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Second Edition

the A-Z Guide to Food as Medicine

Diane Kraft

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Second Edition

Diane Woznicki Kraft, M.S., R.D.N., L.D.N.

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Foreword

The link between diet and health has become increasingly clear. Epidemiological, laboratory, and human intervention studies have indicated that overall diets, as well as individual foods and food components, have the potential to both promote and mitigate chronic diseases such as cancer, metabolic syndrome, and cardiovascular disease. The increased research focus on the relationship between diet and health has led to a rapid growth in both the available scientific literature (as of this writing, a search of PubMed for the terms "diet" and "health" returned over 120,000 citations) and interest in the topic among scientists, clinicians, and the general public. While the growth in available data has shed light on many important questions, it also makes the topic difficult to approach for laypersons and scientists and clinicians new to the field, and creates the potential for erroneous interpretation, oversimplification, and deliberate misrepresentation of the conclusions of this large body of work.

The *A–Z Guide to Food as Medicine, 2nd Edition* provides a valuable resource to the general public, as well as scientists and clinicians who are seeking a quick reference that is authoritative and scientifically-grounded in its conclusions. Key topics addressed by this volume include whole foods, spices, and individual bioactive components and nutrients. The 2nd Edition features 15 new food entries, information about FDA-defined "good sources" of nutrients, updated scientific data on bioactive doses and effects, and a useful index which allows readers to locate specific diseases and conditions in addition to the foods and food components presented in the book.

Kraft's approach in preparing this volume is highly effective. The presentation of the scientific binomial name as well as the common name of the plants discussed provides the reader with unambiguous identification. There is no confusion of whether a section on sweet potatoes (*Ipomoea batatas*) is actually about yams (*Dioscorea spp.*). The succinct definition and summary of the scientific findings for each entry make it clear to the reader what is being discussed and what has been reported. Finally, the inclusion of sections on "Bioactive Dose" and "Safety" provide answers, when data is available, to two questions frequently asked by both the general public

and clinicians. Each entry is supported by numerous primary research papers, peer-reviewed review articles, and scholarly monographs. These references provide lay readers with access to the underlying literature, but are a particularly useful entrée for scientists and clinicians new to the field of food and health.

The *A–Z Guide to Food as Medicine, 2nd Edition* is a useful addition to the scientific reference literature on the relationship between food and health. Kraft has done an outstanding job of writing a volume that is approachable by a wide audience, but provides the scientific accuracy and nuances necessary to avoid the overstated claims and popular myths that are all too common in books about this topic. I highly recommend this volume to anyone, layperson, scientist, or clinician, with an interest in the relationship between food and health.

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Preface

The 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.[1] In contrast to the folkloric use of foods as medicine, where "an apple a day kept the doctor away" for reasons unknown, modern science:

- has isolated immunomodulatory phytochemicals in apples;
- is testing their effects in various disease states;
- suggests a number of servings (a bioactive dose) of fruits that, in the context of a balanced diet, help to maintain health and avert disease;[2] and
- is observing trends in epidemiological studies (suggestive but inconclusive) in consumption of specifically white-fleshed fruits (and vegetables) and decreased rates of certain diseases.

Phytochemicals, literally "plant chemicals," are produced by the plant for survivability, that is, as protection against pathogens and pests,[1] and these same bioactive ingredients impart health benefits to the consumer. For example, glucosinolates in *Brassica* vegetables are plant-protective[2] and have been shown to exert anticancer properties when consumed.[3] Major categories of health-promoting phytochemicals addressed in *The Guide* include: alkaloids; carotenoids; fatty acids; fibers; flavonoids; glucosinolates/indoles/isothiocyanates; phenols, phenolics; phytoestrogens/isoflavones; plant sterols; prebiotics/probiotics; saponins; sulfides; thiols; and terpenoids. The actions of phytochemicals in the diet are characterized by Dillard and German as follows:[4]

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.

A single food contains many dozens of bioactive ingredients that are beneficial to health. Phytochemicals also impart physical attributes to foods such as aroma, flavor, texture, and color. Unique phytochemicals occur in like-colored plant foods, so consumers are advised to ingest a variety of different colored fruits and likewise vegetables, as well as other plant foods, to purposefully ingest the greatest array of micronutrients, phytochemicals, and other bioactive constituents. Major public health recommendations and food guidance suggest that a plant-based diet is the optimal approach to maintaining health and preventing disease.

The A-Z Guide to Food as Medicine, 2nd Edition is a dictionary of the bioactive effects of more than 250 foods, food groups, nutrients, and phytochemicals, presented in concise summaries that include:

- Definition (common and historical medicinal use and characteristics important to understanding properties and function)
- Scientific Findings relevant to known or potential physiological function
- Bioactive Dose, when known, such as:
  - Recommended Dietary Allowances (RDAs) and Adequate Intakes (AIs), that are daily goal amounts for micronutrient, fiber, and water intake;
  - Acceptable Macronutrient Distribution Ranges (AMDRs) that are daily recommended amounts for the macronutrients protein, fat, and carbohydrate; and
  - Recommended numbers of daily servings of foods from the dairy, fruit, vegetables, protein foods, and grains group
- Safety data, such as Tolerable Upper Intake Levels (ULs) for nutrients, as well as adverse effects and precautionary information, when known, for foods and their non-nutrient constituents.

The Guide is intended to be a clinician handbook for use by health professionals and provides consumer information according to what has been reported in the scientific literature. Only enteral, and not topical, uses of phytochemicals are addressed, and only naturally occurring foods and food constituents are addressed while dietary supplements are not,

because their physiological effects may be due to dose; so while dietary supplements are not addressed as dictionary entries, studies using nutrient or phytochemical supplements to elicit a measurable effect may be cited.

Regarding the Scientific Findings and Bioactive Dose sections, the reader is aware that in vitro and animal studies do not prove in vivo biological activity. In many cases, data about the physiological effects of a food or phytochemical are limited to laboratory research. By providing such preliminary data, *The Guide* is informing the reader that the research is in its infancy. Health professionals are urged to use the information to explain the current evidence base to the consumer: it would not be prudent to consider making dietary changes based on preliminary data.

Rarely have individual foods or non-nutrient phytochemicals been sufficiently studied in well-designed, adequately powered clinical trials necessary to establish their physiological effects. In these many cases, a bioactive dose is not known. Bioactive doses are known for the majority of nutrients, fiber, and for certain food groups; they are intended to be used as daily intake goal amounts by healthy adults for the age ranges specified.

The Guide features diet and nutrition information indexed with easy-find, alphabetical tabs, and the Index, in addition to listing food constituents, has been updated to include diseases and conditions. New to the 2nd edition are more than a dozen new foods, updated Scientific Findings sections, and the addition of several nutrients: *The Guide* now addresses *all* nutrients that have a Dietary Reference intake. Nutrient entries feature "good" and "excellent" food sources and corresponding % DVs are displayed. *The Guide* is a comprehensive vitamin, mineral, and macronutrient resource that summarizes sources, dose, deficiency, and assessment data.

Most whole foods are known to be safe as long as the caveats of good science and common sense are observed:[1]

1. Most common foods and food constituents are Generally Recognized as Safe by FDA and therefore 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, and, when harmful levels are known, they are included in the Safety section of each entry.

3. All data provided in *The Guide* are intended to enhance diet and nutrition knowledge in keeping with clinical nutrition evidence-based practice guidelines that will educate consumers to improve their proficiency in communicating with their physicians on diet-related decision-making.
4. Non-nutrient phytochemicals, such as flavonoids and antioxidants, are probably best utilized by the body when provided as part of the whole food matrix rather than as individual entities. The whole food is preferable as a source of nutrients and phytochemicals (with few exceptions), as opposed to taking a concentrated source of a nutrient or phytochemical via a dietary supplement, unless advised to do so by a physician. This is because the numerous symbiotic elements contained within foods are working in concert with one another, both enhancing the beneficial elements and diluting the less desirable elements.

Diane Woznicki Kraft, M.S., R.D.N., L.D.N.

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Diane Woznicki Kraft, M.S., R.D.N., L.D.N., holds a Master of Science degree in Clinical Nutrition from New York University and a Bachelor of Science degree in Human Nutrition from Penn State. Kraft is a nutrition educator at Alvernia University in Reading, PA. She has written or been quoted on nutrition in over 100 consumer nutrition articles, including in *USA Today,* and has edited chapters in science text books, including the dietary supplement chapter of *The Merck Manual*. With colleague Ara Der Marderosian, Kraft coauthored *The A-Z Guide to Food As Medicine,* nutrition book recipient of a 2017 American Library Association Outstanding Academic Title award. The updated *Guide* is a nutrition reference for healthcare professionals that addresses physiological aspects of foods, food groups, nutrients, and phytochemicals.

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A

Açaí Berry (Euterpe oleracea)

Acai fruit. (Image from diogoppr/Shutterstock.)

Definition

Small, dark purple fruit of the South American açaí palm known for its antioxidant properties due to constituents such as polyphenols.[1,2] Available as a pure juice but typically sold mixed with other juices as a juice blend, pureed, or in dehydrated, powdered form.

Scientific Findings

In laboratory testing, açaí juice inhibited low-density lipoprotein (LDL) oxidation and exerted an antioxidant potency greater than cranberry juice but less than pomegranate juice.[3] Açaí pulp reduced hypercholesterolemia in animal models.[4] In healthy human volunteers (n = 12), açaí berry juice and pulp significantly increased plasma antioxidant capacity measured 12 and 24 hours after consumption, but it did not affect several other markers of antioxidant activity, such as urine antioxidant capacity.[5] A small, open-label study of healthy overweight adults (n = 10) found that consuming 100 g (approximately ½ a cup) of açaí pulp for one month reduced mean plasma fasting insulin levels, total cholesterol, and post-prandial plasma glucose.[2] Açaí berry is an excellent source of vitamin A and a good source of vitamin C and potassium.[6]

Bioactive Dose

Not known.

Safety

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

Alfalfa (Medicago sativa)

Definition

Legume that yields seeds which are made into tea and used medicinally,[7] and sprouts that are eaten fresh, stir-fried, and juiced. The major bioactive components of *M. sativa* include saponins, flavonoids, phytoestrogens, coumarins, alkaloids, amino acids, phytosterols, vitamins, digestive enzymes, and terpenes.[8] *M. sativa* has a history of use in nervous and digestive system disorders and is an ancient plant whose name derives from the words "father of all foods."[8]

Scientific Findings

M. sativa has exhibited neuroprotective, hypolipemic, antioxidant, antiulcer, antimicrobial, and estrogenic properties in vitro.[8,9] A small clinical trial of hypercholesterolemic subjects (n = 15) eating 40 g of alfalfa seeds three times daily with meals for 8 weeks reduced the elevated total and LDL cholesterol.[10] Saponins in alfalfa seeds decreased intestinal absorption of cholesterol by promoting fecal excretion of bile in animal studies.[11,12]

Bioactive Dose

Not known.

Safety

Alfalfa herb and seed are GRAS (Generally Recognized as Safe) by the FDA; however, alfalfa seeds and sprouts have the potential for bacterial contamination and should be avoided by children, older adults, and immune-compromised individuals.[13] Chronic ingestion of alfalfa seeds has been associated with increasing the symptoms of autoimmune diseases.[7] Furthermore, the long-term safety of alfalfa seeds has not been adequately studied and, therefore, are not recommended.[14] 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.[7] When the alfalfa herb is prepared and used as a tea as described above, it is presumed to be safe for use by adults.[7]

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 onions *(Allium cepa)*, shallots *(Allium ascalonicum)* garlic *(Allium sativum)*, green onions *(Allium macrostemon)*, leeks *(Allium porrum)*, scallions *(Allium tartaricum)*, chives (*Allium schoenoprasum*) and others. Their pungent flavor and odor, whether eaten fresh or cooked, are due to organosulfur compounds, such as allyl derivatives,[15] which are also thought to be largely responsible for allium health attributes; and they are also a source of quercetin, a flavonoid.[16] Allium vegetables have been used for medicinal purposes throughout recorded history to increase longevity, stamina, and strength, and as an antiparasitic agent, antiseptic, antimicrobic, antipyretic, and analgesic.[17]

Scientific Findings

Allyl derivatives inhibited carcinogenesis in the stomach, esophagus, colon, mammary gland, and lungs of experimental animals and improved immune function, reduced blood glucose, and conferred radioprotection and protection against microbial infection.[18] 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 vegetables (>10.0 g/day which is approximately 1 tablespoon[19])

had a statistically significant lower risk of prostate cancer than those who consumed the lowest amount of allium vegetables daily.[20] Allium vegetable intake of > or = 1 portion per week compared with low or no consumption was associated with a reduced risk of myocardial infarction (MI) in a case-control study (n = 760 patients with a first episode of non-fatal acute MI and 682 controls).[21] 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).[22] 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."[23] A large prospective population-based cohort study (n = 1,226 older women) followed subjects free of atherosclerotic vascular disease (ASVD) and diabetes for 15 years and found that 6.2 g/day allium vegetable intake (approximately = to 1 ½ teaspoons[24]) was strongly associated with a lower risk of ASVD mortality and inversely associated with ischemic heart disease mortality and ischemic cerebrovascular disease mortality.[25]

Bioactive Dose

Small amounts of allium vegetables, ranging from 6.2 g/day (approximately 1 ½ teaspoons) to 10 g/day (approximately 1 tablespoon) have been associated with decreased risk of atherosclerotic vascular disease and prostate cancer risk, respectively.

Safety

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

Allspice (Pimenta dioica)

Definition

Dried fruit of a Caribbean tree[26] 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 component of pumpkin pie spice. *Pimenta dioica* contains numerous phytochemicals including phenolics, vanillin, eugenol, and terpenoids.[27] In traditional medicine, allspice has been used to treat hypertension, inflammation, pain, diarrhea, fever, cold, pneumonia, and bacterial infection.[30]

Scientific Findings

Laboratory studies have shown allspice to have antioxidant properties.[28,29] A review of allspice found its glycosides and polyphenols exerted antibacterial, hypotensive, anti-neuralgic, 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 anti-tumor properties on human cancer cells and their animal models."

Bioactive Dose

Not known.

Safety

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

Almond (Prunus dulcis)

Definition

Tree nut, also known as sweet almond, that is typically eaten roasted and in candy and baked products, pureed as almond butter, and made into milk. Almonds are a source of protein, alpha-tocopherol, manganese, magnesium, copper, phosphorus, and riboflavin,[30] in addition to fiber, phytosterols, and polyphenolic compounds, such as proanthocyanidins and lignans.[31] Almond fat is mostly monounsaturated;[32] approximately 50% of an almond's weight is fat.[33] Per 8 oz, almond milk supplies 450 mg of calcium and 3.75 µg (150 IU) of vitamin D compared to cow's milk that supplies 276 mg of calcium and 3 µg (124 IU) of vitamin D.[33]

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 by 7–12%, according to the results of five small human studies, two of which also found a 1.7% to 3.5% increase in HDL cholesterol.[34] Conversely, a 22-week randomized, controlled crossover-design trial of coronary artery disease patients (n = 145) found that the addition of almonds to a cholesterol-lowering diet regimen did not significantly

impact vascular function, lipid profile, or systematic inflammation.[35] Despite nuts' general reputation of being high-calorie, two randomized, controlled trials (RCTs) found that a low-calorie diet which 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.[36] 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.[37] Both studies found improvements in blood lipids in almond-supplemented groups compared to control groups.[36,37] In a third, non-placebo-controlled study (n = 20), healthy women added almonds to their diet for 10 weeks, followed by a 3-week 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."[38]

Bioactive Dose

Scientific evidence suggests, but does not prove, that eating 1.5 oz per day of most nuts, such as almonds, as part of a diet low in saturated fat and cholesterol may reduce the risk of heart disease.[39]

Safety

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

Anise (Pimpinella anisum)

Definition

Anise seeds are used as a spice and to flavor liqueurs. Though anise seeds are commonly consumed after meals to freshen breath and 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

Anise demonstrated antimicrobial, antifungal, antiviral, antioxidant, immunostimulant, muscle relaxant, analgesic, and anticonvulsant activity, reduced morphine dependence, antagonized *Helicobacter pylori, and* exerted cytotoxic activity in human prostate cancer cells in vitro.[40–43]

Bioactive Dose

For antiflatulence, an oral dose of 1 tablespoon of the tea, prepared by steeping 1–2 teaspoons of the crushed seed for 10–15 minutes and then straining, taken several times a day.[7]

Safety

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

Anthocyanins

Definition

Purple or red plant antioxidant food pigments, found in foods such as berries, black currant, blueberry, cherry, cranberry, eggplant, lingonberry, mulberry, lettuce, and strawberry.[44] Chemically classified as polyphenolic compounds, examples of anthocyanins include cyanidin, malvidin, and petunidin.[45] Used in folk medicine to treat liver dysfunction, hypertension, vision disorders, microbial infections, diarrhea, and other disorders.[45]

Scientific Findings

In laboratory research, anthocyanins demonstrated estrogenic activity that altered the 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. A comprehensive review of eight prospective, controlled interventional and observational studies (n = 390,769 participants) found no evidence to suggest that a high anthocyanin intake is inversely associated with colorectal adenomas.[46]

Bioactive Dose

Not known.

Safety

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

Antioxidant

Definition

Phytochemicals 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 inactivate metal catalysts, repairing oxidative damage, or stimulating the activity of antioxidant enzymes.[47][48] 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).[48]

Scientific Findings

Epidemiological data suggest that the intake of foods rich in vitamin E, C, and beta-carotene is associated with a decreased risk for coronary heart disease.[49] Studies support a beneficial effect of food-derived beta-carotene, vitamin C, vitamin E, lutein, and xeaxanthin in delayed progression of advanced age-related macular degeneration; while other studies have reported inconclusive findings.[49] A measure of the antioxidant capacity of a 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).[51]

Bioactive Dose

Not known and/or varies by antioxidant (*See: Bioactive Dose for Selenium, Vitamin C, and Vitamin E—each has an RDA. Note beta-carotene has no RDA*).

Safety

Varies by antioxidant (*See: Safety for Selenium, Vitamin C and Vitamin E—each has a UL*.) Beta-carotene has no UL.

Apple (Malus sylvestris)

Definition

Member of *Rosaceae* family and popular snack fruit that is available dehydrated, dried, and as sauce, juice, and cider. There are thousands of varieties of apples having fairly similar nutritional profiles. Their polyphenol content varies greatly from one variety to another and include monomers (e.g., chlorogenic acid and catechins), flavonoids (e.g., quercetin glycosides and other flavonoids), and tannins, such as procyanidins.[52] Apple pulp and cloudy apple juice are sources of the soluble fiber pectin,[53,54] while apple peel contains insoluble fiber.[55] Applesauce has been traditionally used to treat diarrhea as part of the BRAT (bananas-rice-applesauce-toast) diet.[56]

Scientific Findings

Pectin may reduce diarrhea by stimulating epithelial growth in the colon.[57] Soluble fibers slow upper gastrointestinal transit time, increase fecal water-holding ability, and promote excretion of bile acids and cholesterol. Insoluble fibers provide bulk and promote the excretion of stool. 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.[58] In a one-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.[59] A non-randomized trial of healthy subjects (n = 23) found that apples, but not apple juice, significantly reduced total and LDL cholesterol.[60] Epidemiologic studies suggest an inverse relationship between apple consumption and colon cancer risk[54] and that regular consumption of one or more apples a day may reduce the risk for lung and colon cancer.[61] Apples and apple products have been associated with beneficial effects on the risk, markers, and etiology of cancer, cardiovascular disease, asthma, and Alzheimer's Disease.[62] A prospective, population-based cohort study (n = 20,069 men and women aged 20 to 65 years free of cardiovascular diseases at baseline) found that a high intake of white-fleshed fruits may protect against stroke. Each 25-g/day (approximately ¼ of a cup) increase in white fruit (and vegetable) consumption was associated with a 9% lower risk of stroke.[63] In a laboratory analysis, apple extracts showed strong antioxidant activity.[64] Apple cider vinegar had no

effect on postprandial plasma glucose and insulin in a small, randomized clinical trial (n = 30 subjects with Type II diabetes) where half of the group received apple cider vinegar and water and the other half received water alone after each consuming 58 g of carbohydrate.[65] Procyanidins favorably modulate cancer-related processes in animal research and in vitro.[52] Anthocyanidins in cloudy apple juice antagonized colon carcinogenesis in vivo,[54] but apple juice was not cancer-preventative in a study of obese rats.[54]

Bioactive Dose

Not known.

Safety

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

Apricot (Prunus armeniaca)

Definition

Small stone-fruit member of the *Rosaceae* family that supplies, per four apricots (a standard serving): 2.8 g of fiber (10% DV), 14 mg of vitamin C (15% DV), and 2696 IU of vitamin A (89% DV) and phytochemicals including flavonoids.[66–68] In folk medicine, apricots have been used to treat hemorrhage, infertility, eye inflammation, and spasm.[69]

Scientific Findings

Apricots bound bile acids in an in vitro study.[70] Soluble fiber binds bile acids and cholesterol in the intestine, promoting their excretion, thereby reducing serum cholesterol.

Bioactive Dose

Not known.

Safety

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

Artichoke (Cynara scolymus)

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

Definition

Herb whose name derives from the Greek word *cynara* meaning "dog" that refers to the spines on the flowering head resembling a dog's tooth.[71] Removal of the artichoke's outer leaves reveal petals with edible bases, held in place by a core (artichoke "heart") that is the main edible portion. Artichokes are cooked by steaming or boiling, but jarred artichokes, packed in salt water or pickled, are commonly eaten in salads. Artichoke hearts contain both soluble and insoluble fiber and are a good source of fiber, vitamin C, folate, and magnesium.[72] Artichoke's phytochemicals include caffeic acid and flavonoids.[73]

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.[74] 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.[75] 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 four hours after a meal containing boiled wild artichoke, white bread,

refined olive oil, and lemon juice, and a control meal that did not contain boiled artichoke. The boiled artichoke meal, compared with the control meal, reduced postprandial serum glucose and insulin response in normal subjects but had no effect on patients with metabolic syndrome or on homocysteine levels in either group.[76]

Bioactive Dose

Not known.

Safety

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

Arugula (Eruca sativa)

Definition

Also called "rocket," this aromatic *Brassicacea* salad green makes a distinctively earthy tasting salad or may be finely chopped and combined with garlic, parmesan cheese, and seasonings to make pesto. A good source of vitamin K[77] and glucosinolates.[78] *Eruca sativa* seed extract has been used to treat skin disorders in traditional Middle Eastern medicine.[79] Arugula seeds are used to grow microgreens used in salads and as a garnish.

Scientific Findings

Arugula (*Eruca sativa* cv. *Sky*) extract exhibited antioxidant properties in vitro in human colon cancer cells.[80]

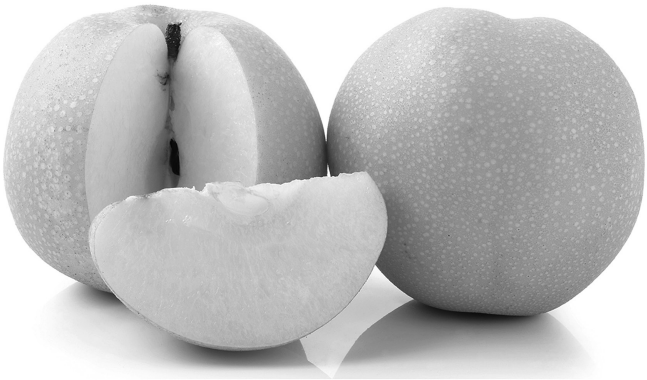
Bioactive Dose

Not known.

Safety

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

Asian Pear (Pyrus pyrifolia)



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

Definition

Crisp-fleshed, juicy pear, sometimes called Asian apple pear or Japanese pear. It resembles a yellow apple with rough, sandpaper-like skin, and it tastes like a watered-down apple.[81] A source of malaxinic acid, a phenolic acid compound found mainly in pears, and they contain 4 g fiber (14% DV) per medium fruit.[82,83]

Scientific Findings

In laboratory research, *Pyrus pyrifolia* cv. *Shingo* (Korean pear), a specific variety or cultivar of Asian pear, stimulated two key alcohol-metabolizing enzymes involved in alcohol detoxification.[84] Phenolics have been found to have numerous potent beneficial biological effects in laboratory studies.

Bioactive Dose

Not known.

Safety

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

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Asparagus (Asparagus officinalis *L.*)

Definition

Green shoot vegetable (the spears are "shoots") that is commonly eaten after boiling or steaming. Asparagus is a good source of vitamin K and folate,[85] and contains numerous phytochemicals, including flavonoids[86] and saponins.[87] 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 and contraceptive.[86,88]

Scientific Findings

In laboratory studies, asparagus has exhibited antifungal, antiviral, and antitumor properties attributed to steroidal saponins.[87] 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.[89] The *Asparagus racemosus* species of asparagus, commonly used in the manufacture of dietary supplements of asparagus,[90] exhibited diuretic properties in an experimental study of laboratory animals that compared asparagus to furosemide, a diuretic medication.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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 breastfeeding. Eating asparagus caused urticaria, dysphagia, dyspnea, anaphylaxis, and skin lesions in sensitized individuals.

Astaxanthin

Definition

Naturally occurring antioxidant that imparts the characteristic pink pigment to shrimp, lobster, and salmon, and is added as a colorant to

farm-raised crustaceans and salmon.[91] A 200-gram portion of salmon contains approximately 1–7 mg of astaxanthin.[92]

Scientific Findings

In laboratory studies, astaxanthin reduced oxidative stress and inflammation, enhanced immune response, exhibited cardioprotective properties, and inhibited cancer cell growth.[92]

Bioactive Dose

Not known.

Safety

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

Avocado (Persea americana)

Definition

Fruit commonly consumed fresh 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 the phytochemicals lutein, xeaxanthin, and beta-sitosterol, supplying 114 mg of beta-sitosterol per cup of commercial variety avocado and 175 mg per cup of California avocado.[93–96] 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 Body Mass Index [BMI] of 32) substituted it for 30 g of mixed dietary fat.[97] 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.[98]

Bioactive Dose

Not known.

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Safety

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

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B

Banana (Musa paradisiaca)

Definition

Popular snack fruit frequently recommended to maintain or restore blood potassium levels because it is a good source of potassium (487 mg of potassium, 10% DV) per large, 8–9-inch fruit; also a good source of fiber (3.5 g, 12.5% DV) and vitamin C (11 mg, 12% DV), and an excellent source of vitamin B6 (0.449 mg, 29% DV). Bananas contain serotonin, a precursor of melatonin.[1–4] A low glycemic index food. A mainstay of the pediatric "BRAT" (bananas-rice-applesauce-toast) diet, used to reintroduce bland, easily tolerated foods when transitioning from liquids to solid food,[5] although not uniformly recommended by pediatric experts for this purpose.[6]

Scientific Findings

Green bananas and pectin significantly reduced diarrhea in a small, double-blind clinical trial (n = 62 boys aged 5–12 months with diarrhea for > 14 days) in which subjects were randomly assigned to receive 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) for 7 days. The improvement in the banana-and-pectin-supplemented group was significant compared to the rice-only group.[7] Banana pulp had a cholesterol-lowering effect in laboratory rats partly attributed to soluble fiber.[8] An experimental study found that 2-pentanone in banana inhibited biomarkers of colon cancer in human colon cancer cells.[9]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. A case of acute pancreatitis possibly resulting from banana allergy has been reported.[10] Excessive consumption of

bananas (up to 20 bananas/day), with no other foods for two 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.[11]

Barley (Hordeum vulgare *L.*)

Definition

Whole grain and a good source of fiber, barley is used to make vegetable barley soup (3.9 g fiber [14% DV] per 1 cup). Contains β-glucan, a soluble fiber, in addition to B vitamins (thiamin, riboflavin, niacin, vitamin B6, folate, pantothenic acid, and biotin), iron, zinc, phosphorus, and magnesium. When ground into smaller pieces it is called pearled barley, and barley malt, its sugar form, is used to flavor beer. In ancient Egypt barley was used as a purgative, applied to wounds to decrease healing time, decrease phlegm, and treat eye diseases. Roman gladiators believed barley bread imparted greater strength and stamina than other foods.[12] In 1494, Columbus brought barley to North America.[12]

Scientific Findings

A meta-analysis of eight trials (n = 391 patients) evaluating the effects of barley on lipids found that barley, consumed for 4–12 weeks, significantly lowered total cholesterol and triglycerides without affecting HDL.[13]

Bioactive Dose

See: β-*glucan, fiber.*

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Allergy to barley has been reported.[14]

Basil, sweet (Ocimum basilicum)

Definition

Mint family herb that contains phenolics, terpenoids, and steroids including stigmasterol and β-sitosterol.[15] When it is consumed in a significant quantity rather as a culinary herb, e.g., in a ½-cup (100 g) portion of pesto (basil, garlic, parmesan cheese, and walnut made into a paste and used

to coat cooked pasta), it supplies significant amounts of vitamins A 633 IU (20% DV) and K 50 µg (41% DV).[16] Thai basil has pointed leaves and is dark green with purple pigments, especially on its stems; whereas, sweet basil is uniformly grass-green with rounded leaves. Thai basil is native to Southeast Asian cooking and is commonly sold in Asian markets, but either type of basil can be grown domestically.

Scientific Findings

In laboratory studies, sweet basil cultivars exhibited an antioxidant and free radical scavenging activity attributed to their phenolic constituents.[17–19] In experimental research, eugenol, a constituent in basil (as well as clove, nutmeg, cinnamon, and bay leaves) demonstrated anticancer and anti-inflammatory activity in human cervical cancer cells[20] and exhibited antiproliferative and antitumor properties in human cancer cells and in animal models.[21]

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 oz of regular (5% alcohol) beer provides approximately 150 calories, 14 g of ethanol (alcohol), 13 g of carbohydrate, negligible micronutrients—such as niacin 1.8 mg (11% DV), potassium 96 mg (2% DV), selenium 2.1 µg (3% DV), and fluoride 157 µg (no DV)—in addition to polyphenols, which are lower in beer than in wine.[22–25] Beer consumption dates to at least 5,000–7,000 BC when wet grains combined with yeast fermented.

Scientific Findings

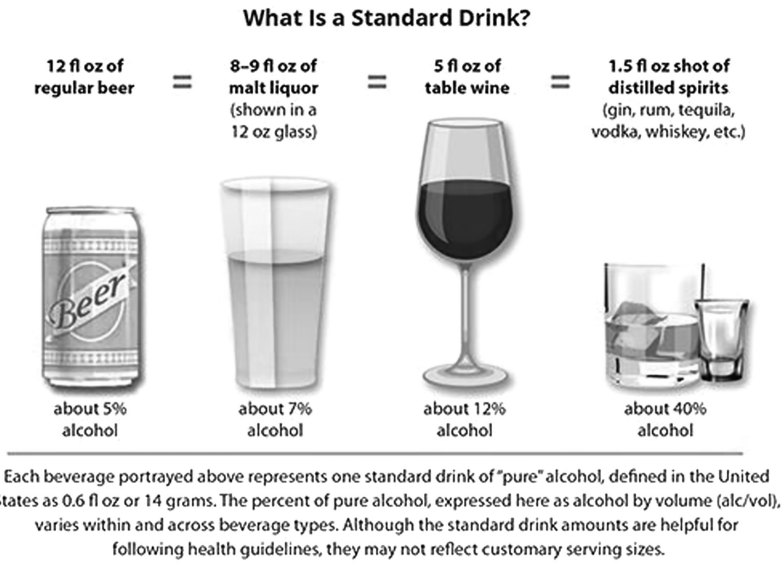
Polyphenols, such as xanthohumol, and phytochemical metabolites in beer have exhibited anti-inflammatory, antithrombotic, antiatherogenic, antioxidant, anticarcinogenic, estrogenic, and antiviral properties in experimental research (in vitro, cell culture, enzyme assay).[20] A meta-analysis of

26 studies examining beer and vascular risk found evidence of an inverse association between light-to-moderate beer consumption and vascular disease risk.[26] 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 [< 24 oz]) is associated with general or abdominal obesity, but concluded that "higher intake (>24 oz), may be positively associated with abdominal obesity."[27] Its probiotic effects are due to in part to the yeast used to make beer. *Saccharomyces cerevisiae* yeast reduced abdominal pain in irritable bowel syndrome (IBS) in a small, randomized, controlled, clinical trial (n = 179 adults with IBS).[28]

Bioactive Dose

Moderate consumption has been defined as no more than one drink per day for women and no more than two drinks per day for men where a "standard" drink contains roughly 14 g of pure alcohol, found in:

- 12 oz of regular beer, which is usually about 5% alcohol.
- 5 oz. of wine, which is typically about 12% alcohol.
- 1.5 oz of distilled spirits, which is about 40% alcohol.[21]



The National Institute of Alcohol and Alcoholism. What is a standard drink? National Institutes of Health National Institute of Alcohol Abuse and Metabolism (Available at: www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/what-standard-drink)

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. ≥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.[29] 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.[30] *See also Ethanol.*

Beet (Beta vulgaris)

Beet. (Image from yamix/Shutterstock.)

Definition

Also known as red beet and sugar beet. Root vegetable that supplies iron (<3% DV) and is a good source of folate (18% DV) per ½ cup.[31] Beets have high levels of polyphenols and betalaines that exert antioxidant effects.[32] Fresh beets are roasted, baked, boiled, pickled, or finely shredded or otherwise peeled and consumed raw as a salad ingredient or as a pasta alternative. Beet juice consumption has increased amid its reputation as a health food and is also sold in fruit-vegetable juice blends. Beet greens are good sources of calcium (12% DV), iron (15% DV), and vitamin E (17% DV), and excellent sources of magnesium (23% DV) and vitamin K (580% DV) per one cup. Beet greens are sold with spinach as a fresh salad mix or can be boiled or sautéed.

Scientific Findings

B. vulgaris exhibited antioxidant properties in a laboratory analysis.[33] Beetroot juice increases blood levels of nitric oxide and may increase

cardiorespiratory performance due to its ability to increase blood flow, gas exchange, and mitochondrial efficiency theoretically strengthening muscle contractions. A review of 23 studies (n = not elucidated) hypothesized that supplementing with beetroot juice could mitigate the ergolytic effects of hypoxia on cardiorespiratory endurance in athletes.[34] A meta-analysis of 16 clinical trials (n = 254 hypertensive subjects) found beetroot juice to be associated with a significant reduction in systolic blood pressure.[32]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Approximately 10% of people may experience beeturia, pink or red urine, following the ingestion of beets, which has been associated with iron deficiency.[35,36] However, serum ferritin testing is the standard assessment tool for detecting iron deficiency.

Beta-carotene (β-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 β-carotene bioavailability.[37]

Scientific Findings

Laboratory studies suggest β-carotene functions as an antioxidant.[38] Observational epidemiological studies suggest an association between higher dietary levels of fruits and vegetables containing β-carotene and a lower risk of lung cancer.[39]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. No UL has been established for β-carotene and no adverse effects except for carotenodermia—yellow discoloration of skin—have been reported from consumption of food β-carotene.[38] Carotenodermia

is considered to be harmless when it occurs due to the intake of food carotenoids.[38]

Beta-glucan (β-*glucan*)

Definition

Bioactive polysaccharide found naturally in foods that contain yeast, fungi (e.g., mushrooms), certain bacteria, seaweeds,[40] and grains, such as oats and barley. β-glucans in cereals are soluble fibers.

Scientific Findings

The regular consumption of β-glucans contributes to the maintenance of normal blood cholesterol concentrations.[41] Yeast-derived β-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.[42] In a meta-analysis, ingesting β-glucans derived from barley in doses of 3–10 g/day significantly reduced total and LDL cholesterol without significantly affecting HDL cholesterol over 4–6 weeks of treatment.[42] Adding β-glucans, as during food enrichment, may adversely affect β-glucan structure or solubility, decreasing its ability to reduce cholesterol levels.[42] A barley product highly enriched with β-glucans (75% by weight) exhibited altered ability to significantly reduce total cholesterol.[42]

Bioactive Dose

Consumption of > 3 g of β-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.[41] There is insufficient reliable information available about the effectiveness of β-glucans for uses other than cholesterol-lowering.[42]

Safety

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

Biotin

Definition

Water-soluble vitamin that functions as a coenzyme in energy metabolism that is widely distributed naturally in foods such as meats, cereals,

and fruits. Biotin is also synthesized in the intestine though not in a form that contributes significantly to absorbed biotin—perhaps less than 20% of a person's daily requirement for biotin is from enterically synthesized biotin.[43,44] Biotin intake is not routinely tracked by major food surveys but the most recently available, nationally representative data shows mean biotin intake to be higher than the RDA (approximately 39.9 µg/day for young women).[43] Avidin, in uncooked egg whites, prevents biotin absorption. Consumption of raw egg white over long periods, exclusive total parenteral nutrition without biotin, short-gut syndrome, and the use of anticonvulsant medications can cause a biotin deficiency.[43] Biotin deficiency symptoms include: dermatitis (red, scaly rash around the eyes, nose, and mouth), conjunctivitis, alopecia (thinning of hair and loss of hair color), and central nervous system abnormalities (depression, lethargy, hallucinations, and paresthesia of the extremities).[43] Biotin deficiency can present with cutaneous findings similar to that of zinc deficiency (periorificial dermatitis with angular cheilitis),[45] but often additionally manifests with hypotonia, ataxia, seizures, and hearing loss.[45] Low plasma biotin concentration is not a sensitive indicator of inadequate biotin intake.[43] For healthy adults, the concentration of biotin is 133–329 pmol/L in serum and 18–127 nmol/24 hours in urine. Abnormally low urinary excretion of biotin is an indicator of biotin deficiency, as is abnormally high excretion of 3-hydroxyisovaleric acid (higher than 3.3 mmol/mol creatinine) or 3-hydroxyisovalerylcarnitine (higher than 0.06 mmol/mol creatinine) resulting from the reduced activity of methylcrotonyl-CoA carboxylase (MCC). "The most reliable individual markers of biotin status, including deficiency and sufficiency, are biotinylated MCC and propionyl-CoA carboxylase in white blood cells."[46]

Scientific Findings

Higher than food amounts of biotin have not been shown to improve any condition except to correct for biotin deficiency.[43]

Bioactive Dose

The AI for biotin for men and non-pregnant women 19–50 years old is 30 µg/d.[43]

Safety

There is no UL for biotin. Toxicity has not been reported in patients treated with daily doses up to 200 mg (200,000 µg) orally and up to 20 mg (20,000 µg) intravenously.[43]

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 US.[47] Used to make marmalade, relishes, candy, and condiments.[48] Bitter orange has been used in traditional or folk medicine for weight loss; to relieve nausea, indigestion, constipation, heartburn, loss of appetite, and nasal congestion; topically, it is used to treat fungal infections, such as ringworm and athlete's foot.[49]

Scientific Findings

Bitter orange peel extract is used in herbal weight-loss products because of its sympathomimetic, ephedra-like constituent synephrine, however, significant adverse effects have been reported to be associated with its use.[50–52] Bitter orange (the food) has not been evaluated in weight reduction.[49] *C. aurantium* fruit juice improved insulin-induced glucose uptake into adipocytes in an in vitro study.[53] *C. aurantium* flavonoids demonstrated antiadipogenic activity in vitro.[54]

Bioactive Dose

Not known.

Safety

Bitter orange as a food is presumed safe when consumed in normal dietary quantities by nonallergic individuals, although *C. aurantium* may increase serum levels of drugs due to the action of its constituents on liver cytochrome p450 enzyme.[48]

Black Currant (Ribes nigrum)

Definition

Also spelled blackcurrant. High-vitamin C berry that is a significant source of anthocyanins. Used to make liqueurs, preserves, and the European beverage Ribena® which originated as a source of vitamin C for pregnant women and children when fresh fruit was scarce during World War II in Great Britain.[55]

Scientific Findings

The effect of black currant anthocyanins on the 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 black currant anthocyanins (n = 19) or a placebo (n = 19) for two years. In the black currant anthocyanins group, a nonsignificant improvement in ocular blood flow, but not intraocular pressure, was observed, whereas, no effect occurred in the placebo group.[56] Forty healthy subjects aged 50–70 years were randomized to receive a mixed berry (150 g blueberries, 50 g blackcurrant, 50 g elderberry, 50 g lingonberries, 50 g strawberry, and 100 g tomatoes) beverage or a volume-matched control beverage for 5 weeks. Cognitive and biochemical testing were performed. Subjects receiving the berry beverage showed a modest but significant improvement in memory testing 30 minutes after ingestion of the berry beverage compared to the control beverage, and had significantly improved total and LDL cholesterol compared to baseline and compared to the control beverage, but no change in fasting glucose or insulin concentration.[57]

Bioactive Dose

Not known.

Safety

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

Black Pepper (Piper nigrum)

Definition

Peppercorn of the *Piper nigrum* vine that is among the most-used culinary seasonings and considered "the king of spices" throughout the world due to its pungent principle piperine.[58] Usually consumed in such minute quantities that nutrient intake from it is nominal.

Scientific Findings

In laboratory studies, black pepper exhibited antioxidant and free radical scavenging properties.[59,60] Piperine exerted beneficial, protective effects against inflammation and alveolar bone loss, supported bone microstructures and prevented collagen fiber degradation in an experimental periodontitis study.[61] Experimental studies have also found *Piper nigrum* and its secondary metabolites to have antiapoptotic, antibacterial, anti-inflammatory, and hepatoprotective properties.[58]

Bioactive Dose

Not known.

Safety

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

Blackberry (Rubus *spp.*)

Definition

High-fiber (3.8 g, 24% DV), high-vitamin C (15 mg, 16% DV) berry (values per ½ cup) that has an edible but bitter solid center. It is not the same as a black raspberry which is hollow.[62] Contains polyphenolic compounds such as ellagic acid.

Scientific Findings

In hypercholesterolemic animals that received either a hypercholesterolemic diet, blackberry nectar with a hypercholesterolemic diet, or a standard diet, the blackberry nectar regimen reduced triglycerides, total cholesterol, and LDL cholesterol without reducing HDL cholesterol or blood glucose concentrations, but hepatic steatosis was not prevented by the intervention.[63] Ellagic acid reduced oxidative stress in laboratory studies.[64,65]

Bioactive Dose

Not known.

Blueberry (Vaccinium *spp.*)

Definition

Common sweet berry eaten fresh, frozen, dried, as a preserve, and as a constituent of mixed juice beverages. Blueberries supply vitamins A, C, and B6, thiamin, riboflavin, folate, potassium, and fiber, in addition to being abundant in flavonoids.[66–68] Blueberries' high antioxidant capacity relative to other fruits[69] have made them the focus of neurological research examining blueberry flavonoids in protecting the brain from oxidative stress.[58]

Scientific Findings

An in vitro study found that blueberries were a potent in vivo antioxidant at very low concentrations.[70] Blueberry anthocyanins crossed the blood–brain barrier in an animal study and were associated with learning performance in one of the earliest experimental studies of blueberries and cognition in laboratory rats.[58] A subsequent review of 21 studies found overall evidence that flavonoids benefit cognitive outcomes, such as attention and working memory in the general population, within an acute time frame of 0–6 hours after ingestion.[71] The effect of blueberry supplementation on regional brain activation in older adults at risk for dementia was examined in a 16-week RCT of elderly subjects (n = 21 people aged 68 or older with mild cognitive impairment) and found that consuming a freeze-dried whole blueberry powder daily--at a dose equivalent of 1 c (approximately 148 g) whole blueberry fruit enhanced neural response but did not enhance working memory.[72] A 300-g portion of blueberries (approximately 2 cups) improved cell antioxidant defense against one type of DNA damage compared to a control in a small, randomized crossover-design study (n = 10 young healthy men), but did not protect against several other markers of DNA damage or vascular function.[63]

Bioactive Dose

Not known.

Safety

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

Bok Choy (Brassica campestris)

Bok choi. (Image from SOMMAI/Shutterstock.)

Definition

Also called pak choi. Hardy, green-and-white-variegated leaf vegetable usually prepared by stir-frying or sauteeing. All parts of bok choy can be consumed. First cultivated by the Chinese thousands of years ago.[73] Bok choy is a good source of calcium, vitamin K, potassium, and vitamin C,[74] in addition to glucosinolates such as isothiocyanates and indoles.[75]

Scientific Findings

See: Brassica Vegetables.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. A case report of severe hypothyroidism with myxedema coma was reported in an elderly person who consumed 1.0 to 1.5 kg of raw bok choy daily for several months, attributed to glucosinolates in raw, uncooked *Brassica* foods inhibiting thyroid uptake of iodine.[76]

Boron

Definition

Essential trace mineral highest in avocado, peanut butter, peanuts, prune, grape juice, chocolate powder, wine, pecans, granola raisin cereal, and raisin bran cereals.[81,82]

Scientific Findings

Boron plays a role in metabolic processes related to bone[83] and is required for growth.[81] Median consumption of boron ranged from 0.87 to 1.35 mg/day with coffee, milk, apples, dried beans, and potatoes, accounting for approximately ⅓ of US intake in a survey of the American diet.[94] A clinical trial of postmenopausal women (n = 53 postmenopausal women) found that daily boron intake of 1 mg/L naturally occurring in drinking water increased serum osteocalcin levels and positively affected bone metabolism.[84]

Bioactive Dose

No RDA has been established for boron.

Safety

A tolerable upper limit of 20 mg has been established.[74]

Boysenberry (Rubus ursinus)

Definition

Hybrid berry that is a cross between a blackberry, raspberry, and loganberry.[77] Commercially available as syrup, canned and frozen, and in fruit yogurt, preserves, fruit spreads, pies, and beverages. Boysenberries are rich in polyphenolic compounds (flavonoids), the main antioxidant group in berries.[78]

Scientific Findings

A 4-week open-label intervention study evaluating the effect of daily boysenberry juice (180 ml/d) on vascular health parameters found positive changes in flow-mediated dilation of the brachial artery and changes in systolic blood pressure consistent with reducing cardiovascular risk.[79] A 4-week clinical trial (n = 25 healthy subjects) found no significant differences in quantitative measures of gut health from consuming beverages containing boysenberry.[80]

Bioactive Dose

Not known

Safety

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

Brassica Vegetables (Brassica oleracea)

Brassica vegetables. (Image from Serg64/Shutterstock.)

Definition

Also called cruciferous or mustard family vegetables. Genus consisting of many common species of cabbage family vegetables that exclusively contain glucosinolates, such as sulforaphane and indole-3-carbinol, and glucosinolate breakdown products called isothiocyanates (ITCs), in addition to polyphenols, terpenes, anthocyanins, coumarins,

antioxidant vitamins C and E and carotenoids, and beneficial antioxidant enzymes.[85–89] *Brassica* is the largest and most widely consumed group of plants worldwide.[88]

Scientific Findings

Sulforaphane exhibited chemoprotective properties in experimental research; it may prompt the body to make higher levels of chemoprotective enzymes.[90] In a small clinical trial (n = 20 men with recurrent prostate cancer), treatment with 200 μmoles/day of sulforaphane-rich broccoli sprout extract did not decrease prostate-specific antigen in the majority of patients.[91] Glucosinolates and *Brassica*-derived ITCs have exhibited anticarcinogenic and anti-inflammatory effects in vivo and in vitro,[87] and "accumulating evidence increasingly supports the beneficial effects of dietary glucosinolates on overall health, including as potential anticancer agents, because of their role in the prevention of the initiation of carcinogenesis."[92] A high intake of brassica vegetables may diminish cancer risk, according to epidemiological research.[93] "A high consumption of brassica vegetables is associated with a decreased risk of cancer. This association appears to be most consistent for lung, stomach, colon and rectal cancer, and least consistent for prostatic, endometrial and ovarian cancer."[93] Indole-3-carbinol's chemoprotective properties include the induction of phase II enzymes.[94] In animal studies, indole-3-carbinol exhibited chemopreventive properties.[95,96] Laboratory research found that brassinin demonstrated antiproliferative effects against cancer in both in vivo and in vitro models.[97]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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).[98] Raw brassica vegetables contain goitrogens that interfere with iodine utilization, thereby affecting the functionality of the thyroid. Goitrogens are inactivated by cooking.[99]

Brazil Nut (Bertholletia excelsa)

Brazil nut. (Image from Jessmine/Shutterstock.)

Definition

Crescent-shaped oily white nut sourced from a tree native to the Amazon rainforest that is large in comparison to other nuts, weighing approximately 5 g each.[100] Typically eaten raw, straight out of the shell, Brazil nuts are a particularly rich source of selenium, supplying 95 mcg of selenium (172% DV) per 1 nut.[101] High in fat, each 5 g nut provides 3 g of monounsaturated and polyunsaturated fat and 30 calories, plus nutrients including thiamin, vitamin E, magnesium, copper, and manganese.[101,102] Brazil nuts are sold in commercial mixed nut products and many brands of chocolate coated Brazil nuts are now commercially available. One Brazil nut supplies 3 mg of β-sitosterol,[101] five times the amount found in commercially popular β-sitosterol dietary supplements, which supply 600 µg per dose.

Scientific Findings

Brazil nuts have been used to correct selenium deficiency.[103] 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.[104]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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 (5% DV) of calcium.[105] Phytochemical components include glucosinolates, phenolic acids, and flavonoids.[106]

Scientific Findings

More than 50% of the calcium in broccoli is absorbed compared to approximately 30% absorption of the calcium in dairy products.[107] Glucosinolate in broccoli was shown to be antimicrobial against Staphylococcus aureus in a laboratory study.[108] Broccoli consumption is associated with a modestly reduced risk of breast cancer in premenopausal, but not postmenopausal women, according to epidemiological research.[44] Epidemiological research suggests, but is not definitive that, consumption of broccoli may be associated with a reduced risk of colorectal and stomach cancer.[44] A laboratory study found that broccoli soluble fiber prevented *E. coli* translocation in Crohn's disease cells which may have implications in preventing Crohn's disease by limiting harmful bacteria's access to vulnerable intestinal cells.[109]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Glucosinolate degradation products might have undesirable genotoxic effects, the relevance of which to human health is not yet known.[110]

Brussels Sprouts (Brassica oleracea *var.* gemmifera *DC.*)

Definition

Brassicacea is a vegetable that resembles a greenish-yellow miniature cabbage. It can be tossed with oil and grilled or otherwise quick-cooked on a

high heat, or steamed, and it is a source of vitamin K, lutein, xeaxanthin, and the antioxidant glutathione.[111,112]

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.[114]

Bioactive Dose

Not known.

Safety

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

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C

Cabbage (Brassica oleracea *var.* capitata)

Napa cabbage. (Image from Kellis/Shutterstock.)

Definition

Brassica leaf vegetable that is eaten fresh, cooked, and fermented as sauerkraut (white or red cabbage) or kimchee (napa cabbage). Both white cabbage, which is pale green, and red cabbage, which is magenta and white, per 1 cup, are good sources of vitamin C (32 mg, 11% DV) and vitamin K (67 μg; 55% DV), and supply glucosinolates and antioxidants; additionally red cabbage is a good source of vitamin A (993 IU, 33% DV).[1–3] In traditional medicine, cabbage juice has been used to treat peptic ulcer.[4,5]

Scientific Findings

In an in vitro gastric model, cabbage juice extract significantly inhibited ulcer formation, stimulated the synthesis of mucus, increased pH, and decreased hydrogen ions.[5] Brassinin in cabbage exerted chemopreventive properties during the initiation and promotion phases of carcinogenesis in a laboratory study.[6] In a case-control study (n = 697 newly diagnosed bladder cancer cases compared to n = 708 healthy controls matched to cancer cases by age, gender, and ethnicity), median isothiocyanate (ITC) intake from cabbage family vegetables was statistically significantly lower in bladder cancer cases (1.41 ½-cup servings of cabbage family vegetables) than in healthy controls (1.76 ½-cup servings, significant for green and red cabbage coleslaw and sauerkraut).[7] *Brassica oleracea* var. *capitata* extract raised blood glucose levels in diabetic rats.[8] *See also: Brassica Vegetables.*

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. *See also: Brassica Vegetables.*

Caffeine

Definition

Bitter alkaloid commonly consumed worldwide that is a nervous system stimulant and diuretic found naturally in over 60 different plants including coffee beans, tea, kola nuts (used to flavor cola), and cacao pods (used to make chocolate products).[9] Caffeine is also produced synthetically for use in foods and drugs.[10] The average adult ingests 200 mg daily, but there is no nutritional need for caffeine.[10] The caffeine content in 8 oz of common beverages include: coffee, 95–200 mg; black tea, 40–120 mg; and green tea, 15–60 mg.[11]

Scientific Findings

Caffeine improves mental alertness, prevents fatigue, and may relieve a simple headache, though caffeine withdrawal can cause headache and fatigue.[12] Caffeine is an ergogenic aid that increases work output; it

increases the catabolism of serum free fatty acids and muscle triglycerides to enhance performance.[13]

Bioactive Dose

Doses of 100–250 mg have been used for mental alertness, and 1.6–10 mg/kg has been used for athletic performance.[14]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Tolerance varies by individual; and adverse effects include blunted appetite, headache, dizziness, nervousness, irritability, and dependence. Tolerance varies by individual, but amounts greater than 250–300 mg per day have been associated with tachyarrhythmias and sleep disturbances. Elevation in blood pressure may occur with acute caffeine consumption: in six studies of hypertensive adults, 200–300 mg of caffeine raised blood pressure by 3 to 12 mmHg in systolic blood pressure and 3 to 4 mmHg in diastolic blood pressure; two other studies reported an unclear effect of habitual consumption of caffeine on blood pressure.[15] Caffeine's effects in the maternal diet can be summarized as follows: caffeine crosses the placenta but is not considered to be a teratogen. Fetal blood and tissue levels are similar to maternal concentrations. The use of caffeine during pregnancy is controversial; however, moderate consumption, less than 200 mg/day, has not been associated with clinically important adverse fetal effects. Quantities over 200 mg/day are associated with a significantly increased risk of miscarriage. Mothers should keep caffeine consumption below 200 mg/day. This is similar to the amount of caffeine in about 2 cups of coffee or tea. Breast milk concentrations of caffeine are thought to be approximately 50% of maternal serum concentrations, and caffeine is excreted slowly by and may accumulate in infants. Caffeine can cause sleep disturbances, irritability, and increased bowel activity in breastfed infants.[14] Large amounts of caffeine may cause or worsen fibrocystic breast disease.[12]

Calcium

Definition

Major mineral found primarily in the skeleton but necessary in the blood and soft tissue for nerve transmission, muscle contraction, blood clotting, blood pressure maintenance, and other physiological processes.[16–18] Good sources, in addition to dairy products, include many dark green

vegetables, such as bok choi and broccoli; tofu made with calcium (Ca) sulfate; canned fish with edible bones; and beverages such as Ca-, vitamin D (D)-fortified orange juice, almond milk, rice milk, and soy milk.

Scientific Findings

Adequate, lifelong Ca and D are associated with optimal bone development and bone mineral density (BMD); when coupled with physical activity these reduce the risk of osteoporosis in later life.[19] An estimate of average intake of all age groups in the US found calcium intake to be below requirements.[20,21]

Life Stage Group	Calcium Recommended Dietary Allowance (mg/day)
Infants 0 to 6 months	*
Infants 6 to 12 months	*
1 - 3 years old	700
4 - 8 years old	1,000
9 - 13 years old	1,300
14 - 18 years old	1,300
19 - 30 years old	1,000
31 - 50 years old	1,000
51 - 70 years old	1,000
51 - 70 year old females	1,200
71+ years old	1,200
14 - 18 years old, pregnant/lactating	1,300
19 - 50 years old, pregnant/lactating	1,000

Source: [26]

Some clinical trials and observational studies have found that consuming the recommended amount of Ca can modestly reduce blood pressure in people with or without hypertension.[22] Ca may be more effective at lowering blood pressure in salt-sensitive people and those with low baseline dietary Ca intake.[14] Dietary Ca intake of 800 mg or more per day (primarily from dairy products) reduced systolic blood pressure up to 4.0 mmHg and diastolic blood pressure up to 2.0 mmHg in four of six studies of adults with hypertension.[23] Obesity often coexists with low Ca and vitamin D intake; however, evidence from randomized clinical trials does not support that Ca and vitamin D accelerates weight loss or fat loss in obesity.[24] Higher dietary intakes of Ca have been associated with a decreased risk of metabolic syndrome.[25]

Bioactive Dose

The RDA for Ca is 1,000 mg for 19–50-year-old adults.

Safety

The UL for Ca for non-pregnant adults aged 19–50 is 2,500 mg. High Ca intake may interfere with the absorption of minerals, and is associated with hypercalcemia and milk-alkali syndrome.[26] High Ca intake

suppresses vitamin D activity.[27] The high intake of Ca from supplements, but not foods, is associated with the development of kidney stones.[22] Ca from food sources and Ca from dietary supplements each independently increased the risk of total, advanced, and metastatic prostate cancer, especially at intakes exceeding 2,000 mg/d in a prospective examination of Ca effect on prostate cancer risk in The Health Professionals Follow-Up Study (n = 47,781 men) that followed subjects free of cancer at baseline in 1986 through 1994.[26]

Cantaloupe (Cucumis melo)

Definition

Orange-fleshed melon that contains vitamin E (0.9 mg, < 1% DV) and fiber (1.6 g, 5% DV), and is a good source of vitamin C (65 mg, 72% DV) and an excellent source of vitamin A (5986 IU, 199% DV) per 1 cup.[28] Cantaloupe also supplies carotenoids, phenolics, and terpenoids.[29]

Scientific Findings

In mice, cantaloupe extract reduced diabetes-induced renal oxidative stress, a precursor of diabetic nephropathy.[30] 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; further, constituents of cantaloupe, including vitamins C and fiber were inversely associated with breast cancer risk.[31]

Bioactive Dose

Not known.

Safety

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

Canthaxanthin

Definition

A type of xanthophyll carotenoid chemically related to the vitamin A precursor beta-carotene[32] and presumed to be an antioxidant. Found naturally in plant and animal foods such as mushrooms[33] and trout[34] and added to foods such as farmed salmon,[35] drugs, and cosmetics as a colorant.[36]

Scientific Findings

Canthaxanthin scavenged free radicals in a laboratory study.[37] A cross-sectional study (n = 235 women) found mean plasma levels of canthaxanthin and other antioxidants were lower in women with cervical cancer and cervical intraepithelial neoplasia.[38]

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,[31] a condition termed canthaxanthin retinopathy, while other carotenoids have not been reported to cause this phenomenon.[27] An Acceptable Daily Intake of 0.00–0.03 mg/kg body weight has been established for canthaxanthin.[39] 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.[14]

Caper (Capparis spinosa)

Caper. (Image from Africa Studio/Shutterstock.)

Definition

The unopened flower bud of the *Capparis spinosa* shrub that is pickled and used as a pungent, salty condiment due to its strong flavor. Capers contain

numerous phytochemicals including phenolics, tocopherols, sterols, alkaloids, glucosinolates, and fatty acids.[40] Traditionally used as a diuretic, astringent, and antidiabetic, antihyperlipidemic, and antirheumatic agent.[36]

Scientific Findings

There is inadequate scientific evidence to support caper's traditional uses. Laboratory studies have demonstrated caper's antioxidant and anti-inflammatory effects.[41,42] In an experimental study, caper extract demonstrated potent lipid-lowering properties in diabetic rats.[43]

Bioactive Dose

Not known.

Safety

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

Capsaicin, see: Pepper, Chili

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 (10% DV) and 40

mg of vitamin C (44% DV per fruit), making it a good source of fiber and an excellent source of vitamin C,[44] in addition to a source of polyphenolic compounds.[45.]

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 α-amylase in vitro, mechanisms that may be hypoglycemic in human beings.[46] *Averrhoa carambola* inhibited hepatic lipogenesis and prevented hepatic steatosis in laboratory mice.[47]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Carambola should not be used by uremic patients because it has been documented to cause neurotoxicity and nephrotoxicity.[48]

Caraway (Carum carvi)

Definition

Aromatic herb whose crescent-shaped seed is used to make rye bread and distilled to produce an essential oil that flavors cheese, sausage, and other products. Source of the phytochemicals quercetin and limonene.[53] Caraway oil is used in herbal products formulated for abdominal discomfort and pain. Caraway contains the monoterpene carvone; foods containing carvone have a history of use as carminatives.[53]

Scientific Findings

Caraway essential oils inhibited colon carcinogenesis in rats.[54] Carvone exhibited analgesic and anti-inflammatory properties in a laboratory study.[55]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Pregnant women should avoid the medicinal use of caraway oil because it may stimulate menstruation.[14]

C

Carbohydrate

Definition

Macronutrient comprised of single monosaccharides (the simple sugars) or multiple monosaccharides (complex carbohydrate) that is metabolized aerobically or anaerobically for energy. Simple sugars are found naturally or may be added to fruit, milk, and grains. Complex carbohydrate—fiber and starch—is abundant in fruit, vegetables, grains, and legumes. Carbohydrate is not found in meat/poultry/fish/eggs or fats/oils. Inadequate dietary carbohydrate available for metabolism can cause ketogenesis, a condition that most commonly occurs in Type I diabetics; however, glucose can be synthesized from amino acid and triglyceride through gluconeogenesis.

Scientific Findings

"Evidence has also shown that replacing saturated fats with carbohydrates reduces blood levels of total and LDL cholesterol but increases blood levels of triglycerides and reduces HDL cholesterol. Replacing total fat or saturated fats with carbohydrates is not associated with reduced risk of CVD. Additional research is needed to determine whether this relationship is consistent across categories of carbohydrates (e.g., whole versus refined grains; intrinsic versus added sugars), as they may have different associations with various health outcomes."[49]

The OmniHeart Trial found that replacing some of the carbohydrates in the Dietary Approaches to Stop Hypertension (DASH diet) with the same amount of either protein or unsaturated fats lowered blood pressure and LDL cholesterol levels more than the original DASH dietary pattern which is high in complex carbohydrate.[48] A case-control study (n = 281 women with an incident of polycystic ovarian syndrome [PCOS] and 472 age-matched controls) showed high dietary glycemic index and glycemic load and low fiber intake are significantly associated with the development of PCOS.[50] *See also: Fiber.*

Bioactive Dose

Calories from added sugars should not exceed 10%, or approximately 7 teaspoons of added sugars, per day.[48] 130 g or 45–65% of total calories for carbohydrate with no more than 10% of calories per day from added

sugars are Daily Nutritional Goal, Dietary Reference Intake, and AMDR carbohydrate recommendations. *See also: Fiber for separate dietary recommendations specific to fiber.*

Safety

Safe when consumed in normal dietary quantities by nonallergic individuals.

Carnitine

Definition

Also called L-carnitine which is the form found in food, as well as skeletal and cardiac muscle. Dietary sources of carnitine include meats, especially red meats; dairy products; breads; and vegetables.[51] The average adult consumes 60–180 mg of carnitine daily and vegans consume 10–12 mg daily.[50] Healthy people do not need to ingest carnitine because it is nonessential, that is, made in vivo from lysine and methionine via the liver and kidney in quantities that are probably sufficient to meet daily requirements,[52] with the exception of certain preterm infants unable to synthesize sufficient amounts.[51]

Scientific Findings

Carnitine transports long-chain fatty acids into the mitochondria for oxidation and energy production and transports waste compounds out of the mitochondria.[50] 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 may include encephalopathy, cardiomyopathy, confusion, vomiting, muscle weakness, and hypoglycemia.[50]

Bioactive Dose

Not known.

Safety

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

Carotenoids

Definition

Subclass of terpenoids that includes two distinct types of molecules: carotenes and xanthophylls. More than 600 types of naturally occurring

carotenoids have been identified, of which approximately 50 have provitamin A activity.[56] Carotenoid sources include fruits, vegetables, and oils.[57]

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.[56] Major public health benefits could be achieved by increasing consumption of carotenoid-rich fruits and vegetables.[56]

Safety

No UL has been established for beta-carotene (or other carotenoids) and no adverse effects except for carotenodermia, the yellow discoloration of the skin, is thought to occur from ingesting excessive amounts of dietary beta-carotene. Carotenodermia is harmless when it occurs due to the intake of food sources of carotenoids.[58] ULs have not been established for carotenoids.

Bioactive Dose

Not known.

Carrot (Daucus carota *L.*)

Definition

Root vegetable widely recognized for its role in vision because it is a rich source of provitamin A carotenoids. Vitamin A performs functions essential to the eye and visual process (*see also: Vitamin A*). Carrots are a good source of insoluble fiber,[59] and the purple cultivar is rich in anthocyanins.[60] Commonly eaten fresh and as part of processed foods, carrots are among the ten most economically important vegetable crops grown worldwide.[60]

Scientific Findings

Daucus carota exhibited anticancer and antioxidant activities in laboratory research, and in an experimental study, its oil suppressed proliferation and induced apoptosis of human colon adenocarcinoma cells.[61] 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, crossover-design study (n = 22 healthy young men).[62]

Bioactive Dose

Not known.

Safety

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

Catechin

Definition

Polyphenol flavonoids found in black, oolong, and green tea, apples, pears, chocolate, and broad beans.[63] Types of catechins include epicatechin, epicatechin gallate, and epigallocatechin gallate (EGCG).

Scientific Findings

A number of human observational studies found that tea catechins were associated with a reduced risk of stroke.[64] 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 total catechin intake was positively associated with pulmonary function and inversely associated with a chronic cough.[65] The Netherlands Cohort Study (n = 4,280 men and women aged 55–69 years at baseline) assessed the association between Body Mass Index (BMI) and catechins over a 14-year period. Women with the highest intake of total catechins had a significantly lower BMI increase, while no significant change in BMI was observed in men.[63] Catechin intake was inversely associated with ischemic heart disease mortality but not associated with myocardial infarction or stroke incidence in the Zutphen Elderly Study (n = 806 men), a prospective cohort study.[66] Catechins exhibited the following properties in laboratory studies: antioxidant, antiproliferative, vascular-protective (antihypertensive, anti-inflammatory, anti-thrombogenic, lipid-lowering), and monoamine oxidase inhibitory.[67–69] A meta-analysis of 11 studies (n = 763) found that catechins or an EGCG–caffeine mixture had a small positive effect on weight loss and maintenance, and that effects in Asians vs. Caucasians were more pronounced, and lastly that caffeine > 300 mg/d attenuated these effects.[69]

Bioactive Dose

Not known.

Safety

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

Cauliflower (Brassica oleracea)

Definition

Brassica vegetable consumed raw or cooked that is an excellent source of vitamins C and K[70] 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.[71]

The 6.3-year Netherlands Cohort Study (n = 120,852 men and women aged 55–69 years) examined the consumption of 21 vegetables and nine fruits and urothelial cancer risk and found a statistically significant inverse association between cauliflower and urothelial cancer risk, whereas total vegetable consumption did not appear to be associated with urothelial cancer risk.[72] *See also: Brassica Vegetables.*

Bioactive Dose

Not known.

Safety

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

Celery (Apium graveolens)

Definition

Salad herb and umbelliferous (hollow, umbrella-shaped aromatic) vegetable that is commonly sautéed or added cooked or uncooked for its characteristic flavor and crisp texture. While not an appreciable source of any particular nutrient, a stalk of celery contains about 2 g of fiber, and celery contains important flavonoids, such as the flavonol quercetin and flavones, such as luteolin and apigenin, and celery is considered to be a principal dietary source of flavones in the US diet, along with parsley and peppermint.[73–75] Celery and celery seed have been traditionally used as carminatives. Umbelliferous vegetables are considered to be among the foods and herbs having the highest anticancer activity.[76]

Scientific Findings

Of six case-control studies examining dietary flavonoid intake and cancer risk, total flavonoids and quercetin were associated with a reduced risk of lung cancer in two studies but a nonsignificant increased risk in a third study.[75] "The magnitude of protection ranged from 30% to 42% reduction in risk for persons in the top vs. bottom quantiles of intake."[75] A carminative dose of celery seed is 1–4 g;[77] however, neither dose nor efficacy has been proven.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Celery oil or seeds in amounts larger than are normally consumed in the diet should be avoided during pregnancy because celery may have uterine stimulant or abortifacient effects.[78] Dietary allergy to celery has been reported.[79,80]

Chamomile (Matricaria recutita *[German chamomile]*, Chamomilla recutita *[Roman chamomile]*)

Definition

Herb that is made into one of the most popular single-ingredient herbal, caffeine-free teas.[81] Chamomile tea is negligible in nutrients but supplies many phytochemicals, including apigenin.[82,83] German chamomile is the most commonly consumed type of chamomile tea in the U.S.[80] Chamomile has been traditionally and is currently used for sleeplessness, anxiety, and gastrointestinal conditions such as upset stomach, gas, and diarrhea, although its efficacy for any of these uses is unknown and studies examining chamomile alone are lacking.[80]

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 vs. placebo.[84] In a laboratory analysis, apigenin was anti-inflammatory, antioxidant, and anticarcinogenic properties.[81]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Allergic reactions and anaphylaxis have been reported in people who have consumed or come into contact with chamomile.[85–90]

Cheese (see also: Feta Cheese)

Definition

High-protein, low-carbohydrate dairy food made by converting fluid milk to a semisolid mass, or curd, through the use of a coagulating agent, such as an edible food acid. Cheese is generally high in fat, for example, full-fat feta cheese made from goat's milk is approximately 45% fat.[91] It is a good source of Ca (200 mg, 15% DV per 1–1.5-oz serving), protein, riboflavin, vitamin B12, and potassium,[92] and fermented cheese may or may not contain appreciable lactose and/or probiotics. Cheese is not routinely fortified with vitamin D except for American cheese and a few others that list "vitamin D" in "ingredients."

Scientific Findings

Cheeses such as aged cheddar, Swiss, blue, Monterey Jack, mozzarella, Brie, Gouda, and American processed can help to prevent cavity formation when consumed with cariogenic foods because their nutrient constituents (protein, Ca, and phosphorus) neutralize plaque acids even in the presence of sucrose.[93,94] The cheese-making process changes protein into peptides that possess antioxidant, antimicrobial, anti-inflammatory, immunomodulatory, and analgesic/opioid activity. In addition, these peptides can inhibit angiotensin-converting enzymes and produce functional lipids, such as conjugated linoleic acid that has anti-inflammatory, anticarcinogenic, antimicrobial, hypotensive, diuretic, and vitamin synthetic properties.[95]

Bioactive Dose

Not known.

Safety

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

Cherimoya (Annona cherimola)

Cherimoya. (Image from EsHanPhot/Shutterstock.)

Definition

Green-skinned fruit with yellowish, creamy flesh and large, inedible seeds. Grown in the US, but believed to be native to South America,[96] cherimoya has been described as succulent and custard-like with a flavor blending banana, pineapple, papaya, peach, and strawberry. It can be made into juice or used to make fruit salad. Cherimoya has been used in traditional Mexican medicine for its antianxiety, anticonvulsant, and tranquilizing properties.[97]

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.[98] Cherimoya is a source of fiber, magnesium, potassium, cryptoxanthin, lutein, and xeaxanthin.[99]

Bioactive Dose

Not known.

Safety

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

Cherry, sweet (Prunus avium) *and Cherry, sour or tart* (Prunus cerasus)

Definition

Smallest member of the *Rosaceae* stone-fruit family. Fresh, dried, or canned, ½ cup of raw sweet cherries contains vitamin C (5 mg 5.5% DV) and potassium (103 mg 5% DV) in addition to phenolic compounds that contribute to cherries' color, taste, aroma, and flavor, [100–103] and cherries are a natural source of melatonin.

Scientific Findings

In an animal model of arthritis, cherry anthocyanins were anti-inflammatory antioxidants.[104] Cherry phenols demonstrated anti-inflammatory properties in vitro and in vivo.[102] Sweet cherry and sour cherry anthocyanins suppressed cyclooxygenase (COX) enzymes "comparable to ibuprofen and naproxen," according to researchers, and sweet yellow Rainier cherries were potent against pro-inflammatory COX-1 and -2 enzymes;[102,105] Tart cherries contain high levels of anti-inflammatory substances comparable to a number of nonsteroidal anti-inflammatory products.[106] Tart cherry juice 30 mL standardized to contain 1.42 µg/mL of melatonin twice daily for seven days (n=20 healthy adults) significantly increased melatonin, total sleep time and sleep efficiency compared to placebo, although there was no change in circadian rhythm which would have been a desirable effect.[106] A randomized, placebo-controlled, double-blind, crossover trial (n = 43 adults with insomnia) found that 8 oz of tart cherry-apple juice—containing the equivalent of 50 whole tart cherries with approximately 60 mg of anthocyanins and 550 mg of total phenolic compounds—twice daily for 2 weeks modestly improved sleep.[107]

Bioactive Dose

Not known.

Safety

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

Chia (Salvia Hispanica *L.*)

Definition

Seed that forms a mucilaginous gel in water.[108] Among its marketed forms, chia fresca refers to chia seeds mixed with a beverage, and chia

seeds also are added to ready-to-eat mixed fruit cups, used to make chia pudding, made into bars, and ready-to-eat chia seeds are sold alongside seeds and nuts. Chia seeds are a source of soluble and insoluble fiber (9.8 g total fiber, 35% DV per 1 oz) and supply linolenic acid. Other chia constituents include approximately 5 g of protein (10% DV) and 15.6 μg of selenium (28% DV) per 1 oz;[109] in addition to quercetin, kaempferol, caffeic acid, and chlorogenic acid.[110] Chia seeds were used as an offering to the Aztec gods[111] and have a history of use as a medicine, though modern health claims that it reduces risks of cardiovascular heart disease, cognitive decline, and cancer[111] have not been proven.

Scientific Findings

A meta-analysis of 14 clinical trials (n = 526 healthy subjects) examining chia seed doses ranging from 7 g to > 15 g daily found that high doses significantly reduced diastolic (but had no effect on systolic) BP; had modest but not clinically significant effects on postprandial blood glucose and HDL cholesterol (and no effect on total cholesterol, LDL, triglycerides, or VLDL). However, the quality of evidence was low or very low indicating substantial uncertainty about any effects.[111] Using some of the same studies, an earlier meta-analysis of seven clinical trials (six randomized and one nonrandomized n = 200), of which five were blinded, found no statistically significant relationship of chia seed consumption on CVD risk factors.[112] An animal study found that chia improved dyslipidemia and insulin resistance in dyslipidemic rats.[113]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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.[114] The fructan inulin, a natural, low-calorie sweetener, is sourced from *Cichorium intybus*.

Scientific Findings

In laboratory studies, *Cichorium intybus* exhibited antioxidant, antimicrobial, anthelmintic, antidiabetic, hepatoprotective, gastroprotective, analgesic, antiallergic, and tumor-inhibitory activity.[115,116] *See also: Fructan.*

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Chicory is possibly unsafe when used orally in excessive amounts because it may induce menstruation or miscarriage.[78] The secondary metabolites in *C. intybus* have shown potential toxicological effects.[113]

Chive (Allium schoenoprasum)

Definition

Long green stem of a bulbous allium vegetable whose leaves are used as a culinary herb fresh or dried for eggs, soups, salads, and vegetables.[117] One tablespoon (3 g) of fresh chives provides: 1 calorie; negligible fat, protein, and carbohydrate (less than 1 g of each), vitamins A (131 IU), C (1.7 mg), vitamin K (6.4 µg), folate (3 µg), calcium (3 mg), magnesium (1 mg), phosphorus (2 mg); and potassium (9 mg).[118]

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 [3–4 tablespoons of chives=9.5–10 g][119]) had a statistically significantly lower risk of prostate cancer than those in the lowest category (<2.2 g/day).[120]

Bioactive Dose

Not known.

Safety

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

Chocolate (Theobroma cacao)

Cacao bean. (Image from eversummerphoto/Shutterstock.)

Definition

Confection made from the cacao bean that can be made with or without milk, the latter of which, dark chocolate, is richer in flavonoids. High in fat, 1 oz (28 g) of dark chocolate (45– 59% cacao solids) is a source of magnesium (41 mg, 9% DV) and a good source of iron (2.27 mg, 13% DV).[121] Chocolate products and cocoa are "among the most concentrated sources of the procyanidin flavonoids catechin and epicatechin."[122] Approximately 3.5 oz of dark chocolate (100 g) contains about 50 mg of flavanols and milk chocolate (100 g) contains about 13 mg of flavanols.[123] "Epidemiological studies suggest that cocoa-rich products reduce the risk of cardiovascular disease. Flavanols found in cocoa have been shown to increase the formation of endothelial nitric oxide which promotes vasodilation and therefore blood pressure reduction."[124]

Scientific Findings

Intake of flavonoid-rich foods and risk for cardiovascular disease are inversely related, due possibly to flavonoid-induced changes in oxidant defense, vascular reactivity, and platelet reactivity.[122] Meta-analyses of hypertensive adults have reported that average daily flavanol intake ranging from 30 mg to 1000 mg reduced systolic and diastolic blood pressure and found dark chocolate superior to placebo in reducing systolic hypertension and diastolic prehypertension.[125] A meta-analysis of 35 clinical trials in healthy adults (n = 1,804) found a small but statistically significant blood pressure-reducing effect of flavanol-rich cocoa products compared with controls in trials of 2–18 weeks' duration. This study concluded that

systolic blood pressure was reduced by 4 mmHg, a significant reduction, in hypertensive subjects, and a lower effect was seen in prehypertensive subjects, while there was no significant difference in normotensive subjects.[124]

Bioactive Dose

Blood-pressure-lowering effects resulted from consuming 30–1,218 mg of flavanols/d (mean = 670 mg of flavanols) found in ⅓ oz to 3.6 oz of dark chocolate.[124,125]

Safety

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

Choline

Definition

Vitamin that serves as a precursor for the neurotransmitter acetylcholine, a methyl donor that is used for phospholipid synthesis, and is necessary to convert homocysteine to methionine.[126,127] Betaine is its metabolite. The average adult consumes 730–1,040 mg of choline a day in food sources such as milk, liver, eggs, peanuts, milk, and orange juice.[126,127]

Scientific Findings

Preconception dietary intakes of choline between 350 and 544 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 healthy children).[127] Neural tube defect risk estimates were lowest for women whose diet 3 months prior to conception were rich in choline.[127]

Bioactive Dose

The AI for adults aged 19–50 years old is 425–550 mg; for pregnant women, it is 450 mg per day.

Safety

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

Chromium

Definition

Ultra-trace mineral necessary for insulin action that is referred to as the glucose tolerance factor.[57,128] Chromium is widespread in plant and animal foods in minuscule amounts, and eating a variety of whole grains, fruits, vegetables, meats, and milk products is recommended to obtain adequate amounts. Broccoli contains 11 µg per ½ cup; grape juice supplies 8 µg per 1 cup; dried basil supplies 2 µg per tablespoon; and green beans supply 1 µg per ½ cup.[128]

Scientific Findings

Chromium may improve insulin sensitivity, which can modify the risk of diabetes and cardiovascular disease (CVD).[129] 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).[129]

Bioactive Dose

The AI for chromium is 25–35 µg for adults aged 19–50.

Safety

No UL has been established for chromium because few adverse events have been reported for excess intake of chromium from food.

Cilantro (Coriandrum sativum)

Definition

Herb grown from coriander seeds. Cilantro leaves and stems are chopped and used in Latin, Thai, and other cuisines, for example, freshly chopped or torn and used as the aromatic green herb in salsa, pico de gallo, and the fried noodle and vegetable dish pad Thai. Though normally consumed in insignificant quantities to be an appreciable source of nutrients, cilantro contains vitamins A and K, and contains numerous phytochemicals including caffeic acid, chlorogenic acid, quercetin, and limonene[130,131] Coriander has been used in traditional medicine to treat cystitis.[132]

Scientific Findings

Laboratory studies have shown coriander essential oils to have antioxidant and hepatoprotective properties.[133] Coriander extract exerted anti-anxiety activity in a laboratory study.[134]

Bioactive Dose

Not known.

Safety

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

Cinnamon (Cinnamomum cassia)

Definition

A spice sourced from the bark of a tree native to Asia that is used as a flavored stick or as a finely ground powder to flavor fruit or savory dishes. Contains the phytochemical cinnamaldehyde.[135] Cinnamon is rich brown in color and has a delicately fragrant aroma and warm, sweet flavor. Cinnamon was once more valuable than gold.[136]

Scientific Findings

In animal models, cinnamon exhibited hypoglycemic, antimicrobial, antifungal, antiviral, antioxidant, antitumor, blood pressure-lowering, cholesterol-lowering, lipid-lowering, gastroprotective, and anticholinesterase properties.[137,138] According to a meta-analysis of ten randomized, controlled trials (n = 543 patients with Type II diabetes), the consumption of cinnamon was associated with a statistically significant decrease in fasting plasma glucose, total cholesterol, LDL cholesterol, and triglyceride levels, and an increase in HDL cholesterol but no significant effect on hemoglobin A1C.[139]

Bioactive Dose

Cinnamon doses of 120 mg/d (approximately ½ teaspoon) to 6 g/d (2 ⅓ teaspoons)[140] for 4–18 weeks reduced levels of fasting plasma glucose, total cholesterol, LDL cholesterol, and triglycerides; and increased levels of HDL cholesterol in Type II diabetics in a meta-analysis of 15 randomized, controlled clinical trials.[139]

Safety

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

Citrus

Definition

Juicy, segmented fruits of the genus *Citrus* that are vitamin C- and folate-rich and among the best sources of flavonoids, such as naringenin, hesperidin, nobiletin, and tangeretin, in addition to others. The skin, peel, and rinds of citrus fruits are rich in essential oils and contain more phytochemical compounds on a per gram basis than the edible interior flesh.[141] 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 consumed in marmalade. Citrus rinds contain a variety of phytochemicals including carotenoids, flavanone glycosides, and flavonoids.[142]

Scientific Findings

Epidemiological data suggest that frequent consumption of citrus fruits is associated with reduced risk of CVD, cerebral infarction, and ischemic stroke.[143] A systematic review of 22 observational and preclinical studies from 1970 through 2017, examining the effect of citrus juices on cancer risk reduction, concluded that the evidence strongly corroborates the role of citrus juices and their derivatives as a potential resource against cancer.[144] Epidemiological, experimental, and limited clinical studies suggest constituents in citrus foods, including flavonoids such as hesperidin, naringenin, nobiletin, and the terpenoid carvone, exert antimicrobial; lipid-lowering; insulin-sensitizing; antihypertensive; anti-inflammatory; antinociceptive; cardioprotective, and vascular-protective effects.[55,145–151] Tangeretin, a flavone found in citrus peel,[152] has been shown to have antiatherogenic and anti-inflammatory properties.[153] A review of ten clinical trials examining the effect of citrus juice on markers of blood lipids found weak, but positive, evidence in five of the studies that one or more blood lipids may be positively influenced by consumption of 100% citrus fruit juice.[154] In one study, 750 mL of orange juice daily, for 4 weeks, increased HDL cholesterol by 21% and decreased the LDL-to-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); however, it raised triglycerides by 30%.[155] A dosage of 200 mL of orange juice three times daily (600 mL/d) compared

to placebo for 4 weeks reduced endothelial dysfunction in male subjects with two CVD risk factors (n = 25 and high LDL).156 Women consuming ≥ 1 serving of citrus fruits a day had a 22% lower endometriosis risk in a large (n = 70,835 premenopausal Nurses' Health Study II cohort female subjects) observational study.[157]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Consuming citrus or coming into physical contact with citrus peel has resulted in allergic reactions. Citrus flavonoids have low or no cytotoxicity to healthy, normal cells.[158]

Clove (Eugenia caryophyllata)

Definition

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.[159]

Scientific Findings

Clove was shown to have anti-inflammatory effects in a laboratory study.[160] Clove is not effective for vomiting, upset stomach, nausea, gas, or diarrhea.[161]

Bioactive Dose

Not established.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Ingesting clove oil has been linked to reports of coagulopathy, liver damage, and other serious side effects in infants and children.[55]

Coconut (Cocos nucifera)

Definition

Large *Arecaceae* family nut used in shredded form in baked products. The flesh of coconuts is a source of potassium and saturated fat,[162] in addition

Table C.1 Nutrient Comparisons in Milk vs. Coconut Milk

Nutrient	Fortified 1% milk per 8 oz	Coconut milk per 8 oz
Ca, mg	300	451
Vitamin D, IU	120	101
Vitamin D, µg	3.0	2.5

Sources: [188,209,210]

to flavonoids and saponin. Coconut water contains potassium (400 mg, 8% DV per 1 cup). Coconut milk is an emulsion of grated coconut meat[14] and is used as a cooking ingredient; when it is prepared as a milk-alternative beverage, coconut milk is fortified with Ca and vitamins A, D, and B12, similar to fortified milk (Table C.1).

Coconut products include coconut water, oil, flour, shavings, and coconuts and its derivatives are added to snack foods and baby food.[163] Coconut has been used in traditional medicine for the treatment of metabolic disorders and as an anti-inflammatory, antimicrobial, and analgesic.[164]

Scientific Findings

The saturated medium-chain triglycerides in coconut oil increase total serum cholesterol but affect HDL cholesterol levels favorably, and are easier to digest and absorb than long-chain triglycerides, and are therefore used during fat malabsorption.[165] Diets rich in coconut oils have been shown to reduce coronary artery disease risk factors, such as tissue plasminogen activator antigen and lipoprotein(a);[155] however, current recommendations are to limit saturated fats, including coconut oil to no more than 7% of calories.[166] Lauric acid, the most abundant fatty acid in coconut oil, is effective in preventing tooth decay and plaque buildup.[155] Saponin and polyphenols in coconut were attributed with anti-inflammatory and antinociceptive properties in an animal study.[167]

Bioactive Dose

Not known.

Safety

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

Coenzyme Q_{10}

Definition

C

Also called CoQ_{10}. A fat-soluble antioxidant synthesized in the body[168] 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.[169] It is present in the highest quantities in the heart, liver, kidney, and pancreas.[78] Rich dietary sources include meat, fish, nuts, and certain oils, while dairy products, vegetables, fruits, and cereals provide smaller amounts.[170] The average daily intake of CoQ_{10} from foods has been estimated in the European diet to be approximately is 3–6 mg.[171] "In humans, normal blood levels of coenzyme Q_{10} have been defined variably, with reported normal values ranging from 0.30 to 3.84 μg/mL."[158]

Scientific Findings

Endogenous coenzyme Q_{10} production decreases with age.[172] Secondary deficiency may be linked to the use of statins to treat hyperlipidemia.[173] Coenzyme Q_{10} deficiency is thought to be a rare condition, the symptoms of which include weakness, fatigue, and seizures.[174] 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.[175] "CoQ_{10} has also been studied for a variety of other conditions, including amyotrophic lateral sclerosis (Lou Gehrig's disease), Down syndrome, Huntington's disease … male infertility," migraine headache, and CVD, but the research is too limited for any conclusions to be drawn.[176,177]

Bioactive Dose

Not known.

Safety

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

Coffee (Coffea arabica)

Definition

Seed that is roasted to make one of the most consumed beverages in the world. Its caffeine constituent prevents fatigue and improves mental alertness, varying in content per 1 cup (8 oz) between 75–150 mg with darker roasts providing less caffeine than light roasts.

Caffeine Content of Coffee	
Percolated (including K-cup®), light and dark roasts	75–150 mg
Instant coffee	85–100 mg
Decaffeinated coffee	8 mg

Sources: [14,178]

The average adult ingests 200 mg of caffeine per day.[179] Coffee is a source of phytochemicals including polyphenols such as chlorogenic acid.[180]

Scientific Findings

Coffee consumption has been inversely associated with the prevalence of Type II diabetes mellitus in observational studies.[181,182] Coffee consumption may also be protective against the development of gallstones.[183] Epidemiological evidence suggests that drinking more than 3 cups of coffee daily may significantly reduce the risk of rectal cancer.[14] In experimental research, chlorogenic acid protected cells from oxidative damage, induced growth of beneficial microorganisms in colon cancer cells, and exerted preventative effects against cardiovascular disease and Type II diabetes.[180,184]

Bioactive Dose

The typical dose of caffeine for headache relief or restoring mental alertness is up to 250 mg per day or up to about 2 cups of coffee.[168]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Coffee consumption has been associated with hyperhomocysteinemia in some observational studies, but not in others.[185] *See also: Caffeine.*

Copper

Definition

Trace mineral found in shellfish, nuts, beans, organ meats, and whole grains that functions as a component of a number of metalloenzymes and that is involved in red blood cell formation, immunity, and in maintenance of blood vessels, nerves, and bones.[57] The median dietary intake

of copper by US women is 1.0–1.1 mg/day (1000–1100 μg), men consume 1.2–1.6 mg/day (1200–1600 μg).[179]

Scientific Findings

One measure of copper deficiency is serum copper.[57] Copper deficiency, although rare, causes normocytic, hypochromic anemia, leukopenia, and neutropenia.[176] Copper is an antimicrobial agent.[186]

Bioactive Dose

The RDA for adults aged 19–50 years old is 1,000 μg.

Safety

A 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).[187] Corn is a source of fiber (1.8 g, 5% DV per 1 cob)[188] and phytochemicals such as lutein, xeaxanthin, and ferulic acid.[204] It is notably deficient in the amino acids lysine and tryptophan, the latter of which is converted into niacin. In the pellagra epidemic of the 1800 s in the Southern US, consumers who ate a corn-based diet with little variety developed pellagra due to deficiency of niacin or its precursor tryptophan, both of which were absent in corn. Eaten cooked, canned, frozen, and used to make oil, flour, starch, and other food products, such as high-fructose corn syrup. Traditional medicinal uses of *Zea mays* include use as a diuretic and for treating dropsy (edema), hypertension, hemorrhage, warts, and diabetes.[179]

Scientific Findings

Zea mays exhibited antioxidant properties and slowed glucose absorption in a laboratory study.[190] Its glycemic index, a measure of how quickly the carbohydrate in a food is digested and absorbed, is "low" (52) on a scale where < 55 is low and > 70 is high.[191]

Bioactive Dose

Not known.

Safety

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

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 choline, vitamins C, A, and K,[194] and proanthocyanidins.

Scientific Findings

Daily doses of 120–4,000 mL/day of cranberry juice or 400 mg of cranberry extract have been used to help prevent urinary tract infections (UTIs)[77] based on the results of small studies that postulated cranberry prevents bacteria from sticking to the cells that line the bladder.[195] A review including 24 studies (n = 4,473 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.[196] Nonetheless, certain practice guidelines currently recommend consumption of pure cranberry-lingonberry juice as an option for preventing recurrent UTI.[197]

Bioactive Dose

Not known.

Safety

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

Cucumber (Cucumis sativus)

Definition

Low-calorie gourd vegetable that is high in water similar to watermelon and cantaloupe members of the *Cucumis* genus.[198] Cucumbers contain vitamin K (8.5 µg, 6% DV per ½ cup) and are so low in calories (8 calories per ½ cup)[199] that they are considered to be calorie-free for purposes of weight and diabetes management. A common salad vegetable and staple

food of the Greek and Middle Eastern diets, the cucumber is thought to be native to India, where it has been cultivated for more than 3,000 years.[198] Cucumber has a history of use in ancient medicine for cooling, diuresis, and as an antihelminthic.[200,201]

Scientific Findings

Cucurbitacins[200] demonstrated anticancer properties in colon, breast, lung, and central nervous system cancer cell lines, and inhibited the COX-2 enzyme and lipid peroxidation.[202]

Bioactive Dose

Not known.

Safety

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

Cumin (Cuminum cyminum)

Definition

Ground seed that supplies the characteristic aromatic and earthy flavor of taco seasoning. Because it is usually consumed in minuscule amounts, cumin's nutrient content is negligible but includes antioxidant vitamins.[203] Cumin is used in traditional Indian medicine for the treatment and management of sleep disorders, indigestion, and hypertension.[204] Cumin complements the flavor of chili peppers, cilantro, cinnamon, coriander seed, garlic, mint, orange, parsley, saffron, and scallion.[205]

Scientific Findings

Cuminum cyminum in animal models exerted antihypertensive,[204] antihyperglycemic,[206] and anticarcinogenic effects.[207]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Safrole, a natural mutagenic compound that is degraded by cooking, is a constituent of cumin.[208]

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D

Dairy Foods Group

Definition

Foods produced from milk that are good sources of protein, riboflavin, vitamin B12, calcium, magnesium, potassium, and, when fortified, vitamins A and D.[1] One serving of dairy food is equivalent to 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; 8 oz of yogurt or frozen yogurt; or 2 cups of cottage cheese.

What Counts as a Cup in the Dairy Group?

	Amount that Counts as a Cup in the Dairy Group	Common Portions and Cup Equivalents
Milk (choose fat-free or low-fat milk)	1 cup milk	
	1 half-pint container milk	
	½ cup evaporated milk	
Yogurt (choose fat-free or low-fat yogurt)	1 regular container (8 fluid ounces)	1 small container (6 ounces) = ¾ cup
	1 cup yogurt	1 snack size container (4 ounces) = ½ cup
Cheese (choose reduced-fat or low-fat cheeses)	1 ½ ounces hard cheese (cheddar, mozzarella, Swiss, Parmesan)	1 slice of hard cheese is equivalent to ½ cup milk
	⅓ cup shredded cheese	
	2 ounces processed cheese (American)	1 slice of processed cheese is equivalent to ⅓ cup milk
	½ cup ricotta cheese	
	2 cups cottage cheese	½ cup cottage cheese is equivalent to ¼ cup milk
Milk-based desserts (choose fat-free or low-fat types)	1 cup pudding made with milk	
	1 cup frozen yogurt	
	1 ½ cups ice cream	1 scoop ice cream is equivalent to ⅓ cup milk
Soymilk (soy beverage)	1 cup calcium-fortified soymilk	
	1 half-pint container calcium-fortified soymilk	

Source: [2]

Scientific Findings

Consuming the recommended daily servings of dairy products (see Bioactive Dose) or otherwise consuming the calcium and vitamin D RDA (*see also: Calcium and Vitamin D*) is necessary to maintain bone mineral density (BMD) during every stage of the life cycle. Although some data has suggested that consuming an adequate intake of reduced- and nonfat dairy products is associated with a reduced risk of cardiovascular disease and Type II diabetes,[2] a large Swedish cohort study (n = 103,256 adults), found that milk and dairy products (but not fermented milk products such as yogurt) were associated with higher all-cause mortality.[3] Milk, yogurt, and cheese were associated with increased odds for development of acne in a meta-analysis of observational studies in males and females aged 7–30 years (n = 78,529).[1]

Bioactive dose

Three servings of dairy foods are recommended daily for people aged 19–50 to meet the calcium RDA (note: three servings of vitamin-D-fortified milk meets < 100% of the vitamin D RDA—*see also: Vitamin D*).[2]

Daily Dairy Recommendation					
Children	2–3 years old	2 cups	**Women**	19–30 years old	3 cups
	4–8 years old	2 ½ cups		31–50 years old	3 cups
Girls	9–13 years old	3 cups		51+ years old	3 cups
	14–18 years old	3 cups	**Men**	19–30 years old	3 cups
Boys	9–13 years old	3 cups		31–50 years old	3 cups
	14–18 years old	3 cups		51+ years old	3 cups

Source: [2]

Safety

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

Dandelion (Taraxacum officinale)

Dandelion. (Image from Volosina/Shutterstock.)

Definition

Bitter salad green named for its toothed leaf margins (dent de lion means "lion's tooth"). Dandelion contains calcium (103 mg, 8% DV) and is an excellent source of vitamins C (19 mg, 25% DV) and K (428 µg, 356% DV).[4] It also supplies phytochemicals including taraxasterol.[5] The root is a source of triterpenes, steroids, and inulin.[6] Regarded by some to be a garden weed, it is more commonly eaten as a salad green in Europe than in the US. Dandelion has been used in Asia, Europe, and North America as a diuretic[7] and in Chinese, Arabian, and Native American traditional medicine to treat cancer.[8]

Scientific Findings

Dandelion has been studied for its diuretic effects. A small pilot study (n = 17) recorded urinary volume and fluid intake to establish baseline values for urinary frequency and urinary excretion then subjects were dosed with 8 mL of dandelion extract three times a day for 1 day. The study found significant increases in the frequency of urination in the 5-hour period after the first dose, and there was a significant increase in the excretion ratio (the ratio of urination volume to fluid intake) in the 5-h period after the second dose. A third dose failed to change any measured parameter.[7]

In laboratory studies, dandelion extracts exhibited anticarcinogenic and hepatoprotective properties.[5,8–10] In animal studies, taraxasterol exhibited chemopreventative properties.[5]

Bioactive Dose

Not known.

Safety

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

Date (Phoenix dactylifera)

Date. (Image from Ninell/Shutterstock.)

Definition

Small, cylindrical-shaped fruit covered by a leathery, fibrous skin that is brown and intensely sweet when fully ripe. Two Medjool dates, a common type eaten as a snack and used for baking, contain potassium (280 mg, 6% DV), while ¼ cup is an excellent source of potassium (1124 mg, 33% DV).[11] Dates have the highest total polyphenol content among commonly eaten fruits.[12]

Scientific Findings

Dates exhibited antioxidant activity in laboratory research.[13,14]

Bioactive Dose

Not known.

Safety

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

Dill (Anethum graveolens)

Dill. (Image fron photolinc/Shutterstock.)

Definition

Aromatic herb member of the *Umbelliferae* family. Its fine fronds contain aromatic compounds that impart the distinctive flavor to pickles; dill is also used to flavor and garnish potato salad, Greek yogurt, and borscht. Dill contains numerous phytochemicals including quercetin and limonene.[15] Dill is a widely used traditional medicinal plant used to treat various ailments, such as the prevention and treatment of gastrointestinal (e.g., indigestion, flatulence, colic pain), kidney, and urinary tract diseases and disorders; sleep disorders; and spasms.[16, 17].

Scientific Findings

Dill killed bacteria that cause nosocomial infection, in particular, *P. aeruginosa*, and important pathogens associated with indigestion, dysentery, and diarrhea in laboratory tests.[17] In laboratory studies, dill was shown to be antifungal[18] and effective against vulvovaginal candidiasis in immunosuppressed mice.[19]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary amounts by nonallergic individuals. The essential oil of dill herb and the seed was shown to be genotoxic in in vitro and in vivo tests.[17]

Docosahexaenoic Acid

Definition

Type of omega-3 polyunsaturated fatty acid, along with linolenic acid and eicosapentaenoic acid (EPA), that has anti-inflammatory and immunomodulatory properties, reduces serum triglycerides and cholesterol (possibly by decreasing the number of fats made in the liver),[20] decreases thrombosis and platelet aggregation, and is required for neurocognitive development.[21–23] It is synthesized in limited amounts by the body through the conversion of linolenic acid to EPA and then to docosahexaenoic acid (DHA).[24] DHA is abundant in the brain, retina, and spermatozoa.[17,25] Fatty fish, including salmon, tuna, mackerel, trout, sardines, anchovies, and herring are excellent sources of DHA; and omega-3-fatty-acid-fortified eggs can be a readily available source of DHA (*see also: Egg*).[26] Human milk is a source of DHA and many commercial infant formulas are fortified with DHA. Mean DHA and EPA intake have been estimated to be approximately 100 mg/day in the US, an amount considered to be suboptimal according to some experts.[30]

Scientific Findings

DHA deficiency has been linked to a decline in cognitive ability, and low DHA levels are associated with an increase in neural cell death.[27] DHA is absent in the cerebral cortex of individuals with extreme depression.[28] DHA deficiency is associated with neurodegenerative disease and impaired neurocognitive development. Low plasma levels of DHA and omega-3 fatty acids are associated with attention deficit hyperactivity disorder (ADHD) in children.[19,29]

Bioactive Dose

An RDA has not been established for DHA, but an AI has been set for the DHA precursor, linolenic acid, at 1.1 g daily for women, 1.4 g daily for pregnant women, and 1.6 g daily for men aged 19–50.[31]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Doses greater than 3 g daily increase the risk of excessive bleeding.[32]

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E

Egg

Definition

Low-fat protein source that is also a source of vitamins A, D and E, as well as choline and phytochemicals such as lutein and xeaxanthin.[1] One egg is equal to 1 oz of meat in protein content, and though it is low in fat, it supplies approximately 215–250 mg of cholesterol.[2] Eggs enriched with omega-3-fatty-acid supply approximately 115 mg of omega-3-fatty acid.[3] Eggs are a versatile food that can be hard-boiled, fried, and used as an emulsifying ingredient in baked products and salad dressings.

Scientific Findings

No link between egg consumption and risk for coronary heart disease has been established,[4,5] therefore, The American Heart Association (2013) recommends for cardiovascular disease patients and *The Dietary Guidelines 2015–2020* recommends for the general public no limit on eggs or cholesterol due to insufficient evidence to determine whether lowering dietary cholesterol reduces LDL;[6] however, The Academy of Nutrition and Dietetics and The National Lipid Association recommend a < 200 mg/day cholesterol limit to patients with dyslipidemia.

Bioactive Dose

Not applicable.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. USDA recommends children younger than one year old not be given egg whites due to the potential for an allergic reaction.[7] Raw egg consumption should be avoided due to potential *Salmonella* contamination.

Eggplant (Solanum melongena)

Definition

Spongy-fleshed vegetable that is boiled, baked, or fried with its purple edible skin intact to make dishes such as eggplant parmesan, baba ghanoush, ratatouille, and stir-fried eggplant. Eggplant is a good source of fiber,[8] and contains anthocyanins, phenolics, saponins, terpenoids, and steroidal alkaloids.[9]

Scientific Findings

900 mg of powdered eggplant (< ¼ teaspoon)[10] daily for 3 months performed the same as placebo in a small (n = 41 subjects with hyperlipidemia) randomized, placebo-controlled clinical trial. Both the eggplant and the placebo reduced total and LDL cholesterol and LDL/HDL ratio.[11] 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 a (3) control group. After 6 weeks, a significant reduction in total cholesterol and LDL cholesterol levels was seen in the statin-treated group but not in the eggplant-treated group.[12] While eggplant has not been shown to reduce blood lipids, an experimental study showed phenolic-enriched extracts of eggplant to have moderate to high angiotensin I-converting enzyme inhibitory activity,[13] suggestive of potential antihypertensive properties.

Bioactive Dose

Not applicable.

Safety

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

Eicosapentaenoic Acid

Definition

One of the two predominant omega-3 fatty acids, the other being DHA. Eicosapentaenoic acid (EPA) and DHA are synthesized in limited amounts in the body from linolenic acid.[14] EPA is found in the eyes and the brain and is necessary for growth and cognition.[12] Fatty fish are among the best sources of EPA, for example, mullet, which provides 150 mg of EPA per 3 oz,[15] and others include mackerel, salmon, bluefish, sablefish, menhaden, anchovy, sardines, herring, tuna, and lake trout. Human milk is a source of EPA.

Scientific Findings

Current mean intake of DHA (and EPA) in the US is approximately 100 mg/day, an amount that is suboptimal according to experts.[16] EFAs may be altered in obesity, hypertension, diabetes mellitus, coronary heart disease, alcoholism, schizophrenia, Alzheimer's disease, atherosclerosis, and cancer.[17] Whether the EFA alteration is a cause of or effect of these conditions isn't known.[15]

Bioactive Dose

While there is no specific RDA for EPA, an AI has been set for the EPA precursor, linolenic acid, of 1.1 g daily for women, 1.4 g daily for pregnant women, and 1.6 g daily for men aged 19–50.

Safety

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

Endive (Cichorium intybus)

Endive. (Image from Slavko Sereda/Shutterstock.)

Definition

Hardy, curled lettuce common in Mediterranean cooking that can be eaten blanched, used for salads, and as a garnish.[18] Endive contains folate (35 µg, 8% DV) and is a good source of vitamin A (540 IU, 18% DV) and an excellent source of vitamin K (55 µg, 46% DV) (values per ½ cup). Kaempferol is one of many phytochemicals in endive, and a red cultivar of endive (*Cichorium intybus* L. *cultivar*) is a source of anthocyanins.[19]

Scientific Findings

In laboratory studies, *Cichorium intybus* inhibited free radical-mediated DNA damage,[20] and exerted cytoprotective and antiproliferative effects in cells.[19]

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.)

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. Belgian endive is a source of potassium, vitamin C, and phytochemicals such as phenolics.[21,22] *Cichorium endivia* has been used in folk medicine as an anti-inflammatory.[23]

Scientific Findings

An amino acid in *Cichorium endivia* was shown to be cytotoxic to colorectal cancer cells in a laboratory study.[23]

Bioactive Dose

Not known.

Safety

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

Ethanol

Definition

Also called ethyl alcohol and alcohol. Molecule formed during the anaerobic fermentation of the sugars in berries, grains, and other carbohydrates. A psychoactive compound and central nervous system depressant,[24]

ethanol from beer, wine, and distilled liquor supplies 7 kCals/g. Alcoholic beverages are a major calorie source for many US adults that should be reduced, but light-to-moderate consumption, in addition to being a source of beneficial phytochemicals, is associated with certain health benefits.

Scientific Findings

Alcohol consumption can have beneficial or harmful effects, depending on amount consumed, and other characteristics of the consumer, such as age and health status.[25]

Light-to-moderate alcohol intake is associated with a reduced incidence of ischemic cardiovascular events, increases HDL, and decreases LDL oxidation, platelet aggregation, and insulin resistance, and is associated with lower risk of cardiovascular disease, all-cause mortality among middle-aged and older adults, and retention of cognitive function in aging.[25–27] Most of the following effects are associated with consumption of > 3 alcoholic beverages per day: fetal alcohol spectrum disorder, cardiomyopathy, hypertension, hemorrhagic stroke, cardiac arrhythmia, and sudden death.[28] Heavier than moderate consumption of alcohol over time is associated with weight gain, can predispose individuals to stroke, increased blood pressure, hepatic steatosis, gastroesophageal reflux disease, and cell and tissue injury that result in disease.[14,25–27] Excess alcohol consumption has been identified as one of the top-ten risks contributing to the worldwide burden of disease,[26,29] and in the US, alcohol-related diseases are among the ten leading causes of death.

Bioactive Dose

If alcohol is consumed, it should be consumed in moderation, except by those who, for physiological or other reasons, should not drink at all, e.g., during pregnancy, due to a history of alcoholism, by people taking certain medications, and others. 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 oz of regular beer (5% alcohol), 5 fluid oz of wine (12% alcohol), or 1.5 fluid oz of 80 proof distilled spirits (40% alcohol), each of which contains about 0.6 fluid oz of alcohol.[25] Moderate intake of alcoholic beverages (1 to 2 drinks per day) is associated with a reduced risk of CHD.[28]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals for whom alcohol is safe and legal to consume. Ethanol should not be consumed during pregnancy, by people who have alcohol use disorder, and by many others whose age, condition, or circumstances preclude

them from safely consuming alcohol. High alcohol intake (>31 g/day) may have negative effects on the cardiovascular system, including an increase in blood pressure, activation of the sympathetic system, and an increase in the incidence of atrial fibrillation, cardiomyopathy, and hemorrhagic stroke.[27] Patients who are hypertensive should avoid alcoholic beverages.[28] Alcohol can increase plasma triglyceride levels and can serve as a source of excess calories, and in patients with underlying hypertriglyceridemia, the triglyceride elevations can be marked and are associated with the development of pancreatitis.[28] A deficiency of aldehyde dehydrogenase enzyme, common in Asians, "is associated with facial flushing and other unpleasant symptoms, such as light-headedness, palpitations, and nausea, when alcohol is consumed."[30] 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.[25] The International Agency for Research on Cancer has classified ethanol as a human carcinogen.[31]

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F

Fatty Fish

Definition

Characteristically strong-flavored fish, such as bluefish, herring, salmon, trout (both wild and farmed), mackerel, sardines, and tuna, whose oils are concentrated in their edible flesh; in contrast, mild-flavored white fish, such as haddock and pollack, store their oils in their liver. Fatty fish are high in protein, vitamin D, and omega-3-fatty acids,[1] and are sources of coenzyme Q_{10}.[2] Marinating with various seasonings before broiling or grilling can mask fish flavor.

Scientific Findings

Fish oil constituents DHA, EPA, and vitamin D are anti-inflammatory.[3–5] People who eat seafood one to four times a week are less likely to die of heart disease.[6] Epidemiological studies show that the dietary intake of *n*-3 PUFAs through fish consumption is inversely correlated with the prevalence of depression.[7] Further research is needed to determine whether EPA, DHA or fish consumption has a protective effect on all-cause dementia.[8]

Bioactive Dose

The American Heart Association recommends eating two 3.5-oz servings of (ideally fatty) fish per week; low-mercury options include canned light tuna, salmon, anchovies, herring, shad, sardines, Pacific oysters, trout, and Atlantic and Pacific mackerel (not king mackerel, which is high in methylmercury).[9,10] A daily dose of 3–4 g of EPA and DHA may reduce elevated triglyceride levels by 20–50%.[11] A 6-oz portion of Atlantic salmon supplies 3.9 g of EPA and DHA.[12] *The Dietary Guidelines for Americans 2015–2020* recommends 8 oz of a variety of seafood weekly, for 250 mg of EPA and DHA/day, an amount associated with reduced cardiac deaths among individuals with and without preexisting CVD. For pregnant or breastfeeding women, consumption of at least 8 oz per week from seafood choices that are sources of DHA are associated with improved infant health outcomes. For children, 8 or more oz per week (less for young children) of seafood including some choices with higher amounts of EPA and

DHA is recommended. Pregnant and breastfeeding women and young children should not eat certain fish that is high in methylmercury.[10]

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 should be avoided by pregnant and lactating women. Pregnant and lactating women are also advised to limit white albacore tuna.[13]

Fennel (Foeniculum vulgare)

Fennel. (Image from Diana Taliun/Shutterstock.)

Definition

Herb with a licorice-like flavor having an edible bulb, stalks, and fronds. It contains the phenolic compound anethole.[14] Fennel seeds are used to flavor sausage, and fennel stalks are used raw in salad or braised or sautéed, while fronds can be used as an aromatic garnish in seafood and mushroom dishes.[15]

Scientific Findings

Fennel experimentally improved hypertension[16] and glaucoma,[17] and anethole demonstrated antiplatelet aggregatory properties and provided "significant protection" from ethanol-induced gastric lesions in animal models.[18] Clinical trial data suggests fennel extracts may have potential in treating infantile colic.[19]

Bioactive Dose

Not known.

Safety

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

Fenugreek (Trigonella foenum-graecum)

Definition

Plant whose leaves are used as an herb and whose seeds are used as a spice and to make flour. The first recorded use of fenugreek is described on an ancient Egyptian papyrus dated 1500 BC.[20] Fenugreek has been used in traditional medicine to induce childbirth and promote lactation.[20]

Scientific Findings

Fenugreek reduced serum glucose in diabetes experimentally and in a few small clinical trials.[20,21] The gum within the fenugreek seed fiber reduces serum glucose and cholesterol.[21] There is not enough evidence to support its use as a galactagogue or a pregnancy inducer.[22] Fenugreek fiber significantly increased satiety in a small, single-blind, randomized trial of healthy obese patients (n = 18).[23]

Bioactive Dose

Not known. Trials in which fenugreek was used to reduce glucose have used varying doses and delivery forms; for example, 1 g of fenugreek extract[24] or 100 g of fenugreek seed powder.[25] For hyperlipidemia, 0.6–2.5 g of fenugreek two times daily with meals has been used.[26]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Possible side effects of fenugreek when taken by mouth include gas, bloating, and diarrhea.[24] Since fenugreek has uterine stimulant activity, intake of amounts greater than those found in food should be avoided during pregnancy.[26] Since fenugreek has not been adequately studied during lactation for potential harmful effects to the infant or mother, fenugreek should be avoided during lactation.[26]

Ferulic Acid

Definition

Phytochemical found in seeds and leaves made from the metabolism of the amino acids phenylalanine and tyrosine.[27] Found in high levels in vegetables, fruits, cereals, and coffee with the average intake estimated to be 150–250 mg/day.[28]

Scientific Findings

In laboratory studies, ferulic acid exhibited antioxidant, antimicrobial, anti-inflammatory, antithrombotic, anticancer, and increased sperm viability effects.[29,30]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Ferulic acid has a low toxicity potential.[30]

Feta Cheese

Definition

Soft white cheese produced by fermenting cow's, sheep's, or goat's milk. It is produced in blocks and kept in brine. Feta has been, and remains, a significant element in the Greek diet traditionally produced in Greece since Homeric times.[31] It is available in low- and full-fat versions, the latter is rich in vitamin K2 (menaquinone).[32]

Scientific Findings

In a cross-sectional study (n = 407 men and women, mean age 64 years, about half with Type II diabetes), a Greek pattern of food intake including onions/leeks, olive oil, garlic, and feta cheese, was inversely associated with diabetic retinopathy, hypertriglyceridemia, and hyperhomocysteinemia.[33] An animal study found that 8 weeks of a high-fat, high-canola oil diet + feta cheese resulted in higher HDL and lower total cholesterol, LDL, and triglycerides compared to 8 weeks of a high-fat, high-canola oil + butter diet.[34]

Bioactive Dose

Not known.

Safety

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

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 unique physiological effects and food characteristics.[35] 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.[36–38] Soluble, or viscous, fibers, such as guar gum, pectin, psyllium, and certain hemicelluloses, retain water and form a viscous gel in the gastrointestinal tract. This thereby delays gastric emptying, slowing the transit of food through the upper gastrointestinal 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.[39,40] 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.[35] Insoluble fibers, such as hemicellulose and cellulose, serve as bulk that increases fecal weight and promotes stool passage through the colon.[36] The food group that is highest in fiber as a group is legumes (8 g per ½ cup serving) followed by vegetables (3 g per ½ cup), nuts and seeds (3 g per 1 oz), fruits (2 g per ½ cup), and whole grain products (1 to 2 g per 1 slice or ½ cup). The usual dietary fiber intake in the United States is 15 g per day[41] 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.[42] 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.[37] Soluble fibers help to alleviate diarrhea; reduce fasting plasma cholesterol which is associated with reduced risk of heart disease; and reduce postprandial glucose, which is associated with reduced risk of diabetes.[37,43] Soluble fibers may modestly reduce LDL cholesterol levels beyond that achieved by a diet low in saturated fat and trans fats alone.[35]

Bioactive Dose

The Dietary Reference Intakes recommend 14 g of dietary fiber per 1,000 kcalories, an AI of 25 g/day for women and 38 g/day for men. The National Cholesterol Education Program Expert Panel recommends consuming 10–25 g of soluble fiber per day in addition to a diet low in saturated fat to reduce LDL cholesterol;[44] 5–10 g of soluble fiber per day reduces LDL cholesterol levels by approximately 5%.[45] Diets supplying 30–50 g of fiber per day from whole food sources consistently produce lower serum glucose levels compared to a low fiber diet.[46]

Safety

No UL for fiber has been established. Increasing dietary fiber too quickly can lead to gas, bloating, and cramps. Due to the bulky nature of fibers, excess consumption is likely to be self-limiting.[49] Fiber binds to minerals and increases their excretion; therefore, excessive fiber intake may have adverse effects upon mineral absorption, hence, the World Health Organization recommends an upper limit of 40 g/day.[37]

Fig (Ficus carica)

Fig. (Image from oriori/Shutterstock.)

Definition

Small, 2–3-inch purple fruit with thin skin and edible seeds. It is mild in flavor and a good source of fiber (1.4 g, 10% DV per fig).[48] Phytochemical components include phenolics, coumarins, flavonoids (e.g., anthocyanins, quercetin, luteolin), and terpenoids.[49] Consumed fresh, dried, as jam, and made into fruit filling for baked products. It has a history of use as a laxative, for diabetes, hyperlipidemia, eczema, psoriasis, and vitiligo,[26] although there is no evidence to evaluate its effect on these conditions.

Scientific Findings

Figs demonstrated antioxidant properties[50] and suppressed various types of cancer cells in vitro.[51]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Fig has been associated with allergic reaction.[26]

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."[52,53] "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."[54] 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.[52,54,55] Flavonoids are transported in serum by albumin, thus, theoretically, protein malnutrition may reduce serum circulating levels of flavonoids.[56] Plants containing flavonoids have a long history of use in traditional medicines in many cultures, but flavonoids themselves were not discovered until the 1930s.[57] Certain plants and spices containing flavonoids have been used for thousands of years in traditional Eastern medicine.[49] Flavonoids are the most widely distributed plant polyphenol and account for approximately two-thirds of plant polyphenols in the human diet. It has been estimated that the average daily US intake of flavonoids is between 20 mg and 1 g.[58]

Scientific Findings

"Flavonols, flavanones, and flavones are subclasses of flavonoids that exert cardioprotective and anticarcinogenic properties in vitro and in vivo."[26] Dietary flavonoid intake was associated with a decreased risk of advanced stage prostate cancer in the Netherlands Cohort study (n = 58,279 men).[59] Flavonoids have demonstrated anti-inflammatory properties in experimental models of rheumatoid arthritis (RA), but a review of human data found little evidence to support flavonoids' anti-inflammatory effects in RA.[60] A meta-analysis based on findings of the 20-year Zutphen Elderly Study showed "a nearly statistically significant 43% reduced risk of all cancers associated with high vs. low consumption of flavonoids and a halving in risk for gastrointestinal and respiratory cancers."[61] "The activity of flavonoids as inhibitors of reverse transcriptase suggests a place for these compounds in the control of retrovirus infections, such as [AIDS]."[62]

Bioactive Dose

Not known.

Safety

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

Flaxseed (Linum usitatissimum)

Flaxseed. (Image from hsagencia/Shutterstock.)

Definition

Tiny brown or gold seeds that come from the flax plant whose genus and species name *Linum usitatissimum* derives from "most useful" due to the utility of the plant for food, linen, and linseed oil.[63] Flaxseeds have a mild, nutty flavor and may be consumed ground or whole.[64] Flaxseed are 35–45% fiber, making them an excellent source of fiber of which ⅔ is insoluble and ⅓ is soluble.[65] Flaxseeds contain potassium (341 mg, 7% DV per ¼ cup)[66] are a good source of iron (2.4 mg of iron, 13% DV), in addition to being a rich source of linolenic acid and beta-sitosterol.[67] Flaxseeds, flaxseed cereals and breads, and flaxseed oil may require refrigeration to prevent rancidity and also should not be heated to high temperatures to prevent off-odor and flavor development. Hippocrates wrote about flaxseed being a laxative.[65]

Scientific Findings

Flaxseed contains soluble fiber that is an effective laxative and decreases blood total cholesterol by increasing bile acids in the feces, thereby lowering blood cholesterol. While most research shows that taking flaxseed 30–50 g per day reduces total cholesterol by 5–15% and LDL cholesterol by 8–18%, a meta-analysis of 28 studies found flaxseed oil was not more effective in reducing total cholesterol or LDL cholesterol compared to olive, rapeseed, hempseed, safflower, or sunflower oil.[68] Flaxseed oil suppresses oxygen radical production by white blood cells, prolongs bleeding time, and in higher doses suppresses serum levels of inflammatory mediators, but is not an effective hypolipemic agent.[69]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. A safety review of flaxseed found: severe allergic reactions to flaxseed and flaxseed oil have been reported; that flaxseed or flaxseed oil taken by mouth may cause mania or hypomania in people with bipolar disorder; that people with diarrhea, irritable bowel syndrome, diverticulitis, or inflammatory bowel disease (Crohn's Disease or ulcerative colitis) should avoid flaxseed due to its possible laxative effects; that large amounts of flaxseed by mouth can cause ileus; that people with narrowing of the esophagus or intestine, ileus, or bowel obstruction should avoid flaxseed; based upon animal studies, an overdose of flaxseed may cause shortness of breath, rapid breathing, weakness, difficulty walking, and seizures or paralysis; that flaxseed may stimulate menstruation and that animal studies have shown possible harmful effects during pregnancy; therefore, the use of flaxseed or flaxseed oil during pregnancy and breastfeeding is not recommended.[70] Raw or unripe flaxseeds, which may contain potentially toxic compounds, should be avoided.[65]

Folate

Definition

Also called folic acid. Water-soluble vitamin involved in the manufacture of deoxyribonucleic acid necessary for cell division and tissue growth. Folate requires vitamin B12 to be converted to a form necessary to manufacture deoxyribonucleic acid.[71] Synthetic folic acid is more bioavailable than naturally occurring folate. The quantity of this vitamin in the diet, though measured in μg, may be expressed in Dietary Folate Equivalents to encompass the absorption difference between the synthetic form, found in commercial grain products and dietary supplements (folic acid), and the natural form found foods (folate). Approximately 8% of Americans have inadequate intakes of folate-based on Estimated Average Requirements.[72]

Acceptable range for serum folate is 3–16 mg/mL and an acceptable range for erythrocyte folate is 140–628 ng/mL of packed cells.[73] Folate deficiency impairs cell division and protein synthesis, two of the first symptoms of which are megaloblastic anemia and GI tract deterioration.[73] Deficiency of folate (and other B vitamins including vitamins B6 and B12) is associated with hyperhomocysteinemia (homocysteine > 12–15 μmol/L) (note: there is debate about the definition of hyperhomocysteinemia, with the starting point of "high" homocysteine beginning at 9 μmol/L and ranging up to 20 μmol/L[74]). Hyperhomocysteinemia is "an independent predictor for all-cause mortality and it compromises health of all organ systems."[75, 76]

Scientific Findings

Hyperhomocysteinemia is a risk factor for atherothrombotic and neuropsychiatric disorders.[77] To reduce the risk of in utero neural tube defect development of infants, 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.[78] 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.[79] Some, but not all studies, support an association between folate intake and colon cancer development.[80–82] A diet rich in folate was associated with a statistically significant lower risk of cerebral infarction, but not intracerebral or subarachnoid hemorrhage, in a large observational trial (n = 26,556 Finnish male smokers, aged 50–69).[83] Low serum folate has been found in patients with recurrent mood disorders treated with lithium and in patients with alcoholism who have depression, and is linked to poor response to antidepressants.[84]

Bioactive Dose

The RDA of folic acid for men and non-pregnant women age 19–50 is 400 µg; for pregnant women: 600 µg; and for lactating women: 500 µg.

Safety

The UL for folic acid is 1,000 µg. Exceeding the UL for folic acid might pose a health risk for individuals with vitamin B12 deficiency (*see also: Vitamin B12*) for whom a surplus of folic acid can delay the diagnosis of a vitamin B12 deficiency.

Fructan

Definition

Also called fructooligosaccharide (FOS). Naturally occurring polymer of fructose, an example of which is inulin. Found in asparagus, Jerusalem artichokes, chicory, bananas, garlic, and onion.[85–88]

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.[88,89] Fructans and other fermentable carbohydrates can cause gas and worsen gastrointestinal (GI) symptoms that occur in

irritable bowel syndrome.[90] A review of 34 studies including experimental and human clinical trials concluded that FOS may have a beneficial effect on lipid metabolism and regulation of serum cholesterol levels when combined with lifestyle and dietary changes.[91]

Bioactive Dose

For hypertriglyceridemia, the typical dose of inulin is 10–14 g daily; for hypercholesterolemia, 6 g three times daily has been used for up to 6 weeks.[92]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Fructans and other indigestible carbohydrates are fermented in the lower GI tract and cause gas. People prone to gastrointestinal distress due to IBS, celiac disease, and those following a low FODMAP (fructooligosaccharides, oligosaccharides, disaccharides, and polyols) diet should avoid fructans.[90]

Fruit

Definition

An under-consumed food group that is a good source of vitamins A and C, folate, potassium, and fiber, in addition to different phytochemicals that 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, xeaxathin, indoles, isothiocyanates, and organosulfur compounds; white plant foods contain typically contain flavonols, flavanones, indoles, isothiocyanates, and organosulfur compounds; yellow plant foods typically contain flavonols, flavanones, alpha-carotene, beta-carotene, beta-cryptoxanthin, and xeaxanthin; and red plant foods typically contain anthocyanins, flavonols, flavones, flavan-3-ols, flavanones, proanthocyanidins, lycopene, ellagic acid, and resveratrol.[93]

Scientific Findings

People who consume diets rich in plant foods, including fruits, have a lower risk of getting cancers of the mouth, pharynx, larynx, esophagus, stomach, and lung; some evidence suggests that maintaining a diet rich in plant foods also lowers the risk of cancers of the colon, pancreas, and prostate. As well, this diet reduces the risk of diabetes, heart disease, and hypertension; helps to reduce calorie intake; and may help to control

weight.[94] Consuming a diet containing high amounts of plant foods, including fruits, is associated with fewer age-related diseases such as Alzheimer's Disease.[95]

Bioactive Dose

One to two cups of fruit is recommended for most people for general health,[96] whereas 0.9 daily cup equivalents of fruit per 1,000 calories is recommended to help prevent the cancers cited in Scientific Findings.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Many fruit allergies have been reported.

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G

Garbanzo bean (Cicer arietinum)

Definition

Legume also known as chickpea. A good source of fiber (3 g, 11% DV per ½ cup), garbanzo beans also contain numerous phytochemicals, including flavonoid glycosides.[1,2] Hummus is a purée of garbanzo beans, lemon, cumin, garlic, and tahini.

Scientific Findings

Garbanzo beans have a low glycemic index[3] and may be used as a low-fat substitute for meat. One oz of meat, poultry, or fish is nutritionally equivalent to ¼ cup cooked of garbanzo beans, although the iron content and absorption is lower in garbanzo beans, as is the case for all legumes, compared to meat. *See also: flavonoids* (Table G.1).

Bioactive Dose

Not known.

Safety

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

Table G.1 Iron Comparison in Legumes vs. Meat

ChooseMyPlate.gov Protein Food Group Standard Quantities	Iron, mg	% DV	Iron Bioavailability (Approximate Amount of Iron Absorbed)[68]
Garbanzo beans, ¼ cup	0.72[69]	4%	2–20%
Sirloin steak, 1 oz	1.4[70]	8%	23%

Garlic (Allium sativum)

Definition

Edible lily family bulb that is a common culinary ingredient. It produces allyl sulfur compounds such as allicin, methyl allyl trisulfide, and diallyl trisulfide, when cut or crushed, which each may have unique health properties. Other phytochemical constituents include 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.[4] Allicin is partly responsible for the flavor and odor of cut garlic.[5] Allicin was previously considered to be a key bioactive constituent of garlic, but was found to be highly unstable and freshly crushed garlic may contain only limited amounts of to no allicin.[5] Garlic's biological activity is likely due to several components of garlic, which may include organosulfur transformation products of allicin.

Scientific Findings

Though 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,[6] fresh garlic, dried powdered garlic tablets, and aged garlic extract tablets all were found to be ineffective at lowering serum cholesterol in a controlled trial[6] and a meta-analysis representative of available evidence on the effects of garlic on serum cholesterol from RCTs found no beneficial effect of garlic on serum cholesterol.[7] The same meta-analyses found the methyl allyl trisulfide component of garlic may be antithrombotic.[6] Nevertheless, a dose of fresh garlic 4 g (approximately one clove) once daily has been used to treat hyperlipidemia;[10] for hypertension, the dose of garlic powder 600–900 mg daily has been used.[10] If garlic consumption does reduce the risk of developing cancer, the amount needed to lower risk remains unknown.[14] Garlic may reduce cardiac arrhythmias.[8] Some evidence has suggested that garlic consumption may slightly reduce blood pressure, particularly in people with high blood pressure;[6] other evidence does not support an appreciable effect of garlic in reducing blood pressure in people with high blood pressure.[9] Taking low doses of garlic powder orally, 300 mg per day, lessened age-related decreases in aortic elasticity, while higher doses of 900 mg per day seemed to slow development of atherosclerosis in both aortic and femoral arteries when used over a 4-year period.[10] Laboratory studies demonstrated that garlic, and or some of its allyl sulfur compounds, suppress carcinogen formation and bioactivation and tumor proliferation.[11] Diallyl trisulfide exhibited chemoprotective properties experimentally.[12] However, a review of 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.[13] 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."[14] Garlic's antifungal properties have been demonstrated in laboratory research.[15,16] In laboratory studies, aged garlic extract, but not fresh garlic extract, exhibited antioxidative activity.[17] Aged garlic extract exhibited hepatoprotective and neuroprotective properties.[18] In laboratory studies, allicin and compounds into which it transforms when processed, exhibited antimicrobial properties,[19] and treatment with allicin arrested human mammary cancer cells in a laboratory study.[20]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Side effects may include breath and body odor, heartburn, upset stomach, and allergic reactions. Garlic is an anticoagulant and intake should be considered in patients with bleeding disorders or who are on anticoagulants and during or after surgery (garlic use should be stopped 7–10 days in advance of surgery, or if dental work is planned).[21]

Ginger (Zingiber officinale)

Definition

Rhizome, or underground stem similar to a root, commonly used in Asian cooking, such as in pickled slivers as a sushi condiment. It is also used as a dry spice powder and to flavor ginger ale, and consumers should look for "made with real ginger." Ginger contains niacin and phytochemicals including phytosterols, berberine, and the pungent compound zingerone.[22–24] Ginger has been used in traditional Asian medicine to alleviate stomachache, nausea, and diarrhea.[25]

Scientific Findings

Ginger promotes saliva production and gastric juice secretion, and produces an increase in the tone and peristalsis of the intestine.[26] In an animal study, zingerone inhibited colonic motility via direct action on smooth

muscles.[27] Berberine exhibited anti-inflammatory effects in vivo and in vitro. A systematic review of six RCTs (n = 439 subjects) evaluating the efficacy of ginger for nausea and vomiting found a non-significant difference between ginger and placebo.[28] Another review of 27 RCTs (n = 4,041 subjects) examining various interventions for nausea, vomiting, and retching in early pregnancy found that the "use of ginger products may be helpful to women, but the evidence of effectiveness was limited and not consistent."[29] Ginger may help to reduce nausea due to cancer chemotherapy when used in addition to conventional anti-nausea medication.

Bioactive Dose

The antiemetic dose is 2 g of ginger powder taken with liquid.[29] An infusion is made from pouring boiling water over 0.5–1 g ginger (1 teaspoon = 3 g ginger) and straining after 5 minutes.[29]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. The *Physician's Desk Reference for Herbal Medicines* contraindicates the use of ginger during pregnancy for morning sickness related to reports that ingesting ginger during pregnancy might affect fetal sex hormones and a separate case report of spontaneous abortion during week 12 of pregnancy in a patient who used ginger for morning sickness.[29] However, NIH recommends consulting with a physician regarding the use of ginger during pregnancy and states that ginger may be used short-term to safely relieve the nausea of pregnancy without harm to the fetus.[28] Ginger should not be taken by individuals suffering from gallstones, except after consultation with a medical professional, because it increases bile production.[28]

Glucosinolates

Definition

Secondary plant metabolites found in *Brassica* plants that transform into various active compounds including sulforaphane and indole-3-carbinol.

Scientific Findings

Epidemiological and in vivo evidence suggests sulforaphane indole-3-carbinol exert anticancer properties.[30,31] When *Brassica* foods are prepared by boiling, blanching, or fermenting, glucosinolate content is significantly reduced, whereas preparing by steaming, microwaving, or stir-frying either retains or only slightly reduces the glucosinolate content.[32] Sprouts

of *Brassica* vegetables typically contain significantly higher concentrations of glucosinolates than mature plants.[33]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Glucosinolates impair thyroid uptake of iodine.[34]

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.[35] The spice cumin is also a source of glutathione.[36]

Scientific Findings

Glutathione is thought to prevent free radical formation in humans.[37]

Bioactive Dose

Not known.

Safety

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

Glycosides

Definition

Sugar derivatives produced biochemically in plants, such as garbanzo beans, blackberries,[1,38] and *Stevia rebaudiana*, used to make the natural sweetener Stevia.[39]

Scientific Findings

Glycosides were shown to be antioxidants, suppress cancer cell growth, and exert antiatherogenic properties in laboratory studies.[42]

Bioactive Dose

Not known.

Safety

Presumed to be safe when consumed in normal dietary quantities by nonallergic individuals, except amygdalin, found in non-consumable portions of fruits (for example, 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 (refining) to increase shelf life and palatability, many nutrients are also removed including fiber, fat, protein, vitamins, and phytochemicals. "Enriched" refined grains (containing the word "enriched" in their ingredient listing), are processed grain foods to which thiamin, riboflavin, niacin, folic acid, and iron have been added.

Scientific Findings

A case-control study (n = 384 pancreatic adenoma cases and 983 matched controls) found an increased association between pancreatic adenocarcinoma and intake of non-whole grains, and an inverse association between pancreatic adenocarcinoma and intake of whole grains.[40] A meta-analysis of 48 articles comprising 16 cohorts identified high intakes of refined grains, along with other processed foods, as significantly associated with diabetes risk.[41]

Bioactive Dose

Not applicable.

Safety

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

Grains, Whole

Definition

Grains with the bran, germ, and endosperm intact. 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,[42] antioxidants, and phytoestrogens. Examples include oats, popcorn, brown rice, and products whose first ingredient in the ingredient listing is the word "whole." For example, "Ingredients: Whole wheat."

Scientific Findings

Epidemiological studies have shown that whole grain intake is protective against cancer, cardiovascular disease, diabetes, and obesity.[43] Cancer: A 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.[44] A 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.[45] 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, the production of short-chain fatty acids by the fermentation of fiber, and/or some action of individual constituents, such as antioxidants, vitamins, trace minerals, phytate, phenolic acids, lignans, phytoestrogens, folate, and magnesium.[46,49] 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: decreased insulin resistance, decreased triglyceride levels, and/or elevated high-density lipoprotein levels).[42] Cardiovascular Disease: A meta-analysis of nine randomized clinical trials (n = 1,414 healthy subjects, mean age 45–59) examining whole grain diets for a minimum of 12 weeks compared to lower whole grain or refined grain diets found "insufficient evidence … of an effect of whole grain diets on cardiovascular outcomes or on major CVD risk factors such as blood lipids and blood pressure." Diabetes: A meta-analysis of 1 RCT and 11 prospective cohort studies found evidence "too weak to be able to draw a definite conclusion about the preventative effect of whole grain foods on the development of Type II diabetes."[46] Obesity: Weight-loss diets rich in whole grains, fruits, and vegetables, or both for 10 weeks improved weight and blood pressure in a randomized clinical trial of overweight

and obese women (n = 75), but HDL was most improved within the whole grain compared to the fruit and vegetable or combination whole grain-fruit/vegetable group.[47]

Bioactive Dose

Three servings of whole grains per day and "making half your grains whole" are general USDA recommendations for healthy people. One "serving" varies with each food (e.g., one serving of oatmeal is ½ cup while one serving of a whole wheat bread is a 1-oz slice).

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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.[48] 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.[49] Concord grape (*Vitis labrusca*) juice is high in vitamin C and polyphenols.

Scientific Findings

Purple grape juice (200 ml combined with 30 ml of blackcurrant flavor cordial) dosed on two separate occasions acutely enhanced aspects of cognition and mood in a placebo-controlled double-blind RCT (n = 20 healthy young adults).[50] A dosage of 10 ml/kg of purple grape juice did not improve memory or mood in smokers (n = 36).[51] A 12-week, placebo-controlled, double-blind RCT (n = 12 adults with early memory decline but not dementia) that dosed Concord grape juice at 6–9 mL/kg daily significantly improved a measure of verbal learning and resulted in a nonsignificant enhancement of verbal and spatial recall; however, fasting insulin was increased for those consuming grape juice.[52]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Grape seed extracts have been safely used for up to 8 weeks in clinical studies.[54]

Grapefruit (Citrus paradisi)

Definition

Large yellow- 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.[53] Naringin is a bitter principle of grapefruit and flavonoid that is partly responsible for grapefruit juice enhancing the bioavailability of certain medications.[54]

Scientific Findings

A red grapefruit variety (*Citrus paradise* Macf.) exhibited antioxidant properties in a laboratory study.[55] Eating 1.5 grapefruits daily for six 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.[56] Grapefruit juice produced a greater decrease in mean arterial blood pressure when compared with orange juice in an experimental study.[57] In laboratory studies, naringin exhibited antioxidant properties, inhibited tumor growth, and suppressed age-related blood pressure increases in hypertensive rats.[58–60]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Grapefruit juice has been found to increase the absorption of certain drugs, including simvastatin and lovastatin,[24] and to increase cortisol availability in patients with Addison's Disease;[61] therefore, people on these medications may be advised to avoid grapefruit juice.

Green Leaf(y) Vegetables

Definition

Versatile family of plant foods, 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 green vegetables may be cooked or can be thinly minced and consumed fresh. 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.

Scientific Findings

Consumption of green leafy vegetables is associated with a reduced risk of several types of cancer and cardiovascular disease.[62] A high intake of green leafy vegetables was associated with a reduced risk of non-Hodgkin's Lymphoma in a population-based case-control study (n = 348 cases and 470 controls) in which a higher intake of green leafy vegetables and cruciferous vegetables was associated with a lower risk of non-Hodgkin's Lymphoma.[63] 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.[40]

Bioactive Dose

Not known.

Safety

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

Guava (Psidium guajava)

Guava. (Image from Nuttapong/Shutterstock.)

Definition

Lime-sized fruit whose tough skin may be yellow, red, or purple and whose flesh may be yellow, pink, or red, depending on variety.[64] Guavas are tropical fruits with edible seeds that are sources of polyphenols and are good sources of fiber (3 g, 10% DV) and vitamin A (343 IU, 11% DV), and excellent sources of vitamin C (125 mg, 138% DV) per 1 fruit.[65,66] Guavas are consumed fresh or as juice.

Scientific Findings

300 mL of guava juice added to the diet of anemic children (n = 95 children aged 6–9) for 10 weeks marginally increased hemoglobin and plasma ferritin.[66] The 200 mg of vitamin C per 300 mL serving of guava juice was attributed with increasing the absorption of nonmeat-flesh iron, such as vegetable sources of iron. Preliminary research suggests guava lectin and galactose may have antidiarrheal properties.[67]

Bioactive Dose

Not known.

Safety

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

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H

Hazelnut (Corylus avellana)

Hazelnut. (Image from Valentina Razumova/Shutterstock.)

Definition

Marble-sized nut, also called a filbert, that is a good source of protein, monounsaturated fatty acid, tocopherols, and phytosterols.[1] Hazelnuts, cocoa, sugar, and, palm oil are used to make the popular chocolate spread Nutella®. Dry-roasted hazelnuts are added to nut mixes and sweetened dry-roasted hazelnuts are used as crunchy yogurt toppings.

Scientific Findings

In a laboratory study, hazelnuts' phenolic compounds exerted antioxidant effects.[2] 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.[3]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Hazelnut allergy has been reported.

Hemicellulose

Definition

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

Scientific Findings

Fibers in the large intestine promote stool passage and are associated with lower rates of diverticular disease, hemorrhoids, and appendicitis.[4]

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 per day.[4] Fiber intake exceeding 40 g has been associated with decreased absorption of minerals.

Honey

Definition

Intensely sweet viscous simple sugar, made of glucose and fructose, that is produced by bees from flower nectar. Flavors of honey vary depending upon the flower source. Use has been documented in the world's oldest medical literature for its topical healing properties due to its "high viscosity that helps to provide a protective barrier to infection."[7,8]

Scientific Findings

Honey contains the antibacterial protein royalisin.[7] Four different varieties of honey exerted antimicrobial effects against *S. Aureus* in a laboratory study.[9] Clinical research from several RCTs shows that taking honey 2.5–10 mL (0.5–2 teaspoons) at bedtime can significantly reduce nighttime cough frequency and severity compared to placebo in children with upper respiratory infections.[10] Honey also appears to be at least as effective or more effective than the cough suppressant dextromethorphan in typical over-the-counter doses and the antihistamine diphenhydramine.[12]

Bioactive Dose

For cough, 2.5–10 mL (0.5–2 teaspoons) of honey.[12]

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).[11] Regarding botulism, honey consumption is safe in children over one year of age.[13]

Honeydew melon (Cucumis melo *L. var. inodorus Naud*)[12]

Definition

Considered to be the sweetest commercially available melon and one of the ten most consumed melons in the US, the honeydew melon has pale green, juicy flesh, and its ripeness is reflected by its creamy yellow, inedible rind. One-half cup of honeydew contains potassium (202 mg, 4% DV) and folate (17 µg, 4% DV), and is a good source of vitamin C (15.5 mg, 11% DV).[13] Cucurbitacin-β is among its phytochemical constituents.[17]

Scientific Findings

Cucurbitacin-β has exhibited anti-hepatotoxic, anti-inflammatory, and anticancer properties in laboratory studies.[17]

Bioactive Dose

Not known.

Safety

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

Hops (Humulus lupulus *L.*)

Hops. (Image from Zhukov Oleg/Shutterstock.)

Definition

1. Flower of the hop plant; contains phytoestrogens and chalcones.
2. The major bitter flavoring in beer; also used as a food preservative.
3. Traditional uses of hops include as a sleep aid, stomachic, antibacterial, and antifungal agent[7, 14]

Scientific Findings

Sedative effects of hops have been observed in laboratory animals.[16] In vivo and in vitro studies have demonstrated stomachic, antibacterial, antifungal, and cancer-preventative properties of hops.[16]

Bioactive Dose

Not known.

Safety

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

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, xeaxanthin, and glucosinolates.[15–17] 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 US. Horseradish has been used to cure scurvy due to it vitamin C content (3.7 mg, 4% DV per 1 tablespoon).[18]

Scientific Findings

Horseradish exhibited antibacterial properties in an in vitro study.[19] In a placebo-controlled clinical trial, horseradish also helped prevent urinary tract infections.[19] The German Commission E has approved horseradish for oral use as "supportive therapy for infections of the urinary tract."[20]

Bioactive Dose

Not known.

Safety

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

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I

Inulin

Definition

Fermentable carbohydrate (classified as a fructooligosaccharide or fructan) found in plant foods, such as asparagus, bananas, chicory, dandelion, garlic, Globe artichoke, Jerusalem artichoke, leeks, onions, wheat bran, and wheat flour, that is a prebiotic.[1] The average American eats 2.6 g of insulin daily.[2] Fermentable carbohydrates may produce gas, bloating, pain, and other undesirable GI symptoms.

Scientific Findings

Inulin improves laxation by increasing stool bulk, water content, and certain fecal bacteria, and may strengthen the intestinal epithelium possibly reducing the risk of gastrointestinal diseases.[3,4] Inulin dosed at 15 g daily improved stool frequency in constipated elderly individuals (n = 25) in a 28-day randomized, double-blind, controlled clinical trial (n = 252).[5] Gut microbiota improved in inulin-supplemented (0.8 g/dL) formula-fed newborn infants compared to breastfed infants in a double-blind, randomized, placebo-controlled clinical trial lasting for four months.[6] *See also: Fructan.*

Bioactive Dose

For treatment of constipation in the elderly, 20–40 g daily for 19 days has been used.[7]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. People with inflammatory bowel disease (Crohn's Disease, ulcerative colitis), irritable bowel syndrome, and an estimated 20% of people with celiac disease, could minimize GI distress by avoiding fermentable carbohydrates.[8]

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.[9] Chinese medical literature dating to approximately 3600 BC "were the first to record the decreases in goiter size upon ingestion of seaweed and burnt sea sponge."[10] It has been estimated that ⅓ of the world's population consumes insufficient iodine[11] and more than one billion people worldwide are iodine deficient.[12] In the US, however, average daily adult intake of iodine has been estimated to be between 210 (140% DV) and 300 μg (200% DV),[7] amounts that exceed the Recommended Dietary Allowance and the 150-μg Reference Dietary Intake (used to display % DV). Foods sourced from the ocean, including seafood and seaweed, are good sources of iodine, and sea salt contains some natural iodine; other good sources of iodine are vegetables and fruits grown in coastal, iodine-rich soil. Milk is a source of iodine due to the use of iodophor disinfectants used by the dairy industry (a practice that some commercial dairies have voluntarily discontinued), as well as iodine-containing feed additives given to dairy cows. [13,14] Declaration of iodine content and iodine % DV are not required on Nutrition Facts labels. Additional sources of incidental iodine include iodine-containing dough conditioners used in the bakery industry[12,15] and iodine additives used in processed foods such as calcium iodate, potassium iodate, cuprous iodide, and the type of additive used to fortify salt: potassium iodide. The iodization of salt was initiated in 1924 to eradicate goiter in response to high rates of goiter in inland "goiter belt" (Great Lakes, Appalachians, and Northwest) regions of US.[8] Iodine is also absorbed transcutaneously from exposure to car exhaust that creates iodine vapor from the combustion of organic fuels and topical exposure to iodine preparations, such as iodine antiseptics.[11] Multivitamin-mineral supplements may commonly supply 100% DV for iodine, negating the need for additional iodine intake (Table I.1).

Scientific Findings

Both iodine deficiency and iodine excess in otherwise healthy individuals can compromise thyroid function.[11] Thyroid enlargement is the earliest clinical feature of iodine deficiency, but excess iodine can also produce goiter.[7] Epidemiological studies have shown that an increased incidence of autoimmune thyroid disease frequently parallels an increased dietary iodine intake,[16] underscoring the need for adequate, but not excessive, iodine intake. Determination of individual iodine intake is difficult in part because nutrition databases typically do not include iodine. Recent data that are representative of the general US population showed that

median urinary iodine concentration (UIC) in 2009–2010 was 144 μg/L, a level considered to be associated with adequate intake of iodine; however, pregnant women in their first and second trimesters had inadequate UIC.[17] UIC is generally not useful to classify intake sufficiency or deficiency in a person and is more useful to identify groups at risk of iodine deficiency according to experts;[16] however, other experts believe UIC to be useful: "Roughly 90% of all iodine consumed is excreted in the urine and thus, [UIC] is a sensitive indicator for current intake. UIC can be easily measured in a relatively inexpensive manner through the collection of a spot-urine sample. The World Health Organization (WHO) defines the following median UIC (mUIC) concentrations of nutritional iodine sufficiency for a population: excessive iodine intake, ≥ 300 μg/L; more than adequate intake, 200–299 μg/L; adequate intake, 100–199 μg/L; mild iodine deficiency, 50–99 μg/L; moderate iodine deficiency, 20–49 μg/L; and severe iodine deficiency."[18]

Table I.1 Iodine Content of Common Foods

2% milk, 240 ml	63 μg
Nonfat milk, 240 ml	51 μg
Organic 2% milk, 240 ml	Varies by brand, but this information was not available at several manufacturers who were contacted
Infant formula, 150 ml	6.2–56.8 μg
Cod, cooked, 3 oz (85 g)	99 μg
Shrimp, cooked 3 oz (85 g)	35 μg
Corn grits, enriched, cooked, ½ cup	68 μg
Bread, 1 (~ 50 g) slice	23–300 μg
Whole wheat bread, 2 slices (50 g)	32 μg
Oatmeal, cooked 1 cup	16 μg
Cornflakes, 3 ½ c (100 g)	93 μg
Flour Tortilla, 1 (55 g)	41 μg
Navy beans, ½ cup (~ 90 g)	35 μg
Baked potato, 1 small (110 g)	34 μg
Turkey breast, cooked, 3 oz (85 g)	34 μg
Salami, (100 g)	28 μg
Cottage cheese, 2% (½ cup)	26–71 μg
Egg, cooked, 1 large (50 g)	24 μg
Iodized salt, 1 teaspoon[45] (1 g)[46]	45 μg[15]
One A Day® Women's Multivitamin-Mineral	150 μg[47]
Centrum Silver Multivitamin-Mineral	150 μg[48]

Sources: [7, 10, 12–16]

Insufficient maternal iodine intake during pregnancy 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.[7] Iodine prevented the increase of testosterone-induced oxidative stress in a model of rat prostatic hyperplasia by exhibiting antiproliferative and antioxidant effects.[19]

Bioactive Dose

The adult RDA for iodine is 150 μg. The pregnancy RDA is 220 μg.

Safety

The UL for iodine for adults aged 19–50 years is 1,100 μg. Excessive intake of iodine from food, beverages, and supplements has been associated with adverse effects such as thyroiditis, goiter, hypothyroidism, and hyperthyroidism.[7]

Iron

Definition

Trace mineral found in hemoglobin in red blood cells and myoglobin in muscle cells that supplies oxygen necessary for energy metabolism. Heme iron occurs bound to hemoglobin or myoglobin in animal flesh and sources include meat, poultry, fish, and seafood, but not non-flesh animal foods, such as eggs. Nonheme iron is found in eggs, legumes, beans, peas, processed soy products, and iron-fortified enriched cereals. Heme iron is well-absorbed (approximately 23%) compared to nonheme iron (2–20%), but vitamin C and meat, poultry, and seafood improve nonheme iron absorption[20,24] Hemoglobin concentrations lower than 11–12 g/dL in children younger than 12, 12 g/dL in adolescents and women, and 13 g/dL in men indicate iron deficiency anemia.[23]

Scientific Findings

Insufficient iron intake during pregnancy increases infant 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.[21] Iron deficiency anemia affects approximately 10% of Americans and is especially common in toddlers, children, adolescents, and reproductive-aged women.[21] Symptoms of iron deficiency and iron deficiency anemia include: fatigue upon

physical exertion, poor exercise tolerance, impaired energy metabolism, decreased mental productivity, decreased academic aptitude, decreased neurotransmitter synthesis, irritability, apathy, and restlessness. Iron deficiency is associated with poor diet, malabsorptive disorders, and blood loss, people with iron deficiency usually have other nutrient deficiencies concomitantly.[24]

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.[22] The pregnancy RDA for iron is 27 mg. Iron-deficient pregnant women will require > 27 mg of iron daily 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.[24]

Isoflavones

Definition

Flavonoid phytoestrogens[23] whose chemical structure is similar to estrogen[24] that act as selective estrogen receptor modulators[25] (exerting both estrogenic and non-estrogenic properties) depending on the amount and type consumed and endogenous hormonal status of the organism. They are much less potent than endogenous estrogen.[26] Daidzein, genistein, and glycitein are three major types of isoflavones found in certain fruits, vegetables, breads and cereals, meats, nuts, seeds, legumes, tofu, tempeh, soybeans, and soybean products.[27] US intake of isoflavones has been estimated to be 1.13 mg/d,[28] whereas typical Japanese intake is 30–50 mg/day.[29] One serving of a traditional soyfood, such as 100 g of tofu or 250 mL soymilk, typically provides about 25 mg isoflavones.[27]

Scientific Findings

A meta-analysis showed no cholesterol-lowering effect of soy isoflavones (n = 208 hypercholesterolemic adults)[30] and a second meta-analysis found that ingestion of an average of 70 mg of soy isoflavones/day for 1–3 months did not significantly change total cholesterol or LDL cholesterol compared with a placebo in normocholesterolemic menopausal women (n = 565).[30] A

metabolite of the daidzein, equol, was found, in 14 studies, to significantly improve cholesterol and other lipids, inflammation, and other variables.[31] Soy foods' skeletal effect seems to be dependent upon its content of isoflavones.[32] A meta-analysis of 43 RCTs (n = 4,364 participants) found no conclusive evidence that phytoestrogen supplements effectively reduce the frequency or severity of hot flushes and night sweats in perimenopausal or postmenopausal women, but noted that four trials not combined in the meta-analysis showed high (>30 mg/day) levels of genistein consistently reduced the frequency of hot flushes and that "benefits derived from concentrates of genistein should be further investigated."[33] A meta-analysis that included 47 RCTs (n = 8,326 menopausal women) found that isoflavones were more effective than placebo at relieving vasomotor symptoms, but not significantly better than transdermal estradiol and progestogen, which were effective treatments.[34] S*ee also: Soybean and Phytoestrogens.*

Bioactive Dose

Though doses of isoflavones used to reduce blood lipids in studies have ranged from 40–318 mg/day,[7] the dose needed to achieve significant decreases in total or LDL cholesterol or triglycerides has not been established.[35] Quantities of 50–100 mg/day have been shown to have positive effects on markers of bone mineral density (BMD) in epidemiology and human clinical trials.[33,34]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Isoflavones exert goitrogenic effects.[36]

Isoprenoids

Definition

Phytochemicals such as menthol from peppermint oil, citral from lemongrass oil, and limonene from citrus rinds that impart flavors and fragrances. Fruits, vegetables, and cereal grains contain a variety of isoprenoid compounds.[37]

Scientific Findings

Isoprenoids possess anticancer activity in laboratory research.[38]

Bioactive Dose

Not known.

Safety

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

Isothiocyanates

Definition

Phytochemicals formed from the breakdown of glucosinolates[39] that are found in mustard seed and *Brassica* vegetables, such as watercress and broccoli sprouts.[40]

Scientific Findings

Isothiocyanates are antimicrobial against a wide spectrum of pathogens and exhibited anticancer activity in cell cultures and animal models.[41–44] 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. In those studies showing an effect, it found consistent protective effects for higher dietary intake, serum, plasma, or urinary metabolites of isothiocyanates and lung cancer and gastrointestinal cancer.[47]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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.[46]

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J

Jasmine Rice (Oryza sativa *L.*)

Jasmine rice. (Image from Praisaeng/Shutterstock.)

Definition

Long- or medium-grain rice variety noted for being aromatic and characteristically flowery when cooked due to the chemical 2-acetyl-1-pyrrolin.[1,2] Grown primarily in Thailand, 1 cup of white enriched jasmine rice is a good source of thiamin (0.31 mg, 25% DV), niacin (3.4 mg, 21% DV), iron (2.77 mg, 15% DV), and folic acid (180 µg, 45% DV), and supplies riboflavin (0.03 mg, 2% DV)[3]; and 1 cup of brown jasmine rice is an excellent source of iron (4.3 mg, 23% DV) and fiber (7.9 g, 28% DV).[4] Rice is one of the longest cultivated cereal grains believed to have been grown for at least 5,000 years.[5] It is a primary staple food and significant contributor of calories in the Japanese daily diet.[6]

Scientific Findings

Both white and brown rice are high glycemic index foods;[7] people with diabetes may benefit from lower-glycemic-index foods, such as rice noodles.[8] A questionnaire survey of 1,848 men and women between 20 and 60 years of age found that rice, possibly due to its high glycemic index, was

associated with better sleep quality, while bread and noodles were associated with poor sleep quality.[6]

Bioactive Dose

Not known.

Safety

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

Jerusalem Artichoke (Helianthus tuberosus)

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

Definition

Edible root, also called a sun root or sunchoke, that is a species of sunflower. It is neither from Jerusalem nor an artichoke. Rather, it is a tuber that is cooked. Similar to water chestnuts in taste, Jerusalem artichoke carbohydrate is primarily inulin, an indigestible carbohydrate that is fermented in the colon, versus starch that is digested and absorbed.[9]

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.[10]

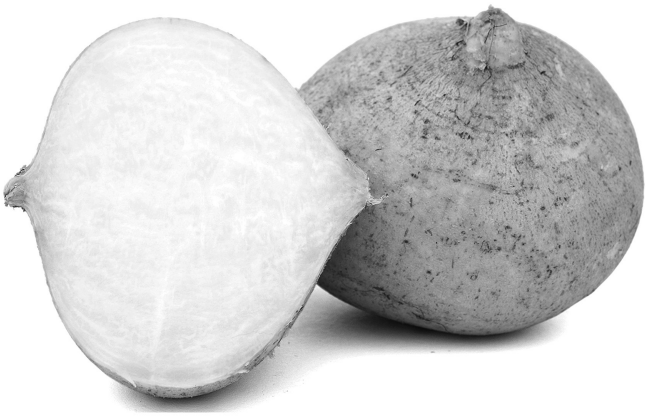
Bioactive Dose

Not known.

Safety

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

Jicama (Pachyrhizus erosus)



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

Definition

Also called "Mexican potato" and "yambean." Sweet, starchy tuber[11] native to Mexico and Central America pronounced "*he*-cama." Jicama can weigh up to 6 pounds. It is peeled, sliced, and used as a crisp dipping vegetable. Its flavor is like a combination of water chestnut and apple and it may be used as a substitute for water chestnut in Asian cooking, such as in stir-fries. Jicama contains fewer than 25 calories per ½ cup, 2.9 g fiber (10% DV), including lignin (a type of fiber), and phenolic compounds.[3,12,13]

Scientific Findings

In animal studies, jicama reduced serum glucose and increased insulin sensitivity.[14,15] *See also: Phenolic Compounds.*

Bioactive Dose

Not known.

Safety

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

Juniper Berry (Juniperus communis *L.*)

Definition

Cone of a shrub that has the appearance of a berry, though it is not a true berry. It contains phenolics and other phytochemicals, including limonene and myrcene.[16,17] Juniper berry provides the characteristic flavor of gin. *Juniperus communis* has been used as a traditional cure for tuberculosis and other respiratory diseases.[18]

Scientific Findings

Juniper has in vitro antioxidant properties that inhibit lipid peroxidation.[17] Juniper berry was hepatoprotective in an animal model.[19]

Bioactive Dose

Not known.

Safety

Juniper, juniper berry, and juniper extract have Generally Recognized as Safe (GRAS) status in the US, but juniper should not be used during pregnancy because it can increase uterine tone, interfere with fertility and implantation, and cause abortion; additionally, it should not be used during lactation because there is insufficient information to evaluate its safety.[20] Prolonged use of high doses can increase the potential for severe side effects such as convulsions or kidney damage.[20]

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K

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.[1]

Scientific Findings

Consuming foods containing kaempferol was associated with a reduced risk of developing cancer and cardiovascular disease in epidemiological studies.[1] Kaempferol was one of several flavonoids associated inversely with lung cancer among tobacco smokers, but not among nonsmokers in a population-based case-control study (n = 558 lung cancer cases and a group of 837 controls).[2]

Bioactive Dose

Not known.

Safety

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

Kale (Brassica oleraceae *var.* acephala)

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

Definition

Dark green leafy *Brassica* vegetable that, per ½ cup, supplies calcium (45 mg, 3% DV), folate (10 µg, 2.5% DV), magnesium (11 mg, 2% DV), and is an excellent source of vitamin A (258 µg RAE, 29% DV), vitamin C (40 mg, 44% DV), and vitamin K (273 IU, 227% DV). Lutein, xeaxanthin, and allyl isothiocyanate are among its phytochemical constituents.[3,4] Fresh, cooked, and cooked frozen kale all supply approximately 45 µg of beta-cryptoxanthin per 100 g.[5] Kale leaves and stems are chopped, sautéed with or without meat, and served as greens, and kale leaves can be baked into snack 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.[6]

Scientific Findings

Kale seeds exhibited antioxidant properties in vitro.[7] *See also: Phenolic Compounds.*

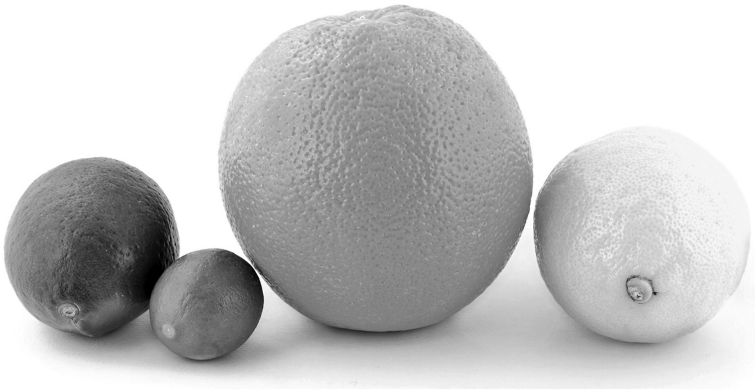
Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Kale's thiocyanate component may induce hypothyroid effects in some individuals when kale is consumed and the amount may vary by individual.[8]

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 after one of the places it grows, 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.[9]

Scientific Findings

Lime essential oil from lime peel reduced body weight in laboratory animals.[10] Key lime inhibited the growth of antibiotic-resistant *H. pylori* in experimental research.[11]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals.[12] Lime juice administered enterally blocked ovulation and compromised fertility in laboratory animals.[13] Lime juice also reduced the effectiveness of warfarin in laboratory animals.[14]

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 xeaxanthin.[15,16] When its small, edible black seeds are consumed, one small, whole kiwifruit supplies 2 g fiber (7% DV).[16]

Scientific Findings

In experimental research, kiwifruit improved markers of immune function in mice.[17] Kiwifruit polysaccharides increased fibroblast activity in an in vitro study, which may have implications for human collagen synthesis.[18] Kiwi may improve laxation, aid digestion, and promote healthy gut microflora in humans, and, in addition, has antioxidant and antiplatelet aggregatory properties.[19]

Bioactive Dose

Not known.

Safety

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

Kombucha

Definition

Fermented tea that is a source of polyphenolic compounds[20] and contains bacteria and yeasts produced by fermenting sugared black tea with tea fungus.[21] Kombucha tea may have Manchurian origins but has been historically consumed in China, Russia, and Germany. It has resurged to

popularity in recent years due to its purported functional properties[22] including anti-inflammatory and radical scavenging.[22,23]

Scientific Findings

"Limited evidence suggests kombucha tea may offer benefits similar to probiotic supplements, including promoting a healthy immune system and preventing constipation. At present, however, valid medical studies of kombucha tea's role in human health are very limited,"[24] and its benefits or side effects have not been widely reported.[25]

Bioactive Dose

Not known.

Safety

"There have been reports of adverse effects, such as stomach upset, infections, and allergic reactions in kombucha tea drinkers. Kombucha tea is often brewed in homes under nonsterile conditions, making contamination likely. When improperly manufactured ceramic pots have been used for brewing, lead poisoning has occurred."[24]

Side effects probably related to consumption of kombucha tea are reported in four patients. Two presented with symptoms of allergic reaction, the third with jaundice, and the fourth with nausea, vomiting, and head and neck pain.[25]

Kumquat (Fortunella *sp.* Swingle, Citrus japonica *var.* margarita)

Kumquat. (Image from Volosina/Shutterstock.)

Definition

Miniature orange whose thin peel is edible. Citrus peel is used in traditional medicine for digestion, severe cold, and fever.[27] Kumquats are a source of flavones, vitamin C, and the carotenoids alpha-carotene, beta-cryptoxanthin, lutein, and xeaxanthin.[28] 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

Kumquat peel and pulp contain phenolic compounds and flavonoids.[28] *See also: Citrus Fruit, Phenolic Compounds, and Flavonoids.*

Bioactive Dose

Not known.

Safety

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

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L

Lactose

Definition

Disaccharide that is unique to milk and found in lesser amounts in yogurt and cheese. It is separated from milk or whey and used as a food additive in processed foods because it is an inexpensive bulking agent. When a lactose-containing food additive has been added to a food, it will appear on the "ingredients" list, but it may be difficult to identify: for example, sodium caseinate, a common food additive, contains lactose (caseinate is derived from casein, a milk component).[1] Foods such as breakfast cereals, sliced bread, and cake mixes; salad dressing and prepared sauces; processed meats (sausage, hot dogs, and sliced meat); restaurant foods, e.g., McDonald's® hotcakes, prepared meals, e.g., Hot Pockets® sandwiches; candy, e.g., Tootsie Rolls® and many other foods contain added lactose (Table L.1). Approximately 20% of prescription drug products and 5% of over-the-counter drug products contain lactose.[2] Lactose is digested by lactase on the jejunum brush border into glucose and galactose. When lactase activity is deficient or absent, lactose maldigestion occurs and undigested lactose travels to the colon where, as an osmotically active particle, it attracts water, possibly resulting in loose stools; as well, colonic bacteria feed upon the sugar, forming gas, leading to abdominal pain, bloating, and other undesirable gastrointestinal symptoms. Up to 75% of all people worldwide are lactose intolerant.

Scientific Findings

Lactose improves the absorption of calcium and magnesium and, because it is an undigested substance in the colon of lactose-intolerant individuals, it serves as food for bacteria, thereby meeting the definition of a "prebiotic," favoring the growth of bifidobacteria and lactobacilli (but with concomitant undesirable GI effects).[3,4] Breakdown of lactose in the large intestine can cause these desirable effects: formation of fatty acids, reduction of luminal pH, decreased formation of toxic secondary bile acids, and suppressed formation of toxic bacterial metabolites such as ammonia.[5] Lactose intolerance is a risk factor for low bone density[5] because milk avoidance limits calcium and vitamin D consumption.[6]

Table L.1 Lactose in Common Foods

Food	Portion size	Lactose, g
1% milk	8 oz	12.69
Nonfat Greek-style vanilla yogurt	8 oz	6.53
Hot Pockets® Ham and Cheese Stuffed Sandwich	127 g	3.01
Cream cheese, fat-free	1 tablespoon	0.87
McDonald's, Hotcakes (with 2 pats margarine & syrup)	1 order	5.26

Source: [78]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. The Surgeon General's 2004 Report on Bone Health and Osteoporosis indicates that an estimated 30–50 million Americans are affected by lactose intolerance who may experience gastrointestinal adverse effects after consuming even minute amounts of lactose.

Legume

Definition

Fabaceae, also called *Leguminosae*, family vegetable that is an excellent source of fiber (7 g, 25% DV), iron (5 mg, 27% DV) and magnesium (109 mg, 25% DV) and a good source of protein (7 g, 14% DV) and folate (60 μg, 15% DV) (per ½ cup of baked beans).[7] Additionally, legumes supply small amounts of zinc, copper, and manganese.[8] One-quarter (¼) cup of legumes, including lentils, black/garbanzo/kidney/pinto/lima/soy beans (but not string beans), black-eyed or green peas (but not snap peas or snow peas), or other starchy beans, is considered to be nutritionally equivalent to 1 oz of meat/fish/poultry, 1 egg, ¼ cup of tofu, ½ oz of nuts, or 1 tablespoon of peanut butter in the USDA ChooseMyPlate.gov model. Only 7.9% of Americans may consume legumes on a daily basis.[9] Phytochemicals in legumes include enzyme inhibitors, phytohemagglutinins (lectins), phytoestrogens, oligosaccharides, saponins, and phenolic compounds.[10]

Scientific Findings

A meta-analysis of six prospective cohort studies (n = approximately 21,899 adults aged 20–86 primarily residing in Asian countries) examining highest intake with lowest intake of legume consumption (average length of follow-up 12 years) found high legume intake was associated with lower risk of all-cause mortality; however, no significant relationship between legume consumption and cardiovascular disease (CVD) mortality was found.[11] A longitudinal cohort study (n = 7,216 elderly Mediterranean individuals at high CVD risk, median follow-up of 6 y) found that higher total legume consumption was associated with a 49% lower risk of cancer mortality.[12] Legumes may help to control blood sugar in people with diabetes,[13] perhaps due to their high soluble fiber content and/or their low glycemic index. Hemoglobin A1c (HbA1c) decreased by 0.5%, a statistically significant decrease, with a low glycemic index diet, compared to a high glycemic index diet in an analysis of 11 RCTs lasting 1–12 months (n = 402 subjects with diabetes mellitus); additionally, hypoglycemic episodes significantly decreased with a low glycemic index diet compared to high glycemic index diet.[13]

Bioactive Dose

While there is no daily recommendation for legumes per se, ChooseMyPlate.gov promotes legume consumption and suggests adults aged 19–50 ingest 5–6.5 oz-equivalents daily (a 1-oz equivalent = ¼ cup of cooked beans), depending on age, from all protein sources including legumes.[14] The Mediterranean Diet includes 1 and a ½ cups of legumes/peas/beans weekly.[15]

Safety

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

Lemon (Citrus limon)

Definition

Tangy, sour citrus fruit used on seafood and to make sauces, drinks, and marinades. Its citrate content is the highest among citrus fruits.[16] Lemon juice is a good source of vitamin C (11.8 mg, 13% DV per 1 tablespoon) and supplies liminoid, beta-cryptoxanthin, lutein, xeaxanthin, coumarins, hesperetin, quercetin, and myricetin.[17,18]

Scientific Findings

Lemon essential oil, from lemon peel, when sprayed as an aerosol, reduced *Staphylococci*, *Streptococci*, and *Sarcina* in the air.[19] In a small prospective, crossover-design trial (n = 21 subjects at risk for kidney stone formation), drinking lemonade corrected one of three markers of improvement, urine volume, but not urinary citrate or uric acid level.[20] A second small trial (n = 12 patients) found that citrate supplementation with lemonade improved urinary citrate, but not total urinary volume.[21] In a third 44-month trial (n = 11), 10 of the hypocitraturic patients experienced a significant decrease in stone formation during lemonade therapy.[17] An experimental study found coumarins in lemon peel inhibited free radical generation.[22] 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.[8] Hesperidin exhibited anti-inflammatory, hypolipidemic, and vasoprotective properties in experimental studies and several small clinical trials.[8] Hesperidin may improve venous diseases, such as hemorrhoids[23] and venous stasis, possibly by reducing capillary permeability.[24,25]

Bioactive Dose

Not known.

Safety

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

Lemongrass (Cymbopogon citratus)

Lemongrass. (Image from tarmizi razali/Shutterstock.)

Definition

Small hard stalk that is a tropical grass. It may be chopped finely and used for its intense lemon flavor in Thai cooking. Lemongrass tea has been used in traditional medicine to treat hypertension and diabetes.[26]

Scientific Findings

Lemongrass essential oil, when sprayed as an aerosol, reduced airborne microorganism contaminants.[26] Laboratory research suggests that anti-inflammatory compounds in lemongrass work by inhibiting the release of pro-inflammatory cytokines.[27] Lemongrass attenuated animal liver damage in an experimental study.[28]

Bioactive Dose

Not known.

Safety

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

Lettuce (Lactuca sativa)

Definition

Salad green, such as the Bibb variety, that grows in small, loose heads and is an excellent source of vitamin K (56 µg, 46% DV per 1 cup);[29] lola rosa (also spelled lola rossa and lolla rosa), a mild-flavored, loose-leaf Italian variety with ruffled burgundy leaves that is frequently included in spring mix and is a rich source of anthocyanins that are concentrated in its intense red-pigmented parts;[30–34] and lollo biondo, the green-leafed sister of lola rosa, that has been described as "pleasantly strong and nutty," although slightly bitter.[35] Lola rosa may originate from *Lactuca serriola*, "a wild species found throughout Europe, Asia, and North Africa," and possibly first cultivated by the ancient Egyptians who believed it was an aphrodisiac and remedy for stomach ache.[33] *Lactuca*, the Roman name for lettuce, comes from "lac" (milk) because wild lettuce contains a milky sap.[32,33] Lettuce was traditionally eaten at the end of the evening meal because it was thought to produce a mild, sedative effect, though it may also have been eaten at the beginning of a meal to enhance appetite.[35]

Scientific Findings

In animal studies, a lettuce-derived protein elicited antibodies with positive reactivity against Human Immunodeficiency Virus, as well as systemic and local immune responses.[36] Lettuce intake correlated with higher serum carotenoid concentrations, specifically of xeaxanthin and beta-cryptoxanthin, in postmenopausal osteoporotic women (n = 59), a subgroup that may have compromised antioxidant defenses.[37]

Bioactive Dose

Not known.

Safety

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

Lignan

Definition

Phytoestrogen that is abundant in the Western diet as are its metabolites enterolactone and enterodiol.[38,39] Lignan is found in flaxseed, pumpkin seed, sesame seed, soybean, broccoli, whole grains, beans, peas, and some berries.[36,40] Lignan is different than lignin; the latter is a type of dietary fiber.[41]

Scientific Findings

A meta-analysis of 21 epidemiologic studies concluded that high lignan exposure is associated with a reduced breast cancer risk in postmenopausal women.[35] GI microorganisms interacting with lignan enterodiol and enterolactone have generated bioactive compounds that retarded experimentally induced cancer.[42] "Ecological data suggest a long-term diet high in plant material rich in biologically active compounds, such as the lignans, can significantly influence the development of prostate cancer over the lifetime of an individual."[43]

Bioactive Dose

Not known.

Safety

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

Limonene

Definition

One of the most common terpenes in nature found in high concentration in orange, lemon, mandarin, lime, and grapefruit oils.[44] Ingested when the peel or "zest" of citrus fruits is consumed and used as a flavoring agent in fruit juices, soft drinks, baked goods, ice cream, and pudding.

Scientific Findings

Limonene has exerted chemopreventative and chemotherapeutic properties in human tumor cell lines and animal models.[45–47]

Bioactive Dose

Not known.

Safety

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

Lingonberry (Vaccinium vitis-idaea)

Definition

Relative of a cranberry that grows in Europe, Asia, and North America. Consumed as preserves, dried, as a powdered drink additive, frozen, and as juice. A rich source of phenolic compounds, such as anthocyanins, procyanidins, flavonols, and catechins,[48,49] "Lingonberry grows in unfavorable climates where 'any palatable fruit is appreciated' and it was considered so important in 13th Century Iceland that laws limited berry-picking on other people's lands to what could be eaten on the spot."[50]

Scientific Findings

In laboratory studies, the phenolics in lingonberries were effective free radical scavengers[45] and antimicrobial against *Staphylococcus aureus*.[51] Cranberry-lingonberry juice dosed at 50 ml daily for 6 months resulted in a significant reduction in recurrence of urinary tract infection (UTI) compared to 100 ml of *Lactobacillus* drink 5 days a week for one year, or no intervention, in a small randomized intervention study (n = 150 women with UTI).[52] Lingonberry extract reduced oxidative stress and exerted neuroprotective effects in diabetic rats.[53]

Bioactive Dose

Not known.

Safety

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

Lipid

Definition

Water-insoluble macronutrient that supplies 9 kcalories/g making it the most calorically dense macronutrient. Found in plant oils and animal fats, its roles in foods include improving palatability, flavor, and aroma; serving as a source of essential fatty acids and energy and as a source of fat-soluble vitamins and phytochemicals.

Scientific Findings

See: Omega-3-Fatty Acid, Omega-6-Fatty Acid.

Bioactive Dose

The AMDR for lipid is 20 35% of daily kcalories. *See also: Docosahexaenoic Acid, Eicosapentaenoic Acid, Omega-3-Fatty Acid and Omega-6-Fatty Acid.*

Safety

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

Lutein

Definition

Xanthophyll carotenoid that commonly occurs with xeaxanthin in foods, such as green vegetables, that are among the richest sources. Lutein and xeaxanthin are major dietary and serum carotenoids that impart a yellow pigment to foods and the macula region of the retina (Table L.2).[54]

Scientific Findings

Macular pigment may protect retinal cells from damage by absorbing blue light, and a low-density of macular pigment is thought to increase risk for

Table L.2 Lutein + Xeaxanthin Content, µg[79,80]

Kale, cooked, 1 cup	5,880 lutein + xeaxanthin
Spinach, raw, 1 cup	3,659 lutein + xeaxanthin
Green peas, canned, 1 cup	4,332 lutein + xeaxanthin
Corn, creamed, canned, 1 cup	2,428 lutein + xeaxanthin
Broccoli, frozen, cooked, 1 cup	2,015 lutein + xeaxanthin
Centrum Silver 50 Plus®, 1 tablet	250 lutein (referred to as "lutein + xeaxanthin" on product literature, but as "lutein" on the Supplement Facts panel)

age-related macular degeneration (AMD).[55] Ample epidemiological evidence suggests that the amount of macular pigment is inversely associated with the incidence of AMD.[54] AMD is an irreversible process that is a major cause of blindness in the elderly.[54] A meta-analysis of six longitudinal cohort studies reported that dietary intake of lutein and xeaxanthin was not associated with a reduced risk of early AMD, but that dietary intake of lutein and xeaxanthin was significantly associated with a reduction in the risk of late AMD.[56] A meta-analysis of five RCTs (n = 76,756 healthy people who did not yet have AMD) ranging in duration from 6 months to 6 years concluded that *dietary supplements* of lutein had little or no effect on AMD progression, but concluded that it is possible that antioxidant vitamins may help to protect the macula against deterioration and loss of vision.[57] People consuming 6.9–11.69 mg of lutein and xeaxanthin as determined by food frequency questionnaire, which assesses usual intake, had a modestly lower risk of developing cataracts, according to two large cohort studies (n = 36,644 men[58] where lutein and xeaxanthin intake included dietary supplements; n = 77,466 women[59] where lutein and xeaxanthin intake did not include dietary supplements). Foods associated with lower risk of cataract in one or both studies included broccoli, spinach, and/or kale.[58,59]

Bioactive Dose

Routinely consuming 6.9 mg (6,900 µg)–11.7 mg (11,696 µg) of lutein and xeaxanthin was associated with a modest reduction in cataract development.[57,58]

Safety

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

Lychee Fruit (Litchi chinensis)

Lychee. (Image from Subbotina Anna/Shutterstock.)

Definition

Also spelled litchi. Golf ball sized fruit whose white or pinkish-white flesh "tastes a grape, but with a stronger, slightly acidic touch."[60] Raw lychee fruit contains vitamin C (6.9 mg, 7% DV) per 1 fruit, and is a source of flavonoids, sterols, and triterpenes.[61–63] Fresh and peeled, pitted lychees canned in syrup are available in Asian food stores, and fresh lychees have been used to make novelty mixed alcoholic drinks.[59] Lychee has been used in traditional Asian medicine for the treatment of a cough, flatulence, stomach ulcers, diabetes, obesity, testicular swelling, hernia-like conditions, epigastric and neuralgic pains; and it has been used as a hypoglycemic, cancer-preventative, antibacterial, antihyperlipidemic, antiplatelet aggregatory, antitussive, analgesic, antipyretic, hemostatic, diuretic, and antiviral agent.[60]

Scientific Findings

Polyphenolic compounds from lychee fruits were strong antioxidants in laboratory studies.[59] Lychee flavonoids exerted immunomodulatory and anticancer activities in vitro.[64]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals; litchi fruit juice and extracts have been proven to be safe at a dose 1 g/kg.[60]

Lycopene (Solanum lycopersicum)

Definition

Carotenoid antioxidant that imparts pink and red pigment to certain fruits and vegetables such as watermelon, pink grapefruit, guava, and tomatoes. Approximately 85% of the dietary lycopene intake in the US is from tomatoes (Table L.3).[65]

Scientific Findings

Lycopene laboratory studies suggest it may help to alleviate cellular oxidative stress.[66] Observational studies have shown that the risk for some types of cancer is lower in individuals who have higher levels of lycopene in their blood;[67] however, in reviewing lycopene for qualified health claim status, FDA found no association between lycopene intake and reduced risk of breast, colorectal, endometrial, gastric, lung, ovarian, prostate, or pancreatic cancer.[68] Lycopene induces beneficial responses in human prostate epithelial cells that are antiproliferative, antioxidative, anti-inflammatory, and androgen regulatory.[69] Two meta-analyses (n = 592,479; n = 563,299) [70,71] found that lycopene intake was inversely associated with the risk of prostate cancer (note: these two studies, published in the same year, analyzed some of the same clinical trials). In the Health Professionals Follow-Up Study, subjects free of diagnosed prostate cancer (n = 47,894) in the highest quintile of lycopene intake who consumed > 10 servings a week of tomatoes, tomato sauce, tomato juice, pizza, had a lower risk of developing prostate cancer than those who consumed fewer than 1.5 servings per week (Table L.4).[72]

The Prostate Cancer Prevention Trial (n = 9,559 participants) observed no association between food lycopene or lycopene from dietary supplements and prostate cancer risk.[73] A meta-analysis of three randomized clinical trials RCTs (n = 154 participants),[74–76] found no statistical difference in PSA levels between men randomized to receive lycopene supplements [8 mg for 1 year, 15 mg for 6 months; or 30 mg for 4 months] and the comparison groups, and "insufficient evidence to either support, or refute,

Table L.3 Lycopene Content, µg[81]

Tomato soup, canned, 1 cup	16,162
Spaghetti, with meatballs in tomato sauce, canned, 1 cup	8,494
Watermelon, fresh, 1 cup	6,979
Ketchup, 1 tablespoon	2,051
Cranberry sauce, 1 cup	0
General Nutrition Centers Mega-Men® Dietary Supplement, 1 caplet	500

Table L.4 Example of > 10 Servings of Tomato Products

Western Omelet made with 1 small tomato (1 serving)
Large salad made with 1 small tomato (1 serving)
2 cups of chili made with 1 cup tomatoes/sauce/paste (1 serving)
4 slices of pizza (1–2 servings)
4 cups of pasta with 4 cups of marinara sauce (4 servings) and salad with 4 tomato wedges (0.5 serving)
1 large meatball submarine sandwich with sauce, lettuce, and tomato (1–1.5 servings)
8 oz tomato juice or V-8® (1 serving)

the use of lycopene supplements for the prevention of prostate cancer" as well as no robust evidence from RCTs to assess the impact of lycopene consumption on incidence of prostate cancer, prostate symptoms, or PSA levels."[77]

Bioactive Dose

Not known.

Safety

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

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M

Magnesium

Definition

Fourth most predominant body mineral and second most abundant intracellular cation that performs roles including participating in energy metabolism, vitamin D metabolism and action, protein synthesis, immunity, carbohydrate metabolism, blood glucose and blood pressure (BP) regulation, and the transport of calcium and potassium ions into cells necessary for nerve impulse conduction, muscle contraction, and normal heart rhythm.[1–5] Magnesium (Mg) regulates parathyroid hormone function that is critical for bone mineralization.[5,6] Most Mg is found in bone and the rest is in soft tissue.[3] Mg is withdrawn from bone to maintain blood levels when dietary intake is inadequate.[7] Mg is generally an under-consumed "nutrient of concern:" men aged 71 years + and adolescent females are most likely to have low intakes.[8,9] Mg is one of three minerals, along with potassium and calcium, supplied by vegetables, dairy foods, whole grains, and protein group foods that contribute to the BP-lowering effect of the Dietary Approaches to Stop Hypertension (HTN) or the DASH Diet that has been shown to significantly lower BP in patients with stage 1 HTN, high-normal BP, and BP in isolated systolic HTN (Table M.1).[10]

Mineral-rich "hard" water is a source of Mg. American men may fulfill 6% to 23% and women 8% to 31% of their Mg RDA by drinking 2 L of tap water, though water mineral content varies widely among and within municipalities;[5] another estimate is that approximately 10% of the daily Mg requirement is derived from drinking water.[5] Mg deficiency can be caused by inadequate intake; vomiting; diarrhea/malabsorption; increased urinary Mg excretion, for example, by uncontrolled diabetes or renal dysfunction; alcohol abuse; protein malnutrition; prolonged nutritionally inadequate intravenous fluid use; use of diuretic medications; and a wide range of inherited and acquired diseases.[2,3,5,11] Mg deficiency can initially result in muscle cramps, HTN, coronary and cerebral vasospasms, loss of appetite, nausea, vomiting, fatigue, and weakness; and as Mg deficiency worsens, numbness, tingling, muscle contractions and cramps, seizures, sudden changes in behavior, personality changes, abnormal heart rhythm, and coronary spasms can occur.[2] Mg deficiency causes bone demineralization in all age groups,[6] abnormal bone growth,

Table M.1 Common Food Sources of Mg

10–19% DV = good sources; > 20% DV = excellent sources of Mg[61]
Dark Green Leafy Vegetables and Legumes
Spinach, cooked, 1 c (157 mg, 37% DV)
Black beans, 1 cup (120 mg, 28.5% DV)
Edamame, ½ cup, frozen (36 mg, 8.5% DV)
Spinach, raw 1 cup (24 mg, 6% DV)
Naked® Green Machine Juice Smoothie, 10 oz (42 mg, 10% DV)
Whole Grains
Oats, 1 cup (276 mg, 65% DV)
Chia seeds, 1 oz (95 mg, 23% DV)
Multigrain bagel, 1 (69 mg, 16% DV)
Dairy Foods
Soymilk, unflavored, 1 cup (61 mg, 14.5% DV)
2% Milk, regular (37 mg, 8% DV)
Protein Group Foods
Almonds, ¼ cup, salted and dry-roasted (96 mg, 22% DV)
Tempeh, 1 cup (134 mg, 32% DV)
Salmon, 3 oz, baked (104 mg, 25% DV)
Peanut butter, 2 tablespoons (57 mg, 13% DV)
Cocoa Products
Cocoa, dry powder, unsweetened, 1 tablespoon (26 mg, 6% DV)
Semisweet chocolate chips, ½ cup (96 mg, 22% DV)
Ovaltine, chocolate malt powder, 3 tablespoons (30 mg, 7% DV)

and skeletal weakness.[12] "Normal serum [Mg] concentrations range between 0.75 and 0.95 mmol/L; however, serum levels have little correlation with total body Mg levels or concentrations in specific tissues. To comprehensively evaluate [Mg] status, both laboratory tests and a clinical assessment might be required."[3]

Scientific Findings

Hard water consumption is associated with decreased arterial BP.[13] Epidemiologic, observational, and clinical trial data generally show that a diet high in Mg (at least 500–1000 mg/day) may reduce blood pressure as much as 5.6/2.8 mm Hg, but clinical trials have shown a wide range of BP reduction, with some showing no change in BP.[10] Most epidemiology demonstrates an inverse relationship between dietary Mg intake and BP.[4,10] A meta-analysis of 12 RCTs (n = 545 subjects with HTN) with 8 to 26 weeks follow-up found that participants receiving Mg supplements compared to controls had statistically significantly reduced diastolic, but not systolic, BP.[14]

Increased intake of Mg and potassium together with reduced sodium intake is more effective at reducing BP than either intake of Mg or potassium alone,[10] "Reducing intracellular sodium and calcium while increasing intracellular Mg and potassium improves BP response."[14] "[Mg] acts as a natural calcium channel blocker, increases nitric oxide, improves endothelial dysfunction, and induces direct and indirect vasodilation."[10] Mg intake, but not calcium intake, was significantly associated with total body bone mineral content and bone mineral density (BMD) according to the findings of a small clinical trial (n = 50 children aged 4–8). Mg deficiency may be associated with the development of insulin resistance and hyperglycemia.[15] A meta-analysis of seven cohort studies (n = 286,668 participants) found an inverse relationship between Mg intake and risk of Type II diabetes in all but one study, and in four studies the association was statistically significant: 100 mg Mg/day reduced the risk of Type II diabetes by 15%.[16] Higher dietary intakes of Mg have been associated with a decreased risk of metabolic syndrome.[17]

Bioactive Dose

The RDA for Mg 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, Mg has not been associated with any adverse events (AEs).[2] Total Mg intake from non-food sources such as dietary supplements and Mg-containing medications should not exceed 350 mg/day for adults; 350 mg/day is the Mg UL. Note the narrow margin between the RDA of 320 mg/day and the UL of 350 mg/day. Excess Mg from non-food sources is associated with AEs such as diarrhea.[2]

Mango (Mangifera indica)

Definition

Juicy, orange-fleshed tropical fruit eaten fresh or dried, that is an excellent source of vitamin A (893 IU, 29% DV) and supplies polyphenols, terpenoids, steroids, phenolics, and flavan-3-ols.[18]

Scientific Findings

In in vitro and in vivo models, mango has exerted antioxidant, iron chelator, anti-inflammatory, antinociceptive, antitumor, and immunomodulatory

properties.[18–20] Raw *M. indica* fruit killed aerobic and anaerobic acne-inducing bacteria and was anti-inflammatory in skin cells.[21] *See also: Phenolics and Flavonoids.*

Bioactive Dose

Not known.

Safety

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

Marjoram, sweet (Origanum majorana)

Marjoram. (Image from Scisetti Alfio/Shutterstock.)

Definition

Mint family herb that contains phenolics and terpenoids.[22] It is used fresh or dried to complement carrots, mushrooms, peas, zucchini, tomatoes, eggs, chicken, duck, halibut, tuna, and lamb.[23] Marjoram has been used for rhinitis and colds in infants and toddlers; gastritis; stimulating appetite; aiding digestion; to promote circulation and healthy sleep; to treat mood swings; and as an astringent, antispasmodic, and antiflatulent.[24]

Scientific Findings

Marjoram essential oils exhibited antimicrobial and antifungal properties in laboratory studies.[25,26]

Bioactive Dose

Not known.

Safety

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

Mediterranean Diet

Definition

Traditional dietary style of the Mediterranean basin that is associated with cardiovascular and cognitive health.[27] It includes large amounts of olive oil, vegetables and leafy greens, fruit, whole grains, nuts, legumes, moderate amounts of fish, meat, dairy products, and red wine, and is low in eggs and sweets. It is high in unsaturated fat and polyphenolic compounds, such as flavonoids and phytosterols from red wine, olive oil, coffee, tea, nuts, fruits, vegetables, herbs, and spices.[27]

Scientific Findings

A meta-analysis of 11 randomized controlled trials (RCTs) of healthy adults at high risk of cardiovascular disease (CVD) (n = 52,044) found limited but favorable evidence of Mediterranean dietary patterns on CVD risk factors.[28] The PREDIMED prospective cohort study (n = 7122 participants aged 55–80 years at high risk for CVD) found reductions in CVD-related mortality due to following a Mediterranean Diet.[29,30] A meta-analysis (n => 4.7 million people) found reduced mortality, CVD-related mortality, and a reduced risk of Parkinson's and Alzheimer's disease related to following a Mediterranean Diet-style eating pattern (Table M.2).[30]

Bioactive Dose

Table M.2 Mediterranean Diet

Vegetables	>2 servings/meal ("high consumption")
Fruit	1–2 servings/meal ("high consumption")
Bread and cereals	1–2 servings/meal ("high consumption")
Legumes	>2 Servings/week ("high consumption")
Nuts	1–2 Servings/daily
Fish/Seafood	>2 Servings/week
Eggs	2–4 Servings/week
Poultry	2 Servings/week
Dairy foods	2 Servings/day ("moderate consumption")
Red meat	<2 Servings/week ("low consumption")
Sweets	<2 Servings/week ("low consumption")
Red wine	low to moderate consumption

Source: [27]

Safety

Components are presumed safe when consumed in normal dietary by nonallergic individuals.

Melatonin

Definition

Pineal gland hormone produced by the metabolism of serotonin;[31] and phytochemical that is ubiquitous in the plant kingdom,[31] found in corn, rice, barley, ginger,[31,32] sour cherries[33,] and other plant foods. The naturally produced melatonin hormone regulates circadian rhythm. Older adults may be prone to develop disorders related to an altered circadian rhythm since levels decline with age.[34] Studies conducted to evaluate the efficacy of melatonin and sleep used chemosynthesized melatonin or melatonin sourced from the pineal gland of beef cattle.[35]

Scientific Findings

In laboratory studies, melatonin suppressed tumor angiogenesis[36] and scavenged hydroxyl radicals.[37] Melatonin supplementation was not effective in treating most primary sleep disorders with short-term use, a

comprehensive review of randomized clinical trials found.[34] A dose of 0.1 mg to 50 mg/kg orally was the dosage used in 16 RCTs to mimic normal physiological circadian rhythm.[34] *See also*: *Cherry.*

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary by nonallergic individuals.

Monounsaturated Fatty Acid

Definition

Dietary triglyceride 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 fat.[38]

Scientific Findings

Replacing saturated and trans fats with monounsaturated and polyunsaturated fats reduces LDL cholesterol.[39] A meta-analysis of 12 long-term, randomized, controlled dietary intervention trials (n = 1,990 participants) found that high-MUFA (>12% of kcalories from MUFA) versus low-MUFA (≤12%) diets induced weight loss and/or prevented weight gain, and positively affected cardiovascular risk factors.[40] *See also: Mediterranean Diet.*

Bioactive Dose

For lowering coronary heart disease risk, the National Cholesterol Education Program recommends consuming up to 20% of total kcalories from monounsaturated fat.[11]

Safety

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

Mulberry (Morus rubrum)

Mulberry. (Image from ravl/Shutterstock.)

Definition

Berry that is either white (*Morus alba* L.), black (*M. nigra* L.), red (also called American [*M. rubra* L.]), or a hybrid of these species.[41] An excellent source of vitamin C (25 mg, 27% DV) and potassium (750 mg, 22% DV) per ½ cup, mulberries also contain 5 g (17% DV) of fiber, and black or red mulberries are a source of anthocyanin and resveratrol.[42–44] "*Morus alba* L. has long been used in traditional oriental medicine."[42] Mulberries are available fresh, dried, added to grain-fruit bars, and as mulberry juice or added to juice blends.

Scientific Findings

In laboratory studies, *M. nigra* exhibited neuroprotective and membrane-protective, antioxidant effects;[45] resveratrol ameliorated stress-induced Irritable Bowel Syndrome-like behaviors by regulating the brain-gut axis,[46] and was anti-inflammatory;[47] additionally, resveratrol, the phytochemical attributed with the cardioprotective effects of red wine in the French diet, modulated synthesis and secretion of lipoproteins, and arrested tumor growth as well as inhibited carcinogenesis in different experimental models; and in healthy humans promoted nitric oxide production by vascular endothelium and inhibited the synthesis of thromboxane in platelets and leukotriene in neutrophils, hindering platelet aggregation.[43,48]

Bioactive Dose

Not known.

Safety

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

Mung bean (Phaseolus aureus)

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

Definition

Olive-colored legume native to India[49] that is prepared similarly to lentils, but takes longer to cook.[50] Mung dal is a traditional Indian dish made with mung beans. In addition to being excellent sources of fiber (8 g, 28% DV) and protein (12 g, 24% DV) per ¼ cup, mung beans are a source of phenolics, flavonoids, and terpenoids.[51–53] Mung bean sprouts are slender, pearl-white sprouts that are most crisp when fresh—before they begin to turn yellow—that can be used to stuff pita sandwiches and in salads and Asian stir-fries.[54] Mung bean sprouts can be homegrown from mung bean seeds and organic mung bean sprouts are available in larger retail supermarkets. Per ½ cup, mung bean sprouts supply 1 g fiber (5% DV) and 2 g protein (4% DV), therefore are not appreciable sources of these important macronutrients.[49]

Scientific Findings

Mung bean sprouts and seed extracts exerted antidiabetic effects in animals with Type II diabetes,[55] and antioxidant effects in laboratory research.[56] Extracts made from mung bean sprout exerted antitumor effects in laboratory studies.[57] Mung beans possess antioxidant activity.[58]
See also: Phenolics, Flavonoids, and Terpenoids.

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.)

Definition

Also called "hen of the woods." Mild-tasting mushroom with edible caps and stems that can be grilled, roasted, seared, or prepared in ways similar to button mushrooms.[59,60] Maitake mushroom contains 22 calories per 1 cup and supplies 4 mg of niacin (20% DV), 786 IU of vitamin D (200% DV), and small amounts of folate (21 μg of folate, 5% DV) and carbohydrate (5 g) including the polysaccharides lentinan and D-fraction.[61]

Scientific Findings

Maitake mushroom polysaccharides exerted antitumor and immune activity in laboratory studies.[62–65] Clinical evidence does not support that maitake mushroom is effective in treating or preventing cancer in humans.[66] Maitake mushroom exhibited antidiabetic properties in laboratory analyses and in two cases of patients with Type II diabetes.[67–69] Maitake mushroom was found to be effective in inducing ovulation in a 12-week clinical trial (n = 80 patients with polycystic ovary syndrome).[70] Maitake mushroom improved dyslipidemia in animal models.[71]

Bioactive Dose

Not known.

Safety

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

Mushroom, oyster (Pleurotus ostreatus)

Definition

Fleshy, mild-flavored mushroom whose flavor resembles oysters when it has been cooked with butter. It is white-to-brown in color with a small, stub-like stalk, having whitish or yellow-tinged gills.[59] Grows wild and is available commercially fresh or dried.

Scientific Findings

Oyster mushrooms exhibited anti-inflammatory properties in laboratory studies.[72] Antitumor and immunomodulating factors have been isolated in oyster mushrooms.[73]

Bioactive Dose

Not known.

Safety

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

Mushroom, shiitake (Lentinus edodes)

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

Definition

Also spelled shitake. Brown and white fungus that has a meat-like texture and is a source of riboflavin (0.082 mg, 6% DV), niacin (1.47 mg, 9% DV), vitamin B6 (0.11 mg 6% DV), and vitamin D (7 IU, 2% DV).[74,75,61] Shiitake are the second most popular edible mushroom marketed globally.[60,76] Shiitake mushrooms are used fresh or rehydrated from dried form.

Scientific Findings

Chemical analysis of shiitake mushrooms have isolated antibiotic, anticarcinogenic, and antiviral compounds.[60] In in vitro and animal studies, shiitake constituents, such as lentinan, a polysaccharide flavonoid, have demonstrated immunomodulatory, antihypertensive, and antitumor effects[80,77–79] Shiitake mushroom alkaloids have exhibited anticarcinogenic properties in laboratory studies.[81] Shiitake mushroom extract given three times daily for 6 months was ineffective in the treatment of clinical prostate cancer in a randomized clinical trial of men with diagnosed prostate cancer (n = 62), mean age 73.2 years.[82] Consuming 5 or 10 g of whole, dried shiitake mushrooms for 4 weeks improved markers of immune function and inflammation in a small, randomized clinical trial (n = 52 healthy men and women).[83]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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.[84] 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.[24]

Scientific Findings

In a laboratory study, mustard exhibited chemoprotective properties, which were attributed to its allyl isothiocyanate content.[85] Flavonoids have been isolated in shoots, roots, and extracts of *Brassica alba*.[86] Mustard seed suppressed psoriasis-like inflammation in laboratory animals.[87]

Bioactive Dose

Not known.

Safety

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

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N

Nectarine (Prunus persica nectarina)

Definition

Rosaceae family member and relative of the peach that has smooth, shiny skin. Both the white and orange cultivars supply fiber (2.4 g, 8.5%), vitamin C (7.7 mg, 27.5%), potassium (285 mg, 6% DV) and cyanidin, a proanthocyanidin compound. The orange cultivar is a good source of vitamin A (471 IU, 15% DV) and carotenoids such as beta-carotene and beta-cryptoxanthin.[1]

Scientific Findings

Epidemiology suggests that diets high in carotenoid-rich fruits reduce the risk of oxidation-dependent diseases, such as cancer, atherosclerosis, and macular degeneration.[2] In laboratory studies, proanthocyanidins demonstrated their free radical scavenging, antibacterial, antiviral, anticarcinogenic, anti-inflammatory, antiallergic, and vasodilatory actions; in addition, they inhibited lipid peroxidation, platelet aggregation, and capillary permeability and fragility, and demonstrated their antithrombotic potential by inhibiting cyclooxygenase and lipoxygenase of platelets in vivo.[3]

Bioactive Dose

Not known.

Safety

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

Niacin

Definition

Also called nicotinic acid, nicotinamide, and vitamin B3.[4] Water-soluble vitamin that participates in energy metabolism. Niacin sources include protein group foods, such as legumes and meat, grain group foods, including enriched and whole grains, and vegetables such as mushrooms, potatoes, and asparagus.[5] Classic niacin deficiency, pellagra, occurred in the Southern US after the Civil War[6] caused by overreliance on corn as a dietary staple because it is deficient in niacin and the niacin precursor tryptophan (TRP), an animo acid. Pellagra symptoms include dermatitis, diarrhea, dementia, and may include skin photosensitivity, neurodegeneration, depression, anxiety, and other neurological disturbances.[7,12]

Scientific Findings

Inadequate iron, riboflavin, or vitamin B6 status decreases the conversion of TRP to niacin.[8] Alcoholism can cause pellagra by inducing malnutrition, gastrointestinal disturbances, and B vitamin deficiencies, inhibiting the conversion of TRP to niacin.[6] Large doses of niacin reduce LDL cholesterol and triglycerides and raise HDL cholesterol by more than 30%.[9,10]

Bioactive Dose

Niacin intake is measured in "niacin equivalents" to include niacin per se and TRP. The RDA for men is 16 niacin equivalents. The RDA for women is 14 niacin equivalents. Dosing to improve blood lipids must be physician-prescribed and monitored.

Safety

The UL is 35 mg/day of niacin equivalents. Pharmacological doses of niacin used to reduce lipids can elevate liver function tests and cause an intense feeling of flushing of the face and neck; even though these doses can be purchased over-the-counter, they should only be taken if prescribed and supervised by a physician.

Nitrates and Nitrites

Definition

Nitrites are naturally occurring compounds associated with the nitrogen cycle in soil and water. They are naturally present in soil, water, all plants, and meats.[11] Concentrations of nitrites in plants and water are usually very low.[12] Cured meats are a primary dietary source of nitrites. Sodium nitrite is added to cured, smoked, and salted meat and fish as a preservative and to develop characteristic flavor. *Nitrates* are found in fruits, vegetables, and products made from them;[13] as well, nitrates are a municipal and well water pollutant.[14] Vegetables are a primary dietary source of nitrate.[11,13] Ingested nitrate is reduced to nitrite, which binds to hemoglobin to form methemoglobin, a compound that, at high levels, interferes with the oxygen-carrying capacity of blood.[15] Nitrites, nitrates and the N-nitroso compounds they form, also called nitrosamines, are associated with gastrointestinal cancers.[16] Although most known for their adverse effects, nitrates and nitrites exert beneficial vascular and immune effects.[17] Nitrate and nitrite levels are regulated in water and certain foods by the Environmental Protection Agency and the FDA.

Scientific Findings

Dietary intake of nitrites and nitrates from vegetables and fruits contribute to the blood pressure-lowering effects of the Dietary Approaches to Stop Hypertension (DASH) diet.[17] In animal models, nitrite enhanced mucosal blood flow and was antimicrobial, protected against heart attack and stroke, and reversed vascular inflammation due to consuming a high-fat diet.[17] Certain probiotic bacteria neutralize the activity of nitrosamines.[18]

Bioactive Dose

Not applicable.

Safety

The World Health Organization established an acceptable daily nitrate intake of 222 mg per day.[11] A hypothetical nitrate intake while following the DASH diet may range from 174–1,222 mg, which exceeds the World

Health Organization Acceptable Daily Intake of nitrate for a 60-kg adult by 550%.[17] Consuming a variety of fruits and vegetables may total 1,000 mg of nitrate and nitrite with no adverse health effects.[17] These data call into question the rationale for recommendations to limit nitrate and nitrite consumption from plant foods.[17]

Noni (Morinda citrifolia)

Noni. (Image from Nipaporn Panyacharoen/Shutterstock.)

Definition

Also called Indian mulberry fruit.[19] Yellow, oval-shaped fruit that has been used in Polynesian folk medicine for over 2,000 years to treat broken bones, deep cuts, bruises, sores, and wounds.[20] There are anecdotal reports of the successful use of noni to treat colds and flu,[21] but the FDA has warned several noni product manufacturers to stop making false claims related to noni product use. "Noni has not been shown to have beneficial effects on any chronic health condition…."[22] Its uniquely purple and sweet juice is used in juice blends, and noni juice is also is a substantial source of potassium, supplying 56.3 mEq of potassium/L, similar to orange juice and tomato juice.[23] It also contains polyphenols.[24]

Scientific Findings

Noni was shown in laboratory studies to have antioxidant, immune-stimulating, tumor-fighting, anti-inflammatory, antioxidant, smooth muscle stimulatory, and histaminergic effects.[21,24,25]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Noni juice has been linked to liver toxicity and damage[17,22] but it is not clear that noni caused the liver problems.[22] Noni may be contraindicated for people on potassium-restricted diets.

Nori (Porphyra tenera)

Definition

Seaweed algae that is a source of calcium, iron, iodine, magnesium, zinc, potassium, sodium, and the phytochemicals chlorophyll, beta-carotene, and lutein.[26,27] 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.[28] In a laboratory study, nori was antimutagenic.[29]

Bioactive Dose

Not known.

Safety

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

Nut

Definition

Protein-rich (7 g of protein, 14% DV per tablespoon or ½ oz) legume (e.g., the peanut) or drupe (e.g., almond or walnut)[30,31] that is low in saturated fat, high in fat (containing 44% to 76% total fat which is mostly unsaturated) and calories (85 calories per ½ oz), and contains fiber (3 g, 10% DV per ½ oz).[31,32] Consumed as nut butter, nut milk, and roasted to make nut mixes, trail mix, and added to cereals. Nut consumption in countries with a Mediterranean-style diet is twice that of the US diet.[31]

Scientific Findings

Nuts contain components, such as monounsaturated fat and vitamin E that may be cardioprotective. Consumed regularly in doses of 50 g (1.75 oz or ½ cup) to 100 g (3.5 oz or 1 cup), nuts may reduce total and LDL cholesterol.[33] A meta-analysis of five RCTs (n = 435 subjects) found a lack of evidence for nut consumption on cardiovascular disease (CVD) clinical events and very limited evidence for the effects of nuts on CVD risk factors.[31] In a large prospective cohort study (n = 86,016 women in The Nurses' Health Study) women who ate more than five oz of nuts per week had a significantly lower risk of coronary heart disease (CHD) than those who rarely or never consumed nuts.[34] *See also: specific nut types (e.g., Almond, Pistachio, Walnut) and see Mediterranean Diet.*

Bioactive Dose

Five oz of any type of nut per week reduced risk of CHD in women.[34] Consumption of 50–113 g (½ to 1 cups) of nuts daily with a diet low in saturated fat and cholesterol decreased total cholesterol by 4–21% and LDL cholesterol by 6–29% when weight was not gained.[33]

Safety

Allergies to nuts have been reported; however, nuts 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. *Myristica fragrans* contains phenolics, such as myristicin, and terpenoids, such as elemicin.[35] Used to flavor eggnog, pumpkin pie, quiche, and apple desserts. Nutmeg has been used as an antiflatulent in traditional medicine.[36] Consuming intact nutmeg nuts has been known to cause lethargy, intoxication, and hallucinogenic effects dating back to early medical literature.[36]

Scientific Findings

In laboratory studies, nutmeg improved insulin sensitivity and secretion, and inhibited intestinal alpha-glucosidase leading to a slower postprandial glucose response.[37,38] Myristicin exhibited hepatoprotective effects in experimental research.[39] Elemicin was antimicrobial against the human enteropathogen *Campylobacter jejuni* in a laboratory study.[40]

Bioactive Dose

Not known.

Safety

Presumed safe when used in normal dietary quantities by nonallergic individuals. Nutmeg significantly inhibited human cytochrome activity in a laboratory study[41] which theoretically may increase the clearance of

certain drugs and reduce their effects.[42] Over 2 tablespoons of nutmeg consumed at once may elicit psychotropic effects and GI distress.[42,43] Elemicin was genotoxic in some experimental research[44] and not genotoxic in other experimental research.[42]

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O

Oat (Avena sativa)

Definition

Versatile whole grain known for its content of beta-glucan, a soluble fiber found in oat endosperm cell walls.[1] Oat beta-glucan is also called oat bran soluble fiber, oat fiber, oat soluble fiber, and oat bran fiber,[2] though beta-glucan is obtainable through other foods, such as barley. Oatmeal and whole oats provide all B vitamins except B12, and in addition, iron and phytochemicals called avenanthramides.[3,4]

Scientific Findings

Whole and processed oats can significantly reduce postprandial blood glucose.[5] At least 3 g of beta-glucan from either whole oats or barley, or a combination of whole oats and barley, consumed daily can reduce plasma total and LDL cholesterol levels by 5–10% in normocholesterolemic or hypercholesterolemic people.[1] Beta-glucan increases fecal bulk, promoting regularity.[6] In the National Health and Nutrition Examination Survey 2001–2010 (n = 22,823), oatmeal consumers had higher dietary quality and lower body weights, waist circumferences, and body mass indices than oatmeal non-consumers.[7]

Bioactive Dose

A dose of 3–10 g/day of beta-glucan reduces total cholesterol.[8] Intake of 3 g or more per day of beta-glucan soluble fiber reduces the risk of CHD.[9] 3–10 g of beta-glucan can be found in approximately ¾ cups (56 g)–1 and ¾ cups (150 g) of oats/oatmeal.[10–12] *See also: Fiber, soluble.*

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Certain strains of oats produce adverse effects in people with celiac disease and other strains do not.[13] 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.[14]

Okra (Abelmoschus esculentus)

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

Definition

Green pod vegetable that is rich in mucilaginous, viscous fiber that can be used to thicken soups and stews. The seeds and skin contain flavonols, such as quercetin, flavonol derivatives, such as catechin, and polyphenolic compounds, such as hydroxycinnamic acid.[15,16] Okra was brought to the Southern US from Africa in the 17th century[17] and is popular in Southern Creole and Indian cooking. Sold fresh and frozen either whole or sliced, okra is eaten fresh in salads, fried, grilled, and is used to thicken gumbo.

Scientific Findings

A. esculentus reduced blood glucose and blood lipids in diabetic rats.[18]

Bioactive Dose

Not known.

Safety

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

Olive (Olea europaea L.)

Definition

Marble-sized fruit that has been cultivated for more than 7,000 years and is a staple of the Mediterranean Diet.[19] Greek kalamata olives (*Olea europaea* L. cv. *Kalamata*) contain the polyphenolic compound oleuropein,[20,21] responsible for the bitterness in olives,[19] and its metabolite, hydroxytyrosol,[22] in addition to being an excellent source of monounsaturated fatty acids (MUFAs).[23] Kalamata olives are made in salty brine making them high in sodium (440 mg, 19% DV) per 10 olives.[24] Olive has been used in folk medicine to treat fever and malaria.[18]

Scientific Findings

As shown in laboratory studies, kalamata olives contain antioxidant, anti-inflammatory, hormone-like, anticarcinogenic, antimicrobial, antihypertensive, antidyslipidemic, laxative and antiplatelet constituents.[19] Olives' high levels of MUFA and phenolic compounds may be cardioprotective.[25] Olive oleuropein and hydroxytyrosol were hypolipidemic and hepatoprotective in laboratory animals with metabolic syndrome.[26]

Hydroxytyrosol was neuroprotective in an animal model of dementia,[27] and "olive oil phenols have shown neuroprotective effects against cerebral ischemia, spinal cord injury, Huntington's disease, Alzheimer's diseases, multiple sclerosis, Parkinson's disease, aging, and peripheral neuropathy in vitro and in vivo."[28] *See also: Mediterranean Diet.*

Bioactive Dose

Not known.

Safety

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

Olive Oil (O. europaea)

Definition

High-MUFA oil expressed from olives is a major fatty component of the Mediterranean Diet and a key contributor to its cardioprotective effects.[29,30]

Extra-virgin olive oil is a source of oleic acid and contains phenolic compounds, including hydroxytyrosol and oleuropein, which provide olive oil's characteristic flavor and high stability.[31] Olive oil is used to cook and flavor foods and is increasing in popularity worldwide.[32]

Scientific Findings

Daily consumption of olive oil seems to modulate cytokines and inflammatory markers related to coronary artery disease (CAD) in individuals at risk for cardiovascular diseases (CVD), but clinical trials that evaluate the effect of olive oil and its phenolic compounds on individuals with CAD are sparse.[33] Consuming MUFA from olive oil and olive oil-containing foods in place of foods high in SFA without increasing the total number of calories consumed daily may reduce coronary heart disease, according to a 2004 FDA Qualified Health Claim for olive oil.[34] The PREvención con DIeta MEDiterránea (PREDIMED) study, a multicenter, randomized, controlled, clinical trial (n = 7,216 men and women at high cardiovascular risk) found olive oil consumption, specifically the extra-virgin variety, to be associated with reduced risks of cardiovascular disease (CVD) in individuals at high CVD risk.[35]

Bioactive Dose

Eating approximately 2 tablespoons (23 g) of olive oil daily reduces the risk of coronary heart disease, and when olive oil replaces a similar amount of saturated fat, does not increase calories.[34] Each 10 g/day increase in extra-virgin olive oil consumption, decreased cardiovascular disease (CVD) by 10% and CVD mortality risk by 7% in the PREDIMED study.[35] PREDIMED findings suggest a nonsignificant possible inverse relation between each 10 g/day (1 tablespoon of oil) increase in total olive oil and extra-virgin consumption and all-cause mortality.

Safety

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

Omega-3 Fatty Acids

Definition

Long-chain polyunsaturated fatty acids (PUFAs) that include the essential fatty acid linolenic acid, eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA), and docosahexaenoic (DHA) acid. Given dietary linolenic

acid, the body can make EPA and DHA. Sources of linolenic acid include canola, soybean, and flaxseed oil; nuts, such as walnuts; and vegetables, such as soybeans. Fish and shellfish are rich sources of omega-3 (*n*-3) fatty acids. Contemporary Western diets are characterized by deficient intake of *n*-3 fatty acids. *N*-3 fatty acid functions include the inhibition and promotion of clotting; reducing serum lipids and lipoproteins; decreasing platelet aggregation; serving as structural membrane lipids especially in nerve tissue and the retina; reducing blood pressure; performing potent immunomodulatory activities; and they are necessary for growth, fertility, cell division, secretion of substances that include digestive enzymes and hormones, muscle relaxation and contraction, and brain development and function. Deficiency of linolenic acid in the diet causes neurological abnormalities and poor growth.

Scientific Findings

Several large studies have linked higher blood levels of *n*-3s with higher risks of prostate cancer; however, research has shown that men who frequently eat seafood have lower prostate cancer death rates and that dietary intakes of *n*-3s are not associated with prostate cancer risk.[36] Epidemiological studies suggest that the dietary intake of *n*-3 PUFAs through fish consumption is inversely correlated with the prevalence of depression;[37] a meta-analysis of 35 randomized, controlled trials found that women with a diagnosis of severe post-partum depression obtained benefit from omega-3 fatty acids, but those with mild depression did not.[38]

Adequate production of *n*-3-fatty-acid-derived prostaglandins seems to protect against heart attack, stroke, and certain inflammatory diseases, including arthritis, lupus, and asthma.[39] Consuming high doses of *n*-3-fatty acids is used in clinical practice to reduce triglycerides. A meta-analysis of 14 randomized, placebo-controlled trials (n = 682; placebo, n = 641) found *n*-3-fatty acid consumption improved insulin sensitivity.[40] The DHA status of the mother during pregnancy is positively associated with length of gestation, birth weight, and visual and cognitive development of the child.[41] *See also: Fatty Fish.*

Bioactive Dose

The AI for linolenic acid is 1.6 g/day for men and 1.1 g/day for women aged 19–50. Fatty acid dosing is also done based on the percentage of daily calories consumed. Linolenic acid should make up roughly 1% of daily calories: this comes to approximately 2 g based on a 2,000 kcalorie diet. Contemporary Western diets are characterized by excessive intake of *n*-6 fatty acids and deficient intake of *n*-3 fatty acids, but a high ratio of dietary *n*-6 to *n*-3 PUFAs may be pro-inflammatory.[37,42] A dose of 2–4 g of EPA and

Table O.1 Foods That Supply 2-4 g of EPA and DHA

Fish, salmon, pink, canned, without salt, solids with bone and liquid (0.46 g EPA + DHA per oz)	2.07 g EPA and DHA per 4 oz
Fish, trout, rainbow, wild, cooked, dry heat (1.4 g EPA + DHA per fillet)	2.82 g EPA and DHA per 2 fillets
Atlantic salmon, baked (0.60 per oz)	3.6 g EPA and DHA per 6 ozs.

Source: [63]

DHA (combined) is used to reduce serum triglycerides by 10–50% (Table O.1).[43] *See also: Fatty Fish.*

Safety

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

Omega-6 Fatty Acids

Definition

Long-chain polyunsaturated fatty acids (PUFA) that include the essential fatty acid linoleic acid and arachidonic acid (AA). Given dietary linoleic acid, the body can synthesize AA. AA is a precursor to form eicosanoids, including prostaglandins, leukotrienes, and thromboxanes.[39] Sources of linoleic acid include soybean, safflower, sunflower or corn oils, nuts, and seeds. Contemporary Western diets are characterized by an excessive intake of omega-6 (*n*-6) fatty acids.[37] Deficiency of linoleic acid in the diet causes poor growth, rough and scaly skin, and dermatitis.[44]

Scientific Findings

High circulating linoleic acid was inversely associated with total and CHD mortality in older adults in the Cardiovascular Health Study (n = 2792 participants aged ≥ 65 years).[45] Contemporary Western diets are characterized by excessive intake of *n*-6 fatty acids and deficient intake of *n*-3 fatty acids.[37] A high *n*-6/3 PUFA ratio may be pro-inflammatory and therefore associated with adverse health effects.[37,42]

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 nonallergic individuals.

Onion (Allium cepa)

Definition

Bulb vegetable that is a source of the mineral sulfur and, in red onions, 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.[46] Commonly used in fresh or cooked forms to add pungent flavoring to all types of cuisines. Onion is used to treat CVDs in traditional medicine.[47]

Scientific Findings

Onion exhibited antiplatelet aggregatory, hypocholesterolemic, hypolipidemic, antihypertensive, antidiabetic, anti-hyperhomocysteinemic, antimicrobial, antioxidant, anticarcinogenic, antimutagenic, antiasthmatic, immunomodulatory, and prebiotic effects in laboratory studies.[48–50] A case-control study (n = 760 patients with a first episode of non-fatal acute myocardial infarction (MI); n = 682 controls) found that a diet rich in onions may have a favorable effect on the risk of acute MI.[50] The Netherlands Cohort Study, a large-scale prospective cohort study of diet and cancer (n = 120,852 men and women, aged 55–69 years), found no association between the consumption of onions and leek and the incidence of male and female colon and rectum carcinoma.[51] *See also: Allium Vegetables.*

Bioactive Dose

Not known.

Safety

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

Orange, Sweet (Citrus sinensis)

Definition

More commonly known as the navel orange, popular citrus fruit that is high in vitamin C (83 mg, 92% DV), a good source of folate (48 µg, 12% DV),[52] and supplies pectin and flavonoids.[53]

Scientific Findings

Flavonoids are potent in vitro antioxidants with pharmacologic properties similar to those of antithrombotic, antifibrotic, and anti-inflammatory drugs.[54] "Evidence suggests that flavonoid consumption can enhance vasodilation in the periphery and lead to increased blood flow in specific regions of the brain in the acute postprandial period,"[55] and regular flavonoid consumption is associated with cognitive benefits.[55] In a small (n = 22 healthy males aged 30–65) randomized, double-blind, placebo-controlled study, consuming 240-ml of flavonoid-rich (FR) orange juice (Tropicana® Pure Premium Orange Juice that contained 5.5 g of added pomace fiber to mimic a whole orange, totaling 272 mg of flavonoids) significantly improved performance on cognitive tests compared to a calorie-controlled placebo.[56] In a small (n = 210) randomized, double-blind study, 500 mL of orange juice daily (Minute Maid® naturally supplying 299 mg/d of polyphenols [the parent compound of flavonoids]) for 12 weeks protected against DNA damage and lipid peroxidation, reduced body weight in overweight or obese nonsmoking adults, decreased apoB (a major component of LDL cholesterol) concentration, significantly decreased diastolic and systolic BP, and glucose and insulin levels at the beginning and at the end of the intervention were within normal range.[54] *See also: Citrus.*

Bioactive Dose

Not known.

Safety

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

Oregano (Origanum vulgare)

Definition

Culinary herb used to flavor sauces, fish, Italian dishes and foods, such as stuffing, with its earthy flavor. A source of numerous phytochemicals including phenolics, caffeic acid, and rosmarinic acid.[57]

Scientific Findings

In laboratory studies, oregano exhibited antifungal[58] and antioxidant[59] properties. Carnosol, a phytochemical found in common herbs including oregano (as well as in rosemary, sage, and parsley)[60] exhibited

antioxidant,[61] anti-inflammatory, and chemoprotective properties in laboratory studies.[62]

Bioactive Dose

Not known.

Safety

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

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Palm (Cocos nucifera)

Definition

Vegetable harvested from the coconut palm (*Cocos nucifera*) tree.[1] Hearts of palm are sold canned packed in salt water and are eaten chilled as a salad vegetable. Canned heart of palm is high in sodium (622 mg, 27% DV); it is a good source of fiber (3.5 g, 12.5% DV), folate (57 µg, 14% DV), vitamin C (11.5 mg, 13% DV), and iron (4.5 mg, 25% DV), and contains less than 1 g of total fat from equal parts saturated and polyunsaturated fat. Palm oil has been a major source of cooking oil in Asia and Africa.[2] Palm oil, a saturated "tropical" oil, is a source of vitamin E (2 mg, 13% DV), and a common processed foods ingredient.

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.[1] Vitamin E in foods is a potent suppressor of cholesterol biosynthesis.[3] Regarding palm oil atherogenicity, there is conflicting evidence suggesting that it both raises and does not raise serum cholesterol; however, the current advice of The American Heart Association is for healthy people to limit saturated fatty acids (SFA), including tropical oils, to < 10% of total kcalories, and for people with CVD to limit SFA to < 5–6% of calories.[4,5]

Bioactive Dose

Not known.

Safety

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

Pantothenic Acid

Definition

Also known as vitamin B5. Water-soluble vitamin found in all food groups, hence the Greek word "pantos" or "everywhere." Good sources include peanut butter, liver, kidney, peanuts, almonds, wheat bran, cheese, and lobster.[6] Refining, cooking, canning, and freezing decrease the pantothenic acid content of foods.[6] A Western diet meets the RDA of pantothenic acid.[7]

Scientific Findings

Pantothenic acid is part of coenzyme A, a necessary component of fatty acid metabolism and a participant in anabolic and catabolic metabolism.[78] Pantothenic acid deficiency is uncommon and has been induced in studies administering a pantothenic acid antagonist or diets devoid of pantothenic acid for long periods, e.g., nine weeks, at which point blood and urine levels of pantothenic acid dropped.[7] Pantothenic acid deficiency signs and symptoms 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.[7] Pantothenic acid status is not routinely measured in healthy people; however, urinary concentrations are the most reliable indicators because of their close relationship with dietary intake; excretion of less than 1 mg pantothenic acid per day suggests deficiency.[8]

Bioactive Dose

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

Safety

No UL has been established for pantothenic acid (toxicity of pantothenic acid has not been observed).

Papaya (Carica papaya *L.*)

Papaya. (Image from Abramova Elena/Shutterstock.)

Definition

Also known as paw-paw (also spelled pawpaw).[9,10] Large, oblong fruit with yellow-green skin that is approximately the size of a football. Papaya has the texture of cantaloupe and is eaten fresh, canned, or as nectar. One cup of papaya is an excellent source of vitamin C (83 mg, 92% DV) and vitamin A (1378 IU, 45% DV); and a good source of folate (54 µg, 13% DV); it also supplies fiber (2.5 g, 8% DV) and potassium (264 mg, 7% DV).[11] It is rich in the carotenoid beta-cryptoxanthin.[12] Papaya is used in folk medicine for contraception,[13] though no evidence supports its effectiveness as a contraceptive. In traditional and present-day African medicine, papaya is mashed and topically applied to burn wounds to prevent infection, deslough necrotic tissue, and help granulate wounds, effects that are attributed to its proteolytic enzymes and antimicrobial activity.[14] In Philippine traditional medicine, papaya is used as an anthelminthic, stomachic, diuretic, emmenagogue, laxative, vermifuge, antiasthmatic. antirheumatic, rubefacient, tonic, poultice, and as a cure for liver and spleen enlargement, freckles, and for cancerous growths.[15]

Scientific Findings

Papaya exerted anti-inflammatory effects in human cells.[16] In vitro research demonstrated papaya's ability to scavenge free radicals and bacteriostatic

properties against enteropathogens including *E. coli*, *Salmonella typhi*, *Staphylococcus aureus*, *Proteus vulgaris*, *and Klebsiella pneumoniae*.[15]

Bioactive Dose

Not known.

Safety

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

Paprika (Capsicum annuum *L.*)

Definition

Dried ground pods of the sweet red or chili pepper that adds earthy or spicy flavor and reddish-brown color to foods. Used to make chili, barbeque sauce, and barbeque potato chips. Contains flavonoids and carotenoids including beta-carotene, lutein, and xeaxanthin, and capsanthin.[17–19]

Scientific Findings

Paprika's free radical scavenging ability has been demonstrated in laboratory research.[20,21] A 12-week randomized trial (n = 33 healthy subjects) found that paprika extract from *Capsicum annuum* L. raised levels of serum carotenoids, especially β-cryptoxanthin.[22] In Japanese epidemiological studies, serum β-cryptoxanthin was inversely associated with risks of atherosclerosis, Type II diabetes, liver dysfunction, and osteoporosis; and daily intake of β-cryptoxanthin has been inversely correlated with rheumatoid arthritis morbidity.[22]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Paprika may be a food allergen and susceptible individuals should avoid eating it.

Parsley (Petroselinum crispum)

Definition

Culinary herb member of the Apiaceous 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 in salads, such as tabbouleh, a mixture of parsley, tomatoes, onions, and bulgur wheat flavored with lemon and olive oil. Parsley is an excellent source of vitamin C (19 mg, 21% DV per ½ cup [15 g])[23] and contains flavones.[24] In traditional medicine, parsley is used as an emenagogue.[25]

Scientific Findings

Parsley flavones were anti-inflammatory and parsley constituents were anticarcinogenic in experimental research studies.[24,26]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Adverse effects have been reported from consuming very large oral doses of parsley due to the apiole constituent; for example, 200 g of parsley (about the amount in 3.25 cups of parsley) has been associated with blood dyscrasias, kidney toxicity, and liver toxicities. Components in parsley, including psoralen, bergapten, and xanthotoxin can cause photosensitization (sensitivity to light).[27]

Passion Fruit (Passiflora edulis)

Passion fruit. (Image from Viktar 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.[28] Passion fruit has been used as a folk medicine for its sedative and antihypertensive effects, and for treating anxiety and nervousness.[29]

Scientific Findings

In experimental research, *Passiflora edulis* pulp extract reduced laboratory animals' total cholesterol and increased their HDL.[30] In a laboratory study, *Passiflora edulis* extract exhibited anxiolytic-like activity.[28] Another laboratory study found that a triterpenoid constituent of *Passiflora edulis* Sims possessed antidepressant-like activity in animals.[29]

Bioactive Dose

Not known.

Safety

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

Peach (Prunus persica)

Definition

Member of the *Rosaceae* family that also includes apples, nectarines, and strawberries. Peaches are a good source of vitamin C (9.9 mg, 11% DV)[31] and contain phytochemicals including chlorogenic acid, phenolics, anthocyanins, and flavonoids.[32,33] When consumed whole, with the skin intact, peaches supply 2.6 g fiber (9% DV per 1 large fruit).[34] Peaches are eaten canned, dried, and as fruit juice and nectar.

Scientific Findings

Fresh and canned peaches inhibited LDL oxidation in vitro.[35] A prospective case study (n=75,929 women aged 38–63 years at baseline) examined the associations of specific fruits and vegetables with the risk of estrogen receptor-negative breast cancer. Dietary data were collected seven times during a 24-year period. Consuming at least 2 servings of peaches/nectarines per week was associated with a lower risk of estrogen receptor-negative breast cancer among postmenopausal women compared with nonusers.[36] Chlorogenic acid protected cells from oxidative damage in a laboratory study.[37]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. A European study showed that the iron, copper, lead, zinc, and tin contents of canned peaches increased over a two-year period.[38]

Peanut (Arachis hypogaea)

Definition

High-protein, low-saturated fat, high-monounsaturated fat legume that is a source of vitamin E (0.7 mg, 5% DV) and resveratrol.[39] Peanuts are consumed roasted, made into peanut butter, and used in making peanut candy, often paired with chocolate.

Scientific Findings

There is moderate evidence that peanut and other nut consumption improves serum lipid levels.[39] Five servings of nuts (1 serving=1 oz or

approximately 28 g) or peanut butter (one serving = 1 tablespoon) was associated with a significantly lower risk of CVD and markers, including lower total and LDL cholesterol and apolipoprotein-B-100 concentrations, and no effect on HDL cholesterol or inflammatory markers in a large epidemiological study (n = 54,656 women with Type II diabetes).[40]

Bioactive Dose

See: Nut.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Peanuts are a common cause of allergic reactions in children, adolescents, and adults;[41] IgE binding proteins have been identified in peanut and allergenic response to them may range from mild skin reactions to the life-threatening anaphylactic reaction. Peanut has the greatest allergenicity among legumes[42] and those who are allergic must avoid peanut.

Pear (Pyrus communis)

Definition

White-fleshed *Rosaceae* family fruit that is a good source of fiber (5–6 g, 19% DV per medium pear),[43] and flavonoids, such as flavon-3-ols.[44] 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.[45] Flavonols exert cardioprotective and anticarcinogenic properties in vitro and in vivo.[46]

Bioactive Dose

Not known.

Safety

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

Pectin

Definition

Nonstarch polysaccharide that cements plant cell walls[47] found in fruits, such as berries and citrus fruits, including in citrus rinds; vegetables, including okra and sugar beets (a variety of *Beta vulgaris* grown for sugar production); and legumes. The pectin in cooked berries gelatinizes to solidify jams, jellies, and preserves, while okra is used as a thickening agent in gumbo.

Scientific Findings

Pectin slows the transit of food through the upper GI tract increasing the likelihood of nutrient absorption, and stimulates epithelial cell growth in the colon theoretically mitigating diarrhea.[48,49] However, in evaluating agents that regulate diarrhea, FDA ruled that pectin seemed to perform similarly to placebo in controlling diarrhea and had no effect on stool consistency in its final ruling on antidiarrheal over-the-counter drug products.[50] Pectin is fermented by anaerobic colonic flora producing beneficial short-chain fatty acids.[49] Pectin, like other soluble fibers, binds bile acids and/or cholesterol promoting their excretion, thereby helping to reduce serum cholesterol.[51]

Bioactive Dose

For persistent diarrhea in children, 4 g per kg of body weight per day of pectin fiber has been used.[52] Pectin at doses of 3–15 g daily for 4–12 weeks has been used for hypercholesterolemia.[52]

Safety

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

Pepper, chili (Capsicum frutescens, Capsicum annuum)

Definition

Also spelled: chilli, chile. Fruit[55] containing pungent capsaicinoid compounds, such as capsaicin, that produces burning sensation upon contact with the skin, and dihydrocapsiate. *Capsicum annuum* is dried and ground to make cayenne pepper. Different cultivars of chili pepper contain different phytochemicals, for example: red habanero peppers contain beta-carotene; Serrano, Tabasco, and jalapeño are high in capsanthin but not β-carotene, yellow habanero and Scotch bonnet contain lutein and alpha- and beta-carotene,

and orange habanero contain antheraxanthin, capsanthin, and xeaxanthin.[56] Native Americans rubbed their gums with pepper pods to relieve toothache.[57] Chili pepper is used as an herbal medicine to treat microbial infections.[58] Capsaicin causes irritation, burning, and 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.[59]

Scientific Findings

Extracts from fresh *Capsicum frutescens* exhibited antimicrobial effects against *Bacillus cereus*, *Bacillus subtilis*, *Clostridium sporogenes*, *Clostridium tetani*, and *Streptococcus pyogenes* in a laboratory study.[58] *Capsicum frutescens* contains vanilloid compounds that in laboratory studies exhibited hepatoprotective,[60] anti-inflammatory,[61] and antioxidative properties.[62] 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).[63] In an experimental study, capsaicin improved endothelial cell function in vitro, which may have implications for cardiovascular health.[64] Dihydrocapsiate nominally increased thermogenesis in two clinical trials (n = 78 healthy subjects)[65] (n = 33 healthy subjects).[66] In an experimental study, dihydrocapsiate was chemopreventive in tumor cells.[67]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Capsaicin is known to cause an extreme burning sensation. Chili pepper consumption may induce liver carcinoma in the rat.[57] Dermatitis can sometimes occur in breastfed infants when mothers ingest foods heavily spiced with capsicum peppers.

Pepper, sweet bell (Capsicum anuum *L.*)

Definition

Versatile vegetable that imparts color, texture, and flavor whether sautéed, stir-fried, or fresh. A salad-bar sized portion, ¼ cup of red bell

peppers, is an excellent source of vitamins A (720 IU, 24% DV) and C (29 mg, 32% DV), and supplies carotenoids and polyphenolic compounds.[53,54] Other bell pepper cultivars include green, yellow, orange, and purple.

Scientific Findings

A food analysis found green pepper had a higher level of phenolics than red and yellow peppers. Red pepper had higher vitamin C content than green and yellow peppers. Red and yellow peppers showed higher carotenoid content than green peppers. Red pepper showed a higher level of free radical scavenging activity compared to green and yellow peppers.[54]

Bioactive Dose

Not known.

Safety

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

Peppermint (Mentha x piperita)

Definition

Cross between water mint and spearmint that contains the monoterpene menthol responsible for its sweet fragrance and cooling sensation.[68,69] 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 tea, candy, and chewing gum.

Scientific Findings

Peppermint oil is used as an antispasmodic agent in Irritable Bowel Syndrome (IBS) due to its intestinal smooth muscle calcium channel blocking activity.[69,70] A meta-analysis of 56 randomized controlled trials comparing bulking agents, antispasmodics, or antidepressants with placebo (n = 3,725 IBS patients aged over 12 years) found a beneficial effect for antispasmodics over placebo for improvement of abdominal pain. Subgroup analyses for different types of antispasmodics found statistically significant benefit for peppermint oil.[71]

Bioactive Dose

The studied IBS dosages were 0.2–0.4 mL of peppermint oil three times daily, or 180–225 mg of peppermint oil three times daily.[52]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Peppermint oil may aggravate heartburn.[68]

Persimmon (Diospyros kaki)

Persimmon. (Image from EM Arts/Shutterstock.)

Definition

Strong-flavored fruit whose phytochemical constituents are responsible for its astringent mouthfeel and aftertaste. It resembles an orange tomato in appearance (size, color, firmness, and the calyx or stem at the top center of the fruit) and is a source of dietary fiber and polyphenols.[71]

Scientific Findings

Tannin, a type of soluble fiber, in persimmon bound bile acids in vitro.[73] Both fresh and dried persimmon possess high amounts of bioactive compounds that have antioxidant and free radical scavenging potential.[72]

Bioactive Dose

Not known.

Safety

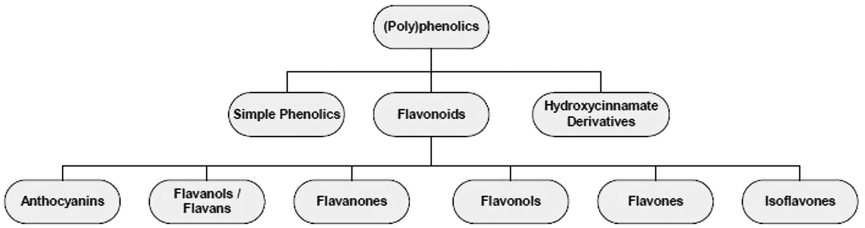
Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Consumption of persimmons, particularly unpeeled persimmons, has been associated with the development of bezoars formed in the GI tract from plant fibers; also, a case report of 15 patients cautioned that patients who have undergone ulcer surgery should avoid eating unpeeled persimmons.[74]

Phenolic Compounds

Definition

Also called phenolics, polyphenolic compounds, and polyphenols. Major class of phytochemicals found in plant foods that include:

- phenolic acids such as:
  - hydroxycinnamic acids (e.g., chlorogenic acid, p-coumaric acid, ferulic acid).
  - hydroxybenzoic acids (e.g., gallic acid, ellagic acid).
- flavonoids such as:
  - flavonols (e.g., quercetin, myricetin, kaempferol).
  - flavanols/flavans (e.g., catechin, epicatechin, proanthocyanidins).
  - flavanones (e.g., hesperitin, naringenin, eriodictyol).
  - flavanes (e.g., chrysin).
  - flavones (e.g., apigenin, luteolin).
  - isoflavones/isoflavonoids (e.g., daidzein, genistein, glycitein).
  - anthocyanins (e.g., cyanidin, malvidin, petunidin).[75,76]



EXAMPLES:

Anthocyanins:	cyanidin, malvidin, petunidin etc. (all have sugars attached)
Flavanols / Flavans:	catechin, epicatechin, proanthocyanidins
Flavanones:	hesperetin, naringenin, eriodictyol
Flavonols:	quercetin, myricetin, kaempferol (most have sugars attached)
Flavones:	apigenin, luteolin
Isoflavones:	daidzein, genistein, glycitein
Hydroxycinnamates:	chlorogenic acid
Simple Phenolics:	phloridzin

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Scientific Findings

Phenolic compounds have exerted antioxidant, anti-inflammatory, vasodilatory, antifibrotic, apoptotic, antimicrobial, and metabolic effects in laboratory studies.[77–81] Epidemiological studies suggest that polyphenols exert cardioprotective effects[81,82] and that consumption of fruits and vegetables is associated with a reduced incidence of cardiovascular disease, in addition, to reduced risk of developing diabetes, cancer, and stroke, partly due to phenolic compounds.[79]

Bioactive Dose

Not known.

Safety

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

Phloretin

Definition

Flavonoid found in apples and citrus fruits.[83]

Scientific Findings

Shown to exert antioxidant properties in vitro.[84] Phloretin exerted a chemoprotective effect against the carcinogen aflatoxin B in a laboratory study.[85]

Bioactive Dose

Not known.

Safety

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

Phosphorus

Definition

Major mineral whose major functions include energy transfer within the adenosine triphosphate molecule, bone structure as a component of hydroxyapatite crystal, pH maintenance, and structural component of cell phospholipid membranes.[86] Abundant in high-protein foods, such as meat, fish, poultry, eggs, and milk. Phosphate salts are also common food additives, such as the acidulant phosphoric acid in some soda beverages.[52] Phosphorus is ubiquitous in foods; a nearly total starvation is required to produce a phosphorus deficiency. Phosphorus intake from the average American diet is typically higher than the RDA.[52]

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.[52]

Bioactive Dose

The RDA for adults is 700 mg/day.

Safety

The UL for adults is 4 g/day.

Phytate

Definition

Also called phytic acid. The primary storage compound of phosphorus in seeds.[87] It binds to calcium, iron, potassium, magnesium, manganese, and zinc in the gut and renders them unabsorbable.[62,88] Phytates are found in legumes, seeds, and the husks of whole grains.

Scientific Findings

Phytic acid is an antioxidant.[89]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. However, diets that provide > 40 g of fiber per day may contain phytate levels that adversely impact the absorption of minerals.[90]

Phytoestrogens

Definition

Category of phytochemicals that includes isoflavones (e.g., genistein, daidzein, and glycitein), lignans, phytosterols, and others.[91] When circulating estrogen level is low, phytoestrogens are thought to become estrogenic; when circulating estrogen level is are high, phytoestrogens become anti-estrogenic.[92] Sources of phytoestrogens include whole grains, fruits, vegetables, such as alfalfa, anise, and soybeans, pumpkin seeds, and legume products such as soy flour, soymilk, tofu, and textured vegetable protein.[90,93–94]

Scientific Findings

Two meta-analyses (43 RCTs, n = 4,364;[92] 15 RCTs, n = 543[95], *note that these meta-analyses overlapped in evaluating some of the same individual studies*) examining the effect of phytoestrogens on the frequency and/or severity of hot flushes (hot flashes) in perimenopausal or postmenopausal women experiencing menopausal symptoms found significantly greater reduction in hot flush frequency compared to placebo, using isoflavone supplements

Table P.1 Sample Foods Containing Approximately 100 mg of Isoflavones

Sample Foods Containing Approximately 100 mg of Isoflavones[171]		
Quantity	**Food**	**mg of isoflavones (a combination of daidzein, genistein, glycitein)**
4 oz	Tempeh, fried	57 mg
8 oz	Soymilk, fortified or unfortified, vanilla or plain	24 mg
2/3 cups	Edamame, cooked	18 mg
Total: 99 mg		
Approximately 4 oz	MORI-NU® Silken, firm	34 mg
Approximately 3.5 oz	Kashi® Go-Lean cereal	17 mg
16 oz	Soymilk, fortified or unfortified, vanilla or plain	48 mg
Total: 99 mg		

in quantities of 25–100 mg/day[92] and no conclusive evidence that phytoestrogen supplements effectively reduce the frequency or severity of hot flushes and night sweats, while noting that "potential benefits of the specific isoflavone genistein are worthy of further investigation (Table P.1)."[95]

A meta-analysis of ten observational studies (n = 4,392 cases, n = 293,500 controls) showed higher phytoestrogen intake from soy foods was associated with a reduced ovarian cancer risk.[96] *See also: Isoflavones.*

Bioactive Dose

Not known.

Safety

Estrogenic adverse effects, such as edema, may occur as a result of consuming phytoestrogens, most often with long-term vs. short-term phytoestrogen supplement use.[97]

Pineapple (Anasas comosus)

Definition

Yellow-, fibrous-fleshed, juicy tropical fruit of the *Bromeliacea* 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.[98]

Pineapple is a natural source of the plant protease bromelain that is used orally as an anti-inflammatory agent.[99] 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.[100] In vitro and in vivo studies demonstrate that bromelain exhibits various fibrinolytic, antiedematous, antithrombotic, and anti-inflammatory activities,[101] but that there is insufficient evidence to rate its effectiveness for anti-inflammation or other uses in humans.[102] Bromelain also contains chemicals that interfere with the growth of tumor cells and slow blood clotting.[65] Bromelain and papain enhance bioflavonoid absorption.[103]

Bioactive Dose

Not known.

Safety

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

Pistachio (Pistacia vera)

Definition

Nut eaten raw or roasted that is a source of protein, 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.[104] Records show that people ate pistachio nuts as far back as 7000 BC.[105]

Scientific Findings

As part of an antiatherogenic diet, pistachios may contribute to a reduction in serum oxidized LDL.[106] A meta-analysis of 21 randomized, controlled trials conducted to evaluate the effect of nut consumption on blood pressure as primary or secondary outcomes in adult populations aged ≥ 18 y found that total nut consumption lowered systolic blood pressure in participants without Type II diabetes, and that pistachios had the strongest effect on reducing systolic and diastolic blood pressure.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Allergies to pistachio nuts have been reported. A case report of exercise-induced anaphylaxis to pistachio consumed ½ hour prior to exercise has been reported.[107]

Plantain (Musa x paradisiaca)

Definition

Starchy, green banana that is usually cooked by frying instead of eaten fresh. It supplies 65 g of carbohydrate and per 1 cup; in addition, it is an excellent source of vitamin A (2227 IU, 74% DV) and potassium (857 mg, 24% DV), and is a good source magnesium (76 mg, 17% DV) and fiber (5 g, 18% DV), while also supplying 9% DV of vitamin E (2.79 mg). Plantains are also a source of flavonoids.[108] Ripe plantains are cooked by slicing and frying, and are not eaten unless cooked.

Scientific Findings

In a clinical trial (n = 80 hospitalized children ranging in age from 1–28 months, who had experienced > 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 hours shorter (significantly different than the yogurt group).[109] Leucocyanidin, a flavonoid having antiulcer properties, has been identified in plantain.[110] A laboratory study found that plantain soluble fiber prevented *E. coli* translocation in Crohn's Disease cells which may have implications in preventing Crohn's Disease by limiting harmful bacteria's access to vulnerable intestinal cells.[111]

Bioactive Dose

Not known.

Safety

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

Plum (Prunus domestica)

Definition

Stone-fruit member of *Rosaceae* family that has been cultivated since ancient times. Its different cultivars (including red, purple, yellow, and green varieties) vary in size and composition. Commonly eaten fresh, canned, and as part of processed foods, such as baby food. An average, 2-inch-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, myricetin, and kaempferol.[112–114] Dried plums (prunes) and prune juice are traditionally consumed to relieve constipation. A 100-g serving (10 prunes or ¾ cups) of dried prunes provides approximately 6.1 g of dietary fiber, 2–3 mg of boron, and 745 mg of potassium,[115,116] making them a good source of fiber, and an excellent source of potassium.

Scientific Findings

Eating 100 g (approximately ¾ cup) of dried plum for 3 months significantly reduced serum levels of C-reactive protein in a small clinical trial (n = 160 postmenopausal women).[117] Dried plums and prune juice are high in sorbitol (14.7 g and 6.1 g/100 g, respectively), which is a laxative,[72] but soluble and insoluble fiber also promote laxation, the former by retaining water in the stool, the latter by providing bulk. Sorbitol is an effective osmotic laxative.[118] In an 8-week, single-blind, randomized crossover study (n = 40 constipated subjects, mean age 38), dried plums (50 g dried plums twice a day providing 6 g fiber/day) were found to be more effective than psyllium (11 g psyllium twice a day providing 6 g fiber/day) for the treatment of mild-to-moderate constipation.[119] A laboratory analysis found that phenolic compounds in prunes, pitted prunes, and prune juice inhibited LDL oxidation in vitro.[120] Animal and limited human data suggest a role for dried plum in preventing bone loss.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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) that are sourced from plants and fish, and omega-6 fatty acids (*n*-6) that are sourced from plants and have long chains of fatty acid chains and contain more than one double bond.

Scientific Findings

Polyunsaturated fatty acids (PUFAs) must be consumed in the diet to prevent deficiency of essential fatty acids, characterized by growth, skin, and other abnormalities. Evidence indicates that 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. Evidence shows that energy replacement of SFA with PUFA decreases total cholesterol, LDL cholesterol, and triglycerides, as well as numerous markers of inflammation. Polyunsaturated fatty acid intake significantly decreases the risk of cardiovascular disease and has also been shown to decrease the risk of Type II diabetes.[121] 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.[122]

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—s*ee Omega-3 and Omega-6 Fatty Acid*.

Safety

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

Pomegranate (Punica granatum)

Definition

Orange-sized fruit that has red, leathery skin, and contains sacs filled with hundreds of edible seeds encased in the juicy red pulp. Pomegranate is high in vitamin C and fiber as well as phytochemicals including ellagic acid, ellagitannins, punicic acid, anthocyanidins, anthocyanins, estrogenic flavonols, and flavonoids.[124] In traditional medicine, *Punica granatum*

has been used as an antiatherogenic, antidiarrheal, and to treat parasitic and microbial infections, ulcers, aphthae (mouth inflammations), hemorrhage, and respiratory complications.[81]

Scientific Findings

Pomegranate constituents, such as ellagic acid, exerted antioxidant properties in experimental research.[81] Drinking pomegranate juice does not seem to improve symptoms or breathing in individuals with chronic obstructive pulmonary disease.[82] There is insufficient evidence to evaluate its use for 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.[25]

Bioactive Dose

Not known.

Safety

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

Potassium

Definition

Main intracellular mineral required for the maintenance of pH balance, blood pressure, and general cellular function.[125] 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.[79]

Scientific Findings

Potassium deficiency affects neural transmission, muscle contraction, blood pressure, and vascular tone.[79] Dietary potassium has significantly lowered blood pressure in both hypertensive and nonhypertensive patients in observational studies, clinical trials, and several meta-analyses.[126] 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."[127]

Bioactive Dose

The AI for adults is 4,700 mg/day.

Safety

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

Potato, sweet (Ipomoea batatas)

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

Definition

Orange- or yellow-fleshed root, depending on variety 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;[128] also, a source of phenolics and flavonoids.[129] One baked sweet potato (3 and a ½ oz serving) provides over 8,800 IU of vitamin A (more than 100% DV), 141 calories, is rich in complex carbohydrates, an excellent source of vitamin C, and a good source of iron and fiber.[130]

Scientific Findings

Constituents in sweet potato exerted antioxidant, antiradical, and antiproliferative effects in laboratory studies.[86] In one study, antioxidant activity was directly related to the total amount of phenolics and flavonoids in

sweet potato.[86] Eating potassium-rich foods as part of an overall healthy diet may lower blood pressure.[131]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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.[132] Some of the phytochemicals in white potatoes include glycoalkaloids (which can exert beneficial or harmful effects), aglycones, and phenolic compounds.[133,134]

Scientific Findings

There is no evidence that the popular white potato protects against cancer.[135] 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.[136] The glycoalkaloids in potato inhibited growth of human colon and liver cancer cells.[137] In laboratory studies, solanine, a glycoalkaloid, was found to possess anticarcinogenic and antiprostate-cancer effects,[138,139] but solanine should not be consumed. Potato peel contains phenolics that exert antioxidant effects.[140]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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 as it ages) to remove solanine. Solanine is a gastrointestinal and neurological toxin.[141]

Prebiotics

Definition

Nondigestible dietary constituents that selectively stimulate 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.[142]

Scientific Findings

Prebiotics beneficially modify gut microbial balance.[92]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Overconsumption of prebiotics could cause intestinal discomfort.[143]

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.[144] Prickly pear contains vitamin C, fiber, flavonoids, and carotenoids.[145] In Mexico, the prickly pear cultivar, *Opuntia streptacantha*, is traditionally used in the treatment of diabetes mellitus.[146]

Scientific Findings

Prickly pear contains betalain that exhibited antioxidant properties in a laboratory study.[96] Prickly pear pectin decreased plasma LDL in guinea pigs fed a hypercholesterolemic diet.[147] According to a review, there is some preliminary clinical evidence that a single dose of the specific species of prickly pear cactus called *Opuntia streptacantha* can decrease blood glucose levels by 17–46% in patients with Type II diabetes, but it is not known if extended daily use can consistently lower blood glucose levels and decrease HbA1C levels.[25] *Opuntia streptacantha* juice was confirmed by maltose tolerance test to be an antihyperglycemic agent.[98]

Bioactive Dose

Not known.

Safety

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

Probiotics

Definition

Live microorganisms that, when consumed in adequate amounts, confer a health benefit.[148,149] For example, *Bifidobacteria* may help to "balance disturbed intestinal microflora and related dysfunction of the human gastrointestinal tract."[150] *Lactobacillus* in Greek yogurt that is labeled "fermented with *Lactobacillus*," *Saccharomyces* in beer, *Bifidobacteria* in kimchi (fermented, spicy Korean cabbage), sourdough bread; kefir, and miso[25] are common examples of probiotics in foods. Probiotics are used to treat diarrhea, urinary tract and female genitourinary tract infections, irritable bowel syndrome, pouchitis following surgical removal of the colon, and to prevent and manage atopic dermatitis (eczema) in children.[104]

Scientific Findings

Probiotic bacteria mechanisms of action include that they produce butyric acid that neutralizes the activity of dietary carcinogens; attach to enterocytes inhibiting the binding of enteric pathogens and initiating signaling of events that result in the synthesis of cytokines; and exert an influence on commensal microorganisms in the gastrointestinal tract.[103] In probiotic clinical trials, the beneficial effects were low and a strong placebo effect was noted[101]; moreover, "the human body can respond differently to the different species and strains of probiotics."[151] There is limited experimental evidence that certain *Bifidobacteria* may protect the host from the carcinogenic activity of intestinal flora,[101] but there is no evidence to support or refute the relationship between a patient's intake of probiotics and reduction of cancer symptoms.[152]

Bioactive Dose

Not known.

Safety

A probiotic review reported that there is a general lack of adverse event reporting in probiotic intervention studies, and that "the current literature is not well equipped to answer questions on the safety of probiotic interventions with confidence."[102] *Bifidobacteria* sourced from food are considered to have low pathogenic potential, and are an "extremely rare" cause of infection in humans; the lack of pathogenicity extends across all age groups and to immunocompromised individuals.[103]

Protease Inhibitors

Definition

Proteins in plants that are thought to respond to the attack of insects and pathogenic microorganisms,[153] but that may also impart a health benefit to the host when consumed. Found in soy products, broccoli, sprouts, potatoes, and legumes.[90]

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.[108]

Bioactive Dose

Not known.

Safety

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

Protein

Definition

Macronutrient whose constituent amino acids are used to synthesize body proteins or are 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 ¼ cup of legumes or tofu, 1 egg, ½ oz nuts or seeds, 1 tablespoon of peanut butter, or 1 oz of lean cooked meat, poultry, or fish.

	Amount that Counts as 1 Ounce-Equivalent in the Protein Foods Group	Common Portions and Ounce-Equivalents
Meats	1 ounce cooked lean beef 1 ounce cooked lean pork or ham	1 small steak (eye of round, filet) = 3 ½ to 4 ounce-equivalents 1 small lean hamburger = 2 to 3 ounce-equivalents
Poultry	1 ounce cooked chicken or turkey, without skin 1 sandwich slice of turkey (4 ½″ × 2 ½″ × 1/8″)	1 small chicken breast half = 3 ounce-equivalents ½ Cornish game hen = 4 ounce-equivalents
Seafood	1 ounce cooked fish or shell fish	1 can of tuna, drained = 3 to 4 ounce-equivalents 1 salmon steak = 4 to 6 ounce-equivalents 1 small trout = 3 ounce-equivalents
Eggs	1 egg	3 egg whites = 2 ounce-equivalents 3 egg yolks = 1 ounce-equivalent
Nuts and seeds	½ ounce of nuts (12 almonds, 24 pistachios, 7 walnut halves) ½ ounce of seeds (pumpkin, sunflower, or squash seeds, hulled, roasted) 1 Tablespoon of peanut butter or almond butter	1 ounce of nuts or seeds = 2 ounce-equivalents
Beans and peas	¼ cup of cooked beans (such as black, kidney, pinto, or white beans) ¼ cup of cooked peas (such as chickpeas, cowpeas, lentils, or split peas) ¼ cup of baked beans, refried beans ¼ cup (about 2 ounces) of tofu 1 oz. tempeh, cooked ¼ cup roasted soybeans 1 falafel patty (2 ¼″, 4 oz) 2 Tablespoons hummus	1 cup split pea soup = 2 ounce-equivalents 1 cup lentil soup = 2 ounce-equivalents 1 cup bean soup = 2 ounce-equivalents 1 soy or bean burger patty = 2 ounce-equivalents

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. The protein foods group is a source of protein, essential fatty acids, niacin, thiamin, vitamin B6, vitamin B12, iron, magnesium, potassium, and zinc.

Scientific Findings

Protein consumption has minimal influence on glycemic response and insulin requirement.[154] Patients who are malnourished or who are in active disease states have higher protein requirements than healthy people.[155] Protein malnutrition is associated with loss of lean body mass.[110] Protein undernutrition was associated with an increased risk of cataract in a population-based study (n = 2,584 subject aged 60–95 years).[156]

Bioactive Dose

The RDA for protein for healthy adults aged 19–50 is 0.8 g/kg/day. The protein AMDR is 10–35% of daily kcalories.

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[157] that may be effective in relieving the symptoms of irritable bowel syndrome, including diarrhea; reducing high blood glucose levels in individuals with Type I and II 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.[157] Small clinical trials have shown psyllium fiber to be associated with lower mean daily glucose concentrations, lower post-meal glucose concentrations, fewer hypoglycemic events, lower hemoglobin A1C levels, and lower insulin concentrations in people with

diabetes mellitus.[158] Psyllium husk may reduce the risk of Type II diabetes, although the FDA has concluded that there is very little scientific evidence for this claim.[25]

Psyllium seems to reduce total and LDL cholesterol, and the LDL–HDL ratio.[25]

Bioactive Dose

Not known,

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Not consuming enough fluid when taking psyllium could lead to choking or obstruction of the esophagus or bowel.[112] Since fiber can speed GI tract transit time and thus limit absorption, psyllium should not be taken within two hours of many orally administered medications.[159]

Pummelo (Citrus grandis)

Definition

Largest citrus family member, weighing 2–3 pounds on average, resembling an oversized grapefruit but with thicker skin. Its segments are white- or red-fleshed. Pummelos are excellent sources of vitamin C[160] and contain 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.[116] Citrus genus fruits contain limonoids, bitter-flavored secondary metabolites that have exhibited antibacterial, antifungal, antimalarial, anticancer, and antiviral properties in laboratory studies.[161,162]

Bioactive Dose

Not known.

Safety

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

Pumpkin (Cucurbita pepo)

Definition

Squash family vegetable that is an excellent source of vitamin A (7050 IU per ½ cup, 235% DV) from beta-carotene,[163] and notably is rich in other carotenoids. Common in baked products, such as muffins and pie, and pumpkin flavoring is added to doughnuts, coffee, and other foods in the autumn season.

Scientific Findings

A review examining natural treatments for benign prostatic hypertrophy found no convincing evidence to support the use of *Curcubita pepo* alone for its treatment.[164] In experimental research, pumpkin exhibited moderate antioxidant activity, and moderate to high alpha-glucosidase and angiotensin-converting enzyme inhibitory activities,[165] which may have implications for hyperglycemia and hypertension management, respectively. 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.[166]

Bioactive Dose

Not known.

Safety

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

Pumpkin Seed

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

Definition

Edible seed of pumpkin (*Curcubita pepo*), eaten roasted. Pumpkin seeds, (roasted per 1 oz), are an excellent source of vitamin E (3.72 mg, 25% DV), phosphorus (333 mg, 26% DV) and zinc (2.17 mg, 20% DV), and contain iron (2.7 mg, 10% DV) and fiber (2 g, 7% DV).[167] Pumpkin seeds' vitamin E is the gamma-tocopherol form (a type of natural vitamin E).[168–170]

Scientific Findings

In a small study (n = 20 boys age 2–7 years), pumpkin seed treatment as compared with treatment with orthophosphate (the control compound), reduced calcium oxalate bladder stone formation.[172]

Bioactive Dose

Not known.

Safety

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

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Q

Quercetin

Definition

Major flavonoid in the US diet consumed in daily amounts of 4 or 5 mg[1] through plant foods, such as white fruits and vegetables, for example, apples, pears, and onions, but in pigmented plant foods as well, for example, red leaf lettuce, leafy green vegetables, green tea, quinoa, wine, and asparagus; whereas median daily intake of quercetin in Japan, because it may consume a higher proportion of calories from plant foods, is estimated to be 15.5 mg/day.[2,3]

Scientific Findings

Quercetin exhibits direct apoptotic effects on tumor cells in in vitro and in vivo cell and animal studies.[4] In vitro data indicate quercetin has antioxidative and anti-inflammatory functions with the potential to lower disease risk factors, but human data are limited.[5] Quercetin has been shown to modify eicosanoid biosynthesis; protect LDL from oxidation; prevent platelet aggregation; and relax cardiovascular smooth muscle–properties which may have antihypertensive and antiarrhythmic effects; and to exert antiviral and carcinostatic properties.[6] A case-control study (n = 558 lung cancer cases; n = 837 controls) found lung cancer to be inversely associated with the flavonoids, including quercetin, among tobacco smokers, but not among nonsmokers, and observed an inverse association of lung cancer with 3 servings of vegetables per day and 1 cup of tea per day.[1] Another case-control study (n = 582 patients with incident lung cancer and n = 582 age-, sex-, and ethnicity-matched control subjects) found a statistically significant inverse association between lung cancer risk and quercetin, from foods such as onions and apples, with onions being particularly strong against squamous cell carcinoma.[2]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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;[7] therefore, it is frequently consumed as sweetened jam.[8] Quince jelly and jam is common in the Greek diet.

Scientific Findings

Quince pulp, peel, and jam exhibited antioxidant activity in a laboratory study.[6] Whole *Cydonia oblonga* Miller fruit, including pulp, peel, and seed, exhibited antiproliferative properties against human kidney cancer cells and colon cancer cells in a laboratory study.[9]

Bioactive Dose

Not known.

Safety

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

Quinoa (Chenopodium quinoa)

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

Definition

Small oval seed, approximately 1.5–2 mm in diameter[10] and whole grain. It is prepared by cooking similarly to rice, using one part grain to two parts water. Consumed as a grain side dish, it can be added to vegetables and salads for starch and texture. Quinoa contains fiber (2.6 g, 9% DV), zinc (1 mg, 9% DV), selenium (2.6 µg, 5% DV), and vitamin E (0.585 mg, 4% DV); and is good source of magnesium (59 g, 14% DV) and phosphorus (140 mg, 11% DV) per ½ cup;[11] in addition, quinoa supplies phytosterols and flavonoids.[12] Quinoa's content of amino acids, though higher than that of many common grains, does not include adequate amounts of the essential amino acids threonine, lysine, and phenylalanine[13]; hence, it is not a complete protein, as has been claimed, because it does not contain all essential amino acids necessary for human growth. Originally from the South American Andes region, quinoa is one of the oldest crops on the American continent.[10]

Scientific Findings

Quinoa seeds fed to rats reduced serum total cholesterol, glucose, LDL, and triglycerides.[14]

Bioactive Dose

Not known.

Safety

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

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R

Radicchio (Cichorium intybus *L.*)

Radicchio. (Image from marmo81/Shutterstock.)

Definition

Hardy, variegated, magenta variety of chicory served as salad, usually mixed with other salad greens to mellow its bitterness. Radicchio, per 1 cup, contains folate (24 µg, 6% DV) and is an excellent source of vitamin K (102 µg, 25.5% DV). Phytochemical constituents in radicchio include lutein + xeaxanthin (3,533 µg [3.5 mg]), and phenolics.[1]

Scientific Findings

In a laboratory study, *Cichorium intybus* exhibited antioxidant properties.[2]

Bioactive Dose

Not known.

Safety

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

Radish (Raphanus sativus)

Radish. (Image from amphaiwan/Shutterstock.)

Definition

Small, round, white-fleshed vegetable that has thin, edible red skin and a sharp, burning flavor. The daikon is a large, conical white variety of radish eaten fresh, for example, shredded, served with sushi, or pickled and fermented in Asian cooking. Radish sprouts are a source of glucosinolates and antioxidants.[3] Radishes are so low in calories, they are considered a calorie-free food and they are a source of vitamin C.[4] Traditional uses of radish include to treat peptic disorders, bile duct dyskinesia, loss of appetite, inflammation of the mouth and pharynx, bronchitis, fever, colds, and cough, and to prevent infection or inflammation or excessive mucus of the respiratory tract.[5]

Scientific Findings

See Brassica Vegetables.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Consuming large amounts may lead to gastrointestinal irritation.[5]

Raisin (Vitis vinifera)

Definition

Dried grape eaten as a snack and in cereal, trail mix, raisin bread, candy, and baked dessert foods. Raisins are a good source of potassium (749 mg, 11% DV), and fiber (3.7 g of both soluble and insoluble fiber, 13% DV) per 50 g or approximately ⅓ cups.[6,7] Compared to grapes, raisins contain more calories (approximately 149 calories per ⅓ cup) and fructans (*see: Fructan*), but fewer phenolic compounds that are lost during processing, including procyanidins and flavan-3-ols.[1,8]

Scientific Findings

A small clinical trial (n = 13 healthy subjects) found that eating 120 g (0.80 cups or slightly < 1 cup[9]) of sun-dried raisins improved fecal bile acid composition and beneficially modulated colonic short-chain fatty acids.[10] In a crossover-design study (n = 16 healthy adults), 84 g (0.58 cup or slightly more than ½ cup[11]) of sun-dried raisins improved measures of colon health, including intestinal transit time, fecal weight, and fecal bile acid composition.[12]

Bioactive Dose

Not known.

Safety

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

Raspberry, red (Rubus idaeus)

Definition

High-vitamin C berry that provides 4 g of fiber per ½ cup serving (14% DV),[13] phenolics, anthocyanins,[14] and caffeic acid (not to be confused with caffeine—the two substances are unrelated).[15] Eaten fresh, frozen, in juice blend drinks, and in prepared foods, such as desserts, applesauce fruit blends, and baby food.

Scientific Findings

Red raspberry muffins exerted measurable antioxidant properties attributed to raspberry phenolics and anthocyanins.[11] Red raspberry phenolics and

ellagitannins formed compounds beneficial to colonic cells in in vivo and in vitro studies.[16] In laboratory studies, caffeic acid exhibited antioxidant, immunomodulatory, and anti-inflammatory properties.[17,18] In an experimental model, caffeic acid protected human skin from photo-oxidative damage.[19]

Bioactive Dose

Not known.

Safety

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

Resveratrol

Definition

Polyphenol linked to the "French Paradox" phenomenon, referring to the anti-atherogenicity of the high-saturated-fat French Diet, presumably due to the inclusion of red wine. Red wine is the major dietary source of resveratrol, while white wine has a low content of resveratrol, a phytochemical that is particularly rich in grape skins and also found in peanuts, as well as other foods.[20–23]

Scientific Findings

Resveratrol inhibited LDL oxidation and platelet aggregation, and exerted anti-inflammatory and anti-proliferative effects in laboratory resea rch.[22,24,25] In a 4-week RCT (n = 19), resveratrol improved insulin sensitivity in patients with Type II 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.[26] A meta-analysis of 17 RCTs (n = 736 subjects) found significant reductions in the inflammatory markers tumor necrosis factor-α and C-reactive protein in subjects taking resveratrol supplements.[27] A second meta-analysis of 15 RCTs (n = 658) concluded resveratrol supplements might not be able to change concentrations of the inflammatory markers interleukin-6 or tumor necrosis factor-α, but found a "possible decreasing effect of resveratrol on CRP."[28]

Bioactive Dose

Not known.

Safety

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

Rhubarb (Rheum officinale)

Rhubarb. (Image from photogal/Shutterstock.)

Definition

Polygonaceae family vegetable consisting of edible stalks or "petioles", that is, the portion from the stem to the leaf. Rhubarb leaves should not be consumed. Rhubarb is used to make pies, jam, jelly, and sauces, and is an excellent source of vitamin K (40 µg, 33% DV) and a good source of mostly insoluble but also soluble fiber totaling 2.5 g of total fiber (9% DV) per 1 cup.[29,30] Thought it contains 344 mg of calcium (26% DV) per 1 cup, its high oxalic acid content somewhat blocks calcium absorption.[30,31] It is also a source of the phytochemical anthraquinone.[32] Rhubarb has been used in traditional Chinese medicine to treat constipation, blood stasis, diabetic nephropathy, chronic renal failure, acute pancreatitis, gastrointestinal bleeding, and other diseases.[33]

Scientific Findings

Anthraquinone exhibited antiviral properties in laboratory studies.[32,34] Anthraquinones have cathartic effects in vivo.[32]

Bioactive Dose

Not known.

Safety

Rhubarb leaves are poisonous.[35] Rhubarb petioles and products made from them are presumed safe when consumed in normal dietary quantities by nonallergic individuals. Anthraquinone studied separately, outside of the food matrix in cell cultures, has demonstrated mutagenic, carcinogenic, and adverse genetic effects.[36]

Riboflavin

Definition

Also referred to as vitamin B2. Water-soluble vitamin that functions as a coenzyme in redox reactions.[37] The best sources of riboflavin are milk and enriched grain products. The median riboflavin intake in the US meets the riboflavin RDA.[37] 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.[37]

Scientific Findings

Higher intake of riboflavin was associated with a reduction in age-related lens opacification progression in a subset (n = 408 aged 51–72 y at baseline) of The Nurses' Health Study.[38]

Bioactive Dose

The RDA for men aged 19–50 it is 1.3 mg. The RDA for non-pregnant women aged 19–50 is 1.1 mg.

Safety

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

Rosemary (Rosmarinus officinalis)

Definition

Culinaryherb with a pine-like flavor used fresh or dried to season meat, poultry, pasta, sauces, stuffing, potatoes, peas, and lima beans.[39] Contains rosmarinic acid, "one of the most important and well known natural antioxidant compounds."[40]

Scientific Findings

In experimental studies, rosemary exhibited anti-inflammatory, antispasmodic, analgesic, antirheumatic, carminative, cholagogue, diuretic, expectorant, antiepileptic, and neuroprotective, properties.[40–42]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic 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." Cooked rutabaga is a good source of vitamin C (16 mg, 17% DV), and rutabaga supplies potassium (184 mg, 5% DV) and glucosinolates.[43,44] 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 nonallergic individuals. High levels of goitrogens have been found in rutabaga.[45] Cooking destroys goitrogens.[46]

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S

Sage (Salvia officinalis, Salvia lavandulaefolia)

Definition

Earthy-flavored herb used fresh or dried to flavor meats, fish, and stews. Consumed as a culinary herb in small quantities, sage is not an appreciable source of nutrients. *Salvia officinalis* contains tannins; essential oils that contain monoterpenes called thujones; flavones; phenolic acids; glycosides; triterpenoids; and diterpenes. Spanish sage (*Salvia lavandulaefolia*) is a species related to *Salvia officinalis* that contains similar bioactive constituents, but its thujone content is lower.[1] "Sage is often misidentified and adulterated; *Salvia bertolonii* or *Salvia pratensis* are sometimes used" in place of or as an adulterant in *Salvia officinalis*.[1] In traditional medicine, sage tea was used to treat dyspepsia, mouth and throat inflammation, excessive sweating, and minor skin inflammations.[2] Ancient Greek physicians used a sage and water solution to stop wounds from bleeding and to clean sores and ulcers.[3] In Native American rituals, dried sage is burned to promote healing, wisdom, protection, and longevity.[3] Many species of sage have been used historically as "brain-enhancing tonics."[4] *Salvia officinalis* L. (sage) has been widely used in Tunisian traditional medicine, and *Salvia* species in European folk medicine, for the treatment of memory disorders.[5,6]

Scientific Findings

S. officinalis demonstrated anticholinesterase (i.e., acetylcholinesterase inhibitory/acetylcholine-binding/cholinergic binding), antioxidant, anti-inflammatory, and estrogenic (i.e., anti-hot flush [also referred to as hot flash]) properties in vitro.[5,7–9] In laboratory research, *S. lavandulaefolia* and/or its constituents have demonstrated anticholinesterase, antioxidant, anti-inflammatory, estrogenic, and central nervous system depressant, or sedative, effects.[10] There is insufficient scientific evidence to support sage as a treatment for a sore throat.[3] Binding receptor sites of the neurotransmitter acetylcholine may favorably impact cognition in Alzheimer's Disease.[11] *Salvia fruticosa* has bound acetylcholine receptor sites in animal studies.[5] S*alvia officinalis* was found to be better than placebo to enhance cognitive measures in older adults with a mild-to-moderate AD in a 4-month, placebo-controlled clinical trial (n = 42 men and women).[12] A review of eight

clinical trials that included the aforementioned study and consisted of two studies in AD patients and six in healthy subjects) found that *S. officinalis* and *S. lavandaeluaefolia* exerted certain beneficial cognitive effects; however, no dose was proven to be efficacious in healthy or AD patients. Sage purportedly reduces lactation and has been used to aid with weaning or an overabundant milk supply, but studies evaluating the effect of sage and human lactation could not be found in the scientific literature.[1]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Thujone is a neurotoxin; however, when sage is used in normal dietary quantities, thujone poses little risk.[2] Thujone may have menstrual stimulant and abortifacient effects, and may suppress lactation.[14] No data exist on the safety of sage in nursing mothers or infants.[1] "Large amounts or prolonged use of sage leaf or ingestion or sage oil may cause restlessness, vomiting, vertigo, tachycardia, tremors, seizures, and kidney damage."[14] Twelve or more of drops of sage essential oil is considered a toxic dose.[14]

Saponin

Definition

Glycoside compound found in a wide variety of plants, such as soybeans, chickpeas, peanuts, spinach, quinoa, and beer.[15] When fruits and vegetables are cut or otherwise processed, saponin produces a soapy foam.[15]

Scientific Findings

Dietary saponins, either isolated or as saponin-containing food plants, have reduced plasma cholesterol levels in animal studies.[7] Experimental data show saponin exert blood-pressure-lowering effects.[16] Saponins demonstrated immune properties in vitro including stimulating phagocytic, bactericidal, and adhesion activities of white blood cells.[17]

Bioactive dose

Not known.

Safety

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

Selenium

Definition

Trace mineral found in meat, seafood, and certain plant foods, such as nuts, especially Brazil nuts, which supply 290 μg of selenium (Se) per 1 nut[18] (five times the Reference Dietary Intake amount of 55 μg). Se is a cofactor for antioxidant enzymes, including glutathione peroxidase, whose main role is to prevent oxidative damage.[14,19] Se is necessary also for thyroid function; immune function; normal testicular development, spermatogenesis, and spermatozoa motility and function in males; and it exhibits insulin-mimetic properties.[20–22]

Scientific Findings

Consuming one Brazil nut daily for 8 weeks improved Se status, erythrocyte glutathione peroxidase activity, and HDL cholesterol in a small clinical trial (n = 38 Se-deficient, obese women).[9] A meta-analysis examining Se and cancer risk that included 49 prospective observational studies (n => 1,078,000 participants 41% men 21% women and remainder gender was not reported) and six randomized controlled trials (n = 43,408 94% men, 6% women), found no relationship between Se and increased risk of cancer;[23] whereas, a meta-analysis of 38 studies including observational and clinical trials (n = 36,419 cases and 105,293 controls) concluded that Se plays a protective role against prostate cancer development and its progression to advanced stages.[24] Higher toenail Se was associated with a substantial decrease in the risk of advanced prostate cancer in the 17.3-year Netherlands Cohort Study (n = 58,279 men aged 55–69 years). Researchers concluded that if there is a benefit of Se on prostate cancer risk, it appears to be limited to those who are Se-deficient.[25] Se is a nutrient consumed less by short sleepers (<5 h per night) in an observational study that examined associations between

self-reported sleep duration and intake of various dietary components (n = 5587 participants in The 2007–2008 National Health and Nutrition Examination Survey); normal sleep duration was associated with the greatest food variety.[26] Se status appears to have an impact on the development of thyroid pathologies.[27] "Low Se levels or Se deficiency may reduce the conversion of thyroxine (T4) to triiodothyronine (T3) … Taking Se [supplements] can worsen hypothyroidism in people with iodine deficiency. People who are iodine- and Se-deficient should not take Se supplements without concomitant iodine because this might further exacerbate the hypothyroidism. In these individuals, the Se increases conversion of T4 to T3, but the thyroid gland lacks iodine to synthesize more T4. Se does not have a significant effect on thyroid function when iodine intake is adequate."[14] Patients with newly diagnosed Graves' Disease (n = 97) and autoimmune overt hypothyroidism (n = 96) had significantly lower serum Se compared with random controls (n = 830), suggesting a link between inadequate Se status and overt autoimmune thyroid disease, especially Graves' Disease.[28] Adequate Se, together with optimal iodine and iron intake, is required for a healthy and functional thyroid during development, adolescence, adulthood, and aging.[29]

Bioactive Dose

The RDA for adults aged 19–50 is 55 µg/day. The World Health Organization recommends between 30 and 40 µg/day for men and women.[23]

Safety

The UL for adults aged 19–50 is 400 µg/day. "Signs and symptoms of selenosis (Se toxicity) include pruritis, nail changes, brittle hair and nails, and garlic breath, and have been reported at serum Se levels > 1000 ng/mL corresponding to daily intakes > 910 µg"[30]—quantities that would most likely occur due to dietary supplementation and not food intake of Se.

In two large clinical trials examining Se supplementation and prostate cancer development, Se supplementation of 200 µg of Se daily for 7.7 years reduced prostate cancer development but participants in the top tertile of plasma Se had a higher risk of developing Type II diabetes, while Se had no effect on prostate cancer development in the second study and higher risk of newly diagnosed Type II diabetes mellitus.[22]

Shallot (Allium cepa *L. var.* aggregatum)

Shallot. (Image from NeydtStock/Shutterstock.)

Definition

Miniature purple onion that contains allyl sulfides and flavonol glycosides, including quercetin.[31] Used for their strong, characteristically burning flavor in salads and salad dressings.

Scientific Findings

See Allium vegetables and Quercetin.

Bioactive Dose

Not known.

Safety

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

Snap Pea (Pisum sativum *L.*) and *Snow Pea* (Pisum sativum *var.* macrocarpon, Pisum sativum *var.* saccharatum)

Snap pea (Image from NeydtStock/Shutterstock).

Snow pea (Image from jiangdi/Shutterstock).

Definition

Fabaceae green pod vegetables containing edible legumes. The snap pea (also called sugar snap pea[32] and green pea[33]) may be stir-fried or otherwise cooked and is available as a baked, salted, ready-to-eat snack. Fresh shoots of the snap pea are used as microgreens, i.e., young sprouts or "pea shoots," in salads or as a garnish, and dried, split peas are an excellent source of choline (153 mg, 28% DV) per ½ cup[34] in addition to many other nutrients (*see also: Legume*). The snap pea is plump with slightly tough skin. Snap peas contain fiber (2 g, 7% DV) and are an excellent source of vitamin C (36 mg,

40% DV), while also supplying phenolic compounds and flavonoids.[35,36] The snow pea is flat and tender. It is eaten fresh or steamed, usually after the tough strings along the edges are removed.[32] The snow pea supplies 2 g of fiber (7% DV) and is a good source of vitamin C (15 mg, 16% DV) per 3 oz.[37] Sativin isolated from snow pea (*Pisum sativum* var. *macrocarpon*) exerted antifungal activity in vitro against a variety of organisms.[38]

Scientific Findings

In an animal study, diets containing *P. sativum* reduced serum total cholesterol, LDL, VLDL, and cholesterol-to-HDL ratio.[39] *See also: Legume.*

Bioactive Dose

Not known.

Safety

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

Sodium

Definition

Major mineral electrolyte and primary intracellular cation that is necessary for maintaining fluid balance, blood volume, blood pressure, nerve impulse transmission, acid-base balance, muscle function, and plays many other vital roles.[40]

Typical dietary intake: Sodium is a common food additive, abundant in processed, ready-to-eat foods; table salt is a combination of sodium and chloride and the most common source of dietary sodium in the American diet. Most people in the US get more sodium in their diets than they need, while sodium deficiency is unlikely. Acute sodium deficiency and excess can occur due to illness or extreme conditions. Deficiency may occur in cases of fluid loss such as vomiting, diarrhea, blood loss, sweating, excessive urination, and use of certain medications, such as diuretics. Sodium deficiency causes disturbances in acid-base balance, poor appetite, muscle cramps, confusion, apathy, constipation, and cardiac arrhythmia,[40] Sodium excess is associated with hypertension.[41]

Scientific Findings

A review of 257 randomized and nonrandomized controlled trials and observational studies found that "interventions that reduce sodium intake (including those that use potassium-containing salt substitutes in

the diet) reduce blood pressure in normotensive adults and, to a greater extent, in those with hypertension. Prospective cohort studies show that higher sodium intakes may be associated with greater risk for hypertension and CVD, CHD, and stroke morbidity, and mortality.[42] *The Dietary Guidelines 2015–2020* recommends consuming a Healthy Eating Pattern that limits sodium.[43]

Bioactive Dose

The AI for sodium for adults aged 19–50 is 1,500 mg.

Safety

The UL for sodium for adults aged 19–50 is 2,300 mg.

Soybean (Glycine max)

Definition

Fabaceae vegetable that contains protein which is similar, but not equal, to animal protein, and is a source of isoflavones—*see also: Isoflavones*.[44] Edamame are immature soybeans that are good sources of fiber (5.2 g fiber, 17% DV) and zinc (1.25 mg, 11% DV), and excellent sources of vitamin C (37 mg, 41% DV), calcium (250 mg, 19% DV), potassium (793 mg, 23% DV), iron (4.5 mg, 25% DV), and folate (211 µg, 52% DV) per ½ cup.[45] Tofu, tempeh, miso, natto, soy milk, and soy-based infant formula also are commonly used in vegetarian diets as protein substitutes, but they lack vitamin B12 unless their ingredients state that it has been added. Soybean oil, an omega-6 polyunsaturated fatty acid, supplies 23 mg of β-sitosterol per tablespoon.[46,47]

Scientific Findings

Some evidence suggests soy protein added to a diet low in saturated fat reduces the risk of coronary heart disease, but there are inconsistent findings concerning the ability of soy protein to lower LDL cholesterol.[48,49] A review of 13 studies found conflicting evidence on the effect of increased soy food intake and blood pressure.[50] *See also: Isoflavones.*

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,[50] but a dose of 20 (approximately ⅔ cups of cooked edamame)–50 g (approximately 1.5 cups of cooked edamame)[51] of soy protein daily was used in for hyperlipidemia in clinical trials.[14]

A healthy eating pattern based on a 2,000-calorie level should include:

- 3 c-equivalent/day of fat-free or low-fat dairy, including milk, yogurt, cheese, and/or fortified soy beverages (commonly known as soymilk)
- 5½ oz-equivalent/day of a variety of protein foods, including seafood, lean meats and poultry, eggs, legumes (beans and peas), and nuts, seeds, and soy products.[43]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Allergies to soybean have been reported. "A systematic review and meta-analysis that included 15 placebo-controlled treatment groups and an additional 32 reports involving 36 treatment groups found no effects of soy protein or isoflavone intake on testosterone, sex hormone binding globulin, free testosterone or the free androgen index," though two cases of male feminization have been reported that involved men ingesting 360 mg isoflavones a day;[44] as 8 oz cup of low-fat soymilk contains 25 mg of isoflavones,[52] 14 8 oz glasses of low-fat soymilk would be required to ingest 360 mg of isoflavones.

Spinach (Spinacia oleracea)

Definition

Dark green leaf vegetable that is a good source of folate (58 µg, 14.5% DV) and an excellent source of vitamins A (2,813 IU, 94%) and K (144 µg, 120% DV) per 1 cup.[53] Spinach supplies lutein,[54] saponin, and oxalate (the phytochemical that gives raw spinach its distinctive "mouth feel" described as a film in the mouth). Unlike other dark green vegetables, spinach is a poor calcium source, providing only 30 mg per 1 cup (2% DV). Despite its high-iron reputation, spinach is only a fair source of iron, providing approximately 0.8 mg of nonheme iron per 1 cup (4% DV)[55] depending on the brand (some brands may contain slightly more), whereas a "good source" would supply 10–19% DV. Spinach is high-iron vegetables, than many vegetables (e.g., 1 cup of green onions supplies 0.48 mg and 2.6% DV and watercress has 0.7 mg and 0.3% DV of iron),[56] whereas legumes are high-iron vegetables, supplying up to 10 mg per cup (55% DV of iron).[57] Baby spinach salad, the Greek dish spanakopita (literally meaning "spinach with bread"), and sautéed spinach are some typical uses of spinach.

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.[58,59] High intake of green leafy vegetables was linked to a reduced risk of non-Hodgkin lymphoma in a population-based case-control study (n = 348 cases and 470 controls) that compared dietary intake of cases to controls.[60] A randomized, controlled, crossover trial (n = 30 healthy men and women) found that flavonoid-rich apples and nitrate-rich spinach independently augmented nitric oxide status, enhanced endothelial function, and lowered blood pressure acutely.[61]

Bioactive Dose

Not known.

Safety

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

Squash (Curcubito pepo)

Definition

Cultivar that yields immature fruits (summer squash) and mature fruits (winter squash), *pepo* being the Latin word for fruit.[62] Squash is high in starch (15 g per ½ cup), rich in vitamin A (400 IU, 13% DV), and a source of all B vitamins except vitamin B12.[63] Summer squash has a thin, edible skin and includes yellow squash (*Cucurbita pepo* L.), zucchini (*Cucurbita pepo*), and patty pan squash (*Cucurbita pepo* var. *ovifera*). Yellow- or orange-fleshed spaghetti (*Cucurbita pepo* L., *Cucurbitaceae*), acorn (*Cucurbita pepo* ssp. *ovifera*), butternut (*Cucurbita moschata*), and Hubbard squash (*Curcubita maxima*), is carotenoid-rich and therefore a good source of vitamin A and a significant source of starch (15 g per) per ½ cup. The *Cucurbita* species are of American origin.[64] Winter squash's hard skin increases 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 shell and then baking and mashing the flesh. Prehistoric cultures could have used these species primarily as containers or for their seeds, which are edible and nutritious.[62]

Scientific Findings

Greater intake of yellow/orange vegetables was one of several dietary patterns that were associated with significantly lower breast cancer risk in a 30-year observational study (n = 182,145 women initially aged 27–59 years in the Nurses' Health Study).[65]

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 dark orange vegetables.

Safety

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

Stanols, sterols

Definition

Steroid compounds, such as sitostanol, campestanol, sitosterol, campesterol, and stigmasterol have chemical structures similar to cholesterol[66] and prevent cholesterol absorption which in turn helps to lower serum LDL cholesterol by an average of 6% and as much as 14% in four weeks.[67] 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,[67] these compounds are underconsumed. 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."[68] Vegetable-oil-based, steroid-enriched spreads, mayonnaise, yogurt, milk, orange juice, cereals, and snack bars that have been fortified with plant sterols and stanols are commercially available.[23]

Scientific Findings

Including plant sterol/stanol esters in the diet helps to lower blood total and LDL cholesterol levels.[69] A meta-analysis that included 14 studies (n = 531 patients) showed that there is no statistically or clinically significant difference between plant sterols and plant stanols in their abilities to modify serum total cholesterol.[66]

Table S.1 Phytosterol Content of Common Foods Totaling 3 g

Food, quantity	mg of phytosterol
Olive oil, 3 tablespooons	90
1 sesame bagel (containing 1 tablespoon sesame seeds)	64
Cashew nuts, dry-roasted with salt, 4 tablespoon (approx ¼ cup)	57
Snacks, vegetable chips, made from garden vegetables, 1 cup	43
Banana, 1 medium	36
Cauliflower, 1 cup	19
Total	309

Source: [82]

Bioactive Dose

The National Heart Lung and Blood Institute's National Cholesterol Education Program Therapeutic Lifestyle Changes recommends individuals with elevated LDL cholesterol consume 2 g of plant sterols/stanols per day.[70] "A reduction of up to 10% total cholesterol is observed when 2–3 g of plant stanol/sterol esters are consumed daily (Table S.1)."[30]

Safety

An intake of 2–3 g of plant sterols and stanols per day generally appears to be safe.[71] "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 β-carotene decrease after the consumption of sterols and stanols."[72] Preliminary research suggests that consuming one extra carotenoid-rich fruit or vegetable per day has been shown to maintain plasma carotenoid levels when also consuming sterol-enriched spreads.[73]

Starchy Vegetables

Definition

Vegetables that generally have a higher carbohydrate content (~15 g of carbohydrate per ½–1 cup serving) than non-starchy vegetables, such as lettuce and tomatoes (~5 g of carbohydrate per ½–1 cup serving), and therefore are considered to be equivalent to grains for diet planning purposes.[74] Parsnips, winter squash, white potatoes, sweet potatoes, yams, plantains, and legumes are starchy vegetables.

Scientific Findings

Starch is the major glycemic carbohydrate, along with sugars, in foods. Starchy vegetables increase serum glucose.[75] However, some starchy vegetables contain resistant starches that either reduce or have no effect upon glycemic load in addition to having other health benefits—*see also: Fructan*.[76]

Bioactive Dose

Not applicable.

Safety

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

Strawberry (Fragaria x ananassa)

Definition

Berry that is a source of fiber (2.3 g, 8% DV), potassium (177 mg, 5% DV) folate (28 µg, 7% DV), and an excellent source of vitamin C (68 mg, 75% DV).[77] Eaten fresh, frozen, dried, and added to juice, cereals, desserts, and baked products.

Scientific Findings

Strawberry constituents ameliorated allergy symptoms in a laboratory study.[78] "Strawberry phenolics are best known for their antioxidant and anti-inflammatory action, and possess direct and indirect antimicrobial, anti-allergy and antihypertensive properties, as well as the capacity to inhibit the activities of some physiological enzymes and receptor properties."[79] Ellagic acid, a phenolic compound in strawberries, acid reduced oxidative stress in laboratory studies.[80,81]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Allergy to strawberries has been reported.

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Tamarind (Tamarindus indica)

Tamarind. (Image from Jiang Hongyan/Shutterstock.)

Definition

Pod-shaped *Leguminosae* family fruit that is indigenous to tropical Africa[1] but is also grown commercially in Florida.[2] Tamarind is a good source of potassium (377 mg, 11% DV)[3] that contains large amounts of the phytochemical tartaric acid.[4] The beanlike fruit is made into a sweet sauce used in Asian and Indian cuisine and tamarind-flavored carbonated beverages and salad dressings.[4] Tamarind has been used in traditional African medicine as a laxative, for abdominal pain, to treat diarrhea and dysentery, to treat helminth infections, for wound healing, and to treat malaria, and for fever, constipation, inflammation, cell cytotoxicity, gonorrhea, and eye diseases.[5,6]

Scientific Findings

Tamarindus indica seeds exhibited antioxidant properties and *Tamarindus indica* extract exhibited antidiabetic properties in laboratory research.[7,8] Tartaric acid may be beneficial for digestion and bowel regulation.[9]

Bioactive Dose

Not known.

Safety

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

Tangerine (Citrus reticulata)

Definition

Citrus genus fruit that is similar, but smaller than, the navel orange. Usually eaten fresh or consumed as juice. A large (2¾-inch diameter) tangerine supplies 199 mg (6% DV) of potassium, 19 µg (5% DV) of folate, is an excellent source of vitamin C (32 mg, 35% DV), and contains an array of flavonoids (flavones, flavonols, and flavanones, such as kaempferol). Both canned tangerine (mandarin oranges) and fresh tangerines are a significant source of the antioxidant beta-cryptoxanthin, one of five carotenoids that predominate in human plasma.[10–13]

Scientific Findings

In a laboratory study, beta-cryptoxanthin exhibited antitumor effects.[14] Kaempferol and some of its glycosides have a wide range of beneficial pharmacological activities, including analgesic, antiallergic, anticancer, antidiabetic, anti-inflammatory, antimicrobial, antiosteoporotic, antioxidant, antiapoptotic, anxiolytic, cardioprotective, estrogenic/antiestrogenic, and neuroprotective.[15,16] *See also: Citrus.*

Bioactive Dose

Not known.

Safety

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

Tannin

Definition

Secondary plant metabolite classified as a proanthocyanidin.[17] Found in many foods including black-eyed peas, grapes, lentils, persimmon, black and green teas, coffee, and red and white wines.[18,19] Tannins contribute color, bitterness, and astringency, for example, of wine.[20]

Scientific Findings

In in vitro studies, tannins exhibited chemoprotective properties[18] and bound bile acids.[19] Tannins can form insoluble complexes with carbohydrates and protein; their concomitant ingestion with nonheme iron inhibits nonheme iron absorption[21,22] and can significantly impact iron status.[23] Consuming vitamin C improves nonheme iron absorption and nullifies tannins' opposite effects.

Bioactive Dose

Not known.

Safety

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

Tarragon (Artemisia dracunculus)

Definition

Culinary herb used fresh or dried in cooking. Its flavor has been described as "strong and tangy with lingering lemon, anise, and basil undertones and a sweet aftertaste."[24] Tarragon complements chicken and fish and can be used to flavor salad dressings and vegetables. It has been used in traditional folk medicine to treat pain and gastrointestinal disturbances;[25] and in Iranian folkloric medicine, tarragon has been used orally as an antiepileptic remedy.[26]

Scientific Findings

In vitro, tarragon exhibited antioxidant and antinociceptive properties[27, 25] and induced potent anticancer effects, including inhibiting esophageal squamous cell carcinoma.[28] Tarragon exhibited antiseizure and sedative effects that were attributed to its monoterpenoids content in laboratory research.[26]

Bioactive Dose

Not known.

Safety

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

Tea (Camellia sinensis)

Definition

One of the most ancient and popular beverages consumed around the world, second only to water, [29,30] that is prepared by steeping *Camellia sinensis* leaves in water. Consumed hot, iced, and sweetened or unsweetened. "After harvesting, tea leaves begin to oxidize … Black tea is produced when tea leaves are … fully oxidized. … Green tea is made from … leaves that are not oxidized. Oolong tea is made from … partially oxidized leaves, creating an intermediate kind of tea. White tea is made from young leaves or growth buds that have undergone minimal oxidation."[29] Traditionally consumed for its mild central nervous system stimulating effects, all tea contains caffeine. Per 8 oz, brewed green tea contains approximately 29 mg of caffeine[31] and black tea contains 36 mg of caffeine,[32] depending on how long the tea is steeped (stronger tea would contain more caffeine). Tea phytochemicals include alkaloids (caffeine, theophylline, and theobromine), chlorophyll, flavon-3-ols, including catechins, and trace elements, such as fluoride.[29] Green tea is particularly rich in catechins which are the substances most associated with health benefits.

Scientific Findings

Laboratory studies have shown that "tea catechins act as powerful inhibitors of cancer growth in several ways: they scavenge oxidants before cell injuries occur, reduce the incidence and size of chemically induced tumors, and inhibit the growth of tumor cells. In studies of liver, skin, and stomach cancer, chemically induced tumors were shown to decrease in size in mice that were fed green and black tea."[29] Some epidemiological studies comparing tea drinkers to non-tea drinkers support the claim that drinking tea prevents cancer; others do not. A 12-year prospective cohort study (n = 18,244 men aged 45–64 years compared with 772 control subjects) found that tea drinkers were about half as likely to develop stomach or esophageal cancer as men who drank little tea; whereas, no link was found between black tea consumption and the subsequent risk of stomach, colorectal, lung, and breast cancers in a 4.3-year prospective cohort study (n = 58,279 men, n = 62,573 women aged 55–69).[33] Though "There is insufficient and conflicting evidence to give any firm recommendations

regarding green tea consumption for cancer prevention," according to a meta-analysis of 51 studies (n=>1.6 million participants) that observed 3 to 5 cups per day (up to 1200 ml/day), providing a minimum of 250 mg/day of catechins may be a "desirable" amount.[34]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Aluminum (Al), a neurotoxic element, is found in green and black tea, because the tea plant naturally takes up Al from soil, in levels of 14 to 27 µg per liter (µg/L) to 431 to 2239 µg/L, though it is not clear how much Al is bioavailable, and there is no evidence of Al toxicity associated with drinking tea.[35]

Terpenoids

Definition

Group of phytochemicals whose main subclasses are monoterpenes (including limonene, carvone, and carveol); diterpenes (including the retinoids); triterpenes (such as saponins); tetraterpenes (e.g., carotenoids, including carotenes and xanthophylls), triterpenoids (e.g., glycosides), and steroids (including stanols, sterols, and tocopherols). Terpenoids occur in nearly every natural food,[36] 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.[37] Specific examples of foods that contain terpenoids include citrus fruits, coriander, lemongrass, caraway, peppermint, rosemary, sage, and thyme.[38]

Scientific Findings

Terpenoids exhibited antimicrobial effects in a laboratory study.[25] 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."[39]

Bioactive Dose

Not known.

Safety

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

Thiamin (vitamin B1)

Definition

Water-soluble vitamin necessary for glucose, alcohol, and branch chain amino acid metabolism; to synthesize RNA; and for neuronal activities, including to synthesize neurotransmitters, such as acetylcholine.[40–42] Thiamin is found in whole, fortified, and enriched grains, legumes, pork, and sunflower seeds;[41] breads, ready-to-eat cereals, and mixed foods whose main ingredient is grain are major thiamin contributors in the US diet.[40] The average US diet contains adequate thiamin,[40] but thiamin deficiency occurs due to insufficient ingestion (e.g., in those who consume limited food, including alcoholics, the malnourished, and the homeless); heightened requirements (e.g., in pregnancy, lactation, adolescence, postsurgery, infection, fever, and alcohol dependency); and loss (e.g., when it is excreted in high amounts as with the use of certain medications, such as loop diuretics, malabsorption, and/or persistent vomiting/hyperemesis gravidarum.[41,43,44] Thiamin deficiency is mistakenly thought to be confined to alcoholism. The inability of brain and nerve tissue to produce energy from glucose rapidly affects nervous system function and reduces neurotransmitter synthesis: early symptoms include depression and muscle weakness after only about 10 days on a thiamin-free diet.[41] Neurological deficits related to thiamin deficiency, or "dry beriberi," may include anorexia, weight loss, mental status changes, apathy, decreases in short-term memory, confusion, irritability, poor coordination, tingling in the arms and legs, peripheral neuropathy, delirium, structural and functional brain injury, and paralysis. Cardiovascular manifestations of thiamin deficiency, or "wet beriberi," may include: enlarged heart, rapid heartbeat, pedal edema, anasarca, and/or other severe cardiac abnormalities; in addition, renal failure has been reported.[40,45–49] Thiamin deficiency is prevalent in congestive heart failure (CHF) patients.[43] Thiamin deficiency is erroneously assumed to be associated only with alcoholism.[50] Wernicke encephalopathy, the neuropsychiatric syndrome characterized by mental status changes (e.g., short-term memory loss, disorientation, and confabulation [confusion between real and imagined memories]), ocular dysfunction, and gait ataxia,[50,51] and Korsakoff syndrome (also called Korsakoff psychosis or Wernicke-Korsakoff syndrome), the permanent damage to areas of the brain involved with memory, are conditions

caused by acute and chronic thiamin deficiency, respectively.[52,53] A case of Wernicke encephalopathy with symptoms of weakness, areflexia, followed by confusion, ophthalmoplegia, and nystagmus has been reported following bariatric surgery,[48] and thiamin deficiency was found to be common in post-surgical sleeve gastrectomy patients (n = 147).[54] "Thiamin deficiency should always be considered in cases with acute or subacute amnesia."[55] Several foods, such as tea, coffee, blueberries, and red cabbage, contain antithiamin factors that cannot be inactivated by cooking, whereas, antithiamin factors in raw shellfish and raw freshwater fish are destroyed by cooking.[41] Thiamin status can be assessed by in vitro erythrocyte transketolase activity assay.[40,56] Thiamin status has also been measured using erythrocyte levels of thiamin diphosphate.[57]

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.[58] Higher intake of thiamin was associated with reduced prevalence of nuclear cataract in a population-based study (n = 2,900 healthy people aged 49–97 years).[59] Compared with placebo, thiamin supplementation resulted in a significantly improved net change in left ventricular ejection fraction in CHF patients on diuretic therapy (n = 38 patients in two randomized, double-blind, placebo-controlled trials).[43] Administering glucose to thiamin-deficient patients has been associated with the development of Wernicke encephalopathy.[60]

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 regarded as non-toxic.

Thyme (Thymus vulgaris)

Definition

Culinary herb that contains phenolics, flavonoids, and terpenoids.[61] Used fresh or dried to flavor beef, chicken, fish, lamb, pork, and venison,[62] and tomato-based soups such as seafood chowder.

Scientific Findings

Phenolic compounds have exerted antioxidant, anti-inflammatory, and antimicrobial effects in laboratory studies.[63–65] Thyme exerted DNA-protective activity in a laboratory study.[66]

Bioactive Dose

Not known.

Safety

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

Tofu

Definition

White gelatin-like curd formed when soybean protein is precipitated. Its firmness is determined by the amount of liquid it contains, e.g., 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, but tofu is not a source of vitamin B12, unless it has been fortified with vitamin B12 which would be stated in the ingredients list. Tofu is used in Asian-inspired cuisine such as miso soup and as a meat substitute in stir-fries. Soybean-based foods have been common in Asian diets for thousands of years.[67]

Scientific Findings

Daily soy protein intake has a mild LDL-lowering effect,[67] especially when substituted for animal protein.[68]

Bioactive Dose

Not known.

Safety

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

Tomatillo (Physalis philadelphica)

Tomatillo. (Image from bonchan/Shutterstock.)

Definition

Miniature green tomato-like vegetable used to make salsa verde (green salsa). A medium, 34-g tomatillo contains 10 calories, 1 g of fiber (3% DV) and 4 mg vitamin C (4% DV) and is a source of phytochemicals including lutein, beta-carotene, and ixocarpalactone A.[71,72]

Scientific Findings

Ixocarpalactone A has been shown to be a cancer chemopreventive agent against human cancer cell lines in laboratory studies.[44,73]

Bioactive Dose

Not known.

Safety

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

Tomato (Lycopersicon esculentum)

Definition

Popular culinary vegetable that is botanically classified as a fruit. A source of many phytochemicals including lycopene, a carotenoid, which is concentrated in processed tomato products, e.g., the lycopene content in one cup of tomato juice (salt added) is 21,960 μg (21.9 mg) whereas there are 3,834 μg (3.8 mg) in 1 cup of fresh cherry tomatoes.[69]

Scientific Findings

Tomato consumption, specifically, tomato foods, cooked tomatoes, and sauces, but not raw tomatoes, were associated with a reduced risk of prostate cancer risk in a systematic review and meta-analysis of 30 studies that summarized data from 24,222 cases and 260,461 participants.[70]

Bioactive Dose

Not known.

Safety

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

Turmeric (Curcuma longa)

Definition

Herb member of the ginger family that is known for its golden color used to make curry powder, yellow mustard, and Indian cuisine. The whole rhizome (underground stem) is peeled and used to make healthy smoothies. Its flavor has been described as mildly aromatic with the essence of orange or ginger and a pungent, bitter flavor.[74] Traditional uses of turmeric include to aid in digestion and liver function, relieve arthritis pain, and regulate menstruation.[75]

Scientific Findings

Curcumin, a vanilloid compound in turmeric, exhibited apoptotic, anti-inflammatory, chemoprotective, antitumor, antioxidant, antiarthritic, anti-amyloid, anti-ischemic, anti-inflammatory, hepatoprotective, and bone-protective effects.[76–81]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. High doses of turmeric may cause indigestion, nausea, or diarrhea.[82]

Turnip (Brassica rapa)

Definition

White or white-and-purple *Brassica* root vegetable that varies in size and has been used as a vegetable for human consumption in Europe since prehistoric times.[83] One cup of raw turnip is low in calories (36 calories) and carbohydrate (8 g, 2% DV), and high in vitamin C (38 mg, 42% DV).[84] Its greens, commonly boiled or cooked with ingredients such as meats, onions, and garlic, are rich in phenolics and glucosinolates.[85]

Scientific Findings

See: Brassica Vegetables.

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Goitrin in turnip blocks uptake of iodine into the thyroid gland, but cooking destroys goitrin, thus negating its anti-thyroidal potency.[86]

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U

Ugli fruit (Citrus paradisi *x* reticulata)

Ugli fruit. (Image from 75857518/Shutterstock.)

Definition

Also known as unique fruit and ugli tangelo. Ugli fruit is a hybrid of a mandarin and a grapefruit1 that is native to Jamaica.[2] Larger than an orange with yellow-green, easily peeled skin, ugli fruit eaten fresh is an excellent source of vitamin C and fiber.[2]

Scientific Findings

See: Citrus.

Bioactive Dose

Not known.

Safety

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

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V

Vegetables

Definition

Under-consumed food group[1] that 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," or those not otherwise categorized (e.g., artichokes, mushrooms, wax beans, zucchini, etc.), each having different nutrient and phytochemical constituents. As a group, vegetables supply folate, beta-carotene, vitamins C, K, and E, magnesium, potassium, and fiber.[2] Different colored vegetables are characteristically rich in certain nutrients, e.g., dark green vegetables are particularly rich in folate, vitamin K, and magnesium, therefore ChooseMyPlate.gov advice to "Vary your veggies" promotes consuming an array of nutrients and phytochemicals. Each vegetable may contain more than 100 different phytochemicals.[3,4] Biologic mechanisms whereby vegetables exert healthful effects are likely to be multiple and include both nutrients and phytochemicals.[5] Fruits and vegetables, low in calories because they're high in fiber and water, promote fullness and volume. Vegetables are good substitutes for foods of high energy density. [6]

Scientific Findings

Low vegetable consumption is a factor, along with reduced fruit consumption, linked to poor health and increased risk of noncommunicable diseases.[7] 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 II diabetes; blood pressure; kidney stones; and bone loss.[8] 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.[9] Consuming a diet containing high amounts of vegetables (and fruits) is associated with fewer age-related diseases, such as Alzheimer's Disease.[10]

Bioactive Dose

The daily vegetable recommendation for general health for women (age 19–50) is 2.5 cups, and for men (age 19–50) is 3 cups.[8] Cancer-preventative recommendations for men and women are to consume 1.14 daily cup equivalents of vegetables per 1,000 calories, with at least 0.55 cup equivalents of dark green or orange vegetables or legumes per 1,000 calories. Since 2,000 calories is a typical reference amount, the approximate daily recommendation is 2 ¼–2 ½ cups with 1 cup from legumes or dark green or orange vegetables.[13]

Safety

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

Vinegar

Definition

Acidic edible liquid made from fermented carbohydrate that is used to impart sour flavoring, make condiments such as salad dressing, mustard, and ketchup, and to ferment foods, such as pickles and sauerkraut. One of its many phytochemical components is cinnamate, a polyphenolic compound (also found in beer, carrots, cereal brans, garlic, mung bean, peanuts, strawberry, raspberry, spinach, and wine).[11–13] Vinegar has a long history of use dating to Babylonia in 5000 BC[14]

Scientific Findings

In laboratory animals, coumaric acid reduced LDL cholesterol levels[15] and exhibited significant neuroprotective activity following an ischemia-reperfusion injury of the spinal cord.[16] In a 12-week, double-blind, placebo-controlled RCT trial (n = 176 obese subjects), 15 ml of vinegar reduced body weight, body fat mass, and serum triglyceride levels in the treatment group.[14]

Bioactive Dose

Not known.

Safety

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

Vitamin A

Definition

Fat-soluble vitamin necessary for vision and corneal health, growth, epithelial cell integrity, reproduction, gene expression, immune function, embryonic development, cell differentiation, to increase collagen production and improve wound healing, in addition to other functions.[17–20] Food groups that supply vitamin A are vitamin-A-fortified dairy foods, fruits, and vegetables. Preformed, active vitamin A (retinol is one of several types), is found in animal foods, including fortified milk, cereal, and margarine; fatty fish; eggs; and liver. Provitamin A carotenoids, such as beta-carotene, alpha-carotene, and beta-cryptoxanthin, are concentrated in dark green, orange, and yellow fruits and vegetables, such as spinach, apricots, squash, and carrots.[17] Provitamin A carotenoids serve as antioxidants or can be converted into vitamin A. Xerophthalmia, referring to the ocular abnormalities resulting from A deficiency, has been known for 3,500 years and was treated in ancient Assyria, Egypt, and Greece with foods now known to be rich in preformed vitamin A.[21] The median intake of vitamin A in the US is lower than the RDA for vitamin A for individual men and women, but are considered to be adequate for population groups.[17] 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; impaired digestion and absorption; growth retardation; increased risk of death due to infectious disease; and death.[21–23] Vitamin A deficiency can occur due to abnormal storage and transport of vitamin A in people with abetalipoproteinemia, protein or zinc deficiency, diabetes mellitus, hyperthyroidism, fever, liver disease, cystic fibrosis, malabsorption, and due to other conditions that limit intake, absorption, or utilization of vitamin A.[20,24]

Risk Groups for Deficiency and Excess Risk of Vitamin A Deficiency
• Preterm infants, who have low stores as a result of interrupted accretion during gestation • Infants and children, particularly those whose mothers are vitamin A deficient during lactation • People with malabsorption conditions including biliary atresia and cystic fibrosis • People living in food-insecure environments without access to fortified foods • Individuals suffering from alcoholism
Risk of vitamin A Excess
• People with access to multiple fortified foods or who consume liver on a regular basis • Chronic preformed vitamin A supplement users

Source: [21]

The most commonly used biomarker to assess vitamin A status is plasma retinol concentration; but because plasma levels do not decline

until vitamin A levels in the liver are almost depleted, plasma retinol cannot detect marginal vitamin A status. Plasma retinol is also affected by recent dietary intake and is suppressed by infection and inflammation.[17,21,24,25] Liver vitamin A concentration is considered the gold standard for measuring vitamin A status,[21] while retinol isotope dilution, is less invasive and an indirect method to evaluate liver vitamin A concentration.[25,26] Excessive preformed vitamin A (but not beta-carotene) intake can lead to hypercalcemia and may negatively impact bone mineral density (BMD).[17,27]

Scientific Findings

Vitamin A deficiency contributes to iron deficiency anemia.[23] Sweet potatoes are used to prevent vitamin A deficiency disease and blindness in regions of endemic vitamin A deficiency.[19,28] Adequate serum concentrations of retinol and beta-carotene minimized the side effects of radiation in breast cancer patients in an observational study (n = 230 patients mean age 63.6 years).[20,29] Concentrations of uric acid were significantly and positively associated with concentrations of vitamin A (an undesirable effect), and inversely (a desirable effect) with concentrations of beta-carotene in a nationally representative sample of US adults (n = 10,893 participants aged ≥ 20 years) in The National Health and Nutrition Examination Survey.[30]

Bioactive Dose

The RDA for adult men aged 19–50 is 900 µg/day Retinol Activity Equivalents (RAE)[31] (3000 IU)[32] and for adult, non-pregnant women aged 19–50: 700 µg/day RAE[33] (2333 IU).[34]

Safety

The vitamin A UL is 3,000 µg (10,000 IU).[35,36] Exceeding the UL during pregnancy, with preformed vitamin A sources (natural preformed vitamin A foods, A-fortified cereals, and dietary supplements), is associated with teratogenicity including orofacial malformation.[37] Tissue levels take a long time to fall after high doses, and the resulting liver damage may or may not be reversible after discontinuing vitamin A.[17,24] Either short-term, massive intakes or chronic high intakes of vitamin A can cause hypervitaminosis A characterized by increased intracranial/cerebral spinal fluid pressure; headache; dizziness; nausea; bone demineralization; alopecia; skin irritation/skin rashes and desquamation; pain in joints and bones; liver damage/hepatomegaly, anemia, coma, and death.[21,24]

Vitamin B1 see: Thiamin
Vitamin B2 see: Riboflavin
Vitamin B3 see: Niacin

Vitamin B6

Definition

Related forms: pyridoxine, pyridoxal, pyridoxamine, and each form paired with phosphate, e.g., pyridoxal phosphate.[38] Water-soluble vitamin required for protein, carbohydrate, and lipid metabolism; tryptophan conversion to niacin; erythrocyte metabolism and function; nervous system function and neurotransmitter synthesis; homocysteine degradation; immune function; cognitive function; and other roles.[39–41] Vitamin B6 (B6) sources include fortified, ready-to-eat cereals; all members of the protein foods group (meat, poultry, seafood, egg, legumes or tofu, nuts, seeds, and soy products); white potatoes and starchy vegetables; and non-citrus fruits, including bananas and watermelon.[2,42] Median B6 dietary intake in the US has been estimated to be higher than the B6 RDA.[43] Deficiency of B6 (and other B vitamins including folate and B12), caused by inadequate intake, decreased absorption, or increased requirement, is associated with hyperhomocysteinemia (*see also: Folate*). B6 status is measured by using plasma pyridoxal phosphate; values of > 20–30 nmol/L have been suggested as the lower end of normal status.[44,45] Symptoms of deficiency include depression, confusion, stomatitis, cheilosis, glossitis, irritability, seborrheic dermatitis, convulsions, poor growth, decreased immune function, hypochromic microcytic anemia, convulsions, and electroencephalogram abnormalities.[40,46]

Scientific Findings

"Elevated homocysteine level is an independent predictor for all-cause mortality and it compromises [the] health of all organ systems."[47] In the Taiwan Elderly Nutrition and Health Survey (n = 1094 males and 1135 females aged 65–90 years), B6 status was significantly lower in males with hyperhomocysteinemia, though the same was not true for females.[45] B6 can raise serotonin levels in serotonin deficiency.[48] Low B6 status was associated with increased pro-inflammatory markers.[49] A meta-analysis of 32 published trials (n = 8,401 cases and 11,009 controls) found that decreased blood B6 levels increased the risk of colorectal cancer.[47] In three cases of seizures refractory to conventional antiepileptic medications, seizures persisted despite escalation of conventional antiepileptic medications but resolved within 2 days of pyridoxine supplementation and corrected low serum pyridoxal 5'-phosphate concentrations; researchers concluded that

refractory seizures caused by vitamin B6 deficiency, although rare, should be considered in critically ill adult patients with refractory seizures.[50]

Bioactive Dose

The RDA is 1.3 mg/day for men and non-pregnant women aged 19–50.

Safety

The Tolerable Upper Intake Level (UL) for adults is 100 mg of B6. Usually, dietary supplement use is associated with toxicity; no adverse effects have been associated with high intakes of food B6.[51] Doses exceeding the UL might result in peripheral neuropathy.[52]

Vitamin B12

Definition

Also called cobalamin and cyanocobalamin. Water-soluble vitamin necessary for folate metabolism, DNA synthesis, red blood cell formation, to convert homocysteine to methionine, to synthesize the myelin sheath of nerves, for fatty acid metabolism, and other numerous additional functions.[53,54] Vitamin B12 (B12) is found in all animal foods, including meat, poultry, fish and shellfish, eggs, and dairy products, but is not found naturally in plant foods. Nori (seaweed) contains nominal amounts of natural B12. Generally, "nothing that grows out of the ground contains [B12]."[55] Soymilk, certain ready-to-eat cereals, and vegetarian meat substitutes may be fortified with crystalline B12, which is also used in dietary supplements. Crystalline B12 is more bioavailable than natural food B12.[56] The amount of B12 in the average Western diet (5–15 μg/d) is more than sufficient to meet the RDA of 2 μg/d.[57] Separation of B12 from food protein and from secreted proteins involve pepsin, gastric acid, and pancreatic proteases. Free, unbound B12 attaches to intrinsic factor forming an intrinsic factor-B12 complex that is absorbed in the small intestine. A small amount of B12 not bound to IF is absorbed by passive diffusion.[55] The liver stores 3–5 mg, of which 50% is in the liver.[40] It can take years to use body stores and B12 deficiency can take months to years to become symptomatic;[20,55] however, B12 stores become significantly depleted by a persistent vegetarian diet.[58] B12 deficiency may readily develop in elderly vegetarians.[58] Cobalamin deficiency is common worldwide.[59] No single parameter can be used to diagnose cobalamin deficiency.[59] Diagnosis of B12 deficiency requires a complete blood count and measurement of serum B12, but measurement of serum homocysteine and methylmalonic acid (MMA) should be used

to confirm deficiency in asymptomatic high-risk patients with low-normal levels of B12.[56] Serum B12 is neither sensitive nor is it specific for B12 deficiency.[59] For example, a study of patients with myeloproliferative disorders (n = 58) found a high prevalence of B_{12} deficiency, despite high serum vitamin B_{12} levels.[60] "Numerous studies have now established that serum B12 has limited diagnostic value as a stand-alone marker."[61] Serum homocysteine and MMA are metabolites that arise from B12 insufficiency, and they are more sensitive indicators of B12 deficiency than the serum B12 value.[62] High homocysteine and high MMA are associated with low levels of serum B12. Serum holotranscobalamin (the metabolically active vitamin B12 fraction) has been proposed as a better marker for assessing initial B12 status, to replace serum B12, and to accompany serum MMA and serum homocysteine levels.[59] Serum holotranscobalamin is an earlier marker that decreases before total serum B12 declines.[59] B12 deficiency is characterized by megaloblastic anemia; low or low-normal serum B12 (normal = 170–250 pg/mL[63]), elevated homocysteine, elevated MMA, and low serum holotranscobalamin. Symptoms of B12 deficiency include neurological complications such as sensory disturbances especially in the lower extremities including paresthesias such as tingling and numbness, loss of sensation, loss of strength in limbs, ataxia, slowed or increased reflexes, and vibration and position sensitivity; as well as neuropsychiatric symptoms, such as irritability, memory loss, and dementia.[56,64–66] Neurological signs of B12 deficiency can occur in patients with normal hematocrit and red cell indices.[64] Patients with B12 deficiency may not exhibit all symptoms because B12 deficiency symptoms span a continuum.[56] 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;[54] B12 malabsorption is common in elderly subjects.[59] Approximately 10–30% of people over age 50 do not absorb food-bound B12 efficiently.[67] Low serum B12 concentrations are found in more than 10% of older adults.[68] The average age of onset of B12 deficiency in the elderly has been estimated to be between 60 and 70 years.[64] Other groups at risk for B12 deficiency include: vegans and people with low intake of animal foods; those who: lack intrinsic factor (including those with autoimmune atrophic gastritis, pernicious anemia, and gastrectomy); have bacterial overgrowth of the small intestine; are infected with the B-12-consuming parasite *Diphyllobothrium latum;* have disease of or who have had resection of the terminal ileum; have pancreatic disease or insufficiency; in addition to: patients with Crohn's Disease, celiac disease, thyrotoxicosis, hemolytic anemia, hemorrhage, malignancy, hepatic disease, renal disease, myeloproliferative disorders, and/or who use drugs that suppress gastric acid production or otherwise interfere with B12 absorption or metabolism, such as cholestyramine or metformin, among other medications.[20,56,60,64,69–71]

Scientific Findings

B_{12} deficiency may go undetected in vegetarians because their diets are rich in folate, which can mask the diagnosis of B_{12} deficiency (the hematological effects of B12 deficiency are indistinguishable from those of folate deficiency).[58] For individuals who are at risk of B12 deficiency, B12-fortified food and/or dietary supplements should be used, rather than relying solely on food sources of B12.[56] Plasma homocysteine rises in deficiency of B12 (as well as in deficiency of folate and B6—*see also Folate* and *Vitamin B6*).[40] B12 supplementation has not been shown to improve cardiovascular outcomes, cognitive decline, or hyperhomocysteinemia in people with low serum B12 levels and dementia.[56,72] High serum homocysteine is a risk factor for fractures, the pathophysiology of which is unclear but may involve bone mineral density (BMD), bone turnover, bone blood flow, DNA methylation, and/or physical function and fall risk.[73]

Bioactive Dose

The RDA is 2.4 μg/day for men and non-pregnant women aged 19–50. According to one nutrition authority, "further research may be required to determine appropriate levels of oral B12 supplementation for deficient older adults,"[74] however, others have found that an oral dose of 1–2 mg daily has been used to correct deficiency and "is as effective as intramuscular administration for correcting deficiency, regardless of etiology."[56] Intramuscular injection may be more appropriate in severe cases of deficiency with neurological involvement or in patients with diarrhea or vomiting or nonadherence to taking medications orally.[20]

Safety

No UL has been established for B12. "No adverse effects have been associated with excess B12 intake from food or supplements in healthy individuals."[75]

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 various components of immune response, collagen metabolism, and synthesis of amino acids, collagen, carnitine, cholesterol, hormones, and neurotransmitters[76–78] Vitamin C (C) increases the intestinal absorption

of nonheme iron[79] either by changing iron's ionic state in its capacity as an electron donor,[77] or by forming a soluble complex with iron in the alkaline pH of the small intestine.[80] The C deficiency disease scurvy caused illness and death through the end of the 18th century when its cause and treatment were established.[81] Scurvy afflicts those with low socioeconomic status, alcoholism, severe psychiatric illness leading to poor nutrition, and critical illness.[81] Impaired wound healing, petechiae, bleeding gums, and loose teeth occur due to the inability of the body to make collagen; other manifestations of scurvy include synovitis with effusion, anemia, markedly elevated erythrocyte sedimentation rate and C-reactive protein levels, pulmonary hypertension, purpuric rash, and hemarthrosis.[82] The fruit and vegetable groups supply C. Approximately 30% of Americans failed to consume adequate C from foods in a nationally representative survey comparing intake to Estimated Average Requirement.[83]

Scientific Findings

Plasma ascorbic acid concentration was inversely related to mortality from all causes in men and women, including cardiovascular disease and ischemic heart disease, and to cancer mortality in men, but not women, in a prospective observational study (n = 19,496 subjects aged 45–79 years). The study concluded that eating the equivalent of 50 g (one typical serving) of fruit or vegetables daily increased plasma ascorbate levels to cancer-protective levels.[20,84] Intake of dietary C and several food groups high in C content were inversely related to hypertension, whereas supplemental C was not in the CARDIA prospective cohort study (n = 2,884 black and white adults) in which dietary quality, plasma ascorbate levels, and cases of hypertension were measured over a 25-year period.[85] A 14.2-year observational study that evaluated all-cause, cancer and cardiovascular mortality risks and serum antioxidant levels (n = 16,008 adult in the Third National Health and Nutrition Examination survey, 1988–1994) found that a dose-response decrease in cancer and overall mortality risk was associated with higher C levels.[86]

Bioactive Dose

The RDA is 75 mg for nonsmoking women and 90 mg for nonsmoking men age 19–50. The requirement for smokers is increased by 35 mg/day.

Safety

The UL is 2,000 mg for adults aged 19–50. With large doses, unabsorbed ascorbate is degraded in the intestine, a process that may account for

diarrhea and intestinal discomfort.[87] In doses of 500 mg or more, such as in dietary supplements, C has exhibited pro-oxidant properties in vitro.[88]

Vitamin D

Definition

Vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol) are the two major, naturally occurring types of vitamin D (D), a fat-soluble vitamin and hormone. D2 is found in mushrooms and is used to make dietary supplements.[89,90] D3 is found in egg yolks; heavy cream; American cheese; meats including beef, turkey, and pork; fatty fish; and D-fortified milk-soymilk-rice milk-almond milk-coconut milk/margarine/orange juice/ready-to-eat breakfast cereals/and nutrition drinks and bars; it is also used in dietary supplements. Dairy products other than milk generally are not fortified with D: it should not be assumed that yogurt, cheese, ice cream, and other dairy foods are sources of D unless the ingredient list lists specifically includes "vitamin D." D is classified as a nonessential nutrient because it can be synthesized by the exposure of skin to the sun. Precursor D3 in the skin is converted into D3 by skin exposure to UVB radiation. Both D2 and D3 require hydroxylation by the kidney and liver to be converted into 1,25-dihydroxyvitamin D, also called calcitriol, the active D metabolite that performs skeletal and nonskeletal roles.[90,91] Total serum 25-hydroxyvitamin D, the major circulating form of D derived from dietary intake and sunlight exposure, is used to measure D adequacy. Though there is lack of agreement on "optimal" total serum 25-hydroxyvitamin D level, 25–80 ng/mL is a target range in use in clinical practice.[90] Hypovitaminosis D has been described as total serum 25-hydroxyvitamin D < 25 ng/mL, normal calcium and phosphorus blood levels, elevated or high-normal levels of parathyroid hormone (PTH), normal to elevated levels of alkaline phosphatase, and a low 24-hour urine calcium excretion rate, in addition to symptoms of bone pain, myalgias, and generalized weakness.[90] Likewise, deficiency cut-off points are controversial. The Endocrine Society defines D deficiency as total serum 25-hydroxyvitamin D < 20 ng/mL and insufficiency as levels of 21–29 ng/mL.[92] D deficiency causes rickets in children, and osteomalacia in adults that induces secondary hyperparathyroidism with consequent bone loss and osteoporosis.[93] Common risk factors for D deficiency include decreased intake, malabsorption, hepatic or renal disease, use of certain medications that suppress D absorption or cause its malabsorption, obesity, and decreased skin synthesis of D caused by older age, lack of skin-UVB exposure (due to indoor occupation, season, latitude, veiling, or use of sunscreens), or skin pigmentation.[93] Non-Hispanic blacks have the highest prevalence of low total serum 25-hydroxyvitamin D concentrations.[93] Older adults, people with dark skin, and people exposed to

insufficient UVB radiation should consume extra D from D-fortified foods or supplements, according to several leading health authorities.[93] D regulates bone mineral density (BMD) by promoting intestinal calcium and phosphorus absorption, regulating bone metabolism, and prompting PTH to mobilize bone calcium into the blood when dietary calcium intake is inadequate. Every tissue and cell has a D receptor. D's nonskeletal functions include regulating arterial blood pressure and insulin production, modulating immunological responses and reproductive processes, and enabling normal neuromuscular function.[94,95]

Scientific Findings

Optimal D levels maintain skeletal health and could reduce the risk of chronic diseases, such as colon cancer, autoimmune diseases, infectious diseases, Type II diabetes mellitus, cardiovascular disorders such as atherothrombosis, neurocognitive disorders, and mortality, according to a meta-analysis of 1980–2015 studies.[96] A separate summary evaluating the association between vitamin D status and health outcomes found a decreased risk for colorectal cancer with higher total serum 25-hydroxyvitamin D levels; in white populations a low D status correlated with an increased risk for fractures and cardiovascular disease, and, in institutionalized populations, an increased risk for falls. Studies have generally suggested an increased risk of functional limitations, diabetes, and depression with lower serum total 25-hydroxyvitamin D levels.[92] The American College of Obstetricians and Gynecologists, the American Geriatric Society, and the National Osteoporosis Foundation recommend D testing as part of osteoporosis management and falls prevention.[92]

Bioactive Dose

The RDA for adults aged 19–50 is 600 IU (15 μg).[97] Some experts say that optimal amounts for all adults are closer to 800–1000 IU.[93] Eight oz of D-fortified milk, perhaps the food most likely to be consumed routinely, supplies approximately 120 IU of D, therefore, five 8-oz glasses would be required to meet the goal amount (though soymilk and almond milk supply higher amounts of D than cow's milk—*see also: Soybean and Almond*). The RDA was formulated assuming no D contribution from sun exposure and was based on D levels consistent with maintaining BMD (extraskeletal roles of D were not taken into account).[98] Severe hypovitaminosis D (total serum 25-hydroxyvitamin D < 10 ng/mL) has been treated with 50,000 IU of D orally once weekly for 2–3 months or 3 times weekly for one month, though the practice has not been validated in clinical trials.[90]

Safety

A UL of 2,000 IU (50 µg) has been established for adults aged 19–50. Some scientists are calling for an upward revision.[93] Doses below 10,000 IU/day are not usually associated with toxicity, whereas doses equal to or above 50,000 IU/day for several weeks or months are frequently associated with toxic side effects including hypercalcemia.[99]

Vitamin E

Definition

Fat-soluble antioxidant in the vitamin family of which there are more than eight naturally occurring tocopherol and tocotrienol types;[100] technically "vitamin E" should be called "the vitamin E's." Gamma-tocopherol is the predominant form in foods.[100,101] Alpha-tocopherol is the most extensively studied form; most dietary supplements contain synthetic alpha-tocopherol (d-l-alpha-tocopherol), but dietary supplements may also contain natural E (d-alpha-tocopherol).[101] One oz of roasted pumpkin seeds is an excellent source of vitamin E (3.72 mg, 25% DV) primarily from gamma-tocopherol, with a small amount as alpha-tocopherol, and a minute quantity of delta-tocopherol.[102] Certain vegetables and all vegetable oils are sources of vitamin E. Since E is destroyed by heat, French fries contain only a fraction of the E originally in the oil (Table V.1).

Nuts, seeds, whole grains, and certain fruits, e.g., avocado, are reliable sources of E. LDL oxidation and plaque formation are precursors for atherosclerosis. In addition to its major antioxidant role, E is necessary for immune function, cell signaling, regulation of gene expression, inhibition of platelet aggregation, and metabolic processes.[77] E may be lacking in the American diet according to several surveys, or E intake may have been underestimated in these surveys due to underreporting or not accounting for fat added in cooking; if so, E intake among healthy adults may exceed the RDA.[77] Consuming salad and salad dressing promoted adequate E intake in a large, nationally representative survey (n = 9,466 women and 8,282 men).[77] E deficiency is rare. When it occurs, it is characterized by neurological abnormalities (e.g., poor transmission of nerve impulses, muscle weakness, nerve damage, inability to walk, and retinal degeneration that leads to blindness).[77] Fat malabsorption disorders (e.g., hepatobiliary disorders, cystic fibrosis, celiac disease) and protein-energy malnutrition can cause E deficiency.[77] Deficiency due to dietary inadequacy in healthy persons has not been reported.[77] "Although low serum or plasma E concentrations indicate E deficiency, measurement of plasma levels are insufficient for patients with various forms of lipid malabsorption. Calculation of effective plasma E concentrations needs to take into account plasma lipid levels. Patients with elevated cholesterol or

Table V.1 Vitamin E in Common Foods

Canola oil 2 tablespoons	4.89 mg vitamin E 33% DV
French fries, 1 kid's meal serving (71 g)	1.42 mg vitamin E 9% DV
Mayonnaise 4 tablespoons	0.90 mg vitamin E 6% DV
Quinoa, cooked, ½ cup	0.585 mg vitamin E, 4% DV
Peas and carrots, cooked from frozen ½ cup	0.42 mg vitamin E, 3% DV

Source: [116]

triglyceride concentrations may have E levels in the 'normal' range, but these may not suffice to protect tissues."[40]

Scientific Findings

Gamma-tocopherol inhibits cyclooxygenase activity and possesses anti-inflammatory properties.[101] Alpha-tocopherol has been referred to as "the most important lipophilic radical-chain-breaking antioxidant in living tissues."[103] In general, clinical trials have not provided evidence that routine use of E supplements prevents cardiovascular disease or reduces its morbidity and mortality; however, extensive evidence has demonstrated that dietary E has cardiovascular disease preventative effects.[104] Evidence that free radicals may contribute to the pathological processes of cognitive impairment including Alzheimer's Disease (AD) has led to interest in the use of E in AD treatment; however, a meta-analysis of three clinical trials (n = 769 subjects with mild cognitive impairment) found no convincing evidence that E supplements are of benefit in the treatment of AD.[105]

Bioactive Dose

The RDA is 15 mg/day for adults aged 19–50. This is equivalent to approximately 22 IU of natural E (d-alpha-tocopherol).[106]

Safety

A UL of 1000 mg for adults aged 19–50. This is equivalent to approximately 1490 IU of natural E (d-alpha-tocopherol) or 1100 IU of synthetic (d-l-alpha-tocopherol, such as is in dietary supplements).[106] Research has not found any adverse effects from consuming food E.[77]

Vitamin K

Definition

Also called phylloquinone and menaquinone. Fat-soluble vitamin that functions as a coenzyme in the synthesis of proteins involved in blood coagulation and bone metabolism.[107] The vitamin is named for the Danish word

"koagulation." It occurs in several forms. Phylloquinone (vitamin K1) is the major dietary source and plant-based form of vitamin K that is concentrated in dark green, chlorophyll-rich leafy vegetables, such as collards and spinach, and certain plant oils including soybean, canola, cottonseed, and olive, and products made from them, such as margarine and salad dressings.[108] Phytonadione is a synthetic form of vitamin K1. About 50% of the daily requirement of vitamin K2 (menaquinones such as MK-4 and MK-7) is synthesized in the gut from bacteria;[109] menaquinones are also derived from the conversion of dietary phylloquinones,[108] and are found in milk, butter, cheese, and natto, a fermented soybean food. Vitamin K intake from food in the US has been estimated to be less than the AI[110] without taking menaquinones' contribution to the diet into account. Food composition databases are limited for menaquinones[108] (although many foods contain additional K as menaquinones). Prothrombin time (PT), a measure of the time it takes for blood to clot, and International Normalized Ratio (INR), a calculation of blood clotting time based on PT, are measured simultaneously[111] to assess plasma procoagulant potential. Vitamin K deficiency increases PT,[112] but PT is not a sensitive indicator of vitamin K status and PT does not respond to a change in dietary vitamin K in healthy subjects.[113]

Scientific Findings

Epidemiological studies suggest that a lack of vitamin K is associated with low bone mineral density (BMD) in women of all ages, and has been associated with osteoporosis, bone fractures, and vascular calcification.[114] In Japan and other parts of Asia, foods rich in menaquinone are used to prevent and treat osteoporosis.

Bioactive Dose

The AI is 120 μg for men and 90 μg for women aged 19–50. Infants routinely receive 0.5–1 mg of phylloquinone intramuscularly or 2.0 mg orally within 6 hours of birth.[115]

Safety

No UL has been established for vitamin K.

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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, and phytosterols, flavonoids (including proanthocyanidins), phytates, and lignans.[1]

Scientific Findings

A comprehensive systematic review and meta-analysis of 20 randomized parallel trials and six crossover-design studies (n = 1,059) found that including walnuts in the diet improved total, LDL, and HDL cholesterol and triglycerides without adversely affecting body weight or blood pressure. Apolipoprotein-B was also reduced significantly more on walnut-enriched diets compared with control groups.[2] These findings concurred with a previous nut analysis where in 25 human trials the mean daily consumption of 67 g of nuts was associated with improved total cholesterol, LDL cholesterol, LDL–HDL ratio, and total cholesterol–HDL ratio in normolipemic and hypercholesterolemic subjects; and an analysis of 61 clinical trials that found walnut consumption was associated with significant reductions in total and LDL cholesterol and apolipoproteins A and B.[2] The effective studied dose of 67 g is approximately equivalent to ½–¾ of a cup or 2.33 oz.

Bioactive Dose

The FDA Qualified Claim for walnuts reads: "Supportive but inconclusive research shows that eating 1.5 oz per day of walnuts, as part of a low-saturated fat and low cholesterol diet and not resulting in increased caloric intake, may reduce the risk of coronary heart disease."[3]

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals. Allergic and fatal anaphylactic reactions to walnuts have been reported.[4]

Wasabi (Wasabia japonica)

Wasabi. (Image from matin/Shutterstock.)

Definition

Also known as Japanese radish. Pine-cone-shaped *Brassica* vegetable that contains isothiocyanates.[5] It is ground into a pungent sushi condiment, used to coat peas and peanuts that are then dry-roasted and eaten as a spicy snack, and to make wasabi sauce (wasabi mayonnaise).

Scientific Findings

In laboratory studies, *Wasabia japonica* killed *H. pylori*,[6] exhibited detoxification, anti-inflammation, and cancer cell apoptosis, including colon cancer cells.[7,8]

Bioactive Dose

Not known.

Safety

Presumed safe when consumed in normal dietary quantities by nonallergic individuals, except for the adverse effects of extreme burning sensations.

Water

Definition

Major component of body fluids whose functions include blood volume and pressure maintenance, body temperature regulation, transport of nutrients, oxygen, waste products, and other substances, chemical reactant, component of secretions, and other roles vital to life and well-being. Water is an essential nutrient that is perhaps the most vital nutrient needed to sustain life. Water is derived not only from drinking water itself but from all nonalcoholic beverages as well as water (moisture) in foods; also, some water is generated during energy metabolism. Collecting urine for 24 hours to measure the volume of urine produced is a proxy of water intake.[9] "Eight 8-oz glasses of water daily," the quantity of water a person ingesting 2,000 calories daily would require is approximately equal to 2,000 mL, or 2 L/day. On a 2-L/day water intake, a normal 24-hour urine volume collection is 800–2,000 mL/day.[10] Hydration is commonly assessed using plasma or serum osmolality[8] that measures the concentration of chemical particles found in the fluid part of blood (and normal values range from 275–295 milliosmoles per kg).[11]

Scientific Findings

Hard water is a source of magnesium and calcium, which are associated with maintenance of normal blood pressure, while soft water is higher in sodium and can aggravate high blood pressure and heart disease.[12,13] Effects of dehydration include metabolic and functional abnormalities ranging from mild dehydration manifesting as nausea and lack of energy to severe dehydration characterized by dark-colored, low-volume urine output, inability to maintain normal body temperature, rapid heart rate, and possible seizure or death. Low water intake is associated with a number of chronic diseases as well.[8]

Bioactive Dose

The AI for total water is 2.7 L/day for non-pregnant, non-lactating women and 3.7 L/day for men aged 19–50, which is met by drinking water and nonalcoholic beverages and eating fruits, vegetables, and other foods;[8] however, water needs are highly variable based on size, body composition,

physical activity level, climate, and other factors,[14] and therefore water intake exceeding the AI is required for individuals including athletes.

Safety

Though 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,[15] and is a source of lutein and carotenes.[16] Watercress has been traditionally used as an antioxidant, anti-inflammatory, hypolipidemic, and cardioprotective agent.[15]

Scientific Findings

In an experimental study in animals, watercress juice protected cells and did not damage DNA.[17] In a single-blind, randomized, crossover study (n = 30 smokers and 30 nonsmoking men and women, mean age 33 years),

consuming 85 g raw watercress daily for 8 weeks in addition usual diet resulted in beneficial reductions in markers of DNA damage, while plasma lutein and beta-carotene increased significantly, with beneficial changes being more significant in smokers than in nonsmokers after watercress supplementation.[15]

Bioactive Dose

Not known.

Safety

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

Watermelon (Citrullus lanatus)

Definition

Member of the cucumber and squash family that includes fruits of different sizes, shapes, rind patterns, and flesh colors.[18] Watermelon contains a relatively high sugar content, consisting of sucrose, fructose, and glucose,[19] and is rich in lycopene.[20] 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.[21]

Bioactive Dose

Not known.

Safety

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

Wheat germ

Definition

Wheat grain embryo that contains high concentrations of unsaturated fats, protein, fiber (3.2 g, 11%), and vitamin E (0.147 mg, 1% DV) per 2 tablespoons. 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.[22]

Bioactive Dose

Not known.

Safety

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

Wheatgrass (Triticum aestivum)

Definition

Sprouted leaves of wheat that can be homegrown from wheatgrass seed (also called wheatberry) and eaten when the plant is around one or two weeks old.[23] A 1-oz wheatgrass shot is a source of vitamin C (1 mg, 1% DV), vitamin A (94 IU, 3% DV), and phytochemicals such as chlorophyll and flavonoids.[24,25] Young, newly sprouted seedlings have greater health properties, such as the content of phenolics and flavonoids, compared to older plants.[26]

Scientific Findings

Wheatgrass contains the superoxide dismutase which converts potentially harmful free radical reactive oxygen species into hydrogen peroxides (having extra oxygen molecule to kill cancer cells) and an oxygen molecule.[27] Wheatgrass showed anticancer potential including superoxide scavenging and antioxidative properties in in vitro and animal studies.[24,25] Chlorophyll was shown to inhibit metabolic activation of carcinogens in laboratory research.[24,28]

Bioactive Dose

Not known.

Safety

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

Whey

Definition

Complete protein found in the watery portion of milk. Milk protein is primarily casein (80%) and partly whey (20%).[29] Whey is filtered out of milk to make cheese. Greek-style yogurt has most whey (and water) strained out, whereas thin-style (non-Greek) yogurt contains whey. Whey is a significant source of lactose and a good source of calcium,[30] and whey protein is particularly rich in substrates that make the antioxidant glutathione.[31]

Scientific Findings

Whey protein exerted chemoprotective effects and was more effective at reducing body weight gain and increasing insulin sensitivity than red meat in laboratory research.[31,32] In healthy Type II diabetes subjects, whey protein exerted insulinotropic and glucose-lowering properties, theoretically because whey protein breakdown products stimulate gut hormones that regulate food intake or potentiate insulin secretion.[29] Whey protein exerted anti-HIV effects in laboratory research; however, in a meta-analysis of various treatments used in HIV-infected children and adults, whey protein concentrate did not significantly alter clinical, anthropometric or immunological outcomes compared with placebo.[33,34.]

Bioactive Dose

Not known.

Safety

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

Wine

Definition

Alcoholic product of fermented grape that has been part of human culture for 6,000 years.[35] Wine may be classified as red, white, and rosé based on sweetness, alcohol content, carbon dioxide content, color, grape variety, fermentation, and maturation process or geographic origin.[36] Phytochemicals in wine include phenolics, such as resveratrol, quercetin, and catechins, and proanthocyanidins.[36,37] In Europe, proanthocyanidins are used mainly for the treatment of vascular disorders such as venous insufficiency, varicose veins, and microvascular problems including capillary fragility and retinopathies;[37] in Chinese and Japanese traditional medicine, resveratrol, in the form of plant extracts, have been used to treat inflammation, headaches, cancers, and amenorrhea.[38]

Scientific Findings

Resveratrol, a stilbene, exerts antioxidant, anti-inflammatory, cardioprotective, and neuroprotective activities in laboratory studies and possess anticancer properties in various preclinical animal models.[38,39] Proanthycyanidins have shown antibacterial, antiviral, anti-inflammatory, antiallergic, and vasodilatory properties in laboratory studies, inhibited lipid peroxidation, platelet aggregation, capillary permeability and fragility, and thrombosis due to inhibition of cyclooxygenase and lipoxygenase of platelets and macrophages; and enhanced capillary strength, vascular function, and peripheral circulation.[37] Catechin, quercetin, and resveratrol performed vasculoprotective functions including promoting nitric oxide production by vascular endothelium.[35,40] Moderate wine drinking did not increase serum uric acid level, a precursor to gout, in a cross-sectional study of National Health and Nutritional Examination Survey (NHANES) participants (n = 14,809 men [6,932] and women [7,877] aged > 20 years of age).[41] Moderate red wine consumption—in females 200 ml of red wine (25.5 g alcohol) daily and in males 300 ml of red wine (38.3 g alcohol) daily—for 4 weeks was associated with desirable changes in HDL and fibrinogen, including a significant, 11–16% increase in fasting HDL, compared with drinking water with or without red grape extract in an intervention trial (n = 69 males and females aged 38–74 years).[42] A meta-analysis of 17 case-control and cohort studies (n = 611,169 men) found that moderate wine consumption did not impact the risk of prostate cancer (and moderate consumption of white wine increased the risk of prostate cancer, while moderate consumption of red wine had a protective effect).[43]

Bioactive Dose

International guidelines suggest light-to-moderate alcoholic beverage consumption of 15–30 g/day of ethanol, about 130–250 mL, or 4.5–8.25 oz, of wine daily for cardiovascular risk reduction.[36]

Safety

Presumed safe when consumed by nonallergic individuals excluding those who cannot safely consume alcohol (*see also: Ethanol*). Many consumers believe that sulfites in red wine cause headache, although people who are allergic to sulfur often develop asthmatic reaction instead of headache.[44] Daily intake of more than moderate amounts of alcoholic beverages is a clear risk factor for the development of hypertension, therefore, patients who are hypertensive should avoid alcoholic beverages.[45] *See also: Ethanol*.

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X

Xeaxanthin

Definition

Also spelled zeaxanthin. Xanthophyll carotenoid that occurs commonly with lutein in foods. Rich sources include egg yolk, dark green leafy vegetables, orange bell pepper, kiwi fruit, grapes, spinach, zucchini, corn, and squash.[1,2]

Scientific Findings

The macular region of the retina is yellow due to the presence of a macular pigment, consisting largely of lutein and xeaxanthin. The amount of macular pigment correlates with dietary intake of lutein and xeaxanthin and other factors,[3] and may be protective against age-related macular degeneration according to epidemiological evidence. Laboratory data suggest inverse correlations between plasma xanthophyll carotenoids and oxidative damage in DNA and lipids.[4]

Bioactive Dose

Not known.

Safety

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

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Y

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, pink, or purple, with skin that is off-white to dark brown.[1] Yam differs from the darker orange sweet potato, *Ipomoea batatas*, a member of a different botanical family. Approximately 150 different species of yam are commercially cultivated, and white yam (*D. rotundata*) is the most predominant yam species produced worldwide.[2] In traditional folk medicine, yams have been used to treat menopausal symptoms. Although yam contains natural steroid precursors, it does not have oral contraceptive properties, contrary to popular belief. 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."[3] Yams are baked, boiled or fried. Yams contain folate (34 mcg, 8% DV), are an excellent source of fiber (6.2 g, 22% DV) and vitamin C (26 mg, 28% DV), and a good source of potassium (1,224 mg, 36% DV) per 1 cup.[4]

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.[5] A laboratory study found yam extract to protect against cancer proliferation in human breast cancer cells.[6]

Bioactive Dose

Not known.

Safety

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

Yogurt

Definition

Curdled, fermented milk that is acidified with live bacteria (*Lactobacillus bulgaricus* and *S. thermophiles*).[7] When skim milk is used, low-fat yogurt is produced and full-fat milk produces full-fat yogurt. Yogurt can also be produced from tofu, rice, soy, or nuts.[7] Yogurt has been a part of the human diet for several millennia and references to the health-promoting properties of yogurt date back to 6000 BC in Indian Ayurvedic scripts.[7] While patterns of yogurt consumption vary greatly from country to country, consumption is generally low.[7] In the United States, only 6% of the population consume yogurt on a daily basis.[7] The use of fermented dairy foods, such as yogurt and the yogurt beverage kefir, is common in areas of the world where lactase deficiency is prevalent.[8] Yogurt is a dairy group food; 1 cup (8 oz) of low-fat vanilla yogurt supplies 388 mg of calcium (29% DV) and no vitamin D (0% DV) because yogurt is not usually fortified with vitamin D.

Scientific Findings

Yogurt is well tolerated by lactase-deficient subjects resulting in little or no gastrointestinal distress due to "lactase released from the yogurt organisms."[8] In ten healthy, lactose-intolerant subjects, aged 20–28, lactose

in yogurt appeared to have been digested by lactase released from the yogurt organisms. The approximately 18 g of lactose in a serving of yogurt produced only ⅓ of the hydrogen excretion in a hydrogen breath test, and subjects consuming it, compared to milk, had fewer reports of diarrhea or flatulence.[9]

Bioactive Dose

Not known.

Safety

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

Yuca (Manihot esculenta)

Definition

Also known as cassava, manioc, and tapioca. Starchy tuber that supplies antioxidants, such as beta-carotene,[10] resistant starch[11] and is a good source of potassium (271 mg, 5% DV per 100 g).[12] As a worldwide food source of carbohydrate, it is second only in importance to cereals and is a staple food in Africa, Latin America, and Asia,[7] providing calories for more than half a billion people.[13]

Scientific Findings

Catechins and flavone 3-glycosides, suggested to have cardiovascular health benefits, have been identified in cassava.[14]

Bioactive Dose

Not known.

Safety

Raw, uncooked yuca contains cyanide that is destroyed by cooking.[15] Products made from processed yuca such as cassava flour or tapioca contain minimal to no cyanide and are not harmful.[18] Uncooked yuca contains levels of cyanide than have been associated with acute poisoning and conditions.[7] Certain cassava-eating populations have an increased risk of developing stomach cancer.[7]

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Z

Zinc

Definition

Trace mineral necessary for immune function, growth, protein and DNA synthesis, wound healing, and taste and sense perception.[1,2] Rich sources of zinc include red meat, seafood, such as oysters, crab, and lobster, whole grains, and zinc-fortified breakfast cereals.

Scientific Findings

Features of Zn deficiency are nonspecific and vary according to severity; mild deficiency is characterized by impaired growth as characterized in children by decreased linear growth and inadequate weight gain), appetite, and immune function; additional Zn deficiency symptoms include: diarrhea, hair loss, decreased ability to taste and smell, weight loss, delayed wound healing, and reduced mental alertness.[1–3] Delayed sexual development in children and adolescents, e.g., hypogonadism in males; impotence in men; and impaired spermatogenesis and male fertility are associated with Zn deficiency.[2,4,5] When evaluating Zn status, clinicians should consider Zn deficiency risk factors (e.g., inadequate intake of Zn, alcoholism, digestive diseases, etc.) and symptoms of Zn deficiency (e.g., impaired growth in infants and children, impaired appetite, and impaired immune function, etc.), because plasma and serum Zn levels don't necessarily reflect cellular Zn.[2] 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).[4] Zn deficiency is common worldwide, mostly in developing countries (Table Z.1). Doses higher than are in foods may be necessary to restore depleted Zn levels, e.g., due to diarrhea.

Bioactive Dose

The RDA for adult women (aged 19–50) is 8 mg/day and for adult men (aged 19–50) is 11 mg/d. Vegetarians might need to eat as much as 50% more Zn than the RDA to overcome Zn antagonists in foods, such as phytates, present in whole grains and legumes that bind Zn and inhibit its absorption.[2]

Table Z.1 Subgroups at Risk for Zn Deficiency

Subgroups at risk for Zn deficiency	Rationale
Vegetarians and vegans	Insufficient Zn intake; phytates in whole grains and legumes bind and inhibit Zn absorption
People who have severe diarrhea, liver cirrhosis, or malabsorption syndromes, e.g., weight-loss surgery or digestive disorders, such as ulcerative colitis, celiac disease, Crohn's disease, and short bowel syndrome	Zn malabsorption
Older infants who are breastfed	Breast milk does not have enough Zn for infants over 6 months of age
Alcoholics	Limited, unvaried diet, and because alcohol decreases zinc absorption and increases urinary zinc excretion
Exclusive total parenteral nutrition without Zn supplementation	No Zn intake
Sickle cell anemia	Possible greater demand for Zn utilization in children with sickle cell anemia pain crisis, resulting in lower serum Zn levels
Other diseases including acrodermatitis enteropathica (a rare inherited Zn deficiency disease); chronic liver and renal disease, and other chronic illnesses	

Sources: [1,2,4,13]

Safety

A UL of 40 mg/day has been established for adult men and women aged 19–50.

Zucchini (Cucurbita pepo L.*)*

Zucchini. (Image from unverdorben jr/Shutterstock.)

Definition

Mild-flavored, white-fleshed vegetable that resembles a cucumber in its cylindrical shape. Cooked zucchini supplies 1,000 IU (33% DV) of vitamin A per ½ cup, in addition to cucurbitosides, flavonoids, triterpenes, sterols, and beta-cryptoxanthin, one of five predominant carotenoids in plasma.[6–8] One cup of cooked zucchini with skin supplies 4,186 µg (4.1 mg) of lutein and xeaxanthin.[9] A versatile vegetable that can be stir-fried, used in casseroles, or cooked with tomato as an ingredient in ratatouille; zucchini can also be cut into ribbons and used as a gluten-free pasta substitute.[10]

Scientific Findings

Lutein and xeaxanthin consumption is associated with a decreased risk of age-related macular degeneration.[11] In a laboratory study, beta-cryptoxanthin exhibited antitumor effects.[12] See also: Lutein and Xeaxanthin.

Bioactive Dose

Not known.

Safety

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

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Appendix 1: Major Phytochemical Groups and Specific Phytochemicals Addressed in The A-Z Guide to Food as Medicine, 2nd ed.

Major phytochemical category	Specific phytochemicals in foods addressed in this guide
dietary fiber	**insoluble fiber** • cellulose • lignin **soluble fiber** • beta-glucan • fructooligosaccharide • pectin
fatty acids	**monounsaturated fatty acids** **polyunsaturated fatty acids** • linoleic acid (omega-6-fatty acid) • linolenic acid (omega-6 fatty acid)
glucosinolates	**aglycones** **indoles** • piperine **isothiocyanates** • sulforaphane **organosulfur compounds, also called sulfur compounds or sulfides** • allyl sulfides • thiols

(*Continued*)

Major phytochemical category	Specific phytochemicals in foods addressed in this guide
phenolic compounds	**aromatic acids** • phenolic acids (chlorogenic acid, ferulic acid, syringic acid, vanillic acid) • hydroxycinnaminic acids (caffeic acid, chlorogenic acid, ferulic acid, gingerol) **capsaicin** **polyphenols** • curcuminoids (curcumin) • flavonoids (anthocyanins; catechins; chalcones, flavanols flavones, flavonols, flavanones, glycosides, glycoalkaloids) • isoflavonoids (isoflavones) • lignans (lignan) • stilbenoids (resveratrol, stilbene) • tannin
terpenoids	**monoterpenes** • limonene **diterpenes** • retinol **tetraterpenes** • carotenoids (carotenes, xanthophylls) **triterpenoids** • glycosides **steroids** • stanols • sterols • tocopherol

Appendix 2: Reference Daily Intakes Used to Calculate % DVs in The A-Z Guide to Food as Medicine, 2nd ed.

Reference Daily Intakes are used to determine % Daily Values on Nutrition Facts labels, and were used to calculate % DVs and point out foods that are "good sources" (10–19% DV) and "excellent sources" (>20% DV) of nutrients.

RDIs - nutrients		
Nutrient	**Unit of measure**	**Adults and children ≥4 years**
Vitamin A	Micrograms RAE[2] (µg)	900
	International Units (IU)	3,000
Vitamin C	Milligrams (mg)	90
Calcium	Milligrams (mg)	1,300
Iron	Milligrams (mg)	18
Vitamin D	Micrograms (µg)	20
	International Units (IU)	800
Vitamin E	Milligrams (mg)	15
Vitamin K	Micrograms (µg)	120
Thiamin	Milligrams (mg)	1.2
Riboflavin	Milligrams (mg)	1.3
Niacin	Milligrams NE (mg)	16
Vitamin B_6	Milligrams (mg)	1.7
Folate	Micrograms DFE (µg)	400

(*Continued*)

RDIs - nutrients		
Nutrient	**Unit of measure**	**Adults and children ≥4 years**
Vitamin B_{12}	Micrograms (µg)	2.4
Biotin	Micrograms (µg)	30
Pantothenic acid	Milligrams (mg)	5
Phosphorus	Milligrams (mg)	1,250
Sodium	Milligrams (mg)	2,300
Iodine	Micrograms (µg)	150
Magnesium	Milligrams (mg)	420
Zinc	Milligrams (mg)	11
Selenium	Micrograms (µg)	55
Copper	Milligrams (mg)	0.9
Manganese	Milligrams (mg)	2.3
Chromium	Micrograms (µg)	35
Molybdenum	Micrograms (µg)	45
Chloride	Milligrams (mg)	2,300
Potassium	Milligrams (mg)	4,700
Choline	Milligrams (mg)	550
Protein	Grams (g)	50

Source: US Food and Drug Administration. https://www.fda.gov/downloads/food/guidanceregulation/guidancedocumentsregulatoryinformation/labelingnutrition/ucm513817.pdf. Accessed April 13, 2018.

Appendix 3: Definitions of Drug Terms Used in The A-Z Guide to Food as Medicine, 2nd ed.

abortifacients agent that interrupts pregnancy after implantation
analgesic compound that relieve pain without loss of consciousness
anesthetic agent that can cause total or partial loss of feeling
anticarcinogenic agent that prevents or delays the development of cancer
anti-inflammatory substance that reduces or suppresses inflammation
anti-ischemic agent that counters the restriction of blood supply to tissues
anti-neuroinflammatory agent that counters the inflammation of nervous tissue
antiallergic agent used to treat allergic reactions
antiamyloid agent that inhibits amyloids
antianxiety agent that alleviates anxiety, tension, and anxiety disorders
antiapoptotic agent that prevents apoptosis (a type of cell death)
antiarrhythmic agent used for the treatment or prevention of cardiac arrhythmias
antiarthritic agent that relieves or prevents arthritis symptoms
antiasthmatic drug used to treat asthma
antiatherogenic agent that protects against the formation of fatty plaques in the arteries
antibacterial substance that reduces the growth or reproduction of bacteria
anticancer agent that is effective in the treatment of malignant, or cancerous tumors
anticholinesterase agent that decreases the breakdown of acetylcholine
anticonvulsant drug used to prevent seizures or reduce their severity
antidepressant mood stimulator used in the treatment of depression and related conditions
antidiabetic substance that lowers blood glucose levels
antidiarrheal agent found useful in the treatment of diarrhea

antidyslipidemic agent that reduces the level of unhealthy lipids
antiedematous agent that counteracts an excess of watery fluid collecting in cavities or tissues
antiepileptic drug used to prevent seizures or reduce their severity
antiestrogenic agent that counteracts compounds that interact with estrogen receptors in target tissues
antifibrotic agent that reduces or prevents the thickening and scarring of connective tissue
antiflatulent agent used to prevent the formation of gas and to treat gas or bloat
antifungal substance that destroy fungi by suppressing their ability to grow or reproduce
antihelminthic drugs are prescribed to treat parasitic infestation
antihepatotoxic substance that counteracts the damaging or destruction of liver cells
antihistamine drug that block the actions of histamines
antihyperglycemic substance that lowers blood glucose levels
antihyperhomocysteinemic agent that treats abnormally high levels of homocysteine in the blood
antihyperlipidemic agent used in the treatment of high levels of lipids
antihypertensive drug used in the treatment of acute or chronic hypertension
antimalarial agent used for the treatment of malaria
antimicrobial substance that prevents infectious agents or organisms from spreading
antimutagenic compound that reduces the rate of mutation
antineuralgic agent that counteracts the intermittent pain along the course of a nerve
antinociceptive compound that relieves pain without loss of consciousness
antiosteoporotic drug that either slows down the rate at which bone is broken down, gradually reverses the excessive breakdown or bone, or stimulates bone formation
antioxidant substance that inhibits the oxidation of a substance or counteracts the harmful and damaging effects of oxidation in animal tissues
antiparasitic drug used to treat or prevent parasitic infections
antiplatelet agent that decreases platelet aggregation and inhibit thrombus formation
antiproliferative substance used to prevent or retard the spread of cells, especially malignant cells, into surrounding tissue
antipyretic drug that are used to reduce body temperature in fever
antirheumatic drug used to treat rheumatoid arthritis
antiseptic substance that destroys harmful microorganism or inhibit their activity

antispasmodic agent that inhibits the actions of the parasympathetic nervous system; relieves smooth muscles spasms
antithrombogenic agent that prevents the formation of a blood clot especially within a blood vessel
antithrombotic drug that reduces the formation of blood clots
antitumor substance that inhibits or prevents the proliferation of neoplasm, which prevents tumors
antiulcer drug used to treat ulcers in the stomach and the upper part of the small intestine
antiviral agent used to prevent or treat viral diseases
anxiolytic agent that alleviates anxiety, tension, and anxiety disorders
astringent agent (usually topical) that cause tissues to contract for control of bleeding or secretion
biomembrane-protective agent that protects the membranes that act as a selectively permeable barrier within living things
capsaicinoid compound found in members of the capsicum family
carcinostatic capable of inhibiting the growth of malignant tumors
cardioprotective agent that has a strengthening effect on the heart or can increase cardiac output
cardiotonic see cardioprotective
carminative agent used to prevent the formation of gas and to treat gas or bloat
chelators chemical that bind to remove ions from solutions
chemoprotective drugs that protect healthy tissue from the toxic effects of anticancer drug
cholagogue gastrointestinal agent that stimulates bile flow into the duodenum or stimulates the production of bile by the liver
contraceptive chemical substances that prevent or reduce the probability of contraception
cytotoxic substances that are toxic to cells
detoxification the process of removing toxic substances
diuretic agent that promote the excretion of urine through their effects on kidney function
emmenagogue chemical compounds that induce menstruation
estrogenic compound that interacts with estrogen receptors in target tissues
expectorant agent that increases mucous excretion or drugs that liquefy mucous secretions
fibrinolytic agent capable of stimulating the dissolution of a blood clot
galactogogue agent that increases lactation
gastroprotective agent used in the treatment or prevention of injury to the gastrointestinal tract
hepatoprotective substance that has protective effects on liver cells
hypocholesterolemic substance used to lower plasma cholesterol levels

hypolipidemic substance that lower levels of certain lipids in blood
immunomodulatory agent that modifies the immune response or the functioning of the immune system
immunostimulant substance that augments, stimulates, activates, potentiates, or modulates the immune response at either the cellular or humoral level
immunosuppressive agent that suppresses immune function by one or several mechanisms of action
laxative agent that produces a soft formed stool, and relaxes and loosens the bowels; used to relieve constipation
lipophilic agent capable of dissolving, being dissolved in, or of absorbing lipids
morphine the principal alkaloid in opium and the prototype analgesic and narcotic
muscle relaxant drug that relaxes muscles and is used in the treatment of muscle spasms and muscle pain
neuroprotective drug intended to prevent damage to the brain or spinal cord from ischemia, stroke, convulsions, or trauma
psychoactives grouping of drugs that have effects on psychological function
purgative agent that is used to stimulate evacuation of the bowels
secretagogue substance that promotes secretion; a substance that specifically promotes secretion of human milk is a galactogogue
sedative drug used to induce drowsiness or sleep or to reduce psychological excitement or anxiety
spasmolytic agent that relieves smooth muscle spasms
spermatogenesis the process of germ cell development in the male from the primordial germ cells
stomachic agent that aids in digestion or improves appetite
stool softener agent that produce a soft formed stool, and relax and loosen the bowels; used to relieve constipation
vascular protective agent that protects vessels (especially blood vessels) of the body
vasodilatory agent that widens the blood vessels

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