> Consumption of carrot juice led to a marked increase in  $\beta$ -carotene and  $\alpha$ -carotene in fecal markers, which in turn showed high dose-dependent cytotoxic and antiproliferative effects on colon adenocarcinoma cells in a small randomized, cross-over design study (n = 22 healthy young men).<sup>59</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Catechin

### *definition*

Polyphenol flavonoids that have strong antioxidant properties and can protect against oxidative damage.<sup>60</sup> Found in tea (black, oolong, and green), apples, pears, chocolate, and broad beans.<sup>61</sup> Types of catechins include epicatechin, epicatechin gallate, and epigallocatechin gallate.

### *scientific findings*

A number of human observational studies found that tea catechins were associated with a reduced risk of stroke.<sup>62</sup> A beneficial effect of a high intake of catechins against chronic obstructive pulmonary disease was seen in a

large observational trial (n = 13,651 adults) in which dietary intake of catechins and pulmonary function were estimated in three Dutch cities from 1994 to 1997. In this study, total catechin intake was positively associated with pulmonary function and inversely associated with chronic cough.<sup>63</sup> The Netherlands Cohort Study (n = 4280 men and women aged 55–69 years at baseline) assessed the association between body mass index and catechins over a 14-year period. Women with the highest intake of total catechins experienced a significantly lower increase in body mass index while no significant differences in body mass index change were observed in men.<sup>61</sup> To evaluate the effect of a high catechin intake and the incidence of and mortality from ischemic heart disease and stroke, data from the Zutphen Elderly Study, a prospective cohort study of 806 men aged 65–84 years at baseline in 1985, were evaluated. Catechin intake was inversely associated with ischemic heart disease mortality but was not associated with the incidence of myocardial infarction or stroke incidence.<sup>64</sup> Catechins exhibited the following properties in laboratory studies: antioxidant; anti-proliferative; vascular protective (antihypertensive, anti-inflammatory, antithrombogenic, lipid lowering); and monoamine oxidase inhibitory.<sup>65,66</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Experimental data in animal models suggest that catechins are not teratogenic.<sup>7</sup>

## *Cauliflower (Brassica oleracea)*

### *definition*

*Brassica* vegetable consumed raw or cooked that is an excellent source of vitamins C and K<sup>67</sup> and a source of glucosinolates.

### *scientific findings*

In a laboratory study, an antioxidant in cauliflower neutralized free radical activity and inhibited the peroxidation of linolenic acid.<sup>68</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Celery (Apium graveolens)*

### *definition*

Salad herb and umbelliferous vegetable that is commonly sautéed or added cooked or uncooked for its characteristic flavor and crisp texture. Source of fiber and numerous phytochemicals, including flavonoids such as quercetin, flavonols, and flavones.<sup>69,70</sup> Celery and celery seed have been traditionally used as carminatives.

### *scientific findings*

Umbelliferous vegetables are considered to be among the foods and herbs having the highest anticancer activity.<sup>71</sup>

### *bioactive dose*

Not known. The carminative dose of celery seed is 1–4 g<sup>72</sup>; however, neither dose nor efficacy has been proven.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. When celery oil or seeds are used orally in amounts larger than are normally consumed in the diet, celery may have uterine stimulant or abortifacient effects<sup>7</sup> and should be avoided during pregnancy. Celery consumption has been associated with allergic reactions.<sup>73,74</sup>

## *Chamomile (Matricaria recutita*

[German chamomile], *Chamomilla recutita*

[Roman chamomile])

### *definition*

Herb consumed as tea. One of the most popular single ingredient herbal teas,<sup>75</sup> chamomile is caffeine-free, supplies negligible nutrients, and is a source of the phytochemical apigenin.<sup>76,77</sup> German chamomile is the most commonly consumed type of chamomile tea in the United States.<sup>75</sup>

Chamomile is in use today as a traditional remedy for sleeplessness, anxiety, and gastrointestinal conditions such as upset stomach, gas, and diarrhea, although studies examining chamomile alone are lacking for many of these uses.<sup>75</sup>

### *scientific findings*

A randomized, double-blind, placebo-controlled study (n = 57 subjects with anxiety) found significant reductions in total Hamilton Depression Rating scores for chamomile for 8 weeks for all participants versus placebo.<sup>78</sup> In a laboratory analysis, apigenin demonstrated anti-inflammatory, antioxidant, and anticarcinogenic properties.<sup>76</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergic reactions and anaphylaxis have been reported in people who have eaten or come into contact with chamomile products.<sup>75,7</sup>

## *Cheese*

### *definition*

High-protein, low-carbohydrate dairy group food that, depending on type, is generally high or moderately high in fat calories, a good source of calcium, providing approximately 200 mg of calcium per 1–1.5-ounce serving.<sup>79</sup> Unlike milk, cheese is not routinely fortified with vitamin D but is a source of potassium, phosphorus, riboflavin, niacin, and vitamin B12.<sup>80</sup>

### *scientific findings*

Eating cheese can be an effective strategy for preventing cavities when consumed in combination with cariogenic foods,<sup>81</sup> possibly because chewing stimulates saliva flow, which washes away sugars and/or cariogenic bacteria, or because nutrients in cheese, including protein, calcium, and phosphorus, neutralize plaque acids.<sup>81,82</sup> Even in the presence of sucrose, cheeses such as aged cheddar, Swiss, blue, Monterey Jack, mozzarella, brie, gouda, and American processed cheese may prevent plaque pH from dropping to a level conducive to cavity formation.<sup>82</sup> Constituents

C in cheese, including calcium, may help to meet the RDA for calcium and perform functions such as maintaining normal blood pressure (calcium relaxes blood vessels), in which calcium is thought to play a role due to its ability to relax blood vessels.<sup>83,84</sup> Fermented cheeses such as Camembert contain prebiotic and probiotic bacteria.<sup>85</sup>

#### *bioactive dose*

Not known.

#### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

### *Cherimoya (Annona cherimola)*



Cherimoya. (Image from EsHanPhot/Shutterstock.)

#### *definition*

Green-skinned fruit with yellowish, creamy flesh and large black inedible seeds. It is thought to be native to South America but is grown in California.<sup>86</sup> Cherimoya's flavor has been described as succulent and custard-like and like a blend of banana, pineapple, papaya, peach, and strawberry.<sup>87</sup> It can be made into juice or used to make fruit salad. Cherimoya has been used in traditional Mexican medicine for its anti-anxiety, anticonvulsant, and tranquilizing properties.<sup>88</sup>



*scientific findings*

In an animal study, *Annona cherimola* extract administered intraperitoneally significantly decreased plasma total cholesterol, triglycerides, and LDL-cholesterol, and increased HDL-cholesterol levels.<sup>88</sup> Cherimoya is a source of fiber, magnesium, potassium, cyptoxanthin, lutein, and xeaxanthin.<sup>89</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Cherry (Prunus avium)**definition*

Also called sweet cherry. Common small Rosaceae family fruit, to which apples also belong, known for sweetness. Eaten fresh, dried, and canned. One cup of raw sweet cherries is a good source of vitamin C.<sup>90</sup> Cherries are a source of the phytochemicals phenolics and anthocyanins.<sup>91</sup>

*scientific findings*

In an animal model of arthritis, cherry anthocyanins exhibited anti-inflammatory and antioxidative effects.<sup>92</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Chicory (Cichorium intybus)**definition*

Perennial with a periwinkle blue flower that grows in the wild. The leaves are used raw in salads, the roots are boiled and eaten, and roasted, ground roots may be used to enhance the richness of coffee.<sup>93</sup> Fructans

(natural, low-calorie sweeteners) are sourced from the chicory plant (see also *fructans*).

## C

*scientific findings*

In a laboratory study, *Cichorium intybus* exhibited antioxidant properties.<sup>94</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Chicory is possibly unsafe when used orally in excessive amounts because it may induce menstruation or miscarriage.<sup>7</sup>

*Chive (Allium schoenoprasum)**definition*

Long green leaves of a bulbous allium vegetable, hollow and similar to those of an onion, but smaller in diameter.<sup>95</sup> Used as a culinary herb fresh or dried.

*scientific findings*

In a population study (n = 238 men with confirmed cases of prostate cancer compared to n = 471 male control subjects), intake of allium vegetables, including chives, was inversely associated with the risk of prostate cancer: men in the highest of three intake categories of total allium vegetables (>10.0 g/day) had a statistically significantly lower risk of prostate cancer than those in the lowest category (<2.2 g/day).<sup>96</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Chocolate (Theobroma cacao)*

Cacao bean. (Image from eversummerphoto/Shutterstock.)

*definition*

Confection made from the cacao bean that could be made with or without milk, the latter of which is flavonoid rich. High in fat, a 160-g (6-ounce) bar of dark chocolate is an excellent source of iron, potassium, and magnesium, and a good source of zinc.<sup>97</sup> Chocolate products and cocoa are “among the most concentrated sources of the procyanidin flavonoids catechin and epicatechin.”<sup>98</sup>

*scientific findings*

Intake of flavonoid-rich foods and risk for cardiovascular disease are inversely related, possibly due to flavonoid-induced changes in oxidant defense, vascular reactivity, and platelet reactivity.<sup>98</sup> A meta-analysis of 13 randomized, controlled trials published between 1955 and 2001 in which treated groups consumed an average daily flavanol intake ranging from 30 mg to 1000 mg<sup>99</sup> showed that dark chocolate reduced systolic hypertension or diastolic prehypertension (note: there are approximately 50 mg of flavanols in a 100-g portion of dark chocolate and approximately 13 mg of flavanols in a 100-g portion of milk chocolate).<sup>100</sup> In another study, active treatment with cocoa products for 2–18 weeks reduced mean systolic and diastolic blood pressure across all trials in a meta-analysis of 10 randomized controlled trials (n = 297) of healthy normotensive adults or patients with prehypertension/stage 1 hypertension.<sup>101</sup> A review concluded that the evidence about cocoa or chocolate and blood pressure is unclear and the results of six studies published through 2007 are conflicting.<sup>102</sup>

### *bioactive dose*

For cardiovascular disease prevention, 19–54 g of cocoa per day or 46–100 g of dark chocolate per day has been used.<sup>7</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Choline*

### *definition*

Vitamin, which serves as a precursor for the neurotransmitter acetylcholine, is necessary for *de novo* synthesis of phospholipids and participates as a methyl donor in the conversion of homocysteine to methionine.<sup>103,104</sup> Betaine is its metabolite. The average adult consumes 730–1040 mg of choline a day in food sources such as milk, liver, eggs, peanuts, and orange juice.<sup>103,104</sup>

### *scientific findings*

Preconception dietary intakes of choline between 350.56 and 544.36 mg or more were associated with reduced risk of neural tube defects in an epidemiological study (n = 424 mothers of children with neural tube defects and n = 440 mothers of nonneural tube defect-affected children).<sup>104</sup> Neural tube defect risk estimates were lowest for women whose diet 3 months prior to conception were rich in choline, possibly due to the impact of choline deficiency on folate metabolism.<sup>104</sup> Dietary supplements of choline are not addressed in this guide.

### *bioactive dose*

The AI for adults aged 19–50 years is 425–550 mg, and for pregnant women is 450 mg/day.

### *safety*

An UL of 3.5 g of choline has been established for adults.

## *Chromium*

### *definition*

Trace mineral necessary for insulin action<sup>105</sup> is referred to as the glucose tolerance factor.<sup>95</sup> Broccoli contains 11 mcg per 1/2 cup; grape juice supplies

8 mcg per 1 cup; dried basil supplies 2 mcg per tablespoon; and green beans supply 1 mcg per 1/2 cup.<sup>105</sup> Eating a variety of whole grains, fruits, vegetables, meats, milk, and milk products provides adequate amounts of chromium.<sup>105</sup>

### *scientific findings*

Chromium may improve insulin sensitivity, which can modify the risk of diabetes and cardiovascular disease,<sup>106</sup> but a deficiency can have the opposite effect. Symptomatic chromium deficiency is considered to be rare but can occur due to malnutrition.<sup>95,105</sup> Symptoms include severe glucose intolerance and weight loss.<sup>95</sup> Chromium deficiency impairs the body's ability to use glucose to meet its energy needs and raises the body's insulin requirements.<sup>105</sup> Chromium status is difficult to measure. The assessment of toenail chromium has been used to determine chromium status in the research setting.<sup>106</sup> Diabetic men with CVD had lower toenail chromium than healthy control subjects in a cross-sectional analysis comparing men with diabetes only (n = 688), diabetes with prevalent CVD (n = 198), and healthy control subjects (n = 361).<sup>106</sup>

### *bioactive dose*

The AI for chromium is 25–35 µg.

### *safety*

No UL has been established for chromium.

## *Cilantro (Coriandrum sativum)*

### *definition*

Coriander leaves and soft stems are chopped and used in Latin cooking, for example, in salsa or to garnish bean-and-rice dishes. Cilantro is grown from coriander seed. It is a source of vitamin A and vitamin K, and contains numerous phytochemicals, including caffeic acid, chlorogenic acid, quercetin, and limonene.<sup>107,108</sup>

### *scientific findings*

Laboratory studies have shown coriander essential oils to have antioxidant and hepatoprotective properties.<sup>109</sup> Coriander extract exerted anti-anxiety activity in a laboratory study.<sup>110</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Cinnamon (Cinnamomum cassia)**definition*

Spice sourced from the bark of a tropical tree native to Asia that is used as a flavorful stick or in ground form to flavor fruity or savory dishes. Contains the phytochemical cinnamaldehyde.<sup>111</sup>

*scientific findings*

In animal models, cinnamon exhibited hypoglycemic, antimicrobial, antifungal, antiviral, antioxidant, antitumor, blood pressure-lowering, cholesterol-lowering, lipid-lowering, gastroprotective, and anticholinesterase properties.<sup>112,113</sup> A few clinical trials have shown conflicting results regarding the effects of cinnamon in the treatment of diabetes, and additional randomized controlled clinical trials are needed before therapeutic recommendations can be made for the use of cinnamon as an effective treatment in humans.<sup>7</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Citrus fruit**definition*

Juicy, segmented fruits of the genus *Citrus* that are good sources of vitamin C and folate and are among the best sources of flavonoids (e.g., naringenin, hesperidin, nobiletin, and tangeretin). The skin, peel, or rinds of citrus fruits

are rich in essential oils and contain more phytochemical compounds on a per gram basis than the edible interior flesh.<sup>114</sup> Otherwise, inedible fruit peels are consumed, for example, when lemon peel is scraped and added to recipes as lemon “zest”; a small piece of lime is twisted to expel its juice and the peel is added to a beverage (lime “twist”); or sour orange rind is included in marmalade. Citrus rinds contain a variety of phytochemicals, including carotenoids, flavanone glycosides, and flavonoids.<sup>115</sup>

### *scientific findings*

Consumption of citrus fruit and citrus juice was inversely related to the risk of pancreatic cancer, according to an observational study (n = 384 cases and 983 controls).<sup>116</sup> A prospective analysis (n = 185,885 older adults participating in the Multiethnic Cohort Study) showed consuming citrus fruits was inversely associated with the risk of invasive bladder cancer in women, but not in men (in addition, women with the highest intakes of nutrients rich in citrus fruits, including C and folate had a lower risk of bladder cancer).<sup>117</sup> Epidemiological research suggests citrus flavonoid-containing foods attenuate cardiovascular diseases; experimental and a limited number of clinical studies have shown properties in citrus fruit to be lipid-lowering, insulin-sensitizing, antihypertensive, and anti-inflammatory; citrus flavonoids blunt the inflammatory response in metabolically important tissues, including liver, adipose tissue, kidney, and the aorta; and in animal models, citrus flavonoids show marked suppression of atherogenesis through improved metabolic parameters and also through direct impact on the vessel wall.<sup>118</sup> Results from epidemiologic and experimental studies suggest that citrus may have a role in promoting vascular health, although clinical trial data are lacking.<sup>119</sup> Citrus bioflavonoid and a related metabolite, hesperidin, exerted antiviral effects on human cell lines.<sup>120</sup> Nobiletin, a bioflavonoid found in citrus flesh and peel, has exhibited anti-inflammatory effects in laboratory studies.<sup>121–123</sup> Tangeretin, a flavone found in citrus peel,<sup>124</sup> has been shown to have anti-atherogenic and anti-inflammatory properties<sup>125</sup> and chemoprotective properties in leukemia cells<sup>126</sup> and colon cancer cells.<sup>124</sup> Carvone exhibited antinociceptive and anti-inflammatory activities in a laboratory study.<sup>48</sup> Flavonoids exert cardioprotective and anticarcinogenic properties *in vitro* and *in vivo*.<sup>127</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Consuming citrus or coming into physical contact with citrus peel has resulted in allergic reaction. Citrus flavonoids have low or no cytotoxicity to healthy, normal cells.<sup>128</sup>

## Clove (*Eugenia caryophyllata*)

### *definition*

**C** Spice sourced from an evergreen tree commonly used in fruit-based dishes, such as pumpkin pie and mulled wine (wine to which mulling spices, such as cinnamon and cloves, have been added). Clove oil, which contains eugenol, is most popularly known as being a toothache remedy topically; however, according to FDA, efficacy is lacking for this use. In addition to eugenol, other phytochemical components in clove include phenolics.<sup>129</sup>

### *scientific findings*

Clove was shown to have anti-inflammatory effects in a laboratory study.<sup>130</sup> Clove is not effective for common uses: vomiting, upset stomach, nausea, gas, or diarrhea.<sup>131</sup> Clove also has mild topical anesthetic properties, but has not been clinically proven to be effective for toothache.<sup>131</sup>

### *bioactive dose*

Not established.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Ingesting clove oil has been linked to reports of coagulopathy, liver damage, and other serious side effects in infants and children.<sup>131</sup>

## Coconut (*Cocos nucifera*)

### *definition*

Large Arecaceae family nut. The flesh of coconuts, a source of potassium and saturated fat,<sup>132</sup> in addition to flavonoid and saponin, is used in shredded form in baked products. Coconut water, which contains 400 mg of potassium per cup, making it a good source of potassium, and coconut oil have become popular products. Coconut milk is an emulsion of grated coconut meat.<sup>7</sup> Coconut has been used in traditional medicine for the treatment of metabolic disorders and particularly as an anti-inflammatory, antimicrobial, and analgesic.<sup>133,134</sup>

### *scientific findings*

The saturated medium-chain triglycerides in coconut oil increase total serum cholesterol, but affect HDL-cholesterol levels favorably.<sup>135</sup> Diets rich



in coconut oils have been shown to reduce coronary artery disease risk factors, such as tissue plasminogen activator antigen and lipoprotein(a)<sup>135</sup>; however, current recommendations are to limit saturated fats, including coconut oil to no more than 7% of calories.<sup>136</sup> Lauric acid, the most abundant fatty acid in coconut oil, is effective in preventing tooth decay and plaque buildup.<sup>135</sup> Saponin and polyphenols in coconut were attributed with anti-inflammatory and antinociceptive properties in an animal study.<sup>137</sup> The predominate fat in coconut, medium-chain triglyceride, is easier to digest and absorb than long-chain triglycerides and therefore may be useful in fat malabsorption.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Coenzyme Q10*

### *definition*

Also called Co Q10. Fat-soluble antioxidant<sup>138</sup> synthesized in the body that occurs in virtually all cells—it is ubiquitous—hence it is also known as “ubiquinone.” A participant in ATP generation in aerobic metabolism that is essential for electron and proton transport in the mitochondrial respiratory chain.<sup>139</sup> It is present in highest quantities in the heart, liver, kidney, and pancreas.<sup>7</sup> The richest sources include meat, fish, nuts, and some oils, while dairy products, vegetables, fruits, and cereals provide smaller amounts.<sup>140</sup> The average dietary intake of Co Q10 is 3–6 mg.<sup>138</sup>

### *scientific findings*

Primary deficiency is caused by genetic mutations that affect Co Q10 biosynthesis. Secondary deficiency may be linked to the use of statins to treat hyperlipidemia.<sup>141</sup> Coenzyme Q10 deficiency is thought to be a rare condition, the symptoms of which include weakness, fatigue, and seizures.<sup>142</sup> Low blood levels of ubiquinone have been found in cancer patients with myeloma, lymphoma, and cancers of the breast, lung, prostate, pancreas, colon, kidney, and head and neck.<sup>143</sup> Not enough evidence exists to demonstrate the benefits or harm of supplemental coenzyme Q10 and its use in cardiovascular disease.<sup>144</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary amounts by non-allergic individuals.

*Coffee (Coffea arabica)**definition*

Popular beverage made from brewing the roasted seeds of the coffee plant that is drunk to improve mental alertness and prevent fatigue. The average adult ingests 200 mg of caffeine per day.<sup>11</sup> Caffeine content in 8 ounces of common beverages includes coffee, 95–200 mg (with darker roasts containing less caffeine due to sublimation during roasting).<sup>7</sup> Coffee provides numerous phytochemicals, including chlorogenic acids and other polyphenols.<sup>145</sup>

*scientific findings*

Epidemiology suggests that polyphenols exert cardioprotective effects and laboratory studies suggest that polyphenols exert antioxidant, vasodilatory, anti-inflammatory, antifibrotic, antiapoptotic, and metabolic effects.<sup>146</sup> Coffee consumption was inversely associated with the prevalence of type 2 diabetes mellitus in several observational studies.<sup>147,148</sup> Coffee consumption may also be protective against the development of gallstones.<sup>149</sup> Epidemiological evidence suggests that drinking more than 3 cups of coffee daily may significantly reduce the risk of rectal cancer.<sup>7</sup> Chlorogenic acid protected cells from oxidative damage in a laboratory study,<sup>150</sup> induced growth of beneficial microorganisms in colon cancer cells in an *in vitro* study,<sup>151</sup> and, along with other polyphenols, has been postulated to exert preventive effects against cardiovascular disease and type 2 diabetes.<sup>151</sup>

*bioactive dose*

The typical dose of caffeine for headache or restoring mental alertness is up to 250 mg/day, about 2 cups of coffee.<sup>7</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Four to seven 5-ounce cups of caffeinated coffee per day provide approximately 600 mg of caffeine, which is considered

to be excessive for most people.<sup>11</sup> Even 250–300 mg/day has been associated with significant adverse effects, such as tachyarrhythmias and sleep disturbances.<sup>7</sup> Coffee consumption has been associated with hyperhomocysteinemia in some observational studies.<sup>152</sup>

## Copper

### *definition*

Trace mineral found in shellfish, nuts, beans, organ meats, and whole grains<sup>54</sup> that functions as a component of a number of metalloenzymes and that is involved in red blood cell formation, immunity, and in the maintenance of blood vessels, nerves, and bones.<sup>54</sup> The average dietary intake of copper by U.S. women is 1.0–1.1 mg/day (1000–1100 µg), and men consume 1.2–1.6 mg/day (1200–1600 µg).<sup>7</sup>

### *scientific findings*

Copper deficiency, although rare, causes normocytic, hypochromic anemia, leukopenia, and neutropenia.<sup>54</sup> Copper toxicity is also rare in the U.S. population.<sup>153</sup> Measurement of copper status is difficult.<sup>153</sup>

### *bioactive dose*

The RDA for adults aged 19–50 years is 1000 µg.

### *safety*

An UL of 10,000 µg has been established.

## Corn (*Zea mays*)

### *definition*

Poaceae family fruit that is sometimes eaten as a starchy vegetable (e.g., corn on the cob) and other times as a grain (e.g., popcorn).<sup>154</sup> Corn is a source of potassium, phosphorus, fiber, xeaxanthin, and ferulic acid.<sup>155</sup> It is deficient in the amino acids lysine and tryptophan. Eaten cooked, canned, frozen, and used to make oil, flour, starch, and other food products, such as high-fructose corn syrup. Traditional medicinal applications of *Zea mays* include use as a diuretic and for treating dropsy, hypertension, hemorrhage, warts, and diabetes.<sup>155</sup>

### *scientific findings*

*Zea mays* exhibited antioxidant properties and slowed glucose absorption in a laboratory study.<sup>156</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Coumaric acid (p-coumarate)**definition*

Polyphenolic compound called a cinnamate found in many foods, including beer, carrots, cereal brans, garlic, mung bean, peanuts, strawberry, raspberry, spinach, wine, and vinegar.<sup>157–159</sup>

*scientific findings*

In laboratory animals, coumaric acid reduced LDL cholesterol levels.<sup>160</sup> Phenolic compounds have exhibited antioxidant properties *in vitro*.<sup>161</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Coumarin**definition*

Chemical compound found in milk, vodka, cinnamon (*Cassia cinnamon*) and products flavored with cinnamon such as liqueurs.<sup>162</sup>

*scientific findings*

An experimental study found coumarins in lemon peel inhibited free radical generation.<sup>163</sup>

*bioactive dose*

Not established.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Coumarin may be toxic when used at high doses for long periods of time. It has hepatotoxic and carcinogenic properties<sup>164</sup>; therefore, a European Tolerable Daily Intake has been set at 0.1 mg/kg of body weight.<sup>164</sup> According to a European survey, intake of coumarin may approach the tolerable daily intake when foods flavored with cinnamon are heavily used.<sup>164</sup>

*Cranberry (Vaccinium macrocarpon)**definition*

Bitter fruit of an evergreen shrub that is consumed as a fruit or juice cocktail, dried, and fresh or canned as cranberry sauce. Cranberry is a source of vitamin C, choline, vitamin A, and vitamin K,<sup>165</sup> and proanthocyanidin. Some practice guidelines currently recommend consumption of pure cranberry–lingonberry juice as an option for preventing recurrent urinary tract infection (UTI).<sup>166</sup>

*scientific findings*

Daily doses of 120–4000 mL/day of cranberry juice or 400 mg of cranberry extract were used to help prevent UTIs<sup>72</sup> based on the results of small studies that theorized cranberry prevents bacteria from sticking to the cells that line the bladder.<sup>167</sup> A review including 24 studies (n = 4473 subjects) concluded that cranberry juice cannot currently be recommended for the prevention of UTIs, and that although some small studies demonstrated a small benefit for women with recurrent UTIs, there were no statistically significant differences when the results of a much larger study were included.<sup>168</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals.

*Cryptoxanthin,  $\beta$ -cryptoxanthin**definition*

Xanthophyll carotenoids are found in foods such as oranges, tangerines, yellow pepper, papaya, pumpkin, zucchini, and corn.<sup>169–171</sup>

### *scientific findings*

β-cryptoxanthin is one of the five carotenoids that predominate in human plasma<sup>172</sup> and serves as an antioxidant and a source of vitamin A.<sup>55</sup> In a laboratory study, it exhibited antitumor effects.<sup>170</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Cumin (Cuminum cyminum)*

### *definition*

Seed that is used whole or ground into a spice in Indian and Middle Eastern cooking. Though it would be consumed in miniscule amounts, cumin is a source of calcium, magnesium, potassium, iron, zinc, phosphorus, and selenium and numerous antioxidants.<sup>173</sup> Traditionally used for the treatment and management of sleep disorders, indigestion, and hypertension.<sup>174</sup>

### *scientific findings*

Cumin has demonstrated antihyperglycemic and antihypertensive properties in animal studies.<sup>174,175</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Safrole, a natural mutagenic compound, which is degraded by cooking, is a constituent of cumin.<sup>173</sup>

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# D

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## D

### *Dairy foods group*

#### *definition*

Foods produced from milk are good sources of protein, riboflavin, vitamin B12, calcium, magnesium, potassium, and when fortified, vitamins A and D.<sup>1</sup> One serving of dairy food supplies approximately 300 mg of calcium and includes 1 cup of vitamin-D-fortified milk/rice milk/almond milk/soy milk; 1.5 oz of hard, natural cheese such as cheddar, or 2 oz of processed cheese such as American Cheese; 8 oz of yogurt or frozen yogurt; or 2 cups of cottage cheese. Only vitamin-D-fortified milk and other dairy products expressly labeled “fortified with vitamin D” are sources of vitamin D.

#### *scientific findings*

Meeting the recommended servings of dairy products is necessary to maintain adequate bone mineral density and is especially important for bone mineralization during childhood and adolescence. Adequate intake of reduced- and non-fat dairy products is associated with a reduced risk of cardiovascular disease and type 2 diabetes.<sup>2</sup>

#### *bioactive dose*

Three servings of dairy foods are recommended daily for people aged 19–50. This amount meets the calcium RDA, but not the vitamin D RDA.

#### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Dandelion (*Taraxacum officinale*)

D



Dandelion. (Image from Volosina/Shutterstock.)

### *definition*

Bitter dark green leaf named for its toothed leaf margins (*dent de lion* means “lion’s tooth”). A good source of calcium and an excellent source of vitamins C and K.<sup>3</sup> It also supplies numerous phytochemicals including taraxasterol.<sup>4</sup> The root is a source of triterpenes, steroids, and inulin.<sup>5</sup> Regarded by some to be a garden weed, it is more commonly eaten as a salad green in Europe than in the United States. In traditional medicine, dandelion has been used as a diuretic and, in Chinese, Arabian, and Native American traditional medicine, to treat cancer.<sup>6,7</sup>

### *scientific findings*

In a small, non–placebo-controlled, nonrandomized pilot study (n = 17), urinary volume and fluid intake were recorded to establish baseline values for urinary frequency and urinary excretion ratio (urination volume:fluid intake) at intervals. Subjects were dosed with 8 mL of dandelion extract three times a day for 1 day. The study found “a significant increase in the frequency of urination in the 5-h period after the first dose. For all subjects, there was also a significant increase in the excretion ratio in the 5-h period after the second dose of extract. The third dose failed to change any of the measured parameters,” although the study concluded that “*T. officinale* ethanolic extract shows promise as a diuretic in humans.”<sup>6</sup> In laboratory studies, dandelion extracts exhibited anticarcinogenic and hepatoprotective properties.<sup>4,7–9</sup> In animal studies, taraxasterol was chemopreventative.<sup>4</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic adults. No negative effects have been reported of consuming dandelion during pregnancy or lactation, in children, or in combination with pharmaceutical drugs; however, dandelion impaired the absorption of ciprofloxacin.<sup>5</sup>

D

*Date (Phoenix dactylifera)*



Date. (Image from Ninell/Shutterstock.)

*definition*

Small, intensely sweet cylindrical fruit covered by a leathery, fibrous skin that is brown when ripe. A 1/4-cup of medjool dates, a common type eaten as a snack and used for baking, supplies approximately 105 cal, 27 g of carbohydrate (23 g of sugar and 3 g of fiber), and 7% DV of potassium.<sup>10</sup> Dates have the highest total polyphenol content among commonly eaten fruits and vegetables.<sup>11</sup>

*scientific findings*

Dates exhibited antioxidant activity in laboratory research.<sup>12,13</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary amounts by nonallergic individuals.

*Dihydrocapsiate**definition*

A major capsaicinoid, the other being capsaicin, found in *Capsicum frutescens* (chili pepper).

*scientific findings*

Dihydrocapsiate nominally increased thermogenesis in two clinical trials. In a double-blind, parallel-arm trial (n = 78), healthy subjects were randomly assigned to receive either 0 (placebo), or 3 or 9 mg dihydrocapsiate/day for 28 days. After a 10-h overnight fast, resting metabolic rate was measured by indirect calorimetry for 30 min before and 120 min after ingestion of dihydrocapsiate. Dihydrocapsiate had a small, thermogenic effect of  $\approx 50$  kcal/day, which was significant compared to placebo, but that is within the range of day-to-day resting metabolic rate variability.<sup>14</sup> In a second study, outpatients (n = 33) following a very low calorie diet (800 kcal/day providing 120 g/day protein) over 4 weeks were randomly assigned to receive either dihydrocapsiate capsules three times per day (3 mg or 9 mg) or placebo. In the treatment group, postprandial increases in thermogenesis and fat oxidation secondary to administration of dihydrocapsiate occurred.<sup>15</sup> In an experimental study, dihydrocapsiate was chemopreventive in tumor cells.<sup>16</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals.

## Dill (*Anethum graveolens*)



Dill. (Image from photolinc/Shutterstock.)

### *definition*

Aromatic herb with very fine, fern-like, feathery leaves whose distinctive taste is used to flavor pickles; also used to garnish foods such as potato salad, Greek yogurt, and borscht. Dill contains numerous phytochemicals including quercetin and limonene.<sup>17</sup> Dill has been used to increase menstrual flow.<sup>18</sup>

### *scientific findings*

Laboratory studies have shown essential oil of dill to have antibiotic and antifungal properties.<sup>19,20</sup> There is insufficient reliable information available about the effectiveness of dill for any physiological use.<sup>18</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary amounts by nonallergic individuals. The essential oil of dill herb and seed was shown to be genotoxic in a laboratory study.<sup>21</sup>

## Docosahexaenoic acid (DHA)

### *definition*

An omega-3 polyunsaturated fatty acid that is synthesized in limited amounts by the body through the conversion of  $\alpha$ -linolenic acid to

eicosapentaenoic acid (EPA) and then to docosahexaenoic acid (DHA). DHA is abundant in the brain and retina. Fatty fish, including kippers, mackerel, trout, salmon, sardines, anchovies, herrings, and tuna are good sources of naturally occurring DHA. Human milk is a source of DHA.<sup>1</sup>

## D

### *scientific findings*

DHA is essential for normal growth and neurological function.<sup>22</sup> DHA deficiency has been linked to a decline in cognitive ability, and low DHA levels are associated with an increase in neural cell death.<sup>23</sup> It is also absent in the cerebral cortex of individuals with extreme depression.<sup>24</sup> Increased dietary consumption of DHA is associated with a decreased risk of age-related macular degeneration.<sup>18</sup> Increased dietary consumption of DHA may reduce the risk of death in patients with coronary artery disease.<sup>18</sup>

### *bioactive dose*

The current mean intake for DHA and EPA in the United States is approximately 100 mg/day, an amount that is suboptimal according to experts.<sup>25</sup> An RDA has not been established for DHA, but an AI has been set for its precursor, linolenic acid (also called omega-3-fatty acid). See also omega-3-fatty acid. Prenatal ingestion of at least 200 mg of DHA daily has been suggested as adequate for normal fetal growth and development.<sup>18,26</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Doses greater than 3 g daily might decrease platelet aggregation and increase the risk of bleeding.<sup>18</sup>

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# E

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## Egg

### *definition*

Low-fat, high-protein food and source of vitamins A, D, E, and choline, as well as phytochemicals lutein and zeaxanthin.<sup>1</sup> A large egg supplies approximately 215–250 mg of cholesterol.<sup>2</sup> The American Heart Association (AHA) recommends a limit of 300 mg of cholesterol per day for people whose LDL (low-density lipoprotein) cholesterol level is normal (and a limit of 200 mg of cholesterol per day for people who have high LDL cholesterol or heart disease),<sup>3</sup> and according to AHA, eggs can be part of one's recommended level of dietary cholesterol intake. Eggs enriched with omega-3-fatty-acid supply 115 mg of omega-3-fatty acid per large egg depending on the commercial brand.<sup>4</sup> Eggs are a versatile food that can be prepared in a variety of ways and are used as an emulsifying ingredient in baked products and salad dressings.

### *scientific findings*

According to reviews examining the evidence of egg consumption and plasma cholesterol, extensive research and epidemiologic literature has not clearly established a link between egg consumption and risk for coronary heart disease.<sup>5,6</sup>

### *bioactive dose*

Not applicable.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. USDA (United States Department of Agriculture) recommends children younger than 1-year old not be given egg whites due to the potential for allergic reaction.<sup>7</sup> Raw egg consumption is not recommended due to potential *Salmonella* contamination.

## Eggplant (*Solanum melongena*)

### definition

White, spongy-fleshed vegetable with purple, shiny skin that is cooked and used to make dishes such as eggplant parmesan (Italian cooking), baba ghanoush (Middle Eastern cooking), ratatouille (French cooking), and stir-fried eggplant (Asian cooking). Eggplant is a good source of fiber<sup>8</sup> and contains anthocyanins, phenolics, saponins, terpenoids, and steroidal alkaloids.<sup>9</sup>

### scientific findings

Dried powdered fruits of eggplant provided as capsules containing 450 mg of *Solanum melongena* (SM) or placebo (450 mg) twice daily reduced serum lipids in a small (n = 41 subjects with hyperlipidemia), randomized, placebo-controlled clinical trial.<sup>10</sup> After 3 months, serum total cholesterol, LDL, and LDL/HDL decreased in the eggplant-treated group.<sup>10</sup> To compare eggplant to lovastatin, a small, placebo-controlled study (n = 21 individuals with total cholesterol >200 mg/dL) divided participants into three groups each having similar baseline cholesterol levels: (1) a group that consumed eggplant extract; (2) a group that received 20 mg of lovastatin; and (3) a control group. After 6 weeks, a significant reduction in total cholesterol levels and in LDL-cholesterol levels was seen in the statin-treated group, but not in the eggplant-treated group.<sup>11</sup>

### bioactive dose

Not applicable.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Eicosapentaenoic acid

### definition

One of the two predominant omega-3 fatty acids, the other being DHA. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are synthesized in limited amounts in the body from linolenic acid.<sup>12</sup> EPA is found in the eyes and the brain and is necessary for growth and cognition.<sup>12</sup> Good sources of EPA include mullet, which provides 150 mg of EPA per three ounces,<sup>13</sup> and other fatty fish, including mackerel, salmon, bluefish,

sablefish, menhaden, anchovy, sardines, herring, tuna, and lake trout. Human milk is also a source of EPA.

### *scientific findings*

Current mean intake for DHA and EPA in the United States is approximately 100 mg/day, an amount that is suboptimal according to experts.<sup>14</sup> One of the two predominant omega-3 fatty acids, the other being DHA, that the body can use to make the essential fatty acid (EFA) linolenic acid.<sup>15</sup> Whether the EFA alteration is a cause of or an effect of conditions, such as obesity, hypertension, diabetes mellitus, CHD, alcoholism, schizophrenia, Alzheimer's disease, atherosclerosis, and cancer, was not elucidated.<sup>15</sup>

### *bioactive dose*

Although there is no specific RDA (recommended dietary allowance) for EPA, an RDA has been established for its precursor, linolenic acid. The adult RDA for linolenic acid is 1.1 g.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Ellagic acid*

### *definition*

Polyphenolic antioxidant found in a wide variety of fruits including blackberries and strawberries.

### *scientific findings*

In laboratory studies, ellagic acid reduced oxidative stress.<sup>16,17</sup>

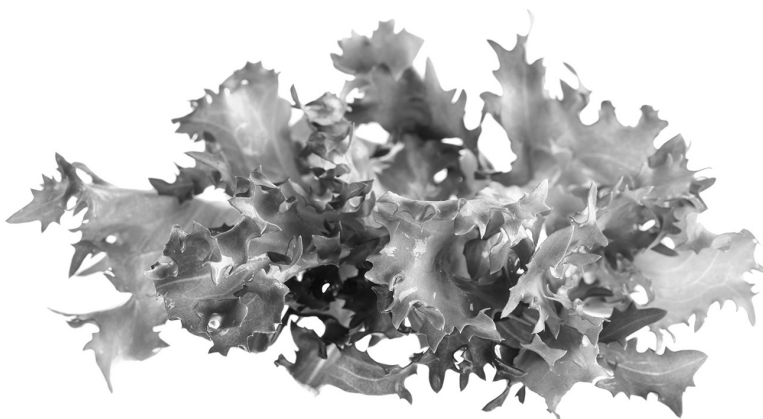
### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed as part of a food and consumed in normal dietary quantities in foods by nonallergic individuals.

## Endive (*Cichorium intybus*)



Endive. (Image from Slavko Sereda/Shutterstock.)

### *definition*

Hardy, curled lettuce common in Mediterranean cooking. It can be eaten blanched, used in salads, and as a garnish.<sup>18</sup> One-half cup of endive provides 35 µg of folate (8% DV [daily value]), 540 IU of vitamin A (10% DV), and 55 µg of vitamin K (70% DV), and is a source of kaempferol. A red cultivar of endive (*Cichorium intybus* L. cultivar) is a source of antioxidant anthocyanins.<sup>19</sup>

### *scientific findings*

In laboratory studies, *C. intybus* inhibited free radical-mediated DNA damage,<sup>20</sup> and exerted cytoprotective and antiproliferative effects in cells.<sup>19</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed as part of a food and consumed in normal dietary quantities by nonallergic individuals.

## Endive, Belgian (*Cichorium endivia*)



Belgian endive (Image from marmo81/Shutterstock.)

E

### *definition*

Pale yellow-green, mild-tasting lettuce that grows in small, tight, cylindrical heads, differentiating it from curly endive, which has a bitter flavor and loose, lacy appearance. It may be eaten as a salad vegetable or steamed and consumed. Belgian endive is a source of potassium, vitamin C, and phytochemicals such as phenolics.<sup>21,22</sup> *Cichorium endivia* has been used in folk medicine for its anti-inflammatory properties.<sup>23</sup>

### *scientific findings*

An amino acid in *C. endivia* was shown to be cytotoxic to colorectal cancer cells in a laboratory study.<sup>23</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Ethanol

### *definition*

Also called ethyl alcohol and alcohol, a molecule formed during anaerobic fermentation of carbohydrate, such as sugars in berries or grains. It is a psychoactive compound and central nervous system depressant.<sup>24</sup> Alcohol from beer, wine, and distilled liquor supplies 7 kcal/g. Alcoholic beverages are a major calorie source that should be reduced for many U.S. adults.

### *scientific findings*

Alcohol consumption can have beneficial or harmful effects, depending on the amount consumed, age, and other characteristics of the person consuming the alcohol.<sup>25</sup> Alcohol consumption may have beneficial effects when consumed in moderation.<sup>25</sup> Strong evidence from observational studies has shown that moderate alcohol consumption is associated with a lower risk of cardiovascular disease.<sup>25</sup> Moderate alcohol consumption is also associated with reduced risk of all-cause mortality among middle-aged and older adults and may help to keep cognitive function intact with age.<sup>25</sup> Beginning to drink alcohol or drinking more frequently on the basis of potential health benefits is not recommended, because even moderate alcohol intake is associated with certain health risks such as increased risk of breast cancer, involvement in violence, drowning, and injuries from falls and motor vehicle accidents.<sup>25</sup> Light-to-moderate alcohol intake is associated with reduced incidence of ischemic cardiovascular events, whereas heavy alcohol intake can predispose individuals to stroke.<sup>26</sup> Heavier than moderate consumption of alcohol over time is associated with weight gain.<sup>25</sup> Excess alcohol consumption increases blood pressure.<sup>25</sup> Alcohol aggravates many conditions, for example, it increases symptoms of gastrointestinal reflux disease. Ethanol increases oxidative stress.<sup>27</sup> Ethanol metabolism can produce free radicals and reduce the levels of glutathione, the major cellular protection against oxidative stress, and alcohol consumption has been identified as one of the top 10 risks contributing to the worldwide burden of disease.<sup>27</sup> The International Agency for Research on Cancer has classified ethanol as carcinogenic to humans.<sup>28</sup>

### *bioactive dose*

If alcohol is consumed, it should be consumed in moderation. Moderate consumption of alcohol is defined as one drink per day for women, no more than two drinks per day for men. A drink has been defined as 12 fluid ounces of regular beer (5% alcohol), 5 fluid ounces of wine (12% alcohol),



or 1.5 fluid ounces of 80 proof distilled spirits (40% alcohol), each of which contains about 0.6 fluid ounces of alcohol.<sup>25</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Safety can vary by individual, gender, and other factors; therefore, following the Dietary Guidelines for Americans 2010 may be warranted for most people. Ethanol should not be consumed at all by certain individuals including pregnant women, people with a history of alcoholism, individuals taking certain medications, and people not of legal drinking age. More than 24 oz/day can cause significant adverse health effects.<sup>29</sup>

## *Eugenol*

### *definition*

Constituent of clove, nutmeg, cinnamon, basil, bay leaves, and other plant foods. It (and clove) has long been used topically for toothache pain.<sup>30</sup>

### *scientific findings*

A review on eugenol states that eugenol has analgesic properties.<sup>31</sup> However, eugenol's effect on toothache has not been adequately clinically studied; therefore, there is insufficient evidence to support the use of topical eugenol to prevent toothache pain, according to FDA (Food and Drug Administration).<sup>32</sup> Experimental research in dental cells has shown eugenol to have anti-inflammatory properties in pulp cells but not in gingival cells.<sup>33</sup> In experimental research, eugenol demonstrated anticancer and anti-inflammatory activity in human cervical cancer cells<sup>31</sup> and had selective antiproliferative and antitumor properties on human cancer cells and their animal models.<sup>34</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Eugenol is cytotoxic in large doses,<sup>35</sup> that is, in quantities greater than are normally eaten in the diet.

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# F

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## *Fatty fish*

### *definition*

Characteristically strong-flavored fish owing to concentration of fish oils concentration in flesh, as opposed to white fish that has a relatively low fish oil concentration in flesh. Fatty fish are generally excellent sources of protein, vitamin D, and omega-3 fatty acids,<sup>1</sup> and supply coenzyme q10.<sup>2</sup> Bluefish, herring, salmon, trout (both wild and farmed), mackerel, sardines, and tuna are fatty fish. Canned sardines with edible bones are excellent sources of calcium: 3 oz supplies 325 mg of calcium.<sup>3</sup> Marination and use of various seasonings before broiling or grilling can mask the fishy flavor.

### *scientific findings*

Fish oil constituents DHA, EPA, and vitamin D are anti-inflammatory.<sup>4–6</sup> A meta-analysis of 14 randomized, controlled trials (n = 682; placebo, n = 641) found omega-3 fatty acid consumption improved insulin sensitivity.<sup>7</sup> Fish oil reduces triglycerides by 20%–50%.<sup>8</sup>

### *bioactive dose*

The American Heart Association recommends eating two 3.5-oz servings of (ideally fatty) fish per week.<sup>9</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Shark, swordfish, tilefish, and king mackerel (*Scomberomorus cavalla*), not to be confused with North Atlantic mackerel (*Scomber scombrus*), are considered high-methyl-mercury fish and therefore should be avoided by pregnant and lactating women; and in addition, pregnant and lactating women may eat no more than 6 oz of (white) albacore tuna per week.<sup>10</sup> According to a review: “The vast majority of epidemiological studies have proven that the benefits of fish intake exceed the potential risks [of ... contaminated fish] with the exception of a few selected species in sensitive populations.”<sup>11</sup>

## Fennel (*Foeniculum vulgare*)



Fennel. (Image from Diana Taliun/Shutterstock.)

### *definition*

Herb with a licorice-like flavor that contains the phenolic compound anethole.<sup>12</sup> Fennel leaves are used to season pork roasts, fennel seeds are used to flavor spicy sausages, and fennel stalks are used in preparing soups or mixed dishes.

### *scientific findings*

Fennel experimentally improved hypertension<sup>13</sup> and glaucoma<sup>14</sup> in animal models. Limited clinical trial data suggest fennel extracts may have the potential to treat infantile colic.<sup>15</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Fenugreek (Trigonella foenum-graecum)*

### *definition*

Plant whose leaves are used as an herb and seeds as a spice. Its seeds are also used to make flour. Fenugreek is a common flavor in Middle Eastern

foods. It is commonly used to fortify the maple flavor in imitation maple syrup. Flour supplemented with fenugreek fiber has been used in the production of baked goods such as bread, pizza, muffins, and cakes. The first recorded use of fenugreek is described on an ancient Egyptian papyrus dated 1500BC.<sup>16</sup> Folkloric knowledge describes uses of fenugreek to induce childbirth and promote lactation.<sup>17</sup>

### *scientific findings*

Fenugreek reduced serum glucose in diabetes in a few small clinical trials and animal studies.<sup>16,18</sup> The gum within the fenugreek seed fiber contains galactose and mannose, which are associated with reducing serum glucose and cholesterol.<sup>18</sup> There is not enough evidence to support its use as a galactagogue (to promote breast milk production in lactating women) or a pregnancy inducer.<sup>19</sup> Fenugreek fiber significantly increased satiety in a small, single-blind, randomized trial of healthy obese patients.<sup>20</sup>

### *bioactive dose*

Not known. Trials in which fenugreek was employed to reduce glucose have used varying doses and delivery forms; for example, 1 g of fenugreek extract<sup>21</sup> or 100 g of fenugreek seed powder.<sup>22</sup> For hyperlipidemia, 0.6–2.5 g of fenugreek two times daily with meals has been used.<sup>23</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Possible side effects of fenugreek when taken by mouth include gas, bloating, and diarrhea.<sup>21</sup> Since fenugreek has uterine stimulant activity, intake of amounts greater than those found in food should be avoided during pregnancy.<sup>23</sup> Since fenugreek has not been adequately studied during lactation for potential harmful effects to the infant or mother, it should be avoided during lactation.<sup>23</sup>

## *Ferulic acid*

### *definition*

Phytochemical found in seeds and leaves made from the metabolism of phenylalanine and tyrosine.<sup>24</sup> Found in high levels in vegetables, fruits, cereals, and coffee with the average intake estimated to be 150–250 mg/day.<sup>25</sup>

### *scientific findings*

In laboratory studies, ferulic acid exhibited antioxidant, antimicrobial, anti-inflammatory, antithrombotic, anticancer, and increased sperm viability effects.<sup>26,27</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Ferulic acid has a low toxicity potential.<sup>27</sup>

## *Fiber*

### *definition*

Nondigestible, structural material in plant foods that is generally categorized into soluble and insoluble types, each varying in water solubility, fermentability, and viscosity, characteristics responsible for distinct physiological effects and unique food characteristics. Soluble and insoluble fibers often occur together in foods. Particularly rich sources of soluble fiber include citrus fruits, apple pulp, apple pectin, infant banana flakes, green bananas, legumes, oat bran, oatmeal, barley, beans, okra, peas, rice bran, and strawberries.<sup>28–30</sup> Soluble fibers (also called viscous fibers), such as guar gum, pectin, psyllium, and certain hemicelluloses, retain water and form gels within the GI tract, thereby delaying gastric emptying and slowing the transit of food through the upper GI tract, slowing the absorption of nutrients from the small intestine, and entrapping bile salts and cholesterol in the large intestine; in addition, soluble fiber holds moisture in stools, softening them.<sup>31</sup> Rich sources of insoluble fibers include whole-wheat breads, wheat cereals, wheat bran, rye, rice, barley, most other grains, cabbage, beets, carrots, brussels sprouts, turnips, cauliflower, and apple skin.<sup>30</sup> Insoluble fibers, such as hemicellulose and cellulose, serve as bulk that increases fecal weight and promotes stool passage through the colon.<sup>31</sup> The food group that is highest in fiber as a group is legumes (8 g per 1/2 cup serving) followed by vegetables (3 g per 1/2 cup), nuts and seeds (3 g per 1 oz), fruits (2 g per 1/2 cup), and whole-grain products (1–2 g per 1 slice or 1/2 cup). The usual dietary fiber intake in the United States is 15 g/day<sup>32</sup> and should be increased by expanding variety in daily food patterns to include more and different types of plant foods.



*scientific findings*

Foods high in dietary fiber are generally low in calories. Dietary fiber intake from whole foods may lower blood pressure, improve serum lipids, and reduce indicators of inflammation.<sup>33</sup> Insoluble fibers help to prevent and alleviate constipation; reduce the risk of diverticulosis, hemorrhoids, and appendicitis; and promote satiety, which may aid in weight management.<sup>31</sup> Soluble fibers help to alleviate diarrhea; reduce fasting plasma cholesterol which is associated with reduced risk of heart disease; and reduce postprandial glycemia, which is associated with reduced risk of diabetes.<sup>31,34</sup> Soluble fibers may help to modestly reduce LDL cholesterol levels beyond that achieved by a diet low in cholesterol, saturated fat, and trans fats alone.<sup>30</sup>

*bioactive dose*

The Dietary Reference Intakes recommend 14 g dietary fiber per 1000 kcal; the AI for adults aged 19–50 is 25 g/day for women and 38 g/day for men.<sup>35</sup> Due to the bulky nature of fibers, excess consumption is likely to be self-limiting.<sup>35</sup>

*safety*

There is no UL for fiber. Increasing dietary fiber too quickly can lead to gas, bloating, and cramps. Fiber binds to minerals and increases their excretion; therefore, excessive fiber intake may have adverse effects on mineral absorption. The World Health Organization recommends an upper limit of 40 g/day.<sup>29</sup>

*Fig (*Ficus carica*)*

Fig. (Image from oriori/Shutterstock.)

### *definition*

Purple snack fruit that is approximately the size of a ping-pong ball. It is mild in flavor and full of small edible seeds. Figs are a good source of fiber. Phytochemical components include phenolics, coumarins, flavonoids (e.g., anthocyanins, quercetin, luteolin), and terpenoids.<sup>36</sup> Consumed fresh, dried, as jam, and made into fruit filling for baked products. Used orally as a laxative, for diabetes, hyperlipidemia, eczema, psoriasis, and vitiligo, although there is no reliable evidence to evaluate the effectiveness of fig for any of these conditions.<sup>23</sup>

**F**

### *scientific findings*

The equivalent of one small, fresh fig<sup>37</sup> produced a measurable increase in plasma antioxidant capacity in a small study (n = 10 healthy subjects).<sup>38</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Fig can cause allergy, and in rare cases, anaphylaxis.<sup>23</sup>

## *Flavonoids*

### *definition*

Class of hundreds of structurally unique phytochemicals that are relatively common in the average American diet, and which "... are usually subdivided according to their substituents into: anthocyanidins, catechins, chalcones, flavones, flavonols, flavanones, and isoflavones."<sup>39,40</sup> "Flavonoids provide the bright orange, yellow, and red pigments of various foods, along with characteristic flavors, such as the hearty taste of whole-wheat foods or the bitter taste of red grapes."<sup>41</sup> Flavonoids are found in citrus fruits and citrus-based juices, other fruits, vegetables, grains, nuts, seeds, spices, flowers, tea, red wine, and products made from soy and cocoa beans.<sup>39,41,42</sup> Plants and spices containing flavonoids have been used for thousands of years in traditional Eastern medicine.<sup>39</sup> Flavonoids are transported in serum by albumin, thus, theoretically, protein malnutrition may reduce serum circulating levels of flavonoids.<sup>43</sup>

*scientific findings*

“Flavonols, flavanones, and flavones are subclasses of flavonoids that exert cardioprotective and anticarcinogenic properties *in vitro* and *in vivo*.”<sup>42</sup> Some experimental evidence indicates that flavonoids could prevent prostate cancer.<sup>44</sup> Dietary flavonoid intake and black tea, a major source of flavonoids, were associated with a decreased risk of advanced stage prostate cancer in the Netherlands Cohort study (n = 58,279 men).<sup>44</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Flaxseed (Linum usitatissimum)*

Flaxseed. (Image from hsagencia/Shutterstock.)

*definition*

*Usitatissimum*, or “most useful,” is ascribed to flaxseed because it is a source of food products such as grains, seeds, and oil, and a source of fiber, which can be made into linen. Flaxseeds are a good source of iron and potassium with 1/4 cup supplying 341 mg of potassium (7% DV) and 2.4 mg of iron (13% DV),<sup>45</sup> omega-3 fatty acid, and  $\beta$ -sitosterol.<sup>46</sup> Flaxseeds, flaxseed cereals and breads, and flaxseed oil may require refrigeration to prevent rancidity; the oil should not be heated to high temperatures.

*scientific findings*

Flaxseed is an effective bulk-forming laxative.<sup>47</sup> According to a review, studies of flaxseed preparations used to reduce cholesterol levels have

been inconclusive<sup>47</sup>; however, a review of six clinical trials found that those using various flaxseed preparations significantly reduced total cholesterol and LDL cholesterol in people with both normal and high cholesterol levels,<sup>23</sup> and flaxseed has additional LDL-lowering capabilities when used concomitantly with statin medications.<sup>48</sup> However, flaxseed does not improve triglyceride levels, and a certain type of flaxseed (defatted flaxseed with reduced linolenic acid content) may have raised triglycerides in a clinical trial.<sup>23</sup> Flaxseed lignan, a component of flaxseed but not flaxseed oil, had no effect on bone mineral density body composition, lipoproteins, glucose, or inflammation in a small, randomized, placebo-controlled study (n = 100 adults aged ≥50).<sup>49</sup> β-sitosterol is “likely effective” for symptoms of enlarged prostate, and improved urinary symptoms, increased maximum urinary flow, and decreased post-void residual urine volume; however, it did not affect prostate size in clinical trials according to a review.<sup>23</sup> Taking flaxseed improved renal function in patients with systemic lupus erythematosus nephritis in two clinical trials.<sup>23</sup> Study results are mixed on whether flaxseed decreases hot flashes.<sup>47</sup>

### *bioactive dose*

A dose of 3–50 g (1 teaspoon–5 Tablespoons)<sup>50</sup> of flaxseed daily reduced total cholesterol by 5%–9% and LDL cholesterol by 8%–18% in the majority of clinical trials performed.<sup>23</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals; however, severe allergic reactions have been reported to flaxseed and flaxseed oil, and those with known allergy to any member of the *Linum* genus should avoid flaxseed products.<sup>23</sup> Flaxseed may stimulate menstruation and animal studies have shown possible harmful effects during pregnancy; therefore, the use of flaxseed or flaxseed oil during pregnancy and breastfeeding is not recommended.<sup>51</sup>

## *Folate*

### *definition*

Water soluble vitamin involved in the manufacture of DNA necessary for cell division and tissue growth. Folate deficiency impairs cell division and protein synthesis and can cause megaloblastic anemia. Folate requires vitamin B12 to be converted to a form necessary to manufacture DNA.<sup>52</sup>

Synthetic folic acid is more bioavailable than naturally occurring folate. The quantity of this vitamin in the diet, though measured in micrograms, may be expressed in Dietary Folate Equivalents to encompass the absorption difference between the synthetic form, found in commercial grain products, and the natural form found in fruits, vegetables, and “foliage” such as spinach, in addition to legumes, beets, and orange juice.

### *scientific findings*

To reduce the risk of in utero neural tube defects, women of reproductive age should consume 400 µg of folate/folic acid daily beginning before pregnancy, and 600 µg of folate/folic acid throughout gestation.<sup>53</sup> High dietary intake of vegetables during pregnancy reduces the risk of folate deficiency.<sup>23</sup> Folate deficiency impairs cell division and protein synthesis, and can cause megaloblastic anemia. Several, but not all, epidemiologic studies provide evidence of an inverse relationship between folate intake and the risk of pancreatic cancer, according to Sanchez et al.<sup>54</sup> Observational studies suggest that low folate status, particularly in women, is associated with depression.<sup>23</sup> A diet rich in folate may reduce the risk of stroke in male smokers, according to a large observational trial (n = 26,556 male Finnish smokers, aged 50–69 years).<sup>55</sup> “Dietary intake of folate greater than 249 µg daily in men and 400 µg in women is associated with a reduced risk of colon cancer, especially in women with a family history of the disease,” according to Jellin et al.<sup>23</sup>

### *bioactive dose*

The RDA for folic acid/folate is 400 µg for adults; 600 µg for pregnant women; and 500 µg for lactating women.

### *safety*

The UL for folic acid is 1000 µg. Patients should be warned to avoid treating undiagnosed anemia with folic acid because folic acid can mask pernicious anemia by decreasing megaloblastic anemia.<sup>21</sup>

## *Fructan*

### *definition*

Naturally occurring polymer of fructose molecules such as inulin. Fructooligosaccharides are a type of fructan. Found in asparagus, Jerusalem artichokes, chicory, bananas, garlic, and onion.<sup>56–59</sup>

*scientific findings*

Fructans are natural sweeteners that have a low caloric value, do not lead to a rise in serum glucose, do not stimulate insulin secretion, promote the growth of intestinal bifidobacteria, and may improve the absorption of certain minerals.<sup>59,60</sup> Taking fructans orally does not seem to reduce the incidence of traveler's diarrhea; some evidence suggests that fructans may relieve constipation by increasing fecal mass.<sup>23</sup>

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*bioactive dose*

Not known. For prebiotic effect (to increase fecal bifidobacteria), the typical dose is 4–10 g/day.<sup>23</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Fruit foods group**definition*

Underconsumed food group that is a good source of folate, vitamins C and A, and underconsumed potassium.<sup>61</sup> Fruit phytochemicals may vary by color, where generally blue/purple plant foods contain anthocyanidins, flavonols, flavan-3-ols, proanthocyanidins, ellagic acid, and resveratrol; green plant foods typically contain flavones, flavanones, flavonols,  $\beta$ -carotene, lutein, zeaxanthin, indoles, isothiocyanates, and organosulfur compounds; white plant foods typically contain flavonols, flavanones, indoles, isothiocyanates, and organosulfur compounds; yellow plant foods typically contain flavonols, flavanones,  $\alpha$ -carotene,  $\beta$ -carotene,  $\beta$ -cryptoxanthin, and zeaxanthin; and red plant foods typically contain anthocyanins, flavonols, flavones, flavan-3-ols, flavanones, proanthocyanidins, lycopene, ellagic acid, and resveratrol.<sup>62</sup>

*scientific findings*

"People whose diets are rich in plant foods such as fruits and vegetables have a lower risk of getting cancers of the mouth, pharynx, larynx, esophagus, stomach, and lung, and some evidence suggests that maintaining a diet rich in plant foods also lowers the risk of cancers of the colon, pancreas, and prostate. This diet also reduces the risk of diabetes, heart disease, and hypertension, helps to reduce calorie intake, and may

help to control weight.”<sup>63</sup> Consuming a diet containing high amounts of fruits is associated with fewer age-related diseases such as Alzheimer disease.<sup>64</sup>

### *bioactive dose*

One cup for children aged 2–3 years, to 1 1/2 to 2 cups daily for people aged 19–50 for general health.<sup>65</sup> One to 2.5 cups of fruits daily, depending on age and calorie needs, where 0.9 daily cup equivalents of fruit per 1000 cal is recommended to help prevent the cancers cited in Scientific Findings.<sup>65</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergies to different fruits have been reported.

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## *Garbanzo bean (Cicer arietinum)*

### *definition*

Italian name for the legume commonly called chickpea in the United States. It is an excellent source of vitamin B6, riboflavin, fiber, and protein; and it is a source of flavonoid glycosides.<sup>1,2</sup> It is commonly found on salad bars and made into hummus, a puree of garbanzo beans, lemon, cumin, and tahini.

### *scientific findings*

Garbanzo beans have a low glycemic index<sup>3</sup> and may be used as a cholesterol-free substitute for meat. One ounce of meat, poultry, or fish is nutritionally equivalent to 1/4 cup cooked of garbanzo beans, though the bioavailability of iron in legumes is lower than the bioavailability of heme iron in meat, poultry, or fish.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Garlic (Allium sativum)*

### *definition*

Edible lily family bulb that is a common culinary ingredient. When cut or crushed, it produces allyl sulfur compounds such as allicin, methyl allyl trisulfide, and diallyl trisulfide, each of which may have unique health properties. Other phytochemical constituents include vanillic acid, flavonoids, and terpenoids. Garlic is among the oldest of all cultivated plants and has been used for culinary and medicinal purposes for thousands of years.<sup>4</sup> Allicin is partly responsible for the flavor and odor of cut garlic.<sup>5</sup>

Allicin was previously considered to be a key bioactive constituent of garlic but was found to be highly unstable when processed. It quickly transforms into a variety of other bioactive organosulfur compounds when processed; hence, freshly crushed garlic may contain only limited amounts of allicin and commercially available processed garlic preparations do not contain allicin.<sup>5</sup> The biological activity of garlic is likely due to several components, which may include organosulfur transformation products of allicin.

### *scientific findings*

**G** Although preliminary research demonstrated a relationship between garlic consumption and a slight reduction in blood cholesterol level and that garlic may slow the progression of atherosclerosis,<sup>6</sup> fresh garlic, dried powdered garlic tablets, and aged garlic extract tablets were all found to be ineffective at lowering serum cholesterol in a controlled trial,<sup>6</sup> and a meta-analysis representative of available evidence on the effects of garlic on serum cholesterol from randomized controlled trials found no beneficial effect of garlic on serum cholesterol.<sup>7</sup> The same meta-analyses found the methyl allyl trisulfide component of garlic may be antithrombotic.<sup>6</sup> Garlic may reduce cardiac arrhythmias.<sup>8</sup> Some evidence has suggested that garlic consumption may slightly reduce blood pressure, particularly in people with high blood pressure<sup>6</sup>; other evidence does not support an appreciable effect of garlic in reducing blood pressure in people with high blood pressure.<sup>9</sup> Taking low doses of garlic powder orally, 300 mg/day, lessened age-related decreases in aortic elasticity, while higher doses of 900 mg/day seemed to slow development of atherosclerosis in both aortic and femoral arteries when used over a 4-year period.<sup>10</sup> Laboratory studies support that garlic, and or some of its allyl sulfur compounds, suppress carcinogen formation, carcinogen bioactivation, and tumor proliferation.<sup>11</sup> Diallyl trisulfide exhibited chemoprotective properties experimentally.<sup>12</sup> However, a review on the effects of garlic consumption and various cancers found “no credible evidence to support a relation between garlic intake and a reduced risk of gastric, breast, lung, or endometrial cancer,” and very limited evidence of a relationship between garlic consumption and a reduced risk of colon, prostate, esophageal, larynx, oral, ovary, or renal cell cancers.<sup>13</sup> According to the National Cancer Institute, “Preliminary studies suggest that garlic consumption may reduce the risk of developing several types of cancer, especially cancers of the gastrointestinal tract. Most of the studies evaluated different types of garlic preparations and used them in varying amounts.”<sup>14</sup> Garlic’s antifungal properties have been demonstrated in laboratory research.<sup>15,16</sup> In laboratory studies, aged garlic extract, but not fresh garlic extract, exhibited antioxidative activity.<sup>17</sup> Garlic components exhibited neuroprotective properties in experimental research.<sup>18</sup> In laboratory studies, allicin and compounds into which it transforms when processed,

exhibited antimicrobial properties,<sup>19</sup> and treatment with allicin arrested human mammary cancer cells in a laboratory study.<sup>20</sup>

### *bioactive dose*

Not known. A dose of fresh garlic 4 g (approximately one clove) once daily has been used to treat hyperlipidemia<sup>10</sup>; for hypertension, the dose of garlic powder 600–900 mg daily has been used.<sup>10</sup> If garlic consumption does reduce the risk of developing cancer, the amount needed to lower risk remains unknown.<sup>14</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Raw garlic appears to be safe for most adults and its side effects are generally mild (most commonly, breath and body odor, heartburn, upset stomach, and allergic reactions). Garlic is also an anti-coagulant, and therefore, its intake should be considered when monitoring patients with bleeding disorders or on anticoagulants, during or after surgery (garlic use should be stopped 7–10 days in advance of surgery, or if dental work is planned).<sup>21</sup> In addition, garlic has been found to interfere with the effectiveness of saquinavir, a drug used to treat HIV (human immunodeficiency virus) infection.<sup>6</sup>

## *Ginger (Zingiber officinale)*

### *definition*

A rhizome, or underground stem similar to a root. Ginger contains niacin, phytosterols, berberine, zingerone, a phenolic alkanone<sup>22</sup> responsible for the pungency of ginger,<sup>23</sup> shogaol, and zingiberene.<sup>24</sup> Ginger has been used in Asian traditional medicine to alleviate stomach ache, nausea, and diarrhea. Ginger is also used to treat rheumatoid arthritis, osteoarthritis, and joint and muscle pain; however, evidence for these uses is lacking.<sup>25</sup> Though ginger products are commonly used to relieve nausea,<sup>26</sup> ginger ale may be artificially flavored or contain real ginger, so consumers should look for “made from real ginger.”

### *scientific findings*

Ginger promotes saliva production and gastric juice secretion and produces an increase in the tone and peristalsis of the intestine.<sup>27</sup> Studies are inconclusive on whether ginger is effective for nausea caused by motion, chemotherapy.<sup>26</sup> Though studies do suggest that the short-term use of ginger can safely relieve pregnancy-related nausea and vomiting,

according to the National Institutes of Health.<sup>26</sup> A review of randomized, controlled clinical trials examining various interventions, among them use of ginger for nausea, vomiting, and retching in early pregnancy, found a lack of high-quality evidence.<sup>28</sup> In a meta-analysis of 12 randomized, controlled clinical trials (n = 1278 pregnant women), ginger significantly improved nausea in pregnant women compared to placebo but did not affect vomiting.<sup>29</sup> It is unclear whether ginger is effective in treating rheumatoid arthritis, osteoarthritis, joint pain, or muscle pain.<sup>26</sup> In an animal study, zingerone inhibited colonic motility via direct action on smooth muscles.<sup>30</sup>

## G

*bioactive dose*

For morning sickness, a dose equivalent to 1 g of ginger (250 mg ginger four times daily, or 500 mg twice daily) was found to be effective in two clinical trials; 650 mg three times daily has also been used.<sup>10</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. However, the *Physician's Desk Reference for Herbal Medicines* contraindicates the use of ginger during pregnancy for morning sickness because ginger during pregnancy theoretically might affect fetal sex hormones, and a case report of spontaneous abortion during week 12 of pregnancy in a patient who used ginger for morning sickness has been published.<sup>27</sup> Other reviews state that short-term use of ginger can safely relieve nausea of pregnancy. They state that: "ginger can be used safely for morning sickness without harm to the fetus"<sup>10</sup>; and "short-term use can safely relieve nausea of pregnancy."<sup>26</sup> Ginger should not be taken by individuals suffering from gallstones, except after consultation with a medical professional, because it increases bile production.<sup>10</sup>

*Glucosinolates**definition*

Phytochemicals found widely in *Brassica* plants that undergo biotransformation into various active compounds including sulforaphane and indole-3-carbinol. When *Brassica* foods are prepared by boiling and blanching, glucosinolate content is significantly reduced, whereas when prepared by steaming, microwaving, or stir frying the glucosinolate content is either retained or slightly reduced.<sup>31</sup> Sprouts of *brassica* vegetables typically contain significantly higher concentrations of glucosinolates than mature plants.<sup>32</sup>



*scientific findings*

Sulforaphane and indole-3-carbinol have demonstrated anticarcinogenic properties in laboratory studies.<sup>33</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Glucosinolates are goitrogens; they impair thyroid uptake of iodine.<sup>34</sup>

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*Glutamine**definition*

Nonessential amino acid that is abundant in the American diet. It is required for cell proliferation, immune function, and the maintenance of redox potential; as a respiratory fuel for rapidly proliferating cells; as a regulator of acid–base balance through the production of urinary ammonia; as a carrier of nitrogen; and as a precursor for nucleic acids, nucleotides, amino sugars, and proteins.<sup>35–37</sup> Glutamine is found in many protein foods such as flaxseed protein.<sup>38</sup>

*scientific findings*

Glutamine is considered to be conditionally essential during physiologic stress.<sup>37</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals.

*Glutathione**definition*

Compound that is synthesized in the body and is a component of the antioxidant enzyme glutathione peroxidase. Fresh fruits, vegetables, and

meats have moderate-to-high amounts of glutathione.<sup>39</sup> The spice cumin is also a source of glutathione.<sup>40</sup>

### *scientific findings*

Glutathione is thought to prevent free radical formation in humans.<sup>41</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Glycosides*

### *definition*

Sugar derivatives produced biochemically in plants, such as garbanzo beans, blackberries,<sup>1,42</sup> and *Stevia rebaudiana*, are used to make the natural sweetener Stevia.<sup>43</sup>

### *scientific findings*

Glycosides were shown to be antioxidants, suppress cancer cell growth, and exert antiatherogenic properties in laboratory studies.<sup>42</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed to be safe when consumed in normal dietary quantities by non-allergic individuals, except amygdalin, found in nonconsumable portions of fruits (e.g., the inedible pits of peaches), which is a well-known toxic cyanogenic glycoside.

## *Grains*

### *definition*

Seed-like fruits found at the stem tops of various plants but particularly those plants belonging to the Poaceae (grass) family. Cereals, the edible

grain produced by plants within the grass family, consist of the outer husk called the bran, which encloses the center endosperm and inner germ. The outer bran consists mostly of fibers, but also contains phytates. The endosperm consists mostly of starch and the inner germ contains high concentrations of fats, proteins, and vitamins such as vitamin E. When the bran and germ are removed during processing (refined) to increase shelf life and palatability, many nutrients are also removed including fiber, fat, protein, vitamins, and phytochemicals. “Enriched” refined grains (typically breads, cereals, and baked products containing the word “enriched flour” in their ingredient listing) are processed grain foods to which thiamin, riboflavin, niacin, folic acid, and iron have been added.

### *scientific findings*

Although whole grains are recommended, consuming half of one’s grain food intake as refined grains without high levels of added fat, sugar, or sodium, was not associated with an increased disease risk, according to a review of 135 studies of refined grains and health outcomes.<sup>44</sup> A case-control study (n = 384 pancreatic adenoma cases and 983 matched controls) found an increased association between pancreatic adenocarcinoma and intake of nonwhole grains, and an inverse association between pancreatic adenocarcinoma and intake of whole grains.<sup>45</sup>

### *bioactive dose*

The recommended number of grain group foods one should consume daily varies according to calorie requirements; see also grains, whole.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Grains, whole*

### *definition*

Grains with the bran, germ, and endosperm intact are “whole grains.” Whole grains provide fiber and a wide variety of naturally occurring nutrients, depending upon the specific grain, but generally include B vitamins, vitamin E, selenium, zinc, copper, and magnesium, along with phytochemicals such as phenolic compounds,<sup>46</sup> antioxidants, and phytoestrogens. Examples include oats, popcorn, brown rice, and products whose first ingredient in the ingredient listing contains the word “whole,” for example: Ingredients: Whole wheat.

### *scientific findings*

**G** Epidemiological studies have shown that whole grain intake is protective against cancer, cardiovascular disease, diabetes, and obesity.<sup>47</sup> The exact mechanisms linking whole grains to disease prevention are not known but may include gastrointestinal effects, antioxidant protection, and the intake of phytoestrogens.<sup>46</sup> A systematic review with meta-analysis of 11 cohort studies (n = 1,719,590 participants between 25 and 76 years of age) found consumption of whole grains was inversely associated with the risk of developing colorectal cancer.<sup>48</sup> A systematic review and meta-analysis of 25 prospective observational studies (n = >14,500 cases) found that a high intake of dietary fiber, in particular cereal fiber and whole grains, was associated with a reduced risk of colorectal cancer.<sup>49</sup> Possible mechanisms of action for a protective effect of dietary fiber and whole grain consumption and risk of colorectal cancer include diluting fecal carcinogens, decreasing transit time, thus reducing the contact between carcinogens and the lining of the colorectum, and the production of short-chain fatty acids by the fermentation of fiber, in addition to individual constituents of grains, such as antioxidants, vitamins, trace minerals, phytate, phenolic acids, lignans, phytoestrogens, and a high content of folate and magnesium, which have been associated with a reduced risk of colorectal cancer.<sup>49</sup> In a case-control study (n = 384 pancreatic adenoma cases and 983 matched controls), epidemiologic surveys and food frequency questionnaires showed that highest quintiles of whole grain intake were inversely associated with having pancreatic adenocarcinoma (for which several mechanisms associated with whole grains or fiber were postulated: decrease insulin resistance, decreased triglyceride levels, and/or elevated high density lipoprotein levels).<sup>45</sup>

### *bioactive dose*

Depending upon calorie requirements, approximately three servings of whole grains is the daily minimum whole grain recommendation for men and woman aged 19 to 50, though the actual amount required may vary based on calorie needs. One “serving” varies with each food (e.g., one serving of oatmeal is 1/2 cup while one serving of a whole wheat bread is a 1-oz slice).

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Grape (*Vitis vinifera*)

### definition

Marble-sized snack fruit that contains numerous phytochemicals, depending on variety, such as catechin, epicatechin, resveratrol, flavonoid proanthocyanidins, quercetin, and kaempferol.<sup>50</sup> Eaten fresh and made into other products such as juice, jam or jelly, raisins, and wine. Grape leaves are consumed in Middle Eastern cuisine and are an excellent source of vitamin K.<sup>51</sup> Concord grapes and its juice are violet in color and are a source of vitamin C and polyphenols.

### scientific findings

Grape seed skins contain potent antioxidants that theoretically improve microcirculation and protect the vascular endothelium.<sup>52</sup> Grape seed extract, in doses of 360–720 mg, or its proanthocyanidin constituents, in doses of 150–300 mg/day, orally seemed to reduce subjective symptoms of chronic venous insufficiency and improve venous tone in patients with stage I and stage II chronic venous insufficiency, compared to placebo. Patients also reported significant decreases in subjective complaints such as tired or heavy legs, tension, and tingling and pain after 12 weeks of treatment.<sup>10</sup> Both the concord grape and its juice contain polyphenols, including anthocyanin and proanthocyanidin, which are associated in epidemiological studies with a decreased risk of cancer and heart disease, and a reduction in age-related motor and cognitive deficits.<sup>53</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Grape seed extracts have been safely used for up to 8 weeks in clinical studies.<sup>10</sup>

## Grapefruit (*Citrus paradisi*)

### definition

Large yellow-, white-, red-, or pink-fleshed citrus fruit that is an excellent source of vitamin C and a source of folate and potassium, whether its juice or the whole fruit is consumed.<sup>54</sup>

### *scientific findings*

A red grapefruit variety (*Citrus paradise* Macf.) exhibited antioxidant properties in a laboratory study.<sup>55</sup> Eating 1.5 grapefruit daily for 6 weeks did not significantly reduce markers of inflammation and oxidative stress in a small, controlled clinical trial of overweight/obese subjects (n = 69), though grapefruit consumption produced a favorable modulation of oxidative stress in overweight and obese adults with metabolic syndrome.<sup>56</sup> “Preliminary population research shows that consuming a quart or more per day of grapefruit juice is associated with a 25%–30% increased risk of breast cancer in postmenopausal women, a mechanism for which may be that grapefruit juice reduces estrogen metabolism resulting in increased endogenous estrogen levels; however, more evidence is needed to validate this finding.<sup>10</sup> Grapefruit juice produced a greater decrease in mean arterial blood pressure when compared with orange juice in an experimental study.”<sup>57</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Grapefruit juice has been found to increase the absorption of certain drugs, including simvastatin and lovastatin,<sup>24</sup> and to increase cortisol availability in patients with Addison disease<sup>58</sup>; therefore, people on these medications may be advised to avoid grapefruit juice.

## *Green leaf(y) vegetables*

### *definition*

Versatile family of leafy food plants, such as basil, arugula, and spinach, known for their antioxidant capacity. In particular, *Brassica* vegetables are sources of specific phytochemicals, such as flavonoids and glucosinolates. Generally, dark green leafy vegetables are noted for providing vitamin E, folate, magnesium, vitamin K, and chlorophyll. Tender leafy green vegetables are common salad vegetables; heartier leafy greens are cooked or can be thinly minced and added to cooked recipes. Herb-like leafy green vegetables, such as basil and arugula, are used for their pungent flavors, as seasonings, but can be made into main dishes, such as pesto, when combined with garlic and parmesan cheese.

*scientific findings*

Consumption of green leafy vegetables is associated with a reduced risk of several types of cancer and cardiovascular disease.<sup>59</sup> In a population-based case-control study (n = 348 cases and 470 controls) higher intake of green leafy vegetables and cruciferous vegetables was associated with a lower risk of non-Hodgkin's lymphoma.<sup>60</sup>

In a case-control study (n = 384 pancreatic adenoma cases and 983 matched controls) where dark green vegetable consumption was determined by epidemiologic survey and food frequency questionnaire, evidence was observed to support that higher vegetable consumption, including dark green vegetables and other plant foods, was significantly inversely associated with pancreatic adenocarcinoma.<sup>45</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Guava (Psidium guajava)*

Guava. (Image from Nuttapong/Shutterstock.)

*definition*

Lemon-sized fruit whose skin may be yellow, red, or purple; whose flesh may be yellow, pink, or red, depending on the variety; and whose seeds are edible.<sup>61</sup> A uniquely flavored tropical fruit that contains polyphenol

antioxidants and is a good source of fiber and vitamin A, and an excellent source of vitamin C.<sup>61,62</sup> Consumed fresh or as a juice or juice blend.

### scientific findings

Vitamin C increases nonheme iron absorption. Guava juice added to schoolchildren's diets (n = 95 children aged 6–9), in order to prevent their high-phytate diet from diminishing iron absorption, was found to “marginally increase hemoglobin and plasma ferritin.”<sup>63</sup> Preliminary research suggests guava lectin and galactose may have antidiarrheal properties.<sup>64</sup>

### bioactive dose

Not known.

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# H

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## *Hazelnut (Corylus avellana)*



Hazelnut. (Image from Valentina Razumova/Shutterstock.)

H

### *definition*

Marble-sized nut, also called filbert, which is a good source of protein, monounsaturated fatty acid, tocopherols, phytosterols,<sup>1</sup> and other phytochemicals. Hazelnuts and chocolate are used to make Nutella (Ferrero USA, Inc., Somerset, NJ 08873); dry-roasted hazelnuts add crunchiness to yogurt.

### *scientific findings*

In a laboratory study, phenolic compounds of hazelnuts exerted antioxidant effects.<sup>2</sup> In a 4-week single intervention study (n = 21 normolipemic, healthy individuals), a hazelnut-enriched diet (1 g/kg/day) decreased the atherogenic tendency of LDL by reducing oxidized LDL levels and increasing vitamin E in LDL.<sup>3</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Hazelnut allergy has been reported, and affected individuals must avoid hazelnut exposure.

*Hemicellulose**definition*

Type of dietary fiber that has characteristics of both insoluble and soluble fibers. It surrounds cellulose in plant cell walls.<sup>4,5</sup> Legumes, fruits, and vegetables (particularly younger or less mature vegetables), and grains are the main sources of hemicellulose in the diet.<sup>6</sup>

*scientific findings*

Fibers in the large intestine promote stool passage and are associated with lower rates of diverticular disease, hemorrhoids, and appendicitis.<sup>4</sup>

*bioactive dose*

Not known. The DRI for fiber (of all types) is 25–38 g daily for women and men aged 19–50 years, respectively.

*safety*

The World Health Organization recommends a dietary fiber upper limit of 40 g/day.<sup>4</sup> Fiber intake exceeding 40 g has been associated with decreased absorption of minerals.

*Hesperidin**definition*

Polyphenol compound classified as flavonoid and specifically a flavanone glycoside is found in lemons and sweet oranges.<sup>7</sup> Hesperidin is a citrus by-product.<sup>8</sup> It is converted into hesperetin by GI microflora, absorbed, and circulates in plasma as hesperetin glucuronide.<sup>8</sup>

*scientific findings*

A dietary deficiency of hesperidin has been associated with capillary fragility and extremity pain causing night leg cramps, according to a review of its pharmacologic properties.<sup>8</sup> Hesperidin exhibited anti-inflammatory, hypolipidemic, and vasoprotective properties in experimental studies and several small clinical trials.<sup>8</sup> Hesperidin may improve venous diseases

such as hemorrhoids<sup>9</sup> and venous stasis<sup>10</sup> possibly by reducing capillary permeability.<sup>11</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. No signs of toxicity have been observed with the normal intake of hesperidin or related compounds.<sup>12</sup> Hesperidin appears to be safe when used up to 6 months by nonpregnant, nonlactating individuals.<sup>13</sup>

## *Honey*

### *definition*

Intensely sweet yellow–orange viscous carbohydrate liquid produced by bees from flower nectar. Flavors of honey vary depending upon the flower source. Honey is a concentrated source of the monosaccharides, glucose, and fructose, the same two monosaccharides that comprise sucrose.

### *scientific findings*

Honey has topical healing properties.<sup>14</sup> It contains the antibacterial protein royalisin.<sup>14</sup> Four different varieties of honey exerted antimicrobial effects against *Staphylococcus aureus* in a laboratory study.<sup>15</sup> Some clinical research in children with upper respiratory infections has shown that taking 2.5–10 mL (0.5–2 teaspoons) of honey at bedtime can significantly reduce nighttime cough frequency and severity and improve sleep compared to placebo.<sup>13</sup> Honey appears to be as, or more, effective than the over-the-counter cough suppressant dextromethorphan and the antihistamine diphenhydramine.<sup>13</sup>

### *bioactive dose*

Not known. For cough, 2.5–10 mL (0.5–2 teaspoons) of honey at bedtime has been used.<sup>13</sup>

### *safety*

Fetal and infant exposure should be avoided because honey could contain potentially harmful pyrrolizidine alkaloids. Honey sourced from pyrrolizidine alkaloid-containing plants represents a significant source of honey worldwide.<sup>16</sup> Regarding botulism, honey consumption is safe in children over 1 year of age.<sup>13</sup>

## Honeydew melon (*Cucumis melo* L. var. *inodorus* Naud)

### definition

Considered to be the sweetest commercially available melon and one of the 10 most consumed melons in the United States, honeydew melon has pale green, juicy flesh and its ripeness is reflected by its creamy yellow, inedible rind. One-half cup of honeydew supplies 200 mg of potassium, is an excellent source of vitamin C and folate,<sup>18</sup> and supplies the phytochemical cucurbitacin- $\beta$ .<sup>17</sup>

### scientific findings

Cucurbitacin- $\beta$  has exhibited antihepatotoxic, anti-inflammatory, and anticancer properties in laboratory studies.<sup>17</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Hops (*Humulus lupulus* L.)



Hops. (Image from Zhukov Oleg/Shutterstock.)



### *definition*

Flower of the hop plant. It contains phytoestrogens and chalcones. The major bitter flavoring in beer, it is also used as a food preservative. Traditional uses of hops include as a sleep aid, stomachic (an agent beneficial to digestion or to the stomach), antibacterial, and antifungal agent.<sup>14,19</sup>

### *scientific findings*

Neuropharmacological effects of hops have been observed in laboratory animals.<sup>19</sup> *In vivo* and *in vitro* studies have demonstrated stomachic, antibacterial, antifungal, and cancer preventative properties.<sup>19</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. The phytoestrogen 8-prenylnaringenin was strongly estrogenic in a laboratory study and hops exposure has been attributed to menstrual abnormalities in female beer industry workers.<sup>20</sup>

## *Horseradish (Armoracia rusticana, Cochlearia armoracia)*



Horseradish. (Image from Peter Zijlstra/Shutterstock.)

### *definition*

Thick, woody root vegetable belonging to the Brassicaceae family that is a source of potassium and phytochemicals such as lutein, zeaxanthin, cochlearine, and glucosinolates.<sup>21-23</sup> It is ground and processed into

prepared horseradish that is mixed with other ingredients, such as vinegar, and used as a condiment. Its major flavoring constituent, allyl isothiocyanate, causes a burning sensation when it comes in contact with the mouth. Green-colored horseradish is frequently substituted for wasabi, the sushi condiment, in the United States. Horseradish has been used to cure scurvy due to its high vitamin C content,<sup>24</sup> an effect that would be contingent upon amount consumed.

### *scientific findings*

Horseradish exhibited antibacterial properties in an *in vitro* study.<sup>23</sup> In a placebo-controlled clinical trial, horseradish also helped prevent urinary tract infections.<sup>25</sup> The German Commission E has approved horseradish for oral use as “supportive therapy for infections of the urinary tract.”<sup>26</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. It has a strong and irritating odor and contact with the mouth causes burning sensation.

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# I

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## *Indole*

### *definition*

Phytochemicals, such as indole-3-carbinol and brassinin, that are formed from the hydrolysis of indoleglucosinolates in *Brassica* vegetables.<sup>1</sup>

### *scientific findings*

The chemoprotective properties of indole-3-carbinol include the induction of phase II enzymes.<sup>2</sup> In animal studies, indole-3-carbinol exhibited chemopreventive properties.<sup>3,4</sup> Laboratory research found that brassinin demonstrated antiproliferative effects against cancer in both *in vivo* and *in vitro* models.<sup>5</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Inulin*

### *definition*

Type of carbohydrate that is fermented in the large intestine. Found in plant foods, such as asparagus, bananas, chicory, dandelion, garlic, Globe artichoke, Jerusalem artichoke, leeks, onions, wheat bran, and wheat flour.<sup>6</sup> The average inulin intake in the American diet has been estimated to be 2.6 g/day.<sup>7</sup>

### *scientific findings*

Inulin improves laxation by increasing stool bulk and stool water content, and increases fecal bacteria,<sup>8,9</sup> and may improve stool frequency particularly in slightly constipated individuals.<sup>9</sup> Inulin may strengthen the intestinal epithelium and reduce the risk of gastrointestinal diseases.<sup>9</sup>

*bioactive dose*

Not known. For hypertriglyceridemia, the typical dose of inulin is 10–14 g daily; for treatment of hypercholesterolemia, inulin 6 g three times daily has been used for up to 6 weeks; for treatment of constipation in elderly, 20–40 g/day for 19 days has been used.<sup>10</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Iodine**definition*

Trace mineral that functions as part of the thyroid hormones triiodothyronine (T3) and thyroxine (T4) that regulate basal metabolism, growth, and body temperature.<sup>11</sup> Good sources of iodine include foods sourced from seawater including ocean fish, such as haddock, and seaweed; also iodized salt and processed foods to which additives, such as calcium iodate, potassium iodate, potassium iodide, and cuprous iodide, have been added. Dairy products may be sources of incidental iodine by way of feed additives given to dairy cows. The dairy farm and bakery industries may also use iodine-containing disinfectants, although this practice has been largely discontinued in the dairy industry.<sup>12</sup> Iodine may be absorbed transcutaneously via exposure to ocean mist, exhaust from the combustion of organic fuels, and topical exposure to iodine preparations, such as iodine antiseptics.<sup>12</sup> One-third of the world's population consumes insufficient iodine.<sup>13</sup> The average adult consumes more iodine than the RDA (between 210 and 300 µg daily).<sup>11</sup>

*scientific findings*

Iodine deficiency and iodine excess in otherwise healthy individuals can compromise thyroid function.<sup>12</sup> During pregnancy, insufficient maternal iodine intake causes maternal and neonatal hypothyroidism and increases the risk of neurological damage and cretinism, a form of preventable mental retardation and deafness in the baby.<sup>11</sup>

*bioactive dose*

The adult RDA for iodine is 150 µg.

*safety*

The UL for iodine for adults aged 19–50 years is 1100 µg. Excessive intake of iodine from food, water, and supplements has been associated with adverse effects such as thyroiditis, goiter, hypothyroidism, and hyperthyroidism.<sup>11</sup>

*Iron**definition*

Trace mineral found in the hemoglobin portion of red blood cells that binds to and transports oxygen to cells for energy metabolism. Heme iron occurs bound to hemoglobin or myoglobin in animal flesh and sources include meat, poultry, fish, and seafood, but not nonflesh animal foods such as eggs. Nonheme iron is found in legumes, beans, peas, processed soy products, and iron-fortified enriched cereals. Heme iron is well absorbed (approximately 23%) compared to nonheme iron (2%–20%).<sup>14</sup> Hemoglobin concentrations lower than 1112 g/dL in children younger than 12, 12 g/dL in adolescents and women, and 13 g/dL in men indicate the presence of iron deficiency anemia.<sup>17</sup>

*scientific findings*

Insufficient iron intake during pregnancy increases the infant's risk of low birthweight, premature birth, low iron stores, and impaired cognitive and behavioral development, as well as increases the mother's risk for developing iron deficiency anemia.<sup>15</sup> Iron deficiency anemia affects approximately 10% of Americans, is especially common in toddlers, children, adolescents, and reproductive-aged women. A child with iron deficiency or iron deficiency anemia may exhibit fatigue on physical exertion and poor exercise tolerance; and impaired energy metabolism and decreased mental productivity and aptitude; decreased neurotransmitter synthesis; and irritability, apathy, or restlessness.<sup>16</sup> Children who had iron deficiency anemia as infants perform poorly as they grow older, even if their iron status improves.<sup>16</sup>

*bioactive dose*

The RDA for adults aged 19–50 is 18 mg for women of reproductive age and 8 mg for men. Since it is unlikely that the amount of iron required during pregnancy will be met by diet alone, iron-replete pregnant women require a daily dietary supplement of iron,<sup>16</sup> ideally one that contains the RDA of 27 µg of iron, which is the pregnancy RDA. Women who are iron

deficient going into pregnancy will require more than the RDA of 27  $\mu\text{g}$  of iron to correct their deficiency.

### *safety*

The UL for adults aged 19 and older is 45 mg. Excess iron may be a major cause of iron-induced oxidative stress.<sup>17</sup>

## *Isoflavone*

### *definition*

Phytoestrogen and type of flavonoid<sup>18</sup> whose chemical structure is similar to estrogen.<sup>19</sup> Daidzen, genistein, and glycitein are three major types of isoflavones found in certain fruits, vegetables, breads and cereals, meats, nuts, seeds, legumes, tofu, and tempeh.<sup>20</sup> Soybeans and soybean products are a major source of isoflavones.<sup>22</sup> In the U.S., intake of isoflavones has been estimated to be 1.13 mg/day,<sup>21</sup> whereas typical Japanese intake is 30–50 mg/day.<sup>22</sup> Soybean isoflavones exert estrogenic and nonestrogenic properties that may reduce risk of certain chronic diseases,<sup>22</sup> such as coronary heart disease, osteoporosis, and certain cancers, and alleviate symptoms of menopause.<sup>24</sup>

### *scientific findings*

Meta-analyses have shown nonsignificant effects of soy isoflavones on total and LDL cholesterol<sup>23</sup>; cholesterol-lowering effects of soy isoflavones when consumed concurrently with soy protein<sup>23</sup>; no effect of soy isoflavones on lowering cholesterol levels<sup>24</sup>; and significant effect of soy isoflavones on reducing serum total and LDL cholesterol.<sup>25</sup> Soy isoflavones may reduce LDL cholesterol oxidation.<sup>26</sup> Data on whether soy isoflavones or isoflavone-rich soy protein improve bone mineral density in younger postmenopausal women are inconsistent.<sup>27</sup> Limited “epidemiologic data generally show that among Asian populations isoflavone intake is associated with higher bone mineral density.”<sup>29</sup> Isoflavones did not affect serum prostate-specific antigen levels in healthy subjects, but “significantly favorably affected prostate-specific antigen in 4 of 8 clinical trials involving prostate cancer patients, while in no studies was there an absolute decrease in PSA concentrations.”<sup>24</sup> “Soy isoflavones may mimic the actions and functions of estrogens on brain, and they have been shown to have positive effects on the cognitive function in females; however, studies on their effects on spatial memory have not provided consistent results in males.”<sup>28</sup> Soy isoflavones may help prevent or treat diabetic nephropathy.<sup>24</sup> Laboratory data show isoflavones exert chemopreventive properties, including cell



cycle arrest and cell apoptosis.<sup>22</sup> Some trials reported a slight reduction in hot flashes and night sweats with phytoestrogen-based (isoflavone-based) treatment<sup>29</sup>; however, not all research has found soy extracts containing phytoestrogens to significantly reduce hot flashes leading researchers to conclude that “Isoflavones hold limited promise for the treatment of menopausal vasomotor symptoms.”<sup>30</sup>

### *bioactive dose*

The dose of soy isoflavones needed to achieve significant decreases in total or LDL cholesterol or triglycerides has not been established.<sup>31</sup> Doses used to reduce blood lipids in studies have ranged from 40 to 318 mg/day of isoflavones.<sup>10</sup> Forty milligrams is approximately the amount found in 100 g of tofu (depending on the brand name) and 318 mg would be supplied by two 100-g servings of dry roasted soybeans.<sup>32</sup> Clinical trial data suggest that approximately 80 mg/day isoflavones are needed to achieve improved bone–mineral density, whereas the epidemiologic data suggest lower amounts are efficacious.<sup>27</sup> The dose of isoflavones in the prostate clinical trials (supplied by dietary supplements) ranged from 60 to 900 mg/day.<sup>24</sup> A dose range of 34 to 76 mg isoflavones seemed to modestly reduce the frequency and severity of hot flashes in some menopausal women.<sup>34</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. The soy isoflavone genistein is goitrogenic.<sup>33</sup>

## *Isoprenoids*

### *definition*

Phytochemicals that impart flavors and fragrances, such as menthol from peppermint oil, citral from lemongrass oil, and limonene from citrus rinds. Fruits, vegetables, and cereal grains contain a variety of isoprenoid compounds.<sup>34</sup>

### *scientific findings*

Isoprenoids have demonstrated anticancer activity in laboratory research.<sup>35</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Isothiocyanates**definition*

Phytochemicals formed from the breakdown of glucosinolates<sup>36</sup> that are found in mustard seed and *Brassica* vegetables such as watercress and broccoli sprouts.<sup>37</sup>

*scientific findings*

I Isothiocyanates have exerted antimicrobial and chemoprotective properties in experimental studies.<sup>38,39</sup> A review of epidemiological studies that examined associations between phytochemicals and cancer risk found mostly null associations between individual phytochemicals and cancer risk at various sites, and in those studies showing effect, “consistent protective effects were observed for higher levels—dietary intake, serum, plasma, or urinary metabolites—of ... isothiocyanates and lung cancer, [and] isothiocyanates and gastrointestinal cancer,” among other effects.<sup>40</sup> Isothiocyanate has exhibited antimicrobial activity against a wide spectrum of pathogens, and anticancer activity experimentally (in cell cultures of cancer cells and in animal models) according to a report, which also stated that its bioavailability is very high.<sup>41</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Isothiocyanates are known to be genotoxic, and therefore, pose a potential risk at high levels of intake, the specific level of which is not known.<sup>41</sup>

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# J

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## *Jasmine rice (Oryza sativa L.)*



Jasmine rice. (Image from Praiseng/Shutterstock.)

### *definition*

An Asian variety of long- or medium-grain rice noted for being aromatic and flavorful when cooked owing to the presence of the chemical 2-acetyl-1-pyrrolin.<sup>1,2</sup> Jasmine rice is primarily grown in Thailand and readily commercially available. Nutritionally, jasmine rice, like all rice, is rich in starch, and enriched jasmine rice is a source of thiamin, niacin, iron, and folic acid.<sup>3</sup>

### *scientific findings*

Rice is a high-glycemic index food; people with diabetes may benefit from lower-glycemic index foods such as rice noodles.<sup>4</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Jerusalem artichoke (Helianthus tuberosus)*

Jerusalem artichoke. (Image from Jiang Hongyan/Shutterstock.)

*definition*

Species of sunflower with an edible root, also called a sun root or sun choke. It is neither from Jerusalem nor an artichoke. Its elongated finger-like tubers, which have a crisp texture, are cooked and eaten. Similar to water chestnuts in taste, Jerusalem artichoke tubers resemble potatoes except that the tuber carbohydrate is primarily inulin (and not starch).<sup>5</sup>

*scientific findings*

Fructans from Jerusalem artichokes reduced insulin response, compared to fructose, an effect attributed to fructans' slowing of GI transit time, in a small (n = 8) trial of healthy subjects.<sup>6</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.



## *Jicama (Pachyrhizus erosus)*



Jicama. (Image from Binh Thanh Bui/Shutterstock.)

J

### *definition*

Also called “Mexican potato” and “yambean.” A sweet, starchy tuber<sup>7</sup> native to Mexico and Central America pronounced “hecama.” Jicama can weigh up to 6 lbs, has crunchy flesh, and contains fewer than 25 cal per 1/2 cup. In addition, raw jicama is a good source of vitamin C<sup>8</sup> and contains lignin and phenolic compounds.<sup>9</sup> Jicama tastes like a combination of water chestnut and apple and is used as a substitute for water chestnut in Asian cooking. It is also eaten fresh as thin slices or strips with vegetable dip or lime juice, in salads, and in stir fries.

### *scientific findings*

See also *phenolic compounds*.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Juniper berry (*Juniperus communis* L.)

### definition

Cone of a shrub that appears berry-like, although not a true berry. It contains the phytochemicals limonene, myrcene, and phenolics.<sup>10,11</sup> Juniper berry flavors gin. The juniper berry is commonly used in bath salts for treating rheumatism.<sup>12</sup>

### scientific findings

Juniper has *in vitro* antioxidant properties that may help inhibit lipid peroxidation *in vitro*.<sup>11</sup> An experimental study showed juniper berry to be hepatoprotective in rats.<sup>13</sup>

### bioactive dose

Not known. A typical oral dose of juniper berry is 1–2 g three times daily, or one cup of the tea three to four times daily. The tea is prepared by steeping 1 teaspoon of the crushed juniper berry, about 2–3 g, in 150 mL boiling water for 10 min and then straining. Juniper should be used up to a maximum of 10 g of the dried berry per day, which should be used no longer than 4 weeks without physician consultation.<sup>12</sup>

### safety

Juniper, juniper berry, and juniper extract are likely safe when used orally in amounts commonly found in foods.<sup>12</sup> Juniper berry oil should only be used under medical supervision.<sup>12</sup> *J. communis* extract adversely affected fertility and was abortifacient in studies using albino rats.<sup>14</sup> Juniper should not be used in pregnancy because it can increase uterine tone, interfere with fertility and implantation, and cause abortion.<sup>12</sup> Juniper should not be used during lactation because there is insufficient information to evaluate its safety.<sup>12</sup> Prolonged use of high doses can increase the potential for severe side effects such as convulsions or kidney damage.<sup>12</sup>

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# K

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## *Kaempferol*

### *definition*

Common dietary flavonoid found in a wide variety of plant foods such as tea, broccoli, cabbage, kale, beans, endive, leek, tomato, and strawberry.<sup>1</sup>

### *scientific findings*

According to a review of kaempferol, some epidemiological studies have found a positive association between the consumption of foods containing kaempferol and a reduced risk of developing cancer and cardiovascular disease.<sup>1</sup> Although two epidemiologic studies reported little association between dietary intake of kaempferol and lung cancer, a population-based case-control study (n = 558 lung cancer cases and 837 controls) found an inverse association between kaempferol intake and lung cancer among tobacco smokers.<sup>2</sup> Some experimental research has shown kaempferol and some of its glycosides to have a wide range of pharmacological activities, including analgesic, antiallergic, anticancer, antidiabetic, anti-inflammatory, antimicrobial, antiosteoporotic, antioxidant, antiapoptotic, anxiolytic, cardioprotective, estrogenic/antiestrogenic, and neuroprotective.<sup>1,3</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Kale (Brassica oleracea* var. *acephala*)

Kale. (Image from Binh Thanh Bui/Shutterstock.)

*definition*

Dark green leafy *Brassica* vegetable that is an excellent source of folate, vitamin C,  $\beta$ -carotene, vitamin K, and a good source of magnesium, in addition to supplying lutein, zeaxanthin, and allyl isothiocyanate.<sup>4,5</sup> Kale leaves and stems are chopped, sautéed with or without meat for flavoring, and served as greens or baked into kale chips. Baby kale is more tender than kale and is used as a salad green. The leaves of curly kale (*Brassica oleracea* L. convar. *acephala* var. *sabellica*) were found to contain dozens of different phenolic compounds in a laboratory analysis.<sup>6</sup>

*scientific findings*

Kale seeds exhibited antioxidant properties *in vitro*.<sup>7</sup>

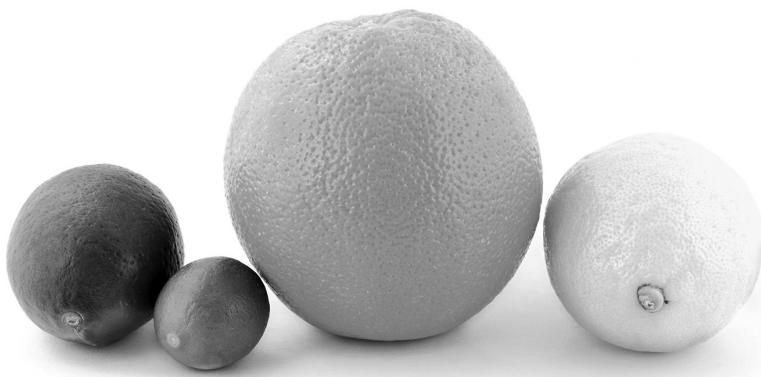
*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. The thiocyanate component of kale may induce hypothyroid effects in some individuals when kale is consumed and the amount may vary by individual.<sup>8</sup>

*Key lime (Citrus aurantifolia)*



Note the small size of Key lime, second from left in this picture featuring lime and other citrus fruits. (Image from Alexandar Iotzov/Shutterstock.)

*definition*

Miniature lime named for one of its growing places, the Florida Keys. Adds zesty flavor to marinades, salads, and Key lime pie; also used to make limeade and to flavor and garnish beverages. A good source of vitamin C and flavonoids.<sup>9</sup>

*scientific findings*

Lime essential oil from lime peel reduced body weight in laboratory animals.<sup>10</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals.<sup>11</sup> Lime juice administered enterally blocked ovulation and compromised fertility in laboratory animals.<sup>12</sup> Lime juice also reduced the effectiveness of warfarin in laboratory animals.<sup>13</sup> Although lime peel is considered to be “likely safe” when used orally in medicinal amounts, lime oil from lime peel contains photosensitizing constituents.<sup>14</sup>

*Kiwifruit (Actinidia chinensis)**definition*

Also called kiwi. Small green- or gold-fleshed fruit that is eaten fresh and, depending on the variety, is a source of vitamins C and E, phenolics, carotenoids, lutein, and zeaxanthin.<sup>15,16</sup> When its small, edible black seeds are consumed, one small, whole kiwifruit supplies 2 g of fiber.<sup>16</sup>

*scientific findings*

In experimental research, kiwifruit improved markers of immune function in mice.<sup>17</sup> Kiwifruit polysaccharides increased fibroblast activity in an *in vitro* study, which may have implications for human collagen synthesis.<sup>18</sup> According to a review, kiwi may improve laxation, aid digestion, and promote healthy gut microflora in humans, and, in addition, it has antioxidant and antiplatelet aggregatory properties.<sup>19</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.



## Kumquat (*Fortunella* sp. Swingle)



Kumquat. (Image from Volosina/Shutterstock.)

K

### *definition*

Miniature citrus genus orange that is approximately the size and shape of a large olive. Its very thin peel is edible; however, its distinctive green seeds are bitter and are not intended to be eaten. Kumquats are a source of flavones, vitamin C, and the carotenoids  $\alpha$ -carotene,  $\beta$ -cryptoxanthin, lutein, and zeaxanthin.<sup>20</sup> Kumquats can be eaten raw and whole or can be used to make marmalade. Canned, peeled kumquats are often served as desserts in Chinese restaurants.

### *scientific findings*

See also *citrus*.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# L

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## *Lactose*

### *definition*

Disaccharide that requires intestinal lactase for its digestion. In lactase deficiency, lactose maldigestion causes bloating, gas, abdominal pain, loose stools, and osmotic diarrhea. Lactose is a common food additive, appearing on label ingredient listings of breads, cereals, breakfast drinks, salad dressings, and cake mixes. Approximately 20% of prescription drug products and 5% of over-the-counter drug products may contain lactose.<sup>1</sup>

### *scientific findings*

Lactose improves the absorption of calcium.<sup>2</sup> Lactose intolerance is a risk factor for low bone density<sup>3</sup> because milk avoidance limits calcium and vitamin D consumption.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities, except by lactose-intolerant individuals who may experience symptoms after consuming even minute amounts of lactose.

## *Legume*

### *definition*

High-protein member of the Fabaceae family (formerly called Leguminosae), including starchy beans, such as black beans, garbanzo beans (also called chickpeas), kidney beans, lentils, pinto beans, and lima beans, but not string beans; and peas, such as black-eyed peas and split peas. Although recommended as a substitute for meat protein, only 7.9% of Americans consume legumes on a daily basis.<sup>4</sup> Eating approximately

1/2 cup of dry beans or peas increases intakes of fiber, protein, folate, zinc, iron, and magnesium without appreciably contributing to fat or saturated fat intake.<sup>4</sup> Legumes contain phytochemicals such as enzyme inhibitors, phytohemagglutinins (lectins), phytoestrogens, oligosaccharides, saponins, and phenolic compounds.<sup>5</sup> White beans can be substituted for other legumes, for example, chili can be made with 1/2 red kidney beans and 1/2 white beans; white beans are used to make minestrone soup.

### *scientific findings*

A review of epidemiological evidence on diet and mortality in older adults found that in general, dietary patterns that demonstrated greater adherence to diets that emphasized whole fruits and vegetables, whole grains, low-fat dairy, lean meats, and legumes and nuts were inversely associated with mortality in adults aged 60 and older.<sup>6</sup> Legumes may help to control blood sugar in people with diabetes<sup>7</sup> due to their soluble fiber content. *In vitro*, white bean extract has been shown to block the carbohydrate-digesting enzyme  $\alpha$ -amylase and is therefore being investigated for its potential to reduce carbohydrate absorption.<sup>8</sup> In a 4-week randomized, double-blind, placebo-controlled study (n = 25 healthy subjects), consumption of 1000 mg of white bean extract (equal to approximately 4 cups of legumes) or placebo twice a day before meals in conjunction with a multicomponent weight-loss program, including diet, exercise, and behavioral intervention, significantly reduced the weight and waist size of test subjects.<sup>9</sup> Legumes have a low glycemic index.<sup>10</sup> A high-legume, low-glycemic index diet improved serum leptin levels in insulin-resistant, middle-aged men.<sup>10</sup> A high-legume, high-fiber, low-glycemic index diet, compared to a healthy American diet, each eaten for 4 weeks, improved serum lipid profiles in men in a randomized, controlled crossover feeding study (n = 64 middle-aged men).<sup>11</sup>

### *bioactive dose*

While there is no daily recommendation for legumes *per se*, ChooseMyPlate.gov promotes legume consumption and suggests adults aged 19–50 ingest 5–5.5 oz equivalents (1 oz equivalent = 1/4 cup of cooked beans) daily from all protein sources.<sup>12</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Lemon (*Citrus limon*)

### definition

Popular citrus fruit used to add tang to salads and seafood, to marinate, and to make juice drinks. Its citrate content is the highest among citrus fruits.<sup>13</sup> Lemon juice is an excellent source of vitamin C and is also a source of liminoid,  $\beta$ -cryptoxanthin, lutein, xeaxanthin, coumarins, hesperetin, quercetin, and myricetin.<sup>14,15</sup>

### scientific findings

Lemon essential oil from lemon peel, when sprayed as an aerosol, reduced *Staphylococci*, *Streptococci*, and *Sarcina* in the air.<sup>16</sup> Lemonade has been studied in small groups of patients to evaluate its ability to increase urinary citrate levels, a desirable effect in preventing kidney stones. Drinking lemonade compared to taking potassium citrate improved urine volume, a desirable effect, in a small prospective, crossover design trial (n = 21 subjects at risk for stone formation). Lemonade, however, did not improve urinary citrate or urinary pH while potassium citrate did, and neither treatment improved uric acid level.<sup>17</sup> In a second small trial (n = 12 patients who were either noncompliant with or intolerant of pharmacological citrate therapy), patients supplemented their routine diet with lemonade citrate (made with 4 oz of reconstituted lemon juice) consumed at uniform intervals throughout the day. "Citrate supplementation with lemonade increased urinary citrate levels more than two-fold without changing total urinary volume."<sup>18</sup> In a third trial, 11 men and women, mean age 52.7 years, were treated with lemonade therapy for a mean of 44.4 months. The control group, 11 men and women mean age 54.5 years, were treated with potassium citrate for a mean of 42.5 months. Of the 11 patients on lemonade, 10 demonstrated increased urinary citrate levels, and all potassium citrate therapy subjects demonstrated an increase in urinary citrate. During lemonade therapy, the stone formation rate decreased from 1.00 to 0.13 stones per patient per year. Researchers in this trial concluded that lemonade appears to be a reasonable alternative for patients with hypocitraturia who cannot tolerate first line therapy due to its significant citraturic effect.<sup>13</sup>

### bioactive dose

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Lemongrass (Cymbopogon citratus)*

Lemongrass. (Image from tarmizi razali/Shutterstock.)

**L***definition*

Tropical grass used in cooking that resembles a small hard stalk. Lemongrass is chopped finely and used as a spice in Thai cooking to impart intense lemon flavor. Lemongrass tea has been used in traditional medicine to treat hypertension and diabetes.<sup>19</sup>

*scientific findings*

Lemongrass essential oil, when sprayed as an aerosol, reduced airborne microorganism contaminants.<sup>16</sup> Laboratory research suggests that anti-inflammatory compounds in lemongrass work by inhibiting the release of pro-inflammatory cytokines.<sup>20</sup> Lemongrass attenuated animal liver damage in an experimental study.<sup>21</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.



## Lettuce (*Lactuca sativa*)

### definition

Salad green available in different varieties, such as Bibb, a tender lettuce that grows in small, loose heads, and lola rosa (also spelled lolla rossa and lolla rosa), a loose-leaf lettuce variety that has a mild taste, green leaves at its base, and ruffled burgundy leaves near the ends.<sup>22</sup> *Lactuca*, the Roman name for lettuce, comes from “lac” (milk) because wild lettuce contains a milky sap. Lettuce was traditionally eaten at the end of the evening meal because it was thought to produce a mild, sedative effect; it may also have been eaten at the beginning of a meal to enhance appetite.<sup>22</sup> Nutritional content varies by variety. Bibb is a source of folate, vitamin A, and vitamin K,<sup>23</sup> and contains the phytochemical zeaxanthin.<sup>24</sup> Lola rosa is a source of vitamin K, potassium, calcium, copper, manganese, fiber,  $\beta$ -carotene, lutein, zeaxanthin, quercetin, and, concentrated in its intense red-pigmented parts, anthocyanins.<sup>25–29</sup>

### scientific findings

A lettuce-derived protein elicited antibodies with positive reactivity against human immunodeficiency virus isolates in a laboratory study, as well as systemic and local immune responses when administered to mice.<sup>30</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Licorice (*Glycyrrhiza glabra*)

### definition

Root of the licorice shrub that is processed as a flavoring agent and included in some authentically flavored licorice foods and candies, though most “licorice” candy sold in the United States is actually flavored with anise, not licorice, and therefore is not a source of licorice or active licorice compounds.<sup>31</sup> True licorice extract contains the active ingredients glycyrrhizin and glycyrrhizic acid. The body converts glycyrrhizin to a

metabolite compound, glycyrrhetic acid.<sup>32</sup> Deglycyrrhized licorice extracts are also available to make licorice candy. Licorice has a history of use for gastrointestinal symptoms<sup>31</sup> and chronic hepatitis.<sup>33</sup>

### *scientific findings*

There are not enough reliable data to determine whether licorice is effective for any health condition.<sup>34</sup> Glycyrrhizic acid was attributed to improving lipoprotein lipase activity, insulin sensitivity,<sup>35</sup> and dyslipidemia<sup>36</sup> in obese laboratory animals.

### *bioactive dose*

Not known.

### *safety*

Licorice is likely safe when used orally in amounts commonly found in foods.<sup>37</sup> Licorice glycyrrhizin, glycyrrhizic acid, and/or glycyrrhetic acid may cause increased potassium excretion, sodium and water retention, body weight gain, hypertension, hypokalemia, alkalosis, suppression of the renin–angiotensin–aldosterone system, and muscular paralysis.<sup>33,38,39</sup> Habitual licorice ingestion, which has been defined as “consuming 30 g or more of licorice daily for several weeks” can cause severe adverse events including hypertension, hypokalemia, alkalosis, weakness, paralysis, and occasionally encephalopathy in otherwise healthy people.<sup>37</sup> Additionally, ingestion of antituberculosis agents containing licorice and long-term ingestion of licorice-containing agents for chronic gastritis, chronic hepatitis, or chronic dermatitis were implicated in 59 cases of glycyrrhizin (licorice)-induced hypokalemic myopathy involving quadriplegia, muscle pain, peripheral dysesthesia in the extremities, and numbness.<sup>40</sup> Large amounts of *G. glabra* must be avoided in pregnancy because it may increase the risk of preterm labor.<sup>31,41</sup>

## *Lignan*

### *definition*

Phytoestrogen that is prominent in the Western diet,<sup>42</sup> classes of which include enterolactone and enterodiol.<sup>43</sup> Lignan is found in flaxseed, pumpkin seed, sesame seed, soybean, broccoli, whole grains, beans, peas, and some berries.<sup>43,44</sup> Lignan should not be confused with lignin (a polymer of phenolic compounds that occurs naturally in plants).<sup>45</sup>

*scientific findings*

Although additional research is required to understand the association between lignan exposure and breast cancer risk, a meta-analysis of 21 epidemiologic studies concluded that “high lignan exposure might be associated with a reduced breast cancer risk in postmenopausal women.”<sup>42</sup> GI microorganisms interacting with lignan enterodiols and enterolactone have generated bioactive compounds that retarded experimentally induced cancer.<sup>46</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Limonoid**definition*

Prominent group of secondary metabolites, some of which have a bitter flavor,<sup>47</sup> that are found in tangerine, grapefruit, and other *Citrus* genus fruits and their juices. Examples of limonoids include aglycones, such as limonin, and glucosides, such as limonin glucoside.<sup>48,49</sup>

*scientific findings*

Compounds belonging to this group have exhibited biological activities such as antibacterial, antifungal, antimalarial, anticancer, and antiviral, in laboratory studies.<sup>50</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Limonene*

### *definition*

Terpene found in high concentration in orange, lemon, mandarin, lime, and grapefruit oils.<sup>51</sup> Ingested when the zest, or peel of citrus fruits, is consumed; also used as a flavoring agent in fruit juices, soft drinks, baked goods, ice cream, and pudding.<sup>51</sup>

### *scientific findings*

Limonene exhibited chemopreventive activity against rat mammary cancer.<sup>52,53</sup> Preliminary data suggest that limonene has shown some efficacy in the chemoprevention and chemotherapy of human malignancies, according to a review.<sup>52</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Lingonberry (Vaccinium vitis-idaea)*

### *definition*

Relative of a cranberry that is a popular fresh fruit in Scandinavian countries, but is available for sale in the United States as jam. Contains anthocyanins, flavonols, resveratrol, and procyanidin.<sup>54</sup> Lingonberry has been used for its antioxidant properties in traditional medicine.

### *scientific findings*

In laboratory studies, the phenolics in lingonberries were effective free radical scavengers<sup>54</sup> and were antimicrobial against *Staphylococcus aureus*.<sup>55</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Lutein

### *definition*

Xanthophyll carotenoid that commonly occurs with zeaxanthin in foods. Lutein and zeaxanthin are considered to be one of the major categories of carotenoids<sup>56</sup> and are responsible for the yellow color in foods and the macula region of the retina.<sup>57</sup> Dark green vegetables are a source of lutein: there are 44 mg of lutein/cup of cooked kale, 26 mg/cup of cooked spinach, and 3 mg/cup of broccoli.<sup>37</sup>

### *scientific findings*

The macular pigment may protect retinal cells from damage due to light by absorbing blue light. There is also “epidemiological evidence that the amount of macular pigment is inversely associated with the incidence of age-related macular degeneration.”<sup>57</sup> A meta-analysis reported that dietary lutein (and zeaxanthin) is not significantly associated with a reduced risk of early age-related macular degeneration, whereas an increase in the intake of these carotenoids may be protective against late age-related macular degeneration.<sup>58</sup> Age-related macular degeneration is an irreversible process that is a major cause of blindness in the elderly.<sup>57</sup> Epidemiology suggests a reduced risk of developing severe cataracts in people consuming higher amounts of lutein in their diet.<sup>37</sup> People consuming 6.9–11.7 mg of lutein per day through diet had the lowest risk of developing age-related macular degeneration and cataracts, according to two large cohort studies (n = 36,644 men; n = 77,466 women).<sup>37</sup> Population research suggests that increasing intake of dietary lutein does not decrease the risk of developing coronary heart disease.<sup>37</sup>

### *bioactive dose*

A dose of 6 mg of food lutein has been used for reducing the risk of cataract and age-related macular degeneration.<sup>37</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Dietary lutein intake of 6.9–11.7 mg/day is considered “high intake” and appears to be safe.<sup>37</sup>

## *Lychee fruit* (also spelled litchi, *Litchi chinensis*)



Lychee. (Image from Subbotina Anna/Shutterstock.)

### *definition*

**L** Small, oval-shaped fruit with an inedible skin, whose white or pinkish white flesh tastes like a grape. Lychee is a source of vitamin C, all B vitamins except B12, calcium, iron, potassium, and polyphenolic compounds.<sup>59,60</sup> Lychee fruit can be eaten fresh or peeled, pitted and canned in syrup.

### *scientific findings*

Polyphenolic compounds from lychee fruits were strong antioxidants in laboratory studies.<sup>60</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Lycopene* (*Solanum lycopersicum*)

### *definition*

Carotenoid antioxidant that imparts pink and red pigments to plant foods such as watermelon, pink grapefruit, guava, and tomatoes. Approximately 85% of the dietary lycopene intake in the United States is from tomatoes.<sup>61</sup>

One cup (240 mL) of tomato juice provides about 23 mg of lycopene. Dietary lycopene intake increases plasma levels of lycopene.<sup>62</sup> Lycopene is found primarily as *trans*-lycopene in food sources; some *trans*-lycopene is converted into *cis*-lycopene due to body metabolism of lycopene.<sup>63</sup>

### *scientific findings*

The Food and Drug Administration found no association between lycopene intake and reduced risk of breast, colorectal, endometrial, gastric, lung, ovarian, prostate, or pancreatic cancer in its 2004 review of lycopene for qualified health claim status.<sup>64</sup> Lycopene may help to alleviate cellular oxidative stress.<sup>65</sup> Observational studies in many countries have shown that the risk for some types of cancer is lower in individuals who have higher levels of lycopene in their blood.<sup>66</sup> Whereas some epidemiological research suggests that a low serum concentration of lycopene is associated with age-related macular degeneration risk,<sup>67</sup> pooled results from nine prospective cohort studies (n = 149,203 people) found that intake of certain carotenoids, including lycopene, had little or no effect on the primary prevention of early age-related macular degeneration.<sup>68</sup> A small clinical trial (n = 55: 34 patients with age-related macular degeneration and 21 control subjects) found that lycopene levels in age-related macular degeneration patients was significantly decreased in serum, in LDL, and in HDL.<sup>67</sup> A review of epidemiological evidence on lycopene and cardiovascular disease in women found that higher serum lycopene levels were associated with reduced risk of cardiovascular disease in some, but not all, studies. In men, it appeared that dietary intake of lycopene was not associated with a reduced risk of cardiovascular disease.<sup>37</sup> Men's consumption of 12 g/day of dietary lycopene and women's consumption of 6.5 mg/day of dietary lycopene was associated with a decreased risk of lung cancer in non-smoking men and women in an observational study.<sup>37</sup> Epidemiological research shows no association between dietary lycopene intake and the risk of developing colon cancer.<sup>37</sup> A meta-analysis that included 10 clinical trials found no evidence of an association between lycopene intake and the risk for having type 2 diabetes.<sup>62</sup> Circulating lycopene was protective against human papilloma virus progression to cervical neoplasia, according to the findings of a small case-control study in women (n = 32 subjects with incident cervical dysplasia and 113 control subjects with normal cervical cytology), a nonsignificant finding due to small sample size.<sup>69</sup> In a case-control study, a 56% reduction in human papilloma virus persistence risk was observed in women with the highest plasma lycopene concentrations compared with women with the lowest plasma lycopene concentrations.<sup>63</sup> "Lycopene induces responses in human prostate epithelial cells that are antiproliferative, antioxidative, and anti-inflammatory, as well as downregulating targets in the androgen receptor signaling pathway."<sup>70</sup>

It has been suggested that lycopene is negatively associated with the risk of prostate cancer.<sup>71</sup> In a large epidemiological study, a cohort of the Health Professionals Follow-up Study (n = 47,894 subjects initially free of diagnosed cancer), increased dietary lycopene intake from foods was associated with a lower risk of developing prostate cancer: Researchers found that combined lycopene intake from tomatoes, tomato sauce, tomato juice, and pizza, which accounted for 82% of lycopene intake, was inversely associated with the risk of prostate cancer for consumption frequency greater than 10 servings per week versus less than 1.5 servings per week.<sup>72</sup> The Prostate Cancer Prevention Trial (n = 9559 participants) found no association between dietary intake of lycopene and prostate cancer risk.<sup>73</sup> An analysis of The Prostate Cancer Prevention Trial reiterated that findings suggest no association between serum lycopene and prostate cancer risk.<sup>74</sup> Three randomized clinical trials (n = 154 participants) found “no statistical difference in prostate-specific antigen levels between men randomized to receive lycopene and control subjects.”<sup>75</sup> There is “insufficient evidence to either support, or refute, the use of lycopene for the prevention of prostate cancer, and no robust evidence from randomized clinical trials to identify the impact of lycopene consumption upon the incidence of prostate cancer, prostate symptoms, prostate specific antigen levels or adverse events.”<sup>75</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Some research suggests that lycopene, in significant quantities as are found in large doses, for example, in dietary supplements but not foods, might worsen established cancers of the prostate.<sup>61</sup>

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# M

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## *Magnesium*

### *definition*

Fourth most abundant mineral in the body, magnesium is necessary for reactions in energy metabolism, vitamin D metabolism and/or action, bone cell activity, regulating the electrical activity of the heart, helping to maintain normal muscle and nerve function, immunity, helping to regulate blood sugar levels, and maintaining normal blood pressure.<sup>1-3</sup> Magnesium is a constituent of bone<sup>4</sup> and most body magnesium is found in bone.<sup>3</sup> Magnesium is withdrawn from bone to maintain blood levels when dietary intake of magnesium is inadequate.<sup>5</sup> Good sources of magnesium include dark green vegetables, such as broccoli, and dark green leafy vegetables, such as curly kale. The chlorophyll molecule contains magnesium.<sup>3</sup> Other good sources include whole grains, such as oatmeal and raisin bran (the bran and germ contain magnesium); nuts and peanut butter; legumes; halibut; and cocoa products.<sup>3</sup> The following foods supply approximately 100 mg: 4 slices of whole grain bread, 1 cup of beans, 1/4 cup of nuts, 1/2 cup of cooked spinach, or 3 bananas.<sup>3</sup> Hard, mineral-rich water, known to be a source of certain cardioprotective nutrients, including magnesium, is associated with decreased arterial blood pressure and blood lipids.<sup>6</sup>

Approximately one-half of the U.S. population has magnesium intakes below their RDA,<sup>7</sup> but children aged 4–8 appear to meet their magnesium RDA.<sup>4</sup> Among the groups with lowest intake are African-Americans and older adults in every racial and ethnic group.<sup>2</sup>

### *scientific findings*

Hypomagnesemia occurs due to vomiting, diarrhea, alcohol abuse, protein malnutrition, prolonged nutritionally inadequate intravenous fluid use, poorly controlled diabetes, and use of diuretic medications.<sup>2,8</sup> Magnesium deficiency can initially result in muscle cramps, hypertension, coronary and cerebral vasospasms, loss of appetite, nausea, vomiting, fatigue, and weakness.<sup>2</sup> As magnesium deficiency worsens, numbness, tingling, muscle contractions and cramps, seizures, sudden changes in behaviors, personality changes, abnormal heart rhythms, and coronary spasms can occur.<sup>2</sup> A meta-analysis of 37 published studies investigating

the association of magnesium and attention deficit hyperactivity disorder concluded that no well-controlled clinical trial has yet been published to support the efficacy of magnesium for attention deficit hyperactivity disorder treatment.<sup>9</sup> A large cross-sectional study of adult men and women (n = 1120 men and 1384 women aged 18–74) found that dietary magnesium intake was inversely associated with fasting blood glucose levels.<sup>10</sup> Magnesium deficiency can negatively affect insulin sensitivity in type 2 diabetes.<sup>11</sup> Magnesium deficiency leads to loss of bone mass, abnormal bone growth, and skeletal weakness.<sup>12</sup> In experimental research, magnesium deficiency in animal bone cells increased formation of osteoclasts.<sup>12</sup> Magnesium deficiency slows the bone mass accretion in childhood and adolescence, and accelerates bone loss after menopause or in old age.<sup>11</sup> Both magnesium deficiency and high magnesium blood levels have been observed in patients with restless leg syndrome.<sup>11</sup>

### *bioactive dose*

The RDA for magnesium for adult women aged 31–50 is 320 mg and for men aged 31–50 is 420 mg.

### *safety*

When ingested as a naturally occurring substance in foods, magnesium has not been associated with any adverse events (AEs).<sup>2</sup> The UL for magnesium is based upon nonfood sources; total magnesium from supplementary sources should not exceed 350 mg for adults. Excess magnesium from nonfood sources (e.g., dietary supplements or magnesium salts used pharmacologically) is associated with AEs such as diarrhea.<sup>2</sup>

## *Mango (*Mangifera indica*)*

### *definition*

Juicy, orange-fleshed tropical fruit, eaten fresh or dried, that is a source of potassium, fatty acids, and numerous phytochemicals including polyphenols, terpenoids, steroids, phenolic esters, flavan-3-ols, and mangiferin, a xanthone.<sup>13</sup>

### *scientific findings*

*In vitro* and *in vivo* models, mango has exerted antioxidant, iron chelator, anti-inflammatory, antinociceptive, antitumor, and immunomodulatory properties.<sup>13–15</sup>

### *bioactive dose*

Not known.



*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Marjoram, sweet (Origanum majorana)*



Marjoram. (Image from Scisetti Alfio/Shutterstock.)

M

*definition*

Mint family herb that contains phenolics and terpenoids.<sup>16</sup> Used fresh or dried to flavor cooked vegetable- or protein-based dishes and pairs well with carrot, mushroom, pea, zucchini, and tomato, chicken, duck, eggs, fish such as halibut and tuna, and lamb chops.<sup>17</sup> It has been historically used for “rhinitis and colds in infants and toddlers, gastritis, stimulating appetite, as a digestive aid, antispasmodic, antifatulent, and astringent, to promote circulation, healthy sleep, [and to] treat mood swings.”<sup>11</sup>

*scientific findings*

Marjoram essential oils exhibited antimicrobial and antifungal properties in laboratory studies.<sup>18,19</sup>

*dioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Melatonin

### definition

Also called *N*-acetyl-5-methoxytryptamine.<sup>20</sup> Pineal gland hormone produced by the metabolism of serotonin<sup>20</sup> and a phytochemical that is ubiquitous in the plant kingdom,<sup>21</sup> found in foods such as corn, rice, barley, ginger,<sup>20,22</sup> and other plant foods.

### scientific findings

In laboratory studies, melatonin suppressed tumor angiogenesis<sup>23</sup> and has been shown to be a scavenger of hydroxyl radicals.<sup>20</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Monounsaturated fatty acid

### definition

Dietary triglycerides whose fatty acids predominately contain one double bond. Monounsaturated fatty acid is the major triglyceride found in canola, olive, peanut, and sunflower oils; avocados; and nuts and seeds. The Mediterranean diet is high in monounsaturated fats, in addition to omega-3-fatty acid and plant foods, and it is low in saturated fat, trans fat, and cholesterol.<sup>24,25</sup>

### scientific findings

Replacing saturated and trans fats with monounsaturated fats and polyunsaturated fats reduces LDL cholesterol.<sup>26</sup> A meta-analysis and review incorporating 12 studies found that high monounsaturated fat intakes (>12%) were associated with lower body fat mass, total cholesterol, LDL cholesterol, HDL cholesterol, triacylglycerols, systolic and diastolic blood pressures, and C-reactive protein.<sup>27</sup> A Mediterranean diet may reduce the risk of all-cause mortality, cardiovascular disease, type 2 diabetes, obesity, certain cancers, and Alzheimer's disease.<sup>25,28</sup> In a prospective observational study, greater monounsaturated fat intakes were associated with

less cognitive decline in women.<sup>29</sup> Monounsaturated fat intake was found to be inversely associated with age-related hearing loss.<sup>30</sup>

### *bioactive dose*

For lowering coronary heart disease risk, the National Cholesterol Education Program recommends consuming up to 20% of total kcals from monounsaturated fat.<sup>8</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Mulberry (Morus rubrum)*



Mulberry. (Image from ravl/Shutterstock.)

M

### *definition*

Blackberry look-alike whose red species, *Morus rubrum*, is cultivated in the United States.<sup>31</sup> Excellent source of vitamin C, good source of manganese and vitamin K,<sup>32</sup> and source of anthocyanin<sup>33</sup> and resveratrol.<sup>34</sup> While black mulberry, *Morus nigra*, native to Iran, has been planted only to a limited extent in America, primarily on the Pacific Coast, red or American mulberry, *Morus rubrum*, grows from Massachusetts to Kansas and down to the Gulf coast.<sup>35</sup>

### *scientific findings*

*M. nigra* contains numerous phytochemicals including  $\beta$ -sitosterol, which exerted anti-inflammatory effects in a laboratory study.<sup>36</sup> *M. nigra* exhibited

neuroprotective and biomembrane-protective, antioxidant effects in a laboratory study.<sup>37</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Mung bean (*Phaseolus aureus*)*



Mung bean. (Image from Chokchai Suksatavonraphan/Shutterstock.)

### *definition*

Pea-sized, oblong-shaped legume that may be red or green depending on the variety. A source of vitamin K, iron, magnesium, phosphorus, potassium, and phytochemicals, including phenolics, vanillic acid, caffeic acid, chlorogenic acid, coumaric acid, flavonoids, and terpenoids.<sup>38,39</sup> The whole bean is cooked and coupled with rice; for example, mung dal is a bright-yellow soup-like entrée commonly served in Indian restaurants. Mung bean sprouts may be purchased ready-to-eat and can be home-grown from mung bean seeds. They are common in Asian cooking, and are a source of phenolics and flavonoids.

### *scientific findings*

Mung bean sprouts and seed extracts exerted antidiabetic effects in animals with type 2 diabetes,<sup>40</sup> and antioxidant effects in laboratory

research.<sup>41</sup> Extracts made from mung bean sprout exerted antitumor effects in laboratory studies.<sup>42</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities as foods by nonallergic individuals.

*Mushroom, maitake (Grifola frondosa)*



Maitake mushroom. (Image from soulgems/Shutterstock.)

M

*definition*

Also called hen of the woods. Mild-tasting mushroom whose white stems branch from its base in clustered, grayish brown masses; it has spoon-shaped caps.<sup>43,44</sup> Both caps and stems are edible and are cooked by grilling, roasting, searing, or preparing in ways similar to button mushrooms. Maitake mushroom contains 22 cal per 1 cup and supplies 4 mg of niacin (20% DV), 786 IU of vitamin D (200% DV), 21 µg of folate (5% DV), and small amounts (5 g) of carbohydrate,<sup>45</sup> including the polysaccharides lentinan and D-fraction, which are among the most studied of its bioactive constituents.

*scientific findings*

Maitake mushroom polysaccharides exerted antitumor and immune activity in laboratory studies.<sup>46–49</sup> Clinical evidence does not support that maitake mushroom is effective in treating or preventing cancer in humans.<sup>50</sup> Maitake mushroom exhibited antidiabetic properties in experimental research and in two cases of patients with type 2 diabetes.<sup>51–53</sup> It is presumed,

based upon laboratory findings, that its hypoglycemic effect may be due to insulin sensitization or activation of insulin receptors in insulin-targeted cells.<sup>53</sup> More evidence is needed to evaluate the effectiveness of maitake mushroom in lowering blood sugar. More evidence is needed to evaluate maitake mushroom effectiveness in inducing ovulation in polycystic ovary syndrome, for which it was found to be effective in a 12-week clinical trial (n = 80 patients with polycystic ovary syndrome).<sup>11,54</sup> In *in vitro* and *in vivo* studies, *Grifola frondosa* extracts or compounds demonstrated neuroprotective effects, including reduced beta amyloid-induced neurotoxicity, and exerted anti-neuroinflammatory effects.<sup>55</sup> Maitake mushroom reduced blood pressure and improved dyslipidemia in animal studies.<sup>11,56</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when used in normal dietary quantities by nonallergic individuals. Dried maitake mushroom powder was safely used in doses up to 2.25 g daily for up to 28 weeks and maitake mushroom polysaccharides 1–1.5 g daily was safely used for up to 2 years.<sup>55</sup>

## *Mushroom, oyster (Pleurotus ostreatus)*

### *definition*

Fleshy, mild-flavored mushroom tastes like oyster when cooked with butter. It is white-to-brown in color with a small, stub-like stalk, having whitish or yellow-tinged gills.<sup>57</sup> Grows wild and is commercially sold fresh or dried.

### *scientific findings*

Oyster mushroom exhibited anti-inflammatory properties in laboratory studies.<sup>58</sup> Antitumor and immunomodulating factors have been isolated in oyster mushroom.<sup>59</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergies to mushrooms have been reported.

## Mushroom, shiitake (*Lentinus edodes*)



Shiitake mushroom. (Image from Elena Elisseeva/Shutterstock.)

### *definition*

Also spelled *shiitake*. Brown and white fungus that has a meat-like texture and is a source of riboflavin, niacin, vitamin B6, phosphorus, and selenium.<sup>60,61</sup> Shiitake are the second most popular edible mushroom marketed globally<sup>44,62</sup> and are used fresh or rehydrated from dried form.

### *scientific findings*

Chemical analysis of shiitake mushrooms have isolated antibiotic, anti-carcinogenic, and antiviral compounds.<sup>62</sup> In laboratory studies, shiitake constituents have demonstrated immunomodulatory properties<sup>63</sup>; and lentinan, a polysaccharide flavonoid,<sup>64</sup> was immunomodulatory and demonstrated antitumor effects in an animal model.<sup>65</sup> Shiitake mushrooms decreased hypertension in rats.<sup>66</sup> Shiitake mushroom extract given three times daily for 6 months did not prevent prostate cancer disease progression, as determined by prostate-specific antigen levels, in a clinical trial (n = 62 men with prostate cancer, mean age 73.2 years who had two consecutive elevated prostate specific antigen readings during a 3-month study period) that found shiitake mushroom extract to be “ineffective in the treatment of clinical prostate cancer.”<sup>67</sup> Shiitake mushroom alkaloids have exhibited anticarcinogenic properties in laboratory studies.<sup>68</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Mustard seed (Brassica alba)**definition*

Small round seeds of the mustard plant that has been grown since ancient times. Contains phenolics, isothiocyanate, glucosinolates, and brassinin.<sup>69</sup> Commercial mustard is made by grinding the seed and vinegar into a paste. Traditionally, mustard powder is used to “brighten and clear the voice” when it is stirred with honey to form balls, and one or two of these honey balls are taken on an empty stomach.<sup>55</sup>

*scientific findings*

In a laboratory study, mustard exhibited chemoprotective properties, which were attributed to its allyl isothiocyanate content.<sup>70</sup> Flavonoids have been isolated in shoots, roots, and extracts of *Brassica alba*.<sup>71</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# N

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## *Naringin*

### *definition*

Bitter principle of grapefruit and flavonoid that is partly responsible, along with a related compound called naringenin, for grapefruit juice enhancing the bioavailability of certain medications.<sup>1</sup>

### *scientific findings*

In laboratory studies, naringin exhibited antioxidant properties, inhibited tumor growth, and suppressed age-related blood pressure increases in hypertensive rats.<sup>2-4</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Nectarine (Prunus persica nectarina)*

### *definition*

Relative of the peach that has smooth, shiny skin. Commonly eaten fresh, the orange and white cultivars of nectarine supply fiber, vitamin C, phenolics, and carotenoids.<sup>5</sup>

### *scientific findings*

Phenolic compounds have exerted antioxidant, anti-inflammatory, and antimicrobial effects.<sup>6-8</sup> Carotenoids exhibited antioxidant activity *in vitro*; whereas, direct evidence of *in vivo* antioxidant activity is limited.<sup>9</sup> Epidemiology suggests that diets high in carotenoid-rich fruits and vegetables reduce the risk of oxidation-dependent diseases such as cancer,

atherosclerosis, and macular degeneration.<sup>9</sup> Vitamin C is a cofactor in collagen, carnitine, and neurotransmitter synthesis,<sup>10</sup> is necessary for immune function, and increases intestinal absorption of nonheme iron<sup>10</sup> by either reducing iron from the ferrous ionic state to ferric state or by forming a soluble complex with the iron in the alkaline pH of the small intestine.<sup>11</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Niacin*

### *definition*

Also called nicotinic acid, nicotinamide, and vitamin B3.<sup>12</sup> B vitamin necessary for energy metabolism. Niacin sources include protein-containing foods such as legumes and meat, enriched and whole grains, and vegetables such as mushrooms, potatoes, and asparagus.<sup>13</sup> Niacin deficiency causes pellagra, which is characterized by dermatitis, diarrhea, dementia, and, if untreated, death.

### *scientific findings*

Niacin deficiency causes neurodegeneration.<sup>14</sup> Eating protein foods prevents niacin deficiency because they supply tryptophan, an amino acid that is converted into niacin. Inadequate iron, riboflavin, or vitamin B6 status decreases the conversion of tryptophan to niacin.<sup>15</sup>

### *bioactive dose*

Niacin intake is measured in “niacin equivalents” to include niacin *per se* and the conversion of the tryptophan to niacin. The RDA for men is 16 niacin equivalents. The RDA for women is 14 niacin equivalents.

### *safety*

The UL is 35 mg/day of niacin equivalents.

## Nitrates and nitrites

### *definition*

Compounds that are present naturally in soil, water (nitrates are the most common chemical contaminant in groundwater),<sup>19</sup> all plants, and in meats.<sup>16</sup> Nitrites are naturally occurring compounds associated with the nitrogen cycle in soil and water; concentrations of nitrites in plants and water are usually very low<sup>16</sup>; however, sodium nitrite is added to cured meats and smoked/salted fish in order to prevent botulism, develop cured meat flavor and color, and retard rancidity, off-odors, and off-flavors and its intake parallels consumption of these processed meats. Both are regulated in water and certain foods by the Environmental Protection Agency and the FDA. Nitrates and nitrites are found in many vegetables, such as spinach and beets, and products made from them, such as commercial baby foods,<sup>17</sup> in addition to fruits.<sup>18,19</sup>

### *scientific findings*

Nitrates and nitrites have physiologic roles in vascular and immune function<sup>20</sup> and the dietary intake of nitrates and nitrites from vegetables and fruits may actually contribute to the blood pressure-lowering effects of the Dietary Approaches to Stop Hypertension (DASH) diet.<sup>20</sup> According to a review, "In humans, dietary nitrate and nitrite sources have been demonstrated to lower blood pressure and decrease oxygen consumption during submaximal and maximal aerobic exercise. In animal models, nitrite has been demonstrated to enhance mucosal blood flow and serve antimicrobial functions, protect against heart attack and stroke, and reverse vascular inflammation from a high fat diet."<sup>20</sup> "However, the adverse effects of nitrates and nitrites are perhaps more well-known than their beneficial effects. Ingested nitrate is reduced to nitrite, which binds to hemoglobin to form methemoglobin,"<sup>19</sup> a compound that, at high levels, adversely affects infant health by interfering with the oxygen-carrying capacity of blood.<sup>19</sup> Nitrates and nitrites are also associated with gastrointestinal cancer and blood disorders.<sup>20,21</sup> A case-control study found, by examining subsequent occurrence of colorectal cancer in a cohort (n = 9985 adult men and women) over a period of 24 years, that "N-nitroso compounds can induce colorectal cancer in humans."<sup>22</sup> Production of butyric acid by certain probiotic bacteria neutralizes the activity of dietary carcinogens such as nitrosamines.<sup>23</sup>

### *bioactive dose*

Not applicable.



*safety*

The World Health Organization established an acceptable daily nitrate intake of 222 mg/day.<sup>24</sup> A hypothetical nitrate intake while following the DASH diet may range from 174 to 1222 mg, which exceeds the World Health Organization's acceptable daily intake of nitrate for a 60-kg adult by 550%.<sup>20</sup>

*Noni (Morinda citrifolia)*

Noni. (Image from Nipaporn Panyacharoen/Shutterstock.)

*definition*

Also called Indian mulberry fruit.<sup>25</sup> A yellow oval-shaped fruit about the size of a potato that when ripe has a yellow, bumpy surface.<sup>26,27</sup> Noni has been used in folk medicine for over 2000 years<sup>28</sup> and also for its immune properties to treat infection.<sup>29</sup> There are anecdotal reports for successful use of noni to treat colds and influenza,<sup>26</sup> but FDA has warned several noni product manufacturers to stop making false claims related to noni product use, including that it treats, cures, or prevents various diseases.<sup>27</sup> Its uniquely purple, sweet juice is used in juice blends. Noni fruit is a good source of vitamins A and C, and is high in potassium.<sup>27</sup>

*scientific findings*

Noni was shown in laboratory studies to have antioxidant, immune-stimulating, tumor-fighting, anti-inflammatory, and antioxidative properties.<sup>29–31</sup>



*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Noni safety has not been adequately studied.<sup>30</sup> The juice has been linked to liver damage,<sup>25</sup> and its high potassium content contraindicates it for use by people on potassium-restricted diets.<sup>30</sup>

*Nori (Porphyra tenera)**definition*

Seaweed algae is a source of calcium, iron, iodine, magnesium, zinc, potassium, sodium, and the phytochemicals chlorophyll,  $\beta$ -carotene, and lutein.<sup>32,33</sup> Dried nori is commonly used as a seaweed wrap in making sushi-rice rolls. It is also consumed as a dried vegetable.

*scientific findings*

Raw nori contains vitamin B12; however, dried nori is not a reliable source of vitamin B12.<sup>34</sup> In a laboratory study, nori was antimutagenic.<sup>35</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Nut**definition*

High-protein food that is low in saturated fat, high in unsaturated fat, and a rich source of insoluble fiber.<sup>36</sup> At approximately 85 cal per 1/2 oz of mixed nuts, different nuts supply different nutrients and phytochemicals. Typically sold roasted and salted to make trail mixes and nut mixtures, and as nut butters.

*scientific findings*

Consuming 5 oz of any type of nut per week is associated with a reduced risk of congestive heart failure.<sup>37</sup>

*bioactive dose*

Not known.

*safety*

Allergies to nuts have been reported; however, they are presumed safe when consumed in normal dietary quantities by nonallergic individuals.

*Nutmeg (Myristica fragrans)*

Nutmeg. (Image from Diana Taliun/Shutterstock.)

*definition*

Ground seed of a tropical evergreen tree fruit. *M. fragrans* contains phenolics, such as myristicin, and terpenoids, such as elemicin.<sup>38</sup> Used to flavor eggnog, pumpkin pie, quiche, and other dishes. It has been used as an antifatulent effect and for nausea and diarrhea.

*scientific findings*

In laboratory studies, nutmeg showed antidiabetic properties, possibly due to improvements in insulin sensitivity,<sup>39</sup> insulin secretagogue action, and/or the ability to inhibit intestinal  $\alpha$ -glucosidase leading to a slower

postprandial glucose response.<sup>40</sup> Myristicin exhibited hepatoprotective effects in experimental research.<sup>41</sup> Elemicin was antimicrobial against the human enteropathogen *Campylobacter jejuni* in a laboratory study.<sup>42</sup>

### *bioactive dose*

Not known. The following doses have been used: for antifatulent effect, 0.03 mL nutmeg oil; for nausea, gastric upset, or chronic diarrhea, the common dose is 3–5 drops of the essential oil on a sugar lump or in honey; and for diarrhea, 4–6 tablespoons of the powder has been used daily.<sup>43</sup>

### *safety*

Presumed safe when used in normal dietary quantities by nonallergic individuals. Nutmeg significantly inhibited human cytochrome activity in a laboratory study.<sup>44</sup> In traditional medicines, *M. fragrans* may have been used in high doses as a hallucinogenic (over 2 tablespoons of nutmeg consumed at once)<sup>40</sup> and nutmeg seeds are abused because of the psychotropic effects that result after ingesting large doses,<sup>45</sup> which may also induce GI upset. Elemicin was found to be genotoxic in a laboratory study.<sup>46</sup>

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# O

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## *Oat (Avena sativa)*

### *definition*

Versatile whole grain that is commonly used as a hot breakfast cereal, used to make granola, or used in baking. A good source of soluble  $\beta$ -glucan fiber found in the endosperm cell walls of oats.<sup>1</sup> It also supplies the phytochemical avenanthramides.<sup>2</sup>

### *scientific findings*

According to a review, “Intact grains as well as a variety of processed oat and barley foods containing at least 4 g of  $\beta$ -glucan ... can significantly reduce postprandial blood glucose.”<sup>3</sup> At least 3 g of oat  $\beta$ -glucan consumed daily may reduce plasma total and LDL cholesterol levels by 5%–10% in normocholesterolemic or hypercholesterolemic subjects.<sup>1</sup> Consuming 56–150 g (1/4 cup to 2/3 cup<sup>4</sup>) contains approximately 3.6–10 g of  $\beta$ -glucan.<sup>5</sup>

### *bioactive dose*

A dose of 3–10 g/day of oat  $\beta$ -glucan reduces total cholesterol.<sup>6</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Recent research has suggested that only certain strains of oats produce adverse effects in people with celiac disease.<sup>7</sup> Most people with celiac disease can safely eat small amounts of oats, as long as the oats are not contaminated with wheat gluten during processing. People with celiac disease should work closely with their healthcare professional when deciding whether to include oats in their diet.<sup>8</sup>

## Okra (*Abelmoschus esculentus*)



Okra. (Image from Binh Thanh Bui/Shutterstock.)

### *definition*

Green, finger-shaped, antioxidant-rich vegetable,<sup>9</sup> the seeds and skin of which contain flavonols, hydroxycinnamic acid, and quercetin.<sup>10</sup> Mucilaginous fiber in okra imparts a slippery texture and enables its use as a thickening agent in foods. Okra is popular in Southern Creole and Indian cooking, and is eaten fresh, fried, grilled, and in stews.

### *scientific findings*

*A. esculentus* exhibited antidiabetic and antihyperlipidemic properties in diabetic rats.<sup>11</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities in non-allergic individuals.

## Olive (*Olea europaea* L.)

### *definition*

Marble-sized fruit that has been cultivated in warm climates for more than 7000 years.<sup>12</sup> Olives contain pectin and lipophilic phenolic compounds



such as flavonoids. Olive has been used in folk medicine to treat fever and malaria.<sup>12</sup> Usually brined, olives are eaten in salad, sandwiches, and in Mediterranean meals, as a vegetable side dish.

### *scientific findings*

The lipophilic phenolic compounds in olive “are known to possess multiple biological activities such as antioxidant, anticarcinogenic, anti-inflammatory, antimicrobial, antihypertensive, antidyslipidemic, cardio- tonic, laxative, and antiplatelet.”<sup>12</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Olive oil (O. europaea)*

### *definition*

Monounsaturated oil that is expressed from olives. It is the main fatty component of the Mediterranean diet and a key contributor to the beneficial effects of the Mediterranean diet.<sup>13,14</sup> Extra-virgin olive oil is a source of oleic acid and contains phenolic compounds, including hydroxytyrosol and oleuropein, which provide its characteristic flavor and high stability.<sup>15</sup> Olive oil is now popularly used in place of butter on breads and is used to manufacture numerous products including salad dressings, mayonnaise, and bread spreads.

### *scientific findings*

Olive oil phenolics are powerful antioxidants, both *in vitro* and *in vivo*.<sup>15</sup> An oleic-acid-rich diet in a small study (n = 11 type 2 diabetic subjects) reduced insulin resistance and restored endothelium-dependent vasodilatation, “suggesting an explanation for the anti-atherogenic benefits of a Mediterranean-type diet.”<sup>16</sup> There is limited but not conclusive evidence that suggests that consumers may reduce their risk of coronary heart disease if they consume monounsaturated fat from olive oil and olive oil-containing foods in place of foods high in saturated fat, while at the same time not increasing the total number of calories consumed daily.<sup>17</sup>

Olive oil normalized systolic pressure in hypertensive elderly, in a small clinical trial (n = 31 elderly patients with hypertension and n = 31 normotensive elderly patients) in which subjects consumed diets enriched in sunflower oil for 4 weeks, followed by a 4-week washout period, and then a diet enriched with virgin olive oil for 4 weeks.<sup>18</sup>

### *bioactive dose*

Eating about 2 tablespoons (23 g) of olive oil daily may reduce the risk of coronary heart disease when olive oil replaces a similar amount of saturated fat and does not increase total number of calories eaten in a day.<sup>17</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Omega-3 fatty acid*

### *definition*

Long-chain polyunsaturated fatty acid family that includes linolenic acid (also called  $\alpha$ -linolenic and linolenic acid), EPA, docosapentaenoic acid (DPA), and DHA. The first double bond in the fatty acid chain occurs on the third carbon atom from the end of the fatty acid chain. Linolenic acid must be consumed in the diet—the body cannot make it. Given linolenic acid, the body can make EPA and DHA.<sup>19</sup> Sources of linolenic acid include canola, soybean, and flaxseed oil; nuts such as walnuts; and vegetables such as soybeans. Sources of EPA and DHA include fish. Omega-3 fatty acids perform various physiologic functions, including the relaxation and contraction of muscles, blood clotting, digestion, fertility, cell division, growth, and the movement of calcium and other substances in and out of cells<sup>20</sup> and that have anti-inflammatory properties.<sup>21</sup> Omega-3 fatty acids increase bleeding time and decrease platelet aggregation, blood viscosity, and fibrinogen, thereby decreasing the potential for thrombus formation.<sup>5</sup>

### *scientific findings*

Omega-3 fatty acids reduce serum lipids and lipoproteins, impair platelet aggregation, increase cell membrane fluidity, and lower blood pressure in humans.<sup>22</sup> Omega-3 fatty acids reduce serum triglycerides among type II diabetics.<sup>23</sup> Fish consumption and various cardiovascular disease outcomes in 39 observational and clinical trials of at least 1 year in duration were reviewed, and it was concluded that “consumption of omega-3 fatty

acids from fish ... reduces all-cause mortality and various cardiovascular disease outcomes.”<sup>24</sup> Omega-3 fatty acids appear to have no effect upon most of the clinical outcomes in rheumatoid arthritis, although tender joint count may be reduced.<sup>23</sup> Data are insufficient to draw conclusions about omega-3 fatty acid intake and insulin resistance in type II diabetics, inflammatory bowel disease, renal disease, systemic lupus erythematosus, bone density, or fractures, or the requirement for anti-inflammatory or immunosuppressive drugs.<sup>23</sup> Strong evidence from meta-analyses suggests that omega-3-fatty acids improve bipolar depressive symptoms.<sup>25</sup>

### *bioactive dose*

The AI for linolenic acid is 1.6 g/day for men and 1.1 g/day for women aged 19–50. Scientists generally agree that people should consume fewer omega-6 fatty acids and more omega-3 fatty acids; however, the ideal ratio of omega-6s to omega-3s has not been determined. “For primary prevention of coronary heart disease, approximately 1.2–2 g per day from dietary sources seems to be associated with the greatest benefit; for secondary prevention of coronary heart disease, approximately 1.6 g per day as part of a Mediterranean diet appears to be beneficial.”<sup>5</sup> Fatty acid dosing is often determined based on percentage of daily calories. Some researchers suggest that linolenic acid should make up roughly 1% of daily calories. This comes to approximately 2 g based on a 2000 kcal diet.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Omega-6 fatty acid*

### *definition*

Long-chain polyunsaturated fatty acid family that includes linoleic acid. Linoleic acid is necessary for growth, and a dietary intake of 1%–2% of total calories as linoleic acid is sufficient to prevent EFA deficiency. Linoleic acid is the precursor of arachadonic acid, which in turn serves as a substrate for prostaglandin synthesis.<sup>26</sup> Sources of linoleic acid include soybean, safflower, sunflower or corn oils, nuts, and seeds.

### *scientific findings*

Consumption of omega-6 fatty acids in place of saturated fats and trans fats is associated with a decreased risk of coronary heart disease<sup>27</sup>; however,

a meta-analysis showed that “current evidence does not clearly support cardiovascular guidelines that encourage high consumption of polyunsaturated fatty acids and low consumption of total saturated fats.”<sup>28</sup>

U.S. dietary intake of omega-6 PUFA has been estimated to be 6%–8% of total energy intake.<sup>29</sup> A high ratio of dietary n-6 to n-3 PUFAs is being investigated for possible pro-inflammatory physiological effects.<sup>30</sup>

### *bioactive dose*

The AI for linoleic acid is 17 g/day for men aged 19–50 and 12 g/day for women aged 19–50.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Onion (Allium cepa)*

### *definition*

Popular bulb vegetable is a source of mineral sulfur and provides flavonoids, anthocyanins (that imparts a red or purple color to certain varieties), and flavonols such as quercetin, which is responsible for the yellow and brown skins of many other varieties.<sup>31</sup> Commonly used in fresh or cooked forms to add a pungent flavoring to all types of cuisines. Onion is used to treat cardiovascular disease in traditional medicine.<sup>32</sup>

### *scientific findings*

Onion exhibited the following properties in experimental studies: anti-platelet aggregatory, hypocholesterolemic, hypolipidemic, antihypertensive, antidiabetic, and antihyperhomocysteinemic effects, antimicrobial, antioxidant, anticarcinogenic, antimutagenic, antiasthmatic, immunomodulatory, and prebiotic effects,<sup>33–35</sup> but clinical trials examining these effects have not been performed. A case-control study (n = 760 patients with a first episode of nonfatal acute myocardial infarction; n = 682 controls) found that a diet rich in onions may have a favorable effect on the risk of acute myocardial infarction.<sup>35</sup> The Netherlands Cohort Study, a large-scale prospective cohort study on diet and cancer (n = 120,852 men and women, aged 55–69 years) did not find an association between the consumption of onions and leeks and the incidence of male and female

colon and rectum carcinoma, female breast cancer risk, or risk of lung carcinoma.<sup>36</sup>

### *bioactive dose*

Not known. A typical dose of onion is 50 g of fresh onion per day (approximately 4–5 tablespoons), but 50 g fresh onion juice and 20 g dried onion has also been used.<sup>5</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Orange, sweet (Citrus sinensis)*

### *definition*

More commonly known as the navel orange, this popular citrus fruit and its juice are excellent sources of vitamin C, good sources of folate and potassium, and contain numerous phytochemicals, including pectin and flavonoids.<sup>37</sup>

### *scientific findings*

Consuming commercial *C. sinensis* juice decreased blood pressure in a single-blind randomized crossover study (n = 22 healthy subjects 18–59 years old) in which subjects were randomly divided into two groups of 11, each consuming 500 mL/day of commercial orange juice twice a day for 4 weeks with breakfast and dinner, followed by a 2-week wash-out period, followed by natural orange juice for another 4 weeks dosed according to the same schedule. Commercial orange juice significantly reduced diastolic and systolic blood pressure, but natural orange juice did not have significant effects on either diastolic or systolic blood pressure, an effect that was attributed to the higher flavonoid, pectin, and essential oils content of commercial compared to natural orange juice.<sup>37</sup> Consuming 750 mL, but not of 250 or 500 mL, of orange juice daily, for 4 weeks, increased HDL cholesterol by 21% and decreased the LDL–HDL cholesterol ratio by 16% in hypercholesterolemic patients (n = 16 healthy men and 9 healthy women with elevated plasma total and LDL cholesterol and normal plasma triglycerides), while it also raised triglycerides by 30%.<sup>38</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Oregano (Origanum vulgare)**definition*

Culinary herb often used as an ingredient in soups, casseroles, sauces, stews, stuffing, and Italian dishes. Oregano has an earthy, oily, aromatic flavor, and contains numerous phytochemicals including phenolics, caffeic acid, and rosmarinic acid.<sup>39</sup>

*scientific findings*

In laboratory studies, oregano exhibited antifungal<sup>40</sup> and antioxidant<sup>41</sup> properties. Taking 200 mg of the emulsified oil of oregano orally three times daily for 6 weeks eradicated parasites in the stool of infected patients.<sup>5</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Oregano is thought to have abortifacient and emmenagogue effects and should therefore not be used by pregnant women.<sup>5</sup>

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# P

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## *Palm*

### *definition*

Vegetable harvested from the coconut (*Cocos nucifera*) palm tree.<sup>1</sup> Hearts of palm are sold canned in salt water and are eaten as a salad vegetable. It is high in sodium, but is also a good source of fiber, folate, vitamin C, and iron, and contains less than 1 g of fat, being equal parts saturated and polyunsaturated. Palm oil has been a major source of cooking oil in Asia and Africa.<sup>2</sup> Palm oil, a saturated, tropical oil, is a source of vitamin E.

### *scientific findings*

One cup of canned hearts of palm contains 4.5 g of nonheme iron whose absorption is increased by its vitamin C content (11.5 mg/19% DV).<sup>1</sup> Palm oil does not raise serum cholesterol levels and is not atherogenic, despite that it is a saturated fatty acid, according to a review.<sup>2</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Pantothenic acid*

### *definition*

B-vitamin that is found in all food groups, hence its name, “pantos,” the Greek word referring to “everywhere.” Rich sources include peanut butter, liver, kidney, peanuts, almonds, wheat bran, cheese, and lobster.<sup>3</sup> Although refining, cooking, canning, and freezing decrease the pantothenic acid

content of foods,<sup>3</sup> dietary intake from eating the average Western diet has been estimated to meet the RDA.<sup>4</sup>

### *scientific findings*

Pantothenic acid is a required coenzyme in fatty acid metabolism.<sup>4</sup> Pantothenic acid deficiency is uncommon but has been observed in patients who receive no pantothenic acid in their diet or who were given a pantothenic acid antagonist.<sup>4</sup> Signs and symptoms of pantothenic acid deficiency include irritability, restlessness, fatigue, apathy, malaise, sleep disturbances, nausea, vomiting, abdominal cramps, numbness, paresthesias, muscle cramps, a staggering gait, hypoglycemia, and an increased sensitivity to insulin.<sup>4</sup>

### *bioactive dose*

The AI is 5 mg/day for adults aged 19–50 years.

### *safety*

No UL has been established for pantothenic acid.

## *Papaya (Carica papaya L.)*

P



Papaya. (Image from Abramova Elena/Shutterstock.)

*definition*

Also known as paw-paw (also spelled pawpaw).<sup>5,6</sup> Large, oblong fruit with yellow-green skin that is approximately the size of a football. Papaya is eaten raw in fruit salads and sold as a canned fruit or used to make nectar. Papaya is sweet and has the texture of cantaloupe. One cup of papaya is an excellent source of vitamin C (83 mg, 138% DV), folate (54 µg, 13% DV), and vitamin A (1378 IU, 27% DV) and a good source of fiber (2.5 g, 10% DV) and potassium (264 mg; 7% DV).<sup>7</sup> Papaya is used in folk medicine for contraception,<sup>8</sup> though no scientific evidence supports this use.

*scientific findings*

Papaya suppressed inflammatory cytokines in the cells of human subjects (n = 12).<sup>9</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Paprika (Capsicum annuum)**definition*

Dried ground pods of the sweet red or chili pepper that adds earthy or spicy flavor and reddish-brown color to foods such as chili and barbeque sauce. Contains flavonoids and carotenoids, including β-carotene, lutein, and zeaxanthin.<sup>10,11</sup>

*scientific findings*

Paprika contains antioxidants and has demonstrated free-radical-scavenging ability in laboratory research.<sup>12</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Paprika may contain allergens.<sup>13</sup>

*Parsley (Petroselinum crispum)**definition*

Green culinary herb member of the Apiaceous Apiaceae family, which also includes carrots, parsnips, and celery. The flat-leaf variety is more favored for its flavor, whereas the curly variety is typically used as a garnish or as a main component of tabouleh, the Middle Eastern salad. Parsley is an excellent source of vitamin C and contains phytochemical constituents, including flavones.<sup>14</sup> It has been used in traditional medicine to stimulate menstruation.<sup>15</sup>

*scientific findings*

Flavones in parsley possess anti-inflammatory properties *in vitro* and in animal models.<sup>14</sup> Parsley and other apiaceous vegetables inhibited anticarcinogenic activity in laboratory research.<sup>16</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Adverse effects have been reported from consuming excessive amounts of parsley due to the apiole constituent; for example, 200 g of parsley (about the amount in 3.25 cups of parsley) have been associated with blood dyscrasias, kidney toxicity, and liver toxicities.<sup>15</sup> Components in parsley, including psoralen, bergapten, and xanthotoxin, can cause photosensitization (sensitivity to light).<sup>17</sup>

## *Passion fruit (Passiflora edulis)*



Passion fruit. (Image from Viktor Malyshchyts/Shutterstock.)

### *definition*

Also spelled passionfruit; also called granadilla. Small, purple-skinned fruit that is cut into halves to access its chewy, seed-filled sacs. Eaten fresh and used to make tropical juice blends. A source of terpenoids, flavonoids, and fiber.<sup>18</sup> Passion fruit is used as a folk medicine for its sedative and antihypertensive effects and for treating anxiety and nervousness.<sup>19</sup>

### *scientific findings*

In experimental research, *Passiflora edulis* pulp extract reduced total cholesterol in rats and increased their high-density lipoprotein.<sup>20</sup> In a laboratory study, aqueous extracts of *P. edulis* exhibited an anxiolytic-like activity.<sup>18</sup> Another laboratory study found that a triterpenoid constituent of *P. edulis* Sims possessed antidepressant-like activity in animals.<sup>19</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Peach (Prunus persica)*

### *definition*

Rosaceae family fruit, which also includes apples, nectarines, plums, pears, and strawberries. Peaches are a source of vitamin C and phytochemicals such as chlorogenic acid, phenolics, anthocyanins, and flavonoids.<sup>21,22</sup> When consumed whole, with the skin intact, peaches are a good source of fiber, with one large peach providing 2.6 g (10% DV) of fiber.<sup>23</sup> Peaches are also commonly consumed canned, dried, as fruit juice, and as nectar.

### *scientific findings*

Raw and canned peaches inhibited LDL oxidation *in vitro*.<sup>24</sup> A prospective case study (n = 75,929 women aged 38–63 years at baseline) examined the associations of specific fruits and vegetables with risk of estrogen receptor-negative breast cancer. Dietary data were collected seven times during a 24-year period. Consuming at least two servings of peaches/nectarines per week was associated with a lower risk of estrogen receptor-negative breast cancer among postmenopausal women compared with nonusers.<sup>25</sup> Chlorogenic acid protected cells from oxidative damage in a laboratory study.<sup>26</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. A European study showed that the iron, copper, lead, zinc, and tin contents of canned peaches increased over a 2-year period.<sup>27</sup>

## *Peanut (Arachis hypogaea)*

### *definition*

High-protein, high-monounsaturated fat legume that supplies vitamin E; it is also a source of phytochemicals, such as resveratrol.<sup>28</sup> Peanuts are



consumed roasted, made into peanut butter, and used in making peanut candy, often paired with chocolate, and other confections. Also used in Thai cooking in noodle-based dishes and on salads.

### *scientific findings*

There is moderate evidence that peanut and other nut consumption improved serum lipid levels.<sup>28</sup> At least five servings (28 g [1 oz] of nuts; or 16 g [1 tablespoon] of peanut butter) was significantly associated with a lower risk of cardiovascular disease (including lower total and LDL cholesterol and apolipoprotein-B-100 concentrations, no effect on HDL cholesterol, and no effect on inflammatory markers) in women with type 2 diabetes in an epidemiological study (n = 54,656 women with type 2 diabetes).<sup>29</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals, peanuts are among the most common foods to cause allergic reactions in children, adolescents, and adults.<sup>30</sup>

## *Pear (Pyrus communis)*

### *definition*

White-fleshed fruit that supplies approximately 5–6 g of fiber per medium pear,<sup>31</sup> making it an excellent source of fiber, and flavonoids, such as flavon-3-ols.<sup>32</sup> In addition to many varieties of pear that are consumed fresh, pears are sold canned, dehydrated, dried, and are used to make fruit juice drinks.

### *scientific findings*

In rodents, *Pyrus communis* exerted strong antioxidant activity and protective effects against ethanol- or hydrochloric acid-induced gastric ulcers.<sup>33</sup> Flavonols exert cardioprotective and anticarcinogenic properties *in vitro* and *in vivo*.<sup>34</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Pectin**definition*

Fermentable, water-soluble fiber found in grains, legumes, fruits, and vegetables. In foods such as okra, it imparts a unique, gel-like texture that is useful for thickening soups and stews. Pectin in cooked fruit gelatinizes to solidify jams and jellies; oat bran pectin is the viscous material in cooked oatmeal.

*scientific findings*

Pectin slows the transit of food through the upper GI tract<sup>35</sup> and stimulates epithelial growth within the colon, and thus has been used to manage diarrhea.<sup>36</sup> Pectin significantly reduced diarrhea in a small, double-blind clinical trial (n = 62 boys aged 5–12 months with persistent diarrhea [ $\geq 14$  days]) that randomly assigned subjects to receive a rice-based diet (n = 21); a rice-based diet with 250 g/L of cooked green banana (n = 22); or a rice-based diet with 4 g/kg of pectin (n = 19) for 7 days. Diarrhea significantly improved in the pectin-supplemented and banana groups compared to the rice-only group.<sup>37</sup> Possible mechanisms for pectin to maintain normal stool consistency include that fiber is fermented by anaerobic colonic flora (which constitute the bulk of fecal matter); a lack of dietary fiber may suppress normal colonic metabolism, thereby impairing stool formation/promoting diarrhea; and/or that pectin stimulates epithelial growth in the colon to reduce diarrhea.<sup>38</sup> Pectin, like other soluble fibers, binds bile acids and cholesterol in the small intestine, thereby helping to reduce serum cholesterol.<sup>39</sup>

*bioactive dose*

The recommended dose used to decrease total cholesterol and triglyceride levels is 15–20 g of pectin daily.<sup>36</sup> For persistent diarrhea in children, 4 g/kg of body weight per day of pectin fiber has been used.<sup>15</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Pepper, sweet bell (*Capsicum annuum* L.)

### definition

Popular salad vegetable that is a good source of vitamins A, C, and E, and provides polyphenols.<sup>40</sup> There are many different cultivars, including green, yellow, orange, and purple bell peppers.

### scientific findings

Epidemiology suggests that polyphenols exert cardioprotective effects and laboratory studies suggest that polyphenols exert antioxidant, vasodilatory, anti-inflammatory, antifibrotic, antiapoptotic, and metabolic effects.<sup>41</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed by nonallergic individuals in normal dietary quantities.

## Pepper, chili (*Capsicum frutescens*, *Capsicum annuum*)

### definition

Also spelled chile pepper. Fruit<sup>42</sup> containing pungent compounds, such as capsaicin, that produces a burning sensation upon contact with the skin. *Capsicum annuum* is dried and ground and used to make cayenne pepper. Jalapeño peppers, also called jalapeño chilies, is a variety of *Capsicum frutescens*, that is an excellent source of vitamin C.<sup>43</sup> Different cultivars of chili pepper contain different phytochemicals by color, for example, red habanero peppers contain  $\beta$ -carotene; green serrano and jalapeño peppers contain capsanthin, yellow habanero and Scotch Bonnet peppers contain lutein, and  $\alpha$ - and  $\beta$ -carotene, and orange habanero contain antheraxanthin, capsanthin, and xeaxanthin.<sup>44</sup> Native Americans rubbed their gums with pepper pods to relieve toothache.<sup>45</sup> Chili pepper is used as an herbal medicine to treat microbial infection.<sup>46</sup>

### scientific findings

Extracts from fresh *C. frutescens* exhibited antimicrobial effects against *Bacillus cereus*, *Bacillus subtilis*, *Clostridium sporogenes*, *Clostridium tetani*, and *Streptococcus pyogenes* in a laboratory study.<sup>46</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Chili pepper consumption may induce liver carcinoma in the rat.<sup>47</sup> Dermatitis can sometimes occur in breast-fed infants when mothers ingest foods heavily spiced with capsicum peppers.<sup>15</sup>

*Peppermint (Mentha × piperita)**definition*

A cross between water mint (also spelled watermint) and spearmint that contains a menthol constituent<sup>48</sup> thought to be responsible for its sweet fragrance and cooling sensation. When its leaves are finely shredded, it is used as a culinary herb to flavor meat dishes and vegetable or fruit salads. It is also used fresh or dried to make teas, candies, and chewing gum. Peppermint oil is widely used as a spasmolytic agent in irritable bowel syndrome (IBS).<sup>49</sup>

*scientific findings*

Peppermint oil is antispasmodic due to its calcium channel blocking activity of intestinal smooth muscle.<sup>48</sup> Menthol reduces intestinal motility in animal studies.<sup>49</sup> Peppermint oil improved the symptoms of IBS in clinical trials, and is “likely effective” for IBS.<sup>15,50</sup> In one small randomized, crossover-design clinical trial (n = 26 healthy volunteers) intragastric pressure and motility were improved in healthy volunteers after oral administration of peppermint oil compared to placebo.<sup>49</sup> A prospective, double-blind, placebo-controlled study (n = 74) randomized IBS patients to receive either peppermint oil or placebo three times daily for six weeks, finding that “at six weeks of therapy, abdominal pain ... markedly improved ... in [the] peppermint oil group compared with ... [the] placebo group and the difference was statistically highly significant.”<sup>48</sup> A third study showed “significant improvement in pain after three weeks treatment with peppermint oil compared to placebo, but after six weeks, there were no differences between treatment and placebo groups.”<sup>15</sup>

*bioactive dose*

Not known. For irritable bowel syndrome (IBS), the usual medicinal dose is “1–2 capsules three times daily of enteric coated peppermint oil. Each capsule provides approximately 0.2 mL of peppermint oil or 180–225 mg peppermint oil.”

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Peppermint may aggravate heartburn, presumably by its direct effects upon sensory neurons.<sup>50</sup>

### *Persimmon (Diospyros kaki)*



Persimmon. (Image from EM Arts/Shutterstock.)

### *definition*

Strong-flavored fruit whose phytochemical content is responsible for its characteristic mouth and aftertaste. It resembles a small orange tomato in appearance (color, firmness, and the calyx or stem at the top center of the fruit), and it is typically most palatable when ripe. Unripe persimmon is strongly astringent. Persimmon is a source of dietary fiber and polyphenols.<sup>51</sup>

### *scientific findings*

Tannin in persimmon bound bile acids *in vitro*.<sup>52</sup> Both fresh and dried persimmon possess high contents of bioactive compounds and have a high antioxidant potential and free-radical scavenging capacity.<sup>51</sup>

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Consumption of persimmons, particularly unpeeled persimmons, has been associated with the development of bezoars (a concretion formed in the alimentary canal from plant fibers); a case report of 15 patients cautioned that patients who have undergone ulcer surgery should avoid unpeeled persimmons.<sup>53</sup>

*Phenolic compounds**definition*

Phytochemicals, such as phenolic lipids and phenolic acids, that include chlorogenic acid, hesperidin, kaempferol, luteolin, myricetin, naringenin, *p*-coumaric acid, rosmarinic acid, and quercetin. Phenolic compounds found in herbs include rosmarinic acid in thyme, rosemary, and oregano. Phenolic compounds are also found in coffee beans and coffee, fruits (apples, blueberries, cherries, grapes, oranges, prunes, pears, and strawberries), oats, potatoes, soybeans, and wine.<sup>54</sup>

*scientific findings*

Phenolic compounds have exerted antioxidant, anti-inflammatory, and antimicrobial effects in laboratory studies.<sup>55–58</sup> Epidemiological studies suggest that the consumption of fruits and vegetables is associated with a reduced incidence of cardiovascular disease, diabetes, cancer, and stroke. The disease-protective effects are due, in part, to phenolic compounds.<sup>57</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Phloretin**definition*

Flavonoid found in plant foods such as apples and citrus fruits.<sup>59</sup>

*scientific findings*

Shown to exert antioxidant properties *in vitro*.<sup>60</sup> Phloretin exerted a chemoprotective activity against the carcinogen aflatoxin B in a laboratory study.<sup>61</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Phosphorus**definition*

Mineral that is involved in energy transfer during energy metabolism, is a component of hydroxyapatite crystal of bone, is part of cellular phospholipid membranes, and is involved in numerous body-wide functions, such as maintaining normal pH.<sup>62</sup> Found in abundance in high-protein foods, such as meat, fish, poultry, eggs, and milk. Phosphate salts are also common food additives; for example, as the acidulant phosphoric acid in some soda beverage products.<sup>62</sup> Phosphorus is actually so ubiquitous in foods that nearly total starvation is required to produce a phosphorus deficiency, and phosphorus intake from the average American diet is typically higher than the RDA.<sup>62</sup>

P

*scientific findings*

Phosphorus deficiency resulting in hypophosphatemia causes cellular dysfunction, symptoms of which include anorexia, anemia, muscle weakness, bone pain, rickets, osteomalacia, general debility, increased susceptibility to infection, paresthesias, ataxia, confusion, and even death.<sup>62</sup>

*bioactive dose*

The RDA for adults is 700 mg/day.

*safety*

The UL for adults is 4 g/day.

## *Phytate (Phytic acid)*

### *definition*

Primary storage compound of phosphorus in seeds.<sup>63</sup> It binds to calcium, iron, potassium, magnesium, manganese, and zinc in the gut and renders them inabsorbable.<sup>63,64</sup> Phytates are found in legumes, seeds, and the husks of whole grains.

### *scientific findings*

Phytic acid is an antioxidant.<sup>65</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Diets that provide >40 g of fiber per day may contain phytate levels that adversely impact the absorption of minerals.<sup>54</sup>

## *Phytoestrogen*

### *definition*

Phenolic compound that can exert estrogenic and antiestrogenic properties.<sup>66</sup> When circulating estrogen level is low, phytoestrogens are thought to become estrogenic; when circulating estrogen level is high, phytoestrogens are thought to become antiestrogenic.<sup>67</sup> Sources of phytoestrogens include whole grains, fruits, vegetables, such as alfalfa, anise, pumpkin seeds, and soy products such as soybeans, soy flour, soymilk, tofu, and textured vegetable protein made from soybeans, with soy foods being the richest food sources.<sup>54,66,68</sup>

### *scientific findings*

A meta-analysis found that phytoestrogens appear to reduce the frequency of hot flashes (hot flushes) in perimenopausal or postmenopausal women experiencing menopausal symptoms, though authors stated the data were inconclusive.<sup>67</sup> Another meta-analysis found that “No conclusive evidence shows that phytoestrogen supplements effectively reduce the frequency or severity of hot flashes and night sweats in perimenopausal or postmenopausal women.”<sup>69</sup> A meta-analysis of observational



studies showed higher phytoestrogen intake from foods (dietary supplements were excluded) was associated with a reduced ovarian cancer risk.<sup>70</sup>

#### *bioactive dose*

Not known.

#### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Estrogenic adverse effects may occur as a result of consuming phytoestrogens. Estrogen-like effects seem to be infrequent and increase with long-term therapy.<sup>71</sup>

### *Pineapple (Ananas comosus)*

#### *definition*

Yellow, fibrous-fleshed, juicy tropical fruit of the Bromeliaceae family. It is consumed fresh, canned, and as juice. An excellent source of vitamin C, pineapple supplies vitamin A, and all B vitamins except vitamin B12.<sup>72</sup> Pineapple is a natural source of the plant protease bromelain that is used orally as an anti-inflammatory agent.<sup>73</sup> Pineapple is a source of papain, a proteolytic enzyme.

#### *scientific findings*

In an animal study, pineapple juice significantly decreased plasma triglycerides and delayed gastric emptying.<sup>74</sup> *In vitro* and *in vivo* studies demonstrate that bromelain exhibits various fibrinolytic, antiedematous, antithrombotic, and anti-inflammatory activities,<sup>75</sup> but that there is insufficient evidence to rate its effectiveness for anti-inflammation or other uses in humans.<sup>76</sup> Bromelain also contains chemicals that interfere with the growth of tumor cells and slow blood clotting.<sup>76</sup> Bromelain and papain enhance bioflavonoid absorption.<sup>77</sup>

#### *bioactive dose*

Not known.

#### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Pistachio (Pistacia vera)**definition*

Small tree nut eaten raw or roasted that is a source of protein, monounsaturated fatty acid, vitamin E, and the antioxidant lutein. Antioxidant levels are higher in raw pistachios than in roasted pistachios and in natural shells versus in chemically bleached shells.<sup>78</sup>

*scientific findings*

As part of an antiatherogenic diet, pistachios may contribute to a reduction in serum oxidized-LDL.<sup>79</sup> A meta-analysis of 21 randomized, controlled trials, conducted to evaluate the effect of nut consumption on blood pressure in adult populations aged  $\geq 18$  years, found that total nut consumption lowered systolic blood pressure in participants without type 2 diabetes, and that pistachios had the strongest impact on reducing systolic and diastolic blood pressure compared to other types of nuts.<sup>80</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergies to pistachio nuts have been reported. A case report of exercise-induced anaphylaxis to pistachio consumed 1/2 h prior to exercise has been reported.<sup>81</sup>

*Plantain (Musa  $\times$  paradisiaca)**definition*

Starchy, green-skinned, banana-like fruit whose skin turns yellow when ripe. It supplies 65 g of carbohydrate per 1 cup; in addition, it is an excellent source of vitamin A (2227 IU; 45% DV), magnesium (76 mg of magnesium, 19% DV), and potassium (857 mg; 24% DV), and a good source of vitamin E (2.79 mg of vitamin E, 9% DV)<sup>82</sup> in addition to providing fiber and flavonoids. Ripe plantains are typically cooked by slicing and frying, but are not eaten raw.

*scientific findings*

In a clinical trial (n = 80 hospitalized children ranging in age from 1 to 28 months, who had experienced  $> \text{or} = 14$  days of persistent diarrhea),

the experimental group (n = 40) was given a cooked green plantain-based diet; a control group was given a yogurt-based diet. The average duration of diarrhea in the plantain-based diet group was 18 h shorter (significantly different than the yogurt group).<sup>83</sup> Leucocyanidin, a flavonoid having antiulcer properties, has been identified in plantain.<sup>84</sup> A laboratory study found that plantain soluble fiber prevented *Escherichia coli* translocation in intestinal cells, which may have implications in preventing Crohn's disease symptoms.<sup>85</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Plum (Prunus domestica)*

### *definition*

Stone fruit that has been cultivated since ancient times. Its different cultivars (including red, purple, yellow, and green varieties) vary in size and nutrient and phytochemical composition. Commonly eaten fresh, dried (as dried plums or prunes), canned, and as part of processed foods, such as baby food. An average, 2"-diameter fresh plum supplies approximately 7.5 g of carbohydrate and 1 g of fiber, in addition to vitamin C, vitamin E,  $\beta$ -carotene, and phytochemicals such as phenolics, quercetin, myrecitin, and kaempferol.<sup>86–88</sup> An analysis of yellow plums found conventional plums to be higher in quercetin than organic plums, but organic plums to be higher in myrecitin and kaempferol than conventional plums.<sup>88</sup> Dried plums/prunes and prune juice are traditionally consumed to relieve constipation. A 100-g serving (10 dried plums or 3/4 cups) of dried plums provides approximately 6.1 g of dietary fiber, 2–3 mg of boron, and 745 mg of potassium,<sup>89,90</sup> making them a good source of fiber and an excellent source of potassium.

### *scientific findings*

Eating 100 g (approximately 3/4 cup) of dried plum for 3 months significantly reduced serum levels of C-reactive protein in a small clinical trial (n = 160 postmenopausal women).<sup>91</sup> Dried plums and prune juice are high

in sorbitol (14.7 g and 6.1 g/100 g, respectively), which is a laxative,<sup>89</sup> but soluble and insoluble fiber also promote laxation, the former by retaining water in stool, the latter by providing bulk. Sorbitol is an effective osmotic laxative.<sup>92</sup> In an 8-week, single-blind, randomized crossover study (n = 40 constipated subjects, mean age 38), dried plums (50 g twice a day providing 6 g fiber/day) were found to be more effective than psyllium (11 g twice a day providing 6 g fiber/day) for the treatment of mild to moderate constipation.<sup>93</sup> A laboratory analysis found that phenolic compounds in prunes, pitted prunes, and prune juice inhibited LDL oxidation *in vitro*.<sup>94</sup> Eating dried prunes may improve bone mineral density possibly due to their high boron concentration.<sup>89</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. A sudden increase in the amount of fiber eaten can cause gastrointestinal distress. Adding high-fiber foods to the diet gradually with sufficient amounts of water is recommended.

## *Polyunsaturated fatty acids*

### *definition*

Oils that include omega-3-fatty acids (n-3) in plants and fish, and omega-6 fatty acids (n-6) in plants. Polyunsaturated fatty acids (PUFAs) are long-chained fatty acids that contain more than one double bond and are liquid at room temperature.

### *scientific findings*

PUFAs are necessary for brain function and must be consumed in the diet to prevent deficiency of essential fatty acids. Essential fatty acid deficiency is characterized by growth, skin, and other abnormalities. Clinical studies suggest that children with attention deficit hyperactivity disorder have lower PLASMA levels of essential fatty acids.<sup>15</sup> Dietary n-6 PUFAs are associated with improved blood lipids related to cardiovascular disease, in particular when PUFAs replace saturated fatty acids (SFA) and/or trans fatty acids.<sup>95</sup> Energy replacement of SFA with PUFA decreases total cholesterol, LDL cholesterol, and triglycerides, as well as numerous

markers of inflammation.<sup>95</sup> PUFA intake significantly decreases risk of cardiovascular disease and has also been shown to decrease the risk of type 2 diabetes.<sup>95</sup> Meta-analyses of randomized, clinical trials found no beneficial effects of LCPUFA supplementation on the physical, visual, and neurodevelopmental outcomes of infants born at term.<sup>96</sup>

### *bioactive dose*

There is no RDA for PUFA *per se*. Omega-3 fatty acid (also called linolenic acid) and omega-6 fatty acid (linoleic acid) each have specific RDAs—see *omega-3 and omega-6 fatty acid*. A dietary intake of 1%–2% of total calories as linoleic acid is sufficient to prevent EFA deficiency; whereas 2%–4% is needed to reverse EFA deficiency.<sup>97</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Pomegranate (Punica granatum)*

### *definition*

Orange-sized fruit that has red, leathery skin and contains sacs filled with hundreds of edible seeds encased in juicy red pulp. Pomegranate is high in vitamin C and fiber as well as phytochemicals, including ellagic acid, ellagitannins, punical acid, anthocyanidins, anthocyanins, estrogenic flavonols, and flavonoids.<sup>98</sup> In traditional medicine, *Punica granatum* has been used as an antiatherogenic, antidiarrheal, and as a treatment for parasitic and microbial infections, ulcers, apthae (mouth inflammations), hemorrhage, and respiratory complications.<sup>98</sup>

### *scientific findings*

Pomegranate constituents, such as ellagic acid, exerted antioxidant properties in experimental research.<sup>98</sup> Drinking pomegranate juice does not seem to relieve symptoms or improve breathing in individuals with chronic obstructive pulmonary disease.<sup>15</sup> There is insufficient evidence to evaluate its use in treating other health conditions for which it has been studied or used, including hyperlipidemia; hypertension, atherosclerosis, gum disease, prostate cancer, coronary stenosis, intestinal worm infestation, obesity, fungal mouth infection, diarrhea, dysentery, sore throat, hemorrhoids, or menopausal symptoms.<sup>15</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Potassium**definition*

Main intracellular mineral required for the maintenance of pH balance, blood pressure, and general cellular function.<sup>99</sup> Sources of potassium include fresh foods of all kinds, especially fresh fruits (apricots, dates, bananas), fresh vegetables, soybeans, and dairy products. The average American diet does not meet daily potassium recommendations.<sup>99</sup>

*scientific findings*

Potassium deficiency affects neural transmission, muscle contraction, blood pressure, and vascular tone.<sup>99</sup> Dietary potassium has significantly lowered blood pressure in both hypertensive and nonhypertensive patients in observational studies, clinical trials, and several meta-analyses.<sup>100</sup> Epidemiologic studies and randomized controlled trials have shown an inverse relationship between fruit and vegetable intake and blood pressure. "The antihypertensive effect of potassium ... appears to occur through several mechanisms that include regulation of vascular sensitivity to catecholamines, promotion of natriuresis, limiting plasma renin activity, and improving endothelial function."<sup>101</sup> Consuming potassium from dietary sources seems to decrease the risk of stroke.<sup>15</sup>

*bioactive dose*

The AI for adults is 4700 mg/day. Foods that provide at least 350 mg of potassium per serving and that are low in sodium, saturated fat, and cholesterol might help reduce the risk of developing high blood pressure.<sup>15</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Potato, sweet (*Ipomoea batatas*)



Sweet potato. (Image from Jiang Hongyan/Shutterstock.)

### *definition*

Orange- or yellow-fleshed root vegetable, commonly prepared by steaming, baking, boiling, or frying. One cup of baked sweet potato with its skin is an excellent source of potassium, supplying 950 mg of potassium (30% DV), and, if the skin is consumed, it is a good source of fiber<sup>102</sup>; also a source of phenolics and flavonoids.<sup>103</sup> One baked sweet potato provides over 8800 IU of vitamin A (176% DV) and 141 calories, is rich in complex carbohydrates including fiber, is an excellent source of vitamin C, and is a good source of iron and fiber.<sup>104</sup>

### *scientific findings*

Constituents in sweet potato exerted antioxidant, antiradical, and antiproliferative effects in laboratory studies.<sup>103</sup> In one study, antioxidant activity was directly related to the total amount of phenolics and flavonoids in sweet potato.<sup>103</sup> Eating potassium-rich foods as part of an overall healthy diet helps maintain normal blood pressure.<sup>105</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Potato, white (Solanum tuberosum)*

### *definition*

Tuber vegetable rich in carbohydrate, resistant starch, vitamin C, potassium, and, when its skin is consumed, fiber. It is commonly eaten boiled, fried, baked, and roasted and is the most important food crop worldwide after rice and wheat.<sup>106</sup> Some of the phytochemicals in white potatoes include glycoalkaloids (which can exert beneficial or harmful effects), aglycones, and phenolic compounds.<sup>107,108</sup>

### *scientific findings*

There is no evidence that the popular white potato protects against cancer.<sup>109</sup> Potassium and dietary fiber have been designated as food components to consume in greater quantity by the 2010 Dietary Guidelines for Americans—potato has them both.<sup>110</sup> The glycoalkaloids in potato inhibited growth of human colon and liver cancer cells.<sup>111</sup> In laboratory studies, solanine, a glycoalkaloid, was found to possess anticarcinogenic and anti-prostate-cancer effects,<sup>112,113</sup> but solanine should not be consumed (see safety section below). Potato peel contains phenolics that exert antioxidant effects.<sup>114</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals after cooking and after removing the green layer under the skin and the sprouts (small white shoots that grow out of the eye of the potato) to remove solanine. Solanine is a gastrointestinal and neurological toxin.<sup>115</sup>

## *Prebiotic*

### *definition*

Nondigestible dietary constituent that selectively stimulates the growth and/or activity of beneficial microorganisms in the large intestine. Inulin and fructan (from chicory root), galactooligosaccharides (from lactose), and pyrodextrins (from potato and maize starch) are examples of prebiotic compounds.<sup>116</sup>



*scientific findings*

Prebiotics beneficially modify gut microbial balance.<sup>115</sup> Some evidence suggests that [prebiotics] may relieve constipation by increasing fecal mass, but more evidence is needed to rate [prebiotics] for this use.<sup>15</sup>

*bioactive dose*

Not known. For prebiotic effect (to increase fecal bifidobacteria), the typical dose is 4 to 10 grams per day.<sup>15</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Overconsumption of prebiotics could cause intestinal discomfort.<sup>117</sup>

*Prickly pear (Opuntia sp.)*



Prickly pear. (Image from Glenn Price/Shutterstock.)

*definition*

Edible type of cactus eaten fresh without the skin that may be red, purple, yellow, white, or other colors depending upon the cultivar. The flesh is the texture of a common pear, but less juicy. The seeds are large, hard, and difficult to separate from the flesh.<sup>118</sup> Prickly pear contains vitamin C,

fiber, flavonoids, and carotenoids.<sup>119</sup> In Mexico, the prickly pear cultivar *Opuntia streptacantha* is traditionally used in the treatment of diabetes mellitus.<sup>120</sup>

### *scientific findings*

Prickly pear contains betalain that exhibited antioxidant properties in a laboratory study.<sup>118</sup> Prickly pear pectin decreased plasma LDL in guinea pigs fed a hypercholesterolemic diet.<sup>121</sup> According to a review, there is some preliminary clinical evidence that a single dose of the specific species of prickly pear cactus called *O. streptacantha* can decrease blood glucose levels by 17%–46% in patients with type 2 diabetes, but it is not known whether extended daily use can consistently lower blood glucose levels and decrease HbA1C levels.<sup>15</sup> *O. streptacantha* juice was confirmed by maltose tolerance test to be an antihyperglycemic agent.<sup>119</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Probiotics*

### *definition*

Live microorganisms (in most cases, bacteria) that are similar to beneficial microorganisms found in the human gut.<sup>122</sup> When consumed in adequate amounts they may confer a health benefit to the host.<sup>122,123</sup> For example, *Bifidobacteria* may help to “balance disturbed intestinal microflora and related dysfunction of the human gastrointestinal tract.”<sup>124</sup> Some probiotic foods date back to ancient times, such as fermented foods and cultured milk products.<sup>122</sup> *Lactobacillus* in Greek yogurts labeled “fermented with *lactobacillus*,” *Saccharomyces* in beer, and *Bifidobacteria* in kimchi (fermented, spicy Korean cabbage), sourdough bread, kefir, and miso<sup>15</sup> are common examples of foods that contain probiotics. Probiotics are used to: treat diarrhea from rotavirus and diarrhea generally, prevent and treat female genitourinary tract infections, treat IBS, shorten *Clostridium difficile* intestinal infections, prevent and treat pouchitis following surgical removal of the colon, and prevent and manage atopic dermatitis (eczema) in children.<sup>124</sup>

*scientific findings*

The mechanisms of action of probiotic bacteria include that they produce butyric acid that neutralizes the activity of dietary carcinogens; attach to enterocytes thus inhibiting the binding of enteric pathogens; and promote the growth of beneficial microorganisms in the gastrointestinal tract.<sup>123</sup> In clinical trials examining the benefit of probiotics, findings were that the beneficial effect was usually low [and] ... a strong placebo effect often occurs<sup>15</sup>; moreover, researchers concluded, "the human body can respond differently to the different species and strains of probiotics."<sup>125</sup> There is limited experimental evidence that certain bifidobacteria may protect the host from carcinogenic activity of intestinal flora,<sup>15</sup> but there is no evidence to support or refute the relationship between a patient's intake of probiotics and reduction of cancer symptoms.<sup>126</sup> There is limited evidence supporting some uses of probiotics. Much more scientific knowledge is needed about probiotics, including about their safety and appropriate use.<sup>122</sup>

*bioactive dose*

Not known.

*safety*

A probiotic review reported that there is a general lack of adverse event found in probiotic intervention studies, and that "the current literature is not well equipped to answer questions on the safety of probiotic interventions with confidence."<sup>122</sup> *Bifidobacteria* sourced from food are considered to have low pathogenic potential, and are an "extremely rare" cause of infection in humans; and the lack of pathogenicity appears to extend across all age groups and to immunocompromised individuals<sup>123</sup>; however, "there is insufficient reliable information available to evaluate their safe use in pregnancy or lactation."<sup>124</sup>

*Protease inhibitors**definition*

Proteins in plants that are thought to respond to the attack of insects and pathogenic microorganisms,<sup>127</sup> but that may also impart health benefits to the host when consumed. Found in soy products, broccoli, sprouts, potatoes, and legumes.<sup>54</sup>

*scientific findings*

Protease inhibitors suppressed enzyme production in cancer, slowed tumor growth, inhibited hormone binding, and inhibited malignant changes in cells in an experimental study.<sup>127</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Protein**definition*

Macronutrient whose constituent amino acids are preferentially used to manufacture protein compounds, but which can also be metabolized as a source of energy. All food groups except fruit and oils provide appreciable amounts of protein. Dairy products provide 8 g of protein per 8 oz of milk; protein foods provide 7 g of protein per 1/4 cup of legumes or tofu, 1 egg, 1/2 oz nuts or seeds, 1 tablespoon of peanut butter, or 1 oz of lean cooked meat, poultry, or fish. Grains provide 3 g of protein per 1 slice of bread or 1 cup of cereal. Cooked vegetables provide 2 g of protein per 1 cup of cooked vegetables or 2 cups of raw, leafy salad vegetables. Average healthy Americans exceed their protein RDA.

*scientific findings*

Protein consumption has minimal influence on glycemic response and insulin requirement.<sup>128</sup> Patients who are malnourished or who are in active disease states generally have higher protein requirements than healthy people.<sup>129</sup> Protein malnutrition is associated with the loss of lean body mass.<sup>128</sup> Protein undernutrition was associated with an increased risk of cataract in a population-based study (n = 2584 subject aged 60–95 years).<sup>130</sup>

*bioactive dose*

The RDA for protein for healthy adults aged 19–50 years is 0.8 g/kg/day.

*safety*

No UL for protein has been established.

*Psyllium (Plantago ovate)**definition*

Seed husk of the herb *Plantago ovate*. Psyllium seed husk is made into cereals and is a chief ingredient in bulk laxatives. Psyllium seed husk contains soluble fiber.

*scientific findings*

Psyllium is an effective laxative and stool softener<sup>131</sup> that may be effective in relieving the symptoms of IBS, including diarrhea; reducing high blood glucose levels in individuals with type 1 and 2 diabetes (but not in individuals who do not have diabetes); reducing cholesterol in individuals with diabetes who also have high cholesterol; reducing high systolic blood pressure; and managing ulcerative colitis, dysentery, and hemorrhoids.<sup>131</sup> Small clinical trials have shown psyllium fiber to be associated with lower mean daily glucose concentrations, lower postmeal glucose concentrations, fewer hypoglycemic events, lower hemoglobin A1C levels, and lower insulin concentrations in people with diabetes mellitus.<sup>132</sup> Psyllium seems to reduce total and LDL cholesterol, and the LDL-to-HDL ratio.<sup>15</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Not consuming enough fluid when taking psyllium could lead to choking or obstruction of the esophagus or bowel.<sup>131</sup> Since fiber can speed GI tract transit time and thus limit absorption, psyllium should not be taken within 2 h of many orally administered medications.<sup>133</sup>

*Pummelo (Citrus grandis)**definition*

Largest citrus family member, weighing two to three pounds on average, resembling an oversized grapefruit but with thicker, loose-fitting skin. Its segments are white- or red-fleshed. Pummelos are excellent sources of vitamin C<sup>134</sup> and a source of flavonoids.

*scientific findings*

Fresh red pummelo juice is an excellent source of antioxidant compounds that in a laboratory study scavenged superoxide anion free radicals and hydrogen peroxide radicals.<sup>134</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Pumpkin (Cucurbita pepo)**definition*

Squash family vegetable that is notably rich in carotenoids and therefore an excellent source of vitamin A (7050 IU per 1/2 cup = 140% DV).<sup>135</sup> Common in baked products, such as muffins and pie.

*scientific findings*

**P** A review examining natural treatments for benign prostatic hypertrophy found no convincing evidence to support the use of *Curcubita pepo* alone for its treatment.<sup>136</sup> In experimental research, pumpkin exhibited moderate antioxidant activity and moderate to high  $\alpha$ -glucosidase and angiotensin-converting enzyme inhibitory activities<sup>137</sup> *in vitro*, which may have implications for the management of hyperglycemia and hypertension. Pumpkin consumption was inversely associated with the development of lung cancer in a case-control study comparing the dietary patterns of subjects with incident lung cancer (n = 371) to controls (n = 496); neither cases nor controls had a neoplastic history.<sup>138</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Pumpkin seed*



Pumpkin seeds. (Image from Olga Popova/Shutterstock.)

### *definition*

Edible seed of pumpkin (*C. pepo*) when roasted. Pumpkin seeds are a good source of calcium, potassium, magnesium, iron, zinc, and B-vitamins,<sup>139</sup> and contain phosphorus.<sup>140</sup> Pumpkin seeds are also a good source of the  $\gamma$ -tocopherol form of vitamin E<sup>141</sup> and provide selenium.<sup>139</sup>

### *scientific findings*

In a small study (n = 20 boys aged 2–7 years), pumpkin seed treatment as compared with treatment with orthophosphate (the control compound) reduced calcium oxalate bladder stone formation.<sup>139</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# Q

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## *Quercetin*

### *definition*

Major flavonoid in the U.S. diet consumed in daily amounts estimated to be 4 or 5  $\mu\text{g}$ <sup>1</sup> through plant foods, especially white fruits and vegetables, such as apples, pears, and onions, but diversely in plant foods of all colors ranging from lolla rosa lettuce and plums to tea, red wine to quinoa.

### *scientific findings*

In experimental research, quercetin reduced inflammation.<sup>2</sup> Quercetin appears to have anti-inflammatory and antioxidant properties.<sup>2</sup> It has been shown, in experimental research, to modify eicosanoid biosynthesis; protect LDL from oxidation; prevent platelet aggregation; relax cardiovascular smooth muscle, which may have antihypertensive and antiarrhythmic effects; and to exert antiviral and carcinostatic properties.<sup>3</sup> Quercetin provided relief of pelvic pain in men with prostatitis ( $n = 30$ ) taking quercetin 500 mg twice daily for 1 month in a randomized, controlled, clinical trial compared to men taking placebo. In an additional, open-label arm of the study, 17 more prostatitis subjects had significant symptom relief due to quercetin.<sup>4</sup> Epidemiologic studies have reported that frequent consumption of quercetin-rich foods is inversely associated with lung cancer incidence.<sup>1</sup> A case-control study ( $n = 558$  lung cancer cases;  $n = 837$  controls) found that lung cancer was inversely associated with the consumption of quercetin.<sup>1</sup> In a case-control study of 582 patients with incident lung cancer and 582 age-, sex-, and ethnicity-matched control subjects, a statistically significant inverse association was found between lung cancer risk and eating foods containing quercetin.<sup>1</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Quince (*Cydonia oblonga*)



Quince. (Image from Elena Elisseeva/Shutterstock.)

### *definition*

Fruit closely related to apples and pears that is not edible in raw form due to its hard texture and acidic flavor;<sup>5</sup> therefore, it is frequently consumed, with added sweeteners, as jam.<sup>6</sup> Quince jelly and jam are common in Greek cuisine.

### *scientific findings*

Quince pulp, peel, and jam exhibited antioxidant activity in a laboratory study.<sup>6</sup> *C. oblonga* Miller fruit (pulp, peel, and seed) exhibited antiproliferative properties against human kidney and colon cancer cells in a laboratory study.<sup>7</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Quinoa (*Chenopodium quinoa*)



White and red quinoa grain. (Image from cristi180884/Shutterstock.)

### *definition*

Whole grain that is cooked similarly to rice by using one part grain to two parts water and eaten as a side dish. Quinoa is a good source of fiber, zinc, potassium, phosphorus, and supplies omega-6 fatty acid, vitamin E, polyphenols, phytosterols, and flavonoids.<sup>8,9</sup> Though quinoa, compared to other grains, is higher in protein, it lacks the essential amino acids threonine, lysine, and phenylalanine<sup>10</sup> hence, it is not a complete protein, as has been claimed, because it does not contain all essential amino acids.

### *scientific findings*

Quinoa seeds fed to rats reduced serum total cholesterol, glucose, LDL, and triglycerides.<sup>11</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when used in normal dietary quantities by nonallergic individuals.

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# R

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## *Radicchio (Cichorium intybus)*



Radicchio. (Image from marmo81/Shutterstock.)

### *definition*

Hardy, variegated, magenta-colored variety of chicory that has a bitter taste and contains phenolics.<sup>1</sup> Used fresh as a salad vegetable, usually mixed with other lettuces to mellow its strong flavor.

R

### *scientific findings*

In a laboratory study, *C. intybus* exhibited antioxidant properties.<sup>2</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Radish (*Raphanus sativus*)



Radish. (Image from amphaiwan/Shutterstock.)

### *definition*

Typically a small, round, white-fleshed vegetable with thin, edible red or white skin that has a sharp, burning flavor. The daikon (above) is a large, conical white variety of radish that is eaten fresh; for example, it may be peeled and grated to be served with sushi or pickled and fermented in Asian cooking. Radish sprouts are a source of glucosinolates and antioxidants.<sup>3</sup> Radishes are so low in calories that they are considered a calorie-free food or so-called “free food” for liberal inclusion in weight management and calorie-controlled diets, and they are also a source of vitamin C.<sup>4</sup> Although there is not sufficient scientific evidence to support the use of radish for any health condition, “a typical dosage is 0.5 tablespoon of pressed radish root juice several times daily up to 50–100 mL per day” has been used orally for peptic disorders; bile duct dyskinesia; loss of appetite; inflammation of the mouth and pharynx; prevention of infection, inflammation or excessive mucus of the respiratory tract; bronchitis; fever; colds; and cough, according to a review of historical use of radish.<sup>5</sup>

### *scientific findings*

See *Brassica vegetables*.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Consuming large amounts may lead to gastrointestinal irritation.<sup>5</sup>

## Raisin (*Vitis vinifera*)

### definition

Dried grape that is a popular snack food, ingredient in cereal, trail mix, and raisin bread, and that is used in baking and in making confections. Raisins are an excellent source of potassium (100 g of raisins, which is equal to approximately 2/3 cup, supplies 332 cal and 898 mg of potassium),<sup>6</sup> and compared to grapes, contain more fructans, but fewer phenolic compounds,<sup>1</sup> procyanidins, and flavan-3-ols,<sup>7</sup> which are lost during processing. Raisins are a source of both soluble and insoluble fiber.<sup>8</sup>

### scientific findings

A small clinical trial found that eating 120 g of sun-dried raisins beneficially modulated the composition of fecal bile acids and short-chain fatty acids in healthy subjects (n = 13).<sup>9</sup> In another small clinical trial (n = 13), 84 g of sun-dried raisins caused beneficial changes in measures of colon health (e.g., intestinal transit time, fecal weight, and fecal bile acid composition).<sup>10</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Raspberry, red (*Rubus idaeus*)

### definition

High vitamin C berry that provides 4 g of fiber per 1/2 cup serving<sup>11</sup> and phytochemicals, including phenolics and anthocyanins,<sup>12</sup> and caffeic acid (not to be confused with caffeine—the two substances are unrelated).<sup>13</sup> (Note to reader: Anthocyanins are a type of phenolic compound, but the study author treats the two as separate entities.) Eaten raw, frozen, as juice, and in prepared foods, such as desserts and baby food.

### scientific findings

Red raspberry muffins exerted measurable antioxidant capacity attributed to raspberry phenolics and anthocyanins.<sup>12</sup> *In vivo* and *in vitro* studies

have demonstrated that red raspberry phenolics and ellagitannins form compounds beneficial to colonic cells.<sup>14</sup> In laboratory studies, caffeic acid exhibited antioxidant, immunomodulatory, and anti-inflammatory properties.<sup>15,16</sup> In an experimental model, caffeic acid protected human skin from photo-oxidative damage.<sup>17</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Resveratrol*

### *definition*

Polyphenol linked to the “French Paradox” phenomenon, referring to the antiatherogenicity of the typical French diet, known to be high in fat, presumably offset in part due to the inclusion of red wine. Red wine is the major dietary source of resveratrol,<sup>18</sup> but it is also found in grapes, peanuts, and other foods, with white wine having a low content.<sup>19,20</sup>

### *scientific findings*

Resveratrol inhibited LDL oxidation and platelet aggregation, and exerted anti-inflammatory and antiproliferative effects in laboratory research.<sup>20–22</sup> In a 4-week randomized clinical trial (n = 19), resveratrol improved insulin sensitivity in patients with type 2 diabetes: subjects were randomly assigned into a resveratrol group who received resveratrol (a 5-mg dose twice a day) and a control group receiving placebo. After the fourth week, in the resveratrol group, insulin resistance was significantly reduced.<sup>23</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.



*Rhubarb (Rheum officinale)*

Rhubarb. (Image from photogal/Shutterstock.)

*definition*

Vegetable consisting of edible stalks, also called petioles, meaning the portion from the stem to the leaf. Rhubarb leaves are not consumed. Rhubarb is tart and must be sweetened heavily before making it into pie, jam, jelly, and sauces. Rhubarb is an excellent source of vitamin K, and though it contains 344 cups of calcium, its calcium is poorly absorbed.<sup>24,25</sup> It is also a source of the phytochemical anthraquinone.<sup>26</sup> Rhubarb's dried root has been used to treat constipation and diarrhea.

*scientific findings*

Anthraquinone exhibited antiviral properties in laboratory studies.<sup>27,28</sup>

*bioactive dose*

Not known.

*safety*

Rhubarb leaves are poisonous<sup>29</sup>; however, rhubarb stalks, petioles, and products made from these plant parts are presumed safe when consumed in normal dietary quantities by nonallergic individuals. Several reports of anthraquinones' mutagenicity or other generic or carcinogenic effects have been reported.<sup>30</sup>

## Riboflavin

### definition

Also referred to as vitamin B2. Water soluble vitamin that functions as a coenzyme in redox reactions.<sup>31</sup> The best sources of riboflavin include milk and enriched grain products. The average person in the United States meets daily riboflavin requirements.<sup>31</sup>

### scientific findings

Deficiency symptoms of riboflavin, characterized by low riboflavin levels in the blood (ariboflavinosis) include sore throat, edema of the pharyngeal and oral mucosa, angular stomatitis, magenta tongue, and impaired metabolism of vitamin B6.<sup>31</sup> Higher intake of riboflavin was associated with reduction in the progression of age-related lens opacification, according to the findings of a sample of Nurses' Health Study participants (n = 408 women aged 52–74 years at baseline). In this study, lens density was assessed at baseline and at the end of 5 years and correlated with subjects' usual dietary intake and use of dietary supplements, which were assessed prior to baseline.<sup>32</sup>

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## Rosemary (*Rosmarinus officinalis*)

### definition

Culinary herb that has a pine-like flavor used fresh or dried to season meat, poultry, pasta, sauces, stuffing, potatoes, peas, and lima beans. Contains rosmarinic acid, which has been described as “one of the most important and well known natural antioxidant compounds.”<sup>33</sup>

### scientific findings

In experimental studies, rosemary exhibited anti-inflammatory, antispasmodic, analgesic, antirheumatic, carminative, cholagogue, diuretic, expectorant, antiepileptic, and neuroprotective properties.<sup>33–35</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Rutabaga (Brassica napobrassica)*



Rutabaga. (Image from 17494494/Shutterstock.)

*definition*

Yellow-fleshed root vegetable that has a cabbage-like flavor. Its name means “round root.” A good source of vitamin C and potassium; also contains glucosinolates.<sup>36,37</sup> Rutabaga is peeled, cooked by boiling, and mashed, possibly with potatoes and carrots, or added to soups, stews, or soufflés.

*scientific findings*

See *Brassica oleracea*.

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. High levels of goitrogens have been found in rutabaga.<sup>38</sup> Cooking, especially by boiling, destroys goitrogens.

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# S

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## *Sage (Salvia officinalis, Salvia lavandulaefolia)*

### *definition*

Earthy-flavored herb used fresh or dried to flavor meats, fish, and stews. Sage, in small quantities normally consumed as an herb, is not an appreciable source of nutrients. Its phytochemical constituents include phenolic compounds, catechin, chlorogenic acid, vanillic acid, caffeic acid, and epicatechin.<sup>1</sup> In traditional medicine, sage was boiled and drunk as a tea to treat dyspepsia, mouth and throat inflammation, excessive sweating, and minor skin inflammations.<sup>2</sup> Ancient Greek physicians used a solution of sage and water to stop wounds from bleeding and to clean sores and ulcers.<sup>3</sup>

### *scientific findings*

*S. officinalis* has exhibited antioxidant and anti-inflammatory properties in experimental research.<sup>4,5</sup> Estrogenic flavonoids, compounds that exert anti-hot-flash (also called hot flush) activity, have been isolated in *S. officinalis*.<sup>6</sup> In laboratory research, *S. lavandulaefolia* (Spanish sage) extracts and constituents have demonstrated anticholinesterase, antioxidant, anti-inflammatory, estrogenic, and central nervous system depressant (sedative) effects.<sup>7</sup> There is insufficient scientific evidence to support its use as a treatment for sore throat.<sup>3</sup> Two small studies suggest that sage may improve mood and mental performance in healthy young people and memory and attention in older adults.<sup>3</sup> Findings of another small clinical trial found sage extract to be better than placebo to enhance thinking and learning in older adults with mild-to-moderate Alzheimer disease,<sup>3,8</sup> an explanation for which, according to researchers, could be related to sage's cholinergic binding properties, which have been demonstrated *in vitro*.<sup>8</sup>

### *bioactive dose*

Not known.

*safety*

Sage contains the neurotoxin thujone, a monoterpene; however, when sage is used in normal dietary quantities, thujone poses little risk.<sup>2</sup> Thujone can have menstrual stimulant and abortifacient effects and is thought to reduce the mother's milk supply.<sup>9</sup> Taking large amounts of sage leaf or oil may result in restlessness, vomiting, vertigo, rapid heart rate, tremors, seizures, and kidney damage, and may lead to wheezing.<sup>9</sup> Twelve or more of drops of sage essential oil is considered a toxic dose.<sup>9</sup>

*Saponin**definition*

Glycoside compound found in a wide variety of plants, such as soybeans, chickpeas, peanuts, spinach, quinoa, and beer, but few used as food.<sup>10</sup> When fruits and vegetables are cut or otherwise processed, saponin produces a soapy foam.<sup>10</sup>

*scientific findings*

Dietary saponins, either isolated or as saponin-containing food plants, have reduced plasma cholesterol levels in animal studies.<sup>10</sup> Experimental data show saponins to be one of many bioactive ingredients in foods that has exhibited blood-pressure-lowering effects.<sup>11</sup>

*bioactive dose*

Not known.

**S***safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Selenium**definition*

Trace mineral found in meat, especially organ meats, seafood, and certain plant foods, such as nuts. Brazil nuts, which supply 290 µg of selenium per one nut<sup>12</sup> (more than three times the Daily Reference Value of 70 µg or 415% DV), are an excellent source of the mineral. Selenium is an



antioxidant that seems to inhibit cell proliferation<sup>13</sup>; it is also necessary for thyroid function,<sup>14</sup> immune function, and normal testicular development, spermatogenesis, and spermatozoa motility and function in males<sup>15</sup>; and it exhibits insulin-mimetic properties.<sup>16</sup>

### *scientific findings*

Consuming one Brazil nut daily for 8 weeks improved selenium status, erythrocyte glutathione peroxidase activity, and measures of atherogenic risk, such as HDL cholesterol, in a small clinical trial (n = 38 selenium deficient, severely obese women).<sup>12</sup> The association between selenium status and cancer risk is being investigated. A meta-analysis of cancer studies examining the relationship between dietary selenium intake and cancers that included 49 prospective observational studies and 6 randomized controlled trials, concluded: "No reliable conclusions can be drawn regarding a causal relationship between low selenium exposure and an increased risk of cancer."<sup>17</sup> An analysis of toenail selenium was conducted in the Netherlands Cohort Study (n = 58,279 men aged 55–69 years at baseline) from a random subcohort of 898 advanced prostate cancer subjects and 1176 subcohort subjects. Incident advanced prostate cancer case subjects from the entire cohort were identified during 17.3 years of follow-up. The study found that "toenail selenium was associated with a substantial decrease in risk of advanced prostate cancer."<sup>18</sup> If there is a benefit of selenium on prostate cancer risk, it appears to be limited to patients who are selenium deficient.<sup>19</sup> In an observational study (n = 5587 participants in the 2007–2008 National Health and Nutrition Examination Survey) evaluating associations between self-reported sleep duration and intake of various dietary components, normal sleep duration was associated with the greatest food variety, and nutrients consumed less by short sleepers (<5 h per night) included selenium.<sup>20</sup> A selenium review, while stating that there is no reliable evidence about the effect of selenium on thyroid function, also pointed out that low selenium levels or selenium deficiency may reduce the conversion of thyroxine (T4) to triiodothyronine (T3).<sup>9</sup> Another review stated that selenium status appears to have an impact on the development of thyroid pathologies.<sup>21</sup> Patients with newly diagnosed Graves Disease (n = 97) and/or autoimmune overt hypothyroidism (n = 96) had significantly lower serum selenium compared with random controls (n = 830), suggesting a link between inadequate selenium status and overt autoimmune thyroid disease, especially Graves Disease.<sup>22</sup>

### *bioactive dose*

The RDA for adults aged 19–50 is 55 µg/day.

*safety*

The UL for adults aged 19–50 is 400 µg/day. “Signs and symptoms of selenosis (selenium toxicity) include pruritis, nail changes, brittle hair and nails, and garlic breath, and have been reported at serum selenium levels >1000 ng/mL corresponding to daily intakes >910 µg.”<sup>19</sup>

*Shallot (Allium cepa L. var. aggregatum)*

Shallot. (Image from NeydtStock/Shutterstock.)

*definition*

Miniature purple onion that contains allyl sulfides and flavonol glycosides, including quercetin.<sup>23</sup> Used for their strong, characteristically burning flavor in salads and salad dressings.

*scientific findings*

See *Allium* vegetables.

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Snap pea (Pisum sativum)*

Snap pea.



Snow pea.

*definition*

Fabaceae green pod vegetable containing several edible peas. Snap peas are generally cooked or stir-fried; they are also sold as a freeze-dried, salted, ready-to-eat snack. Fresh shoots of the snap pea are used as micro-greens (sprouts from seeds) in salads or as a garnish. The snow pea (also called sugar snap pea) has a flat pod, while the snap pea pod is plump with tougher skin. Excellent source of vitamin C<sup>24</sup>; contains phenolic compounds.<sup>25</sup>

*scientific findings*

In an animal study, diets containing *P. sativum* reduced serum total cholesterol possibly due in part to an increased fecal bile acid output.<sup>26</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Soybean (Glycine max)**definition*

Fabaceae vegetable that is a good source of protein and fiber and supplies isoflavones. Edamame are immature, raw soybeans, and tofu, tempeh, miso, and soy milk, in addition to soymilk-based infant formula, are products made from soybean. Soybean oil is rich in omega-3 fatty acid and a good source of vitamin E (6% DV) and vitamin K (31% DV).<sup>27</sup>

*scientific findings*

The physiological effects of consuming soy foods are as follows: (1) Eating modest amounts of soy foods during childhood and/or adolescence modestly reduces the risk of developing breast cancer.<sup>9</sup> More evidence is needed to determine the effect of soy foods on patients with existing breast cancer<sup>28</sup>; (2) Consuming soy protein seems to modestly reduce total and LDL cholesterol.<sup>9</sup> Soy foods lower the risk of coronary heart disease<sup>28</sup>; (3) Consuming soy protein isoflavones modestly decreases hot flashes in some menopausal women<sup>9,28</sup>; (4) Soy protein, according to most, but not all, evidence can increase bone mineral density or slow its loss and improve biochemical markers of bone turnover in peri- and postmenopausal women.<sup>9,29</sup> A review of 13 studies found unclear and conflicting evidence on the effect of increased soy food intake and blood pressure.<sup>30</sup>

*bioactive dose*

Not known. The dose of soy protein needed to achieve significant decreases in total or LDL cholesterol or triglycerides has not been established,<sup>31</sup> but a dose of 20–50 g of soy protein daily has been used for hyperlipidemia.<sup>9</sup>

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergies to soybean have been reported. Soy protein

products in doses up to 60 g/day have been safely used in studies lasting up to 16 weeks.<sup>9</sup>

## *Spinach (Spinacia oleracea)*

### *definition*

Dark green leaf vegetable that is a good source of folate and an excellent source of vitamins A and K.<sup>32</sup> Supplies lutein,<sup>33</sup> saponin, and oxalate, the latter of which gives raw spinach a distinctive mouth feel described as a film in one's mouth. Unlike many other dark green vegetables, spinach is a poor calcium source, providing only 30 mg per 1 cup (3%DV), and, despite its reputation to the contrary, spinach is not a good source of iron, providing only 0.8 mg of nonheme iron per 1 cup (4% DV).<sup>34</sup> The bioavailability of nonheme iron is poor compared to the bioavailability of heme iron. Baby spinach is a popular salad ingredient, and spinach is used in many casserole and pasta recipes, in addition to being a main ingredient in the Greek dish spanakopita (literally meaning "spinach with bread") that consists of cooked spinach layered with phyllo dough and feta cheese.

### *scientific findings*

Consumption of green leafy vegetables is associated with a reduced risk of several types of cancer, such as pancreatic cancer, and cardiovascular disease.<sup>35,36</sup> A high intake of green leafy vegetables was linked to a reduced risk of non-Hodgkin's lymphoma in a population-based case-control study (n = 348 cases and 470 controls) that compared dietary intake of cases to controls.<sup>37</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Squash (Curcubita pepo)*

### *definition*

Winter squash is the hard-shelled, orange- or yellow-fleshed variety of squash such as spaghetti, acorn, butternut, or Hubbard, while summer squash has an edible, thin skin and white flesh, for example, zucchini. Winter squash's hard skin serves to increase its storage life. It can be

stored for up to 3 months in cool temperatures. Winter squash is prepared by baking in the shell or by removing the hard outer skin and then baking and mashing the flesh. Many winter squash varieties are rich in starch and, therefore, are counted as starchy vegetables for purposes of carbohydrate counting in diabetes. Winter squash per 1/2 cup supplies 4.5 grams of fiber and 400 IU of vitamin A,<sup>38</sup> making it a good source of both.<sup>39</sup> Zucchini is commonly eaten baked, boiled, or may be eaten in matchsticks, raw, and added to salads. Zucchini per 1/2 cup supplies 113 IU of vitamin A.<sup>40</sup>

### *scientific findings*

The vitamin A activity of squash is due to its provitamin A carotenoid,  $\beta$ -carotene.  $\beta$ -carotene becomes active vitamin A if necessary, or remains in its antioxidant form. Since  $\beta$ -carotene from food has no potential for toxicity, it is a safe form of vitamin A, which has an upper limit of safety of  $\geq 10,000$  IU, and which may be important, for example, during pregnancy.<sup>41</sup>

### *bioactive dose*

Not known. Adult women and men aged 19–50 require 2.5 cups or 3 cups of vegetables, per day, respectively, ideally including all subgroups, including “red and orange” vegetables to which winter squash belongs, and “other vegetables” to which zucchini belongs.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Stanols, sterols*

### *definition*

Steroid compounds, such as sitostanol, campestanol, sitosterol, campesterol, and stigmasterol, that have chemical structures similar to cholesterol.<sup>42</sup> Found naturally in fruits, grains, vegetables and vegetable oils, nuts and seeds, wheat germ and wheat bran; peanuts; corn, sesame, canola, and olive oil; almonds; and brussels sprouts.<sup>43</sup> These compounds are under consumed. Normal dietary intake of plant sterols is 200–400 mg/day, a level that would not significantly affect cholesterol absorption, but when consumed at levels 5–10 times higher than normal, they have been shown to reduce total and LDL cholesterol.<sup>44</sup> Vegetable

oil spreads, mayonnaise, yogurt, milk, orange juice, cereals, and snack bars that have been fortified with plant sterols and stanols are commonly available in grocery stores.<sup>43</sup>

### *scientific findings*

Plant sterols and stanols in the diet help to lower blood total and LDL cholesterol levels.<sup>45</sup>

### *bioactive dose*

The National Heart Lung and Blood Institute's National Cholesterol Education Program Therapeutic Lifestyle Changes recommends that individuals with elevated LDL cholesterol consume 2 g of plant sterols/stanols per day.<sup>46</sup> "A reduction of up to 10% total cholesterol is observed when 2–3 g of plant stanol/sterol esters are consumed daily."<sup>44</sup>

### *safety*

An intake of 2–3 g of plant sterols and stanols per day generally appears to be safe.<sup>47</sup>

"It is unclear whether there are unintended AEs when consuming sterols. Some studies have detected no significant changes in the plasma concentrations of  $\alpha$ -carotene, lycopene, and vitamins A, D, and E; however, other studies have found that the plasma concentrations of  $\alpha$ -tocopherol and  $\alpha$ - and  $\beta$ -carotene decrease after the consumption of sterols and stanols."<sup>48</sup>

## *Starchy vegetables*

### *definition*

Vegetables that generally have a higher carbohydrate content (~15 g of carbohydrate per 1/2–1 cup serving) than nonstarchy vegetables, such as lettuce and tomatoes (~5 g of carbohydrate per 1/2–1 cup serving), and therefore, are considered to be equivalent to grains for diet planning purposes.<sup>49</sup> Examples of starchy vegetables, according to The American Diabetes Association (ADA), include parsnips, winter squash, white potatoes, sweet potatoes, and yams. Examples of starchy vegetables according to ChooseMyPlate.gov differ from that of ADA, for example, ChooseMyPlate.gov classifies winter squash as an Orange and Red Vegetable, not a starchy vegetable, which should be noted in patients who are required to control their carbohydrate intake. The flesh and/or skin of many starchy vegetables can be rich sources of fiber.

*scientific findings*

Starch is a major glycemic carbohydrate in foods. Starchy vegetables may increase dietary glycemic load and raise blood glucose appreciably.<sup>50</sup> Some starchy vegetables contain resistant starches and fibers that either reduce or have no effect upon glycemic load in addition to having other health benefits.<sup>51</sup>

*bioactive dose*

Not applicable.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Strawberry (Fragaria × ananassa)**definition*

Popular snack fruit that is an excellent source of vitamin C and folate<sup>52</sup> and a source of flavonoids. Eaten fresh, frozen, dried, as juices, or added to cereals, desserts, or baked products.

*scientific findings*

Strawberry constituents ameliorated allergy symptoms in a laboratory study.<sup>53</sup> A laboratory study demonstrated synergism and antagonism among the seven phenolic compounds in strawberries, including *p*-coumaric acid, cyanidin, catechin, quercetin-3-glucoside, kaempferol, and ellagic acid,<sup>54</sup> illustrating the unique interactions that occur among phytochemicals within the complex food matrix using strawberry as a model. Strawberry phenolics are known for their antioxidant and anti-inflammatory action, and possess direct and indirect antimicrobial, anti-allergy and anti-hypertensive properties based on laboratory research.<sup>55</sup> They also inhibit the activities of some physiological enzymes and receptor properties which may have various disease-preventative implications.<sup>55</sup>

*bioactive dose*

Not known.



*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergy to strawberries have been reported.

*Sulforaphane**definition*

Isothiocyanate found in broccoli, broccoli sprouts, and other *Brassica* vegetables.

*scientific findings*

Sulforaphane exhibited chemoprotective properties in experimental research; it may prompt the body to make higher levels of chemoprotective enzymes.<sup>56</sup> In a small clinical trial (n = 20 men with recurrent prostate cancer), treatment with 200  $\mu$ moles/day of sulforaphane-rich broccoli sprout extract did not decrease prostate-specific antigen in the majority of patients.<sup>57</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Syringic acid**definition*

A phenolic acid found in plants, such as sage and wheat.

*scientific findings*

In animal research, syringic acid exhibited hepatoprotective properties.<sup>58</sup>

*bioactive dose*

Not known.

## safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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## *Tamarind (Tamarindus indica)*



Tamarind. (Image from Jiang Hongyan/Shutterstock.)

### *definition*

Pod-shaped fruit indigenous to tropical Africa<sup>1</sup> that is grown in Florida.<sup>2</sup> Tamarind is a good source of potassium<sup>3</sup> and contains tartaric acid.<sup>4</sup> Tamarind is used to make a sweet sauce that is used in Asian and Indian cooking.<sup>4</sup> The fruit is used in traditional medicine as a laxative, for abdominal pain, to treat diarrhea and dysentery, to treat helminthes infections, for wound healing, and to treat malaria, fever, constipation, inflammation, cell cytotoxicity, gonorrhea, and eye diseases.<sup>5,6</sup>

### *scientific findings*

*T. indica* seeds exhibited antioxidant properties, and *T. indica* extract exhibited antidiabetic properties in experimental research.<sup>7,8</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Tangerine (Citrus reticulata)*

### *definition*

Small dark orange citrus fruit that is an excellent source of vitamin C and a source of the flavanones hesperetin and naringenin.<sup>9</sup> Its juice is a source of flavones, flavonols, and flavanones, such as kaempferol and quercetin. Tangerines are commonly eaten fresh and added to salads.

### *scientific findings*

See *citrus*.

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Tannin*

### *definition*

Polyphenol found in black-eyed peas, grapes, lentils, persimmon, black and green teas, and red and white wines, in addition to many other foods.<sup>10,11</sup>

### *scientific findings*

Tannins exhibited chemoprotective properties<sup>10</sup> and bound bile acids in experimental research.<sup>11</sup> Tannin inhibits nonheme iron absorption<sup>12</sup> and can have a significant impact on adult iron status.<sup>13</sup> Tea should be avoided during meals and for at least 1 h after meals to prevent its impairment of nonheme iron absorption.<sup>13</sup>

### *bioactive dose*

Not known.



*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Tarragon (Artemisia dracunculus)**definition*

Culinary herb used fresh or dried. Tarragon pairs well with chicken and fish, including salmon, and can be used to flavor salad dressing. It has a licorice-like flavor. Tarragon is used orally as an antiepileptic remedy in middle Eastern folkloric medicine.<sup>14</sup>

*scientific findings*

*In vitro*, tarragon exhibited antioxidant properties.<sup>15</sup> Tarragon exhibited anticonvulsant and sedative effects that were attributed to its monoterpenoids content in experimental research.<sup>14</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Tartaric acid**definition*

Organic plant acid found naturally in foods such as grapes raisins, and tamarind.<sup>16,17</sup> Tartaric acid is used in manufacturing sour-flavored confections; for leavening when used in combination with baking soda, in baked goods, and as a food preservative to maintain the quality of processed foods.<sup>18</sup>

*scientific findings*

Tartaric acids in dried fruits, along with other naturally occurring compounds, such as sugar alcohols and fiber, may positively affect bowel regularity.<sup>17</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Tea (Camellia sinensis)**definition*

Beverage prepared with leaves that have undergone varying degrees of fermentation corresponding to color differences, such as green (without fermentation), red (lightly fermented), oolong (medium fermentation), and black (fermented). All teas contain caffeine and are traditionally consumed for their mild central nervous system stimulating effects. In addition, all types of tea provide between 100 and 300 mg of flavonoids, such as flavon-3-ol, per serving.<sup>19</sup> Tea is consumed hot, iced, and sweetened or unsweetened. It may also be added to recipes as a marinade.

*scientific findings*

Epidemiological studies support the potential health-protective effects of flavan-3-ols and their derived compounds upon chronic diseases.<sup>20</sup> The flavonoid catechin is found to a great degree within green tea as compared to black and oolong tea because the latter are processed by fermenting, which destroys catechins. Epidemiologic studies suggest that green tea consumption is associated with cardiovascular benefits and that it may possess antioxidative, antihypertensive, anti-inflammatory, antiproliferative, antithrombogenic, and lipid-lowering properties.<sup>21–23</sup> Epidemiologic studies examining the association between tea consumption and cancer risk have been inconclusive.<sup>13</sup> A number of human observational studies found that tea catechins were associated with a reduced risk of stroke<sup>24</sup>; however, a large observational study in elderly men found no association between tea and stroke, but did find a reduced risk of ischemic heart disease.<sup>25</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. See also tannin.

*Terpenoids**definition*

Group of phytochemicals whose main subclasses are monoterpenes (including limonene, carvone, and carveol); diterpenes (including the retinoids); and tetraterpenes (including  $\alpha$ - and  $\beta$ -carotene, lutein, lycopene, zeaxanthin, and cryptoxanthin). Terpenoids occur in nearly every natural food,<sup>26</sup> and, along with other phytochemical constituents in foods, impart sensory qualities, for example, the characteristic “green,’ ‘woody,’ ‘earthy,’ ‘fruity,’ ‘floral,’ ‘sweet,’ and ‘musty’” flavor of pomegranate.<sup>27</sup> Foods that contain terpenoids include citrus fruits, coriander, lemon grass, caraway, peppermint, rosemary, sage, and thyme.<sup>28</sup>

*scientific findings*

Terpenoids exhibited antimicrobial effects in a laboratory study.<sup>26</sup> Cancer-prevention advice to eat at least 2.5 cups of vegetables and fruits each day is based on plant foods’ “numerous potentially beneficial bioactive substances, such as terpenes ... that may help prevent cancer.”<sup>29</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Thiamin (Vitamin B1)**definition*

Water-soluble vitamin required for carbohydrate and ethanol metabolism. It is found in whole, fortified, and enriched grains, legumes, and

pork products. The average U.S. diet maintains an adequate thiamin status.<sup>30</sup> However, thiamin status may be reduced if sufficient thiamin is not ingested (for example, due to poor diet or dietary intake < RDA during conditions of heightened requirement, such as pregnancy or hyperthyroidism<sup>31</sup>). Thiamin can also increase (due to alcoholism), or losses can occur (due to malabsorptive disorders). Clinical signs of thiamin deficiency include anorexia, weight loss, mental changes, apathy, decreases in short-term memory, confusion, irritability, muscle weakness, and cardiovascular abnormalities,<sup>30</sup> the latter of which is characterized by symptoms ranging from pedal edema and anasarca to severe cardiac abnormalities.<sup>32</sup> Dry beriberi is characterized by peripheral neuropathy<sup>33</sup> and mental status changes,<sup>34</sup> which may clinically manifest as Wernicke encephalopathy, Wernicke–Korsakoff syndrome, and structural and functional brain injury.<sup>35</sup>

### *scientific findings*

A high dietary intake of thiamin was associated with a reduced risk of lens opacification in a 5-year study (n = 408 women from the Nurses' Health Study aged 52–74 years at baseline) evaluating nutrition and vision.<sup>36</sup> Higher intake of thiamin was associated with reduced prevalence of nuclear cataract in a population-based study (2900 healthy people aged 49–97 years).<sup>37</sup>

### *bioactive dose*

The RDA is 1.2 mg for men aged 19–50 and 1.1 mg for women aged 19–50.

### *safety*

No UL has been established for thiamin. Thiamin is generally considered nontoxic, though rare hypersensitivity reactions have been reported.<sup>31</sup>

## *Thiols*

### *definition*

Sulfur compounds that impart characteristic aromas to foods found in fruits, such as grapefruit, vegetables, beer, and wine.<sup>38–40</sup>

### *scientific findings*

*In vitro*, thiols exhibited antioxidant properties.<sup>41</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Thyme (Thymus vulgaris)**definition*

Culinary herb that contains phenolics, flavonoids, and terpenoids.<sup>42</sup> Used fresh or dried to flavor meats, and tomato-based soups such as seafood chowder.

*scientific findings*

Phenolic compounds have exerted antioxidant, anti-inflammatory, and antimicrobial effects in laboratory studies.<sup>43–45</sup> Thyme exerted DNA-protective activity in a laboratory study.<sup>46</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Tofu**definition*

White gelatin-like curd formed when soybean protein is precipitated. Its firmness is determined by the amount of liquid it contains. Silken tofu contains a high amount of liquid, whereas firm tofu contains less liquid. Tofu is a rich source of soy protein and can be a good source of calcium, depending on whether the soybean is precipitated with a calcium compound, such as calcium chloride; it is not a source of vitamin B12 (unless it has been fortified with vitamin B12 which would be stated on the ingredients label). Tofu is used raw or cooked in Asian-inspired cooking as a meat substitute.

*scientific findings*

Research suggests that a daily intake of soy protein has a mild LDL-lowering effect,<sup>47</sup> especially when soy protein is substituted for animal protein.<sup>48</sup> A population study found Western-culture women who ate tofu once weekly, compared to women who did not, reduce their risk of premenopausal bilateral breast cancer.<sup>31</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Tomato (Lycopersicon esculentum)**definition*

Popular culinary vegetable that is botanically classified as a fruit. A good source of vitamin C and a source of many phytochemicals including lycopene, a carotenoid, the parent compound of which is a terpenoid.

*scientific findings*

Consuming  $\geq 10$  servings/week of tomato-based foods as compared to consuming  $< 1.5$  servings/week, significantly, but only modestly, improved total cholesterol, total cholesterol:HDL ratio, and hemoglobin A1C in an observational trial of women.<sup>49</sup> Eating a tomato-rich diet is associated in epidemiology with a decreased risk of prostate cancer,<sup>50</sup> but “there is insufficient evidence to either support, or refute, the use of lycopene for the prevention of prostate cancer,” according to a recent meta-analysis and review.<sup>51</sup> Some epidemiological studies suggest that the risk of prostate cancer is decreased modestly in men who consume tomato products, including tomatoes, tomato sauce, pizza, or tomato juice, one time or more per week, according to a review, which also found that other epidemiological evidence suggests that tomato consumption is not associated with a reduced risk of prostate cancer.<sup>31</sup> For preventing prostate cancer, four or more servings of tomato products per week (equivalent to a dietary lycopene intake greater than 6 mg daily) have been used.<sup>31</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Tomatillo (Physalis philadelphica)*



Tomatillo. (Image from bonchan/Shutterstock.)

*definition*

Small, green tomato-like vegetable used to make salsa verde (green salsa). A small, 34-g tomatillo contains 10 cal, 1 g of fiber, 6% DV for vitamin C, 2% DV for iron, and is a source of phytochemicals including lutein,  $\beta$ -carotene, and ixocarpalactone A.<sup>52,53</sup>

*scientific findings*

Ixocarpalactone A has been shown to be a cancer chemopreventive agent cytotoxic against human cancer cell lines in laboratory studies.<sup>52,54</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

*Turmeric (Curcuma longa)**definition*

Herb member of the ginger family known for its golden color that is used to prepare curry powder and yellow mustard. Traditional use of turmeric to aid in digestion and liver function, relieve arthritis pain, and regulate menstruation involves drying the rhizome (underground stem) and taking turmeric powder in capsules, teas, or liquid extracts.<sup>55</sup> However, few clinical trials have been conducted to evaluate these effects in humans.<sup>31</sup> A biologically effective dose of curcumin in humans has not been reported;<sup>56</sup> however, a dose of 500 mg of turmeric four times daily has been used for dyspepsia,<sup>31</sup> and a dose of 500 mg of turmeric extract four times daily has been used for osteoarthritis.<sup>31</sup>

*scientific findings*

Curcumin, a vanilloid compound in turmeric, exhibited apoptotic, anti-inflammatory, chemoprotective, antitumor, antioxidant, antiarthritic, antiamyloid, anti-ischemic, anti-inflammatory, and bone-protective effects.<sup>57–61</sup> Some clinical research shows that taking turmeric orally can relieve symptoms of dyspepsia,<sup>31</sup> but turmeric has not been adequately studied for effectiveness in humans for any health condition.<sup>55</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. High doses or long-term use of turmeric may cause indigestion, nausea, or diarrhea.<sup>55</sup> People with gallbladder disease should avoid using turmeric as a dietary supplement, as it may worsen the condition.<sup>55</sup>

*Turnip (Brassica rapa)**definition*

White or white-and-purple Brassica root vegetable about the size of a small onion that has been used as a vegetable for human consumption



in Europe since prehistoric times.<sup>62</sup> One cup of raw turnip is low in calories, supplying 36 cal, 8 g of carbohydrates, 2 g of fiber, and 250 mg of potassium, and 38 mg of vitamin C, making it an excellent source of vitamin C.<sup>66</sup> Its greens, commonly boiled or cooked with ingredients such as meats, onions, and garlic, are a source of vitamins C and K, magnesium, potassium, phenolics and glucosinolates<sup>64</sup>; canned turnip greens contain more iron than fresh turnip greens.<sup>65</sup>

### scientific findings

See *Brassica vegetables*.

### bioactive dose

Not known.

### safety

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# U

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## *Ugli fruit (*Citrus paradisi* × *reticulata*)*



Ugli fruit. (Image from 75857518/Shutterstock.)

### *definition*

Also known as unique fruit and ugli tangelo. Hybrid of a mandarin and a grapefruit<sup>1</sup> that is native to Jamaica.<sup>2</sup> Larger than an orange with yellow-green, easily peeled skin, ugli fruit eaten fresh is an excellent source of vitamin C (70% DV) and a good source of fiber (% DV).<sup>2</sup>

### *scientific findings*

See *citrus fruits*.

### *bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# V

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## *Vanilloid*

### *definition*

Phytochemical family that includes capsaicin in *Capsicum frutescens* (chili pepper),<sup>1</sup> curcumin in the spice turmeric,<sup>2</sup> and gingerol in ginger.<sup>3</sup>

### *scientific findings*

In laboratory studies, vanilloids exhibited hepatoprotective,<sup>4</sup> anti-inflammatory,<sup>5</sup> and antioxidative properties.<sup>3</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when used in normal dietary quantities in foods by non-allergic individuals.

## *Vegetable Foods Group*

### *definition*

Underconsumed food group<sup>6</sup> that is a source of folate,  $\beta$ -carotene, vitamin C, vitamin K, vitamin E, magnesium, potassium, and fiber<sup>7</sup> which has been divided into five subgroups by color: dark green (e.g., broccoli), starchy (e.g., potatoes), beans and peas (e.g. lentils), red and orange (e.g. tomatoes and carrots), and other (e.g. artichokes, mushrooms, wax beans, zucchini etc.). Dark green vegetables are particularly rich in folate, vitamin K, and magnesium and chlorophyll, and likewise, other subgroups contribute unique nutrients and phytochemicals. Naturally low in fat, calories, and cholesterol, the low-energy density of vegetables makes them good food choices to include for weight reduction; due to their fiber content, vegetables can help to promote a feeling of fullness as well.<sup>8</sup> It is

estimated that there could be more than 100 different phytochemicals in just a single serving of vegetables.<sup>9</sup>

### *scientific findings*

Reduced vegetable consumption is a factor, along with reduced fruit consumption, that is linked to poor health and increased risk of noncommunicable diseases.<sup>10</sup> A diet rich in vegetables, as part of an overall healthy diet, may reduce the risk of heart disease, including heart attack and stroke; certain types of cancer; obesity; type 2 diabetes; blood pressure; kidney stones; and bone loss.<sup>11</sup> Biologic mechanisms, whereby vegetables exert healthful effects, are likely to be multiple and are likely to include both nutrients and phytochemicals.<sup>12</sup> People whose diets are rich in vegetables (and fruits) have a lower risk of developing cancers of the mouth, pharynx, larynx, esophagus, stomach, and lung; and some evidence suggests this dietary pattern also lowers the risk of cancers of the colon, pancreas, and prostate, in addition to lowering the risk of developing diabetes, heart disease, hypertension, and overweight.<sup>13</sup> Consuming a diet containing high amounts of vegetables (and fruits) is associated with fewer age-related diseases such as Alzheimer disease.<sup>14</sup>

### *bioactive dose*

The daily vegetable recommendation for general health for 19-to-50-year-old women is 2.5 cups and for 19-to-50-year-old men is 3 cups.<sup>8</sup> Cancer preventative recommendations for men and women are similar: to consume approximately 1.25–4 cups/day emphasizing dark green and orange vegetables and legumes.<sup>13</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## V

## Vitamin A

### *definition*

Fat-soluble vitamin whose roles include (1) vision because it converts light energy into nerve impulses that enable vision and because it maintains the cornea; (2) bone growth; (3) maintaining the integrity of epithelial cells, which occur in the eye, respiratory tract, genitourinary tract, and intestinal tract; (4) reproduction; (5) gene expression; (6) immunity;

(7) embryonic development; and (8) cell differentiation, in addition to other functions.<sup>15,16</sup> Preformed, active vitamin A (e.g., retinol) is found in animal foods, such as fortified milk, fish oils, and liver. Provitamin A carotenoids, such as  $\beta$ -carotene,  $\alpha$ -carotene, and  $\beta$ -cryptoxanthin,<sup>15</sup> are found in dark green, orange, and yellow fruits and vegetables, such as spinach, apricots, squash, and pumpkin. The median intake of vitamin A in the United States is higher than the RDA for vitamin A.<sup>15</sup> Vitamin A deficiency is characterized by eye and visual changes, such as drying and hardening of the cornea and night blindness, progressing to blindness, skin keratinization, susceptibility of the salivary glands and other mucous membranes to infection, general body-wide susceptibility to infection, and impaired digestion and absorption.<sup>17</sup> "Vitamin A deficiency can occur due to abnormal storage and transport of vitamin A in people with abetalipoproteinemia, protein deficiency, diabetes mellitus, hyperthyroidism, fever, liver disease, and cystic fibrosis."<sup>18</sup> To assess vitamin A status, plasma retinol and carotenoid levels are typically measured; however, these values have limited utility in assessing marginal vitamin A status, because they do not decline until vitamin A levels in the liver are almost depleted.<sup>15,19</sup>

### *scientific findings*

Epidemiological evidence suggests that high intake of vitamin A from foods is associated with a reduced risk of breast cancer among premenopausal women with a positive family history of breast cancer; it is not known whether supplemental vitamin A has a similar benefit.<sup>18</sup> High dietary intake of vitamin A was associated with a reduced risk of cataracts.<sup>18</sup>

### *bioactive dose*

The RDA for adult men aged 19–50 is 900  $\mu\text{g/day}$  Retinol Activity Equivalents (RAE)<sup>19</sup> (approximately 3000 IU)\* and for adult women aged 19–50 is 700  $\mu\text{g/day}$  RAE<sup>19</sup> (approximately 2333 IU).†

### *safety*

The vitamin A UL is 3000  $\mu\text{g}$ <sup>16</sup> (approximately 10,000 IU).‡ Either short-term, massive intakes or chronic intakes of high amounts of vitamin A can

\* Conversion from mcg to IU by Diane Kraft:  $900 \mu\text{g}/0.3 = 3000 \text{ IU}$ .

† Conversion from mcg to IU by Diane Kraft:  $700 \mu\text{g}/0.3 = 2333 \text{ IU}$ .

‡ Conversion from mcg to IU by Diane Kraft:  $3000 \mu\text{g}/0.3 = 10,000 \text{ IU}$ .

cause tissue levels of vitamin A to rise and hypervitaminosis A to occur, as characterized by increased intracranial pressure, headache, dizziness, nausea, skin irritation, pain in joints and bones, coma, liver damage, and even death. Tissue levels take a long time to fall after high doses, and the resulting liver damage may or may not be reversible after discontinuing the vitamin A.<sup>15,19</sup> Exceeding the UL during pregnancy is teratogenic and has been associated with development of fetal orofacial malformations, such as cleft palate.<sup>20</sup>

## *Vitamin B6 (B6)*

### *definition*

Water-soluble vitamin also called pyridoxine that is required for protein, fat, and carbohydrate metabolism.<sup>21</sup> Sources include fortified, ready-to-eat cereals; meats, fish, and poultry; white potatoes and starchy vegetables; and noncitrus fruits, including bananas and watermelon.<sup>21</sup> Vitamin B6 (B6) can also be synthesized in the lower gut. Median B6 intake of adults is higher than the B6 RDA.<sup>21</sup> Deficiency of B6 is characterized by depression, confusion, seborrheic dermatitis, microcytic anemia, convulsions,<sup>21</sup> poor growth, and decreased immune function.<sup>21</sup> B6 status is measured by using plasma 5'-pyridoxal phosphate; a value of 20 nmol/L or higher is adequate.<sup>21</sup>

### *scientific findings*

Low B6 status was associated with increased pro-inflammatory markers.<sup>22</sup> Epidemiological research suggests that male smokers with higher serum levels of pyridoxine have a lower risk of lung cancer.<sup>18</sup> Deficiency of vitamin B6 increases blood homocysteine,<sup>18</sup> a marker for cardiovascular disease that also has been suggested as a cause or mechanism in the development of Alzheimer's disease and other forms of dementia.<sup>23</sup>

### *bioactive dose*

The RDA is 1.3 mg/day for adults aged 19–50.

### *safety*

The tolerable UL for adults is 100 mg of B6 per day, an amount that is likelier to be reached from taking dietary supplements of B6 rather than from foods.

## Vitamin B12 (B12)

### *definition*

Also called cobalamin and cyanocobalamin. Water-soluble vitamin found naturally in animal foods, such as meat, poultry, fish and shellfish, eggs, and dairy products, but generally not in plant foods except for scant amounts in mushrooms and nori (seaweed),<sup>24</sup> hence, the rule of thumb: “Nothing that grows out of the ground contains vitamin B12.”<sup>25</sup> Soy milk, cereal, and vegetarian meat substitutes may be fortified with crystalline B12, which is also used in dietary supplements. Crystalline B12 is absorbed better than naturally occurring B12 in food.<sup>26</sup> B12 is necessary for folate metabolism, DNA synthesis, red blood cell formation, to convert homocysteine to methionine, and to synthesize the myelin sheath of nerves.<sup>27</sup> Absorption of B12 is unique. In the stomach, gastric acid and pepsin separate B12 from the protein to which it is bound in food.<sup>25</sup> Free B12 attaches to intrinsic factor, a gastric secretion, forming an intrinsic factor (IF)-B12 complex that is absorbed in the small intestine.<sup>25</sup> A small amount of B12 not bound to IF can be absorbed by passive diffusion.<sup>25</sup> B12 is stored in the liver.<sup>25</sup>

### *scientific findings*

The elderly are considered to be at high-risk for B12 deficiency because they have a higher incidence of gastric mucosa atrophy, altered production of intrinsic factor, and altered gastric acid secretion.<sup>26</sup> Approximately, 10%–30% of people over the age of 50 do not absorb food-bound B12 efficiently, and therefore, should meet their RDA mainly by consuming foods fortified with B12 or a B12 supplement,<sup>28</sup> rather than attempting to get B12 strictly from dietary sources.<sup>24</sup> Low serum vitamin B12 concentrations are found in more than 10% of older adults.<sup>29</sup> Average age of onset of B12 deficiency in the elderly has been estimated to be between 60 and 70 years.<sup>30</sup> Other groups at risk for B12 deficiency include those who eat a vegan diet,<sup>26</sup> cannot produce intrinsic factor, and/or have pernicious anemia, and/or malabsorption, such as from celiac disease or gastrectomy; use proton pump inhibitor drugs or metformin on a prolonged basis<sup>24</sup>; have thyrotoxicosis, hemolytic anemia, hemorrhage, malignancy, hepatic disease, renal disease, myeloproliferative disorders, or who are pregnant.<sup>18,30,32</sup> Individuals at high risk of B12 deficiency should consume B12-fortified food and/or take dietary supplements of B12 to help them meet the RDA.<sup>24</sup> Diagnosis of B12 deficiency requires a complete blood count and measurement of serum B12,<sup>24</sup> but measurement of serum homocysteine and methylmalonic acid should be used to confirm deficiency in asymptomatic high-risk patients with low-normal levels of B12.<sup>24</sup> Serum holotranscobalamin has been proposed as a better marker for assessing initial vitamin B12 status, to replace serum vitamin B12, and to accompany

serum methylmalonic acid and serum homocysteine levels.<sup>30</sup> Serum vitamin B12 is neither sensitive nor specific for vitamin B12 deficiency, which might explain why many deficient subjects would be overlooked by utilizing it as a status marker, whereas, serum holotranscobalamin is an earlier marker that becomes decreased before serum vitamin B12.<sup>33</sup> B12 deficiency is characterized by megaloblastic anemia, low or low-normal serum B12, elevated homocysteine, elevated methylmalonic acid, and low serum holotranscobalamin; in addition, neuropathy, and a variety of neuropsychiatric symptoms, such as paresthesia, loss of sensation and strength in the limbs, ataxia, slowed or increased reflexes, and vibration and position sensitivity, irritability, memory loss, and dementia,<sup>18,24,30,34,35</sup> though patients with the disorder may not exhibit all of the symptoms because B12 deficiency symptoms span a continuum.<sup>31</sup>

### *bioactive dose*

The RDA is 2.4 µg/day for adults aged 19–50. Further research is required to determine appropriate levels of B12 for deficient older adults; however, it is recommended that individuals aged 50 and older consume vitamin B12 in its crystalline form, available in fortified foods and supplements, to assure absorption.<sup>36,37</sup>

### *safety*

No UL has been established for vitamin B12. “No adverse effects have been associated with excess B12 intake from food or supplements in healthy individuals.”<sup>30</sup>

## *Vitamin C*

### *definition*

Also called ascorbic acid and ascorbate. Water-soluble antioxidant vitamin that reduces cellular oxidative stress, scavenges free radicals, and inhibits peroxidation of membrane phospholipids. It is necessary for immunity and the synthesis of amino acids, collagen, carnitine, cholesterol, hormones, and neurotransmitters.<sup>38–40</sup> Vitamin C increases the intestinal absorption of nonheme iron<sup>41</sup> either by reducing iron from the ferrous ionic state to the ferric state (in its capacity as an electron donor) or by forming a soluble complex with the iron in the alkaline pH of the small intestine.<sup>42</sup> Vitamin C deficiency, which causes scurvy, might affect up to 30% of the population, including those of low socioeconomic status or who suffer from alcoholism, severe psychiatric illness leading to poor nutrition, and other critical illness.<sup>43</sup> Perhaps the most recognizable symptoms of scurvy are

those involving decreased collagen synthesis, such as impaired wound healing, petechiae, bleeding gums, and loose teeth, but rheumatologic and other symptoms can occur, and include synovitis with effusion, anemia, markedly elevated erythrocyte sedimentation rate and C-reactive protein levels, pulmonary hypertension, purpuric rash, and hemarthrosis.<sup>44</sup>

### *scientific findings*

Vitamin C has been shown to affect immune function.<sup>45</sup> Vitamin C depletion has been correlated with histaminemia, but its role in allergy is not well understood.<sup>46</sup> Vitamin C deficiency has been associated with the development of age-related macular degeneration according to a review citing “clinical and laboratory studies”,<sup>47</sup> but increasing dietary vitamin C does not appear to significantly reduce the risk of developing age-related macular degeneration.<sup>43</sup> Plasma ascorbic acid concentration was inversely related to mortality from all causes, including cardiovascular disease and ischemic heart disease in men and women, and to cancer mortality in men but not women, in a prospective observational study (n = 19,496 men and women aged 45–79 years), that concluded eating the equivalent of a 50-g serving (one typical serving) of fruit or vegetables daily increased plasma ascorbate levels to cancer-protective levels.<sup>45</sup> Some research suggests that dietary vitamin C reduces breast cancer risk, while other research suggests no association between vitamin C intake and breast cancer risk.<sup>43</sup> Overall, dietary vitamin C appears to slow progression of atherosclerosis, and decrease the risk of atherosclerosis and peripheral arterial disease.<sup>43</sup> Dietary restriction of vitamin C is associated with increases in both diastolic and systolic blood pressure.<sup>43</sup> Consuming vitamin C from dietary sources seems to reduce blood concentrations of lead.<sup>43</sup>

### *bioactive dose*

The RDA is 75 and 90 mg/daily for nonsmoking women and men, respectively, aged 19–50.

### *safety*

The UL is 2000 mg for adults aged 19–50.

## *Vitamin D*

### *definition*

Fat-soluble vitamin found naturally in beef, egg yolk, fatty fish, and mushrooms, and added to vitamin-D-fortified milk (and milk alternates, such as vitamin-D-fortified soy milk), margarine, and vitamin-D-fortified

ready-to-eat breakfast cereals. One 8-oz glass of milk supplies approximately 100 IU of vitamin D, which meets 1/6 of the adult RDA (of 600 IU). Dairy products other than milk are generally not fortified with vitamin D. Vitamin D<sub>2</sub> (ergocalciferol) and vitamin D<sub>3</sub> (cholecalciferol) are the two major, naturally occurring forms.<sup>48</sup> Both are found in dietary supplements, but some evidence indicates that ergocalciferol (D<sub>2</sub>) is less potent than cholecalciferol (D<sub>3</sub>).<sup>48</sup> D<sub>2</sub> is found in mushrooms.<sup>18</sup> D<sub>3</sub> is found in animal foods; it is used to fortify milk and cereal; in addition, provitamin D<sub>3</sub> in skin is converted into vitamin D<sub>3</sub> by exposure to ultra violet B (UVB) radiation.<sup>49</sup> Vitamin D is classified as a nonessential nutrient because it can be synthesized by exposure of skin to sun. Both D<sub>2</sub> and D<sub>3</sub> require hydroxylation by the kidney and liver to be converted into active vitamin D, 1,25-dihydroxyvitamin D (1,25(OH)<sub>2</sub>D), also called calcitriol.<sup>48,50</sup> Blood level of 25-hydroxyvitamin D (25(OH)D) is used to measure body status of vitamin D, and it reflects dietary and cutaneously synthesized vitamin D.<sup>51</sup> A blood value of 25–80 ng/mL has been described as the target range for 25(OH)D.<sup>48</sup> Vitamin D promotes intestinal calcium and phosphorus absorption, regulating bone metabolism, and controlling parathyroid hormone secretion.<sup>48</sup> Every tissue and cell has a vitamin D receptor,<sup>53</sup> and vitamin D performs diverse roles body-wide including that it regulates arterial blood pressure; modulates immunological responses, regulates insulin production,<sup>49</sup> modulates male and female reproductive processes,<sup>52</sup> and it is necessary for neuromuscular function.<sup>53</sup> It has been estimated that 25%–50% or more of patients encountered in clinical practice are vitamin D deficient.<sup>45</sup> The Centers for Disease Control and Prevention have reported that 30% of whites and 5% of blacks have sufficient vitamin D levels, using 25-hydroxyvitamin D of  $\geq 30$  ng/mL as a marker of vitamin D adequacy.<sup>45</sup> Symptoms of hypovitaminosis D include bone pain, myalgias, and generalized weakness, and laboratory values will include 25(OH)D  $< 25$  ng/mL, normal calcium and phosphorus blood levels, elevated or high-normal levels of PTH, normal to elevated levels of alkaline phosphatase, and a low 24-h urine calcium excretion rate.<sup>45</sup> Common risk factors for vitamin D deficiency include decreased intake, GI malabsorption, hepatic or renal disease, use of certain medications that suppress vitamin D absorption, obesity, and decreased skin synthesis of vitamin D caused by older age, low sun exposure (indoor occupation, time of day, season, latitude), use of sunscreens, and ethnicity (other than Caucasian).<sup>45,47</sup>

### *scientific findings*

Vitamin D deficiency has been linked to an increased risk of autoimmune diseases.<sup>47,48</sup> Bone manifestations of vitamin D deficiency include osteomalacia in adults and rickets in children,<sup>45</sup> increasing risk of



fracture.<sup>53</sup> Vitamin D deficiency in athletes has been linked to decreased physical performance and a predisposition to stress fractures.<sup>54</sup> A study that searched the literature for evidence of a cancer–vitamin D relationship yielded 63 observational studies of vitamin D status in relation to cancer risk, including 30 of colon, 13 of breast, 26 of prostate, and 7 of ovarian cancer, and several that assessed the association of vitamin D receptor genotype with cancer risk. The majority of studies found a protective relationship between sufficient vitamin D status and lower risk of cancer.<sup>55</sup> The greatest risk for cancer appears to be associated with 25(OH)D levels below 20 ng/mL.<sup>56</sup> Vitamin D intake may play a key role in the prevention of cardiovascular disease.<sup>57</sup> Vitamin D deficiency is often present in patients with chronic obstructive pulmonary disease and evidence suggests that vitamin D plays a role in the lung pathology of patients with chronic obstructive pulmonary disease.<sup>58</sup> The relation between Vitamin D deficiency with depressive and fatigue symptoms in healthy populations and patients with multiple sclerosis have been reported.<sup>59</sup> Poor vitamin D status was significantly associated with increased depression symptoms in a study (n = 178) of pregnant African-American women.<sup>60</sup>

Chronic vitamin D deficiency is associated with an increased risk of type 1 and type 2 diabetes.<sup>53</sup> Vitamin D deficiency has been associated with decreased spermatogenesis and decreased male fertility,<sup>61</sup> while vitamin D is positively associated with semen quality and androgen status.<sup>52</sup>

Vitamin D might influence steroidogenesis of the sex hormones estradiol and progesterone in healthy women and high 25(OH)D levels might be associated with endometriosis.<sup>52</sup> Population research suggests that lower 25(OH)D levels are associated with a higher risk of developing hypertension compared to people with higher vitamin D levels.<sup>51</sup> Hypovitaminosis D is considered to be an important environmental factor associated in the etiology of multiple sclerosis according to physiological, experimental, epidemiological, immunological, and biological studies.<sup>59</sup> Vitamin D plays a role in skeletal muscle health and function; and vitamin D deficiency is characterized by myopathy; muscle weakness and atrophy.<sup>56</sup> Vitamin D deficiency in athletes has been linked to decreased physical performance.<sup>54</sup> Adequate vitamin D intake in pregnancy is optimal for maternal, fetal, and child health. Adverse health outcomes of low vitamin D status during pregnancy include preeclampsia; gestational diabetes mellitus, and caesarean section, while consequences to newborns include increased risk of low birth weight, neonatal rickets, neonatal hypocalcaemia, asthma, and/or type 1 diabetes.<sup>62</sup> Population research suggests that low vitamin D levels are associated with increased risk of upper respiratory infection in children.<sup>53</sup>

*bioactive dose*

The RDA for adults aged 19–50, who are vitamin-D-adequate, is 600 IU.<sup>63</sup> Eight ounces of vitamin-D fortified milk (note not all dairy products are fortified with vitamin D) supplies approximately 100 IU. The vitamin D RDA was based upon the amount of vitamin D needed to maintain adequate bone mineral density not on the extra-skeletal roles of vitamin D.<sup>51</sup> Hypovitaminosis D (25(OH)D <10 ng/mL) has been treated with 50,000 IU of vitamin D orally once weekly for 2–3 months or three times weekly for 1 month, though the practice has not been validated in clinical trials.<sup>48</sup>

*safety*

A UL of 4000 IU/day has been established for adults aged 19–50. Vitamin D toxicity is “extremely rare and generally only occurs after ingestion of large doses of vitamin D (>10,000 IU) for prolonged periods in patients with normal gut function or in patients who may be concurrently ingesting generous if not excessive amounts of calcium.”<sup>48</sup> Most patients with vitamin D toxicity have levels of 25(OH)D > 150 ng/mL, hypercalcemia, and usually, but not always, hypercalciuria and hyperphosphatemia.<sup>48</sup>

*Vitamin E**definition*

Fat-soluble antioxidant vitamin of which there are more than eight naturally occurring forms;  $\gamma$ -tocopherol is the predominate form in foods<sup>64</sup> though  $\alpha$ -tocopherol and other tocopherols are also found in foods.<sup>65</sup> In addition to vegetable oils and products made from them, such as salad dressing, nuts, seeds, whole grains, and certain fruits and vegetables are sources of vitamin E. Vitamin E serves as an antioxidant, and is involved in immune function, cell signaling, regulation of gene expression, various metabolic processes, and inhibits platelet aggregation.<sup>66</sup> Consuming salad and salad dressing promoted adequate vitamin E intake in a dietary examination study (n = 9466 women and 8282 men).<sup>45</sup> Vitamin E deficiency is rare and most commonly occurs in people with malabsorption disorders such as abetalipoproteinemia; cystic fibrosis; gastrectomy; hepatic-biliary tract disease including chronic cholestasis, hepatic cirrhosis, biliary atresia, and obstructive jaundice; in infants receiving formula with insufficient vitamin E; and in intestinal disease, such as celiac disease and regional enteritis.<sup>18</sup>

*scientific findings*

$\gamma$ -tocopherol, but not  $\alpha$ -tocopherol, inhibits cyclooxygenase activity and, thus, possesses anti-inflammatory properties.<sup>64</sup> Some human and animal studies indicate that plasma concentrations of  $\gamma$ -tocopherol are inversely associated with the incidence of cardiovascular disease and prostate cancer.<sup>64</sup> Different forms of vitamin E appear to exert different effects on prostate cancer, with  $\alpha$ -tocopherol potentially increasing and  $\gamma$ -tocopherol potentially decreasing risk of the disease.<sup>67</sup> Extensive evidence has demonstrated that many antioxidants, such as vitamin E, have protective effects in preventing cardiovascular disease.<sup>68</sup> Some population study data suggest that increasing dietary vitamin E from food is associated with a reduced risk of prostate cancer, but other population study data suggest that increasing food vitamin E is not associated with prostate cancer risk.<sup>18</sup>

*bioactive dose*

The RDA is 15 mg/day of  $\alpha$ -tocopherol for adults aged 19–50. This is equivalent to 22 IU of natural vitamin E or 33 IU of synthetic vitamin E.<sup>18</sup>

*safety*

A UL of 1000 mg for adults aged 19–50 (approximately equivalent to 1100 IU of synthetic vitamin E or 1500 IU of natural vitamin E<sup>69</sup>) has been established.

*Vitamin K (Phylloquinone)**definition*

Fat-soluble vitamin that functions as a coenzyme in the synthesis of proteins involved in blood coagulation and bone metabolism.<sup>16</sup> Vitamin K occurs as phylloquinone, also called vitamin K1, and menaquinone, also referred to as vitamin K2. Phylloquinone is concentrated in dark green, chlorophyll-rich leafy vegetables, such as collards and spinach; in addition, certain plant oils including soybean, canola, cottonseed, and olive, and products made from them, such as margarine and salad dressings, are important dietary sources of phylloquinone.<sup>70</sup> Menaquinone is primarily the product of bacterial production or conversion from dietary phylloquinone or is consumed as menaquinone-4 found in kidney, milk, butter, and cheese.<sup>70</sup> The vitamin gets its name for the Danish word “koagulation.”

### scientific findings

Low circulating vitamin K levels have been observed in subjects with reduced bone mineral density in two of three observational studies.<sup>16</sup> Vitamin K intakes were inversely associated with the risk of hip fracture in a large observational study (n = 71,327 women aged 38 to 63).<sup>16</sup> Vitamin K deficiency increases prothrombin time.<sup>16</sup> Evidence from randomized controlled trials (n = 32 subjects) on the benefits of routine vitamin K supplementation for people with cystic fibrosis is weak and limited to two studies of limited duration.<sup>71</sup>

### bioactive dose

The AI is 90 µg for women and 120 µg for men aged 19–50. Vitamin K1 (phytonadione) 2.5–25 mg is administered to newborns to prevent hypoprothrombinemia and hemorrhage.<sup>18</sup>

### safety

No UL has been established for vitamin K.

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# W

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## *Walnut (Juglans regia L.)*

### *definition*

Also called English walnut. Common tree nut that is a source of protein, monounsaturated fatty acids, polyunsaturated fatty acids, including omega-3 fatty acid, carotenoids, phytosterols, flavonoids, proanthocyanidins, phytates, and lignans.<sup>1</sup>

### *scientific findings*

A small, randomized clinical trial (n = 18 healthy men) found that replacing 20% of calories from high-fat foods in the diet with walnuts within a cholesterol-lowering diet for 4 weeks decreased serum levels of total cholesterol.<sup>2</sup> Some research suggests that people who increase consumption of walnuts and other nuts might have a lower risk of coronary heart disease and death due to coronary events, and that substituting walnuts for other dietary fats may improve HDL and cholesterol-to-total-cholesterol ratios in patients with type 2 diabetes.<sup>3</sup>

### *bioactive dose*

Not known. “For lowering cholesterol, approximately 30–56 grams English walnuts (about 1/4 to 1/2 cup or 8 to 11 nuts) has been substituted for other dietary fats.”<sup>3</sup>

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals. Allergic and fatal anaphylactic reactions to walnuts have been reported.<sup>4</sup>

*Wasabi (Wasabia japonica)*

Wasabi. (Image from martin/Shutterstock.)

*definition*

Also known as Japanese radish, a pine-cone-shaped *Brassica* vegetable that is ground into a pungent sushi condiment. It contains isothiocyanates.<sup>5</sup>

*scientific findings*

In laboratory studies, *Wasabia japonica* killed *Helicobacter pylori*,<sup>6</sup> exhibited detoxification, anti-inflammation, cancer cell apoptosis, and colon cancer cell apoptosis.<sup>7</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals, except for the adverse effects of extreme burning sensations.

*Water**definition*

Essential nutrient necessary for many functions, including hydration and maintenance of adequate blood volume and blood pressure, regulation of body temperature, and transporting nutrients, oxygen, and other substances in blood. Total water intake includes drinking water, water in nonalcoholic beverages, and water (moisture) in foods. There are no uniform standards for water purity. Collecting urine for 24 h to measure the volume of urine produced is a proxy of water intake.<sup>8</sup> The normal range for 24-h urine volume is 800–2000 mL/day (with a normal fluid intake of about 2 L/day).<sup>9</sup> Hydration status is assessed by several methods, the primary indicator being plasma or serum osmolality<sup>8</sup> that measures the concentration of chemical particles found in the fluid part of blood (and normal values range from 275 to 295 milliosmoles/kilogram).<sup>10</sup>

*scientific findings*

Hard water is a source of magnesium and calcium, which are associated with the maintenance of normal blood pressure, while soft water is higher in sodium and can aggravate high blood pressure and heart disease.<sup>11,12</sup> Effects of dehydration include metabolic and functional abnormalities, and low intake of water is associated with some chronic diseases.<sup>8</sup>

*bioactive dose*

The AI for total water is 2.7 L/day for women and 3.7 L/day for men aged 19–50 years, which is met by drinking water and nonalcoholic beverages and eating fruits, vegetables, and other foods<sup>8</sup>; however, water needs are highly variable based on size, body composition, physical activity level, climate, and other factors,<sup>13</sup> and therefore water intake exceeding the AI is required for individuals, including athletes.

### *safety*

Although no UL has been established for water, excessive water intake, without concomitant electrolyte consumption, can cause water intoxication and hyponatremia that is potentially life-threatening.

## *Watercress (Nasturtium officinale)*



Watercress. (Image from Binh Thanh Bui/Shutterstock.)

### *definition*

Dark green *Brassica* salad vegetable whose small leaves and soft stems have a radish-like flavor. Watercress is a good source of calcium<sup>14</sup> and is also a source of lutein and carotenes.<sup>15</sup> Watercress has been traditionally used as an antioxidant, anti-inflammatory, hypolipidemic, and cardioprotective agent.<sup>15</sup>

### *scientific findings*

In an experimental study in animals, watercress juice protected cells and did not damage DNA.<sup>16</sup> In a single-blind, randomized, crossover study (n = 30 smokers and 30 nonsmoking men and women, mean age 33 years), subjects were fed 85 g raw watercress daily for 8 weeks in addition to their usual diet. The effect of watercress supplementation was measured on a range of end points, including DNA damage in lymphocytes, activity of detoxifying enzymes (glutathione peroxidase and superoxide dismutase) in erythrocytes, plasma antioxidants (retinol, ascorbic acid,  $\alpha$ -tocopherol,

lutein, and  $\beta$ -carotene), plasma total antioxidant status, and plasma lipid profile. Watercress supplementation in the treated group compared to the control group was associated with beneficial reductions in markers of DNA damage, and plasma lutein and  $\beta$ -carotene increased significantly, with beneficial changes being more significant in smokers than in non-smokers after watercress supplementation.<sup>15</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Watermelon (Citrullis lanatus)*

### *definition*

Member of the cucumber and squash family that includes fruits of different sizes, shapes, rind patterns, and flesh colors.<sup>17</sup> Watermelon contains a relatively high sugar content, consisting of sucrose, fructose, and glucose,<sup>18</sup> and is a source of lycopene.<sup>19</sup> Eaten fresh, alone, or in fruit salads; its pickled rind is eaten in certain cultures.

### *scientific findings*

A case-control study (n = 438 Chinese women age matched to n = 438 controls) that examined dietary intake and breast cancer risk found consumption of the “watermelon/papaya/cantaloupe” fruit group was significantly inversely associated with breast cancer risk.<sup>20</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Wheat germ*

### *definition*

Wheat grain embryo that contains high concentrations of unsaturated fats, protein, and vitamin E, it is removed from the grain to reduce grain

perishability when whole grains are refined. Eaten by the spoonful or sprinkled onto other foods.

### *scientific findings*

In animal studies, wheat germ improved markers of antioxidant status in animal tissues.<sup>21</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

## *Whey*

### *definition*

Complete protein found within the watery portion of milk. Whey comprises 20% of milk protein, while casein makes up 80%.<sup>22</sup> Cheese is a source of whey, and whey is filtered from milk to make cheese. Greek-style yogurt has most of the water and whey strained out, whereas thin-style (non-Greek) yogurt contains whey. Whey contains lactose and provides more than 20% of the DV for calcium per cup.<sup>23</sup>

### *scientific findings*

Whey has exerted chemoprotective, anti-HIV effects, and reduced body weight gain relative to red meat consumption in laboratory animals.<sup>24–26</sup> In healthy and type 2 diabetes subjects, whey protein has exerted insulinotropic and glucose-lowering properties, according to a review that theorized whey protein may generate bioactive products during digestion that stimulate the release of gut hormones that in turn regulate food intake or potentiate insulin secretion.<sup>22</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# X

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## *Xeaxanthin*

### *definition*

Also spelled *xeaxanthin*. Xanthophyll carotenoid that occurs commonly with lutein in foods. Rich sources of xeaxanthin include egg yolk, dark green leafy vegetables, orange bell pepper, kiwi fruit, grapes, spinach, zucchini, corn, and squash.<sup>1,2</sup>

### *scientific findings*

The macular region of the retina is yellow owing to the presence of macular pigment, consisting largely of lutein and xeaxanthin.<sup>2</sup> The amount of macular pigment correlates with dietary intake of lutein and xeaxanthin and other factors,<sup>3</sup> and may be protective against age-related macular degeneration according to epidemiological evidence.<sup>2</sup> Laboratory data suggest inverse correlations between plasma xanthophyll carotenoids and oxidative damage in DNA and lipids.<sup>4</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# Y

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## *Yam (Dioscorea rotundata)*



Yam. (Image from jiangdi/Shutterstock.)

### *definition*

Tuber root vegetable that is long and cylindrical whose flesh, depending on species, can range from off-white to yellow or pink or purple, with skin that is off-white to dark brown.<sup>1</sup> Yam differs from the darker orange sweet potato, *Ipomoea batatas*, which is classified under a different botanical family, and because yams are not dark orange in color, their vitamin A content is much lower than sweet potatoes. Approximately 150 different species of yam are commercially cultivated, and white yam (*D. rotundata*) is the most predominant yam species produced worldwide.<sup>2</sup> In traditional folk medicine, yams have been used to treat menopausal symptoms. Yam contains natural steroid precursors but does not have oral contraceptive properties, contrary to popular belief that the phytochemical diosgenin found in wild yam is used to manufacture human steroidal hormones, such as dehydroepiandrosterone, though “taking wild yam extract will not increase dehydroepiandrosterone levels in humans.”<sup>3</sup> Yams are baked, boiled, or fried. They are a good source of fiber and an excellent source of vitamin C, folate, and potassium.<sup>4</sup>

### *scientific findings*

In a clinical trial (n = 24 postmenopausal women), replacing a staple food with 390 g of the *Dioscorea alata* species of yam per day for 30 days increased serum levels of sex hormones (estrone, sex hormone binding globulin, and estradiol) compared to a control group (n = 19 healthy postmenopausal women) fed 240 g of sweet potato for 41 days who had no change in serum levels of hormones.<sup>5</sup> A laboratory study found yam extract to protect against cancer proliferation in human breast cancer cells.<sup>6</sup>

### *bioactive dose*

Not known.

### *safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# Z

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## *Zinc*

### *definition*

Trace mineral necessary for immune function, growth, protein and DNA synthesis, wound healing, and taste and sense perception.<sup>1,2</sup> Rich sources of zinc include red meat, seafood, such as oysters, crab and lobster, whole grains, and zinc-fortified breakfast cereals.<sup>3</sup> The median intake of zinc for adults exceeds the zinc RDA (median intake for women is 9 mg/day and for men is 13 mg/day<sup>3</sup>).

### *scientific findings*

Certain individuals may be at risk for zinc deficiency, including vegetarians and vegans who ingest insufficient amounts; people who have severe diarrhea or malabsorption syndromes (e.g., due to weight loss surgery, or digestive disorders, such as ulcerative colitis or Crohn's disease); liver cirrhosis; after major surgery; during long-term administration of total parenteral nutrition; older infants who are breastfed because breast milk does not have enough zinc for infants over 6 months of age; alcoholics due to their limited, unvaried diet, and because alcohol decreases zinc absorption and increases urinary zinc excretion; and possibly people with sickle cell anemia.<sup>1,4</sup> Zinc deficiency symptoms include slowed growth in children, delayed sexual development in adolescents, impotence in men, hair loss, diarrhea, eye and skin sores, a loss of appetite, impaired immune function, decreased taste sensation, weight loss, delayed wound healing, and reduced mental alertness.<sup>3</sup> Zinc deficiency decreases spermatogenesis and impairs male fertility.<sup>5</sup> Zinc adequacy is necessary for male fertility for testicular development, sperm maturation, and testosterone synthesis; and for female fertility because it plays a role in female sexual development, ovulation, and the menstrual cycle.<sup>6</sup>

### *bioactive dose*

The RDA for adult women (aged 19–50 years) is 8 mg/day and for adult men (aged 19–50 years) is 11 mg/day.

*safety*

An UL of 40 mg/day has been established for adult men and women aged 19–50 years.

*Zucchini (Cucurbita pepo)*

Zucchini. (Image from unverdorben jr/Shutterstock.)

*definition*

Mild-flavored, white-fleshed vegetable that resembles a cucumber in its cylindrical shape and green skin. It supplies >1000 IU per 1/2 cup cooked, in addition to cucurbitosides, flavonoids, triterpenes, sterols, lutein, and zeaxanthin.<sup>7,8</sup> Zucchini is commonly stir-fried, used in casseroles, or cooked with tomato as an ingredient in ratatouille; zucchini may be cut into ribbons and substituted for fettucini.<sup>9</sup>

*scientific findings*

Zucchini contains substantial amounts of lutein and zeaxanthin whose intake is associated with a decreased risk of age-related macular degeneration.<sup>10</sup>

*bioactive dose*

Not known.

*safety*

Presumed safe when consumed in normal dietary quantities by non-allergic individuals.

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# Appendix

*Table A1* Major phytochemical groups and specific phytochemicals addressed in this guide

Major phytochemical category	Specific phytochemicals in foods addressed in this guide
Dietary fiber	Insoluble fiber <ul style="list-style-type: none"> <li>• Cellulose</li> <li>• Lignin</li> </ul> Soluble fiber <ul style="list-style-type: none"> <li>• Beta-glucan</li> <li>• Fructooligosaccharide</li> <li>• Pectin</li> </ul>
Fatty acids	Monounsaturated fatty acids Polyunsaturated fatty acids <ul style="list-style-type: none"> <li>• Linoleic acid (omega-6-fatty acid)</li> <li>• Linolenic acid (omega-6 fatty acid)</li> </ul>
Glucosinolates	Aglycones Indoles <ul style="list-style-type: none"> <li>• Piperine</li> </ul> Isothiocyanates <ul style="list-style-type: none"> <li>• Sulforaphane</li> </ul> Organosulfur compounds, also called sulfur compounds or sulfides <ul style="list-style-type: none"> <li>• Allyl sulfides</li> <li>• Thiols</li> </ul>
Phenolic compounds	Aromatic acids <ul style="list-style-type: none"> <li>• Phenolic acids (chlorogenic acid, ferulic acid, syringic acid, vanillic acid)</li> <li>• Hydroxycinnaminic acids (caffeic acid, chlorogenic acid, ferulic acid, gingerol)</li> </ul>

(Continued)

Table A1 (Continued) Major phytochemical groups and specific phytochemicals addressed in this guide

Major phytochemical category	Specific phytochemicals in foods addressed in this guide
Terpenoids	Capsaicin
	Polyphenols
	• Curcuminoids (curcumin)
	• Flavonoids (anthocyanins, catechins, chalcones, flavanols, flavones, flavonols, flavanones, glycosides, glycoalkaloids)
	• Isoflavonoids (isoflavones)
	• Lignans (lignan)
	• Stilbenoids (resveratrol, stilbene)
	• Tannin
	Monoterpenes
	• Limonene
	Diterpenes
	• Retinol
	Tetraterpenes
	• Carotenoids (carotenes, xanthophylls)
	Triterpenoids
	• Glycosides
	Steroids
	• Stanols
	• Sterols
	• Tocopherol

# the A-Z Guide to Food as Medicine

**The A-Z Guide to Food as Medicine** is a dictionary for health care professionals that indexes more than 250 foods, food groups, nutrients, and phytochemicals, organized into entries that include:

- Definition, description, use, and unique properties
- A summary of scientific findings about physiological effects
- Bioactive dose (when known)
- Safe consumption information

Written by a clinical nutritionist and a pharmacognocist, the guide highlights bioactive components of foods and physiological effects of nutrients and phytochemicals, according to what is reported in the scientific literature.

Given the plethora of pseudoscientific information available, the guide is an authoritative resource that helps readers understand the current evidence base on a variety of foods and food constituents, from acai to zucchini, vitamin A to zinc, and alkaloids to zeaxanthin. It presents and summarizes research findings from more than 1,000 scientific articles and uses the conclusions and recommendations of reputable, peer-reviewed sources.

The guide is a significant source of nutrition information, supplying nutrients' Adequate Intakes or Recommended Dietary Allowances, physiological functions, deficiency symptoms, and descriptions of biochemical tests used to assess nutrient adequacy. Major categories of health-promoting phytochemicals are addressed, including carotenoids, fatty acids, fibers, flavonoids, glucosinolates/indoles/isothiocyanates, phenols, phytoestrogens, plant sterols, prebiotics, probiotics, saponins, sulfides, thiols, and terpenoids.

This guide serves as an expedient resource for the quick access of fact-based information about foods for both health care professionals and individuals looking to learn more about the medicinal effects of food.



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