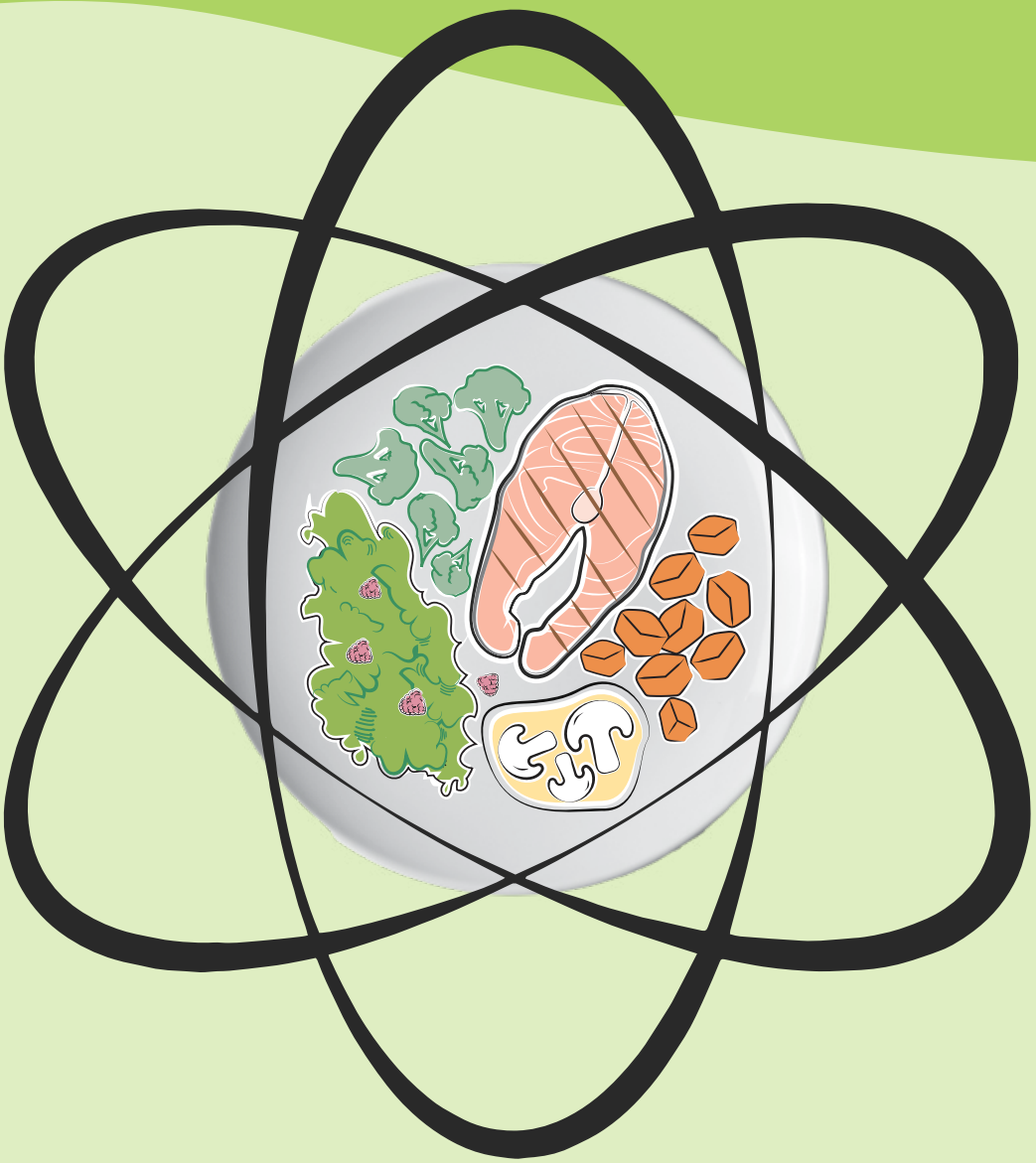
Nutrivore Foundational Foods



BROUGHT TO YOU BY THE TEAM AT NUTRIVORE

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What is a Nutrivore?

Nutrivore is a revolutionary yet simple dietary concept: Get all the nutrients our bodies need from the foods we eat. That's it!

noŏ-trĭ-vôr'

noun

A person who chooses foods to supply all the nutrients their body needs to thrive.

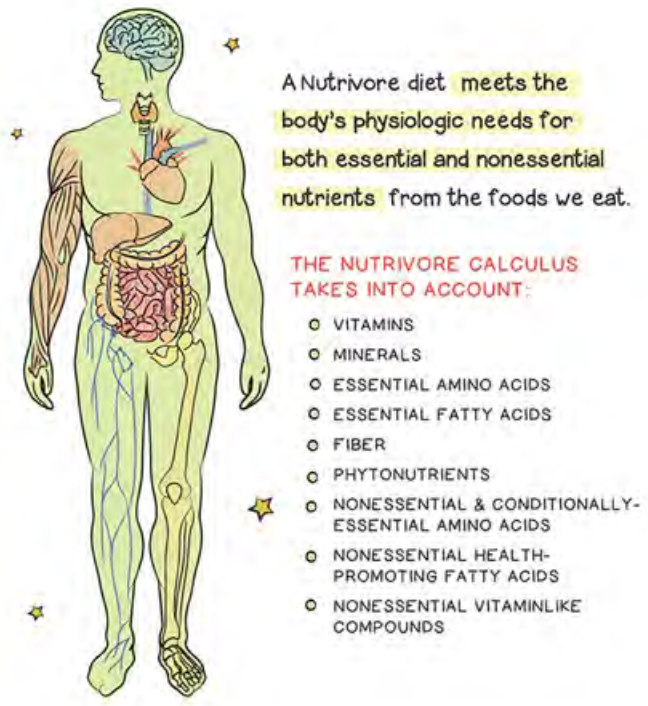
A diet predominantly comprised of nutrient-dense whole foods.

A radical yet simple idea: Get all the nutrients we need from the food we eat.

Nutrivore represents a completely new way to think about foods. Instead of labeling foods as "good" or "bad", we look at the overall quality of the whole diet.

The concept of Nutrivore is very simple: Choose foods such that the total of all the nutrients contained within those foods adds up throughout the day to meet or safely exceed our daily requirements for the full complement of essential and nonessential (but still very important) nutrients required to fully meet our body's physiologic needs, without consuming excess energy (i.e., while also staying within our daily caloric requirements).

The easiest way to do this is to have the foundation of the diet be a wide variety of nutrient-dense whole and minimally-processed foods, including selections from all of the nutritionally distinct food families. But, how do we identify the most nutrient-dense options? That's where the Nutrivore Score comes in!



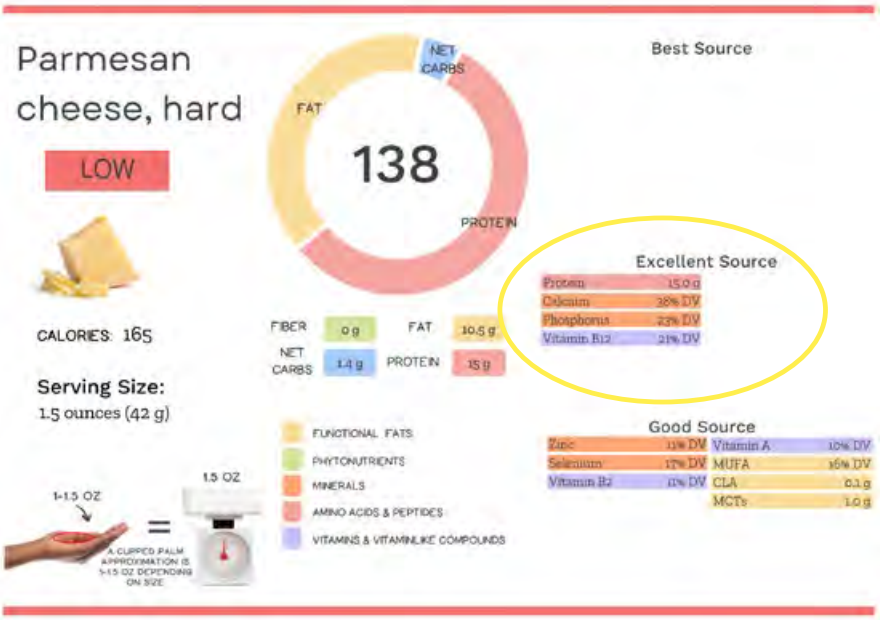
What is the Nutrivore Score?

Simply put, the Nutrivore Score is an objective way to quantify the nutrient-density of foods!

Nutrient density refers to the concentration of nutrients (mainly vitamins and minerals, but also protein, fiber, phytonutrients, and other micronutrients) per calorie of food. High nutrient-density foods supply a wide range of nutrients (or alternatively, high levels of a specific, important nutrient) relative to the calories they contain.

"The Nutrivore Score is a measurement of the total amount of nutrients per calorie a food contains."

What Is a Good Nutrivore Score?



Any food with a Nutrivore Score over 150 contributes more nutrients than calories to the diet but note that there is no cusp below which a food is "bad" and above which a food is "good". In fact, there are plenty of examples of foods with lower scores that are still incredibly valuable sources of nutrients. For example, cheese has an average Nutrivore Score of 140 but is also the most concentrated food source of calcium!

This example shows us that all foods lie on a spectrum of nutrient density and the Nutrivore Score is just one tool to help identify good options. Overall, we want to focus on whole and minimally-processed foods but it's also important to remember that we don't need to feel guilty about eating a food that isn't particularly nutrient-dense. Instead, let's focus on celebrating any choice we make that is nutrient focused.

Nutrivore Foundational Foods

The easiest path to Nutrivore is to have the foundation of the diet be a wide variety of nutrient-dense whole and minimally-processed foods, including selections from all of the nutritionally-distinct food families, which I call the Nutrivore foundational foods. We've covered all of these foods (and then some) in the previous four chapters; so here, I will compile that information into one place while summarizing the scientific studies that provide us with some guidance on how many servings of each Nutrivore foundational food family we need to support overall health.

We use the term food family to denote a more granular approach to food groups. So, instead of the usual five food groups (vegetables, fruit, dairy products, protein foods, and grains), I divide foods up into a few dozen categories where each member is much more closely related nutritionally, such as cruciferous vegetables (a.k.a. the cabbage family), mushrooms, shellfish, citrus fruits, and pulse legumes each as their own food family. You can view every member of a food family as nutritionally interchangeable—swapping broccoli for Brussels sprouts, or lemons for limes, or oysters for mussels, for example. I deem a food family to be nutritionally-distinct when it offers nutrients that are difficult or impossible to get from other food families.

The Nutrivore foundational foods are really just those groups of foods that offer something special nutritionally, because when it comes to food choices, the more different ones we make within food subgroups, the better.

Nutrivore Foundational Foods

Foods benefit our health by supplying us with nutrients our bodies can use as biological constituents or for biological processes. Foods that supply a wide range of important nutrients, or alternatively, a large amount of a nutrient that's harder to get, quantitatively improve health, for example, by reducing risk of chronic disease. When determining which foods form the foundation of Nutrivore, we first look at what nutrients those foods contain that are hard or impossible to get from other sources. Then we look at the vast variety of studies evaluating how varying intake levels of those foods impact health outcomes, the most relevant of which is all-cause mortality, but also cardiovascular disease and risk factors, cancer prevention, risk of developing and worsening type 2 diabetes, and risk of neurodegenerative disease.

THE NUTRITIONALLY-DISTINCT NUTRIVORE FOUNDATIONAL FOODS ARE:

vegetables in general

cruciferous vegetables (the cabbage family)

root vegetables

leafy vegetables

mushrooms

alliums (the onion family)

fruit in general

citrus fruits

berries

pulse legumes

nuts and seeds

seafood

These food families each have something uniquely beneficial to offer us and we maximize both our nutrient density and health benefits when we focus on these foods as the foundation of our diet.

But this does not mean these are the only foods to eat on Nutrivore; it just means that getting all of the nutrients your body needs from the foods you eat will be easiest when you prioritize these foods in your diet. You can then round out your diet with whatever other foods you choose. There are plenty of other food families with nutritional merit, they just aren't so amazing to be elevated to foundational food status.

Let's review the 12 Nutrivore foundational food families and the nutrients they deliver that earn them this status!

Vegetables

Vegetables are rich sources of diverse fiber types, a vast array of phytonutrients, vitamin C, vitamin K, manganese and copper, with many also being abundant in B-vitamins (especially B1, B5, B6, biotin and folate), potassium, and magnesium.

In general, aim for at least five servings of vegetables, and as much as you want above that amount. A serving is one cup for most raw vegetables and two cups for raw leafy veggies. Most vegetables will shrink to half a cup when cooked. You don't need to weigh or measure your veggie servings—approximations are just fine. And yes, your servings of cruciferous vegetables, root vegetables, leafy vegetables, mushrooms and alliums also count towards your five-plus servings of total vegetables.

If eating five or more servings of veggies feels intimidating, you're not alone! In fact, the average vegetable consumption is a mere 1.64 cup equivalents of vegetables per day, which is about one third of optimal intake. What's important to know is that every bit counts—you'll get way more health bang for your veggie serving buck going from zero to some than you will from going to quite a lot to even more—so it's okay to work up to that intake slowly over time.

Note that Nutrivore uses the culinary definition of a vegetable (i.e., savory applications in the kitchen) rather than the botanical definition (i.e., any plant part not derived from the ovary of a plant) because the culinary definitions better align with the nutrient profiles. So yes, you can think of tomatoes, cucumber, okra and avocadoes all as vegetables!

Select from as many different vegetable families as possible. In addition to the foundational food families specified below (cruciferous vegetables, alliums, mushrooms, root vegetables and leafy vegetables), other veggie families include:

- nightshades (e.g., tomatoes, peppers, potatoes, eggplant and chilis)
- beet family (e.g., beets, chard, amaranth, dragon fruit and prickly pear)
- parsley family (e.g., parsley, carrots, celery, fennel, dill, parsnips, and cilantro)
- sea vegetables (e.g., kombu, kelp, nori kelp, arame, wakame)
- thistle family (e.g., artichoke and cardoons)
- ginger family (e.g., ginger, turmeric, and galangal)
- edible-podded legumes (e.g., snap peas, green beans, snow peas)
- summer squash (e.g., zucchini and pattypan squash)
- other veggies (e.g., asparagus, fiddleheads, sea beans, avocados, and olives)

Cruciferous Vegetables (The Cabbage Family)

Members of the cruciferous veggie family—like broccoli, Brussels sprouts, cabbage, and turnips—tend to be high in beneficial fiber types, vitamin C, vitamin K, biotin, folate, manganese, carotenoids, and polyphenols; but the super special nutrients they contain that elevate them to foundational foods status are glucosinolates.

The scientific literature makes a strong case for aiming for one serving of cruciferous vegetables daily—two is even better! A serving is one cup measured raw, and two cups for leafy cruciferous veggies like kale. Most cruciferous veggies will shrink to about half a cup when cooked.

Examples of cruciferous vegetables include:

- arugula
- bok choy
- broccoli
- Brussels sprouts
- cabbage
- cauliflower
- Chinese broccoli
- collard greens
- daikon
- horseradish
- kale
- kohlrabi
- mizuna
- mustard
- radish
- rutabaga
- tatsoi

Leafy Vegetables

Nutritionally, leafy greens have diverse nutrient profiles, but they all tend to be high in beneficial fiber types, folate, manganese, magnesium, carotenoids, polyphenols and vitamin K. While we technically can get all of these nutrients from other vegetables, leafy vegetables are our best sources, packing a ton of nutrients into a very low-calorie package, which is why they turn up as protective again and again in scientific studies.

Scientific studies make a strong case for a serving of leafy vegetables every day, and two servings daily would be even better! A serving is two cups measured raw, which shrinks to a third to half a cup when cooked.

Examples of leafy vegetables include:

- amaranth greens
- arugula
- beet greens
- chard
- collard greens
- cress
- dandelion
- endive
- kale
- komatsuna
- lettuce
- microgreens
- mizuna
- mustard greens
- pea leaves
- purslane
- radicchio
- sorrel
- spinach
- sprouts
- sweet potato leaves
- watercress

Root Vegetables

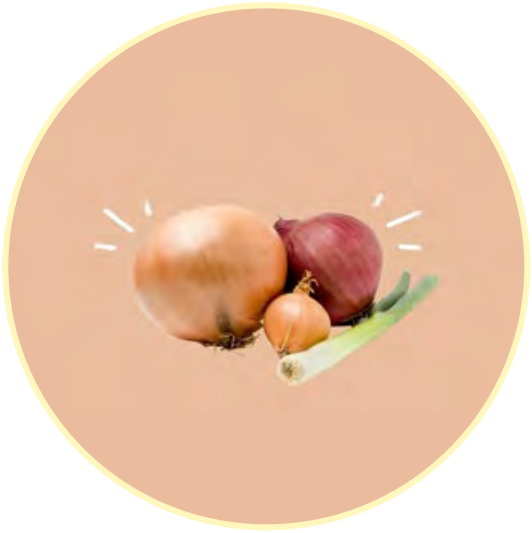
Root vegetables are any underground plant part consumed as vegetables, though not all of them are "true" roots. Botanically, bulbs like onions, corms like taro, rhizomes like ginger, and tubers like potatoes aren't actually roots, but in the Nutrivore and culinary worlds, they all count! Even winter squash, which are botanically fruit, are included in the root vegetable family because they are nutritionally and culinarily similar. Root vegetables tend to be rich in slow-burning carbohydrates, beneficial fiber types, B-vitamins (other than vitamin B12) and minerals, most notably copper, magnesium, manganese, phosphorus and potassium.

Scientific research makes a strong case for eating at least one serving of root vegetables daily. A serving of root vegetables is one cup, chopped and measured raw, which shrinks to about half a cup when cooked.

Examples of root vegetables include:

- acorn squash
- arrowroot
- bamboo shoot
- beet root
- butternut squash
- carrot
- cassava (aka tapioca, yuca)
- celeriac
- daikon
- delicata squash
- ginger
- Hubbard squash
- Jerusalem artichoke
- jicama
- kabocha squash
- lotus root
- parsnip
- potato
- pumpkin
- radish
- rutabaga
- spaghetti squash
- sweet potato
- taro
- tiger nut
- turnip
- water chestnut
- yam

Alliums (The Onion Family)



The onion family, also known as alliums, includes hundreds of different species belonging to the genus Allium, although the ones we're most likely to see on a dinner plate are onions, garlic, leeks, chives, scallions, and shallots. Nutritionally, alliums tend to be excellent sources of beneficial fiber types, vitamin B6, folate, vitamin C, vitamin K, manganese, potassium, copper, and iron. What's more, alliums boast a number of important phytonutrients—most notably their thiosulfinates which is the special thing they have that elevates them to foundational food status, but also carotenoids and polyphenols.

A strong case can be made based on the current scientific evidence for aiming for three servings of alliums per week, and a serving per day would be even better. A serving of garlic is one tablespoon, or about three cloves. A serving of chives is a quarter cup, chopped. A serving of all other alliums is one cup, chopped, measured raw, which shrinks to about half cup when cooked.

Examples of alliums include:

- chives
- elephant garlic
- garlic
- leek
- onion
- scallion
- spring onion
- shallot
- ramp

Mushrooms

Mushrooms aren't just superbly nutrient-dense, they also contain unique fiber types and phytonutrients that support our health in many ways but that we can't get in any other food; plus they are by far our best source of ergothioneine (also known as the longevity vitamin)! Mushrooms earn their foundational food status in multiple ways!

Scientific studies show that even a serving of mushrooms per week is beneficial, but from an ergothioneine perspective, aiming for three servings per week is a better target to get the longevity benefits of the longevity vitamin! Of course, there's no maximum amount of mushrooms to eat, so if you want to eat a serving or even two daily, go for it! A serving is one cup measured raw, and most mushrooms will shrink to about half cup when cooked.

Examples of mushrooms include:

- boletus
- button mushroom
- chanterelle
- cremini
- lion's mane
- maitake
- morel
- oyster mushroom
- portobello
- shiitake
- white mushroom
- wood ear mushroom

Fruits

Fruit are rich sources of diverse fiber types and a vast array of phytonutrients—complementary to those in vegetables—in addition to vitamin C and copper, with many also being a good source of B-vitamins (especially B1, B2, B5, B6, biotin and folate), vitamin K, manganese, magnesium, and potassium.

In general, aim for two or three servings of fruit per day. It's okay to eat more fruit than that, but this is the sweet spot for the most health benefit. A serving is one cup for raw fruits. Most fruits will shrink to about half a cup when cooked. And yes, your servings of citrus and berries also count towards total fruit.

Select from as many different fruit families as possible. In addition to the foundational food families specified below (citrus fruit and berries), other fruit families include:

- apple family (e.g., apples, pear, and quince)
- stone fruit (e.g., peaches, nectarines, plums and cherries)
- melons (e.g., watermelon, honeydew, cantaloupe, and casaba melon)
- tropical and subtropical fruit (e.g., mango, banana, kiwi, pineapple, and pomegranate)
- other fruit (e.g., grapes, pawpaw, persimmon)

Citrus

Citrus fruits offer a wide array of vitamins and minerals, but they're most valuable for their highly bioavailable vitamin C, carotenoids, polyphenols and beneficial fiber types—the combination of flavonoids, pectin fiber, and vitamin C is what elevates citrus fruits to foundational food status.

A strong case can be made based on the current scientific research for aiming for three servings per week of citrus fruits, and up to a serving or even two per day. A serving is one cup, raw, or a medium sized fruit.

Examples of citrus fruits include:

- blood orange
- Buddha's hand
- citron
- clementine
- grapefruit
- kaffir lime
- key lime
- kumquat
- lemon
- lime
- mandarin
- Meyer lemon
- orange
- pomelo
- tangerine

Berries

Nutritionally, berries truly stand out among the fruits thanks to their awesome polyphenol content, especially anthocyanins, which is how they earn foundational food status. They tend to be particularly high in vitamin C (especially strawberries, supplying 141% of the daily value per cup!), beneficial fiber types, manganese, and in some cases vitamin K, and other vitamins and minerals.

In general, eating two or more servings of berries per week is great for overall health, but again, there's no limit to the benefits of berries! A serving is one cup, measured raw.

Examples of berries include:

- açaí
- blackberry
- blueberry
- cloudberry
- cranberry
- currant
- elderberry
- goji
- gooseberry
- huckleberry
- lingonberry
- loganberry
- mulberry
- muscadine
- Oregon grape
- raspberry
- salmonberry
- strawberry

Pulse Legumes

In epidemiological studies, consumption of legumes is frequently associated with better health and greater longevity. This is attributable to their amazing nutrient-density. Pulse legumes—like lentils, chickpeas, soybeans and black beans—are an extremely concentrated source of beneficial fiber types that are known to increase the growth of probiotic bacteria in our guts, which is how they earn foundational food status. Plus, they're typically great sources of vitamin B1, vitamin B2, vitamin B6, biotin, folate, copper, iron, magnesium, manganese, phosphorous, potassium, selenium and zinc! They contain a good amount of protein and typically are very high in polyphenols.

All in all, even a serving or two per week of pulse legumes—like lentils, chickpeas, soybeans and black beans—is going to deliver health benefit, but the preponderance of scientific evidence supports four servings per week as a great goal for optimal health. Of course, there's no maximum amount of legumes, so you can eat them up to every meal if you like! A serving of whole pulse legumes is half a cup cooked, which is the equivalent of one ounce (or about one fifth of a cup) for raw, dried pulse-legumes (like dried beans or lentils). A serving of tofu, tempeh or natto is a quarter cup.

Examples of pulse legumes include:

- black bean
- black-eyed pea
- chickpea
- common bean
- cranberry bean
- fava bean
- Great Northern bean
- kidney bean
- lentil
- lima bean
- navy bean
- mung bean
- peas (split)
- peanut
- pigeon pea
- pinto bean
- runner bean
- soybean

Nuts and Seeds

Nuts are some of the most nutritious, whole-food healthy fat sources out there! They tend to be our best food sources of vitamin E, plus contain beneficial fiber types, alpha-linolenic acid, and monounsaturated fats, the collection of which grants nuts and seeds foundational food status. They are also usually good sources of copper, magnesium, manganese, vitamin B1, biotin, folate, polyphenols and phytosterols (which lower cholesterol).

It really doesn't take much to see impressive health benefits with nuts and seeds, just three 1-ounce servings per week are associated with huge effects in scientific studies. One ounce (28 grams) of nuts and seeds translates to about a quarter cup if they're whole or chopped, and to two tablespoons for nut and seed butters. Importantly, more is not better with nuts and seeds—studies show that benefits cap out at about an ounce per day.

Examples of nuts and seeds include:

- almonds
- Brazil nut
- cashew
- chia
- coconut
- flax
- hazelnut
- hemp
- macadamia nut
- pecan
- pine nut
- pistachio
- poppy
- pumpkin
- sesame
- sunflower seed
- walnut

Seafood

Seafood is our best source of long-chain omega-3 fatty acids by a mile, solidifying foundational food status, but that's not all! Fish is a great source of vitamins B1, B2, B3, B6, B9, B12 and E, zinc, phosphorus, magnesium, iron, copper, potassium and selenium, with oily cold-water fish also providing substantial amounts of vitamin A and vitamin D. Fish with bones remaining, such as canned salmon and sardines, are the best dietary sources of calcium in the food supply. And marine fish are an excellent dietary source of iodine. And, shellfish are extremely rich sources of vitamin B12, zinc, copper and selenium while also providing impressive amounts of vitamin A, vitamin C, vitamin D, iron, copper, calcium, phosphorus, potassium, magnesium, manganese, iodine and selenium. Shellfish also contain smaller but still notable amounts of vitamins B1, B2, B3, B5, B6, and B9, while also providing dozens of trace minerals. Fish and shellfish are typically, but not always, combined in scientific studies.

Scientific studies make a compelling case for aiming for at least three servings of seafood per week, and up to every meal. A serving of seafood is four ounces (115 grams) raw, or about three ounces cooked, about the same size as your palm.

Examples of seafood include:

- anchovy
- bass
- catfish
- clam
- cod
- crab
- crawfish
- hake
- halibut
- herring
- lobster
- mackerel
- mahi mahi
- mussel
- octopus
- oyster
- prawn
- salmon
- sardine
- scallop
- shrimp
- snapper
- squid
- tilapia
- trout
- tuna

Honorable Mentions

It's worth highlighting a few additional food families with impressive health and nutritional benefits, but which are more nutritionally interchangeable than the Nutrivore foundational foods. You can think of these foods as a bonus if you're looking to up the ante on nutrient density. The honorable mentions of food families are: herbs and spices; olives, avocados and their oils; sea vegetables; fermented foods; tea; broth; and organ meats.

Beyond boosting the flavor of your dish, **HERBS** and **SPICES** are concentrated food sources of antioxidant phytonutrients. The health benefits we can glean from herbs and spices are as varied as their distinctive tastes. A good goal is to consume at least one teaspoon of a mix of dried herbs and spices, equivalent to one tablespoon fresh, each day.

OLIVES, AVOCADOS, and **THEIR OILS** are our best foods sources of oleic acid and are also rich in polyphenols and vitamin E. A serving of olive or avocado oil is one tablespoon, and a serving of olives or avocado is ¼ cup, whole or sliced for olives, sliced or mashed for avocado. A good goal is to aim for one or two servings of olives, avocados, or their oils daily.

SEA VEGETABLES deliver unique fiber types, special carotenoids, and 10 times more trace minerals than terrestrial plants. A serving of fresh or rehydrated seaweed is 1 cup (about 15 grams), whereas a serving is 5 grams for dried sea vegetables and 3 grams for sheets (like nori wraps; one of which weighs about 3 grams). A good goal is to aim for at least two servings per week, and up to a serving daily.

FERMENTED FOODS, especially raw and unpasteurized, are great sources of probiotics and postbiotics. Some fermented condiments like fish sauce and soy sauce are pasteurized so, while these are great choices, they don't provide all the goodness of other fermented foods. The same is true for vinegar brine-pickled vegetables and eggs, lactofermented meats like salami, and sourdough bread—since heat is involved, you're missing out on live probiotics. There isn't a specific daily recommended intake for probiotics, but every little bit counts! A great goal is to eat some fermented foods every day.

TEA—especially white, green, oolong, black and pu'er teas—are concentrated sources of polyphenols, including catechins. A variety of clinical trials show that drinking two or three cups per day reduces cardiovascular disease risk, reduces risk of some forms of cancer, improves bone mineral density, reduces risk of type 2 diabetes, and reduces risk of depression! Herbal teas vary in their phytonutrient content, and aren't as well studied, but are also good choices. A good goal is to drink two or more 8-ounce cups of tea daily.

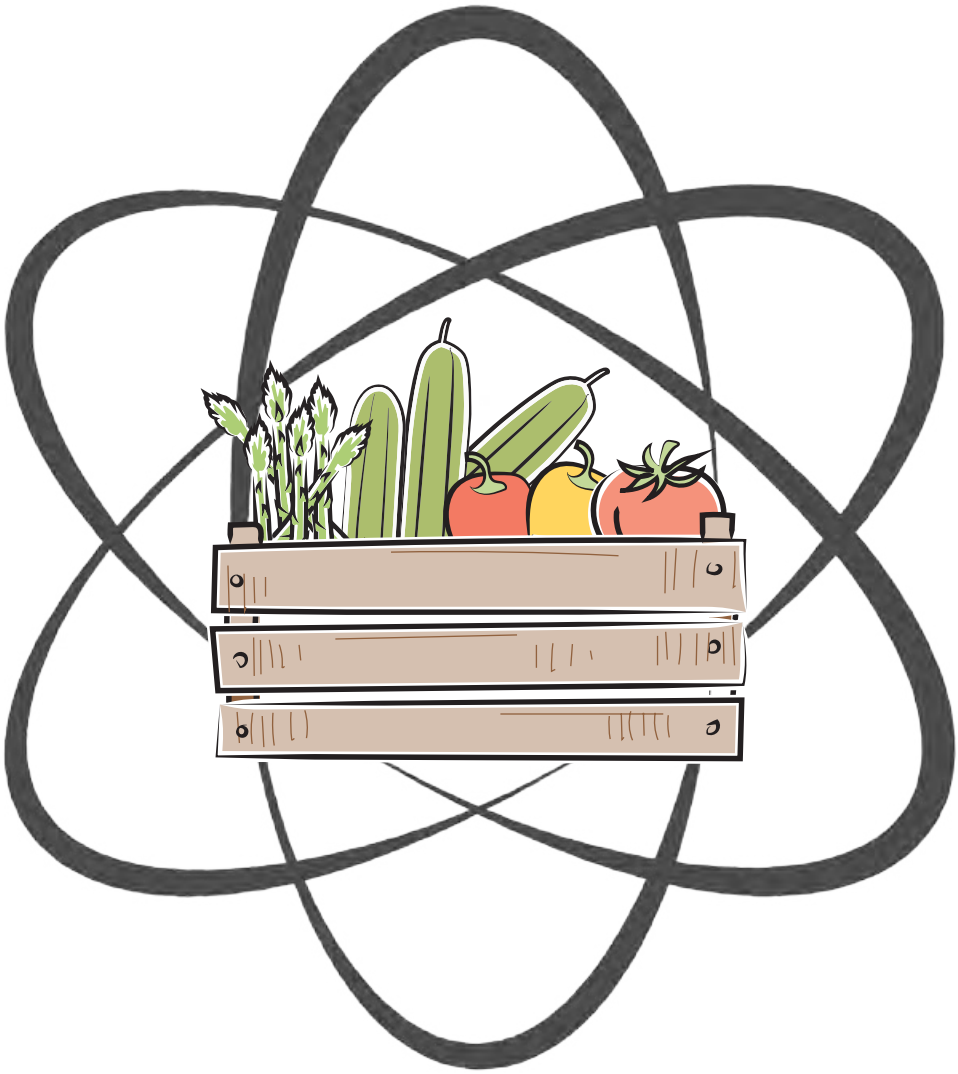
BROTH OR STOCK—especially when made from the highest collagen tissues like beef marrow bones, chicken feet or fish heads, and long-simmered—is a great source of collagen protein. In addition to improving joint health, collagen improves the appearance of aging skin (including increasing elasticity and moisture, and decreasing fine lines and wrinkles), bone mineral density in menopausal females, and can increase muscle mass and strength in young and old alike. Most studies of collagen consumption show benefits at 10 to 20 grams daily, which is about what you get in once cup of broth.

ORGAN MEAT, like liver, kidney and heart, delivers more nutrition per calorie and per serving than just about any other protein foods—mollusks like oysters, mussels and clams are also impressively nutrient dense. Liver and kidney tend to be very high in vitamin A, all of the B vitamins, choline, copper, iron, selenium, zinc and coen-

zyme Q10. (Coenzyme Q10 is a vitaminlike compound with incredible benefits for human health, including helping to treat or prevent cardiovascular disease, type 2 diabetes, neurological diseases, gum disease, infertility, migraine, and some cancers.) Even though heart isn't quite as vitamin- and mineral-rich as liver and kidney, it's the single best food source of coenzyme Q10, containing about four times more than liver or kidney. These are exactly the type of impressively nutritious food that earns more room for quality-of-life foods. A serving is 3.5 ounces (100 grams), measured raw, or about 3 ounces cooked, which can be approximated to the size of your palm. A good goal is to eat 3 to 5 servings of organ meat per week, but any amount is a nutritional win.

Incorporating any or all of the above foods into your diet is a health boon, by upping your intake of beneficial nutrients.

Vegetables



Introduction to Vegetables

No broad category of food says "nutritional powerhouse" quite like vegetables do! From their dazzling array of phytonutrients, to their outstanding variety of vitamins and minerals, to their high content of gut-health-boosting fiber, veggies have a well-earned reputation for being some of the healthiest foods we can eat.

In fact, vegetables have a unique combination of features that pushes them to the top of the health scoreboard. In particular, they're among our very best sources of:

- PHYTONUTRIENTS. Plants produce a variety of biologically active compounds needed for their growth, reproduction, and defense (including against pathogens, predators, and other plants). We refer to these compounds as "phytonutrients"—and while they serve important purposes for plants, they also impart a number of health benefits for humans! The phytonutrients concentrated in vegetables have been shown to benefit nearly every area of health: reducing the risk of cardiovascular disease and cancer, serving as antioxidants, lowering inflammation, reducing type 2 diabetes risk, promoting healthy blood pressure, lowering blood lipids, and even reducing overall mortality. Wow!
- FIBER AND PREBIOTIC CARBOHYDRATES. As plant components, vegetables provide a number of different types of carbohydrate with numerous benefits for gut health (including promoting regularity, maintaining the gut microbiota, and reducing the risk of several chronic diseases!), including:
    - CELLULOSE (the main component of plant cell walls)
    - HEMICELLULOSE (another common component of plant cell walls)
    - PECTIN (a water-soluble and highly fermentable fiber)
    - LIGNIN (a type of fiber with lots of branches made of chemicals called phenols)
    - CHITIN (a fiber similar to cellulose, found abundantly in mushrooms)
    - CHITOSAN (a highly fermentable fiber similar to chitin)
    - GUMS (a diverse group of fibers that plants secrete when they are damaged)
    - BETA-GLUCANS (viscous, fermentable fibers closely related to gums)
    - MUCILAGES (soluble fibers rich in the simple sugars xylose, arabinose, and rhamnose)

    - FRUCTANS (fructose-rich soluble and highly fermentable fibers)
    - RESISTANT STARCH (an insoluble but highly fermentable carbohydrate that plays a major role in generating short-chain fatty acids by gut bacteria)
- MICRONUTRIENTS. On a per-calorie basis, it's hard to beat veggies in terms of micronutrient content! This food group delivers an enormous range of vitamins and minerals, with different vegetables serving as rockstars in their own unique way here: some boasting high levels of vitamin C, others shining in the vitamin B9 (folate) department, others providing abundant vitamin K. (This makes it extra important to "eat the rainbow"!)

Given their generous contributions of health-promoting compounds, it couldn't come as a surprise that science supports a high consumption of these foods!

What Counts as a Vegetable?

For the sake of defining the "vegetable" group, this category includes any part of a plant that we eat for food—with the exception of sweet fruits and seeds. And while technically not a plant, fungi (mushrooms) and algae (seaweeds) are also included here!

Many vegetables fall into one of five sub-categories, united either by their botanical family or their nutritional similarities:

- ALLIUMS (including chives, garlic, green onion, leek, onion, ramps, scallion, shallots, and spring onion)
- CRUCIFEROUS VEGETABLES (including cabbage, cauliflower, broccoli, turnips, Brussels sprouts, collard greens, kohlrabi, gai lan, kale, bok choy, rapini, horseradish, daikon, rutabaga, radish, mustard greens, watercress, and garden cress)
- LEAFY VEGETABLES (including lettuces, endive, escarole, frisee, radicchio, Swiss chard, spinach, lambsquarters, beet greens, amaranth greens, celery, cilantro, dill, fennel, hogweed, lovage, parsley, leafy cruciferous veggies like arugula, bok choy, collard greens, kale, mustard greens, cabbage, watercress, and garden cress, and herbs like basil, lavender, lemon balm, peppermint, sage, spearmint, and tarragon)
- MUSHROOMS (including the common mushroom, shiitake, oyster, enoki, maitake, cremini, portabella, puffballs, boletus, chanterelles, truffles, and morels)
- ROOT VEGETABLES (including beets, carrots, cassava, celery root, jicama, parsnips, potatoes, sweet potatoes, taro, and yams)

As vegetable sub-groups, the above categories tend to have some shared nutritional features (and subsequently, generalizable health benefits). **Alliums**, for example, are rich in thiosulfinates—a class of sulfur-containing compounds that exhibit powerful anticancer properties, as well as antioxidant, anti-inflammatory, and anti-clotting effects. **Cruciferous vegetables** are known for their glucosinolates, which break down into isothiocyanates after the plant cells get damaged—in turn delivering significant anti-cancer, anti-diabetic, cardioprotective, antimicrobial, antioxidant, and neuroprotective effects. **Leafy vegetables** are famous for their cancer-fighting chlorophyll and fiber, while **mushrooms** contain a high content of ergothioneine—a non-proteinogenic amino acid with powerful antioxidant, anti-inflammatory, and detoxification properties, shown to combat diseases associated with aging and oxidative stress (in fact, it's known as the "longevity vitamin!"). Meanwhile, **root vegetables** provide us with prebiotic carbohydrates (including resistant starch, inulin, fructooligosaccharides, and pectin) that beneficially modulate our gut microbiota.

However, plenty of veggies exist outside these sub-groups! Some botanical families provide us with only a few vegetables each that we commonly eat—such as the nightshade family, parsley family, Cucurbitaceae (gourd) family, and thistle family, to name a few. This group of misfits is the "**other vegetable**" category, and very much deserves a tour of its own! (We'll get to that shortly.)

The Health Benefits of Vegetables

Across the board, there's huge benefits to be had for eating more vegetables! Including more veggies in our diet has been linked to lower risk of overall mortality, improved cardiovascular health, reduced risk of type 2 diabetes, protection against numerous cancer types, better gut health, better metabolic health and body composition, reduced risk of depression, better bone health, and more. Here's a rundown of what the research shows!

Vegetables and All-Cause Mortality

Vegetables have been shown to reduce the risk of death from all causes—meaning they promote longevity. For example, a 2014 meta-analysis showed that just three servings of vegetables per day reduced all-cause mortality risk by 25%!

Vegetables and Cardiovascular Disease

Vegetables offer enormous protection for cardiovascular health, including heart disease and stroke! A 2022 meta-analysis showed that compared to eating no vegetables, consuming four or five servings daily reduced the risk of ischemic stroke by 23.2%, hemorrhagic stroke by 15.9%, and ischemic heart disease by 22.9%. A 2023 longitudinal study also found that among women (but not men), consuming 326 to 398 g of vegetables daily was associated with a 40% lower risk of stroke, compared to the lowest quintile of intake (0 to 212 g daily).

A 2017 systematic review and meta-analysis similarly showed that high versus low intake of vegetables was associated with an 11% reduction in cardiovascular disease risk. In a dose-response analysis of the data, every 200 g increase in daily vegetable intake corresponded with a 13% drop in stroke risk and 16% drop in coronary heart disease risk!

Vegetables and Type 2 Diabetes

Vegetables are strongly supportive of metabolic health, and can even reduce the risk of type 2 diabetes. A 2022 meta-analysis showed that compared to eating no vegetables, consuming four or five servings daily reduced the risk of type 2 diabetes by 26.1%!

Vegetables and Cancer

Vegetables are protective against both overall cancer risk, and a variety of individual cancer types!

When it comes to overall cancer protection, a 2017 systematic review and dose-response meta-analysis of prospective studies found that high versus low intake of vegetables was associated with a 5% reduction in total cancer risk. Similarly, every 200 g increase in daily vegetable intake corresponded with a 4% drop in cancer risk!

And, let's not forget about variety! A 2004 prospective study found that over the course of 10 years, greater variety in vegetable intake was associated with a 36% lower risk of cancer.

- **Breast Cancer:** In a 2021 systematic review and meta-analysis of prospective studies, higher total vegetable consumption was associated with 27% lower risk of ER-/PR- breast cancer.
- **Lung Cancer:** A 2016 systematic review and meta-analysis of prospective studies found that compared to people with the lowest intake of vegetables, those with the highest intakes had an 8% lower risk of developing lung cancer. Likewise, for every 100 g increase in daily vegetable intake, lung cancer risk dropped by 6%!

  A 2019 meta-analysis looked at the data based on smoking status, and found that vegetable consumption was associated with a 13% lower risk of lung cancer among current smokers, specifically. What's more, every 100 g increase in vegetable intake was associated with a 3% lower risk of lung cancer among this population.
- **Head and Neck Cancer:** Beyond just incidence, vegetables could protect against death from some cancer types! A 2020 systematic review and meta-analysis of cohort studies found that among head and neck cancer patients, a high vegetable intake prior to diagnosis was associated with a 25% lower risk of death.
- **Ovarian Cancer:** Similar to head and neck cancers, a 2020 systematic review and meta-analysis of cohort studies found that among ovarian cancer patients, a high vegetable intake prior to diagnosis was associated with a 22% lower risk of death.
- **Biliary (Bile Duct) Cancer:** A 2021 meta-analysis of 14 studies found that participants with the highest versus lowest intake of vegetables had a 52% lower risk of biliary cancer. In a dose-response analysis, every 100 g increase in daily vegetable intake was associated with a 69% reduction in cancer risk!
- **Gastric (Stomach) Cancer:** A 2020 pooled analysis of 25 studies found that a higher versus lower intake of vegetables was associated with a 32% lower risk of gastric cancer. Similarly, consuming 10 portions of vegetables each day was associated with a 49% lower risk!

- **Bladder Cancer:** In a 2021 international study of over half a million participants, women in the highest versus lowest tertile of vegetable intake had a 21% lower risk of bladder cancer. However, no significant relationship was found for men.

  Likewise, in a 2015 meta-analysis of 27 studies (12 cohort and 15 case-control studies), the highest versus lowest category of vegetable intake was associated with a 16% lower risk of this cancer; what's more, every 200 g daily increase in vegetable intake was associated with an 8% drop in risk.

- **Esophageal Cancer**

  A 2022 meta-analysis found that compared to eating no vegetables, consuming four or five servings daily reduced the risk of esophageal cancer by 28.5%!

- **Glioma**

  Vegetables could help protect against a relatively rare brain cancer called glioma. A 2022 meta-analysis of 33 observational studies found that compared with the lowest intakes, the highest intakes of total vegetables was associated with a 16% reduction in glioma risk.

- **Endometrial Cancer**

  A 2023 meta-analysis of 27 observational studies found that the highest versus lowest category of vegetable intake was associated with a 24% lower risk of endometrial cancer.

- **Liver Cancer**

  A 2019 meta-analysis of prospective cohort studies found that higher vegetable intake was associated with a 39% reduction in liver cancer risk. For men specifically, the risk reduction was 50%! Likewise, with every 100 g per day increase in vegetable intake, liver cancer risk dropped by 4%.

- **Colorectal Cancer**

  A 2017 case-control study found that among men, a high total intake of vegetables reduced the risk of colorectal cancer by 52%; for women, the risk reduction was 63%!

Vegetables and Inflammatory Bowel Disease

Vegetables could help protect against inflammatory bowel diseases. A 2021 systematic review and meta-analysis found that high intakes of vegetables were associated with a 44% lower risk of ulcerative colitis and a 48% lower risk of Crohn's disease.

Vegetables and Body Weight Regulation

Vegetables also offer significant benefits for body weight regulation. A 2018 systematic review of cohort studies found that consuming more than four servings of vegetables per day was associated with a 73% lower risk of weight gain over time. A 2004 analysis of Nurse's Health Study data found that over the course of a 12-year follow up, participants with the largest increase in vegetable intake had the lowest risk of obesity (a 28% risk reduction!).

Vegetables and Depression

Veggies for better psychological health? Yes please! A 2018 systematic review and meta-analysis of epidemiological studies found that people with the highest versus lowest intake of vegetables had a 14 - 25 % lower risk of depression, with the greatest protection seen in cross-sectional studies. Analyzed a different way, every 100-gram increase in daily vegetable intake was associated with a 3 - 5% drop in depression risk!

Vegetables and Metabolic Health

A meta-analysis from 2018 found that the highest versus lowest category of vegetable intake was associated with a 15% lower risk of metabolic syndrome.

What's more, vegetables may benefit metabolic health independently of weight loss. A 2023 study found that among overweight and obese young people, those in the highest tertile of vegetable intake (about three or four servings daily or greater) had a 94% lower likelihood of being a metabolically unhealthy phenotype, per the International Diabetes Federation definition. In other words, veggie consumption supports better metabolic health even within higher weight ranges!

Vegetables and Gallstone Disease

Vegetables may even help protect against gallstones—a condition in which hardened pieces of bile form in the gallbladder or bile ducts. A systematic review and meta-analysis from 2019, encompassing over 1.5 million participants, found that higher versus lower consumption of vegetables was associated with a 17% lower risk of gallstones. For every 200 g daily increase in vegetable intake, gallstone risk dropped by 4%!

Vegetables and Acute Pancreatitis

A 2013 population-based prospective cohort study of more than 80,000 adults found that over the course of 12 years of follow up, vegetable intake was significantly protective for non-gallstone-related acute pancreatitis (a condition that causes the pancreas to become rapidly inflamed). Specifically, every two additional vegetable servings per day corresponded with a 17% risk reduction!

These protective effects were even more pronounced among regular alcohol drinkers: for participants consuming over one drink per day, the highest versus lowest quintile of vegetable intake was associated with a whopping 71% reduction in risk! Similarly, for participants with BMIs of at least 25 kg/m2, higher vegetable consumption reduced risk by 51%.

Vegetables and Frailty

Vegetables may be protective of frailty—a geriatric syndrome in which people become more susceptible to adverse health outcomes as they age. In a 2016 dose-response analysis of three prospective cohorts, with an average follow-up time of 2.5 years, consuming three portions of vegetables daily (compared to no vegetables) was associated with a 48% lower risk of incident frailty. Consuming even one or two servings was also protective, corresponding with a 31% and 44% lower risk, respectively!

A 2020 longitudinal study likewise found that among older people with robust health at baseline, consuming one or more portions of vegetables per day was associated with significantly lower risk of developing pre-frailty or frailty, compared to consuming less than one portion daily. Consuming four portions or more each day reduced the risk by 47%!

Vegetables and Cognitive Disorders

In a 2022 meta-analysis of observational studies, higher intake of vegetables was associated with a 25% lower risk of cognitive disorders, particularly cognitive impairment and dementia.

Vegetables and Chronic Obstructive Pulmonary Disease

Vegetables could be beneficial for chronic obstructive pulmonary disease (COPD)—a group of conditions caused by damage to the airways or other parts of the lung, resulting in blocked airflow (such as chronic bronchitis and emphysema). In a 2020 dose-response meta-analysis of observational studies, encompassing eight studies and 244,154 participants, vegetable intake appeared protective against COPD. For highest versus lowest category of vegetable intake, risk of this disease was reduced by 24%!

Vegetable and Bone Health

A 2017 population-based cross-sectional study found that for the highest versus lowest tertile of vegetable intake, osteoporosis risk dropped by 20 – 43% (depending on the bone site).

How Many Vegetables Do We Need to Eat to Get Their Health Benefits?

In general, to reap maximum health benefits, science supports an intake of 500 to 600 g of vegetables daily (that's a little over a pound, or about five to eight servings depending on the vegetable), and as much as you want above that. To help envision what this looks like: a serving is one cup (that's about the size of your fist) for most raw vegetables, and two cups (or two fists) for raw leafy veggies. Most vegetables will shrink to half a cup (or half a fist) when cooked. You don't need to weigh or measure your veggie servings—approximations are just fine.

However, if the idea of that many vegetables seems daunting, fear not! It's okay to work up to this lofty goal—every step in the right direction counts. Even though scientific studies show the more vegetables we eat, the better, there's a substantially bigger impact on health going from zero veggies to 200 g daily than there is going from 600 g to 800 g. In other words, lots is good, but some is much, much better than none! If you can manage just three servings for now, you're doing great.

Here's some more good news: when it comes to vegetables, you really can't go wrong! Barring issues like food intolerances or allergies, virtually any veggie you add to your diet will contribute something great. Whether it grows above ground or below, is starchy or leafy, or is raw or cooked, every vegetable deserves a place at the table. So, if you don't normally consider yourself a veggie fan, finding the ones you do enjoy eating is a perfectly fine strategy.

Vegetables and Their Food Groups

Some vegetables belong to two veggie families. For example, kale is both a cruciferous vegetable and a leafy vegetable, carrots belong to both the parsley family and root veggies,

"Other vegetables" encompasses all the veggies that don't fit into any of the other large plant families. It contains many of our most well-loved veggies—including some botanical fruits that we use as culinary vegetables (like tomatoes and peppers), immature legumes (like sugar snap peas and green beans), asparagus, artichokes, and many more!

As a more comprehensive list, here's some common members of this group:

- CRUCIFEROUS VEGETABLES
  - broccoli
  - Brussels sprouts
  - cauliflower
  - kale
  - radishes
- ALLIUMS
  - chives
  - garlic
  - leeks
  - onions
  - shallots
- MUSHROOMS
  - cremini
  - oyster
  - portabella
  - shiitake
  - white
- ROOT VEGETABLES
  - carrots
  - cassava
  - potatoes
  - rutabaga
  - sweet potatoes
- LEAFY VEGETABLES
  - chard
  - endive
  - kale
  - lettuce
  - spinach
- NIGHTSHADES
  - chilis
  - eggplant
  - peppers
  - potatoes
  - tomatoes

- BEET FAMILY
  - amaranth
  - beets
  - chard
  - dragon fruit
  - prickly pear
- PARSLEY FAMILY
  - celery
  - cilantro
  - fennel
  - parsley
  - parsnips
- SEA VEGETABLES
  - arame
  - kombu kelp
  - nori kelp
  - sea lettuce
  - wakame
- WINTER SQUASH
  - acorn squash
  - butternut squash
  - kabocha squash
  - pumpkin
  - spaghetti squash
- GINGER FAMILY
  - galangal
  - ginger
  - turmeric
- EDIBLE-PODDED LEGUMES
  - green beans
  - snap peas
  - snow peas
- THISTLE FAMILY
  - artichoke
  - cardoons
- SUMMER SQUASH
  - pattypan squash
  - zucchini
- OTHER VEGGIES
  - asparagus
  - avocados
  - fiddleheads
  - olives
  - sea beans

Nutritional Highlights from the "Other Vegetables" Group

Like all veggies, members of the "other vegetables" food group are generally high in phytonutrients, fiber, and micronutrients. However, because they hail from so many different taxonomic families, individual vegetables in this group are all unique in what they provide! Let's take a look at some of the top features of this diverse category of veggies.

For starters, eggplants are particularly rich in **anthocyanins**—a type of plant pigment that gives these veggies their beautiful deep purple color. Anthocyanins appear to have anti-inflammatory and neuroprotective effects, could improve glucose tolerance, may reduce the risk of chronic diseases like heart disease and cancer, and may even have pain-relieving properties (due to an affinity for certain "pain-sensation" cell membrane receptors in the brain!).

One particular anthocyanin in eggplants, **delphinidin**, exhibits anti-cancer activity against a number of cancer cell types, including breast, ovarian, lung, colon, prostate, liver, bone, blood, and skin cancers. It also has anti-inflammatory effects, neuroprotective activity, cardio-protective effects, liver-protective activity (reducing liver fibrosis and inflammation), ACE inhibitory activity (giving it blood pressure lowering effects), anti-diabetic activity, antiviral activity, and protective effects against osteoporosis (by reducing bone resorption and inhibiting the differentiation of osteoclasts—AKA specialized cells that break down bone tissue). It's even shown beneficial effects on the gut microbiota, enhancing the proliferation of bifidobacteria and lactobacillus-Enterococcus species, and inhibiting the growth of some pathogens such as Clostridium histolyticum.

Eggplants also contain a derivative of delphinidin called **nasunin**, which also has powerful health-protective effects! This anthocyanin has been shown to protect cells from DNA damage, act against colon cancer cells, suppress angiogenesis, and scavenge free radicals.

Eggplants are also uniquely high in **acetylcholine**—a form of choline that functions as a neurotransmitter. In fact, studies have shown that owing to its acetylcholine content, eggplant can reduce hypertension and improve mental status!

"Other vegetables" of the Cucurbitaceae family—including zucchini, cucumber, summer squash, luffah, bitter melon, and gourds—contain compounds called **cucurbitacins**, a type triterpene with a number of disease-protective activities. Curcurbitacins have been particularly well-studied for their anti-cancer actions, with experiments showing they can induce apoptosis (programmed cell death), autophagy, and cell cycle arrest, while also inhibiting cancer cell proliferation, epigenetic alterations, angiogenesis (the creation of new blood vessels for tumor growth), and cancer cell invasion and migration. There's even evidence that curcurbitacins can enhance the effectiveness of chemotherapy and radiotherapy treatments, and also protect against drug resistance during cancer therapy! One specific curcurbitacin, called curcurbitacin D, is particularly toxic to a number of human cancer types—including lung, pancreatic, oral, colon, breast, and hormone-dependent prostate cancer cells.

Beyond their anti-cancer actions, cucurbitacins have also demonstrated anti-inflammatory, anti-diabetic, cardio-protective, liver-protective, and immune-modulating activities. These phytonutrients really do it all!

Meanwhile, peppers provide us with **capsaicin** (in the case of "hot" peppers) and its non-pungent analog, **capsiate** (found in sweet peppers). Capsaicin is what gives chili pepper its characteristic heat, but it also has a number of health benefits for humans! For example, pre-clinical experiments show it can enhance energy expenditure and reduce the accumulation of body fat, giving it a potential role in body weight regulation. It also has pronounced anti-diabetic actions, anti-inflammatory and antioxidant properties, anti-cancer effects, and cardio-protective effects. And while this phytonutrient is known to cause gastrointestinal distress in some people, a growing body of evidence also suggests it could beneficially modulate the gut microbiota!

Although less well-studied than capsaicin, the capsiate in sweet peppers shows evidence for many of the same health effects as capsaicin. Some experiments show it can enhance energy expenditure and raise core body temperature similarly to capsaicin, although to a somewhat lesser degree—namely by activating TRVP1 receptors in the gut (in turn activating the sympathetic nervous system and inducing the release of catecholamines, which then increase thermogenesis and fat breakdown). In animal and in vitro studies, capsiate has also demonstrated some pain-relieving properties, and also appears to enhance lipid and glucose uptake in liver cells. More research is needed in humans!

Meanwhile, tomatoes are famous for providing **lycopene**—a type of antioxidant carotenoid (it has ten times more free radical scavenging ability than alpha-tocopherol!) with anti-inflammatory, cognitive enhancing, and neuroprotective properties. It's been shown to reduce the risk of aggressive forms of prostate cancer, and higher intakes are associated with a lower risk of chronic diseases like cardiovascular disease, neurological disorders, and cancer (especially laryngeal, oral, and pharyngeal cancers). Although scientists are still researching its precise mechanisms of action, it may modulate the cellular redox environment, protect LDL cholesterol from oxidizing, and reduce neuroinflammation. In the gut, lycopene has antimicrobial activity against some pathogens, while promoting the growth of important probiotic species.

Asparagus are uniquely high in two saponins called **diosgenin** and **protodioscin**—which have been shown to induce cancer cell death, reduce the uptake of cholesterol, lower LDL levels (while increasing HDL levels), and prevent the initiation and development of colon cancer in animal models.

Green-colored members of the "other vegetable" category are also good sources of **chlorophyll**—the pigment that traps light for photosynthesis and gives plants their green color. But, chlorophyll has important functions for humans, too! It can actually combat some of the harmful compounds formed when meat gets cooked, and also has significant anti-inflammatory and antioxidant properties. Some research even shows it can beneficially modulate the gut microbiota, including in ways that contribute to healthy body composition. Asparagus, green beans, and edible-podded peas are good sources.

All of these incredible features are on top of the already vast array of phytonutrients found in vegetables in general—incldluing specific well-studied polyphenols such as:

- KAEMPFEROL (an antioxidant with wide-ranging cancer-fighting properties, as well as an ability to reduce inflammation, regulate the immune system, act as an antimicrobial, prevent diabetes, reduce cardiovascular disease risk factors, prevent neurodegenerative diseases like Alzheimer's disease, improve bone health, and aid weight loss)
- QUERCETIN (shown to reduce blood pressure, enhance insulin sensitivity, reduce inflammation, support wound healing, and even boost immunity)
- LUTEOLIN (which may help reduce inflammation, regulate the immune system, reduce allergic responses, protect the brain, protect against cancer, reduce the risk of neurodegenerative diseases, and reduce pain)
- CHLOROGENIC ACID (shown to help reduce blood sugar, prevent diabetes, aid in weight loss, reduce blood pressure, aid in homocysteine detoxification, and enhance mood)
- P-COUMARIC ACID (which may reduce inflammation, reduce intestinal inflammation, regulate the immune system, improve bone density, act as an antidepressant, prevent cancer, protect against kidney damage, and protect against tissue damage caused by drugs and alcohol)

...among many, many more!

Other Vegetables Nutrivore Scores

As far as their Nutrivore Scores go, "other vegetables" rank as follows:

Root Vegetables and Winter Squash	701
Acorn squash, raw	297
Beets	2013
Butternut squash, raw	670
Carrots	899
Jicama	234
Onions	380
Parsnips	372
Potatoes	272
Pumpkin, raw	1036
Radishes	5863
Sweet potatoes	379
Spaghetti squash, raw	286
Turnips	1954

Alliums (the Onion Family)	2142
Chives	3531
Garlic	5622
Leek	1128
Onion, raw	380
Onion, sweet, raw	170
Shallots, raw	740

Cruciferous Vegetables	3740
Arugula	2019
Broccoli	2833
Brussels Sprouts	2817
Cabbage	2034
Cauliflower	1585
Collard Greens	3323
Kale	4233
Radish	5863
Red Cabbage	1369

Mushrooms	2704
Chanterelle	1555
Cremini	2279
Enoki	4434
Maitake	3551
Morel	2271
Oyster	2550
Portobella	1483
Shiitake	4343
White button	1872

Nightshades	812
Eggplant (raw)	563
Heart of palm, canned	707
Okra	859
Peppers, sweet green	1094
Peppers, sweet red	1358
Peppers, green chili	1234
Peppers, red chili	987
Tomatillos	621
Tomatoes	983

Other Vegetables	744
Artichoke	771
Asparagus	1385
Bamboo shoots	776
Capers, canned	5247
Cardoon, raw	1039
Cucumber	472
Green beans (raw)	605
Heart of palm, canned	707
Okra	859
Peas, edible-podded (raw)	669
Sea Vegetables	1036
Summer squash, all varieties (raw)	1596
Zucchini, raw	1477

The Great Tomato Debate

Out of all the botanical fruits we call vegetables, tomatoes have a particularly colorful history. In fact, the fruit-or-veggie debate made it all the way into the United States Supreme Court, in the Nix v. Hedden case of 1893!

In 1883, President Chester A. Arthur had signed a tariff act that (among other things!) imposed a 10% duty on imported vegetables, while exempting imported fruits. So, when a New York City fruit seller named John Nix found himself owing taxes on a large tomato import from the West Indies, he believed the taxation was wrongful: after all, tomatoes were a fruit, not a vegetable!

Insisting he was owed back duties, Nix filed a lawsuit against the city's tariff collector, a man named Edward L. Hedden. In court, Nix argued that tomatoes should be considered fruits under the common botanical definition; meanwhile, Hedden contended that they should be classified as vegetables based on their common culinary use.

After reading aloud the definitions of "fruit," "vegetables," and "tomato" from three different dictionaries, and calling forth two witnesses who had both been working in the produce-selling business for 30 years, the Supreme Court made its ruling. In a unanimous decision, it declared that for tariff purposes, tomatoes should be classified as vegetables because they are commonly used as such in meals.

Ultimately, the Court acknowledged that a tomato is a botanical fruit, but prioritized what they called the "ordinary" definitions of fruit and vegetable. And where tomatoes were concerned, they were more frequently eaten with the main course rather than dessert—the latter being the domain of fruit.

When it comes to vegetables, just remember: the more the merrier, but some is better than none! Every step you take in the direction of "more vegetables" will pay off.

So, there we have it: in the grocery store, the kitchen, and the Supreme Court, tomatoes are a vegetable!

Some Practical Pointers

Storing Common Vegetables

As a general rule for vegetables, remove any ties or rubber bands, and store the veggies in plastic bags punctured with holes to allow for good airflow or in open containers covered with a damp towel. Pack vegetables loosely in the refrigerator. Some vegetables, like leafy greens, can be soaked in a sink full of cool water before being stored, while others, like mushrooms and herbs, should not be washed until just prior to use.

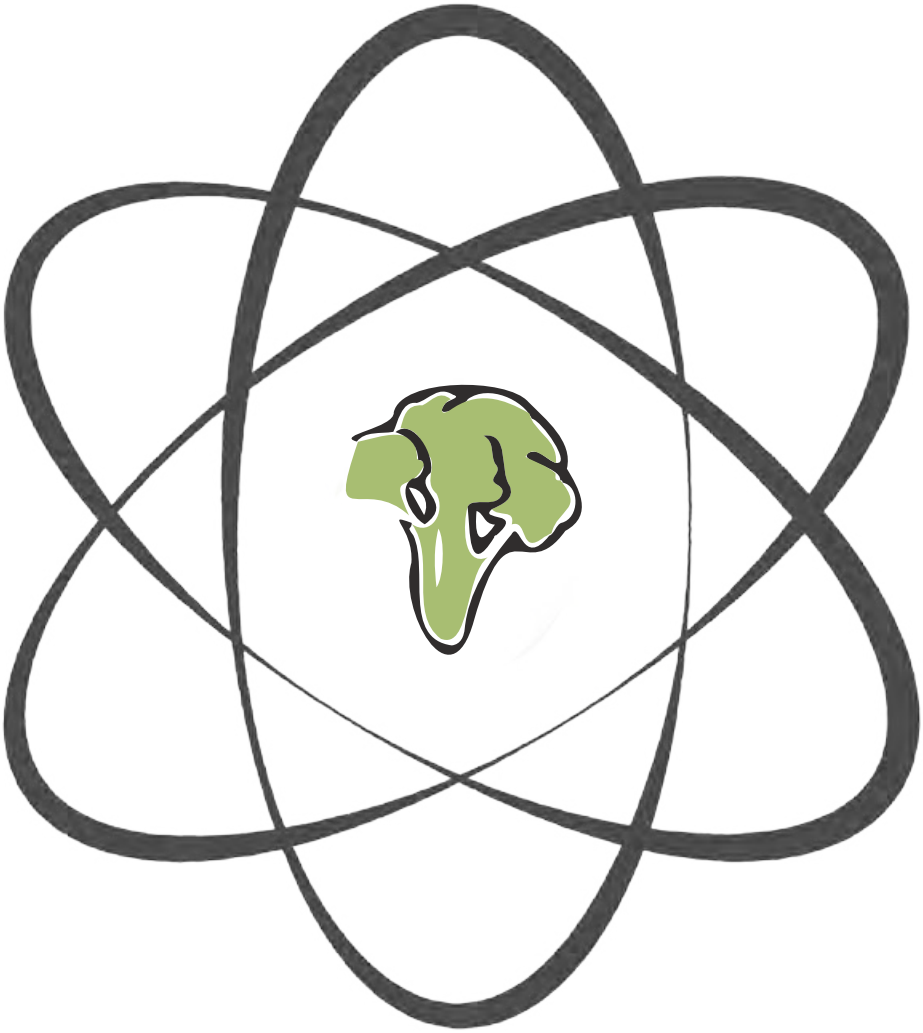
If you find yourself with a surplus of produce, nearly all fruits and vegetables can be stored in the freezer. Freeze them in small pieces on sheet trays, and then place the frozen pieces in airtight containers or resealable freezer bags for use later.

See the list below for storage information for specific vegetables.

- ARTICHOKES: Store in the fridge in an airtight container with a damp piece of paper towel inside.
- ASPARAGUS: Store upright in a glass or bowl filled with water at room temperature for up to a week, or store in the fridge.
- BASIL: Store on the counter loosely packed in a jar with a small, damp piece of paper towel inside.
- BEETS: Wash and store in an open container with a wet towel on top. Cut off any tops and store them separately.
- BROCCOLI: Wrap in a damp towel and place in an open container in the fridge. Use as soon as possible.
- BRUSSELS SPROUTS: If on the stalk, store the entire stalk the fridge. If loose, store in an open container with a damp towel on top.
- CABBAGE: Store on the counter for up to a week, or in the crisper drawer of the fridge. Peel off the outer leaves if they start to wilt.
- CARROTS: Wrap in a damp towel and store in a closed container in the fridge. Cut off the tops and store them separately.

- **CAULIFLOWER**: Store in a closed container in the fridge. Use as soon as possible.
- **CELERY**: Store in a cup or bowl of shallow water on the counter for up to a week. For longer-term storage, wrap in aluminum foil and place in the fridge.
- **CELERY ROOT**: Wrap in a damp towel and place in the crisper drawer of the fridge.
- **FENNEL**: Store in a cup or bowl of shallow water on the counter for up to several days. For longer-term storage, place in the fridge in a closed container with a little water.
- **GARLIC**: Store in a cool, dark place.
- **GINGER**: Store unpeeled in a plastic bag and place in the crisper drawer of the fridge. Ginger roots can also be frozen and microplaned directly from frozen.
- **GREEN GARLIC**: Store in an airtight container in the fridge.
- **HERBS**: Store in a glass or vase full of water in the fridge.
- **LEAFY GREENS**: Remove any bands or twist ties and store in an airtight container with a damp cloth.
- **LEEKS**: Store in a shallow cup of water on the counter (so that only the very bottoms of the stems have water), or wrapped in a damp towel in the crisper drawer of the fridge.
- **OKRA**: Store with a dry towel in an airtight container in the fridge. Use as soon as possible.
- **ONION**: Store in a cool, dark, dry place.
- **MUSHROOMS**: Keep in the fridge in their original packaging or a paper bag.
- **PARSNIPS**: Wrap in a damp cloth and store in an open container in the crisper drawer of the fridge.
- **POTATOES**: Store in a cool, dark, well-ventilated place.
- **RADISHES**: Store in an open container in the fridge with a wet towel placed on top. Remove the greens and store them separately.
- **RHUBARB**: Wrap in a damp towel and place in an open container in the fridge.
- **RUTABAGAS**: Store in a closed container in the crisper drawer of the fridge.
- **SPINACH**: Store loose in an open container in the crisper drawer, and refrigerate as soon as possible. Spinach loves to stay cold.
- **SPRING ONIONS**: Remove any bands or twist ties and store in the crisper drawer of the fridge.
- **SWEET POTATOES**: Store in a cool, dark, well-ventilated place.
- **TURNIPS**: Store in an open container covered with a moist cloth. Remove the greens and store them separately.

Cruciferous Veggies



What Are Cruciferous Veggies?

Many cruciferous veggies actually originated thousands of years ago as a single species of uncultivated wild cabbage, Brassica oleracea. Over time, this species was bred into many now-familiar cultivars such as cabbage, cauliflower, broccoli, Savoy cabbage, Brussels sprouts, collard greens, kohlrabi, gai lan (Chinese broccoli), and kale! Many additional crucifers are cultivars of another species, Brassica rapa: turnips, napa cabbage, bok choy, mizuna, and rapini all fall here. The rest are subspecies of Brassica nigra, Brassica juncea, Brassica napus, and Brassica carnita, and include veggies such as horseradish, watercress, garden cress, radish, daikon, collard greens, rutabaga, and mustard greens. Yum!

In all, we've managed to turn all parts of Brassica plants into foods we can eat. Some Brassica cultivars were bred to have edible roots (like rutabaga and turnips), some were bred for their leaves (like kale and collards), some were bred for edible buds (like Brussels sprouts), some were bred for their flowers (like cauliflower and broccoli), some were bred for their stems (like kohlrabi), and some were bred for their seeds (like mustard). Hence why a mere six Brassica species are able to produce such a diverse range of veggies!

Crucifers are originally native to Western Europe, the Mediterranean, and some temperate areas of Asia. But, thanks to so many years of cultivation, they're now available all over the world—growing in regions as radically different as Alaska and Spain!

What Makes Cruciferous Veggies So Great?

When it comes to health-promoting compounds, these veggies tick all the boxes: they're packed with phytonutrients, teeming with vitamins and minerals, and bursting with fiber. Crucifers, how do we love thee? Let us count the ways!

Phenomenal Phytonutrients

One of the most unique features of crucifers is that they contain glucosinolates—a type of sulfur-containing phytonutrient found exclusively in Brassica plants, and which give these vegetables their characteristic pungent flavor. Glucosinolates aren't biologically active on their own, but when the cells of cruciferous veggies get damaged (such as by chewing, cutting, or other processing), they release an enzyme called myrosinase. This enzyme then breaks down glucosinolates into new compounds called isothiocyanates, which is where the real magic happens!

Research spanning human epidemiology, animal models, and *in vitro* experiments shows that isothiocyanates have significant anti-cancer, anti-diabetic, cardioprotective, antimicrobial, antioxidant, and neuroprotective effects. For example, the isothiocyanate sulforaphane has been studied for its ability to halt cancer cell growth, kill cancer cells, upregulate a number of phase II detoxification enzymes, and protect healthy cells from damage from environmental carcinogens! Another isothiocyanate called indole-3-carbinol, which gets converted from the glucosinolate glucobrassicin, has also been shown to cause cancer cell death and cell cycle arrest, along with altering estrogen metabolism.

Additionally, cruciferous vegetables tend to be high in several important carotenoids—including not only beta-carotene (which can be converted to vitamin A within the body), but also lutein and zeaxanthin. Lutein and zeaxanthin play major roles in maintaining eye health, due to their high concentration in the retina and their ability to filter harmful blue-light rays (in turn protecting critical parts of the eye from light-induced oxidative damage). As a result, these two phytochemicals can help protect against age-related macular degeneration and cataracts, as well as reduce the risk of retinitis pigmentosa.

Crucifers from the above-ground parts of Brassica plants are also excellent sources of chlorophyll—the pigment that traps light for photosynthesis and gives plants their green color. But, chlorophyll has important functions for humans, too! It can actually combat some of the harmful compounds formed when meat gets cooked, and also has significant anti-inflammatory and antioxidant properties. Some research even shows it can beneficially modulate the gut microbiota, including in ways that contribute to healthy body composition.

Crucifers with a purplish or reddish color—such as red radishes, purple cauliflower, red cabbage, purple Brussels sprouts, and purple kale—contain a group of flavonoids called anthocyanins. Anthocyanins appear to have anti-inflammatory and neuroprotective effects, could improve glucose tolerance, may reduce the risk of chronic diseases like heart disease and cancer, and may even have pain-relieving properties (due to an affinity for certain "pain-sensation" cell membrane receptors in the brain!).

Lastly, crucifers are great sources of some other notable phytonutrients. For example, many are high in quercetin—a flavonoid that's been shown to reduce blood pressure, enhance insulin sensitivity, reduce inflammation, support wound healing, and even boost immunity. These activities give it protective effects against diabetes, cancer, cardiovascular disease, arthritis, and even neurodegenerative diseases like Alzheimer's disease! Crucifers also tend to be high in kaempferol, an antioxidant with wide-ranging cancer-fighting properties (including reducing tumor growth, preventing metastasis, inducing cancer cell death, and stopping tumors from creating new blood vessels). Kaempferol intake is linked to lower rates of liver, colon, skin, stomach, bladder, and pancreatic cancer.

Magnificent Micronutrients

Crucifers are rich in some important vitamins and minerals! Although they vary in their exact nutritional profiles, they tend to be high in the following micronutrients:

- VITAMIN K, which plays a vital role in coagulation, bone metabolism, cellular function, and the prevention of soft tissue calcification. Two cups of raw, chopped kale contains 162% of the DV for this nutrient! Cabbage, Brussels sprouts, broccoli, garden cress, watercress, gai lan (Chinese broccoli), and mustard greens are also wonderful sources of vitamin K.
- VITAMIN B9 (FOLATE), an essential B vitamin that plays roles in blood cell production, the formation of genetic material (including DNA), cell growth, cardiovascular health, cancer protection, and cognitive and neurological health. Broccoli, kale, collard greens, cauliflower, Brussels sprouts, mustard greens, gai lan (Chinese broccoli), savoy cabbage, and daikon are all great sources!

- **VITAMIN C**, a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production. Mustard greens, kale, gai lan (Chinese broccoli), kohlrabi, garden cress, bok choy, savoy cabbage, daikon, broccoli, rutabaga, turnips, cauliflower, and cabbage are chock full of vitamin C.
- **CALCIUM**, a major structural component of bones and teeth that also serves as an electrolyte—a type of electricity-conducting mineral needed for regulating nerve impulses, muscle contraction, heartbeat, blood pH, and fluid balance. Mustard greens, kale, and collard greens all contain about 10% or more of the DV for calcium per cup.
- **MAGNESIUM**, an essential mineral that acts as an electrolyte and structural component in cells and bone tissue, and that serves as a cofactor for hundreds of different enzymes (giving it a role in over 300 metabolic reactions!). Rainbow chard provides 14% of the DV of magnesium in a 2-cup serving!
- **MANGANESE**, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Mustard greens, kale, gai lan (Chinese broccoli), garden cress, savoy cabbage, rutabaga, turnips, broccoli, and collard greens all contain notable amounts!

Fabulous Fiber

On top of all their other health-promoting goodies, crucifers are amazing sources of fiber. Fiber is a great example of a nutrient that isn't labelled as essential, but that is absolutely fundamental for our health! Along with regulating gut motility (promoting regularity) and some gastric hormones, it supplies our gut bacteria with fermentable substrate (i.e., food!) so that important microbes can flourish and remain diverse. High fiber intake also reduces the risk of cardiovascular disease and of many forms of cancer (especially colorectal cancer, but also liver cancer, pancreatic cancer, and others), and promotes overall lower inflammation. High-fiber diets reduce the risk of mortality in cases of kidney disease and diabetes, and can even reduce your risk of dying from an infection!

Per 100 g of raw vegetable, crucifers contain the following amounts of fiber:

- **ARUGULA**: 1.6g
- **BOK CHOY**: 1.0g
- **BROCCOLI**: 2.6g
- **BRUSSELS SPROUTS**: 3.8g
- **CABBAGE**: 2.3g
- **CAULIFLOWER**: 2g
- **COLLARDS**: 4g
- **GAI LAN (CHINESE BROCCOLI)**: 2.6g
- **GARDEN CRESS**: 1.1g
- **HORSERADISH**: 3.3g
- **KALE**: 4.1g
- **KOHLRABI**: 3.6g
- **MUSTARD GREENS**: 3.2g
- **RADISHES**: 1.6g
- **RUTABAGA**: 2.3g
- **TURNIP**: 1.8g
- **WATERCRESS**: 0.5g

Health Benefits of Cruciferous Veggies

Given their awesome phytonutrient, micronutrient, and fiber profiles, it shouldn't come as a surprise that cruciferous veggies have demonstrated wide-ranging health benefits and protection against a number of diseases. Here's a rundown of the many ways they've been scientifically shown to benefit our health!

Reduced risk of cardiovascular disease:

Crucifers are astoundingly heart-healthy! Their cardioprotective effects are due in large part to their glucosinolates, which are able to improve lipid metabolism (including reducing LDL cholesterol), reduce inflammation, and lower oxidative stress.

Specifically, studies have directly linked cruciferous veggie consumption with improved cardiovascular and mortality outcomes. For example, a 2017 systematic review and meta-analysis—which included data from 95 studies evaluating fruit and vegetable intake—found that eating 100 grams of cruciferous vegetables per day (about one serving) led to an 18% decrease in ischemic stroke, a 17% decrease in hemorrhagic stroke, and a 12% decrease in all-cause mortality and cardiovascular disease!

Likewise, a 2019 meta-analysis showed that cruciferous vegetables were some of the most health-protective items to consume on a daily basis. For every 100 grams of cruciferous vegetables consumed daily, cardiovascular disease risk dropped by 11%, and all-cause mortality risk decreased by 10%.

A 2011 analysis of the Shanghai Women's Health Study and Shanghai Men's Health Study (encompassing 134,796 adults) also found substantial heart benefits for regularly eating cruciferous vegetables. Compared to people with the lowest intake of crucifers (one or two servings per week), individuals who ate one or two servings daily (an average of 166 grams per day for women and 208 grams per day for men) had an astounding 31% lower risk of cardiovascular disease mortality, and a 22% lower risk of total mortality.

Reduced inflammation:

A 2014 trial of healthy young adults found that eating a high-cruciferous-vegetable diet reduced some markers of inflammation associated with several disease states—particularly the inflammatory cytokine interleukin-6, or IL-6.

Reduced risk of cancer:

Cruciferous vegetables are true warriors against cancer. In fact, many of the activities of their glucosinolates directly translate to cancer protection—including upregulating genes involved in protecting against DNA damage, inflammation, and oxidative stress, while also increasing the activity of detoxification enzymes that help remove toxic substances and carcinogens from the body.

But, that's not all! The chlorophyll in green crucifers is also a powerful cancer fighter, capable of binding to carcinogens and inhibiting their intestinal absorption—in turn preventing them from reaching your tissues and causing harm. In fact, chlorophyll binds to some of the most widespread foodborne carcinogens we're exposed to, including those that form when cooking meat at high temperatures (polycyclic aromatic hydrocarbons and heterocyclic amines) and those that can contaminate peanuts, corn, and dried spices (aflatoxin-B1).

In all, science shows that cruciferous vegetables (and their various bioactive compounds) can induce cancer cell death, inhibit the growth and proliferation of cancer cells, and reduce inflammation and oxidative stress (both drivers of cancer initiation and progression).

With that in mind, it's no surprise that a variety of prospective cohort and case-control studies have found that overall cruciferous vegetable consumption is associated with lower risk of:

- BLADDER CANCER (up to a 20% lower risk)
- BREAST CANCER (up to a 15% lower risk)
- COLORECTAL CANCER (up to an 18% lower risk)
- ENDOMETRIAL CANCER (up to a 21% lower risk)
- GASTRIC CANCER (up to a 19% lower risk)
- LIVER CANCER (up to a 27% lower risk)
- LUNG CANCER (up to a 25% lower risk)
- OVARIAN CANCER (up to an 11% lower risk)
- PANCREATIC CANCER (up to a 21% lower risk)
- PROSTATE CANCER (up to a 10% lower risk)

Reduced risk of diabetes:

Cruciferous veggies could even help protect against diabetes! A 2016 meta-analysis of prospective studies found that people with the highest versus lowest consumption of cruciferous vegetables had a 16% lower risk of developing diabetes over the course of follow-up, even when other diabetes risk factors were accounted for (like BMI, smoking, and physical activity).

A 2012 randomized double-blind trial found that for type 2 diabetics, consuming 10 g daily of broccoli sprouts led to significantly lower insulin levels and HOMA-IR (an important indicator of insulin resistance) measurements than the placebo group. Likewise, a 2016 placebo-controlled crossover trial found that consuming 7 g or 14 g of kale with a high-carbohydrate meal led to significantly lower blood sugar rises in people with elevated fasting blood sugar levels.

And, a variety of animal studies have found that red cabbage in particular can combat not only diabetes, but also complications of the disease. For example, in animal models of diabetes, red cabbage extract has been shown to ameliorate diabetic nephropathy, inhibit digestive enzymes linked to type 2 diabetes, lower blood sugar levels, lower glycated hemoglobin levels, improve glucose tolerance, and increase the number of pancreatic beta-cells—all while also reducing vascular complications caused by diabetes.

Improved gut health:

Crucifers also happen to be incredibly beneficial for gut health! In fact, many of their health benefits come specifically through the interplay of their fiber and phytonutrients with the gut microbiota.

For example, trials of high-cruciferous-vegetable diets have shown that these vegetables can very quickly improve the state of our gut microbiota. In one controlled crossover feeding study, participants underwent several different two-week diets—including a control diet low in fiber and phytochemicals, and a diet rich in cruciferous vegetables (cauliflower, cabbage, broccoli, and radish sprouts). A mere two weeks on a high-cruciferous vegetable diet was enough to cause significant compositional changes in the participants' gut microbiota!

In another randomized crossover study, healthy adults spent two weeks eating a diet high in cruciferous vegetables (including broccoli and cauliflower), with a two-week washout period between the dietary phases. High intake of these vegetables led to a lower abundance of sulfate-reducing bacteria—a big boon for gut health, because these microbes have been associated with ulcerative colitis and irritable bowel syndrome!

Some studies have also examined specific cruciferous vegetables in relation to gut health. In an experiment with rats, for example, a diet supplemented with kale was able to improve microbial diversity, enhance several bacterial metabolic functions, and combat the inflammatory state induced by a high-fat diet. Another study of rats with human-associated microbiota found that four weeks of daily Brussels sprouts consumption led to higher levels of the important short-chain fatty acids butyrate and acetate. And in a controlled feeding study in humans, 18 days of eating 200 g of cooked broccoli daily not only caused beneficial shifts in the gut microbiota composition (including a positive change in the Bacteroidetes to Firmicutes ratio, which has been associated with leanness in a number of studies); it also increased biological pathways involved in endocrine function and energy metabolism!

Cruciferous Vegetable Nutrivore Scores

Wondering how crucifers stack up in terms of their Nutrivore score? Here's a list of some of the most common crucifers and their SUPER scores:

Arugula	2019
Bok Choy	3428
Broccoli	2833
Brussels Sprouts	2817
Cabbage	2034
Cauliflower	1585
Collard Greens	3323
Gail Lan (Chinese Broccoli)	2431
Garden Cress	11265
Horseradish	850
Kale	4233
Kohlrabi	2497
Mustard Greens	5464
Radish	5863
Rapini (Broccoli Rabe)	4155
Red Cabbage	1369
Rutabaga	766
Turnip	1954
Watercress	6929

What About the Goitrogens?

Cruciferous vegetables have long been haunted by rumors that they're bad for thyroid health. This is because some of their glucosinolates act as goitrogens—compounds that interfere with thyroid hormone synthesis, typically by blocking iodine uptake by the thyroid gland.

Early studies in iodine-deficient animals showed that high consumption of cabbage or other cruciferous vegetables increased the incidence of goiters, leading to recommendations that people with hypothyroidism steer clear of this plant family (and in some cases, fears that too many crucifers could cause thyroid dysfunction even in people with initially healthy thyroids). But, research in living humans has painted a much different picture! For example, a human trial found that eating 150 grams of Brussels sprouts daily for four weeks had no effect on thyroid function, even though these veggies contain some of the highest levels of goitrogens out of any crucifer. A 2019 human trial found that 12 weeks of supplementation with a broccoli sprout extract (treated to be particularly high in isothiocyanates, the main goitrogen in broccoli) had no effect on thyroid function, even in people with autoimmune thyroid disease. And, a 2015 meta-analysis of 18 studies found that cruciferous vegetable intake was only associated with thyroid cancer in areas with widespread iodine deficiency.

What's more, some evidence suggests cruciferous vegetables might support thyroid health on the whole! Animal studies show that supplementation with broccoli or rutabaga sprouts reduces inflammation and oxidative stress in the thyroid, improving thyroid function even in cases of iodine-deficiency hypothyroidism. More research is needed in humans to test whether this pans out for us, too.

On the whole, cruciferous vegetables—especially at realistic intakes—appear to be a health-promoting food even for people with autoimmune thyroid disease and subclinical hypothyroidism. And, there's definitely no reason to believe they'll harm the thyroid health of people without existing thyroid disease!

A Note on Fermentation

Some crucifers, particularly various cabbages and radishes, are also commonly used for lacto-fermentation (think: sauerkraut and kimchi!). In fact, fermentation has been used as a preservation method for cruciferous veggies for thousands of years.

When fermented, these veggies offer a unique set of health benefits above and beyond their regular fresh state (which is already a high bar to surpass!). For example, unpasteurized fermented cabbage contains probiotic bacteria such as Lactobacillus brevis and Lactobacillus plantarum, which have immune-modulating effects; Lactobacillus brevis may be particularly beneficial for its ability to resist antibiotic exposure—making sauerkraut potentially useful during antibiotic treatment.

Not only that, but the fermentation process leads to the degradation of glucosinolates into bioactive isothiocyanates, and in some cases, unique phytonutrients not present in the unfermented plant are formed (such as gentisic acid)!

Raw vs. Cooked

When it comes to veggies, the million-dollar question is quite often... *raw or cooked?!*

In the case of crucifers, there are pros and cons to both! Raw crucifers retain their full content of heat-sensitive nutrients, including vitamin C and vitamin B1 (thiamin), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), and vitamin B9 (folate). They also contain fully active myrosinase, the enzyme responsible for turning glucosinolates into isothiocyanates—which means raw crucifers are likely to provide the highest levels of bioactive compounds.

But, cooking has some perks of its own! For one, it helps break down the tough fiber that can make raw crucifers hard to digest, in turn enhancing the accessibility of any nutrients bound to the cell wall or locked inside the cells. Cooking can also enhance the flavor of these vegetables, as well as reduce their bulky volume (due to water evaporation) so we can fit more cruciferous goodness into our stomachs!

Interestingly, even though heat deactivates myrosinase, some common human gut bacteria actually possess myrosinase-like activity of their own. This means that any cooked cruciferous veggies that make it down to our colon (where those gut microbes reside) still have a shot at producing isothiocyanates, even if the enzymes in the vegetables themselves are no longer active. Having a thriving, diverse gut microbiome (particularly with myrosinase-secreting members of *Lactobacillus, Enterococcus, Bacillus,* and others!) increases our ability to obtain isothiocyanates from cooked crucifers.

That being said, the specific method of cooking makes a big difference here! While boiling generally reduces both micronutrient and phytonutrient content of cruciferous veggies, steaming and stir-frying are far less damaging, and even preserve some of the myrosinase activity.

In short, a mix of raw and gently cooked crucifers looks like the ticket for getting the best of all worlds!

Are You a Supertaster?

Do you find cruciferous veggies tough to stomach because they're just too bitter? If so, your genes might be to blame! A substantial number of people (around 25-30% of the population) are what's known as supertasters—possessing a heightened sensitivity to taste, particularly bitterness. These supertasting-powers come from carrying two copies of a TAS2R38 gene variant, which causes the tongue to have a relatively higher density of taste buds (and consequently, more taste receptors that allow for the perception of bitterness). This can cause cruciferous vegetables to taste less palatable.

But fear not! Even if you happen to be a supertaster, there are still ways to prepare cruciferous vegetables so that their tastiness—rather than bitterness—shines. Here are some easy ideas:

- **COOK THEM.** Simply cooking your crucifers will help reduce the bitterness present in their raw state! Steaming, roasting, stir-frying, or grilling them can help to mellow out their flavor and bring out their natural sweetness.
- **SEASON THEM UP!** Adding flavorful seasonings can help mask the bitterness of cruciferous vegetables. For example, try adding garlic, lemon juice, or herbs such as thyme or basil to your veggie dishes.
- **PAIR THEM WITH OTHER FOODS.** Pairing cruciferous vegetables with foods that have complementary, non-bitter flavor profiles can also help reduce their perceived bitterness. For example, try adding sweet or savory ingredients to your dish, such as roasted sweet potatoes, caramelized onions, or bacon!
- **SELECT WISELY.** Young cruciferous vegetables tend to be less bitter than older ones. When shopping, look for young, fresh crucifers with bright green or purple leaves, which are an indication of their freshness and tenderness.

Some Practical Pointers

To get the most out of your cruciferous veggies, quality and freshness are huge wins! That means knowing how to properly select and store crucifers once they've made it home to your kitchen. Not only will these tips help your veggies last longer, they'll also help preserve their nutrient content!

But fear not! Even if you happen to be a supertaster, there are still ways to prepare cruciferous vegetables so that their tastiness—rather than bitterness—shines. Here are some easy ideas:

Selection:

- When it comes to leafy crucifers (like chard, kale, and collard greens), LOOK FOR ONES WITH FIRM, VIBRANTLY COLORED LEAVES—avoiding ones that are yellowing, wilted, or showing brown spots.
- LOOK FOR UNIFORMITY—selecting veggies that are comparable in size, shape, and color. This indicates they were harvested at the same time, which means they'll have a similar taste and texture (as well as cook more evenly).
- FOR ROOT CRUCIFERs (like turnips, rutabagas, and radishes), look for ones that feel heavy for their size, with unblemished skin and a firm texture. Smaller root crucifers are younger and sweeter, with what's generally considered the best flavor.
- CABBAGES SHOULD HAVE FIRM, DENSE HEADS, feel heavy for their size, and have vibrantly colored leaves.
- Broccoli and cauliflower should feel HEAVY FOR THEIR SIZE, have consistent coloration, and have heads that are firm and tightly closed.
- When it comes to Brussels sprouts, LOOK FOR ONES THAT ARE BRIGHT GREEN, have tightly packed leaves, are free from mold, and feel firm when you squeeze them. Smaller sprouts tend to be sweeter and more tender!
- WHEN POSSIBLE, CHOOSE SEASONAL! Although crucifers are often available year-round, choosing the varieties in season helps ensure the best flavor and nutrient content.
- KEEP THEM DRY! Before storing your crucifers, make sure they're totally dry. Excess moisture can lead to mold growth and spoilage. If you wash them before storing, you can pat them dry with

Storage:

a paper towel or use a salad spinner to remove excess water.

- **STORE IN THE REFRIGERATOR.** Crucifers won't last long on the counter!
- **KEEP THEM SEPARATE FROM ETHYLENE PRODUCERS.** Cruciferous vegetables are sensitive to ethylene gas, which some botanical fruits (such as avocados, bananas, pears, peaches, kiwis, cantaloupe, apples, peppers, and tomatoes) emit as they ripen. Exposure to ethylene can cause crucifers to wilt, yellow, and spoil more quickly. So, make sure they don't have any ethylene-producing neighbors where you store them!
- **USE WITHIN A FEW DAYS.** Cruciferous veggies really shine when eaten fresh, so try to use them within a few days of purchase (three to five is best, but they can sometimes last up to a week). If you need to store them longer, blanching and freezing them can help preserve their freshness. (This is an easy process of quickly cooking the veggies in boiling water, and then putting them in an ice bath before transferring them to the freezer!)

With all that in mind, specific crucifers have some storage nuances! For example, cauliflower stores best in a perforated bag in the fridge, while cabbage does well if it's wrapped in a damp paper towel before storage (it's also an exception to the rule in that it doesn't need to be blanched before freezing!). Meanwhile, Brussels sprouts are best stored untrimmed. Crucifers that are root veggies (like turnips and rutabagas) also have a much longer fridge life, lasting up to two weeks!

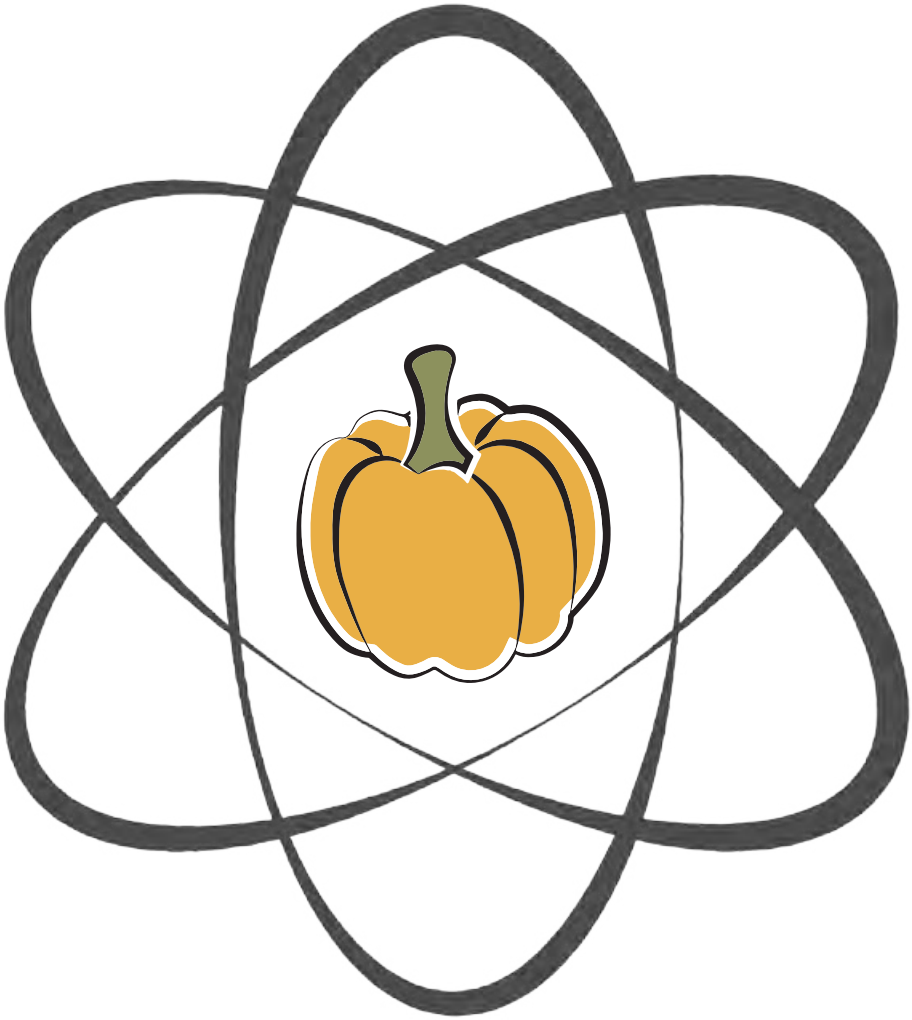
Seasonality:

- **ARUGULA:** Arugula is a cool-weather crop that is typically in season from early spring through late fall.
- **BOK CHOY:** Bok choy is also a cool-weather crop that is typically in season from late fall through early spring.
- **BROCCOLI:** Broccoli is typically in season from late fall to early spring, with its peak season being in the winter months.
- **BRUSSELS SPROUTS:** Brussels sprouts are also in season in the fall and winter months—typically from September through February.
- **CABBAGE:** Cabbage is a cool-weather crop, in season from late fall through early spring.

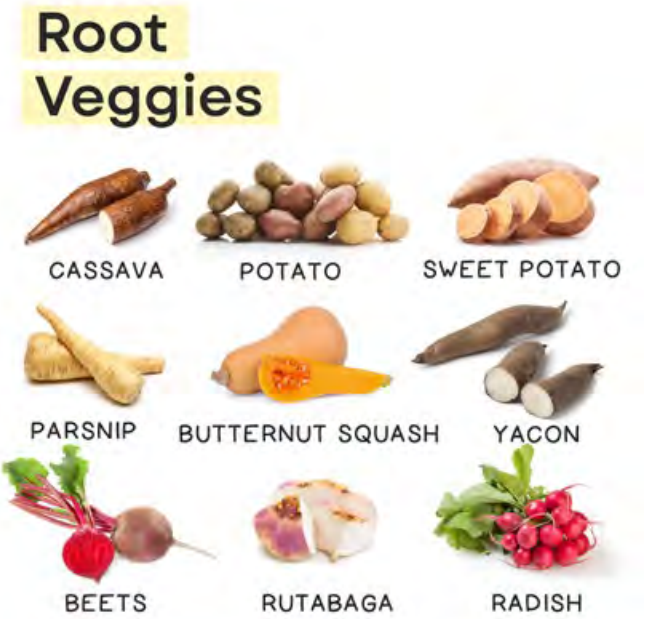
- **CAULIFLOWER:** Cauliflower is in season in the fall and winter months, typically from September through January.
- **COLLARD GREENS:** Collard greens are in season from late fall to early spring, with their peak season being in the winter months.
- **KALE:** Kale is a hardy green that can be grown year-round, but its peak season is from mid-winter through early spring!
- **KOHLRABI:** Kohlrabi is also a cool-weather crop, and is typically in season from early spring through late fall.
- **MUSTARD GREENS:** Mustard greens are in season in the cooler months of the year, typically from late fall through early spring.
- **RADISHES:** Radishes are a spring and fall crop, with peak season being in the cooler months.
- **TURNIPS AND RUTABAGAS:** Turnips are a cool-weather crop and are typically in season from late fall through early spring.

It's worth noting that growing seasons can vary depending on the location and climate, so this list may not apply to all regions. It's always a good idea to check with local farmers or markets to see what's in season in your area!

Root Vegetables



Introduction to Root Veggies



They might grow beneath the ground, but that doesn't mean they're lowly! Root veggies are among the most nutrient-dense carbs in the plant kingdom, boasting an impressive array of vitamins, minerals, fiber, and phytonutrients. They were also one of the earliest foods consumed by humans: archeological evidence suggests people were roasting them at least 170,000 years ago (and likely eating some raw well before then!).

Even today, in many parts of the world, root vegetables are more important as a staple food than grains—especially West and Central Africa, and Oceana. Their versatility, along with their ability to store without spoiling for long periods after being harvested, has made them important crops for numerous societies and regions.

But, the perks of root veggies go well beyond their convenience. Let's take a look at these amazing veggies and the ways they benefit our health!

What Are Root Veggies?

Like many edible plants, the term "root vegetable" can mean different things depending on whether we use a botanical definition or a culinary one. Since we're talking about food, we'll go with the latter: root vegetable refers to any vegetable that grows beneath the ground! This includes not only "true" roots (like sweet potatoes and yacon), but also bulbs (like onions and garlic), rhizomes (like ginger and lotus root), corms (like taro and water chestnuts), and tuberous stems (like potatoes and Jerusalem artichokes).

As you might imagine, that offers us quite a few varieties and options in the root veggie world! Some of the most commonly eaten root vegetables include:

- BEETS
- BURDOCK ROOT
- CARROTS
- CASSAVA (ALSO KNOWN AS YUCA)
- CELERY ROOT (AKA CELERIAC)
- CHICORY ROOT
- DAIKON
- FINGERROOT
- GARLIC
- GINGER
- HORSERADISH
- JERUSALEM ARTICHOKES (AKA SUNCHOKES)
- JICAMA
- KOHLRABI
- LOTUS ROOT
- ONIONS
- PARSNIPS
- POTATOES
- RADISHES
- RUTABAGAS
- SHALLOTS
- SWEET POTATOES
- TARO
- TURMERIC
- TURNIPS
- WATER CHESTNUTS
- YACÓN
- YAMS (yep, they're not the same as sweet potatoes! Even though "yam" is often used interchangeably with "sweet potato," they actually belong to an entirely different plant family, and are distinguished by their rough, bark-like skin)

What Makes Root Veggies So Great?

Root veggies don't always get as much nutritional attention as their non-starchy counterparts (hello, leafy greens and crucifers!), but they actually contain a wealth of health-promoting fibers, micronutrients, and phytonutrients. The exact mix of compounds varies considerably from veggie to veggie, but one thing is universally true: every root veggie offers something special! Here's a rundown of what they can deliver.

Prebiotic Carbohydrates

Root veggies contain an amazing mix of carbohydrates with prebiotic activity (that is, feeding the beneficial species of bacteria in the gut). Depending on the specific root veggie, you'll find any combination of resistant starch, fructooligosaccharides, inulin, or pectin—all of which improve not only gut health, but also the various other body systems affected by the state of our gut!

Resistant starch is among the most famous of these prebiotic carbohydrates. It's a type of highly fermentable, insoluble fiber that "resists" the action of human digestive enzymes, due to its molecular structure. Rather than being fully broken down in the small intestine like most starches, it passes on to the colon to become food for important gut microbes (which then ferment the starch to produce short-chain fatty acids like acetic acid, propionic acid, and butyric acid—all of which have awesome health properties of their own!).

Both human and animal studies have shown that resistant starch and its **short chain fatty acid** (SCFA) metabolites can improve intestinal barrier function, reduce the production of colon cancer precursors, help regulate macronutrient metabolism, increase insulin sensitivity, lower blood sugar responses after high-carb meals, reduce hunger, increase satiation, improve blood lipids, and help combat obesity. There's even evidence that resistant starch helps boost immunity, due to its influence on immune cell production and inflammatory compounds in the gut!

On top of that, the SCFAs produced via bacterial fermentation serve as the main food source for intestinal epithelial cells, giving them a huge role in promoting gut health. These unique fats have also been shown to reduce the risk of inflammatory diseases, maintain a healthy gut barrier, and aid in the absorption of important minerals (including copper, calcium, magnesium, iron, and zinc).

Potatoes that have been cooked and cooled are an excellent source of resistant starch (the cooking-and-cooling process modifies the starch structure to become resistant). But, cassava, yam, water chestnuts, and taro also contain resistant starch!

Meanwhile, **inulin** and **fructooligosaccharides** are soluble fibers that are similar in nature, distinguished mainly by their structural differences (inulin has a longer structure with more cross-links, whereas fructooligosaccharides are shorter and linear). Both have amazing prebiotic properties, significantly boosting populations of **Lactobacillus** and **Bifidobacterium**—which collectively carry out a huge number of roles, including producing vitamins, preventing pathogens from colonizing the gut mucosa (including E. coli), protecting against yeast overgrowths, improving the gut barrier function, reducing endotoxin transport, exerting anti-cancer and anti-diabetic effects, and increasing the generation of SCFAs in the gut. Inulin and fructooligosaccharides have also been shown to improve the absorption of calcium and other minerals in the intestine (in fact, studies have shown these fibers improve bone health in humans!), combat constipation, and reduce blood cholesterol and triglyceride levels.

Inulin and fructooligosaccharides are particularly abundant in chicory root, Jerusalem artichokes, onions, yams, burdock root, jicama, and yacon!

Root veggies also supply **pectin**, a potent prebiotic fiber made up of a long chain of indigestible sugars. Although pectin is more commonly known for being an ingredient that helps thicken jams and jellies, it also possesses a number of benefits for humans! Across studies, pectin has been shown to alter the ratio of gut bacteria in favorable ways, as well as generate SCFAs—with a number of downstream effects such as lowering blood sugar levels, delaying gastric emptying, exerting protective effects against colon cancer, reducing blood levels of insulin and sugar, enhancing the absorption of some minerals, promoting regularity, protecting against pathogenic infections in the gut, and binding to heavy metal ions (in turn reducing their retention and protecting against toxicity). Pectin has also been shown to modulate the immune system, likely through its effects on the gut microbiota—giving it a beneficial role in conditions like allergies.

Among the root veggies, pectin is found in the highest quantities in carrots, turnips, potatoes, sweet potatoes, burdock root, and chicory root.

Phenomenal Phytonutrients

In order to survive in the challenging environment underground, root vegetables produce a number of phytonutrients as defenses—allowing them to evade predators and pathogens in the soil, as well as triumph over competing plants. Luckily for us, these phytonutrients come with a huge range of benefits for human health!

For example, root veggies with yellow or orange coloration (such as carrots and sweet potatoes) are high in **carotenoids**—plant pigments that increase resistance to oxidative stress, reduce inflammation, and have been shown to support vision health (particularly age-related eye diseases like macular degeneration and cataracts). Research shows a high intake of carotenoids could even protect against metabolic syndrome and diabetes!

Betalains are another class of red to yellow pigments found in certain root veggies (particularly beets, but also some less-common tubers like ulluco—an important crop in the Andean region of South America). Along with serving as powerful antioxidants, betalains have strong anti-inflammatory effects. Research suggests betalains could reduce the risk of cancer, cardiovascular disease, type 2 diabetes, and potentially neurodegenerative diseases, while also protecting the liver and kidney from damage. They're also capable of helping improve blood lipid and blood sugar levels!

Many root veggies also contain **anthocyanins**—another type of plant pigment with cardioprotective, neuroprotective, anti-inflammatory, blood-sugar-lowering, and anti-cancer properties. Studies suggest they could help protect against heart disease and diabetes, and may even have pain-reducing properties. These phytonutrient pigments impart blue, purple, or deep red colors to plants, and are found in radishes, sweet potatoes, turnips, red onions, cassava, and carrots.

Root vegetables also contain an array of **polyphenols**—a category of phytonutrients with significant antioxidant and anti-inflammatory properties. These compounds play a huge role in protecting against cancer, heart disease, diabetes, asthma, osteoporosis, neurodegenerative diseases, and other conditions associated with oxidative stress. Although thousands of polyphenols exist, some of the most common in root veggies include:

- QUERCETIN (found in radishes, carrots, chicory root, garlic, jicama, parsnips, burdock root, onions, beets, celery root, kohlrabi, potatoes, rutabagas, sweet potatoes, taro, and cassava), which has been shown to suppress inflammation in the brain and promote a healthy gut barrier.
- APIGENIN (found in carrots, cassava, onion, rutabagas, horseradish, chicory root, and celery root), which has been shown to reduce inflammation, protect against cancer and diabetes, improve brain health, reduce pain, and induce a calming effect.
- KAEMPFEROL (found in beets, carrots, water chestnuts, onions, radish, celery root, and chicory root), which can reduce inflammation, regulate the immune system, protect against cancer, act as an antimicrobial, prevent diabetes, reduce cardiovascular disease risk factors, prevent neurodegenerative diseases (like Alzheimer's disease), improve bone health, and aid weight loss.
- LUTEOLIN (found in carrots, beets, water chestnuts, celery root, rutabagas, sweet potatoes, horseradish, taro, kohlrabi, chicory root, and burdock root), which is strongly neuro-protective with anti-cancer activity, along with being able to reduce inflammation, regulate the immune system, reduce allergic responses, prevent toxicity associated with chemotherapy and radiation, and reduce pain.

- HYDROXYCINNAMIC ACIDS such as p-coumaric acid, caffeic acid, ferulic acid, chlorogenic acid, and sinapic acid (found in carrots, radishes, parsnips, onions, beets, chicory, garlic, onion, and turnips), which have powerful anti-diabetic, anti-inflammatory, antioxidant, and anti-cancer effects; they may help protect against neurodegenerative diseases and other conditions related to oxidative stress.

Root veggies from the Brassica family (such as horseradish, rutabaga, turnips, radishes, and kohlrabi) are rich in **glucosinolates**—a type of sulfur-containing compound that gets converted into bioactive isothiocyanates when the plant cells are chewed, cut, crushed, or otherwise damaged. Research spanning human epidemiology, animal models, and in vitro experiments shows that isothiocyanates have significant anti-cancer, anti-diabetic, cardioprotective, antimicrobial, antioxidant, and neuroprotective effects! In experiments, the isothiocyanates sulforaphane and indole-3-carbinol have shown particularly impressive abilities to kill cancer cells and halt cancer cell growth.

Root veggies in the Allium family (which include onions, garlic, and shallots) are also uniquely high in **organosulfur compounds**, which show evidence of protecting against stomach and colorectal cancers (due to inhibiting carcinogenesis in various parts of the digestive tract, modifying detoxification enzymes, and preventing DNA damage).

A number of root veggies also contain **saponins**—chemical compounds that can reduce cholesterol levels, protect against oxidative stress, inhibit tumor growth, improve lipid metabolism, and even protect against obesity! Saponins can be found in yams, potatoes, onions, garlic, sweet potatoes, beets, and cassava!

Magnificent Micronutrients

Root veggies are rich in a number of vitamins and minerals! Although they vary in their exact nutritional profiles, their role as storage organs (storing nutrients and energy for the rest of the plant) means they tend to accumulate specific micronutrients. These include:

- COPPER, a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). One cup of Jerusalem artichokes has 43% DV of copper! One cup of cooked sweet potato contains 22% of the DV for copper and the same amount of turnips has 12% DV. Other high-copper root veggies include kohlrabi, cassava, potato, beets, and leeks.
- VITAMIN B9 (FOLATE), an essential B vitamin that plays roles in blood cell production, the formation of genetic material (including DNA), cell growth, cardiovascular health, cancer protection, and cognitive and neurological health. A cup of cooked beets contains 37% of the DV for folate, and a cup of cooked parsnips contains 22% of the DV. Cassava and leeks are also notable sources of folate.
- IRON, a mineral needed for the function of numerous proteins involved in electron transport, energy metabolism, oxygen transport and storage, DNA replication and repair, free radical

scavenging, and oxidative processes. One cup of Jerusalem artichokes contains 12% of the DV for iron. Sweet potatoes, potatoes, cassava and beets also contain notable amounts.

- **MAGNESIUM**, an essential mineral that acts as an electrolyte and structural component in cells and bone tissue, and that serves as a cofactor for hundreds of different enzymes (giving it a role over 300 metabolic reactions!). High-magnesium root veggies include Jerusalem artichoke, cassava, daikon, rutabaga, sweet potatoes, and potatoes.
- **MANGANESE**, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Jerusalem artichoke, beets, cassava, leeks, parsnips, and sweet potatoes are high in manganese.
- **VITAMIN B3 (NIACIN)**, a water-soluble B vitamin that's needed for over 400 enzymes involved in DNA repair, fatty acid synthesis, antioxidant systems, detoxification, hormone synthesis, and macronutrient breakdown. One cup of cassava has 14% the DV for niacin. Jerusalem artichokes, sweet potatoes, potatoes, and yacon are also great sources!
- **VITAMIN B5 (PANTOTHENIC ACID)**, a water-soluble vitamin needed for metabolizing many drugs and toxins, as well as forming derivatives that participate in the synthesis of cholesterol, fatty acids, melatonin, the neurotransmitter acetylcholine, steroid hormones, heme, and vitamins A and D. Jerusalem artichokes, sweet potatoes, potatoes, garlic, and parsnips are high in this nutrient.
- **POTASSIUM**, an electrolyte mineral with roles in a wide variety of life-sustaining processes such as heart function, muscle contraction, nerve impulse transmission, blood pressure control, blood pH, and fluid balance. Jerusalem artichokes, kohlrabi, turnips, parsnips, cassava and sweet potatoes are good sources of potassium.
- **VITAMIN B1** (Thiamin), a water-soluble vitamin that serves as a cofactor for a variety of enzymes involved in carbohydrate and amino acid metabolism, RNA and DNA production, and generating energy for the Krebs cycle. One cup of Jerusalem artichokes contains 10% the DV for thiamin, and rutabaga contains 11% the DV. Garlic, cassava, parsnips, potatoes, yacon, and yams are also some delicious thiamin-filled sources.
- **VITAMIN B6 (PYRIDOXINE)**, a group of six water-soluble compounds required by over 100 different enzymes to carry out functions in protein metabolism, fatty acid metabolism, neurotransmitter production, gluconeogenesis, hemoglobin synthesis, the release of glucose from glycogen, and energy metabolism (particularly the production of ATP in the Krebs cycle). Root veggies high in vitamin B6 include cassava, Jerusalem artichoke, kohlrabi, and sweet potato.
- **VITAMIN C**, a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production. Kohlrabi contains 93% of the DV for vitamin C in a one cup serving, while cassava has an impressive 113%. Other awesome sources of vitamin C include Jerusalem artichoke, leeks, parsnips, radish, rutabaga, and turnips.

Health Benefits of Root Veggies

Given how many awesome things they contain, it shouldn't come as a surprise that root veggies have demonstrated wide-ranging health benefits and protection against a number of diseases. When studied as a general food group, they've been shown to be protective against the following conditions:

All-cause mortality

In a 2019 review of available meta-analyses, every 100 g increase in daily root vegetable consumption was associated with a 24% reduction in all-cause mortality!

Mental health

A 2021 cross-sectional study found that among family caregivers of people with dementia, higher root vegetable consumption was associated with lower incidence and severity of anxiety and depression.

Cancer

A prospective study from 2005 found that among Swedish women, root vegetable consumption was associated with a lower risk of kidney cancer. In fact, root veggies had the strongest inverse association with kidney cancer out of any vegetable sub-group: eating at least one serving per day (compared to none) was linked to a 51% decrease in risk!

Another prospective study from 2006 found that eating at least three servings of root vegetables per week, compared to less than half a serving per week, was associated with a 57% lower risk of stomach cancer.

And, a 2012 analysis of the European Prospective Investigation into Cancer and Nutrition found that root vegetable intake was significantly protective of aggressive forms of the disease, reducing risk by 13%.

Cognitive decline

A 2011 prospective cohort study found that higher root veggie consumption was associated with reduced cognitive decline over time—specifically, cognitive flexibility and cognitive function. In fact, people with the lowest root vegetable consumption had over three times the cognitive decline of people with the highest intake!

Diabetes

Root veggies may even be protective against diabetes! In a 2012 analysis of the EPIC-InterAct prospective study, encompassing over 16,000 participants, root veggies were the only fruit or vegetable subtype inversely associated with diabetes (a 13% reduction in risk for the highest versus lowest quartile of intake).

Specific Veggies

Because they belong to a number of different plant families (and therefore possess unique phytochemical and nutrient profiles), root veggies are more often studied individually than as a collective group. And when we look at the science on a veggie-by-veggie basis, their health perks are even more dazzling!

- **BEETS:** Research shows beets are awesome for cardiovascular health, due to their ability to reduce blood pressure, blood sugar, and blood glucose! They can even potentially benefit athletic performance due to their nitrate content, as well as reduce muscle soreness. Various components of beets have also been shown to inhibit cancer growth and induce autophagy.
- **CARROTS:** Along with famously supporting eye health (due to their rich content of carotenoids), carrots are incredibly beneficial for the gut! Specifically, a variety of studies have shown that carrot consumption alters the composition and diversity of the gut microbiota, improves intestinal function, and reduces fecal pH.
- **CHICORY ROOT:** Incredibly rich in fermentable fibers, chicory root has a major role in promoting gut health and feeding beneficial intestinal bacteria (as well as promoting regularity and relieving constipation). It's also been shown to help modulate the immune system, reduce DNA mutations, protect against liver damage, and protect against pathogenic infections (whether from bacteria, fungi, parasites, or viruses!).
- **JERUSALEM ARTICHOKES:** Incredibly rich in prebiotic fibers, Jerusalem artichokes have been shown to help with digestive health, regulate blood sugar and blood pressure levels, reduce cholesterol levels, and exert anti-cancer activities!
- **RADISHES:** Radishes are particularly famous for their anti-diabetic activities—promoting glucose uptake, reducing glucose absorption in the intestine (by inhibiting α-amylase and α-glucosidase enzymes involved in sugar breakdown), and affecting hormones involved in glucose regulation (including adiponectin and insulin). Radishes may even help prevent diabetes-induced oxidative damage, due to their array of antioxidant phytonutrients.
- **RUTABAGAS:** Rutabagas are particularly high in glucosinolates that possess antioxidant properties, and which have been shown to reduce inflammation and inhibit the growth of colorectal, breast, and prostate cancer cells.
- **SWEET POTATOES:** Sweet potatoes exhibit antioxidative, anti-inflammatory, anti-obesity, liver-protective, anti-aging, blood-sugar-lowering, and immunomodulatory properties. Purple-fleshed sweet potato is a particular rockstar here, with studies showing its various components can exert anti-cancer properties against colon tumors, stomach cancer, breast cancer, and bladder cancer cells. Not only that, but sweet potatoes also show promise for enhancing cognitive performance and memory, in part by reducing inflammation and preventing free radical damage in the brain.
- **TURNIPS:** Turnips have been shown to exhibit anti-tumor, anti-diabetic, antioxidant, anti-inflammatory, anti-hypertensive, kidney-protective, liver-protective, and even pain-reducing properties!

- YAMS: Yams have shown positive effects on brain function, cancer protection, diabetes, and even weight loss! Many of these benefits are related to its phytosteroid diosgenin, which demonstrates significant hypoglycemic, antioxidant, anti-inflammatory, cholesterol-lowering, and anti-cancer properties (particularly against colon cancer, leukemia, squamous carcinoma, liver cancer, gastric cancer, breast cancer, and lung cancer cells). Yam may even help boost brain health, with both animal and human studies showing improvements in cognitive function, memory, and learning.

Root Vegetable Nutrivore Scores

Root veggies vary considerably in their Nutrivore scores, with radishes topping the list at a whopping 5863 (skyrocketing to 6660 for the white icicle variety of radish)! The full list includes:

Acorn squash, raw	297
Beets	2013
Burdock Root	182
Butternut squash, raw	670
Carrots	899
Cassava	224
Celery root (AKA celeriac)	345
Chicory Root	207
Garlic	5622
Ginger	192
Horseradish (paste)	850
Hubbard squash, raw	358
Jerusalem artichokes (AKA sunchokes)	195

Jicama	234
Kohlrabi	2497
Lotus Root	351
Onions	380
Parsnips	372
Potatoes	272
Pumpkin, raw	1036
Radishes	5863
Rutabagas	766
Sweet potatoes	379
Spaghetti squash, raw	286
Taro	178
Turnips	1954

What's the Deal With Potatoes?

For years, potatoes have received a fair bit of negative press—the vast majority of which is undeserved! Although potatoes can indeed be problematic for people with nightshade sensitivity, they're a far cry from the empty-calorie, high-glycemic starch they're often portrayed as. In fact, potatoes are good sources of vitamin C, vitamin B6, potassium, manganese, niacin, magnesium, folate, and even iron! With a Nutrivore score of 272, they're considered a medium nutrient-dense food. They also routinely rank high in satiety index studies, suggesting they're actually one of the most satiating foods we can eat!

Part of the potato confusion is due to the way they're commonly prepared and eaten. In observational studies, potato consumption is often in the form of fried foods (such as French fries or potato chips) rather than more healthful preparations (like baking or boiling)—making it hard to determine whether subsequent health outcomes are from the potatoes themselves, or from the processing methods and additional ingredients accompanying them. In fact, studies that adjust for confounders generally show that non-fried potatoes are neutral when it comes to diabetes and cardiovascular disease risk, and may even be linked to a reduced risk of total mortality.

Likewise, some bioactive compounds in potato (including alpha-chaconine and gallic acid) have been shown to induce the death of some cancer cells, including prostate, colon, and liver. The resistant starch in potato can also help improve insulin sensitivity, boost satiety, decrease blood sugar levels, promote feelings of fullness, and reduce food intake.

In other words, there's no reason to view potatoes as an exception to the "root veggies are awesome" rule! Spuds deserve a place at the table just as much as their rooty cousins.

A Note on Contaminants

Among the many impressive features of root vegetables is one potential bummer: their role as plant storage organs makes them uniquely capable of accumulating heavy metals (especially lead and cadmium), pesticides, microplastics, and other contaminants from the surrounding soil. Analyses of root veggies from polluted environments show they tend to have a higher concentration of contaminants than other edible plant parts.

Luckly, most of us don't need to worry about the contaminants in root veggies, even when buying conventional, since they aren't high enough to harm human health. If you do live in an area with high levels of industrial pollution, you can reduce your exposure by making sure to peel and cook your root veggies before eating them, which can reduce the levels of contaminants by over 50%! Other options are to opt for organic root vegetables, or buy from farms located away from industrial pollution, or shop at farmers markets (where you'll be likely to encounter vendors who use sustainable, low-pollution farming methods). And of course, this is yet another reason to advocate for solutions to pollution.

Some Practical Pointers

Root veggies tend to be hardy (no surprise, given they've already roughed it underground!), but selecting and storing them for quality and freshness helps ensure you get the best root veggie bang for your buck. Here are some tips to keep in mind!

Selection:

- In general, root veggies should be springy and hard—the very opposite of selecting ripe fruit!
- Select veggies that feel heavy for their size.
- Avoid buying root vegetables with gashes, bruises, soft spots, wrinkling, or other signs of damage.
- If you're choosing root veggies that have their greens attached (such as a bunch of beets or radishes), check to make sure the stems and leaves are bright, firm, and not wilting.
- When it comes to potatoes, choose ones that are smooth (with small "eyes"), well-shaped, and free from green spots, shriveling, or sprouts.

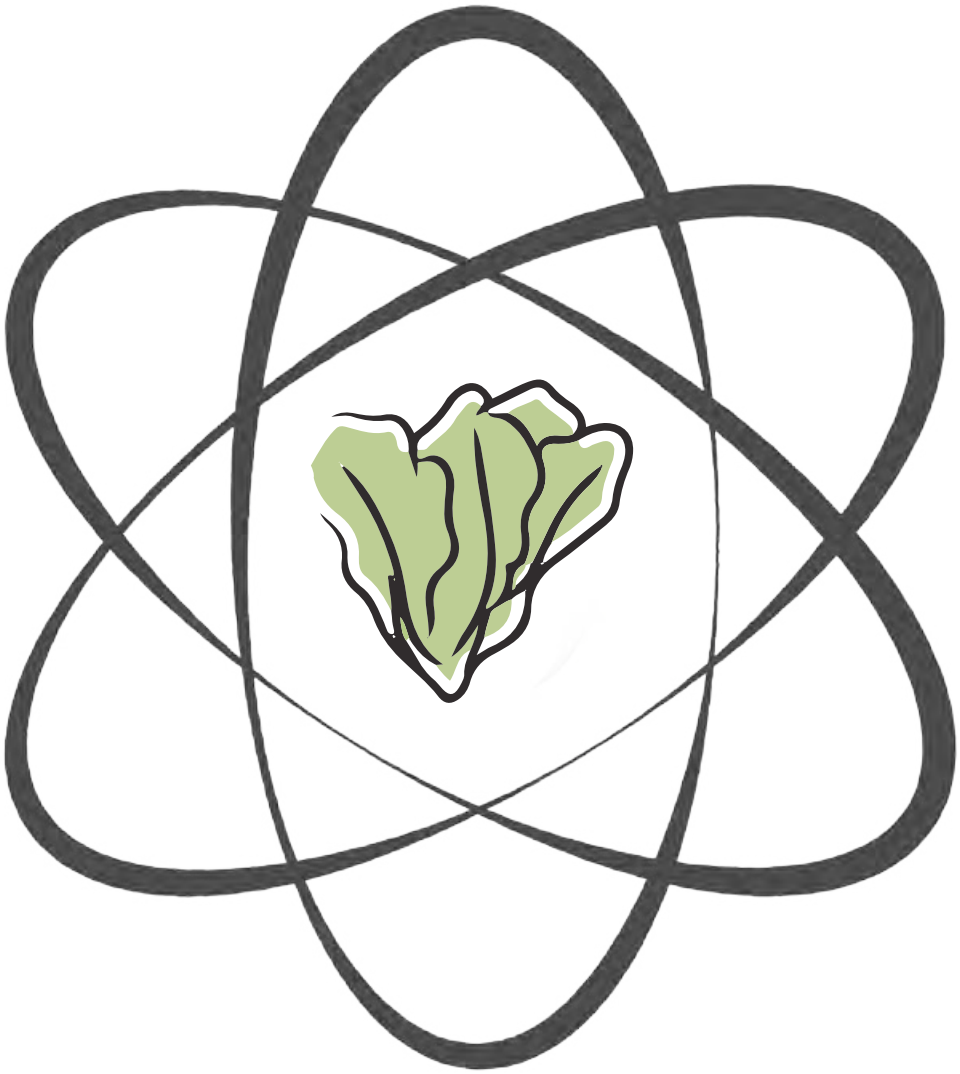
Storage:

Although root veggies can be left at room temperature without spoiling for longer periods than many other vegetables, they can also begin sprouting or decomposing when exposed to light or warmth for extended periods! As a general rule, they store best when unwashed, in cool, dark, humid spaces, at temperatures between 32 and 40 degrees F. Keeping them in paper or plastic bags in the crisper is ideal. For root veggies that have their greens still attached, removing the greens and storing them separately can help prevent early spoilage.

Seasonality:

- **BEETS**: Beets are typically in season from late summer through late fall or early spring.
- **CARROTS**: Carrots are available year-round, but they are at their best in the summer and fall.
- **CASSAVA**: Cassava can be harvested year-round!
- **CELERY ROOT**: Celery root's peak season is the fall and spring.
- **JERUSALEM ARTICHOKES**: Jerusalem artichokes are in season in the late fall and winter.
- **KOHLRABI**: Kohlrabi is also a cool-weather crop, and is typically in season from early spring through late fall.
- **PARSNIPS**: Parsnips are at their best in the fall and winter.
- **POTATOES**: Potatoes are available year-round, but their peak season is in the fall and winter.
- **RADISHES**: Radishes are a spring and fall crop, with peak season being in the cooler months.
- **RUTABAGAS**: Rutabagas are in season from early fall through spring.
- **SWEET POTATOES**: Sweet potatoes are in season in the fall, although they're generally available year-round.
- **TARO**: The best season for taro is typically late summer.
- **TURNIPS**: Turnips are a cool-weather crop and are typically in season from late fall through early spring.

Leafy Greens



Introduction to Leafy Vegetables

When it comes to nutritional bang for the calorie buck, it's hard to beat leafy vegetables! These versatile foods have been part of the human diet since time immemorial, eventually earning their place as staples in ancient cultures around the globe. For example, lettuce was first farmed in Ancient Egypt as early as 2680 BC, where it went from being a wild-growing weed to a food crop used for its leaves and seed oil. Selection of brassica plants with enlarged leaves led to the development of kale in 5th century BCE. Meanwhile, Ancient Egyptians and Romans considered arugula leaves an aphrodisiac—and some writers even suggest this was the reason monasteries were forbidden to grow arugula during the Middle Ages!

Today, leafy vegetables are known not only for their culinary diversity, but also for their outstanding health benefits. In fact, they're among the most nutrient-dense foods on the planet, packed with phytonutrients, micronutrients, and fiber. Don't be-leaf it? Lettuce take a closer look at this fantastic food group!

What Are Leafy Vegetables?

Leafy vegetables include any plant leaves eaten as vegetables. And while many food groups are united by a specific taxonomic family, leafy vegetables include members from all over the plant kingdom!

Most of the leafy veggies we eat come from the lettuce family, chard family, chicory family, Brassica (cruciferous) family, parsley (umbellifer) family, and mint family, but we also eat members of the legume family (such as pea shoots), the plantain family (such as broadleaf plantain), the daisy family (such as dandelion greens), the carnation family (such as chickweed), the valerian family (such as lamb's lettuce), the buckwheat family (such as sorrel), and the morning glory family (such as sweet potato greens and water spinach)... just to name a few!

Some of the most common leafy vegetables from the lettuce family include:

- BUTTERHEAD LETTUCE
- GREEN LEAF
- ICEBERG LETTUCE
- OAK LEAF LETTUCE
- RED LEAF
- ROMAINE LETTUCE
- SUMMERCRISP LETTUCE

And from the chicory family:

- BELGIAN ENDIVE
- CURLY ENDIVE
- ESCAROLE
- FRISÉE
- RADICCHIO

And from the chard family:

- AMARANTH GREENS
- BEET GREENS
- LAMBSQUARTERS
- SPINACH
- SWISS CHARD

And from the brassica family:

- ARUGULA
- BOK CHOY
- BROCCOLI LEAVES
- CABBAGE
- COLLARD GREENS
- GAI LAN
- GARDEN CRESS
- KALE
- MUSTARD GREENS
- RAPINI (BROCCOLI RABE)
- RED CABBAGE
- SAVOY CABBAGE
- WATERCRESS

And from the parsley family:

- CARROT TOPS
- CELERY
- CILANTRO
- DILL
- FENNEL
- HOGWEED
- LOVAGE
- PARSLEY

And from the mint family:

- BASIL
- LAVENDER
- LEMON BALM
- PEPPERMINT
- SAGE
- SPEARMINT
- TARRAGON

On top of "full size" leafy vegetables, microgreens are worth a mention here too! Microgreens are the tasty small shoots of vegetables and herbs, picked right after the first leaves have developed. Along with having delicate textures and distinctive flavors, microgreens are bursting with nutritional goodness. In fact, microgreens are significantly more nutrient-dense than their fully grown counterparts—boasting around a 40% higher concentration of phytonutrients, along with impressive levels of chlorophyll, carotenoids, and many vitamins and minerals. They also contain fewer anti-nutrients than mature plants, making it easier for our bodies to access the minerals they contain.

Common microgreens include:

- BRASSICA FAMILY MICROGREENS *(cauliflower, broccoli, watercress, radish, arugula, cabbage, mustard, kale, kohlrabi)*
- LETTUCE MICROGREENS
- CHICORY FAMILY MICROGREENS *(endive, chicory, radicchio)*
- ALLIUM FAMILY MICROGREENS *(garlic, onion, leek, chives)*
- MELON FAMILY MICROGREENS *(melon, squash, cucumber)*
- CHARD FAMILY MICROGREENS *(amaranth, Swiss chard, beet, spinach, quinoa)*
- PARSLEY FAMILY MICROGREENS *(dill, carrot, celery, fennel)*
- MINT FAMILY MICROGREENS *(basil, marjoram, mint, rosemary, sage, oregano)*

What Makes Leafy Vegetables So Great?

One of the coolest things about leafy vegetables is their diversity of health-promoting compounds. Because they can come from so many different plant families, they possess a huge array of phyto-nutrients micronutrients, and of course, fiber. Let's take a look at what these tasty veggies have to offer!

Phenomenal Phytonutrients

When it comes to the phytonutrients in leafy vegetables, some are near-universal for this food group and some are specific to certain plant families.

For starters, leafy green vegetables are among the only foods that contain **sulfoquinovose**—a unique sulfur-containing sugar derived from glucose. In plants, it plays a role in photosynthesis; in humans, it may have important effects on gut health! Specifically, sulfoquinovose promotes the growth of a select few gut bacteria, one being **Eubacterium rectale**—a key microbe for producing butyrate, reducing intestinal inflammation, and maintaining colonic motility. Kale, spinach, and watercress are particularly high in this special phytonutrient!

Green-colored leafy vegetables are also excellent sources of **chlorophyll**—the pigment that traps light for photosynthesis and gives plants their green color. It boasts significant anti-inflammatory and antioxidant properties, with some research even showing it can beneficially modulate the gut microbiota—including in ways that contribute to healthy body composition.

What's more, the chlorophyll in green leafy vegetables is also a powerful cancer fighter, capable of binding to carcinogens and inhibiting their intestinal absorption—in turn preventing them from reaching our tissues and causing harm. In fact, chlorophyll binds to some of the most widespread foodborne carcinogens we're exposed to, including those that form when cooking meat at high temperatures (polycyclic aromatic hydrocarbons and heterocyclic amines) and those that can contaminate peanuts, corn, and dried spices (aflatoxin-B1). Chlorophyll can also help mitigate the potentially carcinogenic properties of heme iron—the form of iron abundant in red meat!

Leafy vegetables with a purplish or reddish color—such as red cabbage and purple kale—contain a group of flavonoids called **anthocyanins**. Anthocyanins appear to have anti-inflammatory and neuroprotective effects, could improve glucose tolerance, may reduce the risk of chronic diseases like heart disease and cancer, and may even have pain-relieving properties (due to an affinity for certain "pain-sensation" cell membrane receptors in the brain!).

Dark green leafy vegetables are also outstanding sources of carotenoids—plant pigments that increase resistance to oxidative stress, reduce inflammation, and have been shown to support vision health (particularly age-related eye diseases like macular degeneration and cataracts). Research shows a high intake of carotenoids could even protect against metabolic syndrome and diabetes! In particular, vegetables like spinach, kale, and collard greens tend to be high in beta-carotene (a precursor to vitamin A) and lutein (a carotenoid present in high concentration in the retina, and that helps filter harmful blue-light rays).

On top of all that, leafy vegetables boast some specific phytonutrients associated with the particular plant family they come from! Lettuces, for example, have several health-promoting compounds not found in other vegetables. These include a special carotenoid called **lactucaxanthin**, which demonstrates anti-diabetic activity, as well as the compounds **lactucin** and **lactucopicrin**, which have potent pain-reducing properties and gentle sleep-inducing effects!

Meanwhile, one of the standout features of chard family leafy vegetables is the presence of **betalains**—a group of phytonutrients that give many of these vegetables their unique coloration. For example, betalains are responsible for the burgundy hue in beet leaf stems, and the yellow, pink, or red color of Swiss chard stems!

Brassica family plants are exclusive sources of glucosinolates—a type of sulfur-containing phytonutrient that gives these veggies their characteristic pungent flavor. Leafy brassicas are no exception! **Glucosinolates** break down into another compound, **isothiocyanates**, when damaged via chewing, cutting, or other processing. Isothiocyanates, in turn, have tremendous anti-cancer properties, including against bladder cancer, lung cancer, colon cancer, breast cancer, and pancreatic cancer. In fact, one particular isothiocyanate, **sulforaphane**, has become famous for its cancer-fighting activity, with studies showing it can block DNA mutations and stop cancer cells from multiplying!

Leafy members of the parsley family (such as parsley, carrot tops, dill, fennel, and cilantro) are known for containing **apigenin**—a type of flavone with wide-ranging protective effects against diabetes, Alzheimer's

disease, depression, insomnia, and cancer. It's also shown antimicrobial activity against a number of pathogens, including many of the ones responsible for foodborne illness. And, parsley family leaves also contain phytonutrients called **phthalides**, which support cardiovascular health and can help reduce high blood pressure!

And no phytonutrient spotlight would be complete without a tour of the mint family leafy vegetables! Basil, lemon balm, spearmint, peppermint, tarragon, lavender, and sage not only have delightful flavors and aromas; they're also rich in volatile oils and an astounding number of phytonutrients. These include **rosmarinic acid** (a powerful anti-inflammatory and anti-cancer compound, with potential benefits for arthritis, colitis, and atopic dermatitis); **ursolic acid** (a triterpene compound that can improve insulin signaling, reduce heart tissue damage, fight inflammation, boost antioxidant levels in the brain, protect against muscle wasting, and block cancer growth), **limonene** (a monoterpene that exhibits anti-cancer, antioxidant, anti-inflammatory, pain-reducing, cardio-protective, liver-protective, anti-microbial, immune-modulating, and diabetes-reducing activity)... just to name a few!

Believe it or not, that's still just scratching the surface of the phytonutrient goodness in leafy vegetables. The flavonoids **quercetin** and **kaempferol** present in leafy greens like kale have been extensively studied for their protective activity against heart disease, inflammation, cancer, and hypertension. Chickweed contains phytonutrients like **phytosterols** and **saponins** that have been shown to support digestion and healthy body composition. And dandelion greens contain an anti-diabetic phytonutrient called **chlorogenic acid**!

Magnificent Micronutrients

As far as vitamin and minerals go, leafy vegetables pack a mighty bang for the buck! These veggies vary in their exact nutritional profiles, but they tend to be high in the following micronutrients:

- VITAMIN K, which plays a vital role in coagulation, bone metabolism, cellular function, and the prevention of soft tissue calcification. A two-cup serving of raw kale contains 162% of the DV for this nutrient! Cabbage, garden cress, watercress, gai lan, bok choy, and mustard greens are also wonderful sources.
- VITAMIN B9 (FOLATE), an essential B vitamin that plays roles in blood cell production, the formation of genetic material (including DNA), cell growth, cardiovascular health, cancer protection, and cognitive and neurological health. Kale, collard greens, mustard greens, gai lan, and savoy cabbage are all great sources!
- VITAMIN C, a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production. Mustard greens, kale, gai lan, garden cress, bok choy, savoy cabbage, and cabbage are chock full of vitamin C!
- CALCIUM, a major structural component of bones and teeth that also serves as an electrolyte—a type of electricity-conducting mineral needed for regulating nerve impulses, muscle contraction, heartbeat, blood pH, and fluid balance. Mustard greens, kale, and collard greens all contain 10% or more of the DV for calcium per two-cup serving.

- **MANGANESE**, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Mustard greens, kale, gai lan, garden cress, savoy cabbage, and collard greens all contain notable amounts!

Fabulous Fiber

Across the board, leafy vegetables are fantastic sources of fiber. Fiber is a great example of a nutrient that isn't labelled as essential, but that is absolutely fundamental for our health! Along with regulating gut motility (promoting regularity) and some gastric hormones, it supplies our gut bacteria with fermentable substrate (i.e., food!) so that important microbes can flourish and remain diverse.

High fiber intake also reduces the risk of cardiovascular disease and of many forms of cancer (especially colorectal cancer, but also liver cancer, pancreatic cancer, and others), and promotes overall lower inflammation. High-fiber diets reduce the risk of mortality in cases of kidney disease and diabetes, and can even reduce your risk of dying from an infection!

Although all leafy vegetables supply plenty of fiber, leafy members of the chicory family deserve a shout-out for their high content of inulin—a prebiotic fiber with tremendous benefits for gut health (including boosting levels of the beneficial Bifidobacterium genus). Although most heavily concentrated in chicory root, inulin is also present in smaller amounts in the leaves of chicory family vegetables (think: endive, escarole, frisée, radicchio!).

Per serving, leafy vegetables contain the following amounts of fiber:

- **ARUGULA**: 0.6g
- **BASIL**: 0.1g
- **BEET GREENS**: 2.8g
- **BELGIAN ENDIVE**: 3.1g
- **BOK CHOY**: 1.0g
- **BUTTERHEAD LETTUCE**: 1.21g
- **CABBAGE**: 2.0g
- **CELERY**: 1.6g
- **CILANTRO**: 0.2g
- **COLLARD GREENS**: 2.9g
- **CURLY ENDIVE (CHICORY)**: 2.3g
- **DANDELION GREENS**: 3.9g
- **DILL**: 0.2g
- **FENNEL**: 2.8g

- GARDEN CRESS: 1.1g
- GREEN LEAF LETTUCE: 1.3g
- ICEBERG LETTUCE: 1.2g
- KALE: 4.1g
- MUSTARD GREENS: 3.2g
- NEW ZEALAND SPINACH: 1.5g
- PARSLEY: 3.3g
- PEPPERMINT: 8.0g
- RADICCHIO: 0.9g
- RAPINI (BROCCOLI RABE): 2.7g
- RED CABBAGE: 2.1g
- RED LEAF LETTUCE: 0.9g
- ROMAINE LETTUCE: 2.1g
- SAVOY CABBAGE: 3.1g
- SPEARMINT: 6.8g
- SPINACH: 2.2g
- SWEET POTATO GREENS: 5.3g
- SWISS CHARD: 1.6g
- WATER SPINACH: 2.1g
- WATERCRESS: 0.5g

Health Benefits of Leafy Vegetables

Given their awesome phytonutrient, micronutrient, and fiber profiles, it shouldn't come as a surprise that Leafy veggies have demonstrated wide-ranging health benefits and protection against a number of diseases. Here's a rundown of the many ways they've been scientifically shown to benefit our health!

Reduced risk of cardiovascular disease:

Leafy vegetables are awesome for the heart! A prospective study from 2013 found that consuming 1.5 servings of leafy greens per day, versus 1.5 servings per week, is associated with a 17% lower risk of coronary heart disease.

Better cognitive health:

A prospective study from 2018 found that eating just 1.3 servings of green leafy vegetables per day is associated with the equivalent of being 11 years younger in cognitive age.

Likewise, a 2019 cross-sectional study found that for people 55 and older, eating some leafy vegetables every day (versus not eating them every day) is associated with a whopping 78% reduction in risk of mild cognitive impairment!

Reduced risk of breast cancer:

Leafy vegetables could slash the risk of one of the most common cancers. A prospective study from 2012 tracked over 31,000 women and found that for every 50-gram increase in leafy vegetable consumption per day, the risk of developing breast cancer dropped by 15%. (For reference, 50 grams of kale is less than a cup!) This same study found that participants eating over 56 grams of leafy vegetables daily had a 30% lower risk of developing breast cancer, compared to those eating less than 15 grams daily.

Reduced risk of lung cancer:

For people at high risk of lung cancer, regularly eating salads can be enormously protective. A 1993 case-control study found that relative to eating no lettuce, eating lettuce more than three times per week reduced the risk of lung cancer by 49% among former and current smokers.

Reduced risk of colorectal cancer:

Upping those leafy veggies could protect against colorectal cancer! A case-control study from 2017 found that men with the highest versus the lowest intake of green vegetables had a 51% lower risk of developing colorectal cancer. Similarly, in a 2004 prospective study of over 107,000 men and women, frequent green leafy vegetable consumption was associated with a 40% lower risk of death from rectal cancer.

Reduced risk of stomach cancer:

Leafy vegetables can even protect against stomach cancer! In a 2006 prospective study of over 81,000 adults, those consuming at least three servings of green vegetables per week had a 36% lower risk of stomach cancer than those consuming less than half of a serving per week.

Reduced risk of diabetes:

Leafy vegetables can dramatically reduce the risk of diabetes. A cross-sectional study from 1999 found that compared to infrequent consumption of salad vegetables (including leaves), eating salad vegetables daily or near-daily all year long was associated with an 84% lower risk of diabetes. (The all-year-long part is the key here: eating these veggies only during the summer didn't offer the same protection!)

And, a 2008 prospective study of over 71,000 nurses found that for every additional serving of leafy vegetables consumed per day, diabetes risk dropped by 9%!

And, a variety of animal studies have found that red cabbage in particular can combat not only diabetes, but also complications of the disease. For example, in animal models of diabetes, red cabbage extract has been shown to ameliorate diabetic nephropathy, inhibit digestive enzymes linked to type 2 diabetes, lower blood sugar levels, lower glycated hemoglobin levels, improve glucose tolerance, and increase the number of pancreatic beta-cells—all while also reducing vascular complications caused by diabetes.

Reduced risk of non-alcoholic fatty liver disease:

Eating leafy vegetables on a daily basis could protect against fatty liver disease. According to a cross-sectional study from 2021, eating leafy green vegetables at least seven times per week was associated with a 28% lower risk of developing non-alcoholic fatty liver disease, compared to almost never eating green vegetables.

Improved gut health:

In a 2022 study of rotational shift workers, dark green leafy vegetable consumption was associated with higher production of beneficial short-chain fatty acids in the gut. In an experiment with rats, a diet supplemented with kale was able to improve microbial

diversity, enhance several bacterial metabolic functions, and combat the inflammatory state induced by a high-fat diet!

Improved bone health:

A 2009 study of female college students found that daily consumption of green vegetables (including leaves) was associated with a five-fold lower risk of low bone mass, compared to not eating green vegetables daily! And, a randomized controlled trial from 2020 found that among middle-aged and older individuals, consuming 200 grams of leafy vegetables daily improved markers of bone formation—which, if continued, would be expected to boost long-term skeletal health.

Lower risk of death from all causes:

There's even evidence that leafy veggies reduce the risk of all-cause mortality. A 2019 review found that for every 100 grams of green leafy vegetables or salad eaten per day (that's less than a quarter of a pound!), there was a 22% reduction in all-cause mortality.

Leafy Vegetables Nutrivore Scores

Given their ultra-low calorie content and ultra-high nutrient content, it shouldn't come as a surprise that leafy vegetables knock it out of the ballpark in terms of Nutrivore Scores! As a group, leafy vegetables have an average Nutrivore Score of 3476. On a veggie-by-veggie basis, their scores are:

Arugula	2019
Basil	3381
Beet greens	3259
Belgian endive	2390
Bok choy	3428
Butterhead lettuce	1934
Cabbage	1857
Celery	767
Cilantro	2609
Collard greens	3323
Curly endive	3086
Dandelion greens	2815
Dill	1940
Fennel	663
Fiddlehead	1721
Gai lan	2431
Garden cress	11265
Green leaf Lettuce	2245
Iceberg lettuce	773

Kale	4233
Mustard greens	5464
New Zealand spinach	5541
Parsley	5491
Peppermint	1011
Radicchio	2171
Rapini (broccoli rabe)	4155
Red cabbage	1369
Red leaf	2684
Romaine lettuce	2128
Savoy cabbage	1321
Spearmint	914
Spinach	4548
Sweet potato greens	1775
Swiss chard	6198
Water spinach	1297
Watercress	6929

What About Iceberg Lettuce?!

You've probably heard rumors that iceberg lettuce is the nutritional equivalent of cardboard—barely supplying anything other than water and some fiber. Although it's true that iceberg lettuce doesn't pack quite the nutritional punch that other lettuces do (it has about a third of the nutrients per calorie of other lettuce types), it's still filled with fiber, vitamin K, and polyphenols. In fact, iceberg lettuce is more nutrient-dense than a number of other foods widely considered health promoting, such as blackberries and sockeye salmon. So, there's no need to avoid iceberg lettuce— especially if you enjoy its mild, crispy crunch!

Some Practical Pointers

If you've ever opened a bag of spinach and found a clump of slimy leaves, or found yourself tossing out half a head of lettuce due to wilting and browning, you've probably realized how delicate these vegetables can be! Luckily, proper selection and storage can help them stay fresh and flavorful.

Selection:

- Choose fresh-looking leafy vegetables with vibrant color and crisp leaves. Avoid any that are wilted, yellowing, or showing dark spots.
- Check for moisture, avoiding leaves that are overly wet or slimy.
- Inspect the stems for signs of browning or rot; fresh stems indicate the leafy vegetables are still relatively young and may have a longer lifespan in the fridge.
- When possible, choose seasonal! Although leafy vegetables are often available year-round, choosing the varieties in season helps ensure the best flavor and nutrient content.

Storage:

- Refrigerate immediately! To help extend their lifespan, refrigerate your leafy vegetables as soon as possible after bringing them home.
- Keep them dry—moisture can lead to spoilage and decay.
- If purchased pre-washed in a plastic clamshell container, store in the refrigerator as-is, making sure to keep the container sealed and tightly closed after opening.
- If purchased loose, pick out any wilted, slimy, or browning leaves, and wash and dry the remaining ones. You can wash your leafy veggies by submerging them in a bowl of cold water, lifting and re-dunking gently until any dirt or debris is removed, and then drying in a salad spinner.
- If you're short on fridge space, you can use the "rolling method" to store! Lay the veggies out on paper towels, loosely roll the towels, then place the roll into a re-sealable bag and store in the crisper drawer.

- If you have more abundant fridge space, you can use larger containers to store (this will help prevent your leafy veggies from getting crushed)! Line the bottom of a lidded container with paper towels, loosely fill the container with your leafy vegetables, then add one more layer of paper towels before securing the lid.
- Even when stored properly, tender veggies (like baby spinach, arugula, and butterhead lettuce) generally won't last beyond a week, so eat ASAP! Heartier leafy vegetables (like kale, swish chard, broccoli rabe, or collards) can generally last a bit longer.

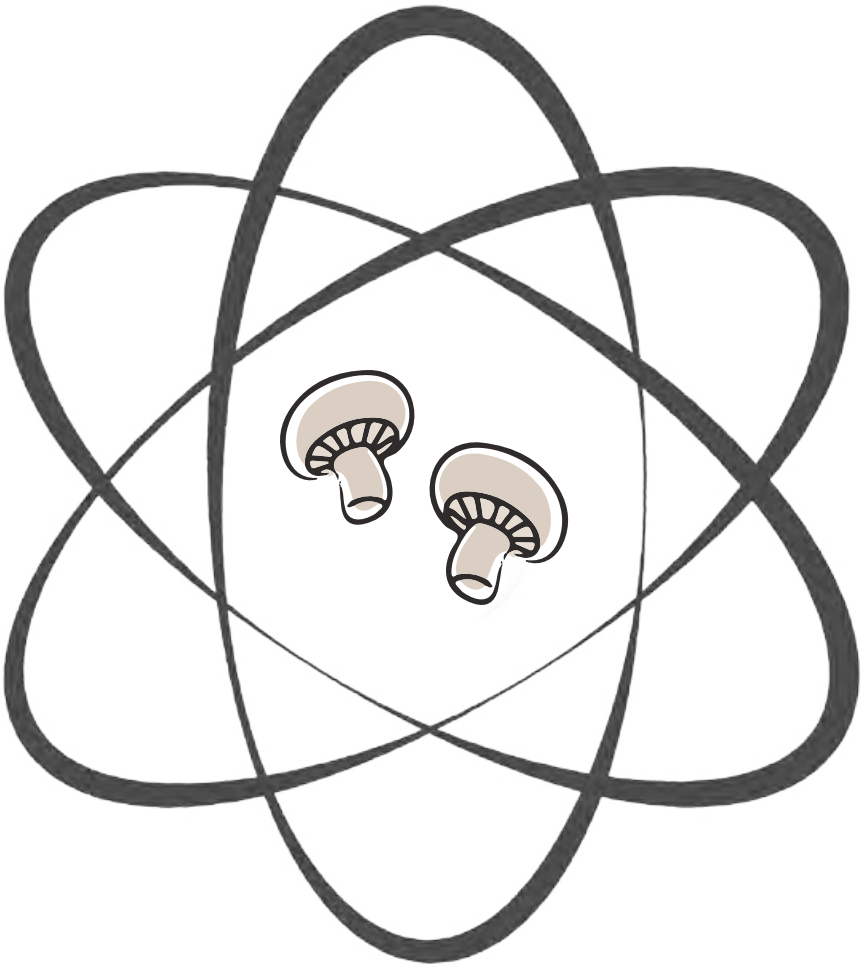
Seasonality:

Leafy vegetables have different peak seasons depending on the climate, local growing conditions, and the specific type of leafy green. With that in mind, here are the general seasons for some popular leafy greens!

- ARUGULA: Arugula is a cool-weather crop that is typically in season from early spring through late fall.
- BOK CHOY: Bok choy is also a cool-weather crop that is typically in season from late fall through early spring.
- CHICORY (ENDIVE, RADICCHIO): Chicory varieties like endive and radicchio are often in peak season in the fall and winter.
- COLLARD GREENS: Collard greens are in season from late fall to early spring, with peak season being in the winter months.
- KALE: Kale is a hardy green that can be grown year-round, but its peak season is from mid-winter through early spring!
- LETTUCE: Many types of lettuce, such as iceberg, are available year-round—but generally speaking, lettuces are a cool-weather crop most widely available in the early spring and fall.
- MUSTARD GREENS: Mustard greens are in season in the cooler months of the year, typically from late fall through early spring.
- SPINACH: For spinach, peak season is typically in the spring (March to June) and fall (September to November). It tends to bolt (go to seed) in hot weather, so it's often harvested before the summer heat!
- SWISS CHARD: Swiss chard is typically in peak season from late spring through early fall. It can withstand some heat, but it's often at its best in cooler temperatures.

Given the enormous assortment of leafy vegetables out there, you can always check with local farmers or markets to see what's in season in your area!

Mushrooms



Introduction to Mushrooms

Edible mushrooms have a rich history of consumption in cultures around the globe. For example, the ancient Greeks believed that mushrooms could help give warriors strength while they fought, and Roman emperors employed "food tasters" to make sure the mushrooms they ate weren't poisonous. In Chile, edible mushrooms have been found in archaeological sites dating back 13,000 years. Egyptian pharaohs prized mushrooms as a delicacy, while commoners were prohibited from eating (or even touching!) them. Even Ötzi the Iceman, Europe's oldest known human mummy, was carrying two species of mushrooms when he died—both of which were preserved along with his body in glacier ice!

Today, mushrooms continue to be highly valued for their taste (hello, umami!), versatility, and medicinal qualities. But, the full extent of their benefits reach as far and wide as the mycelium they spring from. Let's take a tour of the fabulous fungus among-us!

What are Mushrooms?

Although they're often lumped in with vegetables, mushrooms are technically neither plant nor animal: they're part of an entirely separate biological kingdom called fungi. Specifically, mushrooms are the fleshy, fruiting bodies of fungi, emerging from a larger underground root-like network called the mycelium. Discernable by their stem and cap structure, mushrooms can vary tremendously in size, shape, color, and texture. One of their most unique differences relative to the plant kingdom is that they don't contain chlorophyll to produce their own food (energy); rather, they extract nutrients from other organisms—both dead and alive!

While the fungi kingdom encompasses seven different phyla, the vast majority of edible mushrooms belong to only two of them: the Basidiomycota phylum (which includes "gilled" mushrooms like the common mushroom, shiitake, oyster, enoki, maitake, cremini, portabella, puffballs, boletus, and chanterelles), and the Ascomycota phylum (which features truffles and morels). Of course, many tens of thousands of mushrooms belong to these phyla, too, that aren't edible!

Currently, over 200 mushroom species are cultivated for human consumption, though only a small fraction of them are widely available.

What Makes Mushrooms So Great?

Given their unique not-a-plant, not-an-animal status, it's not surprising that mushrooms contain some important and unusual compounds. Here's a rundown of the most notable ones!

Ergothioneine

One of the most awesome nutritional features of mushrooms is their high content of ergothioneine—also known as the "longevity vitamin!"

Ergothioneine is a non-proteinogenic amino acid derived exclusively from our diet. It has powerful antioxidant, anti-inflammatory, and detoxification properties shown to combat diseases associated with aging and oxidative stress. And, it has an ability to absorb ultraviolet light—giving it a role in preventing DNA damage associated with UV radiation! Research suggests it can help protect against cardiovascular disease, cancer, liver disease, cataracts, frailty, and Alzheimer's disease, while also enhancing memory, reducing the risk of depression, reducing neuroinflammation, and improving sleep. There's even evidence for a beneficial role in female fertility and pregnancy (including supporting fetal development and reducing the risk of preeclampsia)!

Amazingly, studies show that ergothioneine reduces all-cause mortality and is associated with longer lifespan. For example, a 2020 study that followed 3200 health-conscious people for over two decades found that out of 112 different metabolites in their blood, ergothioneine was the dominant predictor of cardiovascular disease and all-cause mortality. More specifically, the higher the blood levels, the lower the risk of cardiovascular disease and death! Similarly, another 2020 study showed that lower dietary intake of ergothioneine in America compared to four European countries correlated strongly with shorter average lifespan.

Although scientists are still studying how this fascinating nutrient works, we know that it plays a major role in ageing-related signaling cascades in the body, which have a linear relationship with lifespan. And, it appears particularly important as a "stress vitamin" that comes into play during times of disease, duress, inflammation, and other damaging states.

Mushrooms exceptionally high in ergothioneine are shiitake (24.4 mg per cup), enoki (19.4 mg per cup), maitake (12.2 mg per cup), and oyster (11.3 mg per cup). In fact, these mushrooms are the very best sources of er-

gothioneine out of any food, containing many times more than the highest non-mushroom source (tempeh, which contains 3.4 mg per serving). However, all mushrooms will supply at least some ergothioneine, and collectively rank as the leading dietary source of this nutrient!

Phenomenal Phytonutrients

Mushrooms contain a truly impressive array of phytonutrients, all with their unique contributions to health. Some of the standouts include:

- CATECHINS, which act as antioxidants as well as boost the activity of antioxidant enzymes. Catechins are also anti-inflammatory, modulate the immune system, exert anti-bacterial activity, have anti-cancer properties, and can boost metabolism and promote healthy weight loss.
- GALLIC ACID, which can reduce inflammation and possibly help treat depression and infection.
- GENTISIC ACID, which has anti-inflammatory, antioxidant, and antirheumatic properties—while also protecting cells from gamma radiation!
- MYRICETIN, which can help protect against neurodegenerative diseases (like Parkinson's and Alzheimer's), glaucoma, diabetes, inflammation, liver damage, cardiovascular disease, photoaging, thrombosis, allergies, and hypertension.
- P-COUMARIC ACID, which can help regulate the immune system, improve bone density, protect against gancer and kidney damage, and even protect against tissue damage induced by alcohol and drugs.
- PROTOCATECHUIC ACID, a potent antioxidant that can protect against liver damage, cardiovascular disease, cancer, ulcers, and bacterial or viral infection.
- SYRINGIC ACID, which may protect against cancer, diabetes, liver damage and lung damage.
- VANILLIC ACID, which can act as a pain reliever while also protecting against infection and liver damage—as well as delivering awesome antimicrobial properties!

Mushrooms are also particularly rich in a class of phytonutrient called triterpenes (including ergosterol, ganoleucoin, ganoderic acid and pyrrole alkaloids), which have wide-ranging benefits for sleep, focus, liver function, immunity, brain function, nervous system health, digestion, blood pressure regulation, and cancer protection. About 80 different triterpenes have been isolated from reishi alone, some of which are known to kill liver cells, inhibit histamine release from mast cells (providing an anti-allergic effect), and deliver cardioprotective effects.

Vitamin D

Although mushrooms are rich in a number of micronutrients (as we'll see next!), vitamin D deserves a special shout-out here! One of mushrooms' many unique features is their ability to produce vitamin D in response to UV exposure, due to naturally containing several vitamin D precursors (including ergosterol,

a precursor to vitamin D2, and 22,23-dihydroergosterol, a precursor to vitamin D4). In fact, mushrooms are the only non-animal food with notable amounts of bioavailable vitamin D!

In general, wild-harvested mushrooms contain high levels of vitamin D (often the entire daily value!) due to being exposed to sunlight out in nature, while commercially grown mushrooms contain negligible amounts (due to being grown in atmospherically controlled growing rooms with little to no UV light). But, some growers intentionally expose their mushrooms to UV radiation to produce vitamin D as well. These mushrooms will typically be labeled as containing vitamin D on the package, and can boast just as much—if not more—vitamin D than wild mushrooms.

And, here's where it gets exciting: mushrooms can actually generate vitamin D in response to UV exposure even after they've been harvested! A variety of studies show that exposing fresh-picked mushrooms, such as white button or oyster, to sunlight for 15 – 30 minutes increases their vitamin D content up to at least 25% of the DV, and often much higher (100% of the DV or more!). Sliced mushrooms generate even higher vitamin D quantities, due to increased surface area allowing for greater exposure of vitamin D precursors to UV light. Sun-dried mushrooms also generate vitamin D during their dehydrating process, regardless of how they were grown.

That's right: this means you can make your own "vitamin D enhanced" mushrooms at home, simply by giving them some sunlight prior to use. Pretty cool, huh?

Magnificent Micronutrients

Beyond vitamin D, mushrooms are fabulous sources of some other vitamins and minerals. They contain notable quantities of:

- COPPER, a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). Mushrooms rich in copper include cremini (48% of the DV per cup!) and white button (34% of the DV); portobella, oyster, and maitake mushrooms contain about a quarter of the DV for this nutrient.
- SELENIUM, a trace mineral that helps form over two dozen selenoproteins involved in reproduction, thyroid hormone metabolism, antioxidant defense, DNA synthesis, and immunity. High-selenium mushrooms include cremini (41% of the DV per cup!) and portabella (29% of the DV).
- VITAMIN B5 (PANTOTHENIC ACID), a water-soluble B vitamin that serves as a cofactor for coenzyme A—which in turn is critical for metabolizing many drugs and toxins and synthesizing cholesterol, fatty acids, melatonin, the neurotransmitter acetylcholine, steroid hormones, heme, and vitamins A and D. White button, cremini, and shiitake mushrooms all contain a little over a quarter of the DV for this nutrient per cup!
- VITAMIN B2 (RIBOFLAVIN), a vitamin that helps form important coenzymes involved in oxidation-reduction reactions, antibody production, energy production, growth and development, skin and hair health, and the metabolism of several other nutrients. Mushrooms rich in riboflavin include cremini (33% of the DV per cup), white button (30% of the DV), and oyster (23% of the DV).

- VITAMIN B3 (NIACIN), a water-soluble B vitamin that's needed for over 400 enzymes involved in DNA repair, fatty acid synthesis, antioxidant systems, detoxification, hormone synthesis, and macronutrient breakdown. Maitake mushrooms contain 32% of the DV for niacin per cup, while oyster, portabella, and white button mushrooms contain around a quarter of the DV.
- VITAMIN B7 (BIOTIN), a water-soluble B vitamin that plays an important role in energy metabolism (serving as a coenzyme for five carboxylase enzymes), neurotransmitter production, cellular function, and the function of various organs. Per cup, maitake mushrooms contain 65% of the DV for biotin, while white button, portabella, and cremini mushrooms contain around half the DV.

Fabulous Fiber

One of the most fascinating differences between plants and mushrooms lies in their fiber type. While the cell walls of plants are made of cellulose, the cell walls of mushrooms are composed of entirely different carbohydrate structures—namely chitin, chitosan, and glucans. And, these fibers offer some powerful perks, especially for the gut!

- CHITIN is a type of fermentable oligosaccharide fiber found only in a handful of foods (apart from mushrooms, it's in insect exoskeletons, fish scales, and the shells of crustaceans). It's particularly beneficial for immunity and gut health, with studies showing it can support the growth of beneficial bacteria such as Bifidobacterium, Lactobacillus, Bacteroides, and Akkermansia, while also decreasing levels of the inflammatory microbe Desulfovibrio. Chitin has also been shown to protect gut barrier integrity in animal models of metabolic syndrome, while also normalizing the gut microbiota composition.
- CHITOSAN is a polysaccharide that's only naturally occurring in the cell walls of fungi, including mushrooms. A variety of experiments show chitosan increases gut microbial diversity and decreases levels of potential pathogens (such as Escherichia and Shigella), while also reshaping the gut microbiota to induce anti-diabetic effects. It's also been shown to suppress the growth of Helicobacter, a microbe responsible for stomach ulcers.
- GLUCANS are polysaccharides with impressive immune-modulating and anti-inflammatory qualities. Mushrooms are particularly rich sources of beta-glucans (more specifically, (1-3),(1-6)-beta-glucans, which are different than the type of beta-glucans in grains like oats), which play an extremely positive role in gut health—including feeding populations of beneficial bacteria like Lactobacillus and Bifidobacterium, and increasing the production of short-chain fatty acids. Research suggests that this fiber's actions upon the gut microflora (as well as bacterial metabolites) contributes to its anti-cancer, anti-inflammatory, anti-diabetic, cardio-protective, and immune-modulating effects!

Health Benefits of Mushrooms

When it comes to human health, mushrooms' nutritional uniqueness translates to some powerful disease protection. An ever-growing body of research suggests mushrooms (and their unusual compounds) can boost our health on a number of fronts. Here's a rundown of their best-studied health benefits!

Reduced risk of cancer:

Mushrooms and their polysaccharides have been shown to exhibit anti-tumor activities across a number of cancer cell types. So far, at least 32 species of mushrooms have shown anti-cancer potential! And, human studies confirm a protective effect of mushrooms on cancer incidence and death. A 2021 meta-analysis found that people with the highest versus lowest mushroom consumption had a 34% lower risk of cancer. Additional research suggests a protective effect of mushrooms against some specific cancer types, including:

- BREAST CANCER: A 2021 meta-analysis found that people with the highest versus lowest intake of mushrooms had a 35% lower risk of developing breast cancer. And, a 2010 study suggested that greater mushroom intake was particularly protective against hormone receptor positive tumors (a 70% lower risk for highest versus lowest mushroom intake).
- LIVER CANCER: In a 2013 analysis of the Shanghai Women's and Men's Health Studies, participants in the highest quartile of mushroom intake (over 10 g daily) had a 34% lower risk of developing liver cancer, compared to people in the lowest quartile (2 g or less daily).
- OVARIAN CANCER: A case-control study from 2013 found that people who consumed more than 2 g of mushrooms per day on average had a 32% lower risk of ovarian cancer, compared to people whose mushroom consumption was under 2 g daily.
- PROSTATE CANCER: In a 2020 pooled analysis of cohort studies, participants eating mushrooms at least three times per week (compared to less than once per week) had a 17% lower risk of developing prostate cancer.
- STOMACH CANCER: A 2023 meta-analysis of 11 studies found that higher mushroom consumption was associated with a significantly lower risk of stomach (gastric) cancer. Specifically, people with the highest versus lowest consumption had an 18% lower risk.

What's more, several compounds extracted from mushrooms form the basis of cancer drugs! For example, the drug lentinan is derived from shiitake mushrooms, and has demonstrated anti-cancer activity through its ability to inhibit tumor angiogenesis. It's also used in some countries to boost the efficacy of cancer treatments. A 2019 review of clinical studies confirmed that lentinan could improve the quality of life for

cancer patients, while also boosting the effectiveness of chemotherapy and radiation therapy. Another drug called polysaccharide-K (brand name Krestin) is derived from turkey tail mushroom, and is an approved adjuvant for cancer therapy in Europe and Japan.

In all, we're still just scratching the surface of how mushrooms, including specific varieties and individual compounds, affect cancer in humans. Future research will continue to expand our knowledge here!

Anti-diabetic effects:

A number of mushroom varieties have demonstrated blood sugar-lowering effects, including white button, cremini, shiitake, oyster, maitake, cordyceps, chaga, shaggy mane, and reishi mushrooms. Likewise, specific components of mushrooms (including their polysaccharides and terpenoids) have been shown to impact insulin receptors in ways that increase insulin sensitivity and reduce insulin resistance, while also inhibiting glucose absorption, increasing pancreatic beta-cell mass, and increasing insulin signaling pathways. So far, at least 104 different mushroom polysaccharides have been identified as having anti-diabetic effects! More studies (especially clinical trials) are needed in humans to explore these exciting findings.

Cardiovascular protection:

A variety of in vitro, animal, and human studies have demonstrated a possible protective effect of mushrooms on cardiovascular health. This includes both individual mushroom types, and mushrooms as a collective group! Oyster mushrooms, for example, have been shown to reduce levels of triglycerides and oxidized LDL (the latter being a major component of arterial plaque); experiments show that shiitakes can likewise inhibit LDL oxidation, while maitake and shiitake mushrooms can decrease both VLDL levels and blood pressure. And 2019 experiment found that in an animal model, a mixture of portabella and shiitake mushrooms was able to reduce the formation of atherosclerotic plaque.

A 2021 randomized controlled trial found that in people with elevated blood lipids, 66 days of shiitake mushroom consumption reduced triglyceride levels by 10%. And, a 2021 systematic review of prospective studies determined that edible mushrooms have favorable impacts on LDL cholesterol, HDL cholesterol, total cholesterol, and triglycerides, while also potentially helping lower blood pressure.

However, some studies on this subject have yielded conflicting findings, and more research is needed to determine the effects of mushroom consumption on actual cardiovascular outcomes.

Healthy pregnancy:

Mushrooms may help protect against some maternal complications during pregnancy—especially related to blood pressure and weight. In a 2020 clinical trial, participants were required to eat 100 g of mushrooms daily, beginning before pregnancy and extending to the 20th week of gestation. Compared to the placebo group, participants in mushroom group had a significantly lower incidence of high blood pressure, preeclampsia, gestational diabetes, and excessive gestational weight gain. Likewise, they were three times less likely to have a baby with macrosomia (excessively large size)!

Reduced anxiety:

Could a mushroom a day keep the anxiety away? Research suggests it very well may! So far, animal studies have shown that mushrooms (particularly specific varieties like lion's mane and reishi) exert anti-anxiety effects. One mouse experiment from 2021 found that lion's mane helped relieve anxiety by improving sleep disruptions, while a 2018 experiment determined that lion's mane (in the form of an extract) quelled anxiety by promoting neurogenesis in mood-related brain regions (particularly the hippocampus). Additional animal research suggests specific phenols and flavonoids in mushrooms may be responsible for some of these effects. More research is needed in humans!

Lower risk of depression:

A 2021 analysis of prospective cohort data found that people who reported consuming mushrooms (compared to people who didn't) had a 69% lower risk of depression. Intriguingly, even eating relatively small amounts of mushrooms (just shy of 5 g daily) was associated with this protective effect. Likewise, a 2022 study of nearly 88,000 Korean adults found that compared to people who rarely or never ate mushrooms, those who ate at least one serving per month had significantly lower incidence of depression. Specifically, eating mushrooms monthly was associated with an 8% lower risk of depression; eating mushrooms between once a month and three times per week was associated with a 12% lower risk of depression; and eating mushrooms at least three times weekly was associated with a 14% lower risk of depression.

And, a 2022 review determined that lion's mane mushroom, in particular, was beneficial for patients with major depressive disorder—likely due to its content of 5-hydroxy-L-tryptophan (5-HTP), a direct precursor to the neurotransmitter serotonin (which itself plays a role in regulating mood)!

Protection against cognitive decline:

In a 2022 analysis of prospective cohort data, participants in the highest category of mushroom intake (13.4 g daily on average) versus the lowest intake had significantly better scores on cognitive tests, suggesting a protective effect against cognitive decline.

Improved gut health:

Due in large part to their unique polysaccharides, mushrooms have phenomenal benefits for gut health. Individual mushroom types have been studied here: in mice, white button mushrooms have been shown to increase microbial diversity and expedite healing from gut infections, while oyster mushrooms stimulate the growth of important Bifidobacterium strains. Shiitake mushroom polysaccharides can alter the spatial structure of rodent gut microbiomes and significantly (and beneficially!) alter bacterial ratios. Reishi mushrooms contain polysacchardies that feed Bifidobacteria members, with the potential to improve intestinal barrier function and reduce obesity by modulating the gut microbiota.

And while studies on specific gut disorders are more limited, evidence here, too, points to a beneficial role of mushrooms. In a 2011 trial, a mushroom extract (from the species Agaricus blazei) was given to patients with irritable bowel diseases (ulcerative colitis or Crohn's disease) for 12 days. The results showed significant decreases in levels of inflammatory cytokines in blood, with ulcerative colitis patients also seeing a reduction in fecal calprotectin, a marker of intestinal inflammation and disease activity. A 2016 study using the same extract found improvements in fatigue, intestinal symptoms, and quality of life in ulcerative colitis patients!

Interestingly, a 2016 study also found that in a mouse model of ulcerative colitis, lion's mane mushroom extract significantly decreased intestinal bleeding, improved body weight and colon length, and beneficially altered the production of nitric oxide, malondialdehyde, and superoxide dismutase in ways that suppressed oxidative stress. Similar findings came from a 2021 study of experimental colitis in rats.

Improved bone health:

Fascinatingly, studies suggest mushrooms could help support healthy bones. In a 2016 experiment using a mouse model of osteoporosis, extracts of turkey tail mushroom, maitake mushroom, and shiitake mushroom were able to decrease the activity of osteoclasts (cells that break down bone tissue), while shiitake extract increased the activity of osteoblasts (cells that build bone tissue). A combination of shiitake and maitake mushrooms, in particular, were able to reduce bone loss at the animals' lumbar spine. Additional research shows that a number of commonly eaten mushrooms, including oyster, are able to improve bone stability by influencing various steps of bone formation and mineralization.

A 2021 experiment using bone cells from healthy and osteopenic women found that treatments with oyster and reishi mushrooms (in the form of powders and extracts) had beneficial effects on bone physiology, at least in part by altering the gut microbiota and short-chain fatty acid production. And, several studies suggest that vitamin D-enhanced mushrooms support bone formation by providing a bioavailable source of this nutrient.

More studies are needed in humans to understand the potential benefits of mushrooms on osteoporosis and other bone-related disorders.

Lower all-cause mortality:

Eating more mushrooms appears protective against death from all causes. In a 2021 analysis of Third National Health and Nutrition Examination Survey (NHANES III) data, people who reported eating mushrooms (compared to those who didn't) had a 16% lower risk of all-cause mortality. This finding persisted even after adjusting for important confounders like major lifestyle factors, overall diet quality, demographic features, total energy intake, and other dietary components.

Mushroom Nutrivore Scores

Thanks to their incredibly low energy density and high micronutrient content, mushrooms have some truly impressive Nutrivore Scores. In fact, the average Nutrivore Score for this food group is 2704! For some specific common mushrooms, the Nutrivore Scores are:

Chanterelle	1555
Cremini	2279
Enoki	4434
Maitake	3551
Morel	2271
Oyster	2550
Portobella	1483
Shiitake	4343
White button	1872

Some Practical Pointers

Properly selecting and storing mushrooms is key for maintaining their quality and flavor! Here are some important tips to help maximize the lifespan (and minimize the waste!) of your mushrooms.

Selection:

- Make sure your mushrooms are fresh by looking for ones that have a firm texture and smooth caps, while being free from blemishes, bruises, or discoloration.
- Avoid mushrooms that appear slimy or have a strong, unpleasant odor.
- Buy your mushrooms in small batches! Mushrooms are highly perishable, so it's best to buy only what you need for immediate use.

Storage:

- To keep mushrooms fresh, store them in a paper bag or a porous container in the refrigerator. Avoid storing in plastic bags or airtight containers, since this can cause moisture to build up (in turn accelerating spoilage)!

- As tempting as it may be to get the dirt of ASAP, avoid washing your mushrooms before storing them. Mushrooms are like sponges, and can easily absorb water—leading to a loss of texture and flavor. Wait to wash them until just before use.
- Remove packaging immediately. If your mushrooms come in a plastic-wrapped container (especially one without perforations), remove the packaging as soon as you get home. This helps prevent moisture buildup and prolongs the mushrooms' freshness.
- Use mushrooms within a few days of purchase. The longer they sit in the refrigerator, the higher the chances of spoilage.
- If you have an abundance of mushrooms, consider preserving them by drying, freezing, or pickling them. This can help extend their shelf life by several months or more!

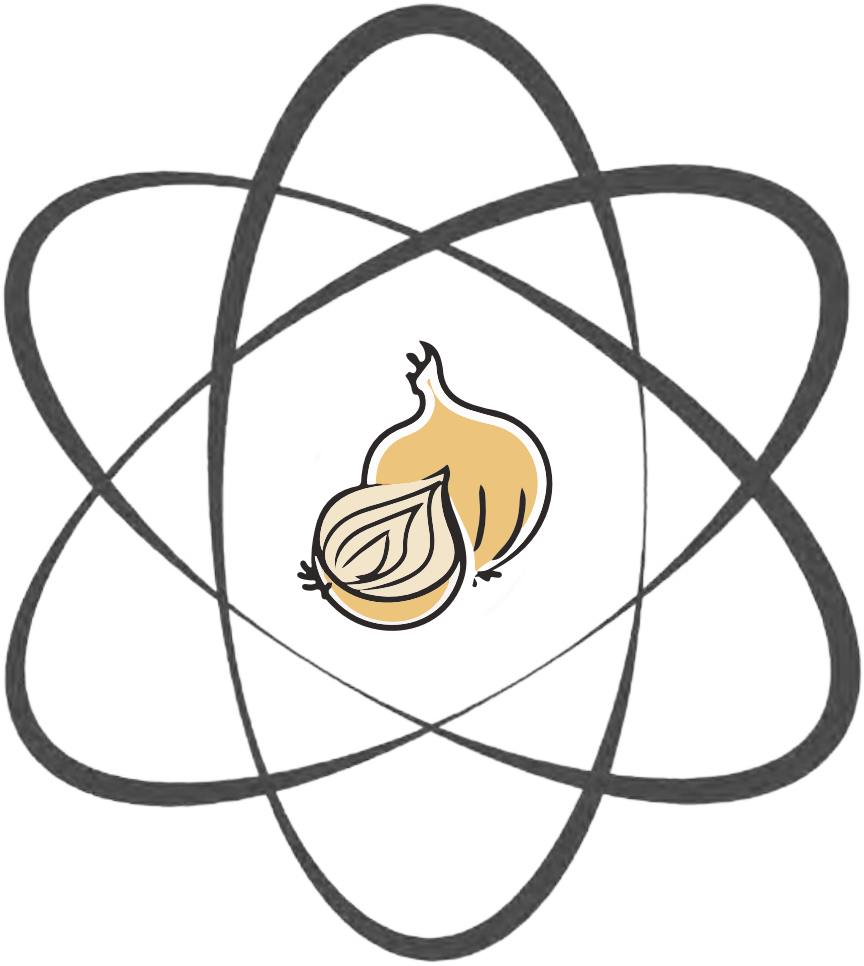
- Speaking of freezing: to freeze mushrooms properly, first clean and slice them, them spread them in a single layer on a baking sheet. Place the sheet in the freezer until the mushrooms are firm, then transfer them to a freezer-safe storage bag.
- Before cooking, clean your mushrooms by gently wiping off any dirt or debris with a damp paper towel. You can also trim the mushroom ends if they appear dry, woody, or discolored.

Seasonality:

The seasonality of edible mushrooms varies depending on the species and geographic location. But, here's a general rundown of when the most common mushrooms are available!

- MOREL MUSHROOMS: Morels typically appear in the spring, usually from late March to early May.
- CHANTERELLE MUSHROOMS: Chanterelles are often found in late summer and early autumn, typically from July to October.
- PORCINI MUSHROOMS:These are usually found in late summer to early autumn, ranging from August to October.
- OYSTER MUSHROOMS: Oyster mushrooms can be found year-round, but they're most abundant in the late spring and early autumn. They tend to thrive in cooler and more humid conditions.
- SHIITAKE MUSHROOMS: Shiitakes are cultivated year-round, and are available commercially throughout the year. But, they can also be found in the wild during the late summer and early autumn!
- ENOKI MUSHROOMS: Enoki mushrooms are available throughout the year (due to being typically grown indoors), but they're more commonly associated with winter.
- MAITAKE MUSHROOMS: Maitake mushrooms are typically found in late summer to early autumn, ranging from August to October.
- WHITE BUTTON AND CREMINI MUSHROOMS: these mushrooms are available year-round, do to being widely commercially grown. (Fun fact: they're actually the same variety of mushroom, just harvested at different stages of growth!)

Alliums



Introduction to Alliums

Alliums, also called the onion family, are a group of plant foods known for their distinctive taste and powerful health properties. The word "allium" is believed to derive from the Greek *ἀλέω* (or aleo), which means "avoid," and refers to the potent odor of these vegetables! Along with their role as modern culinary staples (virtually every global cuisine includes them!), alliums have been cultivated since prehistoric times for use as food, medicine, ornamental purposes, and religious practices.

In fact, these foods were among the first cultivated crops in ancient civilizations! Each member played a fascinating and important part in human history:

- GARLIC was used in ancient Greece to kill parasites, treat medical conditions, honor gods, and increase resiliency (the original Olympic athletes consumed garlic as a "performance enhancer"!), while the ancient Egyptians fed garlic cloves to the builders of the pyramids in order to improve their strength and vigor.
- ONIONS have been a part of the human diet since the Bronze Age! The ancient Greeks used to eat pounds of onions in preparation for Olympic competitions, and ancient Egyptians considered onions to symbolize eternity, due to their concentric rings and spherical shape. (King Ramses IV was even entombed with onions in his eye sockets!)
- Humans have been cultivating LEEKS since at least the ancient Egyptian times, but there is some evidence that they were grown in Mesopotamia as well.
- CHIVES (the only allium variety that are true herbs!) are native to both the Old World and New World, with cultivation dating back 5000 years.
- SCALLIONS (also called green onions) have been used in Asian cultures for at least 2000 years as both a vegetable and medicinal herb.

Pretty cool, huh? It gets even better! On top of their historical significance, culinary diversity, widespread cultivation, and ability to totally transform the flavor of a meal, alliums are packed with health benefits. In fact, allium consumption is consistently linked to lower risk of many chronic diseases, including lower risk of cancer, improved cardiovascular health, and more. Let's take a look at what this delicious food group has to offer!

What Are Alliums?

The allium family includes over 900 different species belonging to the genus *Allium*. Most members of this family grow from bulbs or rhizomes (AKA underground plant structures that store nutrients and energy), which give rise to the plants' leaves, stems, and flowers. In most cases, all parts of the plant are edible!

Although members of the allium family number in the hundreds, only about 30 have ever been cultivated by humans. Among those, even fewer are widely used today. The ones you're most likely to see on your dinner plate are:

- CHIVES
- GARLIC
- GREEN ONION
- LEEK
- ONION
- RAMPS
- SCALLION
- SHALLOTS
- SPRING ONION
- WILD GARLIC

FUN FACT: beyond their use as food, some Allium species are grown for their aesthetic and ornamental appeal. Species like *Allium giganteum* ("giant onion") and *Allium aflatunense* ("Persion onion") produce striking globe-shaped flower clusters in various colors, making them popular choices in garden landscapes!

What Makes Alliums So Great?

Most of the health benefits attributed to allium vegetables are driven by their unique phytonutrient content, but they also contain some important micronutrients and prebiotic fiber. Here are some highlights!

Phenomenal Phytonutrients

Alliums owe many of their outstanding health properties to their phytonutrients. Most notably, they're rich sources of thiosulfinates—a class of sulfur-containing compounds totally unique to the allium family! **Thiosulfinates** are formed when allium vegetables are damaged (such as from chewing, chopping, or crushing), which releases an enzyme called alliinase from its compartments within the plant cells. When alliinase reacts with the sulfoxides also present in allium vegetables, the result is the formation of biologically active thiosulfinates.

Thiosulfinates are what give alliums their pungent aroma and flavor. But, that's not all that they do: thiosulfinates also possess a huge range of biological activities that make them incredibly disease-protective! As a group, these phytonutrients exhibit powerful anticancer properties, as well as antioxidant, anti-inflammatory, and anti-clotting effects. Thiosulfinates exert their effects by modulating important enzymes (like the cytochrome P450 superfamily and glutathione S-transferases) that help detoxify carcinogens and prevent DNA mutations.

While at least 19 beneficial thiosulfinates have been identified in various alliums, the most famous is **allicin**, formed from the precursor *alliin*. Allicin has well-established anti-cancer and anti-tumor effects, while also being strongly cardioprotective (such as by reducing elevated blood pressure and blood lipids, and improving circulation) and possessing antibacterial, antifungal, and anti-parasitic activities! It's extremely concentrated in garlic, but also found in onions, leeks, ramps, shallots, and scallions.

Additional thiosulfinate precursors in alliums include **methiin** (found in garlic, onions, leeks, and shallots), **propiin** (abundant in onions and shallots), and **isoalliinin** (found in onions and shallots). As with allicin, these precursors transform into active thiosulfinates with important health properties—including anti-microbial, anti-inflammatory, and gut microbiota-modulating activities!

After their initial formation, thiosulfinates can further decompose other beneficial sulfur-containing compounds, including *diallyl disulfide, diallyl trisulfide, ajoene,* and *S-allyl cysteine*. These compounds feature their own biological activities, adding to the wide-ranging health protection conferred by alliums!
For example:

- DIALLYL SULFIDE can boost the detoxification functions of the liver, increase production of the antioxidant enzyme glutathione S-transferase, and has liver-protective, cardioprotective, and anti-cancer effects.
- DIALLYL DISULFIDE (a major component of garlic) exhibits anti-cancer, anti-inflammatory, antioxidant, antimicrobial, cardioprotective, and neuroprotective activities.
- DIALLYL TRISULFIDE can inhibit cell proliferation, alter enzyme activities, and modulate immune function in ways that protect against cancer. It also has cardioprotective properties, may help reduce the risk of metabolic syndrome, and can boost immune activity against viruses.
- AJOENE is a powerful antioxidant with antithrombotic, anticancer, antiviral, antibacterial, and antifungal properties.
- And, S-ALLYL CYSTEINE has antioxidant, anti-inflammatory, neuroprotective, and anti-cancer properties—including the ability to suppress cancer cell proliferation, adhesion, and invasion!

Whew! Believe it or not, it doesn't end there: alliums also contain at least 52 different flavonols—a class of phytonutrients within the flavonoid group.

For example, alliums are excellent sources of the flavonol **quercetin**, which has powerful antioxidant, antimicrobial, anti-inflammatory, anti-aging, and immune-modulating properties! A variety of mechanistic and human studies have shown this phytonutrient can inhibit the early stages of viral infections (including influenza and coronaviruses), improve insulin sensitivity (making it beneficial for diabetes), lower blood pressure and blood lipid levels (making it beneficial for cardiovascular health), reduce fat accumulation in the liver (helping protect against non-alcoholic fatty liver disease), regulate the gut microbiota (making it great for supporting gut health), reduce neuroinflammation (helping lower the risk and progression of neurodegenerative diseases like Parkinson's and Alzheimer's), and reduce allergy symptoms. Quercetin has also shown anti-cancer activity against a number of cancer cell types, including prostate cancer, liver cancer, colon cancer, ovarian cancer, breast cancer, and melanoma. Onions are the richest source of this phytonutrient, with red onions boasting the highest amounts of all! Leeks, green onions, and shallots also contain quercetin.

Alliums are also good sources of the flavonol **kaempferol**, which can reduce inflammation, regulate the immune system, protect against cancer, act as an antimicrobial, prevent diabetes, reduce cardiovascular disease risk factors, prevent neurodegenerative diseases (like Alzheimer's disease), improve bone health, and aid weight loss. Chives, leeks, scallions, are the best allium sources of this phytonutrient!

Additionally, allium vegetables (especially onions) contain the flavonol **myricetin**, which can help protect against neurodegenerative diseases (like Parkinson's and Alzheimer's), glaucoma, diabetes, inflammation,

liver damage, cardiovascular disease, photoaging, thrombosis, allergies, and hypertension. They're also sources of the flavonol **isorhamnetin**—a compound that protects heart and artery cells from damage and inflammation, while also helping reduce blood pressure. Sweet onions are particularly high in this phytonutrient!

Beyond their flavonol content, green-colored alliums (think: leeks, chives, and scallions) are good sources of **chlorophyll**—the pigment that traps light for photosynthesis and gives plants their green color. In humans, chlorophyll can help counteract some of the harmful compounds formed when meat gets cooked, and also has significant anti-inflammatory and antioxidant properties. Some research even shows it can beneficially modulate the gut microbiota, including in ways that contribute to healthy body composition!

Lastly, some alliums are high in **carotenoids**—phytonutrients that bestow yellow, orange, red, and purple pigmentation. Carotenoids play major roles in maintaining eye health due to their high concentration in the retina and their ability to filter harmful blue-light rays (in turn protecting critical parts of the eye from light-induced oxidative damage). As a result, these phytochemicals can help reduce the risk of age-related macular degeneration and cataracts. Leeks, chives, and green onions, and scallions are particularly high in carotenoids!

It's worth noting that the phytonutrient content of alliums varies not only based on species and cultivars, but also on the growing environment, post-harvest practices, and season! For example, the flavonol content of onions has been shown to increase during storage (especially after three or six months), and light exposure induces flavonol synthesis in fresh cut onions! Organic onions have also been shown to have higher flavonol content (especially quercetin) than conventionally grown onions.

Magnificent Micronutrients

Nutritionally, alliums don't provide much in the way of macronutrients (at least not in the quantities we typically consume them!), but they do deliver some important micronutrients. The top ones include:

- MANGANESE, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Leeks are particularly high in this nutrient, delivering 19% of the DV per 1 cup serving.
- VITAMIN B9 (FOLATE), an essential B vitamin that plays roles in blood cell production, the formation of genetic material (including DNA), cell growth, cardiovascular health, cancer protection, and cognitive and neurological health.
- VITAMIN C, a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production. Per cup serving, strawberries contain nearly the entire DV for this nutrient!
- VITAMIN K, which plays a vital role in coagulation, bone metabolism, cellular function, and the prevention of soft tissue calcification.

Fabulous Fructans

Alliums are rich in a special type of carbohydrate called *fructans*, made up of strings of fructose molecules. For plants, fructans serve as a storage carbohydrate alternative to starch; for humans, fructans have prebiotic properties that can benefit gut health (and beyond)!

In general, fructans have important functions in regulating the gut microbiota and immunity. A 2018 systematic review and meta-analysis of 64 different fiber studies found that compared to other fiber types, fructan consumption was associated with significantly greater abundance of *Bifidobacterium* and *Lactobacillus*—two important probiotic bacteria that help protect against pathogenic infections (including *E. coli*), boost immunity, reduce gut inflammation, produce vitamins, combat yeast overgrowths, improve the gut barrier function, and even exhibit anti-cancer and anti-diabetic effects. **Fructans** have also been shown to interact with immune cells within the intestinal lumen, in turn modulating immune responses throughout the body. These carbohydrates are even being studied as potential reactive oxygen species scavengers—decreasing inflammation and improving the redox environment of the intestine!

The main fructan in alliums, inulin, has been particularly well-studied. Research shows that that inulin significantly increases levels of SCFA-producing bacteria, including those producing the highly beneficial butyrate (which feeds epithelial cells and may help protect against colorectal cancer!). It's also been shown to influence lipid metabolism, help regulate glucose and insulin levels, and even enhance mineral absorption.

A randomized controlled trial from 2017 found that among adults with mild constipation, inulin consumption suppressed the abundance of *Bilophila*—a gut microbe associated with impaired gut barrier function and inflammatory bowel disease. A 2019 clinical trial found that consuming a diet based on inulin-rich vegetables (providing a total of 15 g of inulin-type fructans per day, for a period of two weeks) led to greater satiety, as well as reduced cravings for sweet, salty, and fatty foods!

The underground bulbs of allium plants are among the richest food sources of fructans. Per 100 g, alliums have the following fructan content:

- GARLIC: 17.4 g
- SHALLOTS: 8.9 g
- SPRING ONION BULB: 6.3 g
- ONION: 1.8 g
- LEEK, WHOLE: 0.5 g

Health Benefits of Alliums

Science has confirmed what many ancient cultures discovered about these amazing foods: they truly are medicinal! Here's a tour of what the most up-to-date research shows.

Reduced risk of cancer:

Perhaps more than any other health condition, alliums have been studied in relation to cancer risk—with research suggesting benefits for a number of different cancer types! Here's a snapshot of what the studies show:

- BREAST CANCER: A 2022 meta-analysis found that for the highest versus lowest categories of total allium intake, breast cancer risk was reduced by 30%! For garlic specifically, the risk reduction was 23%, and for onions, it was 25%.
- COLORECTAL CANCER: A 2014 meta-analysis of observational studies found a 22% reduced risk of colorectal cancer and a 12% reduced risk of colorectal adenomatous polyps for the highest versus lowest intake of total allium vegetables; the risk reduction was 15% for garlic or onion, specifically! And, a case-control study from 2016 found a staggering 79% reduction in colorectal cancer risk with higher versus low total allium intake. In this study, garlic, garlic stalks, leek, onion, and spring onion intake were all individually protective as well. Additionally, a 2020 meta-analysis found that among case-control studies, there was a 29% reduction in colorectal cancer risk for the highest versus lowest categories of garlic intake!
- ENDOMETRIAL CANCER: A 2005 case-control study found a 24% reduced risk of endometrial cancer in the highest (at least 9.6 g daily) versus lowest (les than 1 g daily) quartile of allium intake. In premenopausal women, the results were even more pronounced with a 59% reduced risk!
- GASTRIC (STOMACH) CANCER: A 2011 meta-analysis found that for every 20 g daily increase in allium consumption (approximately the weight of one garlic bulb), gastric cancer risk dropped by 9%! This same analysis showed a 46% reduced risk of gastric cancer for the highest versus lowest consumption of allium vegetables. Similarly, a 2015 case-control study found a 41% lower risk of gastric cancer with consumption of at least two portions of onions per week, a 31% lower risk with high garlic intake, and a 30% lower risk with frequent use of both garlic and onion. And most recently, a 2023 follow-up of a randomized intervention trial found that over the course of 22.3 years, every 2.2 lb increase in garlic intake per year was associated with a 17% lower risk of developing gastric cancer; total allium intake was also protective! (Along with their known anti-cancer effects, both in vitro and in vivo studies have shown that allium vegetables have an antibacterial effect against *H. pylori*, a key risk factor for gastric cancer.)

- LUNG CANCER: A 2016 case-control study found that consuming raw garlic at least twice per week (compared to never) was associated with a 50% lower risk of lung cancer! Similarly, a 2013 case-control study found that higher garlic consumption was associated with a 21% lower risk of developing lung cancer.
- OVARIAN CANCER: A 2021 systematic review and meta-analysis, encompassing 97 cohort studies, found a 21% reduced risk of ovarian cancer with consumption of allium vegetables.
- PROSTATE CANCER: A 2002 case-control study found that men consuming over 10 g of total allium vegetables per day were 49% less likely to develop prostate cancer than men consuming under 2.2 g daily. For the highest versus lowest intake of garlic, the risk reuction was 53%, and for scallions, it was 70%! Likewise, a 2013 meta-analysis found an 18% lower risk of prostate cancer for the highest versus lowest intake of allium vegetables.
- UPPER AERODIGESTIVE TRACT CANCERS (ORAL CAVITY, PHARYNX, LARYNX, NECK, AND ESOPHAGUS): A 2016 meta-analysis found that total allium consumption (comparing highest versus lowest intakes) was associated with a 21% lower risk of squamous cell carcinoma of the upper aerodigestive tract; for garlic or onion, the risk reduction was 26% and 28%, respectively. This protective effect was strongest in case-control studies—a whopping 44% reduction in risk for the highest allium consumption!
- NON-DIGESTIVE TRACT CANCERS: A 2022 meta-analysis of case-control and cohort studies found that the highest versus lowest consumption of allium vegetables was associated with a 14% lower risk of non-digestive tract cancers (collectively encompassing lung cancer, breast cancer, prostate cancer, ovarian cancer, head and neck cancer, endometrial cancer, cervix cancer, and liver cancer).

Reduced risk of cardiovascular disease:

A 2020 systematic review and meta-analysis (including 81 cohort studies and over 4 million subjects!) found that the highest versus lowest consumption of alliums was associated with a 67% lower risk of cardiovascular disease mortality, a 33% lower risk of coronary heart disease mortality, and an 11% lower risk of stroke!

Specific alliums have also been linked to reduced cardiovascular risk factors. For example, a 2014 meta-analysis of randomized controlled trials found that garlic powder (in doses ranging from 300 mg to 1400 mg daily, for a period of seven days to one year) lowered triglyceride levels by 15.83 mg/dL, LDL cholesterol levels by 8.11 mg/dL, fasting blood glucose levels by 17.30 mg/dL, and systolic and diastolic blood pressure levels by 4.34 mmHg and 2.36 mmHg, respectively. A 2019 umbrella review of meta-analyses likewise found that garlic consumption had a powerful cholesterol-lowering effect—with eight weeks of garlic consumption leading to a 17.2 mg/dL drop in total cholesterol levels. And, a 2021 meta-analysis encompassing 10 randomized controlled trials found that onion supplementation significantly improved HDL and LDL cholesterol levels.

Protection against non-alcoholic fatty liver disease (NAFLD):

A 2020 controlled clinical trial found that 12 weeks of consuming four 400 mg tablets of garlic powder per day significantly improved multiple risk factors for NAFLD—including insulin resistance, fasting blood sugar, waist circumference, body fat percent, skeletal muscle mass, total antioxidant capacity, and serum concentration of superoxide dismutase.

Healthy weight regulation:

A 2023 systematic review and meta-analysis found that among people with obesity, onion intake resulted in significant reductions in body weight, BMI, and waist circumference. A 2019 randomized controlled trial found that consumption of 9 g of onion powder daily, for a period of 12 weeks, led to a significant reduction in abdominal fat among participants with low baseline HDL levels. And a 2020 randomized controlled trial found that 12 weeks of steamed onion consumption significantly reduced body fat percentage and fat mass (particularly visceral abdominal fat) without impacting lean body mass!

A 2020 controlled clinical trial found that 12 weeks of 1600 mg of garlic powder a day (spread into four tablets) led to significant reductions in body fat percent and waist circumference, relative to the placebo group. And, a 2023 randomized controlled trial found that among patients with PCOS, eight weeks of garlic supplementation (800 g daily) led to significant reductions in BMI and waist circumference, as well as reducing markers of oxidative stress!

Improved blood sugar control:

Some evidence suggests alliums could help regulate blood sugar, particularly in diabetics. A 2017 meta-analysis of nine randomized controlled trials concluded that garlic consumption effectively lowers fasting blood sugar levels and HbA1c among type 2 diabetics, with improvements increasing with longer duration of garlic consumption. A 2010 trial of patients with type 1 and type 2 diabetes likewise found that consuming 100 g of raw red onion significantly reduced blood sugar levels four hours after eating!

Better bone density:

Alliums show potential for helping improve bone health! A 2016 trial of middle-aged and post-menopausal adults found that consuming 100 mL of onion juice daily for eight weeks improved bone mineral density and antioxidant activity; additional in vitro experiments by the researchers found that onion helped protect against bone breakdown. A 2009 study similarly showed that for peri-menopausal and post-menopausal women over the age of 50, consuming onions at least once per day was associated with 5% greater bone density than those who consumed onions once per month or less. And, a 2017 double-blind

randomized trial of post-menopausal women with osteoporosis found that consumption of two garlic tablets daily, for a period of 30 days, reduced markers of oxidative stress associated with osteoporosis!

Improved cognitive health:

Although the research is limited, some evidence suggests a beneficial effect of allium intake on cognitive health—including improved cognitive performance and protection against depression. A 2015 placebo-controlled trial of healthy adults found that five weeks of consuming 400 mg of garlic daily (in the form of dried powder) led to significant improvements in visual memory and attention! Likewise, a randomized controlled trial from 2021 found that among healthy elderly adults, 24 weeks of daily onion powder supplementation helped prevent cognitive decline—largely by improving depressive symptoms and elevating motivation. What's more, where depression is concerned, a 2023 analysis of two cohort studies found that compared to the lowest onion intake, higher onion intakes were associated with up to a 27% reduced risk of depressive symptoms.

Protection against drug-resistant infections:

Some evidence suggests alliums could help protect against drug-resistant infections! A 2012 study found that garlic extract had a strong inhibitory effect against drug resistant *Escherichia coli, Pseudomonas aeruginosa, Bacillus subtilis, Staphylococcus aureus, Klebsiella pneumoniae, Shigella sonnei, Staphylococcusepidermidis, and Salmonella typhi!* Likewise, a 2021 study found that allium extracts were active against multidrug resistant Candida species.

Improved sleep:

Although more research is needed, some evidence suggests allium consumption could support better sleep! A 2020 randomized controlled crossover trial found that among adults who were dissatisfied with their sleep, five days of consuming onion extract tablets reduced the amount of time it took to fall asleep, significantly improved sleep quality (including entering deep sleep), and reduced markers of stress.

Reduced risk of all-cause mortality:

A 2017 meta-analysis of prospective studies found that for every 100 g increase in daily allium intake, risk of all-cause mortality dropped by 24%! Likewise, high versus low allium intake was associated with a 15% decrease in death from all causes.

Individual alliums vegetables have been associated with a reduction in death from all causes, too: for example, a 2019 cohort study of elderly adults found that those who consumed garlic at least once a week lived longer than participants who ate garlic less frequently. For those who ate garlic at least five times per week, there was an 11% lower risk of death from all causes compared to those who ate garlic less than once per week! (The risk reduction was 8% for people who ate garlic between one time and four times per week.)

Allium Nutrivore Scores

The average Nutrivore Score of alliums is a whopping 2142! And, when it comes to individual allium veggies:

Chives	3531
Garlic	5622
Green onion (tops only)	2097
Leek	1128
Onion, raw	380
Onion, sweet, raw	170
Onion, welsh, raw	1704
Scallion	1932
Shallots, raw	740
Spring onion	1932

Scallion vs. Green Onion vs. Spring Onion

When it comes to telling similar-looking alliums apart, three are known to cause some confusion: scallions, green onions, and spring onions! While these veggies resemble each other in appearance (and tend to be used interchangeably in the kitchen), they're technically different from each other.

For starters, scallions are younger than green onions (that is, harvested at an earlier stage of their growth). But, there's another technical difference too: scallions (*Allium fistulosum*) come from a species of onion that does not form bulbs, while green onions either come from onion varieties that do not form bulbs, or are harvested very young from regular onions that would eventually form bulbs if left to grow!

Meanwhile, spring onions are older than both scallions and green onions. They possess a small, round, white bulb at their base that's larger than that of scallions or green onions, and have a slightly stronger flavor due to their maturity. Now you know!

Onion Tears No More!

If you've ever cut open a raw onion, you've probably encountered the painful, tear-inducing sting these alliums are known for! It's not because onions are mean: it's because they produce a chemical irritant called syn-Propanethial-S-oxide, which stimulates the eye's lachrymal (tear) glands. Specifically, upon getting cut, onions release lachrymatory-factor synthase into the air, which converts the onion sulfoxides into sulfenic acid—an unstable molecule that then re-arranges itself into *syn*-Propanethial-S-oxide. *Syn*-Propanethial-*S*-oxide then forms a cloud around the onion, makes contact with our eyes, and reacts with the thin layer of water covering our eyes to create sulfuric acid (among other irritating substances)!

Luckily, there are some tear-free ways to cut up onions:

- **COOL YOUR ONIONS OFF BEFORE CUTTING THEM!** This helps slow down the enzymatic process that leads to onion tears. You can let your onions chill in the refrigerator, dunk them in ice water right before cutting, or stick them in the freezer for 15 minutes to rapidly cool them.
- **SHARPEN YOUR KNIFE!** Using a well-sharpened blade to cut onions helps minimize the amount of damage and bruising the onion endures, resulting in a lower release of the chemicals that lead to *syn*-Propanethial-*S*-oxide production.
- **CUT YOUR ONIONS NEXT TO A FAN OR UNDER A KITCHEN VENT.** Helping disperse the gas-producing chemicals released by onions can prevent some of them from reaching your eyes.
- **WEAR GOGGLES (AND A NOSE PLUG)!** If all else fails, wearing well-sealed goggles can help protect your eyes while cutting onions. The addition of a nose plug offers further protection, preventing the lachrymatory factor from traveling up your nose and to your eyes!

Some Practical Pointers

Getting the most out of your alliums is a matter of proper selection and storage! Here are some pointers.

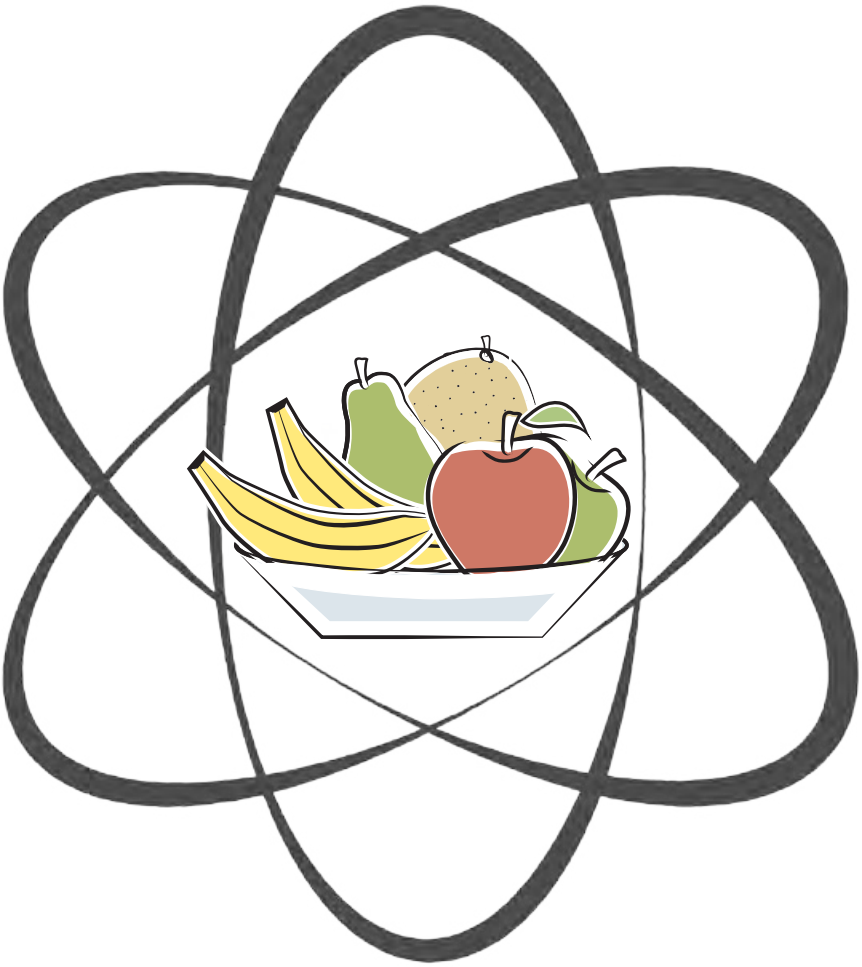
Selection:

- Choose onions and garlic bulbs that are firm and free of soft spots, sprouting, or mold.
- For leeks and shallots, select ones with crisp green tops and firm, unblemished bulbs.
- Avoid alliums with signs of bruising, cuts, or excessive moisture.

Storage and Cleaning:

- ONIONS: Store in a cool, dry, and well-ventilated place (such as a ventilated basket or bowl). Don't store them near potatoes or apples, as they can release moisture and ethylene gases that cause each other to spoil!
- GARLIC: Keep garlic bulbs in a cool, dry place, preferably in a well-ventilated container or a garlic keeper. Avoid storing them in the refrigerator—this can cause them to sprout!
- LEEKS: Store leeks in the refrigerator. They can be kept in a plastic bag or wrapped in a damp paper towel to prevent dehydration.
- SHALLOTS: Keep shallots in a cool, dark, and dry location. They can also be stored in the refrigerator for longer shelf life.
- For LEEKS AND GREEN ONIONS, trim any wilted or discolored green tops before storing. This can help extend their freshness.
- Ensure that different allium vegetables are stored separately, as they can impart their strong flavors to each other.
- Periodically check stored alliums for signs of sprouting, mold, or rot. Remove any affected ones to prevent spoilage from spreading.

Fruits



Introduction to Fruits

Along with vegetables, fruit is one of the few food categories with near-universal acclaim: from fiber to phytonutrients to micronutrients (especially vitamin C), these foods deliver a health-promoting bounty in a tasty package!

Importantly, fruit delivers health benefits independent of vegetables, so it's best to incorporate both into our regular diets. And far from being "nature's candy", eating two to three servings of fruit daily is optimal for reducing risk of cardiovascular disease, type 2 diabetes, obesity, chronic obstructive pulmonary disease, chronic constipation, and inflammatory bowel disease. So, embrace fruit as a convenient snack, a healthy dessert, a whimsical addition to salads, and a sophisticated flavoring agent in the form of salsas, jams, and chutneys.

Fruits and Their Food Groups

Botanically speaking, fruits are seed-bearing structures that develop from the ovary of a flowering plant. However, some foods fitting this criteria—like tomatoes, eggplant, zucchini, and olives—are more commonly used as vegetables in the kitchen. So, for the sake of defining a food group, we'll stick with the culinary definition of fruit: fruits are what we use in sweet applications, while vegetables (even if they're botanically considered fruit!) are what we use in savory applications.

Two sub-categories of fruit even serve as their foundational foods! These are:

- BERRIES, which consist of any small, pulpy fruit with lots of little seeds, and include fruits such as açai berries, bilberries, blackberries, blueberries, boysenberries, cloudberries, cranberries, currants, elderberries, goji berries, gooseberries, huckleberries, lingonberries, loganberries, marionberries, mulberries, raspberries, salal berries, salmonberries, strawberries, tayberries, and thimbleberries.
- CITRUS FRUITS, which come from plants of the citrus genus and includes fruits such as bergamot, blood orange, Buddha's hand, citron, clementine, finger lime, grapefruit, kaffir lime, key lime, kumquat, lemon, lime, mandarin, meyer lemon, orange, pomelo, Satsuma, tangelo, tangerine, and yuzu.

As fruit sub-groups, the above categories tend to have some shared nutritional features (and subsequently, generalizable health benefits). Due to their edible skins and seeds, **berries** boast a higher concentration of fiber, fat, and phytonutrients than most fruits deliver—providing phytosterols like sitosterol and stigmasterol (which help block absorption of cholesterol in the small intestine), tannins (which have antioxidant, lipid-lowering, blood pressure lowering, antimicrobial, and oral-health boosting properties), and a surprising amount of alpha-linolenic acid (the only truly essential omega-3 fat)! Meanwhile, **citrus fruits** are famously high in vitamin C, while also being rich in some unique flavanones such as hesperidin and naringin—which have potent antioxidant, anti-inflammatory, anti-diabetic, anti-cancer, lipid-lowering, neuroprotective, and cardioprotective properties, as well as an ability to enhance the growth of beneficial microbes in the gut. (Combined with the highly fermentable pectin in these fruits, this makes citrus a fantastic choice for gut health!)

Beyond citrus and berries, a diverse (and delicious) world of additional fruits exist, including:

- APPLE FAMILY FRUITS, which belong to the sub-family pomoideae (also called pome fruit) within the plant family Rosaceae, a.k.a. the rose family. That's right, apples are related to roses! These fruits include apple, Asian pear, crabapple, medlar, pear, quince, rose hip, and rowan.
- MELONS, which are the sweet, juicy fruits produced by members of the plant family *Cucurbitaceae*, and are related to squash and cucumbers. These include canary melon, cantaloupe, casaba, Christmas melon, Crenshaw melon, derishi, Galia, honeydew, horned melon, melon pear, muskmelon, Persian melon, Russian melon, and watermelon... among many other lesser-known melons!
- STONE FRUITS (also known as drupes), which are fruits containing a single pit (or stone) surrounded by edible flesh. These include apricot, apriums, cherry, chokecherry, greengage, hawthorn, loquat, nectarine, peach, plum, and pluots.
- TROPICAL AND SUBTROPICAL FRUITS, which grow in the in the hot, humid regions near the earth's equator (tropical fruits) or in the subtropical regions adjacent to them (subtropical fruits). These include acerola, banana, camucamu canistel, cherimoya, coconut, custard apple, date, dragonfruit, durian, fig, grapes, guava, jackfruit, jujube, kiwi, longan, loquat, lychee, mamey sapote, mango, mangosteen, papaya, passion fruit, pawpaw, persimmon, pineapple, plantain, pomegranate, rambutan, soursop, star fruit (carambola), sugar apple, and tamarind, among many other exotic members!

What Makes Fruit So Great?

Like other plant foods, fruits offer a trio of health-promoting compounds: *phytonutrients*, *fiber,* and *micronutrients*. However, fruit really shines in a few specific departments here!

Phenomenal Phytonutrients

Phytonutrients are biologically active compounds produced by plants for their growth, reproduction, and defense (including against pathogens, predators, and other plants). But, they also impart a number of health benefits for humans! When it comes to fruit, some of the most common phytonutrients are:

- ANTHOCYANIDINS, which possess anti-inflammatory, anti-pain, and neuroprotective effects. They're also what give some fruits a blue, purple, or deep red color! Anthocyanidins are found in blueberries, cranberries, blackberries, plums, red and black grapes, cherries, and raspberries.
- FLAVANONES, which have the ability to reduce inflammation, reduce blood lipids, reduce hypertension, exert antioxidant activity, improve insulin sensitivity, and potentially protect against heart disease. They're found abundantly in citrus fruit like oranges, grapefruit, tangerines, and lemons!
- FLAVANOLS (including kaempferol, myricetin, and quercetin), which are known to increase plasma antioxidant capacity, decrease DNA damage in lymphocytes (a type of white blood cell), interrupt the growth of certain cancers, reduce diabetes risk, protect neurons from oxidative damage, and suppress inflammation in the brain. They're abundant in apples, cherries, and pears.
- FLAVAN-3-OLS, which help maintain the elasticity of blood vessels (improving blood flow) and potentially reduce our risk of certain cancers and heart disease. They're found in dark-skinned fruits like elderberries, cranberries, cherries, black currants, and grapes, as well as apples, bananas, peaches, pears, and strawberries.
- TANNINS, which act as antioxidants and can reduce blood pressure, protect against harmful microbes, and improve blood lipids. Some tannins can benefit dental health by combating harmful oral bacteria and inhibiting plaque formation! They're found in pomegranates, persimmons, and berries.

- LYCOPENE, which is famous for supporting prostate health and potentially reducing the risk of certain cancers, heart disease, osteoporosis, and diabetes. It's found in reddish or pinkish fruits like apricots, papaya, watermelon, guava, mango, pink grapefruit, and peaches.
- LUTEIN AND ZEAXANTHIN, which support eye health (they're highly concentrated in the retina, and help filter out damaging blue light rays) and can help prevent cataracts and age-related macular degeneration. They're found in kiwi fruit, oranges, grapes, honeydew melons, mangoes, peaches, nectarines, and apples.
- STILBENES (including resveratrol, rhapontigenin, pterostilbene, and pinosylvin), which are powerful antioxidants that can interfere with all stages of cancer development, as well as potentially protect against neurological diseases (including Alzheimer's), cardiovascular disease, and diabetes. Stilbenes are highly concentrated in grape skins, cranberries, and blueberries.

Fabulous Fiber

The types of fiber found in fruit can not only promote regularity, but also reduce inflammation, reduce risk of heart disease, improve blood sugar control, slow down the absorption of simple sugars (hence why fruit tends to have a low glycemic load, despite having a relatively high sugar content), bind to substances in the digestive tract (such as bile salts and toxins), protect against colorectal cancer, and help our gut critters flourish and produce beneficial short-chain fatty acids.

Compared to other plant foods, fruit is particularly high in the soluble fiber pectin; in fact, it makes up an average of 35% of the cell wall content of fruit fiber! Pectin is a potent prebiotic, encouraging the growth of butyrate-producing bacteria belonging to Clostridium cluster XIV and Sutterella. Likewise, pectin appears to enhance the survival of Lactobacillus (including Lactobacillus fermentum and Lactobacillus reuteri) in the stomach and small intestine, boosting its ability to reach the colon.

Magnificent Micronutrients

Although fruit isn't quite as nutrient dense as vegetables, these foods tend to provide high levels of certain micronutrients! In particular, many fruits are great sources of vitamin C—a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production. Many fruits are also good sources of potassium—an electrolyte mineral with roles in a wide variety of life-sustaining processes such as heart function, muscle contraction, nerve impulse transmission, blood pressure control, blood pH, and fluid balance. However, individual fruits all have their own unique micronutrient composition, providing a range of additional vitamins and minerals. Once again, variety is key!

A Spotlight on Unique Fruits and Their Benefits

Because fruits hail from so many different taxonomic families, individual fruits are all unique in what they provide! Let's take a look at some of the top beneficial nutrients unique to only certain fruits.

Plantains and under-ripe bananas deserve a special shout-out for their high content of **resistant starch**—a type of highly fermentable carbohydrate that bypasses digestion in the small intestine, instead feeding the microbes in our colons. Resistant starch is particularly famous for feeding short-chain fatty acid-producing bacteria and enhancing levels of butyric acid. In particular, bananas and plantains provide resistant starch in the form of **RS2**, which is protected from digestion because of its molecular structure (and only becomes accessible to human digestive enzymes after being cooked).

Meanwhile, melons are some of our very best sources of **l-citrulline**—an amino acid that serves as precursor for l-arginine, subsequently boosting nitric oxide production in the body. Citrulline and its metabolites are extremely beneficial for cardiovascular health due to helping improve blood flow, reducing blood pressure, and enhancing vasodilation. And, citrulline may even play a role in immunity! Watermelon is exceptionally high in citrulline (containing up to 3.5 mg of citrulline per gram!); in fact, the word "citrulline" comes from *Citrullus lanatus*, the Latin term for watermelon. But, other melons like casaba melon, cantaloupe, and horned melon are also good sources of this amino acid.

Mango is a uniquely high source of a polyphenol called **mangiferin**, which serves as an incredibly powerful antioxidant (even more potent than vitamin C or vitamin E). It's also been shown to have anti-inflammatory, anti-cancer, antimicrobial, anti-atherosclerotic, pain-relieving, blood lipid lowering, immunomodulatory, anti-diabetic (by inhibiting glucose absorption in the intestine), and antiallergenic properties. Mangiferin also chelates iron, and may have benefits for reducing oxidative damage from iron overload disorders (such as hereditary hemochromatosis)!

Another famous tropical fruit, pineapple, contains a special group of protein-digesting enzymes called **bromelain** (named from Bromeliaceae—the plant family pineapple belongs to!). Bromelain has been shown to act directly upon cancer cells, as well as modulate the immune, hemostatic, and inflammatory systems in the body. It's even demonstrated an ability to inhibit blood clotting, and some evidence suggests it helps with joint pain and stiffness!

One of the major bioactive compounds in mangosteen is **alpha-mangostin**—a type of xanthone that's been shown to exert anti-obesity, anti-cancer, anti-hyperglycemic, anti-dyslipidemia, anti-inflammatory, and anti-diabetic effects in experimental studies. Several human trials have likewise shown benefit of mangosteen fruit and juice on weight loss.

As a rare "fatty fruit", coconut has some unique features! In particular, it's a great source of **medium-chain triglycerides** (MCTs)—a type of saturated fat composed of at least two medium-chain fatty acids. MCTs have exceptionally rapid and direct absorption (straight from the intestine to the liver), allowing them to be quickly burned for fuel. Research shows they have benefits for weight loss and body composition—including by spontaneously reducing appetite and food intake, and by increasing resting energy expenditure via thermogenesis (heat production). MCTs may also help increase insulin sensitivity among diabetics, improve memory and cognition in Alzheimer's patients, improve exercise performance, and boost gut health.

Some fruits such as grapes, cherries, bananas, pears, and apples are natural sources of **melatonin**—a natural compound (specifically, an indoleamine) that has excellent antioxidant properties and high free radical-scavenging capacity, along with playing important roles in the regulation of circadian rhythms, metabolism, and the immune system! In studies, consumption of melatonin-containing fruit (like cherries) has been shown to significantly increase melatonin levels in the body, increase sleep time, and enhance sleep efficiency in humans.

Many fruits such as bananas, dates, nectarines, persimmons, plums, watermelon, and pomegranate are also high in a type of soluble fiber called **fructans**, which have important prebiotic properties! In studies, fructan consumption is associated with significantly greater abundance of the very important bacteria *Bifidobacterium* and *Lactobacillus* compared to other fiber types, enhancing the production of short chain fatty acids. In addition, fructans can interact with immune cells in the intestinal lumen, in turn helping modulate immune responses in the body! These fibers are even being investigated for their free radical scavenging abilities, potentially improving the redox environment of intestinal cells.

And of course, no fruit discussion would be complete without mentioning grapes! In particular, grapes (and the red wine made from them) are our main dietary sources of **resveratrol**—a stilbene with powerful anti-inflammatory and antioxidant properties. Studies show resveratrol can thwart all three stages of cancer development (initiation, promotion, and progression) by modulating the pathways involved in cell division, cell growth, cell death, inflammation, angiogenesis (the development of new blood vessels), and metastasis (the spread of tumors). Across epidemiological studies, clinical trials, and mechanistic experiments, resveratrol has also been shown to exhibit immunomodulatory, neuroprotective, cardio-protective, glucose-lowering, and lipid regulatory effects—giving it wide-ranging benefits for chronic diseases such as cardiovascular disease, diabetes, liver diseases, obesity, Alzheimer's disease, and Parkinson's disease.

Lastly, a variety of fruits (including apples, pears, and grapes) provide us with **proanthocyanidins**, also known as condensed tannins. These phytonutrients have demonstrated anti-cancer, antioxidant, anti-diabetic, anti-inflammatory, anti-arthritis, neuroprotective, and antimicrobial properties. They also appear to protect against some eye diseases!

The Health Benefits of Fruit

Although "fruit and vegetables" are often lumped together when talking about the benefits of plant foods, fruit is independently beneficial for our health! That means that we benefit from adding fruit to our diet even if we're eating plenty of veggies.

Health benefits attributed to specifically fruit include reductions in all-cause mortality, improved cardiovascular health, protection against many forms of cancer, reduced risk of type 2 diabetes, reduced risk of metabolic syndrome, long-term weight management, protection against lung cancer, reduced risk of depression, improved gastrointestinal health, reduced risk of frailty, reduced severity of chronic obstructive pulmonary disease, better cognitive health, and even stronger bones. Whew! (Worth noting here, whole fruit, rather than fruit juice, tends to be most protective.) Let's take a look at what the research shows!

Fruit and All-Cause Mortality

Some research suggests fruit reduces the risk of death from all causes—a general reflection of health and longevity. In a 2017 systematic review and meta-analysis, the highest intakes of fruit (compared to the lowest intakes) were associated with a 13% lower risk of overall mortality. For every 200 g per day increase in fruit consumption, risk of death from all causes dropped by 15%! These benefits reached their maximum around 600 g of fruit daily, corresponding with a 19% reduction in mortality risk.

Fruit and Cardiovascular Disease

Some research has linked fruit consumption to better cardiovascular health, including protection against heart disease. A 2006 meta-analysis of cohort studies, encompassing a total of 221,080 participants, found that for every portion of fruit consumed daily, risk of coronary heart disease dropped by 7%; some studies included in this analysis saw risk reductions of up to 19% per fruit serving!

Similarly, a 2017 systematic review and dose-response meta-analysis of prospective studies found that high versus low intake of fruit was associated with a 14% lower risk of coronary heart disease, 18% lower risk of stroke, and 13% lower risk of cardiovascular disease in general. In the dose-response analysis, for every 200 g per day increase in fruit consumption, risk of coronary heart disease dropped by 10%, risk of stroke dropped by 18%, and risk of cardiovascular disease dropped by 13%!

A 2022 prospective study also detected a protective effect of fruit on death from cardiovascular disease. In this study, the highest versus lowest quintile of fruit intake was associated with a 9% reduction in cardiovascular mortality!

Fruit and Cancer

Higher fruit intake has been associated with a lower risk of numerous cancers, as well as a reduction in overall cancer risk! A 2017 systematic review and dose-response meta-analysis of prospective studies found that high versus low intake of fruit was associated with an 8% lower risk of total cancer. Every 200 g increase in daily fruit intake was also associated with a 4% drop in risk!

- **Breast Cancer:** In a 2021 systematic review and meta-analysis of prospective studies, higher total fruit intake was associated with a 7% lower risk of breast cancer in general, and a 7% lower risk of postmenopausal breast cancer specifically.

- **Lung Cancer:** A 2016 systematic review and meta-analysis of prospective studies found that people with the highest versus lowest intakes of fruit had an 18% lower risk of developing lung cancer. In a dose-response analysis of the data, every 100 g increase in fruit consumption was associated with an 8% reduction in lung cancer risk!

- A 2019 meta-analysis looked at the data based on smoking status, and found that fruit consumption was associated with a 14% lower risk among current smokers and a 9% lower risk among former smokers. Likewise, every 100 g increase in daily fruit intake was associated with a 5% lower risk in current smokers and a 4% lower risk in former smokers.

- **Ovarian Cancer:** Fruit could also help reduce the risk of mortality from certain cancers. A 2020 systematic review and meta-analysis of cohort studies found that among ovarian cancer patients, a high fruit intake prior to diagnosis was associated with an 18% lower risk of death.

- **Gastric (Stomach) Cancer:** A 2020 pooled analysis of 25 studies found that a higher versus lower intake of fruit was associated with a 24% lower risk of gastric cancer. On top of that, consuming six servings of fruit per day (compared to no fruit) was associated with a 36% lower risk of this cancer type!

- **Biliary (Bile Duct) Cancer:** A 2021 meta-analysis of 14 studies found that participants with the highest versus lowest intake of fruit had a 53% lower risk of biliary cancer. When looking at dose-response associations, every 100 g increase in daily fruit intake dropped the risk by 11%.

- **Bladder Cancer:** In a 2020 pooled analysis of 13 cohort studies, fruit intake was protective of bladder cancer in women, though not in men. Specifically, every 100 g increase in daily fruit intake was associated with an 8% reduction in bladder cancer risk. In a larger 2015 meta-analysis

that also included case-control studies, the highest versus lowest category of fruit intake was associated with a 19% lower risk among participants!

- **Glioma:** Fruit is potentially protective against the brain cancer glioma. A 2023 meta-analysis, including 24 articles and over 2.1 million participants, found that the highest versus lowest category of fruit intake was associated with a 15% lower risk of glioma.

- **Endometrial Cancer:** A 2023 meta-analysis of 27 observational studies found that the highest versus lowest category of fruit intake was associated with a 19% lower risk of endometrial cancer.

- **Colorectal Cancer:** A 2017 case-control study found that among women, a high total intake of fruit reduced the risk of colorectal cancer by 59%!

- **Esophageal Cancer:** A 2022 meta-analysis found that the lowest versus highest fruit consumption was associated with a 36% lower risk of esophageal cancer!

Fruit and Type 2 Diabetes

Boosting our fruit intake could help protect against type 2 diabetes! A 2023 prospective cohort study of nearly 80,000 adults found that whole fresh fruit intake was associated with lower diabetes risk. For every 100 g per day increase in fruit intake, diabetes risk dropped by 2.8%; for participants with normal glucose tolerance at baseline, the risk reduction was 15.2% per every 100 g of fruit! Likewise, in people with normal blood sugar levels at baseline, consuming fruit more than seven times per week (compared to less than one time per week) was associated with a whopping 48.6% lower risk of diabetes.

Controlled trials have also shown an anti-diabetes effect of fruit! In a 2023 meta-analysis of 19 randomized controlled trials, fruit consumption significantly decreased participants' fasting blood sugar levels.

Fruit and Metabolic Syndrome

Fruit is also a boon for our metabolic health in general! A 2018 meta-analysis of 26 observational studies found that higher fruit consumption was associated with a 19% lower risk of metabolic syndrome. And, a dose-response analysis from 2019 found that every 100 g daily increase in fruit intake was associated with a 3% drop in risk!

A separate meta-analysis from 2018 had similar findings, showing that the highest versus lowest category of fruit consumption was associated with a 13% lower risk of metabolic syndrome.

Fruit and Depression

Numerous studies suggest a beneficial effect of fruit on psychological conditions, particularly depression. In a 2015 longitudinal study, consumption of at least two pieces of fruit per day was associated with an 18% lower risk of depression!

A 2018 meta-analysis of 27 studies found that people with the highest versus lowest fruit intake had between a 17 - 24% lower risk of depression, depending on the study type. A meta-regression of the data also found that in cohort studies, every 100 g increase in fruit intake was associated with a 3% lower risk of depression.

Similarly, a 2023 analysis of cross-sectional data found that compared to the lowest quartile of fruit intake (less than 0.12 cup daily), the highest quartile (over 1.49 cups daily) was associated with a 31% lower risk of depression. A Mendelian randomization analysis (which uses genetic variation to help determine cause and effect) confirmed the relationship was causal!

In a 2023 cross-sectional and Mendelian randomization analysis, using data from the National Health and Nutrition Examination Survey, the highest versus lowest quartile of fruit intake (over 1.49 cups vs. under 0.12 cups daily) was associated with a 31% lower risk of depression. The Mendelian randomization analysis confirmed a causative protective association, and also found that fruit intake was associated with a decreased risk of traits related to depression—including feeling lonely (18% lower risk), feeling miserable (21% lower risk), feeling fed-up (25% lower risk), irritable mood (11% lower risk), and neuroticism (15% lower risk). Wow!

Fruit and Inflammatory Bowel Disease

A 2021 systematic review and meta-analysis found that fruit consumption was protective against inflammatory bowel diseases, with higher intakes being associated with a 31% lower risk of ulcerative colitis and a 53% lower risk of Crohn's disease.

Fruit and Constipation

Fruit can help with other gastrointestinal issues, too! A 2022 systematic review and meta-analysis of randomized and crossover studies found that on the whole, fruits can increase levels of beneficial Lactobacillus acidophilus, improve stool consistency, increase stool frequency, and alleviate overall symptoms of constipation!

Fruit and Gestational Diabetes

Fruit could help protect against some complications of pregnancy, particularly gestational diabetes. A 2023 systematic review and meta-analysis, encompassing 12 different studies, found that each 100 g increase in daily fruit consumption was associated with a 3% reduction in gestational diabetes risk. Another systematic review and meta-analysis from 2020

similarly found that women with a higher intake of fruit prior to pregnancy had a 5% lower risk of gestational diabetes.

Fruit and Frailty

Fruit may be protective of frailty—a geriatric syndrome in which people become more susceptible to adverse health outcomes as they age. In a 2016 dose-response analysis of three prospective cohorts, with an average follow-up time of 2.5 years, consuming three portions of fruit daily (compared to no fruit) was associated with a 52% lower risk of developing frailty. Consuming even one or two servings was also protective, corresponding with a 41% and 42% lower risk, respectively!

A 2020 longitudinal study likewise found that among older people with robust health at baseline, consuming between three and six portions of fruit per day significantly reduced the risk of developing pre-frailty or frailty, compared with consuming less than 1.5 portions per day. These higher fruit intakes reduced the risk by 42 – 48%!

Fruit and Chronic Obstructive Pulmonary Disease

Fruit could be beneficial for chronic obstructive pulmonary disease (COPD)—a group of conditions caused by damage to the airways or other parts of the lung, resulting in blocked airflow (such as chronic bronchitis and emphysema). A 2019 systematic review and meta-analysis found that the highest versus lowest intake groups for fruit had a 26% lower risk of COPD.

Fruit and Cognitive Disorders

Could fruit help support our cognitive health? Some research points to "yes!" In a 2022 meta-analysis of observational studies, higher intake of fruit was associated with a 17% lower risk of cognitive disorders—particularly cognitive impairment and dementia.

Fruit and Bone Health

A 2017 population-based cross-sectional study found that for the highest versus lowest tertile of fruit intake, average bone mineral density was significantly higher, and osteoporosis risk dropped by 11 – 52% (depending on the bone site).

How Much Fruit Do We Need to Eat to Get Their Health Benefits?

In general, science points to a "sweet spot" for fruit intake at around two or three servings per day (with a serving being 1 cup, or a fist-sized amount, of raw fruit). Both less and more than this amount isn't as beneficial, although even up to four or five servings per day is still better than eating no fruit!

Why isn't this a case of "the more, the better?" In short, most studies show that this amount provides the majority of the benefits we can glean from high fruit intake. The dose response relationship between fruit consumption and our overall health isn't linear, meaning that each serving we add to our diets doesn't impact our health equally. The benefits of fruit intake increase until we hit that two-serving mark, with additional fruit intake not offering additional benefits. Of course, variety matters here, too: eating a serving of two different fruits per day delivers more benefits than eating two or three servings of the same type of fruit.

A 2019 analysis by the CDC found that only 12.5% of adults eat the current recommended intake of fruit. So, if you're able to hit that two-serving sweet spot (or close to it), you're doing great!

Fruit Nutrivore Scores

As far as their Nutrivore Scores go, "other Fruits" rank as follows:

Citrus Fruits	**391**
Clementines	291
Grapefruit, pink and red	361
Grapefruit, white	315
Lemon	477
Lime	344
Orange, California Valencia	397
Orange, Florida	401

Berries	**294**
Blackberries	743
Blueberries	396
Boysenberries (frozen)	263
Cranberries	288
Goji berries (dried)	780
Mulberries	719
Raspberries	491
Strawberries	762

Stone Fruit	**294**
Apricot	260
Cherry	171
Peach	295
Plum	521

Melons	**307**
Cantaloupe	457
Watermelon	405
Honeydew melon	228

Tropical and Subtropical Fruit	**406**
Coconut meat	179
Dates, medjool	81
Dragon fruit, red flesh	800
Dragon fruit, white flesh	357
Figs, raw	158
Golden kiwi	500
Green kiwi	453
Pineapple	358
Papaya	636
Pomegranate	256
Mango	342

Apple Family	**204**
Apple	213
Asian pear	621
Pear	145

**25 to 50% of nutrient data missing*

What About Fructose?

Although fruit has a long-standing reputation as a health food, you may have also heard arguments against its consumption owing to its fructose content. Luckily, these arguments are generally unfounded!

First, contrary to popular belief, fructose isn't the only type of sugar in fruit—and in some cases, it's not even the main sugar in fruit! All fruit contains a mixture of fructose, glucose, and sucrose (which metabolizes into equal parts fructose and glucose in our bodies). And, each type of fruit has a slightly (or significantly) different proportion of these sugars.

For example, papayas, grapes, and most berries are about half fructose and half glucose. Grapefruit is about a quarter fructose and a quarter glucose, with the rest coming from sucrose. And, when we calculate total metabolic fructose (the fructose in the fruit when we eat it, plus the fructose that gets cleaved from sucrose molecules during digestion), we see that most fruit yields roughly equal parts fructose and glucose. Which is great news! While fructose has to get processed in the liver, glucose is used directly by our cells for energy, and doesn't pose the same metabolic consequences as extremely high fructose intakes (nonalcoholic fatty liver, lipogenesis, and inflammation).

Second of all, while it's true that high fructose consumption (in the 75 to 100 grams per day range) is associated obesity, diabetes, non-alcoholic fatty liver disease, and cardiovascular disease, these effects are all exacerbated by co-occurrence of vitamin D deficiency, inactivity, and high fat intake. Population studies show that fructose consumption (from all sources, including soda) is not associated with obesity below 40 grams daily.

It's unknown how high fructose consumption can be tolerated if we're only getting it from whole fruit, but there are examples of hunter-gatherers who eat tons of fruit and who are extremely healthy. And, studies show that fruit is definitely not the same as refined sources like high-fructose corn syrup. A 2018 study that compared the impact on metabolic markers of a high-fructose diet (100 grams daily!), achieved either by eating fruit or high-fructose corn syrup showed that, while both high-fructose diets caused detriments to metabolism compared to the low-fructose diet (<10 grams daily), the high-fructose corn syrup diet was worse than the fruit diet, and the effect was magnified in obese people compared to people who were a healthy weight.

All in all, the scientific evidence supports staying below about 40 grams per day of fructose from all sources. For reference, that translates to 4 to 8 servings of fruit per day, depending on the fruit!

There's no reason to avoid fruit on account of it being unhealthy, nutrient-poor, "nature's candy", or worthless on the disease protection front. And while we probably don't want to be eating more than 7 or 8 servings of fruit per day, it's a fantastic carbohydrate source that deserves more love than it sometimes gets!

Does an Apple a Day Keep the Doctor Away?

The aphorism "an apple a day keeps the doctor away" was coined in 1913, but was based on a much older rhyme, "eat an apple on going to bed and you'll keep the doctor from earning his bread," which originated in Wales in 1866! What's even cooler than the etymology is how intuitive these phrases were because there is considerable scientific evidence showing that consuming this favorite fruit significantly lowers the risk of certain cancers, cardiovascular disease, type 2 diabetes, and all-cause mortality plus more!

One key nutrient that apples contain, and which contributes to the many benefits of eating apples, is dihydrochalcones, including phloretin and phloridzin. Dihydrochalcones are a class of secondary metabolites of flavonoids that are widespread in very low levels in plants, and only found in higher levels in about 30 plant families—the only abundant source in the human diet is apples. The health beneficial properties of dihydrochalcones include potent antioxidant activity, antidiabetic, antitumor, antithrombotic, neuroprotective, estrogenic, anti-inflammatory, antibacterial, antiviral, and immunomodulatory properties.

A 2017 systematic review and meta-analysis, encompassing 95 studies evaluating fruit and vegetable intake, showed eating 100 grams of apples and pears, about once serving, per day led to a 20% decrease in all-cause mortality! That's impressive!

Practical Pointers

Storing Common Fruits

Fruits generally will continue to ripen if left sitting out on the countertop. Once perfectly ripe, these fruits can typically be refrigerated for at least a few days (even bananas can be refrigerated once ripened to your liking, although the peels will darken in the fridge). Exceptions are grapes, citrus, and berries, which will only deteriorate on the counter and should be refrigerated.

Fruits that give off high levels of ethylene (a ripening agent), like apples, can prematurely ripen and spoil surrounding vegetables. You can take advantage of this property to speed up the ripening of other fruits like bananas, peaches and avocadoes—simply add to a paper bag with an apple or two, and store at room temperature until ripe.

If you find yourself with a surplus of produce, nearly all fruits and vegetables can be stored in the freezer. Freeze them in small pieces on sheet trays, and then place the frozen pieces in airtight containers or resealable freezer bags for use later.

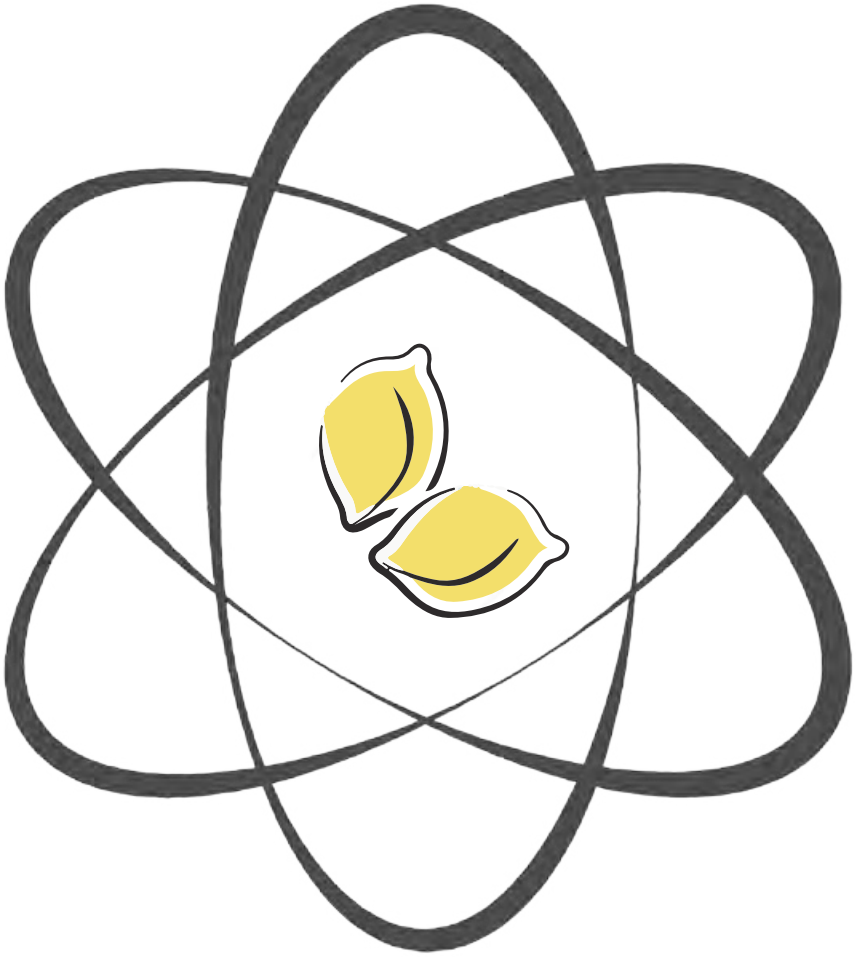
The list below provides storage information for specific fruits. All fruits and vegetables stored at room temperature should be stored out of direct sunlight.

See the list below for storage information for specific vegetables.

- APPLES: Store in a bowl or basket with good airflow at room temperature. For longer storage, keep in a cardboard box in the fridge.
- APRICOTS: Store in a bowl or basket with good airflow at room temperature. Store in the fridge when fully ripe.
- AVOCADOS: Store in bowl or paper bag at room temperature. To speed up ripening, place in a paper bag with an apple.
- BANANAS: Store in a basket with good airflow or hang on a banana holder at room temperature. To slow down ripening, take them apart and store them spaced apart.
- BERRIES: Store in the refrigerator and wash right before you eat them.
- CITRUS: Store in a cool place with good airflow.
- CHERRIES: Store in an airtight container in the fridge and wash right before you eat them.
- CUCUMBERS: Store wrapped in a moist towel in the fridge.
- DATES: Drier dates (like Deglet Noor) can be stored in the original packaging in a cupboard. Moist dates (like Medjool) should be refrigerated in a container that allows for airflow.

- **EGGPLANT**: Store in a container with a moist towel in the fridge.
- **FIGS**: Store in a paper bag or a container that allows airflow in the fridge.
- **GRAPES**: Store in a bag or a container that allows airflow in the crisper drawer of the fridge and wash right before you eat them.
- **KIWIS**: Keep at room temperature until ripe, then refrigerate.
- **LEMONS AND LIMES**: Store in a bowl that allows airflow on the counter. For longer storage, keep in the refrigerator (but they can absorb the odors of foods stored beside them).
- **MANGOES**: Store on the counter until ripe, then move to the refrigerator.
- **MELONS**: Store uncut in a cool, dry place, out of the sun, for up to a couple of weeks. Softer melons like cantaloupe should be moved to the fridge when ripe. Cut melon should be kept in the fridge with the cut side covered with plastic wrap or cut-side down on a plate.
- **NECTARINES**: Store in a bowl that allows airflow on the counter and refrigerate only when fully ripe. To hasten ripening, place in a paper bag with an apple.
- **ORANGES**: Store at room temperature in a bowl or basket that allows airflow. For longer-term storage, move to the refrigerator.
- **PEACHES**: Store in a bowl that allows airflow on the counter and refrigerate only when fully ripe. To hasten ripening, place in a paper bag with an apple.
- **PEARS**: Store in a bowl or basket that allows for airflow or in a paper bag. To hasten ripening, store in a paper bag with an apple.
- **PEPPERS**: Store in a container with a moist towel in the fridge.
- **PERSIMMONS**: Store at room temperature until fully ripe, and then move to the refrigerator. To hasten the ripening process, place in a paper bag with an apple.
- **PLUMS**: Store at room temperature until fully ripe, and then move to the refrigerator.
- **POMEGRANATES**: Store in a cool, dry place.
- **PINEAPPLES**: Whole pineapples can be stored on the counter until ripe. Once ripe, pineapple can be stored whole or peeled and cut in an airtight container in the fridge.
- **RASPBERRIES**: Wash in a solution of 1 part vinegar to 3 parts water and drain well. Place the berries in a bowl lined with a dry paper towel, replacing the paper towel when it gets damp.
- **STRAWBERRIES**: Store in a paper bag in the fridge and wash right before you eat them.
- **TOMATOES**: Store in a bowl that allows airflow on the counter. Use immediately when ripe or freeze for cooking.
- **WATERMELON**: Keep uncut on the counter at room temperature. Store in the fridge after cutting.
- **WINTER SQUASH**: Store in a cool, dark, well-ventilated place.
- **ZUCCHINI AND OTHER SUMMER SQUASH**: Wrap in a damp cloth and store in the fridge.

Citrus



Introduction to Citrus

A juicy orange, a tart grapefruit, a sweet tangerine... the citrus family provides us with some of our most well-loved fruits! In fact, citrus has been present in the human diet since ancient times, originally domesticated by indigenous cultures throughout tropical and subtropical regions of Asia and the Malay Archipelago. From the years 3000 to 1500 BCE, citrus were among the canoe plants carried by voyagers from Austronesia to Micronesia and Polynesia. And by the year 310 BC, the very first citrus fruit—the citron—reached Europe, where it spent hundreds of years being the only citrus known there!

Today, citrus is one of the world's most important fruit crops, grown in over 140 different countries across the globe. Oranges lead in popularity (they account for over half of the world's citrus production!), but tangerines, lemons, and grapefruits are also widely grown and enjoyed.

Although many of us consume citrus for their delicious taste, they also happen to be incredibly health promoting. Let's take a tour of this juicy food group!

What Are Citrus Fruits?

Citrus fruits come from plants of the citrus genus, a group of flowering shrubs and trees in the rue family (AKA Rutaceae). Botanically speaking, citrus fruits are actually a special type of berry called a hesperidium—characterized by a tough outer rind, a segmented interior, juicy pulp, and enclosed seeds.

Some of the most common citrus fruits today include:

- BERGAMOT
- BLOOD ORANGE
- BUDDHA'S HAND
- CITRON
- CLEMENTINE
- FINGER LIME
- GRAPEFRUIT
- KAFFIR LIME
- KEY LIME
- KUMQUAT
- LEMON
- LIME
- MANDARIN
- MEYER LEMON
- ORANGE
- POMELO
- SATSUMA
- TANGELO
- TANGERINE
- YUZU

In all, there are more than 2,500 types of citrus fruits (and more than 600 types of oranges alone!). Many of these fruits aren't separate species, but hybrids of other existing citrus fruits. For example, grapefruits are actually a hybrid of the pomelo and sweet orange, and tangelos are a hybrid of either mandarin oranges or tangerines and grapefruit!

What Makes Citrus So Great?

Citrus contains an outstanding combination of phytonutrients, micronutrients, and fiber. Here's the lowdown!

Phenomenal Phytonutrients

Citrus fruits are bursting with phytonutrients—particularly a unique class of flavonoids known as **flavanones**. Flavanones are universally present in citrus fruits, and are responsible for not only their distinctive bitter taste, but also many of their health benefits.

On the whole, flavanones have impressive free radical-scavenging activity, with evidence suggesting they can help protect against various chronic diseases (including cardiovascular disease and cancer), lower blood lipids, improve insulin sensitivity, reduce hypertension, lower inflammation, and exert antioxidant activity. In the gut, flavanones interact with and influence the microbiota, and these interactions may be responsible for many of these phytonutrients' biological effects! Some flavanones also appear to traverse the blood-brain barrier, giving them potential roles in protecting against neurodegenerative diseases.

Some of the specific flavanones in citrus fruits include:

- HESPERIDIN, one of the most abundant flavanones in citrus (found in particularly high concentrations in the fruit peels and membranes). Hesperidin has potent antioxidant, anti-inflammatory, anti-diabetic, anti-cancer, neuroprotective, and cardioprotective properties, and may help improve blood vessel function! It's also a boon for gut health, helping increase populations of probiotic bacteria like Bifidobacterium bifidum and Bifidobacterium adolescentis. Hesperidin acts as an antioxidant not only through radical scavenging, but also due to enhancing cellular antioxidant defenses, and has been shown to protect against oxidative stress from high fat diet-induced high blood sugar.
- HESPERITIN, the aglycone of hesperidin. It has significant anti-inflammatory, anti-cancer, and lipid-lowering abilities (reducing both cholesterol and triglycerides), with a notable ability to reduce secretion of apoB (the main protein found in low-density lipoproteins).
- NARINGIN, predominantly found in grapefruits, and to a lesser extent in oranges and lemons. Naringin gives a bitter taste to citrus fruits, and has been studied for its potential antioxidant and

anti-inflammatory properties. Studies of naringin have shown its antioxidant effect is due to reducing reactive oxygen species and increasing antioxidant defenses, including catalase, glutathione peroxidase, and superoxide dismutase. It may likewise enhance ethanol metabolism, increase bone cell activity, stimulate DNA repair in prostate cancer cells, act as an anti-apoptotic agent, and stimulate the growth of beneficial microbes (such as bifidobacteria) in the gut—in turn increasing the generation of SCFAs. It's also known for its ability to affect the absorption of certain drugs in the digestive system!

- NARINGENIN, the aglycone of naringin. Naringenin has lipid-lowering, anti-obesity, anti-diabetic, and liver-protective properties, including combatting fatty liver disease. It's also been shown to inhibit the growth of some pathogens (such as E. coli, Staphylococcus aureus, and Salmonella typhimurium).
- NEOHESPERIDIN, a bitter-tasting flavanone particularly abundant in Seville oranges. It's been shown to alter the gut microbiota in a way that helps prevent colorectal tumors and potentially even protect against obesity!
- ERIODICTYOL and its glycoside ERIOCITRIN, found in limes and lemons. These flavanones have neuroprotective, anti-cancer, vascular protective, kidney protective, liver protective, lipid-lowering, and immune-modulating effects, with an ability to inhibit inflammation and oxidative stress. They're particularly promising in the prevention and treatment of diabetes, due to improving insulin production and subsequently enhancing glucose uptake!
- NARIRUTIN, found in oranges, limes, lemons, mandarins, grapefruit, and satsumas. Along with possessing anti-inflammatory and antioxidant properties, it's demonstrated wide-ranging health effects including neuroprotection, liver protection, anticancer activity, anti-allergic activity, antidiabetic activity, anti-obesity action, and immunomodulation.
- PONCIRIN, a bitter-tasting flavanone glycoside particularly abundant in mandarin oranges. It has anti-inflammatory activity (through inhibiting the production of PGE2 and IL-6), and may help protect against bacterial and viral infections, bone loss, liver injury, gastritis, some cancers, and even Alzheimer's disease.

But, the list of citrus phytonutrients doesn't end there! These fruits are also rich in **limonoids**, a type of triterpenoid that's been the subject of numerous studies (with promising findings as far as human health is concerned). Citrus limonoids such as **limonin, obacunone, deacetylnomilin**, and **nomilin** have been been

shown to exert anti-cancer, antimicrobial, anti-diabetic, and antioxidant activities, all of which contribute to the protective effects that show up in observational studies of citrus consumption. These phytonutrients demonstrate antiproliferative activity against human cancer cells (including liver cancer, meningioma, leukemia, lymphoma, pancreatic cancer, breast cancer, and colon cancer cells), and some research has shown that limonoids combined with curcumin from turmeric have an additive effect that makes this duo particularly powerful in fighting colon cancer.

On top of that, citrus limonoids can modulate inflammatory pathways, and some limonoids have been shown to decrease circulating biomarkers of chronic inflammatory conditions (such as cardiovascular disease, diabetes, cancer, and nonalcoholic fatty liver disease).

Citrus are also great sources of **carotenoids**—plant pigments responsible for these fruits' lovely orange, yellow, or pinkish colors! About 115 different carotenoids have been identified in various citrus species, including alpha- and beta-carotene, lycopene, beta-cryptoxanthin, lutein, zeaxanthin, and violaxanthin. In general, carotenoids increase resistance to oxidative stress, reduce inflammation, and have been shown to support vision health (particularly age-related eye diseases like macular degeneration and cataracts). Research shows a high intake of carotenoids could even protect against metabolic syndrome and diabetes!

Some citrus fruits, particularly blood oranges, are also great sources of **anthocyanins**—plant pigments that possess significant antioxidant activity. Along with their ability to capture free radicals, anthocyanins have cardioprotective, neuroprotective, anti-inflammatory, blood-sugar-lowering, and anti-cancer properties. Studies suggest they could help protect against heart disease and diabetes, and may even help reduce the perception of pain!

Some other amazing phytonutrients in citrus include:

- DIDYMIN, a flavonoid found in a variety of citrus fruits (like oranges, lemons, mandarins, grapefruit, lemons, and bergamot). It has antioxidant, neuroprotective, liver-protective, anti-inflammatory, cardioprotective, and anti-cancer activity against several different cancer cell types (including lung and neuroblastoma). It also has promising anti-diabetic potential!
- NOBILETIN, a flavone found in mandarin oranges, tangerines, grapefruit, and oranges. It has anti-inflammatory, antioxidant, lipid-lowering, cardioprotective, and neuroprotective activity, with in vitro and animal studies suggesting it could suppress bone loss and improve insulin sensitivity. It's shown particular promise for improving cognitive deficits and pathological features in Alzheimer's and Parkinson's disease.
- QUERCETIN, a flavonoid that's been shown to suppress inflammation in the brain and promote a healthy gut barrier.
- LUTEOLIN, a flavonoid that's strongly neuro-protective with anti-cancer activity, along with being able to reduce inflammation, regulate the immune system, reduce allergic responses, prevent toxicity associated with chemotherapy and radiation, and reduce pain.

And when it comes to different types of citrus? The more, the merrier! Although they share plenty of things in common, citrus fruits all have unique phytonutrient profiles, with some bioactive compounds being specific to certain fruits. For example, hesperidin and narirutin are the dominant flavanones in sweet oranges and mandarins, while neohesperidin is more dominant in sour oranges. Pummelos and grapefruit contain an abundance of naringin, while lemons are rich in eriocitrin. More brightly colored citrus (like Cara Cara oranges) tend to be higher in carotenoids. So, the greater variety of citrus we eat, the broader the spectrum of phytonutrients we obtain!

Magnificent Micronutrients

As far as micronutrients go, citrus are superstars in a few key areas. Most famously is their high content of VITAMIN C—a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production.

In fact, the vitamin C content of citrus helped form one of the first controlled clinical trials recorded in medicine, centuries before vitamin C was even discovered. In 1747, while on board the HMS Salisbury, a physician named James Lind treated men suffering from scurvy (a disease of vitamin C deficiency) with various remedies including cider, sea-water, vinegar, vitriol, garlic paste and citrus fruit (two oranges and one lemon daily). By the end of the week, sailors receiving citrus fruit felt well enough to help their counterparts, who were not so lucky!

Even though vitamin C was not yet known at that time, these results helped address this serious illness and protect sailors from potentially deadly deficiency. In fact, the Royal Navy made sure all sailors had lemon juice to drink when they were at sea for voyages longer than one month. And as homage to Lind's contributions, to this day a lemon tree adorns the official crest of the British Institute of Naval Medicine!

Along with vitamin C, citrus offers notable amounts of some other vitamins and minerals, including:

- COPPER, a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). Kumquats offer over 10% DV of copper, and limes also offer a notable 7% DV per serving.
- FOLATE, an essential B vitamin that plays roles in blood cell production, the formation of genetic material (including DNA), cell growth, cardiovascular health, cancer protection, and cognitive and neurological health. California Valencia oranges provide nearly 10% DV of folate, while navel oranges are a close second at almost 8% DV per serving.
- POTASSIUM, an electrolyte mineral with roles in a wide variety of life-sustaining processes such as heart function, muscle contraction, nerve impulse transmission, blood pressure control, blood pH, and fluid balance. There is a swath of citrus fruits that are all neck-in-neck for potassium providing around 5% DV per serving: tangerines, clementines, oranges and kumquats.
- VITAMIN B5 (PANTOTHENIC ACID), a water-soluble B vitamin that serves as a cofactor for coenzyme A—which in turn is critical for metabolizing many drugs and toxins and synthesizing

cholesterol, fatty acids, melatonin, the neurotransmitter acetylcholine, steroid hormones, heme, and vitamins A and D. The fruits that offer around 4-5% DV of this vitamin are oranges, grapefruit and tangerine.

- VITAMIN B6 (PYRIDOXINE), a group of six water-soluble compounds required by over 100 different enzymes to carry out functions in protein metabolism, fatty acid metabolism, neurotransmitter production, gluconeogenesis, hemoglobin synthesis, the release of glucose from glycogen, and energy metabolism (particularly the production of ATP in the Krebs cycle). Oranges, tangerines and lemons all provide a noteworthy 4-6% of this vitamin per serving.
- VITAMIN B7 (BIOTIN), a water-soluble B vitamin that plays an important role in energy metabolism (serving as a coenzyme for five carboxylase enzymes), neurotransmitter production, cellular function, and the function of various organs. Oranges are the standout biotin source at over 7% of this nutrient per serving.

Fabulous Fiber

The fiber in citrus is another major driver of this food group's health benefits! Most citrus fruits are rich in the fibers pectin, cellulose, lignin, and hemicellulose, which have benefits ranging from improved digestion to cholesterol reduction (and in some cases, serve as fermentable prebiotics for our gut bacteria).

Citrus pectin, in particular, has exciting potential for our health. Pectin is soluble in water and is highly fermentable (meaning very little passes through to the colon, since it's is so readily fermented by bacteria in the small intestine). Pectins are rich in galacturonic acid and can be found in several types of configurations (further subdividing this class of fibers by structure). Some research indicates that citrus pectin can support weight loss, and this fiber has been shown to inhibit the binding of fibroblast growth factor (FGF) with the FGF receptor—in turn potentially affecting cholesterol metabolism. In vitro studies have shown that pectins may have a role in cancer protection and treatment due to their ability to reduce metastasis, angiogenesis, and solid tumor growth.

When it comes to supporting our gut health, citrus is a particularly worthy addition to our diet. Pectin from lemon has been shown to stimulate the bacteria Ruminococcaceae and Succinivibrionaceae, which in turn produce butyrate that our intestinal cells use for fuel (and which exert important anti-cancer effects). The citrus phytochemicals naringin and hesperidin appear to stimulate short-chain fatty acid production and enhance the growth of Bifidobacterium bifidum, Bifidobacterium adolescentis, and the Clostridium coccoides/Eubacterium rectale cluster.

Per 100g of raw citrus fruit, the fiber contents of some of the most popular varieties are:

- CLEMENTINES: 1.7g
- GRAPEFRUIT: 1.6g
- KUMQUATS: 6.5g
- LEMONS: 2.8g

- LIMES: 2.8g
- ORANGE, CALIFORNIA VALENCIA: 2.5g
- ORANGES, FLORIDA: 2.4g
- ORANGES, NAVEL: 2.2g
- TANGERINES: 1.8g

Health Benefits of Citrus Fruits

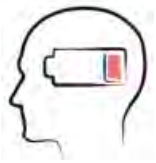
Regular consumption of citrus fruits has been linked to wide-ranging protection against disease—including cardiovascular disease, neurological conditions, cancer, endometriosis, and obesity! Here's the full scoop.

Reduced risk of cardiovascular disease:

Research consistently shows citrus fruits to be powerfully cardioprotective. For example, a 2011 cohort study of over 10,600 Japanese adults with no history of cardiovascular disease found that compared to infrequent intake of citrus fruits, consuming citrus near-daily was associated with a 43% lower risk of cardiovascular disease in men and 49% lower risk in women.

Similarly, a 2017 systematic review and meta-analysis of 95 studies found that high versus low citrus consumption is significantly associated with lower risk of cardiovascular disease and mortality, including:

- 9% lower risk of coronary heart disease
- 26% lower risk of total stroke (as well as a 12% lower risk with every 100 g of citrus consumed daily)
- 22% lower risk of ischemic stroke
- 26% lower risk of hemorrhagic stroke
- 22% lower risk of cardiovascular disease (as well as an 8% lower risk with every 100 g of citrus consumed daily)



Reduced risk of depression:

Likely owing to some of its neuroprotective and neuro-modulating phytonutrients, citrus could help protect against some mood disorders like depression. A 2016 prospective cohort study, following more than 82,000 women over a 10-year period, found a significant protective effect of citrus consumption on this condition: participants who consumed at least two servings of citrus fruit or citrus juice per day had a 18% lower risk of depression, compared to those consuming less than one serving per week!

Reduced risk of dementia:

Citrus may offer cognitive benefits beyond just mood. In a 2017 cohort study, encompassing over 13,000 elderly Japanese participants, frequent citrus consumption was associated with a lower risk of developing dementia over the course of 5.7 years. After controlling for other variables, consuming citrus 3 – 4 times per week was associated with a 18% lower risk of dementia, compared to con-

suming citrus twice or fewer times per week; for those consuming citrus almost every day, the risk reduction was 23%! A 2020 case-control study similarly found a protective effect of citrus consumption on early onset dementia.

Reduced risk of cancer:

A large body of research has been conducted on citrus intake and cancer risk, with evidence pointing to a protective effect for many different cancer types!

For example, a 2021 meta-analysis of 21 observational studies found that people with the highest versus lowest intake of citrus fruit had a 9% lower risk of **lung cancer**. A dose-response analysis of the data found that maximum risk reduction occurred with 60 g of citrus per day.

A 2023 meta-analysis, encompassing eight observational studies, found that high citrus fruit consumption was associated with a 16% lower risk of **renal cell carcinoma** (a type of kidney cancer), with every 100 g increase in citrus intake correlating with a 13% reduction in risk.

Similarly, some evidence suggests a protective effect of citrus on **breast cancer**. A quantitative systematic review from 2014 found that high (versus low) intake of citrus fruits was associated with a 10% lower risk of this disease!

A 2009 systematic review found that higher citrus intake was associated with a 17% lower risk of **pancreatic cancer**—although due to weak study designs, more research is needed here to confirm this relationship.

Citrus may be particularly helpful in preventing digestive system cancers. A 2016 meta-analysis of cohort studies found that citrus intake was strongly inhibitive of **stomach cancer**—particularly a subtype of stomach cancer that occurs near the top of the stomach near the esophagus, known as cardia gastric cancer. For this type of stomach cancer, consuming 100 g of citrus per day was associated with a 40% lower risk! A 2019 analysis of 15 case-control studies similarly found that compared to the lowest third of citrus intake, higher citrus consumption was associated with a 20% reduction in stomach cancer risk. The protective of effects of citrus reached their maximum at three servings per week.

And, a massive 2023 meta-analysis, encompassing 24 studies and over one million participants, found that higher intake of citrus fruit was associated with a 9% lower risk of **colorectal cancer.** A dose-response analysis further found that maximum protection (15% lower risk) occurred with 120 g of citrus per day.

Citrus could even benefit **bladder cancer**! A 2014 meta-analysis of observational studies found a 15% reduction in bladder cancer risk for high versus low intake of citrus. When limited to case-control studies, the risk reduction was an even higher 23%.

Similarly, citrus fruit appears protective against several different head and neck cancers. A 2019 meta-analysis found citrus consumption to be significantly protective against **nasopharyngeal cancer,** with higher intakes associated with a 28% lower risk. Analyzed a different way, the data showed that consuming citrus four times per week was associated with a 21% reduction in cancer risk!

A 2016 literature review determined that every 100 g increase in citrus fruit consumption was associated with a 14% lower risk of **esophageal cancer.** These findings were consistent with a 2015 meta-analysis, which found that higher citrus intake was associated with a 27% reduction in esophageal cancer risk, as well as a 2018 meta-analysis, which showed citrus is particularly protective against a subtype of esophageal cancer known as esophageal squamous cell carcinoma (a 51% lower risk of this cancer for high versus low citrus intake!).

And, a 2018 meta-analysis found that citrus had an impressive protective effect against oral cancer: people with the highest citrus intake (versus the lowest intake) had a staggering 50% lower risk of both **oral cavity cancer** and **pharyngeal cancer!**

Improved body weight regulation:

A 2020 systematic review and meta-analysis of 13 randomized clinical trials found that citrus consumption (and/or supplementation with citrus extracts) led to significant decreases in body weight, BMI, waist circumference, and hip circumference.

Lower risk of endometriosis:

Some evidence suggests citrus may be protective against endometriosis—a painful condition that occurs when endometrial tissue grows outside the uterus. In a 2018 analysis of case-control studies, citrus fruit consumption had a particularly strong inverse relationship with endometriosis: women consuming at least one serving of citrus fruit daily had a 22% lower endometriosis risk, compared to those consuming less than one serving per week!

Lower risk of all-cause mortality:

A 2017 systematic review and meta-analysis of 95 studies found that high versus low citrus consumption was associated with a 10% lower risk of death from all causes!

Citrus Nutrivore Scores

Citrus fruits have an average Nutrivore Score of 391.

Clementines	291
Grapefruit, pink and red	361
Grapefruit, white	315
Kumquats	381
Lemon	477
Lime	344
Orange, California Valencia	397
Orange, Florida	401
Orange, Navel	408
Pomelo	273*
Tangerines/mandarin oranges	238

**25 to 50% of nutrient data missing*

A Note on Grapefruit

Although grapefruit is perfectly healthy for most people, it has a unique contraindication! This fruit contains high levels of **furanocoumarins**—compounds that interfere with the cytochrome P450 superfamily of liver enzymes, and as a result, create potentially harmful drug interactions.

Specifically, furanocoumarins get metabolized by the enzyme CYP3A4 and then bond the active site of the enzyme, inactivating it. When CYP3A4 activity gets impaired, the body no longer metabolizes many drugs as expected—including many statins, calcium channel blockers, loratadine (Claritin), clarithromycin, certain pain medications, and some immunosuppressants. As a result, one of two things can happen:

1. Blood levels of these drugs can rise (if the drug requires liver enzymes to become inactivated), causing in more severe side effects or even brand new side effects; or,
2. Blood levels of the drugs can fall (if the drug requires liver enzymes to become an active metabolite), resulting in a loss of the therapeutic effect.

In either case, the consequence can be dangerous! In all, over 85 medications are either known or predicted to interact with grapefruit, and eating just a single whole grapefruit or drinking 200 mL of grapefruit juice can be enough to cause drug overdose toxicity. Moral of the story, we should make sure to double-check any prescriptions for interactions before we enjoy our grapefruit!

To Juice or Not to Juice?!

One of the most popular ways to consume citrus is in the form of juice. But, how does this stack up to eating citrus whole?

First, the good news: citrus juice indeed delivers some of the good stuff citrus contains, and is much more than empty calories! Along with boasting plenty of vitamin C, citrus juice retains a number of phytonutrients (especially flavanones) that contribute to these fruits' health benefits.

A 2021 review concluded that citrus juice may help beneficially modulate inflammatory and immune responses in the body, while a 2017 review found that citrus juice has a number of impressive anti-cancer properties. Likewise, a 2020 controlled clinical trial found that habitual orange juice consumption (300 mL daily for 60 days) created positive shifts in the gut microbiota, in turn enhancing glycemic control and lowering some blood lipids (including reducing fasting glucose, insulin, insulin resistance, and triglycerides)! In general, citrus juice appears to have prebiotic properties owing to some of its phytonutrients (like hesperidin and naringin).

However, while a glass of fresh-squeezed OJ here and there certainly won't hurt, eating the whole fruit is really where it's at! Research looking at the bioactive compound content and antioxidant capacity of different parts of citrus fruits—the juice sacs, the segment membranes, and the segments—shows that the concentration of phenolic compounds and total antioxidant capacity is highest in the segment membranes, which get removed during juicing. Similarly, studies of Cara Cara oranges, navel oranges, and clementine mandarins have found higher carotenoid values in the pulp versus juice.

On top of that, in nearly all citrus fruits, very high concentrations of phenolic compounds exist in the albedo—the white spongy layer between the fruit segments and the outer skin. (Although this part of the citrus fruit isn't necessarily the tastiest to eat, adding some of it to a smoothie or other recipe can help mask the flavor and deliver a major phytonutrient punch.)

So, while there's little to suggest citrus juice is harmful to health, opting for whole fruit whenever possible ensures we'll receive all the nutritional goodness available from these foods!

Some Practical Pointers

To get the most out of our citrus fruits (both taste-wise and nutrient-wise), proper selection and storage is a must. Here are some tips for picking out the very best fruits, as well as keeping them fresh.

Selection:

- Choose fruits that feel heavy for their size, as this often indicates juiciness.
- Look for fruits with smooth, firm skin, avoiding those with soft spots or wrinkles.
- Different citrus varieties have different colors when ripe, but in general, vibrant and uniform color is a good indicator of ripeness! (For example, oranges should have a bright orange hue, while lemons should be a rich yellow.)
- Select fruits that emit a fresh, strong, citrusy aroma. This can be a sign of ripeness and flavor.
- Opt for fruits that are average in size for their variety.

Storage:

Fun fact: we can maximize our nutrition intake from citrus by how we store these fruits! There's some evidence that storing citrus at temperatures higher than 5°C (about 41°F) for long periods of time increases their loss of vitamin C, so it's best to eat our citrus soon after bringing them home, or storing it in very cool temperatures. Once refrigerated, citrus can store for several weeks without going bad!

Seasonality:

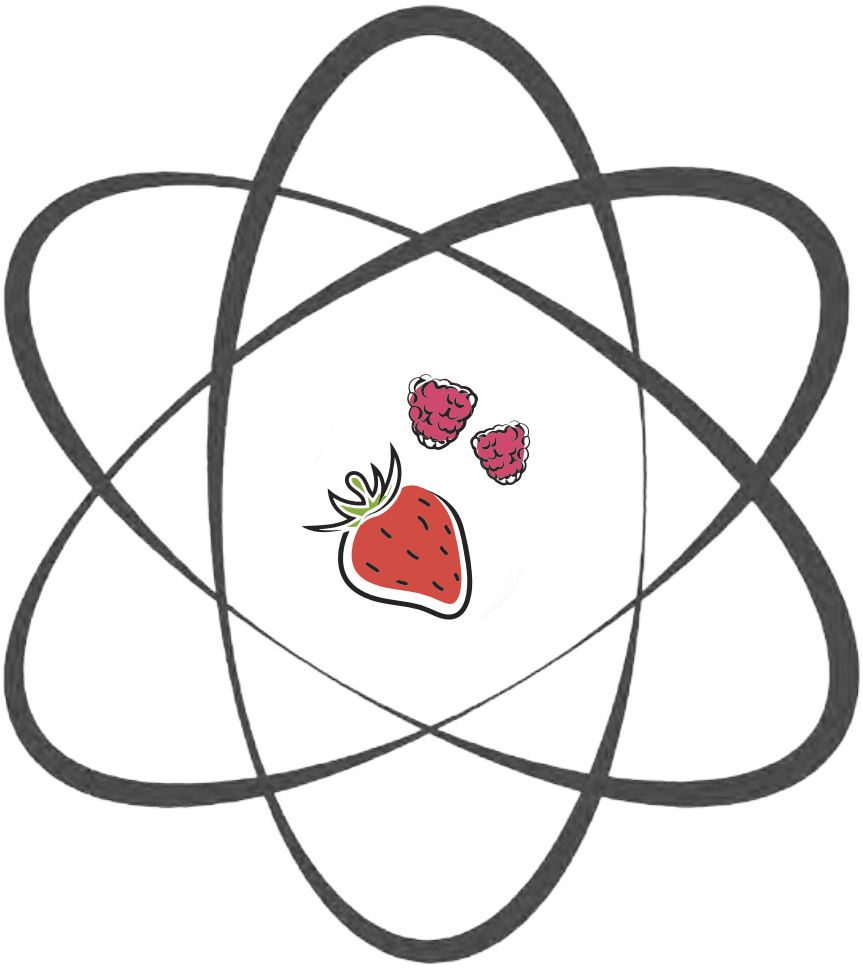
The specific seasons for citrus fruits can vary depending on the region and climate. However, here's a general guide for when some popular citrus fruits reach their peak season:

- NAVEL ORANGES: November until March or April
- VALENCIA ORANGES: March to September
- GRAPEFRUITS, WHITE OR YELLOW: November to June

- **GRAPEFRUITS, PINK OR RED:** December to June
- **LEMONS:** year-round, but peak season from May to August
- **LIMES:** year-round, with peak season in summer
- **BLOOD ORANGES:** December until April
- **CLEMENTINES:** Between late October and January
- **TANGERINES:** November to April
- **POMELOS:** Fall and winter months, typically from November to April
- **KUMQUATS:** November to June

Many citrus fruits are available year-round in grocery stores due to global sourcing. For the freshest and most flavorful citrus, though, consider purchasing fruits when they're in peak season in your local area!

Berries



Introduction to Berries

Berries are a truly ancient food in the human diet, and have been part of the human diet since long before agriculture. In fact, they were a seasonal staple of prehistoric hunter-gatherer populations all around the world—including in extreme environments like the Arctic, where they served as one of the few available plant foods for far north-dwelling populations like the Inuit and the Sami. Blackberries were even found preserved in the stomach contents of the 2500-year-old "Haraldskær Woman," a bog body found in Denmark!

Throughout the centuries, berries continued to be eaten fresh, dried, fermented, and turned into important survival foods like pemmican (a mixture of berries, meat, and fat that originated with Indigenous tribes of North America). And, science has given us plenty of reasons to keep eating them today! These nutrient-dense superfoods are not only delicious; they're also consistently linked with powerful and diverse health benefits.

So, no need for us to beat around the bush: let's gobble up the details about the amazing world of berries!

What Are Berries?

Like many plant foods, berries have both a botanical definition and a culinary one. From a botanical standpoint, berries include any fruit produced from the ovary of a single flower, containing multiple seeds and fleshy pulp. By that definition, berries include some surprising members (bananas, watermelon, tomatoes, grapes, eggplant, and pumpkin!) while excluding some we'd expect to see on the list (like blackberries, strawberries, and raspberries).

However, most of us are much more familiar with the culinary definition: berries being any small, pulpy fruit with lots of little seeds. Along with being a more intuitive classification, this definition makes berries easier to discuss as a food group with shared nutritional features and health benefits. So, that's the definition we'll be using here!

With that in mind, the berry food group includes some fruits that many of us are already familiar with, such as:

- BLACKBERRIES
- BLUEBERRIES
- CRANBERRIES
- HUCKLEBERRIES
- RASPBERRIES
- STRAWBERRIES
- BLACKBERRY-RASPBERRY HYBRIDS *such as boysenberries, tayberries, and loganberries*

However, while these might be the most common berries on store shelves and local bushes, it's far from a complete list! There are actually over 400 different species of berries, ranging dramatically in flavor (from super sweet to mouth-puckering tart) and color (yellow, red, purple, white, green, and blue)!

Some of these more unique berries include:

- AÇAÍ BERRIES, which are small, round, and dark purple, somewhat resembling a grape, and are a major staple of some traditional populations in the Brazilian Amazon
- BILBERRIES, which are a European relative of the blueberry
- CLOUDBERRIES, which belong to the rose family and are amber-colored and tart
- ELDERBERRIES, which are earthy, tart-sweet berries known for their medicinal benefits
- GOJI BERRIES OR WOLFBERRIES, which are native to Asia and have been an ingredient in traditional Chinese, Japanese, Korean, and Vietnamese medicine since the 3rd century BC

- GOOSEBERRIES, which are round, brightly green colored, and striped
- LINGONBERRIES, which are similar to cranberries but less tart
- MARIONBERRIES, which are cultivars of blackberries and have sweet, tart, complex flavors
- MULBERRIES, which grow on deciduous trees of the Morus genus and can be white, lavender, or black
- RED, WHITE, AND BLACK CURRANTS, which are bush-grown berries often consumed dried
- SALAL BERRIES, which are dark blue, distinctively flavored, and meaty textured
- SALMONBERRIES, which belong to the rose family, resemble raspberries in shape and size, and have a subtle sweet taste
- THIMBLEBERRIES, which are delicate, sweet, and bright red

What Makes Berries So Great?

When it comes to human health, berries are jam-packed with beneficial compounds (pun totally intended)! Not only are they rich in some important micronutrients; their edible skins and seeds means we get a higher concentration of fiber, fat, and phytonutrients than most fruits deliver.

Phenomenal Phytonutrients

Berries offer an outstanding spectrum of phytonutrients, which drive many of their health-promoting properties!

For one, the bright colors of berries deliver more than just aesthetic appeal: they're also the result of phytonutrient plant pigments that have numerous biological effects! For example, berries are great sources of anthocyanins—a type of plant pigment that bestows blue, purple, and red coloration. Anthocyanins appear to have anti-inflammatory and neuroprotective effects, could improve glucose tolerance, may reduce the risk of chronic diseases like heart disease and cancer, and may even have pain-relieving properties (due to an affinity for certain "pain-sensation" cell membrane receptors in the brain!). Blueberries, raspberries, cranberries, black currants, salal berries, bilberries, mulberries, and blackberries are particularly rich in **anthocyanins**!

Many berries also contain **carotenoids**—phytonutrients that bestow yellow, orange, red, and purple pigmentation. Goji berries, cloudberries, and blueberries are particularly good sources of the carotenoids lutein and zeaxanthin, which play major roles in maintaining eye health due to their high concentration in the retina and their ability to filter harmful blue-light rays (in turn protecting critical parts of the eye from light-induced oxidative damage). As a result, these two phytochemicals can help reduce the risk of age-related macular degeneration and cataracts. Goji berries, specifically, are also a great source of the carotenoid astaxanthin—an antioxidant that helps protect against damage from UV rays.

Berries also contain **phytosterols** (including sitosterol and stigmasterol), which can help block absorption of cholesterol in the small intestine, due to having a similar chemical structure to animal cholesterol. As a result, these phytochemicals can help reduce high levels of LDL cholesterol in the blood (without impacting HDL levels) and potentially reduce the risk of heart disease.

Additionally, berries are good sources of **tannins**—astringent phytonutrients that serve as antioxidants, improve blood lipids, reduce blood pressure, help fight microbial infection, and can even benefit dental health (by combatting harmful oral bacteria and inhibiting plaque formation). Berries high in tannins include blueberries, strawberries, cranberries, and raspberries.

And, that's still only scratching the surface of the phytonutrients berries are bursting with! They also contain phenolic acids like **ellagic acid** (which has antiviral, anti-cancer, and anti-inflammatory activity) and **gallic acid** (which possesses antioxidant activity three times greater than vitamin E or C!), **quercetin** (which has cardio-protective and anti-cancer properties), **ursolic acid** (which has immune-modulating, anti-diabetic, anti-inflammatory, liver-protective, cardio-protective, and antimicrobial effects), and **pterostilbene** (the main antioxidant in blueberries, which is an analog of resveratrol and may play a particularly beneficial role in Alzheimer's disease!).

In all, each type of berry boasts its own unique phytonutrient composition (and subsequently, health benefits), making it a great idea to "eat the rainbow"!

Fabulous Fiber

Berries are excellent sources of fiber, particularly in the form of cellulose, pectin, and hemicellulose. Fiber is a great example of a nutrient that isn't labelled as essential, but that is absolutely fundamental for our health! Along with regulating gut motility (promoting regularity) and some gastric hormones, it supplies our gut bacteria with fermentable substrate (i.e., food!) so that important microbes can flourish and remain diverse. High fiber intake also reduces the risk of cardiovascular disease and of many forms of cancer (especially colorectal cancer, but also liver cancer, pancreatic cancer, and others), and promotes overall lower inflammation. High-fiber diets reduce the risk of mortality in cases of kidney disease and diabetes, and can even reduce your risk of dying from an infection!

Per cup serving, berries contain the following amounts of fiber:

- BLACKBERRIES: 7.6g
- BLUEBERRIES: 3.6g
- BOYSENBERRIES: 7g
- CRANBERRIES: 3.6g
- ELDERBERRIES: 10.2g
- GOJI BERRIES: 3.6g
- HUCKLEBERRIES: 3.6g
- MARIONBERRIES: 7.6g
- RASPBERRIES: 8g
- STRAWBERRIES: 3g
- TAYBERRIES: 6.5g

Magnificent Micronutrients

Berries are well known for their nutrient density, and each variety has a unique profile of micronutrients Here are some highlights!

- COPPER, a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). High-copper berries include blackberries (about a quarter of the DV per cup) and raspberries (12% of the DV).
- MANGANESE, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Blackberries contain 40% of the DV for manganese, while raspberries contain 36%, and blueberries and strawberries contain about a quarter of the DV.
- VITAMIN C, a water-soluble vitamin with powerful antioxidant properties, with important roles in the immune system and collagen production. Per cup serving, strawberries contain nearly the entire DV for this nutrient! Blackberries and raspberries contain about a third of the DV, while blueberries and cranberries contain 16%.
- VITAMIN E, a fat-soluble vitamin that serves as an important antioxidant, protecting the lipids in cell membranes from oxidative damage. Berries high in vitamin E include blackberries (about a third of the DV per cup), raspberries (28% of the DV), and cranberries (11% of the DV).
- VITAMIN K, which plays a vital role in coagulation, bone metabolism, cellular function, and the prevention of soft tissue calcification. Blackberries and blueberries contain about a quarter of the DV per cup.

Did Someone Say Omega-3?!

Although berries aren't typically known for their fat content, they actually contain slightly higher amounts than most fruits, due to their abundance of tiny edible seeds! And, this makes them a surprising source of fat alpha-linolenic acid (ALA), the only truly essential omega-3 fatty acid.

Although ALA doesn't always get as much attention as the long-chain omega-3s DHA and EPA abundant in fatty fish, that's not for lack of benefits! In fact, ALA has been independently associated with decreases in cardiovascular risk factors (including triglycerides, total cholesterol, LDL cholesterol, and blood pressure), a reduction in arterial plaque, healthier heart rhythm, and better cardiovascular disease outcomes (including lower rates of heart disease mortality and arrhythmia). A 2021 meta-analysis, encompassing nearly 1.2 million participants, found that every 1 g daily increase in ALA intake was associated with a 5% drop in both cardiovascular disease mortality and all-cause mortality!

Additionally, ALA has been identified as potentially cancer-protective. Higher blood and tissue levels of ALA

are associated with lower incidence of colon cancer, rectal cancer, and breast cancer (as well as lower risk of existing breast cancer metastasizing). Likewise, a variety of in vitro experiments show that ALA can inhibit the proliferation of various cancer cell types—including breast cancer cells, bladder cancer cells, colon cancer cells, prostate cancer cells, and esophageal cancer cells.

Although ALA has been less thoroughly studied for other conditions, research has also linked higher ALA intake with a reduced risk of pneumonia, stroke, multiple sclerosis-related depression and fatigue, multiple sclerosis relapse, and clinical depression. There's even some evidence it can inhibit the growth of H. pylori, the bacteria responsible for stomach ulcers.

On top of that, ALA can be partially converted into DHA and EPA, in turn contributing to the health effects of these longer-chain omega-3 fats—including their important roles in regulating inflammation, pain perception, blood pressure, neurological health, immunity, eye health, gut health, and fetal development!

Per cup serving, some common berries contain the following amounts of ALA:

- RASPBERRIES: 10% of the DV (155 mg)
- BLACKBERRIES: 8% of the DV (135.4 mg)
- ELDERBERRIES: 8% of the DV (124 mg)
- STRAWBERRIES: 6% of the DV (98.8 mg)
- GOJI BERRIES: 6% of the DV (90 mg)
- LOGANBERRIES: 5% of the DV (87 mg)
- BLUEBERRIES: 5% of the DV (85.8 mg)

Health Benefits of Berries

Although many studies lump berries in with "fruit" as a general category, research looking specifically at the effects of berry consumption confirms what we might already suspect: berries are berry berry good for us! In fact, they show benefits for conditions as wide-ranging as cancer, neurological disease, cardiovascular disease, type 2 diabetes, osteoporosis, and gut health. Here's a rundown of the impressive evidence!

Reduced risk of cancer:

Berries and their phytonutrients have been shown to affect cancer risk and progression in a number of ways—including protecting cells against oxidative damage, inhibiting cell proliferation, suppressing inflammation, inducing apoptosis (programmed cell death), inhibiting the formation of blood vessels that feed tumors, and protecting against DNA damage.

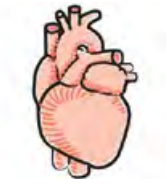
Animal and human studies have confirmed these protective effects! For example, a variety of rodent experiments have shown that berries such as blueberries and black raspberries can protect against colon and esophageal tumor growth. In humans, a 2011 clinical trial of colon cancer patients found that consuming 60g of freeze-dried strawberries every day, for a period of one to nine weeks, led to decreased expression of tumor markers in some patients.

Cognitive benefits:

A 2012 longitudinal study found that higher berry intake (particularly strawberries and blueberries) was associated with a slower rate of cognitive decline. Specifically, eating berries at least once per week, compared to less than one serving per month, was associated with up to a 2.5-year delay in cognitive aging!

Likewise, a small 2011 trial of older adults found that daily consumption of wild blueberry juice led to improvements in memory performance, learning, and word recall, and a trend towards reduced depressive symptoms. A 2017 trial similarly found that among healthy older adults, consuming 30 mL of a blueberry concentrate daily for 12 weeks led to improvements in working memory, as well as improved blood uptake and activation in brain areas associated with cognitive function. And, a 2014 trial found that in children aged 8 to 10, one-time consumption of a blueberry drink led to significant improvements in delayed recall.

Lastly, a 2022 systematic review, spanning 12 studies, looked at the effect of berry consumption on cognitive function in healthy individuals, and found significant positive effects across all cognitive domains (memory, motor skill, executive functioning, attention and concentration, and processing speed)!



Reduced risk of cardiovascular disease:

Berries have been shown to help reduce risk factors for cardiovascular disease! For example, a 2018 systematic review and meta-analysis found that berry intake could reduce total cholesterol, LDL "bad" cholesterol, triglycerides, and blood pressure, while increasing the level of HDL "good" cholesterol. A randomized controlled trial from 2015 found that blueberries in particular could improve endothelial function in adults with metabolic syndrome. And, a 2011 crossover trial of overweight individuals showed that after six weeks of consuming a daily strawberry beverage, inflammatory and thrombotic (blood-clot forming) responses were reduced after eating a high fat, high carbohydrate meal! And, a randomized controlled trial from 2019 found that among people with metabolic syndrome, consuming a cup of blueberries daily for six months resulted in a 12 to 15% reduction in cardiovascular risk (owing to sustained improvements in lipid profiles, nitric oxide activity, and vascular function).

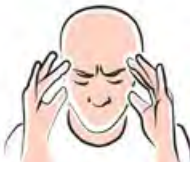
Reduced risk of type 2 diabetes:

Research suggests that berries could be a boon for blood sugar control, insulin resistance, and diabetes risk! For example, a 2010 trial of obese, insulin-resistant adults found that consuming a smoothie containing 22.5g of blueberry bioactives, twice daily for six weeks, significantly increased their insulin sensitivity relative to the placebo group (who received smoothies without any blueberry components). A 2011 randomized controlled trial similarly found that adding a strawberry beverage to a high-carbohydrate, moderate-fat meal helped reduce the subsequent inflammatory and insulin responses of participants.

And, another 2010 randomized controlled trial found that among healthy (non-diabetic) people, consuming a 150g of a berry puree (consisting of bilberries, cranberries, blackcurrants, and strawberries) was able to reduce their blood glucose response to table sugar. A similar trial from 2013 found that consuming either 150g of strawberries or 150g of a mixed berry puree (strawberries, bilberries, cranberries, and blackcurrants) was able to reduce the participants' insulin response to wheat bread and rye bread.

Appetite regulation:

A small 2015 trial found that compared to consuming a 65-calorie snack of confectionary sweets, consuming a 65-calorie snack of mixed berries resulted in decreased subsequent energy intake later in the day!



Protection against Parkinson's disease:

A 2012 pooled analysis of two American cohort studies, examining nearly 130,000 health professionals, showed that people in the highest versus lowest quintile of berry consumption had a 23% decrease in risk for Parkinson's disease. A similar effect was seen with consumption of one of the main phytonutrients in berries, anthocyanins (24% decrease).

Improved gut health:

Given their generous fiber content and many prebiotic phytonutrients, it's not surprising that berries have been shown to improve gut health—particularly through modulating the gut microbiome. In fact, research consistently shows they can enhance the presence of good bacteria while also inhibiting the growth of pathogens!

For example, 2022 systematic review and meta-analysis of 11 studies found that among the various fruit types, berries (along with citrus and pome fruits) had a profound ability to increase levels of Bifidobacterium—probiotic bacteria that help reduce inflammation, protect against colon cancer, produce B vitamins, and ferment fiber into beneficial short-chain fatty acids. A 2020 review found that berries are able to alleviate gut inflammation by modulating pro-inflammatory cytokines. Meanwhile, a 2005 experiment of eight different berry types found that raspberries and cloudberries were the most potent inhibitors of pathogens like Salmonella and Staphylococcus aureus, while cranberries protected against the growth of Listeria, and blueberries were able to reduce endotoxin transport across the gut barrier!

Better bone health:

Research suggests a protective role of berries and their unique constituents on bone health. A randomized crossover trial from 2023 found that in postmenopausal women, consuming freeze-dried blueberries daily (an equivalent of up to 1 cup fresh) for a period of six weeks led to significant improvements in bone calcium retention, indicating protection against bone loss.

A 2014 review noted that in experimental studies, specific berries (particularly blueberries, elderberries, and cranberries) have been shown to decrease the rate of bone degradation, increase the proliferation of bone marrow cells, increase whole-body bone mineral density and bone mass, increase the number of osteoblasts (bone-building cells), and decrease the number of osteoclasts (bone-degrading cells). One rodent study from 2014 using an experimental model of osteoporosis identified delphinidin, one of the major anthocyanidins in berries, as a particularly important player in protecting against bone loss!

Lower risk of all-cause mortality:

Yep, berries may even be protective of death from all causes—a general measure of health and longevity. A 2017 systematic review, encompassing data from 95 studies, found that eating 100 grams of berries (about two-thirds of a cup) per day on average led to an 8% decrease in all-cause mortality. Similarly, a prospective study that followed 10,000 Norwegian men for four decades found that compared to not eating any berries, consuming garden berries (red currants, strawberries, or raspberries) more than 14 times per month was associated with a 23% lower risk of all-cause mortality, while eating wild berries (blueberries, cowberries, or cloudberries) more than 14 times

Berries Nutrivore Scores

Berries have an average Nutrivore Score of 489! Some individual berries are as follows:

Blackberries	743
Blueberries	396
Boysenberries (frozen)	263
Cloudberries	646
Cranberries	288
Currants, black	811
Currants, red or white	393
Elderberry	546
Goji berries (dried)	780
Gooseberries	459
Huckleberries	317
Mulberries	719
Raspberries	491
Salmonberries	327
Strawberries	762

A Note on Foraging

Berries are often considered the quintessential "forage food": depending on where you grew up, you might even have some childhood memories of picking sun-ripened berries off nearby bushes (and maybe eating most of them before they made it home!). And, there's no reason to stop just because you're an adult!

Although not all berries grow in all regions, the list of wild edible berries is a long one, and chances are good that at least some varieties may be available near you. Huckleberries, salmonberries, salal, wild strawberries, wild blackberries, wild blueberries, cranberries, mulberries, gooseberries, and wild raspberries are just some of the berries you might encounter.

Depending on the region and the time of year, different berry varieties can be growing as weeds in the backyard (think: blackberries), as ornamental shrubbery (like strawberries and salal), near swamps and marshes (like cranberries), along trails in the forest (like salmonberries and huckleberries), and in various other parts of urban, suburban, and rural environments.

Of course, safety matters here: if you decide to go on a foraging adventure, it's smart to familiarize yourself with the types of edible berries growing in your area, learn about potentially poisonous lookalikes, and come prepared (long sleeves, pants, and sturdy footwear are helpful!). Likewise, steer clear from areas near pollution and industrial sites, and read up on any local regulations in your area; some places have specificrules and restrictions!

For more information on foraging berries check out the book **Sam Thayer's Field Guide to Edible Wild Plants: of Eastern and Central North America.**

Wild vs. Cultivated

When it comes to edible berries, there's really no wrong way to go: any berry—whether foraged or store-bought—are going to be a boon for your health (and your taste buds!).

However, it's worth noting that wild berries offer a few extra perks. Along with often having a more intense flavor, wild berries are typically higher in vitamins, minerals, and phytonutrients than cultivated berries. For example, a 2012 analysis found that wild strawberries, blackberries, and raspberries had between two and five times as many phenolic compounds relative to their cultivated counterparts!

Some Practical Pointers

Berries are at their peak deliciousness when they're fresh and ripe. However, they also tend to be more delicate and perishable than most other fruits, which means a little extra care is needed with their selection and handling. Here are some pointers for getting the most out of your berries!

Selecting Berries at the store:

- Look for berries that are vibrant and free from discoloration. Their color should be uniform and rich, indicating ripeness (berries with white or green spots are a no-go!).
- If possible, gently touch the berries to make sure they're neither too hard nor too soft or mushy. The "Goldilocks zone" for berries is when they yield slightly to the touch!
- Choose berries that are consistently sized within the container. This is one way to stack the odds in favor of uniform ripening.
- Berries should have a pleasant, sweet aroma. If they lack any fragrance, they might be under-ripe or low quality.
- If the berries still have stems and leaves attached, they should be bright green and fresh-looking. Avoid berries with dried or browning stems.
- For the best flavor and quality, buy berries during their peak season (more on that below!).
- Inspect the container or packaging the berries are in for any signs of mold, moisture, or staining. If the packaging is clear, check the bottom to make sure there aren't any crushed or moldy berries.
- If the store has a refrigerated section for berries, choose from there. Cold temperatures help

Storage and cleaning:

Berries are highly perishable, so it's important to store it at the right temperature and in the right environment!

- Sort and remove. As soon as you bring your berries home, sort through them and remove any damaged or overripe ones. This helps protect the quality of the rest of them!
- Don't wash until you're ready to eat them! Even if you spot some dirt, avoid washing berries before storing them. Moisture can promote mold growth and shorten

the lifespan of your berries. Instead, wash them right before consuming.

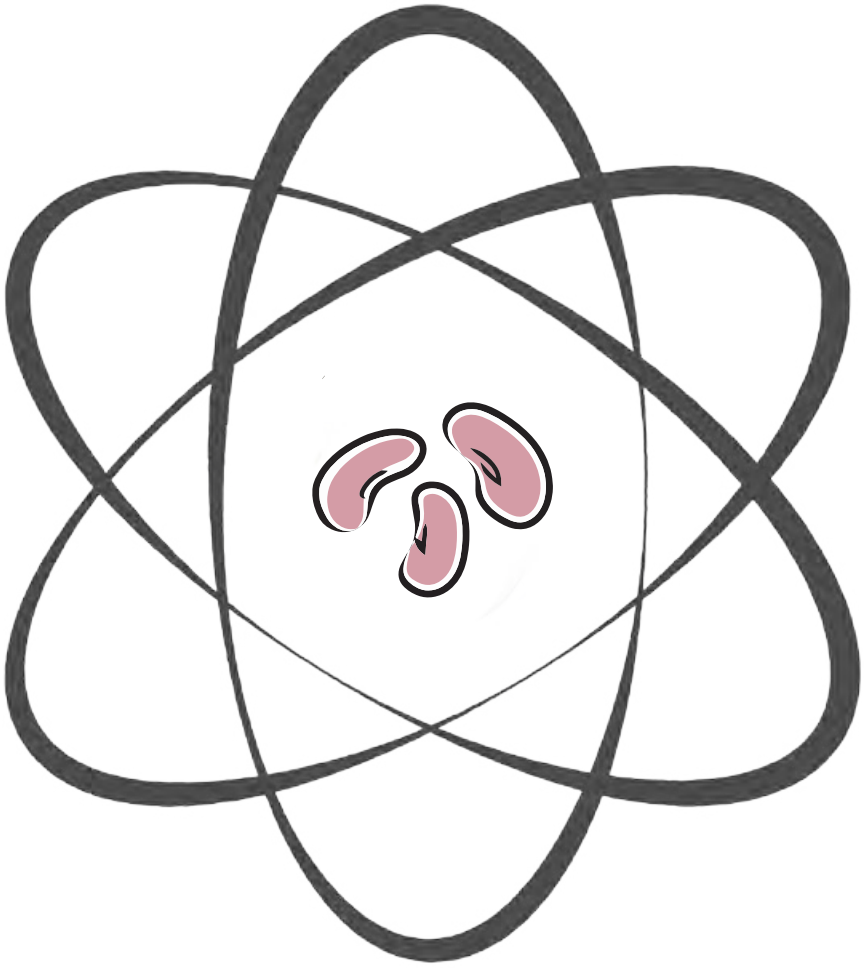
- Use ventilated containers. Store berries in shallow, breathable containers rather than airtight ones. Lack of airflow can cause condensation to build up and promote spoilage! You can also can also place a paper towel at the bottom of the berry container(s) to soak up extra moisture.
- Refrigerate! Berries are best stored in the refrigerator, rather than out on the counter. A temperature around 32 to 36 degrees F is ideal.
- Keep them dark. Store berries away from direct sunlight, as heat and light can accelerate the ripening process and degrade their quality.
- Use within a few days. Due to berries having a relatively short shelf life, it's best to eat them within a few days of purchasing (or harvesting) them.
- ...Or, freeze them! If you have more berries than you can consume before they start to spoil, consider freezing them. Wash, dry, and spread them on a baking sheet in a single layer. Once frozen, transfer them to an airtight container or a re-sealable freezer bag. Voila: you now have a great ingredient for smoothies, baking, and other recipes.

Seasonality:

The seasonality for different berries can vary depending on where you live, but here are some general guidelines!

- BLACKBERRIES: Blackberries are prominent in the summer, with their season usually spanning from June to August.
- BLUEBERRIES: Blueberries are often in season during the summer months, particularly from June to August.
- CRANBERRIES: Cranberries are typically harvested in the fall, with their main season spanning from September to October.
- CURRANTS: Various types of currants—including red, black, and white currants—can be found in summer, typically from June to July.
- ELDERBERRIES: Elderberries usually ripen in late summer, around August to September.
- GOOSEBERRIES: These berries may be available in late spring to early summer, around May to June.
- HUCKLEBERRIES: Huckleberries are often available from late summer to early fall—especially from August to September.
- RASPBERRIES: Some varieties of raspberries might start to ripen in late spring, but their main season typically extends through summer; they can sometimes continue into early fall, too!
- STRAWBERRIES: Depending on the region, strawberries can become available as early as late spring, usually from late April to June.

Legumes



Introduction to Legumes

Legumes might not be the most colorful, flashy, or exotic foods of the bunch, but don't let their humble looks deceive you: this food group is a health-boosting powerhouse! What's more, their history is intertwined with humanity itself, having supported human populations for thousands of years.

Legumes were an important staple food for numerous ancient cultures, and every major civilization has included a legume as part of their food system. Lentils were eaten in Greece as far back as 13,000 years ago, while remains of garbanzo beans have been found in the Middle East that are about 7,500 years old. Meanwhile, lima beans and cranberry beans were cultivated in some of the very first Peruvian and Mexican civilizations around 3000 B.C.E!

Over time, legumes became the centerpiece of a number of iconic national dishes—such as hummus from the Middle East, dal from India, feijoada (bean and meat stew) from Brazil, fasolada (bean soup) from Greece, ful medames (stewed fava beans) from Egypt, and many more.

It's no wonder legumes took our plates by storm as soon as humans learned how to cultivate them. Along with having a long shelf life and extreme versatility, legumes were enhancing the nutrient density of diets long before we even knew what a "nutrient" was! In fact, legumes are among the most nutrient-dense starchy plant foods available.

Without further ado, let's spill the beans on this amazing food group!

What Are Legumes?

Botanically speaking, legumes are members of the pea family (Fabaceae or Leguminosae)—an absolutely massive plant family with nearly 20,000 known species. Although "legumes" technically encompasses everything from the dried, hard beans we see in bulk bins to the garden-fresh snap peas we eat straight off the plant, edible-podded legumes are more commonly classified as vegetables. So, for the sake of discussing legumes a food group, we'll be honing in on pulses—the starchy, dried seeds of legume plants.

Per this definition, legumes include a number of familiar faces, such as:

- ADZUKI BEANS
- BLACK BEANS
- BLACK-EYED PEAS
- CANNELLINI BEANS
- CRANBERRY BEANS
- FAVA BEANS (BROAD BEANS)
- GARBANZO BEANS (CHICKPEAS)
- GREAT NORTHERN BEANS
- KIDNEY BEANS
- LENTILS
- LIMA BEANS
- LUPINS
- MUNG BEANS
- NAVY BEANS (WHITE BEANS)
- PIGEON PEAS
- PINTO BEANS
- RUNNER BEANS
- SOYBEANS
- SPLIT PEAS

(As you might notice, a particularly famous legume member is excluded from this list: peanuts! While technically a legume, peanuts have more in common nutritionally with nuts and seeds, so we'll be discussing them within that food group instead.)

What Makes Legumes So Great?

As far as beneficial compounds go, legumes are the whole package: they're rich in phytonutrients, bioactive peptides, essential micronutrients, and fiber—all of which contribute to their wide-ranging health effects. Here's a rundown of the goodies we ingest every time we eat legumes!

Phenomenal Phytonutrients

Legumes contain a diverse array of phytonutrients! And at the top of that list is their high content of of polyphenols—a phytonutrient class known for their health-protective activities, including reducing the risk of cancer, heart disease, diabetes, asthma, osteoporosis, neurodegenerative diseases, and other conditions associated with oxidative stress. As a result of their antioxidant properties, polyphenols also boost the immune system and protect against both chronic and infectious diseases.

Polyphenols are particularly concentrated in the outer seed coat of legumes. In fact, the specific colors and patterns on legumes are a product of their different polyphenol compositions! For example, legumes that are red, black, or pink tend to be high in anthocyanins—a type of polyphenol that has anti-inflammatory and neuroprotective effects, could improve glucose tolerance, may reduce the risk of chronic diseases like heart disease and cancer, and may even have pain-relieving properties (due to an affinity for certain "pain-sensation" cell membrane receptors in the brain). Similarly, legumes that are light yellow or pink in color (like black-eyed peas and lentils) tend to be particularly high in tannins—a type of astringent polyphenol known to improve blood lipids, reduce blood pressure, help fight microbial infection, and even benefit dental health (by combatting harmful oral bacteria and inhibiting plaque formation).

Additional polyphenols in legumes include:

- CAFFEIC ACID (found in pinto beans, adzuki beans, mung beans, peas, navy beans, lupins, garbanzo beans, fava beans, and black beans), which has been shown to have anti-inflammatory and anti-cancer properties, as well as potentially fighting metabolic syndrome through its effects on lipid metabolism and blood sugar regulation.
- CATECHINS (found most abundantly in fava beans, but also in lentils, cranberry beans, broad beans, kidney beans, mung beans, and pinto beans, black beans), which act as antioxidants as well as boost the activity of antioxidant enzymes. Catechins are also anti-inflammatory, modulate the immune system, exert anti-bacterial activity, have anti-cancer properties, and can boost metabolism and promote healthy weight loss.

- **FERULIC ACID** (found in garbanzo beans, peas, navy beans, fava beans, cranberry beans, cannellini beans, adzuki beans, mung beans, lentils, pinto beans, and black beans), which is a particularly potent antioxidant that can reduce inflammation, prevent cancer, reduce toxicity associated with chemotherapy and radiation, protect against diabetes, lower cardiovascular disease risk factors, and even help prevent neurodegenerative disease.
- **KAEMPFEROL** (found in black beans, pinto beans, kidney beans, mung beans, fava beans, garbanzo beans, lentils, and pinto beans), which can reduce inflammation, regulate the immune system, protect against cancer, act as an antimicrobial, prevent diabetes, reduce cardiovascular disease risk factors, prevent neurodegenerative diseases (like Alzheimer's disease), improve bone health, and aid weight loss.
- **MYRICETIN** (found in black beans, lentils, lupins, adzuki beans, fava beans, garbanzo beans, and mung beans), which can help protect against neurodegenerative diseases (like Parkinson's and Alzheimer's), glaucoma, diabetes, inflammation, liver damage, cardiovascular disease, photoageing, thrombosis, allergies, and hypertension.
- **QUERCETIN** (found in black beans, lupins, adzuki beans, mung beans, pinto beans, lentils, fava beans, garbanzo beans, and kidney beans), a flavonoid that's been shown to reduce blood pressure, enhance insulin sensitivity, reduce inflammation, support wound healing, and even boost immunity. These activities give it protective effects against diabetes, cancer, cardiovascular disease, arthritis, and even neurodegenerative diseases like Alzheimer's disease!

Legumes are also important sources of phytosterols—fat-soluble compounds with structural similarity to cholesterol, giving them the ability block absorption of cholesterol in the gastrointestinal tract. In fact, consuming 2 grams per day of phytosterols can inhibit up to 40% of the cholesterol in the digestive tract from being absorbed or reabsorbed! As a result, phytosterols are supremely effective at helping lower LDL cholesterol, in turn reducing atherosclerosis and heart disease risk. What's more, phytosterols also have antioxidant and anti-inflammatory properties, improve blood sugar regulation and insulin sensitivity, and improve the composition of the gut microbiome. Soybeans, garbanzo beans, lentils, peas, and kidney beans are particularly high in phytosterols!

And, legumes are abundant in saponins—chemical compounds that can reduce cholesterol levels, protect against oxidative stress, inhibit tumor growth, improve lipid metabolism, support immunity, and even protect against obesity! Saponins are distributed in all the cells of legume plants, but are particularly high in kidney beans, soybeans, chickpeas, pinto beans, runner beans, and navy beans.

Lastly, legumes are rich sources of phytic acid. While often often considered a phytonutrient due to its ability to bind to minerals and inhibit their absorption, phytic acid also possesses important antioxidant properties—including potentially protecting against DNA damage, reducing the risk of cardiovascular disease and insulin resistance, reducing the toxicity of mycotoxins, and even helping protect against cancer!

Powerful Peptides

Legumes are sources of bioactive peptides—strings of amino acids derived from protein breakdown (such as during digestion, or fermentation by gut bacteria). A variety of studies show that legume peptides possess important health properties, including protecting against many diseases!

Perhaps the most famous legume peptides are lectins, a group of carbohydrate-binding proteins with similar molecular structures. Although lectins are often viewed negatively due to their potential to stimulate immune responses and block the absorption of some nutrients, they've also been linked to lower rates of obesity, cardiovascular disease, and type 2 diabetes—with a number of in vitro and animal experiments also showing they possess a variety of anti-cancer mechanisms. (In general, lectin consumption from whole-food legumes appears safe and beneficial, provided the legumes are thoroughly cooked!)

Other legume peptides have a pronounced impact on blood sugar regulation and pancreatic function, giving them anti-diabetic effects. Some of these peptides include:

- AGLYCIN, which has been shown to help control hyperglycemia, improve the insulin signaling pathway, enhance glucose uptake, and restore impaired pancreatic function and insulin secretion.
- VGLYCIN, which has been shown to lower blood glucose levels and increase insulin sensitivity.
- SOYMORPHIN-5, which demonstrates blood sugar-lowering activity, as well as helps improve glucose and lipid metabolism.
- γ-CONGLUTIN, which helps regulate glucose metabolism, reduce blood sugar levels, and regulate muscle energy metabolism.

A specific legume peptide found in lupins, called deflamin, has also been shown to inhibit tumor growth and metastasis. And a variety of additional legume-derived peptides have shown promise for helping protect against cardiovascular disease, acting as angiotensin I-converting enzyme (ACE) inhibitors (giving them a role in lowering blood pressure) and serving important antioxidant and anti-thrombotic functions (that is, reducing blood clotting). Some have even shown antimicrobial and immune-modulating activity!

Magnificent Micronutrients

Legumes are great sources of essential vitamins and minerals! Although different legumes vary in their exact micronutrient composition, on the whole, they contribute significant amounts of the following nutrients to our diet:

- **COPPER**, a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). Adzuki beans, soybeans, and garbanzo beans contain 30 to 40% of the DV per ½ cup cooked, while cannellini beans, cranberry beans, fava beans, black-eyed peas, Great Northern beans, pigeon peas, navy beans, lupins, pinto beans, kidney beans, lima beans, and black beans all contain between 20 and 30% of the DV.
- **IRON**, a mineral needed for the function of numerous proteins involved in electron transport, energy metabolism, oxygen transport and storage, DNA replication and repair, free radical scavenging, and oxidative processes. Soybeans are among the highest legume sources of iron, containing 25% the DV per ½ cup cooked! Other good sources (containing 10 to 20% of the DV per ½ cup) include lentils, cannellini beans, pinto beans, adzuki beans, black beans, cranberry beans, lima beans, navy beans, Great Northern beans, kidney beans, garbanzo beans, and black-eyed peas.
- **MAGNESIUM**, an essential mineral that acts as an electrolyte and structural component in cells and bone tissue, and that serves as a cofactor for hundreds of different enzymes (giving it a role over 300 metabolic reactions!). Most legumes contain 10 to 20% of the DV per ½ cup cooked, including adzuki beans, mung beans, lima beans, soybeans, navy beans, pinto beans, black beans, lupins, cannellini beans, black-eyed peas, and Great Northern beans!
- **MANGANESE**, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Per ½ cup cooked, lima beans contain just under half the DV for manganese, while garbanzo beans contain 37%. Soybeans, adzuki beans, lentils, lupins, and cannellini beans all contain between a quarter and a third of the DV. Additional good sources (10 to 20% of the DV) are black beans, Great Northern beans, black-eyed peas, cranberry beans, kidney beans, pinto beans, mung beans, pigeon peas, navy beans, and fava beans!
- **POTASSIUM**, an electrolyte mineral with roles in a wide variety of life-sustaining processes such as heart function, muscle contraction, nerve impulse transmission, blood pressure control, blood pH, and fluid balance. Adzuki beans, cannellini beans, and lima beans all contain between 10 and 20% of the DV per ½ cup.
- **VITAMIN B9** (folate), an essential B vitamin that plays roles in blood cell production, the formation of genetic material (including DNA), cell growth, cardiovascular health, cancer protection, and cognitive and neurological health. Most legumes provide substantial folate, but the richest

sources are lentils and cranberry beans, supplying nearly half the DV per ½ cup serving, and mung beans, supplying 40% of the DV! Other stand-out sources are adzuki beans, pinto beans, garbanzo beans, navy beans, and kidney beans (about a third of the DV), as well as fava beans, pigeon peas, and Great Northern beans (just shy of a quarter of the DV)! Cannellini beans, soybeans, lupins, split peas, all contain between 10 and 20% of the folate DV per serving.

- ZINC, an essential trace mineral that serves as a cofactor for over 300 enzymes and 1000 transcription factors, giving it important roles in immune function, sensory organ function, reproduction, gene regulation, DNA synthesis, wound healing, and the metabolism and activity of multiple other nutrients! Adzuki beans, lentils, black-eyed peas, and lupins all contain between 10 and 20% of the DV per ½ cup cooked.

Fabulous Fiber

Lentils are absolute rockstars in the fiber department! Although not officially labeled as essential, fiber is absolutely fundamental for our health—helping regulate gut motility (promoting regularity), modulating gastric hormones, and supplying our gut bacteria with fermentable substrate (i.e., food!) so that important microbes can flourish and remain diverse.

High fiber intake also reduces the risk of cardiovascular disease and of many forms of cancer (especially colorectal cancer, but also liver cancer, pancreatic cancer, and others), and promotes overall lower inflammation. High-fiber diets reduce the risk of mortality in cases of kidney disease and diabetes, and can even reduce your risk of dying from an infection!

What's more, some of the fiber content of legumes comes in the form of resistant starch—one of the most famous and beneficial prebiotic carbohydrates. This highly fermentable fiber "resists" the action of human digestive enzymes, due to its molecular structure. Rather than being fully broken down in the small intestine like most starches, it passes on to the colon to become food for important gut microbes (which then ferment the starch to produce short-chain fatty acids like acetic acid, propionic acid, and butyric acid—all of which have awesome health properties of their own!).

Both human and animal studies have shown that resistant starch (and its SCFA metabolites) can improve intestinal barrier function, reduce the production of colon cancer precursors, help regulate macronutrient metabolism, increase insulin sensitivity, lower blood sugar responses after high-carb meals, reduce hunger, increase satiation, improve blood lipids, and help combat obesity. There's even evidence that resistant starch helps boost immunity, due to its influence on immune cell production and inflammatory compounds in the gut!

On top of that, the SCFAs produced via bacterial fermentation serve as the main food source for intestinal epithelial cells, giving them a huge role in promoting gut health. These unique fats have also been shown to reduce the risk of inflammatory diseases, maintain a healthy gut barrier, and aid in the absorption of important minerals (including copper, calcium, magnesium, iron, and zinc).

The resistant starch content of legumes varies based on cooking time and storage (more resistant starch forms with extended cooling!), but in general, legumes contain about 2g of resistant starch per ½ cup serving after being cooked. Navy beans, red beans, and cranberry beans tend to be particularly high!

And as far as overall fiber content goes? Any legume is a win! Per ½ cup cooked serving, legumes contain the following amounts of fiber:

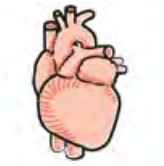
- ADZUKI BEANS: 8.4g
- BLACK BEANS: 7.5g
- BLACK-EYED PEAS: 5.6g
- CANNELLINI BEANS: 5.6g
- CRANBERRY BEANS: 7.6g
- FAVA BEANS (BROAD BEANS): 4.6g
- GARBANZO BEANS (CHICKPEAS): 6.2g
- GREAT NORTHERN BEANS: 6.2g
- KIDNEY BEANS: 6.5g
- LENTILS: 11.6g
- LIMA BEANS: 4.6g
- LUPINS: 2.3g
- MUNG BEANS: 7.7g
- NAVY BEANS (WHITE BEANS): 9.6g
- PIGEON PEAS: 5.6g
- PINTO BEANS: 7.7g
- SOYBEANS: 5.2g
- SPLIT PEAS: 7.5g

Health Benefits of Legumes

Given their outstanding phytonutrient, peptide, micronutrient, and fiber profiles, it's no shocker that legumes show wide-ranging health benefits and protection against a number of diseases. Here's a peek into the many ways they've been scientifically shown to benefit our health!

Reduced blood pressure:

Studies show legumes may have important blood-pressure lowering effects! A 2023 meta-analysis of randomized controlled trials found that for people with overweight/obese BMI, legume consumption significantly reduced systolic blood pressure. And, a 2023 cross-sectional study of people with type 2 diabetes and hypertension found that among this population, eating at least three servings of legumes per week was associated with significantly lower systolic and diastolic blood pressure values.



Improved blood lipids:

Legume consumption supports healthy blood lipid profiles, due in large part to their lipid-lowering saponins, phytosterols, and fiber! A 2007 randomized controlled trial found that eating ½ cup of pinto beans daily for eight weeks resulted in a 19% decrease in LDL cholesterol. A 2014 meta-analysis of randomized controlled trials likewise found that compared to a control diet, consuming about one serving of pulses per day (130 g) significantly lowers LDL cholesterol. A 2021 cross-sectional study found that among older men, higher intake of legumes was associated with both lower LDL cholesterol and higher HDL cholesterol levels. And, a randomized controlled trial from 2021 found that among people with elevated cholesterol, eating one cup of canned beans (black, navy, pinto, dark red kidney, or white kidney) every day for four weeks led to significant reductions in both total and LDL cholesterol!

Reduced risk of heart disease:

Although not all the research has been consistent here, some studies have found a protective effect of legume consumption on heart disease risk. A 2001 analysis of an important prospective cohort study, following nearly 10,000 participants for an average of 19 years, found that eating legumes four times per week (compared to less than once a week) was associated with a 22% lower risk of developing coronary heart disease over the course of the study. Likewise, a 2017 meta-analysis, encompassing 14 cohort studies and 367,000 people, found that people with the highest versus lowest legume consumption had a 10% lower risk of developing cardiovascular disease or coronary heart disease. And, a dose-response meta-analysis from 2023 found that eating 400g of legumes per week appeared to deliver the highest level of cardiovascular benefits!

Reduced risk of cancer:

Legume consumption has been associated with a lower risk of several cancer types in observational studies, with animal and in vitro experiments clearly demonstrating anti-cancer effects as well (including against breast cancer, colon cancer, cervical cancer, lymphoma, and liver cancer cells). Legume polyphenols, phytosterols, bioactive peptides, and fiber appear to be key players in these protective effects!

- COLORECTAL CANCER: A 2015 meta-analysis of cohort studies, encompassing nearly 2 million participants, found that higher legume consumption was associated with a 9% lower risk of colorectal cancer. When the data was stratified into subgroups, Asian populations had an 18% lower risk. And, a 2007 analysis of the Polyp Prevention Trial found that participants consuming at least 39 g of dry beans daily had a 65% lower risk of advanced colorectal adenoma recurrence. Likewise, animal studies have shown specific anti-colon-cancer effects from legumes: for example, in a rat model of colon cancer, supplementation with black beans or navy beans for four weeks led to a 44 to 75% reduction in colon carcinogenesis!
- PROSTATE CANCER: A 2017 meta-analysis of prospective cohort studies found that higher legume consumption was associated with a 15% lower risk of developing prostate cancer. Analyzed another way, every 20 g increase in legume intake was linked with a 3.7% reduction in risk!
- BREAST CANCER: A 2018 case-control study found that participants in the highest versus lowest quartile of bean intake (greater than 109.6 g daily versus less than 6.4 g daily) had a 20% lower risk of developing breast cancer, and a 28 to 36% lower risk of developing the ER-PR- breast cancer subtype in particular. Likewise, a 2022 case-control study of urbanized Nigerian women found that bean consumption (compared to not eating any beans) was associated with a 45% lower risk of developing breast cancer, and a 49% lower risk of developing triple-negative breast cancer.

In addition, legume intake may be protective against cancer mortality as a whole. A 2019 prospective study, following participants for a median of six years, found that people in the highest versus lowest tertile (third) of legume consumption had a 49% lower risk of dying from cancer!

Reduced risk of stroke:

A 2023 meta-analysis of prospective studies found that higher legume consumption was protective against death from stroke—with every 50 g per day increase in legume intake correlating with a 10% reduction in stroke mortality.

Lower body weight and waist circumference:

Legumes appear greatly beneficial for maintaining a healthy body weight. In a 2008 analysis of National Health and Examination Survey (NHANES) data, people who reported eating beans had significantly lower body weight and waist size than people who didn't consume

beans. In fact, bean-consumers had a 22% lower risk of being obese, and a 23% lower risk of having increased weight size (a marker of abdominal obesity—which itself increases the risk of heart disease and diabetes).

Likewise, a 2023 cross-sectional study of over 15,000 adults found that legume consumption was significantly protective of weight gain over time. More specifically, the more legumes a person ate, the less weight they gained over the course of 10 years. Further analyses of the data showed that these effects appeared largely due to the fiber content of legumes!

And, a 2016 meta-analysis of randomized controlled trials found that diets with a legume intervention (an average of one serving of pulses per day) led to significant reductions in body weight—even when the diets weren't intended to be calorie-restricted!

Greater satiety:

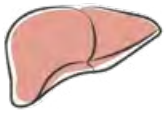
One of the most consistent effects of legumes is how filling they are, leading to major benefits for appetite regulation and satiety. For example, a 2014 systematic review and meta-analysis of acute feeding trials found that meals containing dietary pulses (beans, chickpeas, lentils, or peas) increased satiety levels by 31%, compared to non-pulse meals containing the same amount of calories. A trial from 2017 found that eating 218 calories of canned chickpeas (versus 218 calories of white bread) led to significantly suppressed appetite and energy intake, as well as a 29 to 36% reduction in blood sugar levels!

Reduced risk of diabetes and better glycemic control:

In a 2008 analysis of the Shanghai Women's Health Study, prospectively following almost 65,000 women, participants with the highest legume intake (an average of 65 g per day) had a 38% lower risk of developing diabetes compared to those eating very few legumes. A 2013 cross-sectional study of over 150,000 adults likewise found that among women, daily or weekly consumption of legumes was associated with a 29 to 34% lower risk of diabetes.

Similarly, a 2018 prospective study found that people in the top quartile of legume intake were 35% less likely to develop diabetes. When it came to individual legumes, consuming 6.6 g of lentils per day was associated with a 33% lower risk of diabetes, while 5 g of chickpeas daily was associated with a 32% lower risk!

And, a 2009 meta-analysis of 41 randomized controlled trials determined that dietary pulses significantly lower fasting blood glucose and insulin, and when combined with an overall high-fiber or low-glycemic diet, also help lower glycosylated blood proteins (including HbA1c levels).



Reduced risk of non-alcoholic fatty liver disease (NAFLD):

In a 2019 case-control study, higher total legume intake (beans, lentils, and peas) was associated with a 27% lower risk of developing NAFLD. Lentils, specifically, were associated with a 39% lower risk, and beans were associated with a whopping 65% lower risk!

Reduced risk of all-cause mortality:

A 2023 systematic review and dose-response meta-analysis, encompassing 32 cohorts and over 1.1 million participants, found that higher legume intake was associated with a significantly lower risk of death from all causes. More specifically, every 50 g per day increase in legume consumption was associated with a 6% reduction in all-cause mortality!

A Spotlight on Soy

Although soy deserves the "legume" title just as much as any other bean, it's often studied separately from other legumes due to its unique nutritional composition and phytoestrogen content, as well as its widespread consumption in products like tofu, soymilk, and meat substitutes. So, let's take a look at what makes this legume so unique!

For one, soy is rich in phytoestrogens called isoflavones—a type of phytonutrient that's structurally similar to estrogen, and subsequently can bind to estrogen receptors. Studies show that soy isoflavones possess anti-tumor effects, can help lower blood sugar levels, help protect against osteoporosis, reduce breast cancer risk, may provide relief from menopause symptoms, reduce the risk of cardiovascular disease, and assist in healthy body weight regulation. The soy isoflavones daidzein, genistein, and glycitin are metabolized by the gut microbiota (particularly Clostridium and Eubacterium), and the subsequent metabolites appear responsible for the beneficial effects of soybeans found in some studies.

Relative to other legumes, soybeans also contain slightly higher amounts of certain micronutrients, with a ½ cup of cooked soybeans providing 14% of the DV for vitamin K, 19% of the DV for vitamin B2 (riboflavin), 11% of the DV for selenium, and 7% of the DV for calcium. They also have a higher fat and protein content than most other legumes, containing 7.7 g of fat and 15.7 g of protein per half cup of cooked soybeans!

And, soybeans contain some peptides unique among the legumes! For example, they contain lunasin—a peptide with decades of research demonstrating anti-cancer properties, including an ability to suppress cell proliferation, regulate the cell cycle, and induce apoptosis (programmed death) of cancer cells. In general, research on soy-derived peptides shows they possess neuroprotective effects, benefits for cognitive impairment, anti-obesity effects, anti-diabetic effects, immunoregulatory effects, antioxidant activity, and antimicrobial and antiviral properties!

It's worth noting here that while processed soy products and individual soy components (such as soy protein or soy isoflavones) are often the target of research, the whole-bean package is really where it's at. When eaten in its unprocessed state, soy contains its full spectrum of phytonutrients, fiber, vitamins, minerals, peptides, and more! In fact, many studies assessing whole soy, soy isoflavones, and soy protein find that whole soybean consumption is associated with the greatest disease protection and health benefits.

Here are some science-based health benefits that come from eating whole soybeans:

- **LOWER RISK OF DIABETES.** In a 2008 prospective study following nearly 65,000 women for an average of 4.6 years, found that consuming 32 g of soybeans per day was associated with a 47% lower risk of developing diabetes. By contrast, intake of soy protein and processed soy products didn't show a significant protective effect.
- **LOWER RISK OF CANCER.** In 2015 meta-analysis of cohort studies encompassing nearly 2 million participants, higher soybean intake was associated with a 15% lower risk of developing colorectal cancer. A 2022 systematic review likewise found that higher soybean intake was associated with a 10% lower risk of cancer, with every additional 25 g per day increase in soy intake correlating with a 4% drop in cancer risk. (No risk-reducing effect was seen with soy protein.)
- **LOWER RISK OF ALL-CAUSE AND CARDIOVASCULAR DISEASE MORTALITY.** A 2019 meta-analysis found that whole soybean intake was associated with a lower risk of risk of death from all causes, as well as specifically from ischemic cardiovascular disease—whereas soy protein intake alone showed no significant protective effect.
- **LOWER LDL CHOLESTEROL.** A 2013 randomized controlled trial found that 40 g day of whole soybeans resulted in significant reductions in LDL cholesterol.
- **REDUCED INFLAMMATION.** A double-blind, placebo-controlled trial from 2014 found that whole soy consumption (but not purified isoflavones) significantly lowered serum hs-CRP, a measure of inflammation.

...And Now Some Soy Myth Busting!

Over the years, soy has received a lot of press—and not always good! Early research on soy (especially in animal studies) raised concerns around its isoflavone and goitrogen content, bringing fears that it could spur the growth of hormone-sensitive cancers, impact fertility, increase estrogen levels in men, harm thyroid health, and contribute to heart disease. Unfortunately, this left soy with a soured reputation that sometimes still haunts it today.

However, since the early days of soy research, an enormous number of studies have emerged looking at both the short-term and long-term health effects of soy, including in living humans. And now, the evidence is clear: not only are soy and its isoflavones safe; they're convincingly protective of many the diseases they were once feared to exacerbate!

For example, a 2021 meta-analysis of clinical studies found no evidence that soy protein or isoflavone intake had any effect on male reproductive hormones, including testosterone or estrogen levels. A 2022 meta-analysis found that soy isoflavones had a clear protective effect for breast cancer in both pre- and post-menopausal women. A 2019 review and meta-analysis determined that soy caused no significant changes in thyroid hormone levels. A 2019 systematic review and meta-analysis even found a strong inverse correlation between soy isoflavones and all-cause mortality, with those eating the highest levels of soy isoflavones having a 10% lower risk of death from all causes!

Legumes Nutrivore Scores

Legumes have an average Nutrivore Score of 489! Some individual Legumes are as follows:

Adzuki beans	535
Black beans	429
Cranberry beans	265
Fava beans (broad beans)	442
Garbanzo beans (chickpeas)	454
Great Northern beans	419
Kidney beans, red	413
Lentils	489
Lima beans	304
Lupins	224
Mung beans	249
Navy beans (white beans)	269
Pigeon peas	211
Pinto beans	390
Soybeans	326
Split peas	267

Some Practical Pointers

In general, legumes are remarkably easy to select, store, and cook; after all, that's what made them so valuable as a staple food throughout history! However, here are some tips to help you get the very most from this fabulous food group.

Storing:

- DRY STORAGE: If you're storing dried, uncooked legumes, keep them in a cool, dry place in airtight containers. This helps preserve their quality and prevents insect infestations.
- WET STORAGE: Cooked legumes—whether freshly cooked or from an opened can—can be stored in the refrigerator for about three to five days. Make sure to store them in airtight containers to prevent moisture and odors from seeping in (glass, plastic, or freezer-safe bags all work great here!).

Soaking:

Soaking is an age-old trick when it comes to preparing dry legumes, and for good reason! Soaking offers a number of both culinary and health benefits, including reducing the legume cooking time (especially helpful for larger beans like kidney beans and garbanzo beans), helping improve digestibility (by breaking down some of the complex sugars that tend to produce gas and bloating), enhancing nutrient absorption (by reducing levels of phytic acid and tannins), and creating a softer texture in the final product. Smaller legumes (such as lentils) are generally fine to cook without soaking, but even they can benefit from this extra step!

So, if you're going the soaking route, here are some basic guidelines:

1. Sort through the legumes to remove any stones or damaged legumes.
2. Rinse the legumes under cold water to remove any dirt, dust, or remaining debris.
3. Place the legumes in a bowl, and add water until the legumes are submerged by at least an inch. (You can also add a pinch of salt to the water to help soften the legumes and improve their flavor.)
4. Soaking times vary depending on the type of legume—but in general, larger beans might need to soak for eight to 12 hours, while smaller legumes might require only one to four hours. Refer to specific recipes or package instructions for recommended soaking times.
5. After soaking, drain and rinse the legumes thoroughly under cold water.
6. Now the legumes are ready for cooking!

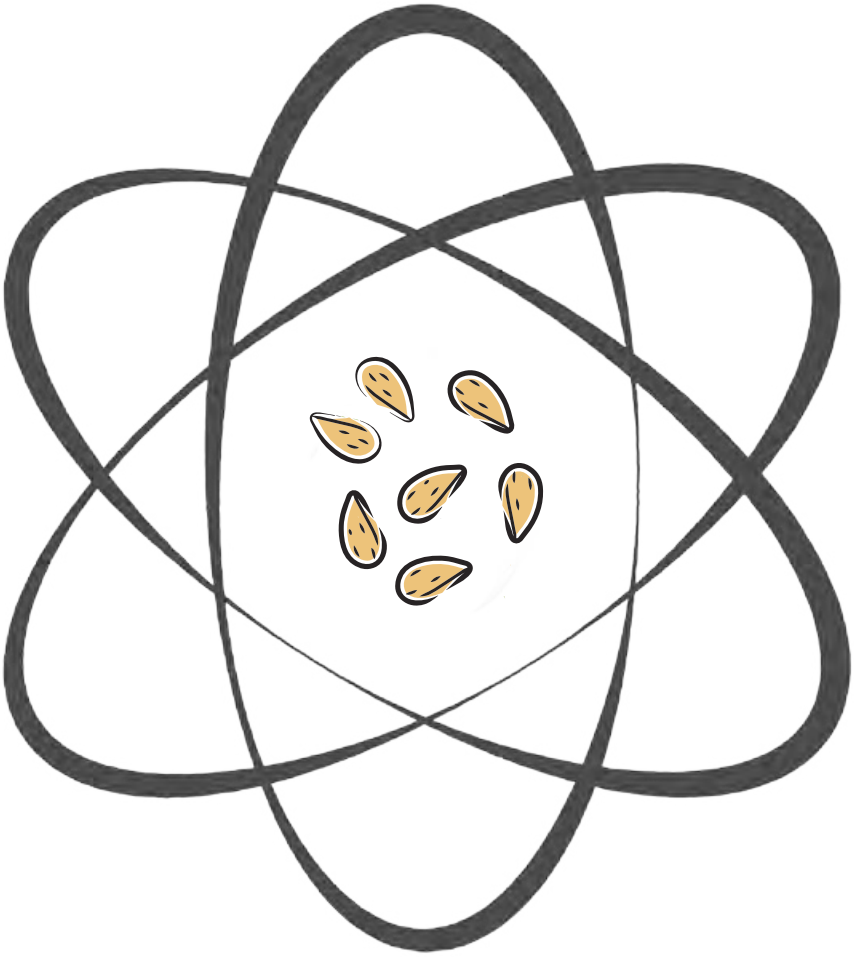
If you're short on time, you can also use a "quick soak" method for legumes: cover them in water, bring to a boil for two minutes, and then let them sit for an hour or two!

Cooking:

When it comes to cooking legumes, you have a few options:

- BOILING: Add soaked legumes to a pot, cover them with water, bring to a boil, then reduce the heat to a simmer. Cooking times vary; smaller legumes like lentils cook faster than larger ones like garbanzo beans. Add salt toward the end of cooking to prevent toughness!
- PRESSURE COOKING: Using a pressure cooker significantly reduces cooking time. It's especially useful for larger legumes that naturally have a longer cooking time. Follow your pressure cooker's instructions for cooking times.
- CROCKPOT/SLOW COOKER: Legumes can easily be cooked in a slow cooker! Combine soaked legumes with water and any desired seasonings, then cook on low for several hours until tender.

Nuts & Seeds



Introduction to Nuts and Seeds

Delicious, energy-dense, and easy to harvest, nuts and seeds helped fuel our species from time immemorial! There's anthropological evidence that 2-million-year-old human relatives (the australopiths) ingested large amounts of nuts and seeds, even developing jaw and dental adaptations to help crack these foods open. Archaeological excavations have also unearthed primitive nut-cracking tools dating back 780,000 years, alongside the remains of ancient almonds, acorns, and pistachios!

Over time, nuts and seeds became important and often revered foods across the globe. Ancient Romans gave sugared almonds as a wedding gift (a tradition that's still alive today!), and by the Middle Ages, almond milk (made from ground almonds and water) was a common ingredient in recipes. Meanwhile, ancient Greeks and Romans used walnuts medicinally, and enjoyed walnut milk as a sweet refreshment.

Today, nuts and seeds remain enormously popular all over the world. Each year, 4.5 million metric tons of tree nuts are produced globally (with coconuts and peanuts topping the list by a landslide)! And, their widespread consumption is good news indeed. Nuts and seeds' outstanding fiber and micronutrient profiles, diverse phytonutrients, amino acids, and fats translate to a range of amazing benefits for human health.

Here's a closer look at why we should be going nuts for this fantastic food group!

What Are Nuts and Seeds?

As with many foods, what defines "nuts and seeds" depends entirely on whether we're using a botanical definition or a culinary one. Technically, a nut is a specific type of fruit that has a hard shell surrounding an inner kernel, while a seed is a plant embryo enclosed in a protective covering (called the seed coat).

However, these botanical definitions exclude a number of foods we think of as nuts (such as cashews and almonds). So, for the purpose of defining a food group, "nuts and seeds" are considered to be any dry edible fruit that typically has a high fat content. (Although peanuts are technically a legume, we're including them in the "nuts and seeds" food group too, due to their higher fat content and nutritional similarities with other members of this group!)

Commonly consumed nuts and seeds include:

- ALMONDS
- BRAZIL NUTS
- CASHEWS
- CHIA SEEDS
- COCONUTS
- FLAXSEEDS
- HAZELNUTS (FILBERTS)
- HEMP SEEDS
- MACADAMIA NUTS
- PEANUTS
- PECANS
- PILI NUTS
- PINE NUTS
- PISTACHIOS
- POPPY SEEDS
- PUMPKIN SEEDS
- SESAME SEEDS
- SUNFLOWER SEEDS
- WALNUTS

What Makes Nuts and Seeds So Great?

Phytonutrients, fats, amino acids, micronutrients, fiber, oh my... what's not to love? Here's a rundown of the many outstanding components nuts and seeds contribute to our diet!

Phenomenal Phytonutrients

Phytonutrients are an amazing gift from the plant kingdom: nutritive compounds in plants that, while not technically considered essential, are absolutely vital for optimal health and disease prevention. It just so happens that nuts and seeds are great sources of these health-promoting goodies; in fact, the phytonutrient content of these foods are responsible for many of their health benefits.

Some of the most common phytonutrients in nuts and seeds include:

- PHYTOSTEROLS: Nuts are rich in phytosterols—fat-soluble compounds with structural similarity to cholesterol, giving them the ability block absorption of cholesterol in the gastrointestinal tract (in turn helping lower LDL cholesterol and reduce cardiovascular risk). Phytosterols also have antioxidant and anti-inflammatory properties, improve blood sugar regulation and insulin sensitivity, and improve the composition of the gut microbiome! The phytosterols in nuts range from 404 mg per 100 g of sesame seeds to 42 mg in 100 g of coconut meat—comparable to the levels found in legumes (another famously phytosterol-rich food group) which offers a peak of 205 mg per 100 g of black beans. Seeds like pumpkin seeds, sesame seeds, and sunflower seeds are particularly impressive sources.
- STILBENES: Some nuts are good sources of phenolic compounds called stilbenes—particularly resveratrol, an antioxidant compound famously found in red wine! Resveratrol has powerful anti-inflammatory, immunomodulatory, cardio-protective, neuro-protective, lipid-lowering, and glucose-modulating activity and has consistently shown up as disease-protective in studies. Peanuts and pistachios are the richest nut sources of this particular stilbene. (In fact, studies have shown that some peanut and pistachio samples have higher concentrations of resveratrol than some red wine samples!)
- CAROTENOIDS: Some nuts and seeds are particularly good sources of the carotenoids alpha- and beta-carotene, beta-cryptoxanthin, lutein, and zeaxanthin—a diverse group of phyto-

nutrients shown to support vision health, protect against metabolic syndrome and diabetes, and reduce inflammation. Pistachios, flaxseed and hazelnuts are particularly high in carotenoids!

- PROANTHOCYANIDINS: Proanthocyanidins are phenolic compounds with anti-cancer, antioxidant, anti-diabetic, anti-inflammatory, anti-arthritis, neuroprotective, and antimicrobial properties! They also appear to protect against some eye diseases. Hazelnuts and pecans have the highest proanthocyanidin content among the nuts, but almonds, peanuts, and pistachios are also good sources.
- FLAVONOIDS: Flavonoids are a diverse group of polyphenols that may help reduce inflammation, exert antibacterial properties, and protect against heart disease and certain cancers. Although flavonoids have a range of different health effects, their benefits seem to be primarily due to helping regulate cell-signaling pathways (rather than by acting as antioxidants, which is a perk many phytonutrients offer). Pecans, almonds, pistachios, and hazelnuts rank the highest in terms of their flavonoid content!

Fantastic Fats

Although nuts were once feared for their fat content, research consistently shows that the lipids in these foods are actually a major driver of their health benefits! Specifically, the major fats in nuts include:

- LINOLEIC ACID: Linoleic acid is the only essential omega-6 fatty acid! Along with being required for human growth and development, it serves as a structural component of cell membranes, plays a role in maintaining skin health and integrity, and is a precursor for bioactive lipid mediators. Walnuts, pine nuts, hemp seed, sunflower seeds, and Brazil nuts are among the richest nut and seed sources of linoleic acid.
- MONOUNSATURATED FAT: Monounsaturated fatty acids (MUFA) play an important role in cellular function. The main MUFA in nuts and seeds is oleic acid, which has demonstrated benefits for cardiovascular health—both in reducing risk factors like high blood pressure, cholesterol, triglycerides, inflammation, and oxidative stress, and in reducing actual cardiovascular disease incidence and events. Oleic acid has also demonstrated anti-cancer activity, may assist in body weight regulation, and influence genes and pathways involved in insulin signaling and glucose metabolism. Macadamia, hazelnuts and pecans top the list here for MUFA content!
- ALPHA-LINOLENIC ACID: Alpha-linolenic acid (ALA) is the only truly essential omega-3 fatty acid. Like other omega-3 fats, it plays an important role in regulating inflammation, pain perception, and blood pressure. It's also a major structural component of the phospholipid layer of cell membranes. Getting enough ALA helps maintain cardiovascular health, while also potentially protecting against cancer, pneumonia, and some forms of depression. Walnuts, flaxseeds, hempseeds, and chia seeds are exceptional sources of this fat; pecans and sesame seeds also contain notable amounts!

Vitamin E, We Love Thee!

Although nuts and seeds are rich in a wide variety of micronutrients (as we'll see shortly), one vitamin in particular deserves a shout-out: vitamin E! In fact, nuts and seeds are the best whole-food sources of this important nutrient.

Vitamin E's most significant role is as a fat-soluble antioxidant, protecting the lipids in cell membranes from oxidative damage. Its free radical-scavenging abilities make vitamin E helpful for cardiovascular health, cancer protection, neurological health (including slowing the progression of Alzheimer's disease), eye health, and any situations where oxidative stress increases (such as during pregnancy). What's more, vitamin E is vital for fertility, during pregnancy, and for maintaining skin health. There's even evidence that getting enough vitamin E can reduce the risk of the common cold!

Not only that, but vitamin E absorption is greatly enhanced by the presence of fat—making nuts and seeds, with their naturally abundant fat content, extremely bioavailable sources of this nutrient. One human trial found that consuming a diet with 10% or 20% of calories from almonds increased blood levels of vitamin E by 12% and 15%, respectively! Another human trial from 2018 similarly found that eating 56 g of almonds per day, for a period of four weeks, increased plasma vitamin E by 8.5%.

Per 100 g serving, nuts contain the following amounts of vitamin E:

- ALMONDS: 27 mg
- BRAZIL NUTS: 16 mg
- CASHEWS: 7 mg
- CHIA SEEDS: 0.5 mg
- COCONUTS: 2 mg
- FLAXSEEDS: 21 mg
- HAZELNUTS (FILBERTS): 20 mg
- HEMP SEEDS: 1 mg
- MACADAMIA NUTS: 0.5 mg
- PEANUTS: 8 mg
- PECANS: 27 mg
- PINE NUTS: 21 mg
- PISTACHIOS: 26 mg
- PUMPKIN SEEDS: 38 mg
- SESAME SEEDS: 0.3 mg
- SUNFLOWER SEEDS: 37 mg
- WALNUTS: 24 mg

Magnificent Micronutrients

Of course, vitamin E is far from the only micronutrient nuts and seeds provide. Other notable vitamins and minerals include:

- COPPER, a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). Per oz, sesame seeds contain 127% of the DV, while cashews contain 68%! Brazil nuts, sunflower seeds, pumpkin seeds, and pistachio seeds are also great sources, containing between 40 and 56% of the DV.
- MAGNESIUM, an essential mineral that acts as an electrolyte and structural component in cells and bone tissue, and that serves as a cofactor for hundreds of different enzymes (giving it a role over 300 metabolic reactions!). Pumpkin seeds, Brazil nuts, sesame seeds, sunflower seeds, almonds, and cashews are all notable sources of magnesium.
- MANGANESE, a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Pumpkin seeds contain 55% of the DV per oz, but sesame seeds, almonds, sunflower seeds, cashews, coconuts, and pistachios also supply substantial amounts.
- VITAMIN B7 (biotin), a water-soluble B vitamin that plays an important role in energy metabolism (serving as a coenzyme for five carboxylase enzymes), neurotransmitter production, cellular function, and the function of various organs. Per oz, almonds contain 45% of the DV for biotin, and pistachios contain 30%.
- ZINC, an essential trace mineral that serves as a cofactor for over 300 enzymes and 1000 transcription factors, giving it important roles in immune function, sensory organ function, reproduction, gene regulation, DNA synthesis, wound healing, and the metabolism and activity of multiple other nutrients. Pumpkin seeds and sesame seeds contain 20% of the DV per oz, while cashews contain 15% and sunflower seeds contain 13%.

Lastly, Brazil nuts deserve a special mention for their incredible content of selenium—a relatively hard-to-get antioxidant mineral that's important for immune and brain function. A one oz serving of Brazil nuts provides 976% of the recommended daily intake!

Fabulous Fiber

Nuts and seeds are excellent sources of fiber! Although not officially labeled as essential, fiber is absolutely fundamental for our health—helping regulate gut motility (promoting regularity), modulating gastric hormones, and supplying our gut bacteria with fermentable substrate (i.e., food!) so that important microbes can flourish and remain diverse.

High fiber intake also reduces the risk of cardiovascular disease and of many forms of cancer (especially colorectal cancer, but also liver cancer, pancreatic cancer, and others), and promotes overall lower inflammation. High-fiber diets reduce the risk of mortality in cases of kidney disease and diabetes, and can even reduce your risk of dying from an infection!

Different nuts and seeds have their own unique fiber compositions, but research generally shows that any nut fiber is likely to have a beneficial effect on gut health, appetite regulation, fat absorption, cholesterol levels, and more! For example, a 2023 in vitro experiment found that nut fibers stimulated the growth of Lachnospiraceae and Ruminococcaceae bacteria, promoting the proliferation of beneficial microbes in the colon (including some that generate short-chain fatty acids). A 2022 randomized crossover trial found that consuming 28 g per day of peanuts, for a period of six weeks, significantly increased levels of Ruminococcaceae and Roseburia intestinalis, an important butyrate producer. In a 2020 experiment using a simulated gastrointestinal model, soluble fiber from chia seeds reduced the accessibility of fats, glucose, and cholesterol, limiting their digestion.

Fiber from flaxseeds, in particular, has been the subject of a number of studies. For example, a 2012 randomized crossover study found that flaxseed fiber (added to either a drink or to bread) increased the excretion of fat, while also decreasing total and LDL cholesterol levels. Another randomized controlled trial from 2012 found that the addition of 2.5 g of flaxseed fiber to a beverage significantly suppressed appetite and energy intake. And yet another human trial found that among young men, flaxseed fiber suppressed post-meal rises in triglyceride levels, while also reducing appetite! A 2005 trial similarly found that supplemental flaxseed fiber (added to bread) reduced the subsequent blood sugar response.

Per 100 g, nuts and seeds contain the following amounts of total fiber:

- ALMONDS (WITH SKIN): 13g
- BRAZIL NUTS (DRIED, UNBLANCHED): 8g
- CASHEWS (RAW): 3g
- CHIA SEEDS: 34g
- COCONUTS (RAW): 9g
- FLAXSEEDS: 27g
- HAZELNUTS (FILBERTS): 10g
- HEMP SEEDS: 4g
- MACADAMIA NUTS: 9g
- PEANUTS: 9g
- PECANS: 10g
- PINE NUTS: 4g
- PISTACHIOS (RAW): 11g

- PUMPKIN SEEDS (SHELLED AND DRIED): 6g
- SESAME SEEDS (WHOLE, DRIED): 12g
- SUNFLOWER SEEDS: 9g
- WALNUTS: 7g

A Spotlight on L-Arginine

Nuts and seeds are some of the best food sources of L-arginine—an amino acid that plays several important roles in human health. The most unique benefit of this amino acid is its ability to increase vasodilation (AKA opening, or dilating, blood vessels)!

More specifically, L-arginine is a precursor to nitric oxide (NO), a molecule that plays a crucial role in blood vessel dilation—in turn helping regulate blood flow, maintaining healthy blood pressure, allowing proper circulation throughout the body, and enhancing the overall health of the cardiovascular system. Studies show L-arginine is particularly beneficial for people with conditions like hypertension and atherosclerosis, but evidence also suggests it could benefit patients with preeclampsia, erectile dysfunction, and peripheral arterial disease! Yet one more reason nuts are truly a heart-healthy food.

Nuts and seeds particularly high in arginine are peanuts, sesame seeds, pumpkin seeds, hazelnuts, chia seeds, pistachios, Brazil nuts, pine nuts, cashews, walnuts, and almonds—all possessing at least 600 mg of arginine per oz.

Health Benefits of Nuts and Seeds

Not surprisingly, numerous in vitro, in vivo, clinical, and epidemiologic studies have associated nut intake with a wide range of health benefits—including the modulation of glucose levels and serum lipids, positive influences on body weight, antioxidant and anti-inflammatory activities, and, consequently, protective effects against certain chronic conditions, such as cancer and cardiovascular diseases. Eating nuts and seeds on a regular basis not only improves health but can potentially extend lifespan too!

Here's what the science says about nut and seed consumption and health risk!

Reduced risk of cardiovascular disease:

Nuts and seeds are a dazzlingly heart-healthy food group. Epidemiological studies consistently show an association between nut intake and reduced risk of heart disease and stroke, as well as a reduced risk of death from these diseases.

For example, a 2023 systematic review and meta-analysis found that high versus low consumption of total nuts and seeds was associated with a lower risk of:

- TOTAL CARDIOVASCULAR DISEASE (19% LOWER RISK)
- CARDIOVASCULAR DISEASE MORTALITY (23% LOWER RISK)
- CORONARY HEART DISEASE (18% LOWER RISK)
- CORONARY HEART DISEASE MORTALITY (25% LOWER RISK)
- NON-FATAL CORONARY HEART DISEASE (15% LOWER RISK)

What's more, a dose-response analysis of the data found that with every 30 g per day increase in nut consumption, cardiovascular disease risk dropped by 24% and cardiovascular disease death dropped by 27%!

And, a 2019 meta-analysis of prospective cohort studies found that along with reducing cardiovascular and coronary heart disease incidence and mortality, higher nut consumption was associated with a 15% lower risk of atrial fibrillation and a 17% lower risk of death from stroke!

The cardiovascular-protective mechanisms of nuts and seeds are almost too numerous to count: the fiber, magnesium, polyunsaturated fatty acids, vitamin E, phytonutrients, and L-arginine in nuts have all been independently linked to reductions in cardiovascular risk—including improving endothelial function, positively impacting glucose and lipid homeostasis, improving blood lipid profiles, reducing inflammation, and more. Few foods have such an impressive resume when it comes to heart health!

Reduced risk of cancer:

Research shows that nuts and seeds may reduce cancer risk, have anti-cancer effects against specific cancer types, and even help protect against death from cancer. For example, a 2020 meta-analysis encompassing 47 studies found that compared with eating no nuts, consuming tree nuts was associated with a 12% lower cancer risk. There was also a 10% lower risk of cancer-specific mortality! These protective protective effects increased with greater nut intake.

A 2021 systematic review and meta-analysis of observational studies likewise found that the highest (versus lowest) intakes of total nuts was associated with a 14% lower risk of cancer. And, every 5 g daily increase in total consumption was associated with a 3% reduced risk of cancer 4% lower risk of cancer mortality!

And, another 2020 meta-analysis found that compared with the lowest category of nut intake, higher nut consumption was associated with a 10% decreased risk of overall cancer. These protective effects started with a consumption of 9 g of nuts per day, and the risk of cancer decreased by 10% for every 20 g per day increase in nut consumption.

Most recently, a 2023 meta-analysis found that every 10 g daily increase in tree nut intake was associated with a 20% reduction in overall cancer mortality!

Along with protecting against cancer on the whole, some research has linked nut and seed consumption to reduced risk of specific cancers. Those include:

- BREAST CANCER: A 2015 study found that high intakes of walnuts, almonds, and peanuts reduced breast cancer risk by 2 to 3 times! And, a 2022 study found that regular nut consumption was associated with better disease-free survival among long-term breast cancer survivors.
- COLORECTAL CANCER: A 2018 case-control study found that consuming at least three servings of nuts per week (compared to consuming no nuts) was associated with a 70 – 72% lower risk of colorectal cancer. Another prospective observational study from 2018, studying patients with stage III colon cancer, found that those who consumed at least two servings of tree nuts per week had a 46% increase in disease-free survival (and 53% increase in overall survival) compared to patients who didn't consume nuts!
- PANCREATIC CANCER: A 2013 prospective study of over 75,000 women found that after adjusting for various risk factors, consuming nuts at least twice per week (compared to rarely or never) was associated with a 35% lower risk of pancreatic cancer.
- LUNG CANCER: A 2017 analysis of two large observational studies found that regardless of smoking status, the highest versus lowest quintile of nut intake was associated with a 26% lower risk of lung cancer.

Improved blood sugar control:

Although the jury's still out about whether nut and seed consumption directly impacts incidence of type 2 diabetes, studies suggest these foods can at least help regulate blood sugar! For instance, a 2021 systematic review of 15 different trials concluded that among type 2 diabetics, tree nut consumption helped reduce both fasting blood sugar and glycated hemoglobin (a measure of long-term blood sugar control). The beneficial role of nuts in glucose and insulin metabolism has been associated with their content of fiber, fat, minerals, and other bioactive molecules.

Improved cognitive health and performance:

Nuts and seeds could rightfully be called "brain food!" A 2023 prospective cohort study found that among adults aged 55 to 75, those consuming at least three servings of nuts per week had a significantly slower decline in cognitive performance, compared to participants eating less than one serving of nuts per week. Another prospective study from 2019 found that even after adjusting for potential demographic, dietary, and behavioral factors, eating at least 10 g of nuts per day was associated with higher cognition scores and a 40% lower risk of poor cognitive function!

Similarly, a 2022 cohort study of elderly adults found that compared to nut non-consumers or less-than-weekly consumers, those consuming at least 70 g per week of nuts had a 17% lower risks of cognitive impairment. Importantly, consistent nut consumption mattered: eating large amounts of nuts on an infrequent basis (e.g., at least 70 g consumed in only one day per week) was not associated with better cognitive performance!

Peanuts specifically have been shown to boost some aspects of cognition, especially memory. In a 2021 randomized controlled trial of healthy young adults, six months of consuming either 25 g daily of roasted peanuts or 32 g daily of peanut butter resulted in significant improvements in immediate memory, as well as better stress responses. These improvements were heavily correlated with polyphenol intake from the peanuts!

These cognition-supportive effects seen observationally are well supported mechanistically. Neurons are particularly susceptible to oxidative stress, and the impressive quantities of vitamin E, antioxidant phytonutrients, and (in some cases) omega-3 fats in nuts and seeds can help protect neurons from free radical damage!

Reduced risk of death from infectious disease:

A 2016 systematic review and meta-analysis of prospective studies found that every 1 oz serving per day increase in tree nut intake was associated with a 75% lower risk of death from infectious disease. A 2019 analysis of data from over 566,000 adults likewise found that after adjusting for potential confounders, nut consumption (compared to no nut consumption) was associated with a 23 – 28% lower risk of death from infectious causes. Indeed, nuts contain a number of potentially immune-boosting components that could explain this finding—particularly their phytonutrients and vitamin E!

Reduced risk of depression:

Nuts and seeds may even help protect against depression! For example, a 2016 cohort study of over 13,000 adults found that consuming nuts at least once per week (compared to less than once per week) was associated with an 18% reduced risk of depressive symptoms. A 2022 systematic review likewise concluded that overall, the available research (both observational studies and controlled trials) suggests that higher nut consumption is associated with lower risk of depression, better mood state, and fewer depressive symptoms in the overall population.

Reduced risk of non-alcoholic fatty liver disease (NAFLD):

A 2023 systematic review and meta-analysis of 12 observational studies found that when comparing the highest nut intake with the lowest, NAFLD risk was reduced by 10%. One prospective study from 2020 found that among men, consuming nuts at least once per day was associated with a 41% lower risk of developing NAFLD. And, a 2021 analysis of National Health and Nutrition Examination Survey (NHANES) data found that nut consumption of 15 – 30 g daily was associated with significantly lower prevalence of NAFLD in both men and women.

This protective effect may be due to nuts' high vitamin E content (which helps prevent lipid peroxidation involved in NAFLD), fiber (which helps reduce liver exposure to harmful bacterial products like endotoxin), and unsaturated fat (which has been shown to help alleviate liver fibrosis and liver fat accumulation).

Reduced risk of respiratory disease death:

A 2016 systematic review and meta-analysis of prospective studies found that every 1 oz serving per day increase in nut consumption was associated with a 52% reduced risk of respiratory disease mortality! A 2015 meta-analysis of over 120,000 adults likewise found a 29% lower risk of death from respiratory diseases when comparing the highest versus lowest intakes of nuts. And, a 2014 analysis of two large cohort studies found that consuming nuts two to four times per week was associated with a 17% reduction in respiratory disease mortality, while consuming nuts at least five times per week cut that risk by 24%!

Although more research is needed to understand the mechanisms at play here, the fatty acids, magnesium, and phytonutrients in nuts and seeds have been shown to have lung-protective effects.

Neutral or reduced risk of weight gain and obesity:

Although nuts were once feared to contribute to weight gain due to their high fat content and energy density, our most up-to-date research suggests they contribute to weight gain in the general population—and what's more, may even help protect against obesity!

For example, a 2021 systematic review and meta-analysis found that in prospective cohort studies, higher nut consumption was associated with a 7% lower risk of being overweight or obese, as well as a lower risk of elevated waist circumference. Similarly, a 2019 systematic review of prospective studies found an inverse association between long-term nut consumption (typically at intakes of at least one to two servings per week) and weight gain over time. Consumed in moderation, the nutrients, fiber, and bioactive compounds in nuts appear to promote metabolic health and assist in healthy weight regulation.

Reduced risk of all-cause mortality:

Nut consumption appears protective over all-cause mortality! The 2020 Prospective Urban Rural Epidemiology (PURE) study, using data from 16 countries from five different continents, found that consuming over 120 g of nuts per week (compared to less than 30 g per month) was associated with a 23% reduced risk of total mortality (including a 28% reduced risk of cardiovascular mortality, and an 18% reduced risk of non-cardiovascular mortality)!

Similarly, a 2016 systematic review and meta-analysis, encompassing 29 prospective studies, found that a mere 10 g serving per day increase in tree nut intake was associated with an 18% reduced risk of all-cause mortality!

What's the Deal with Peanuts?

Arguably the most beloved of the nuts (at least based on global consumption!), peanuts have been subject to some lingering rumors about their healthfulness and safety. In particular, you may have heard the claim that peanuts are widely contaminated with mycotoxin-producing mold, making them dangerous to eat. Yikes! When it comes to peanuts, is there a fungus among-us?

Peanuts can indeed be susceptible to mold growth—primarily Aspergillus flavus, which produces carcinogenic metabolites called aflatoxins (which in turn have been shown to induce liver injury and liver cancer at high enough exposures). This mold is more likely to contaminate crops in warm and humid regions, and can infect peanuts growing in the field, at harvest, or during storage.

However, this doesn't mean the peanuts we buy in the store are swimming in mycotoxins! In many parts of the world (especially in the United States and the European Union), strict regulations and quality control measures are in place for peanuts and peanut products. These regulations involve testing and setting limits on aflatoxin levels, ensuring that peanuts on the market are safe to consume. The FDA also conducts random checks on peanut butter and other peanut products, removing any items from sale that don't meet food safety standards.

What's more, most peanuts sold for human consumption go through processes like roasting or heat treatment. These processes destroy a substantial amount of aflatoxin. For example, a 2017 study found that roasting reduced the aflatoxin content of experimentally contaminated peanuts by up to nearly 90%!

It's also worth noting that, to date, there haven't been any reported outbreaks of human illness caused by aflatoxins in the United States (although such outbreaks have occurred in some developing countries).

Bottom line: by the time peanuts (and peanut products) reach the store shelves, they've been harvested, processed, and screened to eliminate any harmful levels of aflatoxin exposure. Buying major brands of peanut products and peanut butter (opposed to home-grown items) can help further ensure these products are safe!

Nuts and Seeds Nutrivore

Nuts and seeds have an average Nutrivore Score of 276, but different members of this food group vary tremendously here!

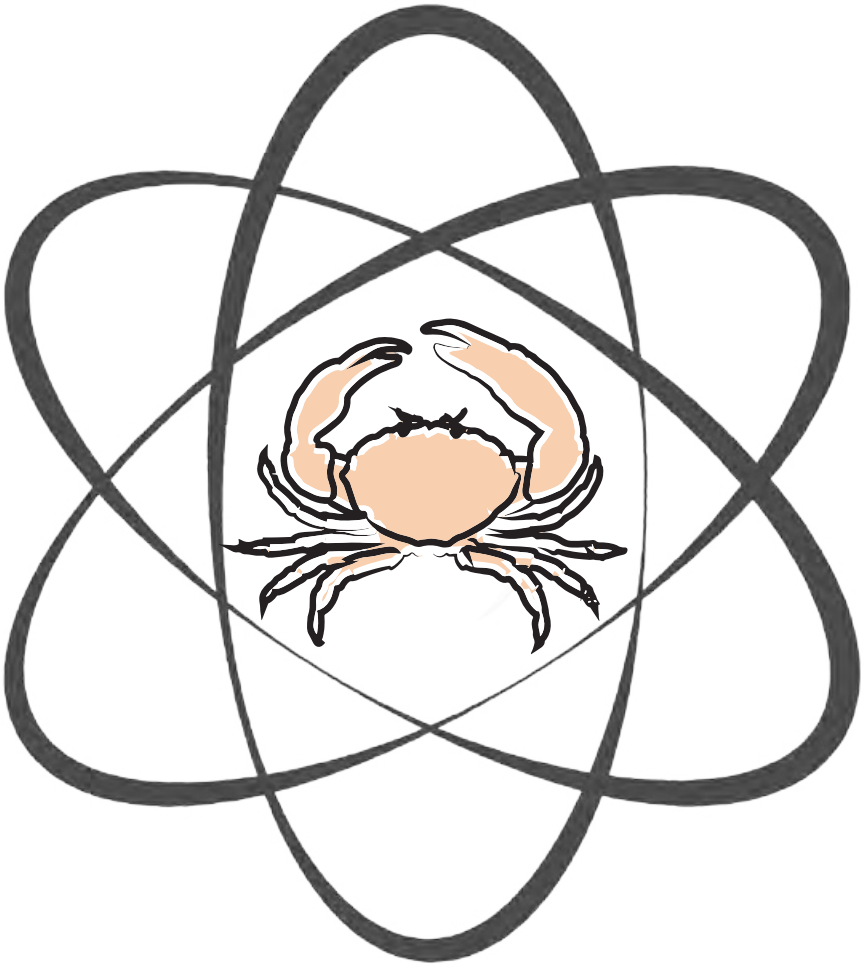
Almonds (with skin)	234
Brazil nuts (dried, unblanched)	694
Cashews (raw)	203
Chia seeds	450
Coconut (raw)	179
Flaxseeds	515
Hazelnuts (filberts)	292
Hemp seeds	415
Macadamia nuts	167
Peanuts	219
Pecans	221
Pine nuts	222
Pistachios	265
Pumpkin seeds	271
Sesame seeds	299
Sunflower seeds	340
Walnuts	303

Some Practical Pointers

Here are some tips for selecting and storing nuts and seeds, to ensure they stay fresh and delicious as long as possible!

- **CHECK FOR FRESHNESS.** When buying nuts and seeds (especially if in bulk containers rather than pre-packaged), look for those with no signs of rancidity or mold. Avoid nuts that look or smell "off"!
- **BUY IN SMALL QUANTITIES.** The unsaturated oils in nuts and seeds can go rancid over time due to more readily oxidizing than saturated fats. Purchase smaller quantities to ensure you use them before they spoil!
- **STORE IN AIRTIGHT CONTAINERS.** Storing nuts and seeds in airtight containers (like glass jars or resealable bags) helps prevent exposure to air and moisture, in turn helping them stay fresh for longer.
- **KEEP THEM COOL AND DRY.** Store nuts and seeds in a cool, dry place, such as a cupboard or pantry (as long as those places aren't near the stove!). Avoid storing in direct sunlight. Moisture can cause nuts and seeds to spoil more quickly (or in the case of raw items, sprout!), so keeping them away from humid environments is idea.
- **REFRIGERATE OR FREEZE.** For nuts with higher polyunsaturated fat content (such as walnuts or flaxseeds), storing in the refrigerator or freezer can help prevent their delicate fats from oxidizing, in turn extending shelf life. Just be sure to use an airtight container or freezer bag!
- **LABEL AND DATE.** To help keep track of freshness, label containers with the date of purchase.

Seafood



Introduction to Seafood

Out of all the animal-based foods out there, one group has consistently topped the scoreboard in terms of health benefits: seafood! In fact, seafood consumption can positively impact nearly every body system, helping improve both our physical and our mental health. It's also an incredibly ancient food group: archeological evidence shows that as far back as 1.95 million years ago, our early ancestors were using stone tools to butcher and process aquatic life. These foods may have supplied critical brain-growth compounds that helped pave human evolution.

Without further ado, let's take a dive into this amazing food group!

What Counts as Seafood?

The term "seafood" encompasses any edible aquatic creature—meaning all freshwater fish, saltwater fish, shellfish (both mollusks and crustaceans), and roe (fish eggs). (While other water-borne organisms like seaweed and algaes are also technically foods from the sea, they have more nutritional similarities to other plant life, and are therefore considered vegetables.)

Although the full list is enormous, some of the most commonly eaten types of seafood include:

- ANCHOVIES
- ARCTIC CHAR
- BARRACUDA
- BLACK COD
- CAVIAR (STURGEON ROE)
- CATFISH
- CLAM
- COD
- CRAB
- CRAWFISH
- EEL
- FLOUNDER
- GROUPER
- HADDOCK
- HALIBUT
- HERRING
- IKURA (SALMON ROE)
- LINGCOD
- LOBSTER
- MACKEREL
- MAHI MAHI
- MONKFUSH
- MUSSEL
- OCTOPUS
- ORANGE ROUGHY
- OYSTER
- PERCH
- PIKE
- POLLOCK
- SALMON
- SARDINES
- SEA BASS
- SEA CUCUMBER
- SEA URCHIN
- SCALLOP
- SHARK
- SHRIMP/PRAWNS
- SMELT
- SNAPPER
- SOLE
- SQUID
- STURGEON
- SWORDFISH
- TILAPIA
- TOBIKO (FLYING FISH ROE)
- TROUT
- TUNA
- WHITEFISH
- YELLOWTAIL

What Makes Seafood So Great?

Most of us have heard about seafood's greatest claim to fame (the omega-3 fats in oily fish), but seafood actually contains a variety of other impressive nutritional features, too—including important carotenoids and micronutrients. What's more, different types of seafood are particularly noteworthy sources of these nutritional goodies, making variety worth striving for!

Omega-3 Fats

Fish and shellfish are our dominant dietary sources of the long-chain omega-3 fatty acids DHA and EPA (opposed to ALA, the shorter-chain omega-3 fat found in plants). These important fats block multiple inflammation pathways in our cells, making them powerfully anti-inflammatory; they also play important roles in neurological health, immune function, eye health and vision, inflammation, pain signaling, gut health, fetal development, and some aspects of cardiovascular health (like triglyceride levels and blood clotting)!

Across endless studies, deficiencies in DHA and EPA have been linked to dyslexia, violence, depression, anxiety, memory problems, Alzheimer's disease, weight gain, cancer, cardiovascular disease, stroke, eczema, allergies, asthma, inflammatory diseases, arthritis, diabetes, autoimmune diseases, and many others. So, it's easy to see why getting enough of them is important! In fact, omega-3s have been shown to reduce our risk of many chronic diseases and chronic disease risk factors, such as high triglycerides.

Oily seafood like salmon, trout, mackerel, herring, sardines, anchovies, and caviar are some of the best sources of EPA and DHA in the world!

Carotenoids

Many types of seafood contain carotenoids—a class of fat-soluble pigments that impart a red, pink, orange, or yellow coloration. For aquatic life, carotenoids are useful for survival because they help protect against UV radiation, free radicals, reactive oxygen species, and other stressors encountered in the water. But, these compounds also impart important health effects for humans when we eat them!

One of the most common carotenoids in seafood is **astaxanthin**, a reddish pigment with potent antioxidant and anti-inflammatory properties. In fact, its ability to fight free radicals is up to 6000 times higher than another famous antioxidant, vitamin C! A variety of in vitro and in vivo studies have demonstrated astax-

anthin can help boost cardiovascular health, reduce high blood pressure, modulate the immune system, protect against diabetes, exert anti-tumor activities, protect the liver, boost neurological health (including protecting against neurodegenerative conditions like dementia, Parkinson's disease, and Alzheimer's disease), support bone health, improve skin health, enhance performance, support eye health (including protecting against glaucoma and cataracts), and beneficially influence the endocrine system. It's also been shown to improve the gut microbiome composition!

Due to its high concentration in algae and seaweed, astaxanthin is particularly abundant in algae-eating fish and shellfish such as salmon, rainbow trout, Arctic char, krill, shrimp, lobster, crawfish, and some crabs. (Indeed, their astaxanthin content is why all these creatures are similarly colored!)

A derivative of astaxanthin, **adonixanthin**, has also been found in seafood such as salmon and rainbow trout. Although relatively little research exists on it so far, the studies we do have show that adonixanthin may possess anti-tumor effects against glioblastoma, protect against hemorrhagic brain injury (even more so than astaxanthin!), and have beneficial activity in the central nervous system.

Some seafood also contains **canthaxanthin**, a red-orange carotenoid with powerful antioxidant activity—including potentially protecting LDL cholesterol from oxidation (in turn giving it a cardio-protective role). It can also help modulate the immune system, including enhancing the function and proliferation of immune competent cells. Canthaxanthin is found in Pacific salmon, sea trout, and some less common edible fish such as seabream and golden grey mullet.

Although less well-studied for their effects on human health, other antioxidant carotenoids in seafood include **mytiloxanthin** (found in shellfish like mussels and oysters, and possessing nearly as much antioxidant activity as astaxanthin!), **pectenolone** (found in scallops), **tunaxanthin** (found in albacore tuna, as the name might imply, as well as salmon and yellowtail), and **alloxanthin** (found in clams, mussels, catfish, lake shrimp, and lake trout). Although their specific benefits are still being explored, these carotenoids all possess antioxidant activity that would likely make them protective against a number of chronic diseases.

Magnificent Micronutrients

Seafood has a dazzling array of micronutrients, including:

- VITAMIN A (RETINOL), a vitamin is essential for bone growth, tooth remineralization, skin health, vision, reproduction, and immune function. It's found in shrimp, salmon, sardines, and tuna.
- VITAMIN B7 (BIOTIN), a water-soluble B vitamin that plays an important role in energy metabolism (serving as a coenzyme for five carboxylase enzymes), neurotransmitter production,

cellular function, and the function of various organs. A 4 oz serving of sardines contains 92% of the DV for biotin, while clams contain 87% of the DV. Halibut and mackerel are also great sources!

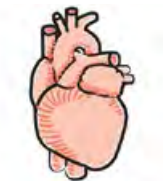
- **CALCIUM,** a major structural component of bones and teeth that also serves as an electrolyte—a type of electricity-conducting mineral needed for regulating nerve impulses, muscle contraction, heartbeat, blood pH, and fluid balance. A 4 oz serving of bone-in sardines contains 34% of the DV for calcium, and crab, scallops, and canned salmon are also great sources.
- **COPPER,** a trace mineral involved in glucose and cholesterol metabolism, gene expression, free radical scavenging, red blood cell production, and the growth, development, and maintenance of various organs (including the heart and brain). Seafood rich in copper includes squid (242% of the DV per 4 oz serving!) and Alaskan king crab (118% of the DV!); sardines and trout contain about a quarter of the DV.
- **IODINE,** a trace mineral that serves as a structural component of thyroid hormones, giving it a major role in thyroid health and function (and subsequently metabolism, reproductive function, growth, and development). Per 4 oz serving, Alaskan king crab contains 162% of the DV for iodine, clams contain 120% of the DV, and mussels contain 80%. Atlantic mackerel, Atlantic herring, and sardines also supply notable iodine.
- **MANGANESE,** a mineral that serves as a cofactor and component of numerous enzymes—giving it roles in carbohydrate metabolism, amino acid synthesis, gluconeogenesis, detoxification, lipid processing, free radical defense, bone and collagen formation, and wound healing. Per 4 oz serving, mussels contain 170% of the DV for manganese, while trout contains 43%!
- **VITAMIN B3 (NIACIN),** a water-soluble B vitamin that's needed for over 400 enzymes involved in DNA repair, fatty acid synthesis, antioxidant systems, detoxification, hormone synthesis, and macronutrient breakdown. Per 4 oz serving, skipjack tuna contains over 100% of the DV for niacin; halibut contains 47% of the DV for niacin, while sardines contain 38%.
- **SELENIUM,** a trace mineral that helps form over two dozen selenoproteins involved in reproduction, thyroid hormone metabolism, antioxidant defense, DNA synthesis, and immunity. Per 4 oz serving, sardines, Atlantic herring, halibut, squid and mussels all supply nearly 100% or more of the DV for iodine. Clams, crab, salmon, and shrimp are also great sources!
- **VITAMIN B1 (THIAMIN),** a water-soluble vitamin that serves as a cofactor for a variety of enzymes involved in carbohydrate and amino acid metabolism, RNA and DNA production, and generating energy for the Krebs cycle. Seafood high in thiamin includes mackerel, trout, salmon, and tuna.
- **VITAMIN B12 (COBALAMIN),** a water-soluble vitamin that serves as a cofactor for enzymes involved in energy metabolism, red blood cell production, DNA synthesis, neurotransmitter production, nervous system health, and folate metabolism. Shellfish are an outstanding source of vitamin B12, with mussels boasting 575% of the DV per 4 oz serving, clams containing 541% of the DV, and Alaskan king crab containing 431% of the DV. Other amazing marine sources of this nutrient include Atlantic herring (655% of the DV) sardines (428% of the DV), Atlantic mackerel

(417% of the DV), and trout (373% of the DV). Halibut, squid, and skipjack tuna also contain notable amounts.

- **VITAMIN D,** a fat-soluble vitamin and steroid hormone that's needed for immune function, gut health, calcium absorption, and skeletal health. Per 4 oz serving, Atlantic mackerel contains 93% of the DV, sardines contain 28% of the DV for vitamin D, and halibut contains 27%.

Health Benefits of Seafood

Given their awesome assortment of omega-3 fats, antioxidants, and micronutrients, it shouldn't come as a surprise that seafood consistently shows up as health-protective against a wide variety of diseases! Here are some highlights.



Cardiovascular Disease

Seafood's reputation as being heart-healthy has enormous backing in the scientific literature! In a 2021 meta-analysis spanning 25 prospective cohort studies and over 2 million participants, cardiovascular disease mortality dropped by 4% with every 20 g increase in daily fish intake. A 2014 meta-analysis additionally found that people in the highest category of fish consumption (four or more times per week) had a 21% lower risk of developing acute coronary syndrome (in which blood flow to the heart suddenly decreases); analyzed another way, every 100 g increase in weekly fish intake was associated with a 5% lower risk.

A 2021 meta-analysis focusing specifically on seafood intake and stroke found that consuming 1000 g of fish per month was associated with a 17.3% drop in stroke risk. Interestingly, another analysis of prospective cohort studies, this one from 2018, found that when fatty fish and lean fish were analyzed separately, both fish types were significantly protective for stroke risk. So, it's more than just the omega-3s in oily fish driving these cardiovascular benefits!

Among people with diabetes, a 2018 cohort study found that over the course of 18 years of follow-up, people who ate fish at least twice a week had a 70% lower risk of death from stroke and a 31% lower risk of death from cardiovascular disease in general.

Controlled trials have also supported the cardiovascular benefits of fish consumption. A 2017 meta-analysis of 14 intervention studies found that oily fish consumption led to a significant improvements in cardiovascular risk factors, including a drop in triglyceride levels (-0.11 mmol/L) and an increase in HDL cholesterol (0.06 mmol/L).

Lastly, a 2023 review of meta-analyses found that per 100 g of daily fish intake, risk of myocardial infarction dropped by 25%, risk of heart failure dropped by 20%, risk of stroke dropped by 14%, risk of coronary heart disease dropped by 12%, risk of atrial fibrillation dropped by 40%, and risk of cardiovascular mortality dropped by 25%. Wow!

Depression and Anxiety

Seafood isn't just a boon for physical health: it's supportive of mental health, too! Specifically, research has linked fish consumption to a lower risk of mood disorders like depression and anxiety.

In a 2018 review of prospective studies, encompassing nearly 110,000 participants, every additional weekly serving of fish was associated with an 11% lower risk of depression. A meta-analysis from 2016 likewise found that people with the highest versus lowest fish consumption had a 17% lower risk of depression. And, a 2017 prospective study in Japan found that people eating at least 111 g of fish per day had a 56% lower risk of depression!

Fish intake appears similarly protective of mental health during pregnancy. Two studies, one from 2013 and one from 2009, found that at 32 weeks gestation, women with no omega-3 intake from seafood had a 53% higher risk of anxiety and a 54% higher risk of depression, compared to women eating over 1.5 of omega-3s from seafood per week.

Cognitive Impairment

Studies suggest a protective role of seafood on cognitive disorders. In a 2016 meta-analysis of 21 cohort studies, every 1 serving per week increment of fish intake was associated with a 5% lower risk of dementia and a 7% lower risk of Alzheimer's disease. A 2021 cohort study likewise found that people in the top two quartiles of fish intake had a 61 – 78% lower risk of developing dementia later in life. And, a 2023 review of meta-analyses found that per 100 g of daily fish intake, risk of Alzheimer's disease dropped by 39%!

Inflammatory Bowel Disease

A 2020 meta-analysis found that higher fish consumption was associated with a 46% lower risk of ulcerative colitis.

Cancer

Seafood intake has been associated with a decreased risk of many different cancers! So far, the research shows protection against:

- BRAIN CANCER: A 2020 meta-analysis of eight observational studies found that higher fresh fish intake was associated with a 28% lower risk of developing glioma.
- COLORECTAL CANCER: A 2022 meta-analysis, looking at the results of 25 different prospective studies, found that every 50 g increase in daily fish consumption was associated with a 4% reduction in colorectal cancer risk. And, a 2022 analysis looking specifically at canned fish consumption (tuna, mackerel, and sardines) found a significantly protective effect at higher intakes: people eating canned fish 1 – 2 times per week had a 19% lower risk of colorectal cancer, while people eating canned fish at least twice a week had a 34% lower risk! Assessed another way, every 10 g daily increase of canned fish reduced colorectal cancer risk by 20%.
- ESOPHAGEAL CANCER: In a 2013 meta-analysis of 34 studies, people with the highest versus lowest intake of fish had a 36% lower risk of developing esophageal cancer.
- LIVER CANCER: A 2015 meta-analysis of 17 case-control and 3 cohort studies found that people with the highest (versus lowest) fish intake had a 35% lower risk of developing liver cancer!

- LUNG CANCER: A 2014 meta-analysis found that people with the highest versus lowest consumption of fish had a 21% lower risk of developing lung cancer.
- LYMPHOMA: A 2020 meta-analysis found that people in the highest category of fish consumption had a 20% lower risk of developing non-Hodgkin's lymphoma, compared to people in the lowest category of fish consumption. This translated to a 15% lower risk per every additional three weekly servings of fish!
- ORAL CANCER: A meta-analysis from 2019 found that Europeans with the highest versus lowest consumption of fish had a 33% lower risk of oral cancer.
- OVARIAN CANCER: Research suggests seafood has a protective effect against ovarian cancer, and may even improve survival among patients who already have the disease. Two case-control studies found that high fish intake was associated with a 24% lower risk of ovarian cancer, and a 2022 meta-analysis found that ovarian cancer patients with the highest intake of fish had significantly lower mortality—a 26% lower risk.
- PROSTATE CANCER: A 2010 meta-analysis of 12 case-control studies found that among patients with prostate cancer, people with the highest fish consumption had a 63% lower risk of cancer-specific death.

Hearing Loss

That's right: the benefits of seafood might extend all the way to our hearing! A 2014 prospective study found that compared to rarely eating fish (less than one serving monthly), consuming fish at least twice per week was associated with a 20% lower risk of hearing loss. When the data was stratified by seafood type, the protective effect remained for all types of fish: canned tuna, light meat fish, dark meat fish, and shellfish (in fact, eating just one serving of shellfish per month was associated with a 14% lower risk of hearing loss!).

Age-Related Macular Degeneration

In a meta-analysis from 2016, looking at data from nearly 129,000 participants across eight cohort studies, higher fish consumption was associated with a 24% lower risk of age-related macular degeneration, with dark-meat fish and tuna fish showing a particularly protective effect (32% lower risk and 42% lower risk, respectively).

A 2023 review of meta-analyses also found that per 100 g of daily fish intake, risk of age-related macular degeneration dropped by 56%.

Total Mortality

A number of studies indicate that regularly eating seafood can reduce risk of death from all causes. A 2023 umbrella review of meta-analyses found that every incremental serving of fish per day was associated with a 7% drop in all-cause mortality risk.

Cooking Method Matters!

Paradoxically, some studies (especially from Europe) have shown a U-shaped curve when it comes to fish consumption, where both low and high intakes are associated with increased risk of cardiovascular disease and all-cause mortality. What's going on here?

Although researchers initially speculated this could be due to increased exposure to some of the toxins that can accumulate in fish (including methylmercury, dioxins, and polychlorinated biphenyls or PCBs), this didn't explain the lack of a U-shaped curve in non-European cohorts (such as from North America or Asia) where fish is equally as likely to contain these toxins. It turned out, the reason may be a simple matter of preparation method! Traditional preparations of fish in many parts of Europe include deep-frying, battering, pickling, or salting—introducing variables such as trans-fatty acids or oxidized frying oils.

What About Mercury?

Amidst the many health benefits of seafood is one well-publicized risk: potential contamination with an organic form of mercury called methylmercury (as well as other toxins, such as PCBs and dioxins). In fact, pregnant women are advised to limit seafood consumption to just two 6-oz servings per week over fears that mercury will cause brain damage to the developing fetus. But, are these concerns based on sound science?

It turns out, there's more to the story than meets the eye! The high micronutrient content of seafood comes to the rescue here—specifically, the trace mineral selenium. Among selenium's many roles is an ability to bind irreversibly with mercury, in turn reducing its absorption and preventing its harmful effects in our bodies. In fact, the selenium in seafood can help protect us from mercury exposure from other sources beyond the seafood itself!

The only exceptions to this rule are the top-predator fish from contaminated waters, in which the methylmercury accumulation is higher than their selenium content. Mercury levels in these fish can be quite high not only due to absorbing mercury from the water, but also from biomagnification, where mercury accumulates from the organisms that these fish consume. Luckily, the list here is fairly short: fish with potentially unsafe mercury levels are king mackerel, marlin, pilot whale, shark, tarpin, tilefish, and swordfish (although some studies show that swordfish is okay!).

What's more, the majority of commonly eaten seafood is actually quite low in methylmercury to begin with. The vast majority of ocean fish and approximately 97% of fresh water fish are low in mercury and/or contain enough selenium to protect against its effects. Extremely safe seafood varieties include shellfish (including oysters, clams, scallops, mussels, crab, shrimp, and lobster), anchovies, salmon, trout, herring, haddock, pollock (Boston bluefish), sole, flounder, Atlantic mackerel, and lake whitefish.

Ultimately, increasing your dietary intake of selenium is a great way to protect yourself from mercury exposure from food sources or from environmental factors. Along with seafood and seaweed, selenium is abundant in Brazil nuts, mushrooms, onions, sunflower seeds, and meat and poultry (especially the liver!).

Seafood Nutrivore Scores

The average Nutrivore score of seafood is 695!

Anchovies	812
Caviar (sturgeon roe)	1582
Catfish (Wild)	559
Clams	1046
Cod (Wild)	475
Crab (Alaskan king)	1211
Crawfish	616
Eel	385
Flounder	749
Grouper	400
Haddock	464
Halibut	523
Herring (Atlantic)	996
Lingcod	418
Lobster	839
Mackerel (Atlantic)	922
Mackerel (King)	1242
Mackerel (Spanish)	770
Mussels	1564
Octopus (Alaska Native)	2322
Orange roughy	392
Oyster, Eastern (Farmed)	3049
Oyster, Pacific	2255
Perch	508
Pike	573
Pollock	675
Salmon (wild Atlantic)	868
Sardines (canned)	654
Sea bass	575
Scallop	645
Shrimp/prawns	535
Rainbow Smelt	834
Snapper	548
Sole	749
Squid	890
Sturgeon	528
Swordfish	557
Tilapia	409
Trout	710
Tuna (skipjack)	645
Whitefish	663
Yellowtail	210

Some Practical Pointers

Getting the most out of your seafood is a matter of proper selection and storage! Here are some tips for optimizing both.

Selecting seafood at the store:

- If buying whole fish, check for clear, bright eyes, red gills, and intact scales. The fish should have a mild ocean scent—not overpoweringly "fishy"! Avoid fish with sunken eyes, dull skin, or a strong ammonia-like smell.
- If buying fish fillets and steaks, they should be moist, translucent, and free of any browning or discoloration. They should have a fresh, mild smell.
- If buying frozen seafood, ensure that the packaging is intact without any signs of freezer burn. The seafood should be solidly frozen and free from ice crystals (which can indicate the package previously thawed and re-froze).

Storage:

Seafood is highly perishable, so it's important to store it at the right temperature and in the right environment!

- The general rule is to keep seafood refrigerated at or below 40°F (4°C), or frozen at or below 0°F (-18°C). If you're not planning to consume it within a couple days, it's best to freeze it.
- If storing seafood in the refrigerator, place it in a clean, sealed container or wrap it tightly in plastic wrap or aluminum foil. This helps prevent any fishy odor from permeating other foods (and also protects your seafood from contamination!).
- If storing seafood in the freezer, wrap it tightly in moisture-proof freezer bags. Alternatively, you can use a vacuum sealer to minimize air exposure (which can cause freezer burn). It can also help to label the packages with the date to keep track of the storage time!

- Fatty fish (like salmon or mackerel) can be stored in the freezer for 2 – 3 moths, while lean fish (like cod) can be stored for up to 6 months. Shellfish (like shrimp or scallops) can be stored for 3 – 6 months, and cooked seafood can be stored for 2 – 3 months.
- When ready to use frozen seafood, thaw it properly to maintain its quality and safety. The best method is to thaw it overnight in the refrigerator. Alternatively, you can use the defrost function on your microwave, or place the seafood in a sealed bag and submerge it in cold water. Avoid thawing seafood at room temperature, as it can promote bacterial growth.

Seasonality:

Thanks to the power of freezing and refrigeration, most types of seafood are available year-round. But, if you're going for fresh, specific fish and shellfish have their own peak seasons!

- AMBERJACK: January through May
- BRANZINI: Year-round
- CATFISH: Year-round
- CHAR: Year-round
- COD: Year-round, with peak season of late winter for Pacific cod and late summer for Atlantic cod
- FLOUNDER: October through early spring
- GROUPER: February through June
- HADDOCK: Fall through winter
- HALIBUT: Year-round
- MAHI MAHI: Summer
- MARLIN: Spring through December
- SALMON: Year-round for Atlantic; summer for king, sockeye, Pacific, Keta, and Coho
- SEABASS (CHILEAN): Year-round
- RED SNAPPER: Winter
- SOLE: Year-round
- SWORDFISH: Summer
- SKATE: Winter
- TILAPIA: Year-round
- TROUT: Year-round
- TUNA: Summer
- CLAMS: Winter through mid-summer

- **CRAB**: Mid fall through winter or spring for Dungeness, king, and stone crab; winter for snow crab; spring and summer for soft shell crab
- **CRAWFISH**: Winter through early summer
- **LOBSTER**: December through spring
- **MUSSELS**: Early winter through mid summer
- **OYSTERS**: Fall through winter
- **SCALLOPS**: Year-round for sea scallops; November for bay scallops
- **SHRIMP**: Late March through early December
- **SQUID**: Year-round

Track Your Foundational Food Servings with the Nutrivore Weekly Serving Matrix

The Nutrivore Weekly Serving Matrix is an easy-to-use and flexible weekly checklist designed to help you maximize nutrient-density, without weighing or measuring your food, without having to use a food tracking app or analyzing micronutrients, and while eating the right amounts of all those superfoods known to improve health outcomes!

The Nutrivore Weekly Servings Matrix will:

- *Help you eat a Nutrivore diet without tracking or measuring your food*
- *Track your progress week-by-week as your work up to your serving goals*
- *Apply to anydietary templates, food allergies and intolerances*
- *Meet you where you are but also inspiring with a bonus servings section*

Includes an instructional guide, handy-dandy food lists and serving size approximations, and shows you step-by-step how to use the Nutrivore Weekly Serving Matrix to track your nutrient density!

Learn More >

About the Creators of this Book

Dr. Sarah Ballantyne, PhD

FOUNDER OF NUTRIVORE

Award-winning public speaker, New York Times bestselling author and world-renowned health expert, Dr. Sarah Ballantyne, PhD believes the key to improving public health is scientific literacy. She creates educational resources to help people improve their day-to-day diet and lifestyle choices, empowered and informed by the most current evidenced-based scientific research.

Charissa Joy, AOS

CHIEF OPERATIONS OFFICER

Charissa Joy has over 15 years of experience working in the wellness space. Charissa has many roles on the team. She is Dr. Sarah's right hand womanand touches every part of Dr. Sarah's businesses. She manages all communications for Nutrivore, both external and internal. She is the project and team manager. She handles all marketing internal and external marketing, as well as all brand/affiliate partnerships.

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Nicole Anouar has a B.A in graphic design from the University of San Francisco and specializes in branding and educational design for healers and health professionals in the online space. With 8+ years of education and practice in graphic design, content marketing and ancestral lifestyle tradition, Nicole expresses her passion for truth and her love for alternative living into the work she does every day.

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CONTENT CREATOR AND PHOTOGRAPHER

Kiersten is a Content Creator for Nutrivore with a focus on recipe creation, practical resources and food photography, with a little writing on the side. After experiencing full body healing with the help of Dr. Sarah's and others' work, she now enjoys finding and creating beauty both in her work for Nutrivore and in her home as she raises two daughters alongside her military husband.

Denise Minger

CONTENT CREATOR AND RESEARCHER

Denise is a health researcher and author of the best-selling book, "Death By Food Pyramid"—an award-winning exposé of the forces that shaped our dietary guidelines and beliefs, and that's been featured in documentaries, UPenn medical writing curricula, the Nutritional Therapy Association certification program, and numerous other health education courses around the world.

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Jacqueline has a degree in Chemical Engineering (Bachelor of Applied Science) from the University of British Columbia in Canada, along with a master's degree in renewable energy technology from the United Kingdom. She has also achieved her Professional Engineering designation in her home province of Alberta, Canada.

Jacqueline does a wide variety of tasks for Nutrivore including, article writing, data design, data visualization, all things excel, research, and content creation. When she's not googling her way out of the excel jungle, she is parenting her two young boys and spending time outdoors.

Lisa Hunter, MSc

CONTENT CREATOR AND RESEARCHER

Lisa has a Bachelor of Science degree in Chemistry and Biochemistry, a Master of Science degree in Biochemistry, and worked in the pharmaceutical industry developing bio-products for 7 years, prior to taking time off to raise her two children.

On Nutrivore.com she is a researcher, writer, and content creator and is responsible for developing and maintaining the expanded Nutrivore Score database of over 7,500 foods (plus many of the nerdy puns sprinkled throughout the website!).

REFERENCES

Vegetables

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Farvid MS, Barnett JB, Spence ND. Fruit and vegetable consumption and incident breast cancer: a systematic review and meta-analysis of prospective studies. Br J Cancer. 2021 Jul;125(2):284-298. doi: 10.1038/s41416-021-01373-2.

Ferro A, Costa AR, Morais S, Bertuccio P, Rota M, Pelucchi C, Hu J, Johnson KC, Zhang ZF, Palli D, Ferraroni M, Yu GP, Bonzi R, Peleteiro B, López-Carrillo L, Tsugane S, Hamada GS, Hidaka A, Malekzadeh R, Zaridze D, Maximovich D, Vioque J, Navarrete-Muñoz EM, Alguacil J, Castaño-Vinyals G, Wolk A, Håkansson N, Hernández-Ramírez RU, Pakseresht M, Ward MH, Pourfarzi F, Mu L, López-Cervantes M, Persiani R, Kurtz RC, Lagiou A, Lagiou P, Boffetta P, Boccia S, Negri E, Camargo MC, Curado MP, La Vecchia C, Lunet N. Fruits and vegetables intake and gastric cancer risk: A pooled analysis within the Stomach cancer Pooling Project. Int J Cancer. 2020 Dec 1;147(11):3090-3101. doi: 10.1002/ijc.33134.

García-Esquinas E, Rahi B, Peres K, Colpo M, Dartigues JF, Bandinelli S, Feart C, Rodríguez-Artalejo F. Consumption of fruit and vegetables and risk of frailty: a dose-response analysis of 3 prospective cohorts of community-dwelling older adults. Am J Clin Nutr. 2016 Jul;104(1):132-42. doi: 10.3945/ajcn.115.125781.

Guo XF, Shao XF , Li JM , Li S , Li KL , Li D. Fruit and vegetable intake and liver cancer risk: a meta-analysis of prospective cohort studies. Food Funct. 2019 Aug 1;10(8):4478-4485. doi: 10.1039/c9fo00804g.

He K, Hu FB, Colditz GA, Manson JE, Willett WC, Liu S. Changes in intake of fruits and vegetables in relation to risk of obesity and weight gain among middle-aged women. Int J Obes Relat Metab Disord. 2004 Dec;28(12):1569-74. doi: 10.1038/sj.ijo.0802795.

Huai J, Ye X. Vegetable, Fruit Consumption and Risk of Biliary Cancer: Evidence from a Meta-Analysis. Nutr Cancer. 2021;73(8):1322-1332. doi: 10.1080/01635581.2020.1800767.

Hurtado-Barroso S, Trius-Soler M, Lamuela-Raventós RM, Zamora-Ros R. Vegetable and Fruit Consumption and Prognosis Among Cancer Survivors: A Systematic Review and Meta-Analysis of Cohort Studies. Adv Nutr. 2020 Nov 16;11(6):1569-1582. doi: 10.1093/advances/nmaa082.

Jansen MC, Bueno-de-Mesquita HB, Feskens EJ, Streppel MT, Kok FJ, Kromhout D. Quantity and variety of fruit and vegetable consumption and cancer risk. Nutr Cancer. 2004;48(2):142-8. doi: 10.1207/

s15327914nc4802_3.

Kojima G, Iliffe S, Jivraj S, Walters K. Fruit and Vegetable Consumption and Incident Prefrailty and Frailty in Community-Dwelling Older People: The English Longitudinal Study of Ageing. Nutrients. 2020 Dec 18;12(12):3882. doi: 10.3390/nu12123882.

Lee J, Shin A, Oh JH, Kim J. Colors of vegetables and fruits and the risks of colorectal cancer. World J Gastroenterol. 2017 Apr 14;23(14):2527-2538. doi: 10.3748/wjg.v23.i14.2527.

Liu H, Wang XC, Hu GH, Guo ZF, Lai P, Xu L, Huang TB, Xu YF. Fruit and vegetable consumption and risk of bladder cancer: an updated meta-analysis of observational studies. Eur J Cancer Prev. 2015 Nov;24(6):508-16. doi: 10.1097/CEJ.0000000000000119.

Liu HM, Tang W, Wang XY, Jiang JJ, Zhang W, Wang W. Safe and Effective Antioxidant: The Biological Mechanism and Potential Pathways of Ergothioneine in the Skin. Molecules. 2023 Feb 8;28(4):1648. doi: 10.3390/molecules28041648.

Lu YT, Gunathilake M, Kim J. The influence of dietary vegetables and fruits on endometrial cancer risk: a meta-analysis of observational studies. Eur J Clin Nutr. 2023 May;77(5):561-573. doi: 10.1038/s41430-022-01213-3.

Lv M, Su C, Huang F, Wang H, Wang Z, Zhang B, Du W. Association of Vegetable Consumption with Stroke in China: A Longitudinal Study. Nutrients. 2023 Mar 24;15(7):1583. doi: 10.3390/nu15071583.

Milajerdi A, Ebrahimi-Daryani N, Dieleman LA, Larijani B, Esmaillzadeh A. Association of Dietary Fiber, Fruit, and Vegetable Consumption with Risk of Inflammatory Bowel Disease: A Systematic Review and Meta-Analysis. Adv Nutr. 2021 Jun 1;12(3):735-743. doi: 10.1093/advances/nmaa145.

Nour M, Lutze SA, Grech A, Allman-Farinelli M. The Relationship between Vegetable Intake and Weight Outcomes: A Systematic Review of Cohort Studies. Nutrients. 2018 Nov 2;10(11):1626. doi: 10.3390/nu10111626.

Oskarsson V, Sadr-Azodi O, Orsini N, Andrén-Sandberg Å, Wolk A. Vegetables, fruit and risk of non-gallstone-related acute pancreatitis: a population-based prospective cohort study. Gut. 2013 Aug;62(8):1187-92. doi: 10.1136/gutjnl-2012-302521.

Qiu R, Cao WT, Tian HY, He J, Chen GD, Chen YM. Greater Intake of Fruit and Vegetables Is Associated with Greater Bone Mineral Density and Lower Osteoporosis Risk in Middle-Aged and Elderly Adults. PLoS One. 2017 Jan 3;12(1):e0168906. doi: 10.1371/journal.pone.0168906.

Saghafian F, Malmir H, Saneei P, Milajerdi A, Larijani B, Esmaillzadeh A. Fruit and vegetable consumption and risk of depression: accumulative evidence from an updated systematic review and meta-analysis of epidemiological studies. Br J Nutr. 2018 May;119(10):1087-1101. doi: 10.1017/S0007114518000697.

Sakai M, Kitagawa Y, Saeki H, Miyazaki T, Yamaji T, Nemoto K, Oyama T, Muto M, Takeuchi H, Toh Y, Matsubara H, Mano M, Kono K, Kato K, Yoshida M, Kawakubo H, Booka E, Yamatsuji T, Kato H, Ito Y, Ishikawa H, Ishihara R, Tsushima T, Kawachi H, Oyama T, Kojima T, Kuribayashi S, Makino T, Matsuda S, Sohda M, Kubo Y, Doki Y; Esophageal Cancer Practice Guidelines Preparation Committee. Fruit and vegetable consumption and risk of esophageal cancer in the Asian region: a systematic review and meta-analysis. Esophagus. 2022 Jan;19(1):27-38. doi: 10.1007/s10388-021-00882-6.

Stanaway JD, Afshin A, Ashbaugh C, Bisignano C, Brauer M, Ferrara G, Garcia V, Haile D, Hay SI, He J, Iannucci V, Lescinsky H, Mullany EC, Parent MC, Serfes AL, Sorensen RJD, Aravkin AY, Zheng P, Murray CJL. Health effects associated with vegetable consumption: a Burden of Proof study. Nat Med. 2022 Oct;28(10):2066-2074. doi: 10.1038/s41591-022-01970-5.

Tian Y, Su L, Wang J, Duan X, Jiang X. Fruit and vegetable consumption and risk of the metabolic syndrome: a meta-analysis. Public Health Nutr. 2018 Mar;21(4):756-765. doi: 10.1017/S136898001700310X.

Tirani SA, Mirzaei S, Asadi A, Asjodi F, Iravani O, Akhlaghi M, Saneei P. Associations of Fruit and Vegetable Intake with Metabolic Health Status in Overweight and Obese Youth. Ann Nutr Metab. 2023;79(4):361-371. doi: 10.1159/000533343.

Vieira AR, Abar L, Vingeliene S, Chan DS, Aune D, Navarro-Rosenblatt D, Stevens C, Greenwood D, Norat T. Fruits, vegetables and lung cancer risk: a systematic review and meta-analysis. Ann Oncol. 2016 Jan;27(1):81-96. doi: 10.1093/annonc/mdv381.

Wang C, Yang T, Guo XF, Li D. The Associations of Fruit and Vegetable Intake with Lung Cancer Risk in Participants with Different Smoking Status: A Meta-Analysis of Prospective Cohort Studies. Nutrients. 2019 Aug 2;11(8):1791. doi: 10.3390/nu11081791.

Wang X, Ouyang Y, Liu J, Zhu M, Zhao G, Bao W, Hu FB. Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. BMJ. 2014 Jul 29;349:g4490. doi: 10.1136/bmj.g4490.

Yu EY, Wesselius A, Mehrkanoon S, Goosens M, Brinkman M, van den Brandt P, Grant EJ, White E, Weiderpass E, Le Calvez-Kelm F, Gunter MJ, Huybrechts I, Riboli E, Tjonneland A, Masala G, Giles GG, Milne RL, Zeegers MP. Vegetable intake and the risk of bladder cancer in the BLadder Cancer Epidemiology and Nutritional Determinants (BLEND) international study. BMC Med. 2021 Mar 9;19(1):56. doi: 10.1186/s12916-021-01931-8.

Zhai H, Wang Y, Jiang W. Fruit and Vegetable Intake and the Risk of Chronic Obstructive Pulmonary Disease: A Dose-Response Meta-Analysis of Observational Studies. Biomed Res Int. 2020 Feb 21;2020:3783481. doi: 10.1155/2020/3783481.

Zhang JW, Xiong JP, Xu WY, Sang XT, Huang HC, Bian J, Xu YY, Lu X, Zhao HT. Fruits and vegetables consumption and the risk of gallstone diasease: A systematic review and meta-analysis. Medicine (Baltimore).

2019 Jul;98(28):e16404. doi: 10.1097/MD.0000000000016404.

Zhang W, Jiang J, Li X, He Y, Chen F, Li W. Dietary Factors and Risk of Glioma in Adults: A Systematic Review and Dose-Response Meta-Analysis of Observational Studies. Front Nutr. 2022 Feb 14;9:834258. doi: 10.3389/fnut.2022.834258.

Zhou Y, Wang J, Cao L, Shi M, Liu H, Zhao Y, Xia Y. Fruit and Vegetable Consumption and Cognitive Disorders in Older Adults: A Meta-Analysis of Observational Studies. Front Nutr. 2022 Jun 20;9:871061. doi: 10.3389/fnut.2022.871061. PMID: 35795585; PMCID: PMC9251442.

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Chen X, Bao J, Guo J, Ding Q, Lu J, Huang M, Wang Y. Biological activities and potential molecular targets of cucurbitacins: a focus on cancer. Anticancer Drugs. 2012 Sep;23(8):777-87. doi: 10.1097/CAD.0b013e3283541384.

Chen YR, Wang SC, Huang SP, Su CC, Liu PL, Cheng WC, Chuu CP, Chen JK, Bao BY, Lee CH, Ke CC, Wu HE, Chang HH, Yeh HC, Li CY. Protodioscin inhibits bladder cancer cell migration and growth, and promotes apoptosis through activating JNK and p38 signaling pathways. Biomed Pharmacother. 2022 Dec;156:113929. doi: 10.1016/j.biopha.2022.113929.

Gupta R, Kapoor B, Gulati M, Kumar B, Gupta M, Singh SK, Awasthi A. Sweet pepper and its principle constituent capsiate: functional properties and health benefits. Crit Rev Food Sci Nutr. 2022;62(26):7370-7394. doi: 10.1080/10408398.2021.1913989.

He K, Hu FB, Colditz GA, Manson JE, Willett WC, Liu S. Changes in intake of fruits and vegetables in relation to risk of obesity and weight gain among middle-aged women. Int J Obes Relat Metab Disord. 2004 Dec;28(12):1569-74. doi: 10.1038/sj.ijo.0802795.

Husain A, Chanana H, Khan SA, Dhanalekshmi UM, Ali M, Alghamdi AA, Ahmad A. Chemistry and Pharmacological Actions of Delphinidin, a Dietary Purple Pigment in Anthocyanidin and Anthocyanin Forms. Front Nutr. 2022 Mar 17;9:746881. doi: 10.3389/fnut.2022.746881.

Jansen MC, Bueno-de-Mesquita HB, Feskens EJ, Streppel MT, Kok FJ, Kromhout D. Quantity and variety of fruit and vegetable consumption and cancer risk. Nutr Cancer. 2004;48(2):142-8. doi: 10.1207/s15327914nc4802_3.

Jing P, Qian B, Zhao S, Qi X, Ye L, Mónica Giusti M, Wang X. Effect of glycosylation patterns of Chinese eggplant anthocyanins and other derivatives on antioxidant effectiveness in human colon cell lines. Food Chem. 2015 Apr 1;172:183-9. doi: 10.1016/j.foodchem.2014.08.100.

Kaushik U, Aeri V, Mir SR. Cucurbitacins - An insight into medicinal leads from nature. Pharmacogn Rev.

2015 Jan-Jun;9(17):12-8. doi: 10.4103/0973-7847.156314.

Kopczyńska K, Kazimierczak R, Średnicka-Tober D, Barański M, Wyszyński Z, Kucińska K, Perzanowska A, Szacki P, Rembiałkowska E, Hallmann E. The Profile of Selected Antioxidants in Two Courgette Varieties from Organic and Conventional Production. Antioxidants (Basel). 2020 May 9;9(5):404. doi: 10.3390/antiox9050404.

Lee DH, Iwanski GB, Thoennissen NH. Cucurbitacin: ancient compound shedding new light on cancer treatment. ScientificWorldJournal. 2010 Mar 5;10:413-8. doi: 10.1100/tsw.2010.44.

Li Y, Li Y, Yao Y, Li H, Gao C, Sun C, Zhuang J. Potential of cucurbitacin as an anticancer drug. Biomed Pharmacother. 2023 Dec;168:115707. doi: 10.1016/j.biopha.2023.115707.

Liu JY, Hou YL, Cao R, Qiu HX, Cheng GH, Tu R, Wang L, Zhang JL, Liu D. Protodioscin ameliorates oxidative stress, inflammation and histology outcome in Complete Freund's adjuvant induced arthritis rats. Apoptosis. 2017 Nov;22(11):1454-1460. doi: 10.1007/s10495-017-1420-0.

Lu M, Chen C, Lan Y, Xiao J, Li R, Huang J, Huang Q, Cao Y, Ho CT. Capsaicin-the major bioactive ingredient of chili peppers: bio-efficacy and delivery systems. Food Funct. 2020 Apr 30;11(4):2848-2860. doi: 10.1039/d0fo00351d.

Matsubara K, Kaneyuki T, Miyake T, Mori M. Antiangiogenic activity of nasunin, an antioxidant anthocyanin, in eggplant peels. J Agric Food Chem. 2005 Aug 10;53(16):6272-5. doi: 10.1021/jf050796r.

Nishimura M, Suzuki M, Takahashi R, Yamaguchi S, Tsubaki K, Fujita T, Nishihira J, Nakamura K. Daily Ingestion of Eggplant Powder Improves Blood Pressure and Psychological State in Stressed Individuals: A Randomized Placebo-Controlled Study. Nutrients. 2019 Nov 16;11(11):2797. doi: 10.3390/nu11112797.

Nour M, Lutze SA, Grech A, Allman-Farinelli M. The Relationship between Vegetable Intake and Weight Outcomes: A Systematic Review of Cohort Studies. Nutrients. 2018 Nov 2;10(11):1626. doi: 10.3390/nu10111626.

Rana A, Samtiya M, Dhewa T, Mishra V, Aluko RE. Health benefits of polyphenols: A concise review. J Food Biochem. 2022 Oct;46(10):e14264. doi: 10.1111/jfbc.14264.

Rosca AE, Iesanu MI, Zahiu CDM, Voiculescu SE, Paslaru AC, Zagrean AM. Capsaicin and Gut Microbiota in Health and Disease. Molecules. 2020 Dec 2;25(23):5681. doi: 10.3390/molecules25235681.

Rosca AE, Iesanu MI, Zahiu CDM, Voiculescu SE, Paslaru AC, Zagrean AM. Capsaicin and Gut Microbiota in Health and Disease. Molecules. 2020 Dec 2;25(23):5681. doi: 10.3390/molecules25235681.

Stanaway JD, Afshin A, Ashbaugh C, Bisignano C, Brauer M, Ferrara G, Garcia V, Haile D, Hay SI, He J, Iannucci V, Lescinsky H, Mullany EC, Parent MC, Serfes AL, Sorensen RJD, Aravkin AY, Zheng P, Murray CJL. Health effects associated with vegetable consumption: a Burden of Proof study. Nat Med. 2022 Oct;28(10):2066-2074. doi: 10.1038/s41591-022-01970-5.

Tirani SA, Mirzaei S, Asadi A, Asjodi F, Iravani O, Akhlaghi M, Saneei P. Associations of Fruit and Vegetable Intake with Metabolic Health Status in Overweight and Obese Youth. Ann Nutr Metab. 2023;79(4):361-371. doi: 10.1159/000533343.

Wang W, Yamaguchi S, Koyama M, Nakamura K. Evaluation of the Antihypertensive Activity of Eggplant Acetylcholine and γ-Aminobutyric Acid in Spontaneously Hypertensive Rats. Molecules. 2023 Mar 21;28(6):2835. doi: 10.3390/molecules28062835.

Wang W, Yamaguchi S, Suzuki A, Wagu N, Koyama M, Takahashi A, Takada R, Miyatake K, Nakamura K. Investigation of the Distribution and Content of Acetylcholine, a Novel Functional Compound in Eggplant. Foods. 2021 Jan 4;10(1):81. doi: 10.3390/foods10010081.

Wang X, Ouyang Y, Liu J, Zhu M, Zhao G, Bao W, Hu FB. Fruit and vegetable consumption and mortality from all causes, cardiovascular disease, and cancer: systematic review and dose-response meta-analysis of prospective cohort studies. BMJ. 2014 Jul 29;349:g4490. doi: 10.1136/bmj.g4490. Erratum in: BMJ. 2014;349:5472.

Wang X, Wu X, Meng G, Bian S, Zhang Q, Liu L, Wu H, Gu Y, Zhang S, Wang Y, Zhang T, Cao X, Li H, Liu Y, Li X, Song K, Niu K. Consumption of chilies and sweet peppers is associated with lower risk of sarcopenia in older adults. Aging (Albany NY). 2021 Mar 26;13(6):9135-9142. doi: 10.18632/aging.104168.

Cruciferous Vegetables

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Bahadoran Z, Tohidi M, Nazeri P, Mehran M, Azizi F, Mirmiran P. Effect of broccoli sprouts on insulin resistance in type 2 diabetic patients: a randomized double-blind clinical trial. Int J Food Sci Nutr. 2012 Nov;63(7):767-71. doi: 10.3109/09637486.2012.665043.

Bandera EV, Kushi LH, Moore DF, Gifkins DM, McCullough ML. Fruits and vegetables and endometrial cancer risk: a systematic literature review and meta-analysis. Nutr Cancer. 2007;58(1):6-21. doi: 10.1080/01635580701307929.

Buko V, Zavodnik I, Kanuka O, Belonovskaya E, Naruta E, Lukivskaya O, Kirko S, Budryn G, Żyżelewicz D, Oracz J, Sybirna N. Antidiabetic effects and erythrocyte stabilization by red cabbage extract in streptozotocin-treated rats. Food Funct. 2018 Mar 1;9(3):1850-1863. doi: 10.1039/c7fo01823a.

Calancie L, Keyserling TC, Taillie LS, Robasky K, Patterson C, Ammerman AS, Schisler JC. TAS2R38 Predisposition to Bitter Taste Associated with Differential Changes in Vegetable Intake in Response to a Community-Based Dietary Intervention. G3 (Bethesda). 2018 May 31;8(6):2107-2119. doi: 10.1534/g3.118.300547.

Chartoumpekis DV, Ziros PG, Chen JG, Groopman JD, Kensler TW, Sykiotis GP. Broccoli sprout beverage

is safe for thyroid hormonal and autoimmune status: Results of a 12-week randomized trial. Food Chem Toxicol. 2019 Apr;126:1-6. doi: 10.1016/j.fct.2019.02.004.

Cho YA, Kim J. Dietary Factors Affecting Thyroid Cancer Risk: A Meta-Analysis. Nutr Cancer. 2015;67(5):811-7. doi: 10.1080/01635581.2015.1040517.

Felker P, Bunch R, Leung AM. Concentrations of thiocyanate and goitrin in human plasma, their precursor concentrations in brassica vegetables, and associated potential risk for hypothyroidism. Nutr Rev. 2016 Apr;74(4):248-58. doi: 10.1093/nutrit/nuv110.

Henriques JF, Serra D, Dinis TCP, Almeida LM. The Anti-Neuroinflammatory Role of Anthocyanins and Their Metabolites for the Prevention and Treatment of Brain Disorders. Int J Mol Sci. 2020 Nov 17;21(22):8653. doi: 10.3390/ijms21228653.

Hu J, Hu Y, Hu Y, Zheng S. Intake of cruciferous vegetables is associated with reduced risk of ovarian cancer: a meta-analysis. Asia Pac J Clin Nutr. 2015;24(1):101-9. doi: 10.6133/apjcn.2015.24.1.22.

Humblot C, Bruneau A, Sutren M, Lhoste EF, Doré J, Andrieux C, Rabot S. Brussels sprouts, inulin and fermented milk alter the faecal microbiota of human microbiota-associated rats as shown by PCR-temporal temperature gradient gel electrophoresis using universal, Lactobacillus and Bifidobacterium 16S rRNA gene primers. Br J Nutr. 2005 May;93(5):677-84. doi: 10.1079/bjn20051372.

Jia X, Zhong L, Song Y, Hu Y, Wang G, Sun S. Consumption of citrus and cruciferous vegetables with incident type 2 diabetes mellitus based on a meta-analysis of prospective study. Prim Care Diabetes. 2016 Aug;10(4):272-80. doi: 10.1016/j.pcd.2015.12.004.

Kaczmarek JL, Liu X, Charron CS, Novotny JA, Jeffery EH, Seifried HE, Ross SA, Miller MJ, Swanson KS, Holscher HD. Broccoli consumption affects the human gastrointestinal microbiota. J Nutr Biochem. 2019 Jan;63:27-34. doi: 10.1016/j.jnutbio.2018.09.015.

Kataya HA, Hamza AA. Red Cabbage (Brassica oleracea) Ameliorates Diabetic Nephropathy in Rats. Evid Based Complement Alternat Med. 2008 Sep;5(3):281-7. doi: 10.1093/ecam/nem029.

Kellingray L, Tapp HS, Saha S, Doleman JF, Narbad A, Mithen RF. Consumption of a diet rich in Brassica vegetables is associated with a reduced abundance of sulphate-reducing bacteria: A randomised crossover study. Mol Nutr Food Res. 2017 Sep;61(9):1600992. doi: 10.1002/mnfr.201600992.

Kirsh VA, Peters U, Mayne ST, Subar AF, Chatterjee N, Johnson CC, Hayes RB; Prostate, Lung, Colorectal and Ovarian Cancer Screening Trial. Prospective study of fruit and vegetable intake and risk of prostate cancer. J Natl Cancer Inst. 2007 Aug 1;99(15):1200-9. doi: 10.1093/jnci/djm065.

Kondo S, Suzuki A, Kurokawa M, Hasumi K. Intake of kale suppresses postprandial increases in plasma glucose: A randomized, double-blind, placebo-controlled, crossover study. Biomed Rep. 2016 Nov;5(5):553-558. doi: 10.3892/br.2016.767.

Korte G, Dreiseitel A, Schreier P, Oehme A, Locher S, Hajak G, Sand PG. An examination of anthocyanins' and anthocyanidins' affinity for cannabinoid receptors. J Med Food. 2009 Dec;12(6):1407-10. doi: 10.1089/jmf.2008.0243.

Kwok CS, Gulati M, Michos ED, Potts J, Wu P, Watson L, Loke YK, Mallen C, Mamas MA. Dietary components and risk of cardiovascular disease and all-cause mortality: a review of evidence from meta-analyses. Eur J Prev Cardiol. 2019 Sep;26(13):1415-1429. doi: 10.1177/2047487319843667.

Lafarga T, Bobo G, Viñas I, Collazo C, Aguiló-Aguayo I. Effects of thermal and non-thermal processing of cruciferous vegetables on glucosinolates and its derived forms. J Food Sci Technol. 2018 Jun;55(6):1973-1981. doi: 10.1007/s13197-018-3153-7.

Lee S, Choi Y, Jeong HS, Lee J, Sung J. Effect of different cooking methods on the content of vitamins and true retention in selected vegetables. Food Sci Biotechnol. 2017 Dec 12;27(2):333-342. doi: 10.1007/s10068-017-0281-1.

Li F, Hullar MA, Schwarz Y, Lampe JW. Human gut bacterial communities are altered by addition of cruciferous vegetables to a controlled fruit- and vegetable-free diet. J Nutr. 2009 Sep;139(9):1685-91. doi: 10.3945/jn.109.108191.

Li LY, Luo Y, Lu MD, Xu XW, Lin HD, Zheng ZQ. Cruciferous vegetable consumption and the risk of pancreatic cancer: a meta-analysis. World J Surg Oncol. 2015 Feb 12;13:44. doi: 10.1186/s12957-015-0454-4.

Li N, Wu X, Zhuang W, Wu C, Rao Z, Du L, Zhou Y. Cruciferous vegetable and isothiocyanate intake and multiple health outcomes. Food Chem. 2022 May 1;375:131816. doi: 10.1016/j.foodchem.2021.131816.

Li Y, Cui Y, Hu X, Liao X, Zhang Y. Chlorophyll Supplementation in Early Life Prevents Diet-Induced Obesity and Modulates Gut Microbiota in Mice. Mol Nutr Food Res. 2019 Nov;63(21):e1801219. doi: 10.1002/mnfr.201801219.

Liu B, Mao Q, Cao M, Xie L. Cruciferous vegetables intake and risk of prostate cancer: a meta-analysis. Int J Urol. 2012 Feb;19(2):134-41. doi: 10.1111/j.1442-2042.2011.02906.x.

Liu B, Mao Q, Lin Y, Zhou F, Xie L. The association of cruciferous vegetables intake and risk of bladder cancer: a meta-analysis. World J Urol. 2013 Feb;31(1):127-33. doi: 10.1007/s00345-012-0850-0.

Liu B, Mao Q, Wang X, Zhou F, Luo J, Wang C, Lin Y, Zheng X, Xie L. Cruciferous vegetables consumption and risk of renal cell carcinoma: a meta-analysis. Nutr Cancer. 2013;65(5):668-76. doi: 10.1080/01635581.2013.795980.

Liu X, Lv K. Cruciferous vegetables intake is inversely associated with risk of breast cancer: a meta-analysis. Breast. 2013 Jun;22(3):309-13. doi: 10.1016/j.breast.2012.07.013.

Mabry ME, Turner-Hissong SD, Gallagher EY, McAlvay AC, An H, Edger PP, Moore JD, Pink DAC, Teakle GR, Stevens CJ, Barker G, Labate J, Fuller DQ, Allaby RG, Beissinger T, Decker JE, Gore MA, Pires JC. The Evolu-

tionary History of Wild, Domesticated, and Feral Brassica oleracea (Brassicaceae). Mol Biol Evol. 2021 Sep 27;38(10):4419-4434. doi: 10.1093/molbev/msab183.

Mangla B, Javed S, Sultan MH, Kumar P, Kohli K, Najmi A, Alhazmi HA, Al Bratty M, Ahsan W. Sulforaphane: A review of its therapeutic potentials, advances in its nanodelivery, recent patents, and clinical trials. Phytother Res. 2021 Oct;35(10):5440-5458. doi: 10.1002/ptr.7176.

McMillan M, Spinks EA, Fenwick GR. Preliminary observations on the effect of dietary brussels sprouts on thyroid function. Hum Toxicol. 1986 Jan;5(1):15-9. doi: 10.1177/096032718600500104.

Mitra S, Emran TB, Chandran D, Zidan BMRM, Das R, Mamada SS, Masyita A, Salampe M, Nainu F, Khandaker MU, Idris AM, Simal-Gandara J. Cruciferous vegetables as a treasure of functional foods bioactive compounds: Targeting p53 family in gastrointestinal tract and associated cancers. Front Nutr. 2022 Aug 4;9:951935. doi: 10.3389/fnut.2022.951935.

Navarro SL, Schwarz Y, Song X, Wang CY, Chen C, Trudo SP, Kristal AR, Kratz M, Eaton DL, Lampe JW. Cruciferous vegetables have variable effects on biomarkers of systemic inflammation in a randomized controlled trial in healthy young adults. J Nutr. 2014 Nov;144(11):1850-7. doi: 10.3945/jn.114.197434.

Oloyede OO, Wagstaff C, Methven L. The Impact of Domestic Cooking Methods on Myrosinase Stability, Glucosinolates and Their Hydrolysis Products in Different Cabbage (Brassica oleracea) Accessions. Foods. 2021 Nov 24;10(12):2908. doi: 10.3390/foods10122908.

Podsędek A, Majewska I, Kucharska AZ. Inhibitory Potential of Red Cabbage against Digestive Enzymes Linked to Obesity and Type 2 Diabetes. J Agric Food Chem. 2017 Aug 23;65(33):7192-7199. doi: 10.1021/acs.jafc.7b02499.

Šalić A, Šamec D. Changes in the content of glucosinolates, polyphenols and carotenoids during lactic-acid fermentation of cruciferous vegetables: A mini review. Food Chem X. 2022 Sep 26;16:100457. doi: 10.1016/j.fochx.2022.100457.

Shahinozzaman M, Raychaudhuri S, Fan S, Obanda DN. Kale Attenuates Inflammation and Modulates Gut Microbial Composition and Function in C57BL/6J Mice with Diet-Induced Obesity. Microorganisms. 2021 Jan 24;9(2):238. doi: 10.3390/microorganisms9020238.

Shapiro TA, Fahey JW, Dinkova-Kostova AT, Holtzclaw WD, Stephenson KK, Wade KL, Ye L, Talalay P. Safety, tolerance, and metabolism of broccoli sprout glucosinolates and isothiocyanates: a clinical phase I study. Nutr Cancer. 2006;55(1):53-62. doi: 10.1207/s15327914nc5501_7.

Silva RFM, Pogačnik L. Polyphenols from Food and Natural Products: Neuroprotection and Safety. Antioxidants (Basel). 2020 Jan 10;9(1):61. doi: 10.3390/antiox9010061.

Speer H, D'Cunha NM, Alexopoulos NI, McKune AJ, Naumovski N. Anthocyanins and Human Health-A Focus on Oxidative Stress, Inflammation and Disease. Antioxidants (Basel). 2020 Apr 28;9(5):366. doi: 10.3390/antiox9050366.

Subramoniam A, Asha VV, Nair SA, Sasidharan SP, Sureshkumar PK, Rajendran KN, Karunagaran D, Ramalingam K. Chlorophyll revisited: anti-inflammatory activities of chlorophyll a and inhibition of expression of TNF-α gene by the same. Inflammation. 2012 Jun;35(3):959-66. doi: 10.1007/s10753-011-9399-0.

Vanduchova A, Anzenbacher P, Anzenbacherova E. Isothiocyanate from Broccoli, Sulforaphane, and Its Properties. J Med Food. 2019 Feb;22(2):121-126. doi: 10.1089/jmf.2018.0024.

Veeranki OL, Bhattacharya A, Tang L, Marshall JR, Zhang Y. Cruciferous vegetables, isothiocyanates, and prevention of bladder cancer. Curr Pharmacol Rep. 2015 Aug;1(4):272-282. doi: 10.1007/s40495-015-0024-z.

Wu QJ, Xie L, Zheng W, Vogtmann E, Li HL, Yang G, Ji BT, Gao YT, Shu XO, Xiang YB. Cruciferous vegetables consumption and the risk of female lung cancer: a prospective study and a meta-analysis. Ann Oncol. 2013 Jul;24(7):1918-1924. doi: 10.1093/annonc/mdt119.

Wu QJ, Yang Y, Vogtmann E, Wang J, Han LH, Li HL, Xiang YB. Cruciferous vegetables intake and the risk of colorectal cancer: a meta-analysis of observational studies. Ann Oncol. 2013

Wu QJ, Yang Y, Wang J, Han LH, Xiang YB. Cruciferous vegetable consumption and gastric cancer risk: a meta-analysis of epidemiological studies. Cancer Sci. 2013 Aug;104(8):1067-73. doi: 10.1111/cas.12195.

Zhang X, Shu XO, Xiang YB, Yang G, Li H, Gao J, Cai H, Gao YT, Zheng W. Cruciferous vegetable consumption is associated with a reduced risk of total and cardiovascular disease mortality. Am J Clin Nutr. 2011 Jul;94(1):240-6. doi: 10.3945/ajcn.110.009340.

Root Vegetables

Ainamani HE, Bamwerinde WM, Rukundo GZ, Tumwesigire S, Mfitumukiza V, Bikaitwoha EM, Tsai AC. Fruit and vegetable intake and mental health among family caregivers of people with dementia in Uganda. Ment Health Prev. 2021 Dec;24:None. doi: 10.1016/j.mhp.2021.200223.

Babic I, Nguyen-the C, Amiot MJ, Aubert S. Antimicrobial activity of shredded carrot extracts on food-borne bacteria and yeast]. J Appl Bacteriol. 1994 Feb;76(2):135-41. doi: 10.1111/j.1365-2672.1994.tb01608.x.

Bakirhan H, Karabudak E. Effects of inulin on calcium metabolism and bone health. Int J Vitam Nutr Res. 2023 Feb;93(1):85-96. doi: 10.1024/0300-9831/a000700.

Banihani SA. Radish (Raphanus sativus) and Diabetes. Nutrients. 2017 Sep 14;9(9):1014. doi: 10.3390/nu9091014.

Birt DF, Boylston T, Hendrich S, Jane JL, Hollis J, Li L, McClelland J, Moore S, Phillips GJ, Rowling M, Schalinske K, Scott MP, Whitley EM. Resistant starch: promise for improving human health. Adv Nutr. 2013 Nov 6;4(6):587-601. doi: 10.3945/an.

Blanco-Pérez F, Steigerwald H, Schülke S, Vieths S, Toda M, Scheurer S. The Dietary Fiber Pectin: Health Benefits and Potential for the Treatment of Allergies by Modulation of Gut Microbiota. Curr Allergy Asth-

ma Rep. 2021 Sep 10;21(10):43. doi: 10.1007/s11882-021-01020-z.

Caetano BF, de Moura NA, Almeida AP, Dias MC, Sivieri K, Barbisan LF. Yacon (Smallanthus sonchifolius) as a Food Supplement: Health-Promoting Benefits of Fructooligosaccharides. Nutrients. 2016 Jul 21;8(7):436. doi: 10.3390/nu8070436.

Campos D, Betalleluz-Pallardel I, Chirinos R, Aguilar-Galvez A, Noratto G, Pedreschi R. Prebiotic effects of yacon (Smallanthus sonchifolius Poepp. & Endl), a source of fructooligosaccharides and phenolic compounds with antioxidant activity. Food Chem. 2012 Dec 1;135(3):1592-9. doi: 10.1016/j.foodchem.2012.05.088.

Cao Q, Wang G, Peng Y. A Critical Review on Phytochemical Profile and Biological Effects of Turnip (Brassica rapa L.). Front Nutr. 2021 Jul 29;8:721733. doi: 10.3389/fnut.2021.721733.

Castaner O, Goday A, Park YM, Lee SH, Magkos F, Shiow STE, Schröder H. The Gut Microbiome Profile in Obesity: A Systematic Review. Int J Endocrinol. 2018 Mar 22;2018:4095789. doi: 10.1155/2018/4095789.

Chandrasekara A, Josheph Kumar T. Roots and Tuber Crops as Functional Foods: A Review on Phytochemical Constituents and Their Potential Health Benefits. Int J Food Sci. 2016;2016:3631647. doi: 10.1155/2016/3631647.

Chen L, Zhu Y, Hu Z, Wu S, Jin C. Beetroot as a functional food with huge health benefits: Antioxidant, antitumor, physical function, and chronic metabolomics activity. Food Sci Nutr. 2021 Sep 9;9(11):6406-6420. doi: 10.1002/fsn3.2577.

Leafy Vegetables

Aloo SO, Ofosu FK, Kilonzi SM, Shabbir U, Oh DH. Edible Plant Sprouts: Health Benefits, Trends, and Opportunities for Novel Exploration. Nutrients. 2021 Aug 21;13(8):2882. doi: 10.3390/nu13082882.

Anandakumar P, Kamaraj S, Vanitha MK. D-limonene: A multifunctional compound with potent therapeutic effects. J Food Biochem. 2021 Jan;45(1):e13566. doi: 10.1111/jfbc.13566.

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Bazzano LA, Li TY, Joshipura KJ, Hu FB. Intake of fruit, vegetables, and fruit juices and risk of diabetes in women. Diabetes Care. 2008 Jul;31(7):1311-7. doi: 10.2337/dc08-0080.

Benincasa P, Falcinelli B, Lutts S, Stagnari F, Galieni A. Sprouted Grains: A Comprehensive Review. Nutrients. 2019 Feb 17;11(2):421. doi: 10.3390/nu11020421.

Bhupathiraju SN, Wedick NM, Pan A, Manson JE, Rexrode KM, Willett WC, Rimm EB, Hu FB. Quantity and variety in fruit and vegetable intake and risk of coronary heart disease. Am J Clin Nutr. 2013 Dec;98(6):1514-23. doi: 10.3945/ajcn.113.066381.

Bolkent S, Yanardağ R, Tabakoğlu-Oğuz A, Ozsoy-Saçan O. Effects of chard (Beta vulgaris L. var. Cicla) extract on pancreatic B cells in streptozotocin-diabetic rats: a morphological and biochemical study. J Ethnopharmacol. 2000 Nov;73(1-2):251-9. doi: 10.1016/s0378-8741(00)00328-7.

Buko V, Zavodnik I, Kanuka O, Belonovskaya E, Naruta E, Lukivskaya O, Kirko S, Budryn G, Żyżelewicz D, Oracz J, Sybirna N. Antidiabetic effects and erythrocyte stabilization by red cabbage extract in streptozotocin-treated rats. Food Funct. 2018 Mar 1;9(3):1850-1863. doi: 10.1039/c7fo01823a.

Calvi P, Terzo S, Amato A. Betalains: colours for human health. Nat Prod Res. 2022 Aug 3:1-20. doi: 10.1080/14786419.2022.2106481.

Chen L, Zhu Y, Hu Z, Wu S, Jin C. Beetroot as a functional food with huge health benefits: Antioxidant, antitumor, physical function, and chronic metabolomics activity. Food Sci Nutr. 2021 Sep 9;9(11):6406-6420. doi: 10.1002/fsn3.2577.

de Vogel J, Jonker-Termont DS, van Lieshout EM, Katan MB, van der Meer R. Green vegetables, red meat and colon cancer: chlorophyll prevents the cytotoxic and hyperproliferative effects of haem in rat colon. Carcinogenesis. 2005 Feb;26(2):387-93. doi: 10.1093/carcin/bgh331.

Fujii H, Noda T, Sairenchi T, Muto T. Daily intake of green and yellow vegetables is effective for maintaining bone mass in young women. Tohoku J Exp Med. 2009 Jun;218(2):149-54. doi: 10.1620/tjem.218.149.

Gao CM, Tajima K, Kuroishi T, Hirose K, Inoue M. Protective effects of raw vegetables and fruit against lung cancer among smokers and ex-smokers: a case-control study in the Tokai area of Japan. Jpn J Cancer Res. 1993 Jun;84(6):594-600. doi: 10.1111/j.1349-7006.1993.tb02018.x.

Gopal SS, Lakshmi MJ, Sharavana G, Sathaiah G, Sreerama YN, Baskaran V. Lactucaxanthin - a potential anti-diabetic carotenoid from lettuce (Lactuca sativa) inhibits α-amylase and α-glucosidase activity in vitro and in diabetic rats. Food Funct. 2017 Mar 22;8(3):1124-1131. doi: 10.1039/c6fo01655c.

Hanson BT, Dimitri Kits K, Löffler J, Burrichter AG, Fiedler A, Denger K, Frommeyer B, Herbold CW, Rattei T, Karcher N, Segata N, Schleheck D, Loy A. Sulfoquinovose is a select nutrient of prominent bacteria and a source of hydrogen sulfide in the human gut. ISME J. 2021 Sep;15(9):2779-2791. doi: 10.1038/s41396-021-00968-0.

Helay AA, Maray M, El Hamd ASA, Mohamed A. Physical and chemical changes in the endive plants (Cichorium endivia L. var. crispum) during developmental stages. Adv Plants Agric Res. 2016;5(1):436-441. doi: 10.15406/apar.2016.05.00164.

Henriques JF, Serra D, Dinis TCP, Almeida LM. The Anti-Neuroinflammatory Role of Anthocyanins and Their Metabolites for the Prevention and Treatment of Brain Disorders. Int J Mol Sci. 2020 Nov 17;21(22):8653. doi: 10.3390/ijms21228653.

Hiel S, Bindels LB, Pachikian BD, Kalala G, Broers V, Zamariola G, Chang BPI, Kambashi B, Rodriguez J, Cani PD, Neyrinck AM, Thissen JP, Luminet O, Bindelle J, Delzenne NM. Effects of a diet based on inu-

lin-rich vegetables on gut health and nutritional behavior in healthy humans. Am J Clin Nutr. 2019 Jun 1;109(6):1683-1695. doi: 10.1093/ajcn/nqz001.

Kadkhoda G, Zarkesh M, Saidpour A, Oghaz MH, Hedayati M, Khalaj A. Association of dietary intake of fruit and green vegetables with PTEN and P53 mRNA gene expression in visceral and subcutaneous adipose tissues of obese and non-obese adults. Gene. 2020 Apr 5;733:144353. doi: 10.1016/j.gene.2020.144353.

Kataya HA, Hamza AA. Red Cabbage (Brassica oleracea) Ameliorates Diabetic Nephropathy in Rats. Evid Based Complement Alternat Med. 2008 Sep;5(3):281-7. doi: 10.1093/ecam/nem029.

Kojima M, Wakai K, Tamakoshi K, Tokudome S, Toyoshima H, Watanabe Y, Hayakawa N, Suzuki K, Hashimoto S, Ito Y, Tamakoshi A; Japan Collaborative Cohort Study Group. Diet and colorectal cancer mortality: results from the Japan Collaborative Cohort Study. Nutr Cancer. 2004;50(1):23-32. doi: 10.1207/s15327914nc5001_4.

Kondo S, Suzuki A, Kurokawa M, Hasumi K. Intake of kale suppresses postprandial increases in plasma glucose: A randomized, double-blind, placebo-controlled, crossover study. Biomed Rep. 2016 Nov;5(5):553-558. doi: 10.3892/br.2016.767.

Korte G, Dreiseitel A, Schreier P, Oehme A, Locher S, Hajak G, Sand PG. An examination of anthocyanins' and anthocyanidins' affinity for cannabinoid receptors. J Med Food. 2009 Dec;12(6):1407-10. doi: 10.1089/jmf.2008.0243.

Lafarga T, Bobo G, Viñas I, Collazo C, Aguiló-Aguayo I. Effects of thermal and non-thermal processing of cruciferous vegetables on glucosinolates and its derived forms. J Food Sci Technol. 2018 Jun;55(6):1973-1981. doi: 10.1007/s13197-018-3153-7.

Larsson SC, Bergkvist L, Wolk A. Fruit and vegetable consumption and incidence of gastric cancer: a prospective study. Cancer Epidemiol Biomarkers Prev. 2006 Oct;15(10):1998-2001. doi: 10.1158/1055-9965.EPI-06-0402.

Lee J, Shin A, Oh JH, Kim J. Colors of vegetables and fruits and the risks of colorectal cancer. World J Gastroenterol. 2017 Apr 14;23(14):2527-2538. doi: 10.3748/wjg.v23.i14.2527.

León A, Del-Ángel M, Ávila JL, Delgado G. Phthalides: Distribution in Nature, Chemical Reactivity, Synthesis, and Biological Activity. Prog Chem Org Nat Prod. 2017;104:127-246. doi: 10.1007/978-3-319-45618-8_2.

Li H, Wang X, Ye M, Zhang S, Zhang Q, Meng G, Liu L, Wu H, Gu Y, Wang Y, Zhang T, Sun S, Wang X, Zhou M, Jia Q, Song K, Wang Y, Niu K. Does a high intake of green leafy vegetables protect from NAFLD? Evidence from a large population study. Nutr Metab Cardiovasc Dis. 2021 Jun 7;31(6):1691-1701. doi: 10.1016/j.numecd.2021.01.009.

Li M, Fan Y, Zhang X, Hou W, Tang Z. Fruit and vegetable intake and risk of type 2 diabetes mellitus: meta-analysis of prospective cohort studies. BMJ Open. 2014 Nov 5;4(11):e005497. doi: 10.1136/bmjopen-2014-005497.

Li N, Wu X, Zhuang W, Wu C, Rao Z, Du L, Zhou Y. Cruciferous vegetable and isothiocyanate intake and multiple health outcomes. Food Chem. 2022 May 1;375:131816. doi: 10.1016/j.foodchem.2021.131816.

Li W, Sun L, Yue L, Li G, Xiao S. The Association Between Eating Green Vegetables Every Day And Mild Cognitive Impairment: A Community-Based Cross-Sectional Study In Shanghai. Neuropsychiatr Dis Treat. 2019 Nov 18;15:3213-3218. doi: 10.2147/NDT.S221074.

Luo C, Zou L, Sun H, Peng J, Gao C, Bao L, Ji R, Jin Y, Sun S. A Review of the Anti-Inflammatory Effects of Rosmarinic Acid on Inflammatory Diseases. Front Pharmacol. 2020 Feb 28;11:153. doi: 10.3389/fphar.2020.00153.

Madadi E, Mazloum-Ravasan S, Yu JS, Ha JW, Hamishehkar H, Kim KH. Therapeutic Application of Betalains: A Review. Plants (Basel). 2020 Sep 17;9(9):1219. doi: 10.3390/plants9091219.

Mangla B, Javed S, Sultan MH, Kumar P, Kohli K, Najmi A, Alhazmi HA, Al Bratty M, Ahsan W. Sulforaphane: A review of its therapeutic potentials, advances in its nanodelivery, recent patents, and clinical trials. Phytother Res. 2021 Oct;35(10):5440-5458. doi: 10.1002/ptr.7176.

Menni C, Louca P, Berry SE, et al. High intake of vegetables is linked to lower white blood cell profile and the effect is mediated by the gut microbiome. BMC Medicine. 2021 Feb;19(1):37. DOI: 10.1186/s12916-021-01913-w.

Miyahira RF, Lopes JO, Antunes AEC. The Use of Sprouts to Improve the Nutritional Value of Food Products: A Brief Review. Plant Foods Hum Nutr. 2021 Jun;76(2):143-152. doi: 10.1007/s11130-021-00888-6.

Montenegro CF, Kwong DA, Minow ZA, Davis BA, Lozada CF, Casazza GA. Betalain-rich concentrate supplementation improves exercise performance and recovery in competitive triathletes. Appl Physiol Nutr Metab. 2017 Feb;42(2):166-172. doi: 10.1139/apnm-2016-0452.

Morris MC, Wang Y, Barnes LL, Bennett DA, Dawson-Hughes B, Booth SL. Nutrients and bioactives in green leafy vegetables and cognitive decline: Prospective study. Neurology. 2018 Jan 16;90(3):e214-e222. doi: 10.1212/WNL.0000000000004815. Epub 2017 Dec 20.

Mortaş H, Bilici S, Öztürk H, Karakan T. Changes in intestinal parameters and their association with dietary patterns in rotational shift workers. Chronobiol Int. 2022 Jun;39(6):872-885. doi: 10.1080/07420528.2022.2044349.

Salehi B, Venditti A, Sharifi-Rad M, Kręgiel D, Sharifi-Rad J, Durazzo A, Lucarini M, Santini A, Souto EB, Novellino E, Antolak H, Azzini E, Setzer WN, Martins N. The Therapeutic Potential of Apigenin. Int J Mol Sci. 2019 Mar 15;20(6):1305. doi: 10.3390/ijms20061305.

Seo DY, Lee SR, Heo JW, No MH, Rhee BD, Ko KS, Kwak HB, Han J. Ursolic acid in health and disease. Korean J Physiol Pharmacol. 2018 May;22(3):235-248. doi: 10.4196/kjpp.2018.22.3.235. Epub 2018 Apr 25.

Sim M, Lewis JR, Prince RL, Levinger I, Brennan-Speranza TC, Palmer C, Bondonno CP, Bondonno NP,

Devine A, Ward NC, Byrnes E, Schultz CJ, Woodman R, Croft K, Hodgson JM, Blekkenhorst LC. The effects of vitamin K-rich green leafy vegetables on bone metabolism: A 4-week randomised controlled trial in middle-aged and older individuals. Bone Rep. 2020 Apr 26;12:100274. doi: 10.1016/j.bonr.2020.100274.

Singh AK, Rehal J, Kaur A, Jyot G. Enhancement of attributes of cereals by germination and fermentation: a review. Crit Rev Food Sci Nutr. 2015;55(11):1575-89. doi: 10.1080/10408398.2012.706661.

Uddin MK, Juraimi AS, Hossain MS, Nahar MA, Ali ME, Rahman MM. Purslane weed (Portulaca oleracea): a prospective plant source of nutrition, omega-3 fatty acid, and antioxidant attributes. ScientificWorldJournal. 2014 Feb 10;2014:951019. doi: 10.1155/2014/951019.

Vanduchova A, Anzenbacher P, Anzenbacherova E. Isothiocyanate from Broccoli, Sulforaphane, and Its Properties. J Med Food. 2019 Feb;22(2):121-126. doi: 10.1089/jmf.2018.0024.

Veeranki OL, Bhattacharya A, Tang L, Marshall JR, Zhang Y. Cruciferous vegetables, isothiocyanates, and prevention of bladder cancer. Curr Pharmacol Rep. 2015 Aug;1(4):272-282. doi: 10.1007/s40495-015-0024-z.

Vieira AJ, Beserra FP, Souza MC, Totti BM, Rozza AL. Limonene: Aroma of innovation in health and disease. Chem Biol Interact. 2018 Mar 1;283:97-106. doi: 10.1016/j.cbi.2018.02.007.

Wen Lee H, Bi X, Jeyakumar Henry C. Carotenoids, tocopherols and phylloquinone content of 26 green leafy vegetables commonly consumed in Southeast Asia. Food Chem. 2022 Aug 15;385:132729. doi: 10.1016/j.foodchem.2022.132729

Wesołowska A, Nikiforuk A, Michalska K, Kisiel W, Chojnacka-Wójcik E. Analgesic and sedative activities of lactucin and some lactucin-like guaianolides in mice. J Ethnopharmacol. 2006 Sep 19;107(2):254-8. doi: 10.1016/j.jep.2006.03.003.

Williams DE, Wareham NJ, Cox BD, Byrne CD, Hales CN, Day NE. Frequent salad vegetable consumption is associated with a reduction in the risk of diabetes mellitus. J Clin Epidemiol. 1999 Apr;52(4):329-35. doi: 10.1016/s0895-4356(99)00006-2.

Wojdyło A, Nowicka P, Tkacz K, Turkiewicz IP. Sprouts vs. Microgreens as Novel Functional Foods: Variation of Nutritional and Phytochemical Profiles and Their In Vitro Bioactive Properties. Molecules. 2020 Oct 12;25(20):4648. doi: 10.3390/molecules25204648.

Yang Y, Huang CY, Peng SS, Li J. Carotenoid analysis of several dark-green leafy vegetables associated with a lower risk of cancers. Biomed Environ Sci. 1996 Dec;9(4):386-92.

Mushrooms

Abrams DI, Couey P, Shade SB, Kelly ME, Kamanu-Elias N, Stamets P. Antihyperlipidemic effects of Pleuro-

tus ostreatus (oyster mushrooms) in HIV-infected individuals taking antiretroviral therapy. BMC Complement Altern Med. 2011 Aug 10;11:60. doi: 10.1186/1472-6882-11-60.

Ahmad R, Riaz M, Khan A, Aljamea A, Algheryafi M, Sewaket D, Alqathama A. Ganoderma lucidum (Reishi) an edible mushroom; a comprehensive and critical review of its nutritional, cosmeceutical, mycochemical, pharmacological, clinical, and toxicological properties. Phytother Res. 2021 Nov;35(11):6030-6062. doi: 10.1002/ptr.7215.

Aramabašić Jovanović J, Mihailović M, Uskoković A, Grdović N, Dinić S, Vidaković M. The Effects of Major Mushroom Bioactive Compounds on Mechanisms That Control Blood Glucose Level. J Fungi (Basel). 2021 Jan 16;7(1):58. doi: 10.3390/jof7010058.

Arunachalam K, Sreeja PS, Yang X. The Antioxidant Properties of Mushroom Polysaccharides can Potentially Mitigate Oxidative Stress, Beta-Cell Dysfunction and Insulin Resistance. Front Pharmacol. 2022 May 5;13:874474. doi: 10.3389/fphar.2022.874474.

Ba DM, Gao X, Al-Shaar L, Muscat J, Chinchilli VM, Ssentongo P, Beelman RB, Richie J. Mushroom intake and cognitive performance among US older adults: the National Health and Nutrition Examination Survey, 2011-2014. Br J Nutr. 2022 Dec 14;128(11):2241-2248. doi: 10.1017/S0007114521005195.

Ba DM, Gao X, Al-Shaar L, Muscat JE, Chinchilli VM, Beelman RB, Richie JP. Mushroom intake and depression: A population-based study using data from the US National Health and Nutrition Examination Survey (NHANES), 2005-2016. J Affect Disord. 2021 Nov 1;294:686-692. doi: 10.1016/j.jad.2021.07.080.

Ba DM, Gao X, Muscat J, Al-Shaar L, Chinchilli V, Zhang X, Ssentongo P, Beelman RB, Richie JP Jr. Association of mushroom consumption with all-cause and cause-specific mortality among American adults: prospective cohort study findings from NHANES III. Nutr J. 2021 Apr 22;20(1):38. doi: 10.1186/s12937-021-00691-8.

Ba DM, Ssentongo P, Beelman RB, Muscat J, Gao X, Richie JP. Higher Mushroom Consumption Is Associated with Lower Risk of Cancer: A Systematic Review and Meta-Analysis of Observational Studies. Adv Nutr. 2021 Oct 1;12(5):1691-1704. doi: 10.1093/advances/nmab015.

Ba DM, Ssentongo P, Pelucchi C, Negri E, Palli D, Ferraroni M, Zhang ZF, Yu GP, Tsugane S, Hidaka A, Hamada GS, Zaridze D, Maximovich D, Obón-Santacana M, Álvarez-Álvarez L, Vioque J, Garcia de la Hera M, López-Carrillo L, López-Cervantes M, Mu L, Lagiou A, Lagiou P, Boffetta P, Camargo MC, Curado MP, Lunet N, La Vecchia C, Muscat J. Mushroom consumption and risk of gastric cancer: a pooled analysis within the stomach cancer pooling project and a combined meta-analysis with other observational studies. Eur J Cancer Prev. 2023 May 1;32(3):222-228. doi: 10.1097/CEJ.0000000000000754.

Beelman RB, Kalaras MD, Phillips AT, Richie JP Jr. Is ergothioneine a 'longevity vitamin' limited in the American diet? J Nutr Sci. 2020 Nov 11;9:e52. doi: 10.1017/jns.2020.44.

Borodina I, Kenny LC, McCarthy CM, Paramasivan K, Pretorius E, Roberts TJ, van der Hoek SA, Kell DB. The

biology of ergothioneine, an antioxidant nutraceutical. Nutr Res Rev. 2020 Dec;33(2):190-217. doi: 10.1017/S0954422419000301.

Cardwell G, Bornman JF, James AP, Black LJ. A Review of Mushrooms as a Potential Source of Dietary Vitamin D. Nutrients. 2018 Oct 13;10(10):1498. doi: 10.3390/nu10101498.

Cerletti C, Esposito S, Iacoviello L. Edible Mushrooms and Beta-Glucans: Impact on Human Health. Nutrients. 2021 Jun 25;13(7):2195. doi: 10.3390/nu13072195.

Cheah IK, Halliwell B. Ergothioneine, recent developments. Redox Biol. 2021 Jun;42:101868. doi: 10.1016/j.redox.2021.101868. Epub 2021 Jan 26.

Dai X, Stanilka JM, Rowe CA, Esteves EA, Nieves C Jr, Spaiser SJ, Christman MC, Langkamp-Henken B, Percival SS. Consuming Lentinula edodes (Shiitake) Mushrooms Daily Improves Human Immunity: A Randomized Dietary Intervention in Healthy Young Adults. J Am Coll Nutr. 2015;34(6):478-87. doi: 10.1080/07315724.2014.950391.

Dasgupta A, Acharya K. Mushrooms: an emerging resource for therapeutic terpenoids. 3 Biotech. 2019 Oct;9(10):369. doi: 10.1007/s13205-019-1906-2.

Durmus A, Durmus I, Bender O, Karatepe O. The effect of Hericium erinaceum on the prevention of chemically induced experimental colitis in rats. Korean J Intern Med. 2021 Mar;36(Suppl 1):S44-S52. doi: 10.3904/kjim.2019.050.

Elieh Ali Komi D, Sharma L, Dela Cruz CS. Chitin and Its Effects on Inflammatory and Immune Responses. Clin Rev Allergy Immunol. 2018 Apr;54(2):213-223. doi: 10.1007/s12016-017-8600-0.

Erjavec I, Brkljacic J, Vukicevic S, Jakopovic B, Jakopovich I. Mushroom Extracts Decrease Bone Resorption and Improve Bone Formation. Int J Med Mushrooms. 2016;18(7):559-69. doi: 10.1615/intjmedmushrooms.v18.i7.10.

Fijałkowska A, Jędrejko K, Sułkowska-Ziaja K, Ziaja M, Kała K, Muszyńska B. Edible Mushrooms as a Potential Component of Dietary Interventions for Major Depressive Disorder. Foods. 2022 May 20;11(10):1489. doi: 10.3390/foods11101489.

Førland DT, Johnson E, Saetre L, Lyberg T, Lygren I, Hetland G. Effect of an extract based on the medicinal mushroom Agaricus blazei Murill on expression of cytokines and calprotectin in patients with ulcerative colitis and Crohn's disease. Scand J Immunol. 2011 Jan;73(1):66-75. doi: 10.1111/j.1365-3083.2010.02477.x.

Fu TT, Shen L. Ergothioneine as a Natural Antioxidant Against Oxidative Stress-Related Diseases. Front Pharmacol. 2022 Mar 18;13:850813. doi: 10.3389/fphar.2022.850813.

Jayasuriya WJ, Wanigatunge CA, Fernando GH, Abeytunga DT, Suresh TS. Hypoglycaemic activity of culinary Pleurotus ostreatus and P. cystidiosus mushrooms in healthy volunteers and type 2 diabetic patients on diet control and the possible mechanisms of action. Phytother Res. 2015 Feb;29(2):303-9. doi: 10.1002/ptr.5255.

Jeong SC, Jeong YT, Yang BK, Islam R, Koyyalamudi SR, Pang G, Cho KY, Song CH. White button mushroom (Agaricus bisporus) lowers blood glucose and cholesterol levels in diabetic and hypercholesterolemic rats. Nutr Res. 2010 Jan;30(1):49-56. doi: 10.1016/j.nutres.2009.12.003.

Kabir Y, Yamaguchi M, Kimura S. Effect of shiitake (Lentinus edodes) and maitake (Grifola frondosa) mushrooms on blood pressure and plasma lipids of spontaneously hypertensive rats. J Nutr Sci Vitaminol (Tokyo). 1987 Oct;33(5):341-6. doi: 10.3177/jnsv.33.341.

Kameda M, Teruya T, Yanagida M, Kondoh H. Frailty markers comprise blood metabolites involved in antioxidation, cognition, and mobility. Proc Natl Acad Sci U S A. 2020 Apr 28;117(17):9483-9489. doi: 10.1073/pnas.1920795117.

Kerezoudi EN, Mitsou EK, Gioti K, Terzi E, Avgousti I, Panagiotou A, Koutrotsios G, Zervakis GI, Mountzouris KC, Tenta R, Kyriacou A. Fermentation of Pleurotus ostreatus and Ganoderma lucidum mushrooms and their extracts by the gut microbiota of healthy and osteopenic women: potential prebiotic effect and impact of mushroom fermentation products on human osteoblasts. Food Funct. 2021 Mar 1;12(4):1529-1546. doi: 10.1039/d0fo02581j.

Krittanawong C, Isath A, Hahn J, Wang Z, Fogg SE, Bandyopadhyay D, Jneid H, Virani SS, Tang WHW. Mushroom Consumption and Cardiovascular Health: A Systematic Review. Am J Med. 2021 May;134(5):637-642.e2. doi: 10.1016/j.amjmed.2020.10.035.

Lee AH, Pasalich M, Su D, Tang L, Tran VD, Binns CW. Mushroom intake and risk of epithelial ovarian cancer in southern Chinese women. Int J Gynecol Cancer. 2013 Oct;23(8):1400-5. doi: 10.1097/IGC.0b013e3182a41dd8.

Li TJ, Lee TY, Lo Y, Lee LY, Li IC, Chen CC, Chang FC. Hericium erinaceus mycelium ameliorate anxiety induced by continuous sleep disturbance in vivo. BMC Complement Med Ther. 2021 Dec 5;21(1):295. doi: 10.1186/s12906-021-03463-3.

Lindequist U, Haertel B. Medicinal Mushrooms for Prevention and Therapy of Osteoporosis (Review). Int J Med Mushrooms. 2021;23(4):13-22. doi: 10.1615/IntJMedMushrooms.2021038084.

Panda SK, Sahoo G, Swain SS, Luyten W. Anticancer Activities of Mushrooms: A Neglected Source for Drug Discovery. Pharmaceuticals (Basel). 2022 Jan 31;15(2):176. doi: 10.3390/ph15020176.

Park SK, Oh CM, Ryoo JH, Jung JY. The protective effect of mushroom consumption on depressive symptoms in Korean population. Sci Rep. 2022 Dec 19;12(1):21914. doi: 10.1038/s41598-022-26549-5.

Paul BD. Ergothioneine: A Stress Vitamin with Antiaging, Vascular, and Neuroprotective Roles? Antioxid Redox Signal. 2022 Jun;36(16-18):1306-1317. doi: 10.1089/ars.2021.0043.

Preuss HG, Echard B, Fu J, Perricone NV, Bagchi D, Kaylor M, Zhuang C. Fraction SX of maitake mushroom favorably influences blood glucose levels and blood pressure in streptozotocin-induced diabetic rats. J Med

Food. 2012 Oct;15(10):901-8. doi: 10.1089/jmf.2012.0011.

Qin M, Geng Y, Lu Z, Xu H, Shi JS, Xu X, Xu ZH. Anti-Inflammatory Effects of Ethanol Extract of Lion's Mane Medicinal Mushroom, Hericium erinaceus (Agaricomycetes), in Mice with Ulcerative Colitis. Int J Med Mushrooms. 2016;18(3):227-34. doi: 10.1615/IntJMedMushrooms.v18.i3.50.

Rahman MA, Abdullah N, Aminudin N. Lentinula edodes (shiitake mushroom): An assessment of in vitro anti-atherosclerotic bio-functionality. Saudi J Biol Sci. 2018 Dec;25(8):1515-1523. doi: 10.1016/j.sjbs.2016.01.021.

Rodriguez MN, Lippi SLP. Lion's Mane (Hericium erinaceus) Exerts Anxiolytic Effects in the rTg4510 Tau Mouse Model. Behav Sci (Basel). 2022 Jul 15;12(7):235. doi: 10.3390/bs12070235.

Ryu S, Kim HG, Kim JY, Kim SY, Cho KO. Hericium erinaceus Extract Reduces Anxiety and Depressive Behaviors by Promoting Hippocampal Neurogenesis in the Adult Mouse Brain. J Med Food. 2018 Feb;21(2):174-180. doi: 10.1089/jmf.2017.4006.

Shamim MZ, Mishra AK, Kausar T, Mahanta S, Sarma B, Kumar V, Mishra PK, Panda J, Baek KH, Mohanta YK. Exploring Edible Mushrooms for Diabetes: Unveiling Their Role in Prevention and Treatment. Molecules. 2023 Mar 21;28(6):2837. doi: 10.3390/molecules28062837.

Shin A, Kim J, Lim SY, Kim G, Sung MK, Lee ES, Ro J. Dietary mushroom intake and the risk of breast cancer based on hormone receptor status. Nutr Cancer. 2010;62(4):476-83. doi: 10.1080/01635580903441212.

Singh R, Dhingra GS, Shri R. Evaluation of Antianxiety Potential of Four Ganoderma (Agaricomycetes) Species from India in Mice. Int J Med Mushrooms. 2016;18(11):991-998. doi: 10.1615/IntJMedMushrooms.v18.i11.40.

Smith E, Ottosson F, Hellstrand S, Ericson U, Orho-Melander M, Fernandez C, Melander O. Ergothioneine is associated with reduced mortality and decreased risk of cardiovascular disease. Heart. 2020 May;106(9):691-697. doi: 10.1136/heartjnl-2019-315485. Epub 2019 Oct 31.

Spim SRV, Pistila AMH, Pickler TB, Silva MT, Grotto D. Effects of Shiitake Culinary-Medicinal Mushroom, Lentinus edodes (Agaricomycetes), Bars on Lipid and Antioxidant Profiles in Individuals with Borderline High Cholesterol: A Double-Blind Randomized Clinical Trial. Int J Med Mushrooms. 2021;23(7):1-12. doi: 10.1615/IntJMedMushrooms.2021038773.

Sun L, Niu Z. A mushroom diet reduced the risk of pregnancy-induced hypertension and macrosomia: a randomized clinical trial. Food Nutr Res. 2020 Jun 8;64. doi: 10.29219/fnr.v64.4451.

Therkelsen SP, Hetland G, Lyberg T, Lygren I, Johnson E. Effect of a Medicinal Agaricus blazei Murill-Based Mushroom Extract, AndoSan™, on Symptoms, Fatigue and Quality of Life in Patients with Ulcerative Colitis in a Randomized Single-Blinded Placebo Controlled Study. PLoS One. 2016 Mar 2;11(3):e0150191. doi: 10.1371/journal.pone.0150191.

Valverde ME, Hernández-Pérez T, Paredes-López O. Edible mushrooms: improving human health and promoting quality life. Int J Microbiol. 2015;2015:376387. doi: 10.1155/2015/376387.

Varshney J, Ooi JH, Jayarao BM, Albert I, Fisher J, Smith RL, Patterson AD, Cantorna MT. White button mushrooms increase microbial diversity and accelerate the resolution of Citrobacter rodentium infection in mice. J Nutr. 2013 Apr;143(4):526-32. doi: 10.3945/jn.112.171355.

Zhang M, Zhang Y, Zhang L, Tian Q. Mushroom polysaccharide lentinan for treating different types of cancers: A review of 12 years clinical studies in China. Prog Mol Biol Transl Sci. 2019;163:297-328. doi: 10.1016/bs.pmbts.2019.02.013.

Zhang S, Sugawara Y, Chen S, Beelman RB, Tsuduki T, Tomata Y, Matsuyama S, Tsuji I. Mushroom consumption and incident risk of prostate cancer in Japan: A pooled analysis of the Miyagi Cohort Study and the Ohsaki Cohort Study. Int J Cancer. 2020 May 15;146(10):2712-2720. doi: 10.1002/ijc.32591.

Zhang W, Xiang YB, Li HL, Yang G, Cai H, Ji BT, Gao YT, Zheng W, Shu XO. Vegetable-based dietary pattern and liver cancer risk: results from the Shanghai women's and men's health studies. Cancer Sci. 2013 Oct;104(10):1353-61. doi: 10.1111/cas.12231.

Zhao J, Hu Y, Qian C, Hussain M, Liu S, Zhang A, He R, Sun P. The Interaction between Mushroom Polysaccharides and Gut Microbiota and Their Effect on Human Health: A Review. Biology (Basel). 2023 Jan 12;12(1):122. doi: 10.3390/biology12010122.

Kim SH, Thomas MJ, Wu D, Carman CV, Ordovás JM, Meydani M. Edible Mushrooms Reduce Atherosclerosis in Ldlr-/- Mice Fed a High-Fat Diet. J Nutr. 2019 Aug 1;149(8):1377-1384. doi: 10.1093/jn/nxz075.

Alliums

Aghababaei F, Hadidi M. Recent Advances in Potential Health Benefits of Quercetin. Pharmaceuticals (Basel). 2023 Jul 18;16(7):1020. doi: 10.3390/ph16071020.

Ahmadian F, Mozaffari-Khosravi H, Azaraein MH, Faraji R, Zavar-Reza J. The effect of consumption of garlic tablet on proteins oxidation biomarkers in postmenopausal osteoporotic women: A randomized clinical trial. Electron Physician. 2017 Nov 25;9(11):5670-5675. doi: 10.19082/5670.

Ahmed W, Rashid S. Functional and therapeutic potential of inulin: A comprehensive review. Crit Rev Food Sci Nutr. 2019;59(1):1-13. doi: 10.1080/10408398.2017.1355775.

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Chiang MC, Tsai TY, Wang CJ. The Potential Benefits of Quercetin for Brain Health: A Review of Anti-Inflammatory and Neuroprotective Mechanisms. Int J Mol Sci. 2023 Mar 28;24(7):6328. doi: 10.3390/

ijms24076328.

Chung MY, Hwang JT, Park SH. Antiobesity effects of onion (Allium cepa) in subjects with obesity: Systematic review and meta-analysis. Food Sci Nutr. 2023 May 16;11(8):4409-4418. doi: 10.1002/fsn3.3426.

Deepika, Maurya PK. Health Benefits of Quercetin in Age-Related Diseases. Molecules. 2022 Apr 13;27(8):2498. doi: 10.3390/molecules27082498.

Di Petrillo A, Orrù G, Fais A, Fantini MC. Quercetin and its derivates as antiviral potentials: A comprehensive review. Phytother Res. 2022 Jan;36(1):266-278. doi: 10.1002/ptr.7309.

Falcón-Piñeiro A, Remesal E, Noguera M, Ariza JJ, Guillamón E, Baños A, Navas-Cortes JA. Antifungal Activity of Propyl-Propane-Thiosulfinate (PTS) and Propyl-Propane-Thiosulfonate (PTSO) from Allium cepa against Verticillium dahliae: In Vitro and in Planta Assays. J Fungi (Basel). 2021 Sep 8;7(9):736. doi: 10.3390/jof7090736.

Franco-Robles E, López MG. Implication of fructans in health: immunomodulatory and antioxidant mechanisms. ScientificWorldJournal. 2015;2015:289267. doi: 10.1155/2015/289267.

Galavi A, Hosseinzadeh H, Razavi BM. The effects of Allium cepa L. (onion) and its active constituents on metabolic syndrome: A review. Iran J Basic Med Sci. 2021 Jan;24(1):3-16. doi: 10.22038/ijbms.2020.46956.10843.

Guercio V, Turati F, La Vecchia C, Galeone C, Tavani A. Allium vegetables and upper aerodigestive tract cancers: a meta-analysis of observational studies. Mol Nutr Food Res. 2016 Jan;60(1):212-22. doi: 10.1002/mnfr.201500587.

Gull I, Saeed M, Shaukat H, Aslam SM, Samra ZQ, Athar AM. Inhibitory effect of Allium sativum and Zingiber officinale extracts on clinically important drug resistant pathogenic bacteria. Ann Clin Microbiol Antimicrob. 2012 Apr 27;11:8. doi: 10.1186/1476-0711-11-8.

Guo L, Yuan X, Yang B, Tang G, Liang H, Guo F. Association between Allium vegetables and the risk of non-digestive tract cancer: A systematic review and meta-analysis of cohort and case-control studies. Cancer Treat Res Commun. 2022;32:100598. doi: 10.1016/j.ctarc.2022.100598.

Hiel S, Bindels LB, Pachikian BD, Kalala G, Broers V, Zamariola G, Chang BPI, Kambashi B, Rodriguez J, Cani PD, Neyrinck AM, Thissen JP, Luminet O, Bindelle J, Delzenne NM. Effects of a diet based on inulin-rich vegetables on gut health and nutritional behavior in healthy humans. Am J Clin Nutr. 2019 Jun 1;109(6):1683-1695. doi: 10.1093/ajcn/nqz001.

Hsing AW, Chokkalingam AP, Gao YT, Madigan MP, Deng J, Gridley G, Fraumeni JF Jr. Allium vegetables and risk of prostate cancer: a population-based study. J Natl Cancer Inst. 2002 Nov 6;94(21):1648-51. doi: 10.1093/jnci/94.21.1648.

Huang W, Tang G, Zhang L, Tao J, Wei Z. Effect of onion on blood lipid profile: A meta-analysis of random-

ized controlled trials. Food Sci Nutr. 2021 May 13;9(7):3563-3572. doi: 10.1002/fsn3.2309.

Imaizumi VM, Laurindo LF, Manzan B, Guiguer EL, Oshiiwa M, Otoboni AMMB, Araujo AC, Tofano RJ, Barbalho SM. Garlic: A systematic review of the effects on cardiovascular diseases. Crit Rev Food Sci Nutr. 2023;63(24):6797-6819. doi: 10.1080/10408398.2022.2043821.

Jeong S, Chae J, Lee G, Shin G, Kwon YI, Oh JB, Shin DY, Lee JH. Effect of Steamed Onion (ONIRO) Consumption on Body Fat and Metabolic Profiles in Overweight Subjects: A 12-Week Randomized, Double-Blind, Placebo-Controlled Clinical Trial. J Am Coll Nutr. 2020 Mar-Apr;39(3):206-215. doi: 10.1080/07315724.2019.1635052.

Jin ZY, Han RQ, Zhang XF, Wang XS, Wu M, Zhang ZF, Zhao JK. [The protective effects of green tea drinking and garlic intake on lung cancer, in a low cancer risk area of Jiangsu province, China]. Zhonghua Liu Xing Bing Xue Za Zhi. 2013 Feb;34(2):114-9.

Khodavandi A, Alizadeh F, Razis AFA. Association between dietary intake and risk of ovarian cancer: a systematic review and meta-analysis. Eur J Nutr. 2021 Jun;60(4):1707-1736. doi: 10.1007/s00394-020-02332-y.

Kwak JS, Kim JY, Paek JE, Lee YJ, Kim HR, Park DS, Kwon O. Garlic powder intake and cardiovascular risk factors: a meta-analysis of randomized controlled clinical trials. Nutr Res Pract. 2014 Dec;8(6):644-54. doi: 10.4162/nrp.2014.8.6.644.

Law YY, Chiu HF, Lee HH, Shen YC, Venkatakrishnan K, Wang CK. Consumption of onion juice modulates oxidative stress and attenuates the risk of bone disorders in middle-aged and post-menopausal healthy subjects. Food Funct. 2016 Feb;7(2):902-12. doi: 10.1039/c5fo01251a.

Lawson LD, Hunsaker SM. Allicin Bioavailability and Bioequivalence from Garlic Supplements and Garlic Foods. Nutrients. 2018 Jun 24;10(7):812. doi: 10.3390/nu10070812.

Matheson EM, Mainous AG 3rd, Carnemolla MA. The association between onion consumption and bone density in perimenopausal and postmenopausal non-Hispanic white women 50 years and older. Menopause. 2009 Jul-Aug;16(4):756-9. doi: 10.1097/gme.0b013e31819581a5.

Muir JG, Shepherd SJ, Rosella O, Rose R, Barrett JS, Gibson PR. Fructan and free fructose content of common Australian vegetables and fruit. J Agric Food Chem. 2007 Aug 8;55(16):6619-27. doi: 10.1021/jf070623x.

Myneni AA, Chang SC, Niu R, Liu L, Swanson MK, Li J, Su J, Giovino GA, Yu S, Zhang ZF, Mu L. Raw Garlic Consumption and Lung Cancer in a Chinese Population. Cancer Epidemiol Biomarkers Prev. 2016 Apr;25(4):624-33. doi: 10.1158/1055-9965.EPI-15-0760.

Nakayama Y, Makita M, Nozaki S, Kikuchi Y. Effects of onion extract containing concentrated cysteine sulfoxides on sleep quality: a randomized, double-blind, placebo-controlled, crossover study. Food Sci Biotechnol. 2020 Oct 6;29(12):1755-1762. doi: 10.1007/s10068-020-00829-0.

Nishihira J, Nishimura M, Kurimoto M, Kagami-Katsuyama H, Hattori H, Nakagawa T, Muro T, Kobori M.

The effect of 24-week continuous intake of quercetin-rich onion on age-related cognitive decline in healthy elderly people: a randomized, double-blind, placebo-controlled, parallel-group comparative clinical trial. J Clin Biochem Nutr. 2021 Sep;69(2):203-215. doi: 10.3164/jcbn.21-17.

Nishimura M, Muro T, Kobori M, Nishihira J. Effect of Daily Ingestion of Quercetin-Rich Onion Powder for 12 Weeks on Visceral Fat: A Randomised, Double-Blind, Placebo-Controlled, Parallel-Group Study. Nutrients. 2019 Dec 28;12(1):91. doi: 10.3390/nu12010091.

Oku S, Ueno K, Sawazaki Y, Maeda T, Jitsuyama Y, Suzuki T, Onodera S, Fujino K, Shimura H. Functional characterization and vacuolar localization of fructan exohydrolase derived from onion (Allium cepa). J Exp Bot. 2022 Aug 11;73(14):4908-4922. doi: 10.1093/jxb/erac197.

Puccinelli MT, Stan SD. Dietary Bioactive Diallyl Trisulfide in Cancer Prevention and Treatment. Int J Mol Sci. 2017 Jul 28;18(8):1645. doi: 10.3390/ijms18081645.

Rauf A, Imran M, Khan IA, Ur-Rehman M, Gilani SA, Mehmood Z, Mubarak MS. Anticancer potential of quercetin: A comprehensive review. Phytother Res. 2018 Nov;32(11):2109-2130. doi: 10.1002/ptr.6155.

Rivlin RS. Historical perspective on the use of garlic. J Nutr. 2001 Mar;131(3s):951S-4S. doi: 10.1093/jn/131.3.951S.

Ruhee RT, Roberts LA, Ma S, Suzuki K. Organosulfur Compounds: A Review of Their Anti-inflammatory Effects in Human Health. Front Nutr. 2020 Jun 2;7:64. doi: 10.3389/fnut.2020.00064.

Sangouni AA, Mohammad Hosseini Azar MR, Alizadeh M. Effects of garlic powder supplementation on insulin resistance, oxidative stress, and body composition in patients with non-alcoholic fatty liver disease: A randomized controlled clinical trial. Complement Ther Med. 2020 Jun;51:102428. doi: 10.1016/j.ctim.2020.102428.

Shi X, Lv Y, Mao C, Yuan J, Yin Z, Gao X, Zhang Z. Garlic Consumption and All-Cause Mortality among Chinese Oldest-Old Individuals: A Population-Based Cohort Study. Nutrients. 2019 Jun 30;11(7):1504. doi: 10.3390/nu11071504.

So D, Whelan K, Rossi M, Morrison M, Holtmann G, Kelly JT, Shanahan ER, Staudacher HM, Campbell KL. Dietary fiber intervention on gut microbiota composition in healthy adults: a systematic review and meta-analysis. Am J Clin Nutr. 2018 Jun 1;107(6):965-983. doi: 10.1093/ajcn/nqy041.

Song K, Milner JA. The influence of heating on the anticancer properties of garlic. J Nutr. 2001 Mar;131(3s):1054S-7S. doi: 10.1093/jn/131.3.1054S.

Song X, Yue Z, Nie L, Zhao P, Zhu K, Wang Q. Biological Functions of Diallyl Disulfide, a Garlic-Derived Natural Organic Sulfur Compound. Evid Based Complement Alternat Med. 2021 Oct 29;2021:5103626. doi: 10.1155/2021/5103626.

Su XQ, Yin ZY, Jin QY, Liu ZC, Han X, Hu ZQ, Zhang L, Ma JL, Li ZX, Zhang Y, Zhou T, Liu WD, You WC, Pan KF, Shi L, Li WQ. Allium vegetable intake associated with the risk of incident gastric cancer: a continuous

follow-up study of a randomized intervention trial. Am J Clin Nutr. 2023 Jan;117(1):22-32. doi: 10.1016/j.ajcnut.2022.10.017. Epub 2022 Dec 20. PMID: 36789941.

Swanson KS, de Vos WM, Martens EC, Gilbert JA, Menon RS, Soto-Vaca A, Hautvast J, Meyer PD, Borewicz K, Vaughan EE, Slavin JL. Effect of fructans, prebiotics and fibres on the human gut microbiome assessed by 16S rRNA-based approaches: a review. Benef Microbes. 2020 Mar 27;11(2):101-129. doi: 10.3920/BM2019.0082.

Taj Eldin IM, Ahmed EM, Elwahab H M A. Preliminary Study of the Clinical Hypoglycemic Effects of Allium cepa (Red Onion) in Type 1 and Type 2 Diabetic Patients. Environ Health Insights. 2010 Oct 14;4:71-7. doi: 10.4137/EHI.S5540.

Tao MH, Xu WH, Zheng W, Gao YT, Ruan ZX, Cheng JR, Xiang YB, Shu XO. A case-control study in Shanghai of fruit and vegetable intake and endometrial cancer. Br J Cancer. 2005 Jun 6;92(11):2059-64. doi: 10.1038/sj.bjc.6602609.

Tasnim S, Haque PS, Bari MS, Hossain MM, Islam SM, Shahriar M, Bhuiyan MA, Bin Sayeed MS. Allium sativum L. Improves Visual Memory and Attention in Healthy Human Volunteers. Evid Based Complement Alternat Med. 2015;2015:103416. doi: 10.1155/2015/103416.

Turati F, Guercio V, Pelucchi C, La Vecchia C, Galeone C. Colorectal cancer and adenomatous polyps in relation to allium vegetables intake: a meta-analysis of observational studies. Mol Nutr Food Res. 2014 Sep;58(9):1907-14. doi: 10.1002/mnfr.201400169.

Turati F, Pelucchi C, Guercio V, La Vecchia C, Galeone C. Allium vegetable intake and gastric cancer: a case-control study and meta-analysis. Mol Nutr Food Res. 2015 Jan;59(1):171-9. doi: 10.1002/mnfr.201400496.

Uma Maheshwari Nallal V, Padmini R, Ravindran B, Chang SW, Radhakrishnan R, Almoallim HSM, Alharbi SA, Razia M. Combined in vitro and in silico approach to evaluate the inhibitory potential of an underutilized allium vegetable and its pharmacologically active compounds on multidrug resistant Candida species. Saudi J Biol Sci. 2021 Feb;28(2):1246-1256. doi: 10.1016/j.sjbs.2020.11.082.

Vandeputte D, Falony G, Vieira-Silva S, Wang J, Sailer M, Theis S, Verbeke K, Raes J. Prebiotic inulin-type fructans induce specific changes in the human gut microbiota. Gut. 2017 Nov;66(11):1968-1974. doi: 10.1136/gutjnl-2016-313271.

Wan Q, Li N, Du L, Zhao R, Yi M, Xu Q, Zhou Y. Allium vegetable consumption and health: An umbrella review of meta-analyses of multiple health outcomes. Food Sci Nutr. 2019 Jul 10;7(8):2451-2470. doi: 10.1002/fsn3.1117.

Wang G, Wang Y, Yao L, Gu W, Zhao S, Shen Z, Lin Z, Liu W, Yan T. Pharmacological Activity of Quercetin: An Updated Review. Evid Based Complement Alternat Med. 2022 Dec 1;2022:3997190. doi: 10.1155/2022/3997190.

Wang J, Zhang X, Lan H, Wang W. Effect of garlic supplement in the management of type 2 diabetes mellitus (T2DM): a meta-analysis of randomized controlled trials. Food Nutr Res. 2017 Sep 27;61(1):1377571. doi: 10.1080/16546628.2017.1377571.

Wu X, Shi J, Fang WX, Guo XY, Zhang LY, Liu YP, Li Z. Allium vegetables are associated with reduced risk of colorectal cancer: A hospital-based matched case-control study in China. Asia Pac J Clin Oncol. 2019 Oct;15(5):e132-e141. doi: 10.1111/ajco.13133.

Xie T, Wu Q, Lu H, Hu Z, Luo Y, Chu Z, Luo F. Functional Perspective of Leeks: Active Components, Health Benefits and Action Mechanisms. Foods. 2023 Aug 27;12(17):3225. doi: 10.3390/foods12173225.

Yang H, Gu Y, Zhang B, Meng G, Zhang Q, Liu L, Wu H, Zhang S, Zhang T, Wang X, Zhang J, Sun S, Wang X, Zhou M, Jia Q, Song K, Wang Y, Huang T, Niu K. The longitudinal association between onion consumption and risk of depressive symptoms: results from the TCLSIH Cohort study and the UK Biobank. Food Funct. 2023 Jan 3;14(1):195-205. doi: 10.1039/d2fo01640k.

Yi H, Peng H, Wu X, Xu X, Kuang T, Zhang J, Du L, Fan G. The Therapeutic Effects and Mechanisms of Quercetin on Metabolic Diseases: Pharmacological Data and Clinical Evidence. Oxid Med Cell Longev. 2021 Jun 23;2021:6678662. doi: 10.1155/2021/6678662.

Zadhoush R, Alavi-Naeini A, Feizi A, Naghshineh E, Ghazvini MR. The Therapeutic Impact of Garlic (Allium Sativum) on Oxidative Stress Markers among Polycystic Ovary Syndrome Patients: A Randomized, Double-Blinded Clinical Trial. Int J Prev Med. 2023 Jan 20;14:1. doi: 10.4103/ijpvm.ijpvm_229_21.

Zhang J, Yang J. Allium Vegetables Intake and Risk of Breast Cancer: A Meta-Analysis. Iran J Public Health. 2022 Apr;51(4):746-757. doi: 10.18502/ijph.v51i4.9235.

Zhou X, Qian H, Zhang D, Zeng L. Garlic intake and the risk of colorectal cancer: A meta-analysis. Medicine (Baltimore). 2020 Jan;99(1):e18575. doi: 10.1097/MD.0000000000018575.

Zhou XF, Ding ZS, Liu NB. Allium vegetables and risk of prostate cancer: evidence from 132,192 subjects. Asian Pac J Cancer Prev. 2013;14(7):4131-4. doi: 10.7314/apjcp.2013.14.7.4131.

Zhou Y, Zhuang W, Hu W, Liu GJ, Wu TX, Wu XT. Consumption of large amounts of Allium vegetables reduces risk for gastric cancer in a meta-analysis. Gastroenterology. 2011 Jul;141(1):80-9. doi: 10.1053/j.gastro.2011.03.057.

Zurbau A, Au-Yeung F, Blanco Mejia S, Khan TA, Vuksan V, Jovanovski E, Leiter LA, Kendall CWC, Jenkins DJA, Sievenpiper JL. Relation of Different Fruit and Vegetable Sources With Incident Cardiovascular Outcomes: A Systematic Review and Meta-Analysis of Prospective Cohort Studies. J Am Heart Assoc. 2020 Oct 20;9(19):e017728. doi: 10.1161/JAHA.120.017728.

Fruits

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. J Nutr. 2006 Oct;136(10):2588-93. doi: 10.1093/jn/136.10.2588.

Farvid MS, Barnett JB, Spence ND. Fruit and vegetable consumption and incident breast cancer: a systematic review and meta-analysis of prospective studies. Br J Cancer. 2021 Jul;125(2):284-298. doi: 10.1038/s41416-021-01373-2.

Ferro A, Costa AR, Morais S, Bertuccio P, Rota M, Pelucchi C, Hu J, Johnson KC, Zhang ZF, Palli D, Ferraroni M, Yu GP, Bonzi R, Peleteiro B, López-Carrillo L, Tsugane S, Hamada GS, Hidaka A, Malekzadeh R, Zaridze D, Maximovich D, Vioque J, Navarrete-Muñoz EM, Alguacil J, Castaño-Vinyals G, Wolk A, Håkansson N, Hernández-Ramírez RU, Pakseresht M, Ward MH, Pourfarzi F, Mu L, López-Cervantes M, Persiani R, Kurtz RC, Lagiou A, Lagiou P, Boffetta P, Boccia S, Negri E, Camargo MC, Curado MP, La Vecchia C, Lunet N. Fruits and vegetables intake and gastric cancer risk: A pooled analysis within the Stomach cancer Pooling Project. Int J Cancer. 2020 Dec 1;147(11):3090-3101. doi: 10.1002/ijc.33134.

García-Esquinas E, Rahi B, Peres K, Colpo M, Dartigues JF, Bandinelli S, Feart C, Rodríguez-Artalejo F. Consumption of fruit and vegetables and risk of frailty: a dose-response analysis of 3 prospective cohorts of community-dwelling older adults. Am J Clin Nutr. 2016 Jul;104(1):132-42. doi: 10.3945/ajcn.115.125781.

Huai J, Ye X. Vegetable, Fruit Consumption and Risk of Biliary Cancer: Evidence from a Meta-Analysis. Nutr Cancer. 2021;73(8):1322-1332. doi: 10.1080/01635581.2020.1800767.

Huo J, Wu L, Lv J, Cao H, Gao Q. Effect of fruit intake on functional constipation: A systematic review and meta-analysis of randomized and crossover studies. Front Nutr. 2022 Oct 6;9:1018502. doi: 10.3389/fnut.2022.1018502.

Hurtado-Barroso S, Trius-Soler M, Lamuela-Raventós RM, Zamora-Ros R. Vegetable and Fruit Consumption and Prognosis Among Cancer Survivors: A Systematic Review and Meta-Analysis of Cohort Studies. Adv Nutr. 2020 Nov 16;11(6):1569-1582. doi: 10.1093/advances/nmaa082.

Jochems SHJ, Reulen RC, van Osch FHM, Witlox WJA, Goossens ME, Brinkman M, Giles GG, Milne RL, van den Brandt PA, White E, Weiderpass E, Huybrechts I, Hémon B, Agudo A, Bueno-de-Mesquita B, Cheng KK, van Schooten FJ, Bryan RT, Wesselius A, Zeegers MP. Fruit consumption and the risk of bladder cancer: A pooled analysis by the Bladder Cancer Epidemiology and Nutritional Determinants Study. Int J Cancer. 2020 Oct 15;147(8):2091-2100. doi: 10.1002/ijc.33008.

Kojima G, Iliffe S, Jivraj S, Walters K. Fruit and Vegetable Consumption and Incident Prefrailty and Frailty in Community-Dwelling Older People: The English Longitudinal Study of Ageing. Nutrients. 2020 Dec 18;12(12):3882. doi: 10.3390/nu12123882.

Lee J, Shin A, Oh JH, Kim J. Colors of vegetables and fruits and the risks of colorectal cancer. World J Gastroenterol. 2017 Apr 14;23(14):2527-2538. doi: 10.3748/wjg.v23.i14.2527.

Lee M, Lim M, Kim J. Fruit and vegetable consumption and the metabolic syndrome: a systematic review and dose-response meta-analysis. Br J Nutr. 2019 Oct 14;122(7):723-733. doi: 10.1017/S000711451900165X.

Liao YP, Zheng QX, Jiang XM, Chen XQ, Gao XX, Pan YQ. Fruit, vegetable, and fruit juice consumption and risk of gestational diabetes mellitus: a systematic review and meta-analysis. Nutr J. 2023 May 20;22(1):27. doi: 10.1186/s12937-023-00855-8.

Liu H, Wang XC, Hu GH, Guo ZF, Lai P, Xu L, Huang TB, Xu YF. Fruit and vegetable consumption and risk of bladder cancer: an updated meta-analysis of observational studies. Eur J Cancer Prev. 2015 Nov;24(6):508-16. doi: 10.1097/CEJ.0000000000000119.

Mihrshahi S, Dobson AJ, Mishra GD. Fruit and vegetable consumption and prevalence and incidence of depressive symptoms in mid-age women: results from the Australian longitudinal study on women's health. Eur J Clin Nutr. 2015 May;69(5):585-91. doi: 10.1038/ejcn.2014.222.

Milajerdi A, Ebrahimi-Daryani N, Dieleman LA, Larijani B, Esmaillzadeh A. Association of Dietary Fiber, Fruit, and Vegetable Consumption with Risk of Inflammatory Bowel Disease: A Systematic Review and Meta-Analysis. Adv Nutr. 2021 Jun 1;12(3):735-743. doi: 10.1093/advances/nmaa145.

Mohammadi T, Irandoost P, Roshanravan N, Khamechi SP, Milajerdi A, Larijani B, Ayati MH, Namazi N. Is there any association between fruit consumption and the risk of gestational diabetes mellitus? A systematic review and meta-analysis. Complement Ther Med. 2020 Nov;54:102445. doi: 10.1016/j.ctim.2020.102445.

Qiu R, Cao WT, Tian HY, He J, Chen GD, Chen YM. Greater Intake of Fruit and Vegetables Is Associated with Greater Bone Mineral Density and Lower Osteoporosis Risk in Middle-Aged and Elderly Adults. PLoS One. 2017 Jan 3;12(1):e0168906. doi: 10.1371/journal.pone.0168906.

Ren Y, Sun S, Su Y, Ying C, Luo H. Effect of fruit on glucose control in diabetes mellitus: a meta-analysis of nineteen randomized controlled trials. Front Endocrinol (Lausanne). 2023 May 5;14:1174545. doi: 10.3389/fendo.2023.1174545.

Saghafian F, Malmir H, Saneei P, Milajerdi A, Larijani B, Esmaillzadeh A. Fruit and vegetable consumption and risk of depression: accumulative evidence from an updated systematic review and meta-analysis of epidemiological studies. Br J Nutr. 2018 May;119(10):1087-1101. doi: 10.1017/S0007114518000697.

Sahashi Y, Goto A, Takachi R, Ishihara J, Kito K, Kanehara R, Yamaji T, Iwasaki M, Inoue M, Shoichiro T, Sawada N. Inverse Association between Fruit and Vegetable Intake and All-Cause Mortality: Japan Public Health Center-Based Prospective Study. J Nutr. 2022 Oct 6;152(10):2245-2254. doi: 10.1093/jn/nxac136. Erra-

tum in: J Nutr. 2023 Aug;153(8):2541. doi: 10.1016/j.tjnut.2023.04.007.

Sakai M, Kitagawa Y, Saeki H, Miyazaki T, Yamaji T, Nemoto K, Oyama T, Muto M, Takeuchi H, Toh Y, Matsubara H, Mano M, Kono K, Kato K, Yoshida M, Kawakubo H, Booka E, Yamatsuji T, Kato H, Ito Y, Ishikawa H, Ishihara R, Tsushima T, Kawachi H, Oyama T, Kojima T, Kuribayashi S, Makino T, Matsuda S, Sohda M, Kubo Y, Doki Y; Esophageal Cancer Practice Guidelines Preparation Committee. Fruit and vegetable consumption and risk of esophageal cancer in the Asian region: a systematic review and meta-analysis. Esophagus. 2022 Jan;19(1):27-38. doi: 10.1007/s10388-021-00882-6.

Seyedrezazadeh E, Moghaddam MP, Ansarin K, Asghari Jafarabadi M, Sharifi A, Sharma S, Kolahdooz F. Dietary Factors and Risk of Chronic Obstructive Pulmonary Disease: a Systemic Review and Meta-Analysis. Tanaffos. 2019 Apr;18(4):294-309.

Shu L, Yu D, Jin F. Healthy dietary patterns, foods, and risk of glioma: A systematic review and meta-analysis of observational studies. Front Nutr. 2023 Jan 4;9:1077452. doi: 10.3389/fnut.2022.1077452.

Tian Y, Su L, Wang J, Duan X, Jiang X. Fruit and vegetable consumption and risk of the metabolic syndrome: a meta-analysis. Public Health Nutr. 2018 Mar;21(4):756-765. doi: 10.1017/S136898001700310X.

Vieira AR, Abar L, Vingeliene S, Chan DS, Aune D, Navarro-Rosenblatt D, Stevens C, Greenwood D, Norat T. Fruits, vegetables and lung cancer risk: a systematic review and meta-analysis. Ann Oncol. 2016 Jan;27(1):81-96. doi: 10.1093/annonc/mdv381.

Yan Z, Xu Y, Li K, Liu L. Increased fruit intake is associated with reduced risk of depression: evidence from cross-sectional and Mendelian randomization analyses. Front Public Health. 2023 Dec 13;11:1276326. doi: 10.3389/fpubh.2023.1276326.

Zhang Y, Zhang DZ. Associations of vegetable and fruit consumption with metabolic syndrome. A meta-analysis of observational studies. Public Health Nutr. 2018 Jun;21(9):1693-1703. doi: 10.1017/S1368980018000381.

Zhou Y, Wang J, Cao L, Shi M, Liu H, Zhao Y, Xia Y. Fruit and Vegetable Consumption and Cognitive Disorders in Older Adults: A Meta-Analysis of Observational Studies. Front Nutr. 2022 Jun 20;9:871061. doi: 10.3389/fnut.2022.871061.

Aron PM, Kennedy JA. Flavan-3-ols: nature, occurrence and biological activity. Mol Nutr Food Res. 2008 Jan;52(1):79-104. doi: 10.1002/mnfr.200700137.

Bertelli A, Bertelli AA, Gozzini A, Giovannini L. Plasma and tissue resveratrol concentrations and pharmacological activity. Drugs Exp Clin Res. 1998;24(3):133-8.

Blanco-Pérez F, Steigerwald H, Schülke S, Vieths S, Toda M, Scheurer S. The Dietary Fiber Pectin: Health Benefits and Potential for the Treatment of Allergies by Modulation of Gut Microbiota. Curr Allergy Asthma Rep. 2021 Sep 10;21(10):43. doi: 10.1007/s11882-021-01020-z.

Burger KN, Beulens JW, van der Schouw YT, Sluijs I, Spijkerman AM, Sluik D, Boeing H, Kaaks R, Teucher B, Dethlefsen C, Overvad K, Tjønneland A, Kyrø C, Barricarte A, Bendinelli B, Krogh V, Tumino R, Sacerdote C, Mattiello A, Nilsson PM, Orho-Melander M, Rolandsson O, Huerta JM, Crowe F, Allen N, Nöthlings U. Dietary fiber, carbohydrate quality and quantity, and mortality risk of individuals with diabetes mellitus. PLoS One. 2012;7(8):e43127. doi: 10.1371/journal.pone.0043127.

Chanet A, Milenkovic D, Manach C, Mazur A, Morand C. Citrus flavanones: what is their role in cardiovascular protection? J Agric Food Chem. 2012 Sep 12;60(36):8809-22. doi: 10.1021/jf300669s.

Chen RJ, Lee YH, Yeh YL, Wu WS, Ho CT, Li CY, Wang BJ, Wang YJ. Autophagy-inducing effect of pterostilbene: A prospective therapeutic/preventive option for skin diseases. J Food Drug Anal. 2017 Jan;25(1):125-133. doi: 10.1016/j.jfda.2016.10.022.

Chitchumroonchokchai C, Thomas-Ahner JM, Li J, Riedl KM, Nontakham J, Suksumrarn S, Clinton SK, Kinghorn AD, Failla ML. Anti-tumorigenicity of dietary α-mangostin in an HT-29 colon cell xenograft model and the tissue distribution of xanthones and their phase II metabolites. Mol Nutr Food Res. 2013 Feb;57(2):203-11. doi: 10.1002/mnfr.201200539.

Dauchet L, Amouyel P, Hercberg S, Dallongeville J. Fruit and vegetable consumption and risk of coronary heart disease: a meta-analysis of cohort studies. J Nutr. 2006 Oct;136(10):2588-93. doi: 10.1093/jn/136.10.2588.

Franco-Robles E, López MG. Implication of fructans in health: immunomodulatory and antioxidant mechanisms. ScientificWorldJournal. 2015;2015:289267. doi: 10.1155/2015/289267.

Gonzalez-Granda A, Damms-Machado A, Basrai M, Bischoff SC. Changes in Plasma Acylcarnitine and Lysophosphatidylcholine Levels Following a High-Fructose Diet: A Targeted Metabolomics Study in Healthy Women. Nutrients. 2018 Sep 6;10(9):1254. doi: 10.3390/nu10091254.

Imran M, Arshad MS, Butt MS, Kwon JH, Arshad MU, Sultan MT. Mangiferin: a natural miracle bioactive compound against lifestyle related disorders. Lipids Health Dis. 2017 May 2;16(1):84. doi: 10.1186/s12944-017-0449-y.

Korte G, Dreiseitel A, Schreier P, Oehme A, Locher S, Hajak G, Sand PG. An examination of anthocyanins' and anthocyanidins' affinity for cannabinoid receptors. J Med Food. 2009 Dec;12(6):1407-10. doi: 10.1089/jmf.2008.0243.

Krinsky NI, Landrum JT, Bone RA. Biologic mechanisms of the protective role of lutein and zeaxanthin in the eye. Annu Rev Nutr. 2003;23:171-201. doi: 10.1146/annurev.nutr.23.011702.073307.

Lee SH, Moore LV, Park S, Harris DM, Blanck HM. Adults Meeting Fruit and Vegetable Intake Recommendations — United States, 2019. MMWR Morb Mortal Wkly Rep 2022;71:1-9. doi: 10.15585/mmwr.mm7101a1.

Ma L, Lin XM. Effects of lutein and zeaxanthin on aspects of eye health. J Sci Food Agric. 2010 Jan

15;90(1):2-12. doi: 10.1002/jsfa.3785.

Majdan M, Bobrowska-Korczak B. Active Compounds in Fruits and Inflammation in the Body. Nutrients. 2022 Jun 16;14(12):2496. doi: 10.3390/nu14122496.

Manivannan A, Lee ES, Han K, Lee HE, Kim DS. Versatile Nutraceutical Potentials of Watermelon-A Modest Fruit Loaded with Pharmaceutically Valuable Phytochemicals. Molecules. 2020 Nov 11;25(22):5258. doi: 10.3390/molecules25225258.

Matkowski A, Kuś P, Góralska E, Woźniak D. Mangiferin - a bioactive xanthonoid, not only from mango and not just antioxidant. Mini Rev Med Chem. 2013 Mar;13(3):439-55.

Meng X, Zhou J, Zhao CN, Gan RY, Li HB. Health Benefits and Molecular Mechanisms of Resveratrol: A Narrative Review. Foods. 2020 Mar 14;9(3):340. doi: 10.3390/foods9030340.

Muraki I, Imamura F, Manson JE, Hu FB, Willett WC, van Dam RM, Sun Q. Fruit consumption and risk of type 2 diabetes: results from three prospective longitudinal cohort studies. BMJ. 2013 Aug 28;347:f5001. doi: 10.1136/bmj.f5001. Erratum in: BMJ. 2013;347:f6935.

Norat T, Aune D, Chan D, Romaguera D. Fruits and vegetables: updating the epidemiologic evidence for the WCRF/AICR lifestyle recommendations for cancer prevention. Cancer Treat Res. 2014;159:35-50. doi: 10.1007/978-3-642-38007-5_3.

Pari L, Satheesh MA. Effect of pterostilbene on hepatic key enzymes of glucose metabolism in streptozotocin- and nicotinamide-induced diabetic rats. Life Sci. 2006 Jul 10;79(7):641-5. doi: 10.1016/j.lfs.2006.02.036.

Pavan R, Jain S, Shraddha, Kumar A. Properties and therapeutic application of bromelain: a review. Biotechnol Res Int. 2012;2012:976203. doi: 10.1155/2012/976203.

Ross JK, English C, Perlmutter CA. Dietary fiber constituents of selected fruits and vegetables. J Am Diet Assoc. 1985 Sep;85(9):1111-6.

Saghafian F, Malmir H, Saneei P, Milajerdi A, Larijani B, Esmaillzadeh A. Fruit and vegetable consumption and risk of depression: accumulative evidence from an updated systematic review and meta-analysis of epidemiological studies. Br J Nutr. 2018 May;119(10):1087-1101. doi: 10.1017/S0007114518000697.

Singh CK, Liu X, Ahmad N. Resveratrol, in its natural combination in whole grape, for health promotion and disease management. Ann N Y Acad Sci. 2015 Aug;1348(1):150-60. doi: 10.1111/nyas.12798.

Slavin JL, Lloyd B. Health benefits of fruits and vegetables. Adv Nutr. 2012 Jul 1;3(4):506-16. doi: 10.3945/an.112.002154.

Snelson M, Jong J, Manolas D, Kok S, Louise A, Stern R, Kellow NJ. Metabolic Effects of Resistant Starch Type 2: A Systematic Literature Review and Meta-Analysis of Randomized Controlled Trials. Nutrients. 2019 Aug 8;11(8):1833. doi: 10.3390/nu11081833.

Tan DX, Hardeland R, Manchester LC, Korkmaz A, Ma S, Rosales-Corral S, Reiter RJ. Functional roles of melatonin in plants, and perspectives in nutritional and agricultural science. J Exp Bot. 2012 Jan;63(2):577-97. doi: 10.1093/jxb/err256.

Verde A, Míguez JM, Gallardo M. Role of Melatonin in Apple Fruit during Growth and Ripening: Possible Interaction with Ethylene. Plants (Basel). 2022 Mar 2;11(5):688. doi: 10.3390/plants11050688.

Yan Z, Xu Y, Li K, Liu L. Increased fruit intake is associated with reduced risk of depression: evidence from cross-sectional and Mendelian randomization analyses. Front Public Health. 2023 Dec 13;11:1276326. doi: 10.3389/fpubh.2023.1276326.

Yang YJ, Kim YJ, Yang YK, Kim JY, Kwon O. Dietary flavan-3-ols intake and metabolic syndrome risk in Korean adults. Nutr Res Pract. 2012 Feb;6(1):68-77. doi: 10.4162/nrp.2012.6.1.68.

Zhang Y, Zhang DZ. Associations of vegetable and fruit consumption with metabolic syndrome. A meta-analysis of observational studies. Public Health Nutr. 2018 Jun;21(9):1693-1703. doi: 10.1017/S1368980018000381.

Zhou DD, Li J, Xiong RG, Saimaiti A, Huang SY, Wu SX, Yang ZJ, Shang A, Zhao CN, Gan RY, Li HB. Bioactive Compounds, Health Benefits and Food Applications of Grape. Foods. 2022 Sep 7;11(18):2755. doi: 10.3390/foods11182755.

Citrus Fruits

Ali MY, Zaib S, Rahman MM, Jannat S, Iqbal J, Park SK, Chang MS. Didymin, a dietary citrus flavonoid exhibits anti-diabetic complications and promotes glucose uptake through the activation of PI3K/Akt signaling pathway in insulin-resistant HepG2 cells. Chem Biol Interact. 2019 May 25;305:180-194. doi: 10.1016/j.cbi.2019.03.018.

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Bae JM, Kim EH. Dietary intakes of citrus fruit and risk of gastric cancer incidence: an adaptive meta-analysis of cohort studies. Epidemiol Health. 2016 Jul 25;38:e2016034. doi: 10.4178/epih.e2016034.

Bae JM, Lee EJ, Guyatt G. Citrus fruit intake and pancreatic cancer risk: a quantitative systematic review. Pancreas. 2009 Mar;38(2):168-74. doi: 10.1097/MPA.0b013e318188c497.

Bailey DG, Dresser G, Arnold JM. Grapefruit-medication interactions: forbidden fruit or avoidable consequences? CMAJ. 2013 Mar 5;185(4):309-16. doi: 10.1503/cmaj.120951.

Bertuccio P, Alicandro G, Rota M, Pelucchi C, Bonzi R, Galeone C, Bravi F, Johnson KC, Hu J, Palli D, Fer-

raroni M, López-Carrillo L, Lunet N, Ferro A, Malekzadeh R, Zaridze D, Maximovitch D, Vioque J, Navarrete-Munoz EM, Pakseresht M, Hernández-Ramírez RU, López-Cervantes M, Ward M, Pourfarzi F, Tsugane S, Hidaka A, Zhang ZF, Kurtz RC, Lagiou P, Lagiou A, Boffetta P, Boccia S, Negri E, La Vecchia C. Citrus fruit intake and gastric cancer: The stomach cancer pooling (StoP) project consortium. Int J Cancer. 2019 Jun 15;144(12):2936-2944. doi: 10.1002/ijc.32046.

Bianchi F, Larsen N, de Mello Tieghi T, Adorno MAT, Kot W, Saad SMI, Jespersen L, Sivieri K. Modulation of gut microbiota from obese individuals by in vitro fermentation of citrus pectin in combination with Bifidobacterium longum BB-46. Appl Microbiol Biotechnol. 2018 Oct;102(20):8827-8840. doi: 10.1007/s00253-018-9234-8.

Brasili E, Hassimotto NMA, Del Chierico F, Marini F, Quagliariello A, Sciubba F, Miccheli A, Putignani L, Lajolo F. Daily Consumption of Orange Juice from Citrus sinensis L. Osbeck cv. Cara Cara and cv. Bahia Differently Affects Gut Microbiota Profiling as Unveiled by an Integrated Meta-Omics Approach. J Agric Food Chem. 2019 Feb 6;67(5):1381-1391. doi: 10.1021/acs.jafc.8b05408.

Cao X, Guo X, Fang X, Ru S, Li E. Effects of Poncirin, a Citrus Flavonoid and Its Aglycone, Isosakuranetin, on the Gut Microbial Diversity and Metabolomics in Mice. Molecules. 2022 Jun 6;27(11):3641. doi: 10.3390/molecules27113641.

Chang SC, Cassidy A, Willett WC, Rimm EB, O'Reilly EJ, Okereke OI. Dietary flavonoid intake and risk of incident depression in midlife and older women. Am J Clin Nutr. 2016 Sep;104(3):704-14. doi: 10.3945/ajcn.115.124545.

Choi SS, Lee SH, Lee KA. A Comparative Study of Hesperetin, Hesperidin and Hesperidin Glucoside: Antioxidant, Anti-Inflammatory, and Antibacterial Activities In Vitro. Antioxidants (Basel). 2022 Aug 20;11(8):1618. doi: 10.3390/antiox11081618.

Cirmi S, Maugeri A, Ferlazzo N, Gangemi S, Calapai G, Schumacher U, Navarra M. Anticancer Potential of Citrus Juices and Their Extracts: A Systematic Review of Both Preclinical and Clinical Studies. Front Pharmacol. 2017 Jun 30;8:420. doi: 10.3389/fphar.2017.00420.

Cirmi S, Navarra M, Woodside JV, Cantwell MM. Citrus fruits intake and oral cancer risk: A systematic review and meta-analysis. Pharmacol Res. 2018 Jul;133:187-194. doi: 10.1016/j.phrs.2018.05.008.

Deng Z, Hassan S, Rafiq M, Li H, He Y, Cai Y, Kang X, Liu Z, Yan T. Pharmacological Activity of Eriodictyol: The Major Natural Polyphenolic Flavanone. Evid Based Complement Alternat Med. 2020 Dec 12;2020:6681352. doi: 10.1155/2020/6681352.

Feng XX, Wang MX, Li M, Tang X, Jiang H, Wang R, Ma L, Yin Y, Wu CR. Citrus fruit intake and the risk of nasopharyngeal carcinoma. Asia Pac J Clin Nutr. 2019;28(4):783-792. doi: 10.6133/apjcn.201912_28(4).0015.

Ferreira PS, Manthey JA, Nery MS, Spolidorio LC, Cesar TB. Low doses of eriocitrin attenuate metabolic impairment of glucose and lipids in ongoing obesogenic diet in mice. J Nutr Sci. 2020 Dec 14;9:e59. doi:

10.1017/jns.2020.52.

Fidélix M, Milenkovic D, Sivieri K, Cesar T. Microbiota modulation and effects on metabolic biomarkers by orange juice: a controlled clinical trial. Food Funct. 2020 Feb 26;11(2):1599-1610. doi: 10.1039/c9fo02623a.

Filippini T, Adani G, Malavolti M, Garuti C, Cilloni S, Vinceti G, Zamboni G, Tondelli M, Galli C, Costa M, Chiari A, Vinceti M. Dietary Habits and Risk of Early-Onset Dementia in an Italian Case-Control Study. Nutrients. 2020 Nov 29;12(12):3682. doi: 10.3390/nu12123682.

Gong Y, Dong R, Gao X, Li J, Jiang L, Zheng J, Cui S, Ying M, Yang B, Cao J, He Q. Neohesperidin prevents colorectal tumorigenesis by altering the gut microbiota. Pharmacol Res. 2019 Oct;148:104460. doi: 10.1016/j.phrs.2019.104460.

Gualdani R, Cavalluzzi MM, Lentini G, Habtemariam S. The Chemistry and Pharmacology of Citrus Limonoids. Molecules. 2016 Nov 13;21(11):1530. doi: 10.3390/molecules21111530.

Guo S, Xing N, Xiang G, Zhang Y, Wang S. Eriodictyol: a review of its pharmacological activities and molecular mechanisms related to ischemic stroke. Food Funct. 2023 Feb 21;14(4):1851-1868. doi: 10.1039/d2fo03417d.

Harris HR, Eke AC, Chavarro JE, Missmer SA. Fruit and vegetable consumption and risk of endometriosis. Hum Reprod. 2018 Apr 1;33(4):715-727. doi: 10.1093/humrep/dey014.

Hwang SL, Yen GC. Neuroprotective effects of the citrus flavanones against H2O2-induced cytotoxicity in PC12 cells. J Agric Food Chem. 2008 Feb 13;56(3):859-64. doi: 10.1021/jf072826r.

Johnson JL, Rupasinghe SG, Stefani F, Schuler MA, Gonzalez de Mejia E. Citrus flavonoids luteolin, apigenin, and quercetin inhibit glycogen synthase kinase-3β enzymatic activity by lowering the interaction energy within the binding cavity. J Med Food. 2011 Apr;14(4):325-33. doi: 10.1089/jmf.2010.0310.

Liang S, Lv G, Chen W, Jiang J, Wang J. Citrus fruit intake and bladder cancer risk: a meta-analysis of observational studies. Int J Food Sci Nutr. 2014 Nov;65(7):893-8. doi: 10.3109/09637486.2014.917151.

Lima ACD, Cecatti C, Fidélix MP, Adorno MAT, Sakamoto IK, Cesar TB, Sivieri K. Effect of Daily Consumption of Orange Juice on the Levels of Blood Glucose, Lipids, and Gut Microbiota Metabolites: Controlled Clinical Trials. J Med Food. 2019 Feb;22(2):202-210. doi: 10.1089/jmf.2018.0080.

Liu S, Lou Y, Li Y, Zhang J, Li P, Yang B, Gu Q. Review of phytochemical and nutritional characteristics and food applications of Citrus L. fruits. Front Nutr. 2022 Jul 18;9:968604. doi: 10.3389/fnut.2022.968604.

Lu JF, Zhu MQ, Zhang H, Liu H, Xia B, Wang YL, Shi X, Peng L, Wu JW. Neohesperidin attenuates obesity by altering the composition of the gut microbiota in high-fat diet-fed mice. FASEB J. 2020 Sep;34(9):12053-12071. doi: 10.1096/fj.201903102RR.

Mahmoud AM, Hernández Bautista RJ, Sandhu MA, Hussein OE. Beneficial Effects of Citrus Flavonoids on Cardiovascular and Metabolic Health. Oxid Med Cell Longev. 2019 Mar 10;2019:5484138. doi:

10.1155/2019/5484138.

Miles EA, Calder PC. Effects of Citrus Fruit Juices and Their Bioactive Components on Inflammation and Immunity: A Narrative Review. Front Immunol. 2021 Jun 24;12:712608. doi: 10.3389/fimmu.2021.712608.

Mitra S, Lami MS, Uddin TM, Das R, Islam F, Anjum J, Hossain MJ, Emran TB. Prospective multifunctional roles and pharmacological potential of dietary flavonoid narirutin. Biomed Pharmacother. 2022 Jun;150:112932. doi: 10.1016/j.biopha.2022.112932.

Panche AN, Diwan AD, Chandra SR. Flavonoids: an overview. J Nutr Sci. 2016 Dec 29;5:e47. doi: 10.1017/jns.2016.41.

Patel DK. Therapeutic Potential of Poncirin Against Numerous Human Health Complications: Medicinal Uses and Therapeutic Benefit of an Active Principle of Citrus Species. Endocr Metab Immune Disord Drug Targets. 2021;21(11):1974-1981. doi: 10.2174/1871530321666210108122924.

Pyrzynska K. Hesperidin: A Review on Extraction Methods, Stability and Biological Activities. Nutrients. 2022 Jun 9;14(12):2387. doi: 10.3390/nu14122387.

Rapisarda P, Amenta M, Ballistreri G, Fabroni S, Timpanaro N. Distribution, Antioxidant Capacity, Bioavailability and Biological Properties of Anthocyanin Pigments in Blood Oranges and Other Citrus Species. Molecules. 2022 Dec 8;27(24):8675. doi: 10.3390/molecules27248675.

Ribeiro CB, Ramos FM, Manthey JA, Cesar TB. Effectiveness of Eriomin® in managing hyperglycemia and reversal of prediabetes condition: A double-blind, randomized, controlled study. Phytother Res. 2019 Jul;33(7):1921-1933. doi: 10.1002/ptr.6386.

Rodrigo MJ, Cilla A, Barberá R, Zacarías L. Carotenoid bioaccessibility in pulp and fresh juice from carotenoid-rich sweet oranges and mandarins. Food Funct. 2015 Jun;6(6):1950-9. doi: 10.1039/c5fo00258c.

Sheng T, Shen RL, Shao H, Ma TH. Citrus fruit intake and incidence of renal cell carcinoma: A meta-analysis of observational studies. Asia Pac J Clin Oncol. 2023 Jan 19. doi: 10.1111/ajco.13925.

Silveira JQ, Dourado GK, Cesar TB. Red-fleshed sweet orange juice improves the risk factors for metabolic syndrome. Int J Food Sci Nutr. 2015;66(7):830-6. doi: 10.3109/09637486.2015.1093610.

Song JK, Bae JM. Citrus fruit intake and breast cancer risk: a quantitative systematic review. J Breast Cancer. 2013 Mar;16(1):72-6. doi: 10.4048/jbc.2013.16.1.72.

Stevens Y, Rymenant EV, Grootaert C, Camp JV, Possemiers S, Masclee A, Jonkers D. The Intestinal Fate of Citrus Flavanones and Their Effects on Gastrointestinal Health. Nutrients. 2019 Jun 27;11(7):1464. doi: 10.3390/nu11071464.

Testai L, Calderone V. Nutraceutical Value of Citrus Flavanones and Their Implications in Cardiovascular Disease. Nutrients. 2017 May 16;9(5):502. doi: 10.3390/nu9050502.

Vingeliene S, Chan DS, Aune D, Vieira AR, Polemiti E, Stevens C, Abar L, Rosenblatt DN, Greenwood DC, Norat T. An update of the WCRF/AICR systematic literature review on esophageal and gastric cancers and citrus fruits intake. Cancer Causes Control. 2016 Jul;27(7):837-51. doi: 10.1007/s10552-016-0755-0. Epub 2016 May 6.

Wang A, Zhu C, Fu L, Wan X, Yang X, Zhang H, Miao R, He L, Sang X, Zhao H. Citrus Fruit Intake Substantially Reduces the Risk of Esophageal Cancer: A Meta-Analysis of Epidemiologic Studies. Medicine (Baltimore). 2015 Sep;94(39):e1390. doi: 10.1097/MD.0000000000001390.

Wang J, Gao J, Xu HL, Qian Y, Xie L, Yu H, Qian BY. Citrus fruit intake and lung cancer risk: A meta-analysis of observational studies. Pharmacol Res. 2021 Apr;166:105430. doi: 10.1016/j.phrs.2021.105430.

Wang X, Li D, Liu F, Cui Y, Li X. Dietary citrus and/or its extracts intake contributed to weight control: Evidence from a systematic review and meta-analysis of 13 randomized clinical trials. Phytother Res. 2020 Aug;34(8):2006-2022. doi: 10.1002/ptr.6673.

Wu GA, Terol J, Ibanez V, López-García A, Pérez-Román E, Borredá C, Domingo C, Tadeo FR, Carbonell-Caballero J, Alonso R, Curk F, Du D, Ollitrault P, Roose ML, Dopazo J, Gmitter FG, Rokhsar DS, Talon M. Genomics of the origin and evolution of Citrus. Nature. 2018 Feb 15;554(7692):311-316. doi: 10.1038/nature25447.

Wu ZY, Chen JL, Li H, Su K, Han YW. Different types of fruit intake and colorectal cancer risk: A meta-analysis of observational studies. World J Gastroenterol. 2023 May 7;29(17):2679-2700. doi: 10.3748/wjg.v29.i17.2679.

Yamada T, Hayasaka S, Shibata Y, Ojima T, Saegusa T, Gotoh T, Ishikawa S, Nakamura Y, Kayaba K; Jichi Medical School Cohort Study Group. Frequency of citrus fruit intake is associated with the incidence of cardiovascular disease: the Jichi Medical School cohort study. J Epidemiol. 2011;21(3):169-75. doi: 10.2188/jea.je20100084.

Zhang S, Tomata Y, Sugiyama K, Sugawara Y, Tsuji I. Citrus consumption and incident dementia in elderly Japanese: the Ohsaki Cohort 2006 Study. Br J Nutr. 2017 Apr;117(8):1174-1180. doi: 10.1017/S000711451700109X.

Zhao W, Liu L, Xu S. Intakes of citrus fruit and risk of esophageal cancer: A meta-analysis. Medicine (Baltimore). 2018 Mar;97(13):e0018. doi: 10.1097/MD.0000000000010018.

Berries

Abu Bakar MF, Ismail NA, Isha A, Mei Ling AL. Phytochemical Composition and Biological Activities of Selected Wild Berries (Rubus moluccanus L., R. fraxinifolius Poir., and R. alpestris Blume). Evid Based Complement Alternat Med. 2016;2016:2482930. doi: 10.1155/2016/2482930.

Afrin S, Giampieri F, Gasparrini M, Forbes-Hernandez TY, Varela-López A, Quiles JL, Mezzetti B, Battino M. Chemopreventive and Therapeutic Effects of Edible Berries: A Focus on Colon Cancer Prevention and

Treatment. Molecules. 2016 Jan 30;21(2):169. doi: 10.3390/molecules21020169.

Aune D, Giovannucci E, Boffetta P, Fadnes LT, Keum N, Norat T, Greenwood DC, Riboli E, Vatten LJ, Tonstad S. Fruit and vegetable intake and the risk of cardiovascular disease, total cancer and all-cause mortality-a systematic review and dose-response meta-analysis of prospective studies. Int J Epidemiol. 2017 Jun 1;46(3):1029-1056. doi: 10.1093/ije/dyw319.

Basu A, Nguyen A, Betts NM, Lyons TJ. Strawberry as a functional food: an evidence-based review. Crit Rev Food Sci Nutr. 2014;54(6):790-806. doi: 10.1080/10408398.2011.608174.

Bougnoux P, Koscielny S, Chajès V, Descamps P, Couet C, Calais G. alpha-Linolenic acid content of adipose breast tissue: a host determinant of the risk of early metastasis in breast cancer. Br J Cancer. 1994 Aug;70(2):330-4. doi: 10.1038/bjc.1994.302.

Bowtell JL, Aboo-Bakkar Z, Conway ME, Adlam AR, Fulford J. Enhanced task-related brain activation and resting perfusion in healthy older adults after chronic blueberry supplementation. Appl Physiol Nutr Metab. 2017 Jul;42(7):773-779. doi: 10.1139/apnm-2016-0550.

Butler LM, Yuan JM, Huang JY, Su J, Wang R, Koh WP, Ong CN. Plasma fatty acids and risk of colon and rectal cancers in the Singapore Chinese Health Study. NPJ Precis Oncol. 2017 Nov 23;1(1):38. doi: 10.1038/s41698-017-0040-z.

Chamberland JP, Moon HS. Down-regulation of malignant potential by alpha linolenic acid in human and mouse colon cancer cells. Fam Cancer. 2015 Mar;14(1):25-30. doi: 10.1007/s10689-014-9762-z.

Curtis PJ, van der Velpen V, Berends L, Jennings A, Feelisch M, Umpleby AM, Evans M, Fernandez BO, Meiss MS, Minnion M, Potter J, Minihane AM, Kay CD, Rimm EB, Cassidy A. Blueberries improve biomarkers of cardiometabolic function in participants with metabolic syndrome-results from a 6-month, double-blind, randomized controlled trial. Am J Clin Nutr. 2019 Jun 1;109(6):1535-1545. doi: 10.1093/ajcn/nqy380.

De Amicis R, Mambrini SP, Pellizzari M, Foppiani A, Bertoli S, Battezzati A, Leone A. Systematic Review on the Potential Effect of Berry Intake in the Cognitive Functions of Healthy People. Nutrients. 2022 Jul 20;14(14):2977. doi: 10.3390/nu14142977.

Devore EE, Kang JH, Breteler MM, Grodstein F. Dietary intakes of berries and flavonoids in relation to cognitive decline. Ann Neurol. 2012 Jul;72(1):135-43. doi: 10.1002/ana.23594.

Edirisinghe I, Banaszewski K, Cappozzo J, Sandhya K, Ellis CL, Tadapaneni R, Kappagoda CT, Burton-Freeman BM. Strawberry anthocyanin and its association with postprandial inflammation and insulin. Br J Nutr. 2011 Sep;106(6):913-22. doi: 10.1017/S0007114511001176.

Eggersdorfer M, Wyss A. Carotenoids in human nutrition and health. Arch Biochem Biophys. 2018 Aug 15;652:18-26. doi: 10.1016/j.abb.2018.06.001.

Ellis CL, Edirisinghe I, Kappagoda T, Burton-Freeman B. Attenuation of meal-induced inflammatory and thrombotic responses in overweight men and women after 6-week daily strawberry (Fragaria) intake. A

randomized placebo-controlled trial. J Atheroscler Thromb. 2011;18(4):318-27. doi: 10.5551/jat.6114.

Gao X, Cassidy A, Schwarzschild MA, Rimm EB, Ascherio A. Habitual intake of dietary flavonoids and risk of Parkinson disease. Neurology. 2012 Apr 10;78(15):1138-45. doi: 10.1212/WNL.0b013e31824f7fc4.

Golovinskaia O, Wang CK. Review of Functional and Pharmacological Activities of Berries. Molecules. 2021 Jun 25;26(13):3904. doi: 10.3390/molecules26133904.

Hjartåker A, Knudsen MD, Tretli S, Weiderpass E. Consumption of berries, fruits and vegetables and mortality among 10,000 Norwegian men followed for four decades. Eur J Nutr. 2015 Jun;54(4):599-608. doi: 10.1007/s00394-014-0741-9.

Hodges JK, Maiz M, Cao S, Lachcik PJ, Peacock M, McCabe GP, McCabe LD, Cladis DP, Jackson GS, Ferruzzi MG, Lila MA, Bailey RL, Martin BR, Weaver CM. Moderate consumption of freeze-dried blueberry powder increased net bone calcium retention compared with no treatment in healthy postmenopausal women: a randomized crossover trial. Am J Clin Nutr. 2023 Aug;118(2):382-390. doi: 10.1016/j.ajcnut.2023.05.033.

Hubert PA, Lee SG, Lee SK, Chun OK. Dietary Polyphenols, Berries, and Age-Related Bone Loss: A Review Based on Human, Animal, and Cell Studies. Antioxidants (Basel). 2014 Mar 11;3(1):144-58. doi: 10.3390/antiox3010144.

Huo J, Wu L, Lv J, Cao H, Gao Q. Effect of fruit intake on functional constipation: A systematic review and meta-analysis of randomized and crossover studies. Front Nutr. 2022 Oct 6;9:1018502. doi: 10.3389/fnut.2022.1018502.

James LJ, Funnell MP, Milner S. An afternoon snack of berries reduces subsequent energy intake compared to an isoenergetic confectionary snack. Appetite. 2015 Dec;95:132-7. doi: 10.1016/j.appet.2015.07.005.

Jiang H, Zhang W, Li X, Xu Y, Cao J, Jiang W. The anti-obesogenic effects of dietary berry fruits: A review. Food Res Int. 2021 Sep;147:110539. doi: 10.1016/j.foodres.2021.110539.

Klein V, Chajès V, Germain E, Schulgen G, Pinault M, Malvy D, Lefrancq T, Fignon A, Le Floch O, Lhuillery C, Bougnoux P. Low alpha-linolenic acid content of adipose breast tissue is associated with an increased risk of breast cancer. Eur J Cancer. 2000 Feb;36(3):335-40. doi: 10.1016/s0959-8049(99)00254-3.

Krikorian R, Shidler MD, Nash TA, Kalt W, Vinqvist-Tymchuk MR, Shukitt-Hale B, Joseph JA. Blueberry supplementation improves memory in older adults. J Agric Food Chem. 2010 Apr 14;58(7):3996-4000. doi: 10.1021/jf9029332.

Kristo AS, Klimis-Zacas D, Sikalidis AK. Protective Role of Dietary Berries in Cancer. Antioxidants (Basel). 2016 Oct 19;5(4):37. doi: 10.3390/antiox5040037.

Lashmanova KA, Kuzivanova OA, Dymova OV. Northern berries as a source of carotenoids. Acta Biochim Pol. 2012;59(1):133-4.

Lavefve L , Howard LR , Carbonero F. Berry polyphenols metabolism and impact on human gut microbiota

and health. Food Funct. 2020 Jan 29;11(1):45-65. doi: 10.1039/c9fo01634a.

Luís Â , Domingues F , Pereira L. Association between berries intake and cardiovascular diseases risk factors: a systematic review with meta-analysis and trial sequential analysis of randomized controlled trials. Food Funct. 2018 Feb 21;9(2):740-757. doi: 10.1039/c7fo01551h.

Mattioli R, Francioso A, Mosca L, Silva P. Anthocyanins: A Comprehensive Review of Their Chemical Properties and Health Effects on Cardiovascular and Neurodegenerative Diseases. Molecules. 2020 Aug 21;25(17):3809. doi: 10.3390/molecules25173809.

McNamara RK, Almeida DM. Omega-3 Polyunsaturated Fatty Acid Deficiency and Progressive Neuropathology in Psychiatric Disorders: A Review of Translational Evidence and Candidate Mechanisms. Harv Rev Psychiatry. 2019 Mar/Apr;27(2):94-107. doi: 10.1097/HRP.0000000000000199.

Merchant AT, Curhan GC, Rimm EB, Willett WC, Fawzi WW. Intake of n-6 and n-3 fatty acids and fish and risk of community-acquired pneumonia in US men. Am J Clin Nutr. 2005 Sep;82(3):668-74. doi: 10.1093/ajcn.82.3.668.

Mikulic-Petkovsek M, Schmitzer V, Slatnar A, Stampar F, Veberic R. Composition of sugars, organic acids, and total phenolics in 25 wild or cultivated berry species. J Food Sci. 2012 Oct;77(10):C1064-70. doi: 10.1111/j.1750-3841.2012.02896.x.

Moon HS, Batirel S, Mantzoros CS. Alpha linolenic acid and oleic acid additively down-regulate malignant potential and positively cross-regulate AMPK/S6 axis in OE19 and OE33 esophageal cancer cells. Metabolism. 2014 Nov;63(11):1447-54. doi: 10.1016/j.metabol.2014.07.009.

Moriwaki S, Suzuki K, Muramatsu M, Nomura A, Inoue F, Into T, Yoshiko Y, Niida S. Delphinidin, one of the major anthocyanidins, prevents bone loss through the inhibition of excessive osteoclastogenesis in osteoporosis model mice. PLoS One. 2014 May 13;9(5):e97177. doi: 10.1371/journal.pone.0097177.

Naghshi S, Aune D, Beyene J, Mobarak S, Asadi M, Sadeghi O. Dietary intake and biomarkers of alpha linolenic acid and risk of all cause, cardiovascular, and cancer mortality: systematic review and dose-response meta-analysis of cohort studies. BMJ. 2021 Oct 13;375:n2213. doi: 10.1136/bmj.n2213.

Puupponen-Pimiä R, Nohynek L, Hartmann-Schmidlin S, Kähkönen M, Heinonen M, Määttä-Riihinen K, Oksman-Caldentey KM. Berry phenolics selectively inhibit the growth of intestinal pathogens. J Appl Microbiol. 2005;98(4):991-1000. doi: 10.1111/j.1365-2672.2005.02547.x.

Stull AJ, Cash KC, Champagne CM, Gupta AK, Boston R, Beyl RA, Johnson WD, Cefalu WT. Blueberries improve endothelial function, but not blood pressure, in adults with metabolic syndrome: a randomized, double-blind, placebo-controlled clinical trial. Nutrients. 2015 May 27;7(6):4107-23. doi: 10.3390/nu7064107.

Stull AJ, Cash KC, Johnson WD, Champagne CM, Cefalu WT. Bioactives in blueberries improve insulin sensitivity in obese, insulin-resistant men and women. J Nutr. 2010 Oct;140(10):1764-8. doi: 10.3945/jn.110.125336. Epub 2010 Aug 19.

Subash S, Essa MM, Al-Adawi S, Memon MA, Manivasagam T, Akbar M. Neuroprotective effects of berry fruits on neurodegenerative diseases. Neural Regen Res. 2014 Aug 15;9(16):1557-66. doi: 10.4103/1673-5374.139483.

Taylor KL, Hadgkiss EJ, Jelinek GA, Weiland TJ, Pereira NG, Marck CH, van der Meer DM. Lifestyle factors, demographics and medications associated with depression risk in an international sample of people with multiple sclerosis. BMC Psychiatry. 2014 Dec 3;14:327. doi: 10.1186/s12888-014-0327-3.

Thompson L, Cockayne A, Spiller RC. Inhibitory effect of polyunsaturated fatty acids on the growth of Helicobacter pylori: a possible explanation of the effect of diet on peptic ulceration. Gut. 1994 Nov;35(11):1557-61. doi: 10.1136/gut.35.11.1557.

Törrönen R, Kolehmainen M, Sarkkinen E, Mykkänen H, Niskanen L. Postprandial glucose, insulin, and free fatty acid responses to sucrose consumed with blackcurrants and lingonberries in healthy women. Am J Clin Nutr. 2012 Sep;96(3):527-33. doi: 10.3945/ajcn.112.042184.

Törrönen R, Kolehmainen M, Sarkkinen E, Poutanen K, Mykkänen H, Niskanen L. Berries reduce postprandial insulin responses to wheat and rye breads in healthy women. J Nutr. 2013 Apr;143(4):430-6. doi: 10.3945/jn.112.169771.

Törrönen R, Sarkkinen E, Tapola N, Hautaniemi E, Kilpi K, Niskanen L. Berries modify the postprandial plasma glucose response to sucrose in healthy subjects. Br J Nutr. 2010 Apr;103(8):1094-7. doi: 10.1017/S0007114509992868.

Wang LS, Arnold M, Huang YW, Sardo C, Seguin C, Martin E, Huang TH, Riedl K, Schwartz S, Frankel W, Pearl D, Xu Y, Winston J 3rd, Yang GY, Stoner G. Modulation of genetic and epigenetic biomarkers of colorectal cancer in humans by black raspberries: a phase I pilot study. Clin Cancer Res. 2011 Feb 1;17(3):598-610. doi: 10.1158/1078-0432.CCR-10-1260.

Wang LS, Hecht SS, Carmella SG, Yu N, Larue B, Henry C, McIntyre C, Rocha C, Lechner JF, Stoner GD. Anthocyanins in black raspberries prevent esophageal tumors in rats. Cancer Prev Res (Phila). 2009 Jan;2(1):84-93. doi: 10.1158/1940-6207.CAPR-08-0155.

Whyte AR, Williams CM. Effects of a single dose of a flavonoid-rich blueberry drink on memory in 8 to 10 y old children. Nutrition. 2015 Mar;31(3):531-4. doi: 10.1016/j.nut.2014.09.013.

Wolfe KL, Kang X, He X, Dong M, Zhang Q, Liu RH. Cellular antioxidant activity of common fruits. J Agric Food Chem. 2008 Sep 24;56(18):8418-26. doi: 10.1021/jf801381y.

Legumes

Agrawal S, Ebrahim S. Association between legume intake and self-reported diabetes among adult men and women in India. BMC Public Health. 2013 Aug 2;13:706. doi: 10.1186/1471-2458-13-706.

Arts IC, van de Putte B, Hollman PC. Catechin contents of foods commonly consumed in The Netherlands.

1. Fruits, vegetables, staple foods, and processed foods. J Agric Food Chem. 2000 May;48(5):1746-51. doi: 10.1021/jf000025h.

Askari M, Daneshzad E, Jafari A, Bellissimo N, Azadbakht L. Association of nut and legume consumption with Framingham 10 year risk of general cardiovascular disease in older adult men: A cross-sectional study. Clin Nutr ESPEN. 2021 Apr;42:373-380. doi: 10.1016/j.clnesp.2020.12.024.

Bahrami A, Teymoori F, Eslamparast T, Sohrab G, Hejazi E, Poustchi H, Hekmatdoost A. Legume intake and risk of nonalcoholic fatty liver disease. Indian J Gastroenterol. 2019 Feb;38(1):55-60. doi: 10.1007/s12664-019-00937-8.

Bazzano LA, He J, Ogden LG, Loria C, Vupputuri S, Myers L, Whelton PK. Legume consumption and risk of coronary heart disease in US men and women: NHANES I Epidemiologic Follow-up Study. Arch Intern Med. 2001 Nov 26;161(21):2573-8. doi: 10.1001/archinte.161.21.2573.

Bazzano LA, Thompson AM, Tees MT, Nguyen CH, Winham DM. Non-soy legume consumption lowers cholesterol levels: a meta-analysis of randomized controlled trials. Nutr Metab Cardiovasc Dis. 2011 Feb;21(2):94-103. doi: 10.1lieu016/j.numecd.2009.08.012.

Becerra-Tomás N, Díaz-López A, Rosique-Esteban N, Ros E, Buil-Cosiales P, Corella D, Estruch R, Fitó M, Serra-Majem L, Arós F, Lamuela-Raventós RM, Fiol M, Santos-Lozano JM, Díez-Espino J, Portoles O, Salas-Salvadó J; PREDIMED Study Investigators. Legume consumption is inversely associated with type 2 diabetes incidence in adults: A prospective assessment from the PREDIMED study. Clin Nutr. 2018 Jun;37(3):906-913. doi: 10.1016/j.clnu.2017.03.015.

Bigman G, Adebamowo SN, Yawe KT, Yilkudi M, Olaomi O, Badejo O, Famooto A, Ezeome E, Salu IK, Miner E, Anosike I, Achusi B, Adebamowo C. A matched case-control study of bean intake and breast cancer risk in urbanized Nigerian women. Cancer Causes Control. 2022 Jul;33(7):959-969. doi: 10.1007/s10552-022-01584-9.

Boutas I, Kontogeorgi A, Dimitrakakis C, Kalantaridou SN. Soy Isoflavones and Breast Cancer Risk: A Meta-analysis. In Vivo. 2022 Mar-Apr;36(2):556-562. doi: 10.21873/invivo.12737.

Doma KM, Dolinar KF, Dan Ramdath D, Wolever TMS, Duncan AM. Canned Beans Decrease Serum Total and LDL Cholesterol in Adults with Elevated LDL Cholesterol in a 4-wk Multicenter, Randomized, Crossover Study. J Nutr. 2021 Dec 3;151(12):3701-3709. doi: 10.1093/jn/nxab323.

Fan Y, Wang M, Li Z, Jiang H, Shi J, Shi X, Liu S, Zhao J, Kong L, Zhang W, Ma L. Intake of Soy, Soy Isoflavones and Soy Protein and Risk of Cancer Incidence and Mortality. Front Nutr. 2022 Mar 4;9:847421. doi: 10.3389/fnut.2022.847421.

Fonseca-Hernández D, Lugo-Cervantes EDC, Escobedo-Reyes A, Mojica L. Black Bean (Phaseolus vulgaris L.) Polyphenolic Extract Exerts Antioxidant and Antiaging Potential. Molecules. 2021 Nov 6;26(21):6716. doi: 10.3390/molecules26216716.

Ganesan K, Xu B. Polyphenol-Rich Dry Common Beans (Phaseolus vulgaris L.) and Their Health Benefits. Int J Mol Sci. 2017 Nov 4;18(11):2331. doi: 10.3390/ijms18112331.

Garcés-Rimón M, Morales D, Miguel-Castro M. Potential Role of Bioactive Proteins and Peptides Derived from Legumes towards Metabolic Syndrome. Nutrients. 2022 Dec 10;14(24):5271. doi: 10.3390/nu14245271.

Ha V, Sievenpiper JL, de Souza RJ, Jayalath VH, Mirrahimi A, Agarwal A, Chiavaroli L, Mejia SB, Sacks FM, Di Buono M, Bernstein AM, Leiter LA, Kris-Etherton PM, Vuksan V, Bazinet RP, Josse RG, Beyene J, Kendall CW, Jenkins DJ. Effect of dietary pulse intake on established therapeutic lipid targets for cardiovascular risk reduction: a systematic review and meta-analysis of randomized controlled trials. CMAJ. 2014 May 13;186(8):E252-62. doi: 10.1503/cmaj.131727.

Hangen L, Bennink MR. Consumption of black beans and navy beans (Phaseolus vulgaris) reduced azoxymethane-induced colon cancer in rats. Nutr Cancer. 2002;44(1):60-5. doi: 10.1207/S15327914NC441_8.

Hou D, Yousaf L, Xue Y, Hu J, Wu J, Hu X, Feng N, Shen Q. Mung Bean (Vigna radiata L.): Bioactive Polyphenols, Polysaccharides, Peptides, and Health Benefits. Nutrients. 2019 May 31;11(6):1238. doi: 10.3390/nu11061238.

Hu K, Huang H, Li H, Wei Y, Yao C. Legume-Derived Bioactive Peptides in Type 2 Diabetes: Opportunities and Challenges. Nutrients. 2023 Feb 22;15(5):1096. doi: 10.3390/nu15051096.

Hu Y, Cheng Z, Heller LI, Krasnoff SB, Glahn RP, Welch RM. Kaempferol in red and pinto bean seed (Phaseolus vulgaris L.) coats inhibits iron bioavailability using an in vitro digestion/human Caco-2 cell model. J Agric Food Chem. 2006 Nov 29;54(24):9254-61. doi: 10.1021/jf0612981.

Johnson JB, Skylas DJ, Mani JS, Xiang J, Walsh KB, Naiker M. Phenolic Profiles of Ten Australian Faba Bean Varieties. Molecules. 2021 Jul 30;26(15):4642. doi: 10.3390/molecules26154642.

Juárez-Chairez MF, Cid-Gallegos MS, Meza-Márquez OG, Jiménez-Martínez C. Biological functions of peptides from legumes in gastrointestinal health. A review legume peptides with gastrointestinal protection. J Food Biochem. 2022 Oct;46(10):e14308. doi: 10.1111/jfbc.14308.

Kadyan S, Sharma A, Arjmandi BH, Singh P, Nagpal R. Prebiotic Potential of Dietary Beans and Pulses and Their Resistant Starch for Aging-Associated Gut and Metabolic Health. Nutrients. 2022 Apr 21;14(9):1726. doi: 10.3390/nu14091726.

Kiersnowska K, Jakubczyk A. Bioactive Peptides Obtained from Legume Seeds as New Compounds in Metabolic Syndrome Prevention and Diet Therapy. Foods. 2022 Oct 21;11(20):3300. doi: 10.3390/foods11203300.

Kim SJ, de Souza RJ, Choo VL, Ha V, Cozma AI, Chiavaroli L, Mirrahimi A, Blanco Mejia S, Di Buono M, Bernstein AM, Leiter LA, Kris-Etherton PM, Vuksan V, Beyene J, Kendall CW, Jenkins DJ, Sievenpiper JL. Effects of dietary pulse consumption on body weight: a systematic review and meta-analysis of randomized

controlled trials. Am J Clin Nutr. 2016 May;103(5):1213-23. doi: 10.3945/ajcn.115.124677.

Lanza E, Hartman TJ, Albert PS, Shields R, Slattery M, Caan B, Paskett E, Iber F, Kikendall JW, Lance P, Daston C, Schatzkin A. High dry bean intake and reduced risk of advanced colorectal adenoma recurrence among participants in the polyp prevention trial. J Nutr. 2006 Jul;136(7):1896-903. doi: 10.1093/jn/136.7.1896.

Li J, Mao QQ. Legume intake and risk of prostate cancer: a meta-analysis of prospective cohort studies. Oncotarget. 2017 Jul 4;8(27):44776-44784. doi: 10.18632/oncotarget.16794.

Li SS, Kendall CW, de Souza RJ, Jayalath VH, Cozma AI, Ha V, Mirrahimi A, Chiavaroli L, Augustin LS, Blanco Mejia S, Leiter LA, Beyene J, Jenkins DJ, Sievenpiper JL. Dietary pulses, satiety and food intake: a systematic review and meta-analysis of acute feeding trials. Obesity (Silver Spring). 2014 Aug;22(8):1773-80. doi: 10.1002/oby.20782.

Liu ZM, Ho SC, Chen YM, Ho S, To K, Tomlinson B, Woo J. Whole soy, but not purified daidzein, had a favorable effect on improvement of cardiovascular risks: a 6-month randomized, double-blind, and placebo-controlled trial in equol-producing postmenopausal women. Mol Nutr Food Res. 2014 Apr;58(4):709-17. doi: 10.1002/mnfr.201300499.

Marventano S, Izquierdo Pulido M, Sánchez-González C, Godos J, Speciani A, Galvano F, Grosso G. Legume consumption and CVD risk: a systematic review and meta-analysis. Public Health Nutr. 2017 Feb;20(2):245-254. doi: 10.1017/S1368980016002299.

Mendes V, Niforou A, Kasdagli MI, Ververis E, Naska A. Intake of legumes and cardiovascular disease: A systematic review and dose-response meta-analysis. Nutr Metab Cardiovasc Dis. 2023 Jan;33(1):22-37. doi: 10.1016/j.numecd.2022.10.006.

Méndez-López LF, Sosa de León D, López-Cabanillas Lomelí M, González-Martínez BE, Vázquez-Rodríguez JA. Phytochemicals From Vicia faba Beans as Ligands of the Aryl Hydrocarbon Receptor to Regulate Autoimmune Diseases. Front Nutr. 2022 Mar 4;9:790440. doi: 10.3389/fnut.2022.790440.

Mustafa AM, Abouelenein D, Acquaticci L, Alessandroni L, Angeloni S, Borsetta G, Caprioli G, Nzekoue FK, Sagratini G, Vittori S. Polyphenols, Saponins and Phytosterols in Lentils and Their Health Benefits: An Overview. Pharmaceuticals (Basel). 2022 Oct 3;15(10):1225. doi: 10.3390/ph15101225.

Nachvak SM, Moradi S, Anjom-Shoae J, Rahmani J, Nasiri M, Maleki V, Sadeghi O. Soy, Soy Isoflavones, and Protein Intake in Relation to Mortality from All Causes, Cancers, and Cardiovascular Diseases: A Systematic Review and Dose-Response Meta-Analysis of Prospective Cohort Studies. J Acad Nutr Diet. 2019 Sep;119(9):1483-1500.e17. doi: 10.1016/j.jand.2019.04.011.

Nakai S, Fujita M, Kamei Y. Health Promotion Effects of Soy Isoflavones. J Nutr Sci Vitaminol (Tokyo). 2020;66(6):502-507. doi: 10.3177/jnsv.66.502.

Nchanji EB, Ageyo OC. Do Common Beans (Phaseolus vulgaris L.) Promote Good Health in Humans? A Systematic Review and Meta-Analysis of Clinical and Randomized Controlled Trials. Nutrients. 2021 Oct 21;13(11):3701. doi: 10.3390/nu13113701.

Oldewage-Theron W, Egal A. The effect of consumption of soy foods on the blood lipid profile of women: a pilot study from Qwa-Qwa. J Nutr Sci Vitaminol (Tokyo). 2013;59(5):431-6. doi: 10.3177/jnsv.59.431.

Otun J, Sahebkar A, Östlundh L, Atkin SL, Sathyapalan T. Systematic Review and Meta-analysis on the Effect of Soy on Thyroid Function. Sci Rep. 2019 Mar 8;9(1):3964. doi: 10.1038/s41598-019-40647-x.

Papandreou C, Becerra-Tomás N, Bulló M, Martínez-González MÁ, Corella D, Estruch R, Ros E, Arós F, Schroder H, Fitó M, Serra-Majem L, Lapetra J, Fiol M, Ruiz-Canela M, Sorli JV, Salas-Salvadó J. Legume consumption and risk of all-cause, cardiovascular, and cancer mortality in the PREDIMED study. Clin Nutr. 2019 Feb;38(1):348-356. doi: 10.1016/j.clnu.2017.12.019.

Papanikolaou Y, Fulgoni VL 3rd. Bean consumption is associated with greater nutrient intake, reduced systolic blood pressure, lower body weight, and a smaller waist circumference in adults: results from the National Health and Nutrition Examination Survey 1999-2002. J Am Coll Nutr. 2008 Oct;27(5):569-76. doi: 10.1080/07315724.2008.10719740.

Rao S, Chinkwo KA, Santhakumar AB, Blanchard CL. Inhibitory Effects of Pulse Bioactive Compounds on Cancer Development Pathways. Diseases. 2018 Aug 3;6(3):72. doi: 10.3390/diseases6030072.

Reed KE, Camargo J, Hamilton-Reeves J, Kurzer M, Messina M. Neither soy nor isoflavone intake affects male reproductive hormones: An expanded and updated meta-analysis of clinical studies. Reprod Toxicol. 2021 Mar;100:60-67. doi: 10.1016/j.reprotox.2020.12.019.

Reinwald S, Weaver CM. Soy components vs. whole soy: are we betting our bones on a long shot? J Nutr. 2010 Dec;140(12):2312S-2317S. doi: 10.3945/jn.110.124008.

Reyneke GL, Beck EJ, Lambert K, Neale EP. The Effect of Non-Oil Seed Legume Intake on Blood Pressure: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Adv Nutr. 2023 Jul;14(4):637-651. doi: 10.1016/j.advnut.2023.04.002.

Sangaramoorthy M, Koo J, John EM. Intake of bean fiber, beans, and grains and reduced risk of hormone receptor-negative breast cancer: the San Francisco Bay Area Breast Cancer Study. Cancer Med. 2018 May;7(5):2131-2144. doi: 10.1002/cam4.1423.

Shi J, Arunasalam K, Yeung D, Kakuda Y, Mittal G, Jiang Y. Saponins from edible legumes: chemistry, processing, and health benefits. J Med Food. 2004 Spring;7(1):67-78. doi: 10.1089/109662004322984734.

Sievenpiper JL, Kendall CW, Esfahani A, Wong JM, Carleton AJ, Jiang HY, Bazinet RP, Vidgen E, Jenkins DJ. Effect of non-oil-seed pulses on glycaemic control: a systematic review and meta-analysis of randomised controlled experimental trials in people with and without diabetes. Diabetologia. 2009 Aug;52(8):1479-95. doi: 10.1007/s00125-009-1395-7.

Silva S, Cavaco A, Basso B, Mota J, Cruz-Duarte R, Costa M, Carvalho L, Lima A, Costa L, Ferreira R, Martins M. Therapeutic Potential of Deflamin against Colorectal Cancer Development and Progression. Cancers (Basel). 2022 Dec 14;14(24):6182. doi: 10.3390/cancers14246182.

Sombié PAED, Compaoré M, Coulibaly AY, Ouédraogo JT, Tignégré JS, Kiendrébéogo M. Antioxidant and Phytochemical Studies of 31 Cowpeas (Vigna unguiculata (Walp L)) Genotypes from Burkina. Foods. 2018 Sep 3;7(9):143. doi: 10.3390/foods7090143.

Tor-Roca A, Garcia-Aloy M, Mattivi F, Llorach R, Andres-Lacueva C, Urpi-Sarda M. Phytochemicals in Legumes: A Qualitative Reviewed Analysis. J Agric Food Chem. 2020 Nov 25;68(47):13486-13496. doi: 10.1021/acs.jafc.0c04387.

Tucker LA. Legume Intake, Body Weight, and Abdominal Adiposity: 10-Year Weight Change and Cross-Sectional Results in 15,185 U.S. Adults. Nutrients. 2023 Jan 16;15(2):460. doi: 10.3390/nu15020460.

Viguiliouk E, Blanco Mejia S, Kendall CW, Sievenpiper JL. Can pulses play a role in improving cardiometabolic health? Evidence from systematic reviews and meta-analyses. Ann N Y Acad Sci. 2017 Mar;1392(1):43-57. doi: 10.1111/nyas.13312.

Villegas R, Gao YT, Yang G, Li HL, Elasy TA, Zheng W, Shu XO. Legume and soy food intake and the incidence of type 2 diabetes in the Shanghai Women's Health Study. Am J Clin Nutr. 2008 Jan;87(1):162-7. doi: 10.1093/ajcn/87.1.162.

Vitale M, Giosuè A, Sieri S, Krogh V, Massimino E, Rivellese AA, Riccardi G, Vaccaro O, Masulli M. Legume Consumption and Blood Pressure Control in Individuals with Type 2 Diabetes and Hypertension: Cross-Sectional Findings from the TOSCA.IT Study. Nutrients. 2023 Jun 26;15(13):2895. doi: 10.3390/nu15132895.

Winham DM, Hutchins AM, Johnston CS. Pinto bean consumption reduces biomarkers for heart disease risk. J Am Coll Nutr. 2007 Jun;26(3):243-9. doi: 10.1080/07315724.2007.10719607.

Zafar TA, Kabir Y. Chickpeas suppress postprandial blood glucose concentration, and appetite and reduce energy intake at the next meal. J Food Sci Technol. 2017 Mar;54(4):987-994. doi: 10.1007/s13197-016-2422-6. Epub 2016 Dec 8.

Zargarzadeh N, Mousavi SM, Santos HO, Aune D, Hasani-Ranjbar S, Larijani B, Esmaillzadeh A. Legume Consumption and Risk of All-Cause and Cause-Specific Mortality: A Systematic Review and Dose-Response Meta-Analysis of Prospective Studies. Adv Nutr. 2023 Jan;14(1):64-76. doi: 10.1016/j.advnut.2022.10.009.

Zhu B, Sun Y, Qi L, Zhong R, Miao X. Dietary legume consumption reduces risk of colorectal cancer: evidence from a meta-analysis of cohort studies. Sci Rep. 2015 Mar 5;5:8797. doi: 10.1038/srep08797.

Zhu F, Du B, Xu B. Anti-inflammatory effects of phytochemicals from fruits, vegetables, and food legumes: A review. Crit Rev Food Sci Nutr. 2018 May 24;58(8):1260-1270. doi: 10.1080/10408398.2016.1251390.

Nuts and Seeds

Amba V, Murphy G, Etemadi A, Wang S, Abnet CC, Hashemian M. Nut and Peanut Butter Consumption and Mortality in the National Institutes of Health-AARP Diet and Health Study. Nutrients. 2019 Jul 2;11(7):1508. doi: 10.3390/nu11071508.

Arnesen EK, Thorisdottir B, Bärebring L, Söderlund F, Nwaru BI, Spielau U, Dierkes J, Ramel A, Lamberg-Allardt C, Åkesson A. Nuts and seeds consumption and risk of cardiovascular disease, type 2 diabetes and their risk factors: a systematic review and meta-analysis. Food Nutr Res. 2023 Feb 14;67. doi: 10.29219/fnr.v67.8961.

Aune D, Keum N, Giovannucci E, Fadnes LT, Boffetta P, Greenwood DC, Tonstad S, Vatten LJ, Riboli E, Norat T. Nut consumption and risk of cardiovascular disease, total cancer, all-cause and cause-specific mortality: a systematic review and dose-response meta-analysis of prospective studies. BMC Med. 2016 Dec 5;14(1):207. doi: 10.1186/s12916-016-0730-3.

Bao Y, Han J, Hu FB, Giovannucci EL, Stampfer MJ, Willett WC, Fuchs CS. Association of nut consumption with total and cause-specific mortality. N Engl J Med. 2013 Nov 21;369(21):2001-11. doi: 10.1056/NEJMoa1307352.

Bao Y, Hu FB, Giovannucci EL, Wolpin BM, Stampfer MJ, Willett WC, Fuchs CS. Nut consumption and risk of pancreatic cancer in women. Br J Cancer. 2013 Nov 26;109(11):2911-6. doi: 10.1038/bjc.2013.665.

Becerra-Tomás N, Paz-Graniel I, W C Kendall C, Kahleova H, Rahelić D, Sievenpiper JL, Salas-Salvadó J. Nut consumption and incidence of cardiovascular diseases and cardiovascular disease mortality: a meta-analysis of prospective cohort studies. Nutr Rev. 2019 Oct 1;77(10):691-709. doi: 10.1093/nutrit/nuz042.

Bolling BW, McKay DL, Blumberg JB. The phytochemical composition and antioxidant actions of tree nuts. Asia Pac J Clin Nutr. 2010;19(1):117-23.

Cao C, Gan X, He Y, Nong S, Su Y, Liu Z, Zhang Y, Hu X, Peng X. Association between nut consumption and cancer risk: a meta-analysis. Nutr Cancer. 2023;75(1):82-94. doi: 10.1080/01635581.2022.2104880.

Cardoso BR, Tan SY, Daly RM, Via JD, Georgousopoulou EN, George ES. Intake of Nuts and Seeds Is Associated with a Lower Prevalence of Nonalcoholic Fatty Liver Disease in US Adults: Findings from 2005-2018 NHANES. J Nutr. 2021 Nov 2;151(11):3507-3515. doi: 10.1093/jn/nxab253.

Chen CY, Blumberg JB. Phytochemical composition of nuts. Asia Pac J Clin Nutr. 2008;17 Suppl 1:329-32.

Dahl WJ, Lockert EA, Cammer AL, Whiting SJ. Effects of flax fiber on laxation and glycemic response in healthy volunteers. J Med Food. 2005 Winter;8(4):508-11. doi: 10.1089/jmf.2005.8.508.

de Souza RJ, Dehghan M, Mente A, Bangdiwala SI, Ahmed SH, Alhabib KF, Altuntas Y, Basiak-Rasała A, Dagenais GR, Diaz R, Amma LI, Kelishadi R, Khatib R, Lear SA, Lopez-Jaramillo P, Mohan V, Poirier P, Rangarajan S, Rosengren A, Ismail R, Swaminathan S, Wentzel-Viljoen E, Yeates K, Yusuf R, Teo KK, Anand SS,

Yusuf S; PURE study investigators. Association of nut intake with risk factors, cardiovascular disease, and mortality in 16 countries from 5 continents: analysis from the Prospective Urban and Rural Epidemiology (PURE) study. Am J Clin Nutr. 2020 Jul 1;112(1):208-219. doi: 10.1093/ajcn/nqaa108.

Eslami O, Shidfar F, Dehnad A. Inverse association of long-term nut consumption with weight gain and risk of overweight/obesity: a systematic review. Nutr Res. 2019 Aug;68:1-8. doi: 10.1016/j.nutres.2019.04.001.

Fadelu T, Zhang S, Niedzwiecki D, Ye X, Saltz LB, Mayer RJ, Mowat RB, Whittom R, Hantel A, Benson AB, Atienza DM, Messino M, Kindler HL, Venook A, Ogino S, Ng K, Wu K, Willett W, Giovannucci E, Meyerhardt J, Bao Y, Fuchs CS. Nut Consumption and Survival in Patients With Stage III Colon Cancer: Results From CALGB 89803 (Alliance). J Clin Oncol. 2018 Apr 10;36(11):1112-1120. doi: 10.1200/JCO.2017.75.5413.

Fernández-Rodríguez R, Jiménez-López E, Garrido-Miguel M, Martínez-Ortega IA, Martínez-Vizcaíno V, Mesas AE. Does the evidence support a relationship between higher levels of nut consumption, lower risk of depression, and better mood state in the general population? A systematic review. Nutr Rev. 2022 Sep 5;80(10):2076-2088. doi: 10.1093/nutrit/nuac022.

Gervasi T, Barreca D, Laganà G, Mandalari G. Health Benefits Related to Tree Nut Consumption and Their Bioactive Compounds. Int J Mol Sci. 2021 May 31;22(11):5960. doi: 10.3390/ijms22115960.

Goren-Inbar N, Sharon G, Melamed Y, Kislev M. Nuts, nut cracking, and pitted stones at Gesher Benot Ya'aqov, Israel. Proc Natl Acad Sci U S A. 2002 Feb 19;99(4):2455-60. doi: 10.1073/pnas.032570499.

Ibrügger S, Kristensen M, Mikkelsen MS, Astrup A. Flaxseed dietary fiber supplements for suppression of appetite and food intake. Appetite. 2012 Apr;58(2):490-5. doi: 10.1016/j.appet.2011.12.024.

Jambazian PR, Haddad E, Rajaram S, Tanzman J, Sabaté J. Almonds in the diet simultaneously improve plasma alpha-tocopherol concentrations and reduce plasma lipids. J Am Diet Assoc. 2005 Mar;105(3):449-54. doi: 10.1016/j.jada.2004.12.002.

Jung H, Chen CO, Blumberg JB, Kwak HK. The effect of almonds on vitamin E status and cardiovascular risk factors in Korean adults: a randomized clinical trial. Eur J Nutr. 2018 Sep;57(6):2069-2079. doi: 10.1007/s00394-017-1480-5.

Kristensen M, Jensen MG, Aarestrup J, Petersen KE, Søndergaard L, Mikkelsen MS, Astrup A. Flaxseed dietary fibers lower cholesterol and increase fecal fat excretion, but magnitude of effect depend on food type. Nutr Metab (Lond). 2012 Feb 3;9:8. doi: 10.1186/1743-7075-9-8.

Kristensen M, Savorani F, Christensen S, Engelsen SB, Bügel S, Toubro S, Tetens I, Astrup A. Flaxseed dietary fibers suppress postprandial lipemia and appetite sensation in young men. Nutr Metab Cardiovasc Dis. 2013 Feb;23(2):136-43. doi: 10.1016/j.numecd.2011.03.004.

Lee J, Shin A, Oh JH, Kim J. The relationship between nut intake and risk of colorectal cancer: a case control study. Nutr J. 2018 Mar 7;17(1):37. doi: 10.1186/s12937-018-0345-y.

Lee JT, Lai GY, Liao LM, Subar AF, Bertazzi PA, Pesatori AC, Freedman ND, Landi MT, Lam TK. Nut Con-

sumption and Lung Cancer Risk: Results from Two Large Observational Studies. Cancer Epidemiol Biomarkers Prev. 2017 Jun;26(6):826-836. doi: 10.1158/1055-9965.EPI-16-0806.

Li F, Jiang W, Wang J, Zhang T, Gu X, Zhai Y, Wu M, Xu L, Lin J. Beneficial Effects of Nut Consumption on Cognitive Function Among Elderly: Findings From a 6-Year Cohort Study. Front Aging Neurosci. 2022 Apr 13;14:816443. doi: 10.3389/fnagi.2022.816443.

Li M, Shi Z. A Prospective Association of Nut Consumption with Cognitive Function in Chinese Adults aged 55+ _ China Health and Nutrition Survey. J Nutr Health Aging. 2019;23(2):211-216. doi: 10.1007/s12603-018-1122-5.

Long J, Ji Z, Yuan P, Long T, Liu K, Li J, Cheng L. Nut Consumption and Risk of Cancer: A Meta-analysis of Prospective Studies. Cancer Epidemiol Biomarkers Prev. 2020 Mar;29(3):565-573. doi: 10.1158/1055-9965.EPI-19-1167.

Maguire LS, O'Sullivan SM, Galvin K, O'Connor TP, O'Brien NM. Fatty acid profile, tocopherol, squalene and phytosterol content of walnuts, almonds, peanuts, hazelnuts and the macadamia nut. Int J Food Sci Nutr. 2004 May;55(3):171-8. doi: 10.1080/09637480410001725175.

Mandalari G, Gervasi T, Rosenberg DW, Lapsley KG, Baer DJ. Effect of Nuts on Gastrointestinal Health. Nutrients. 2023 Apr 1;15(7):1733. doi: 10.3390/nu15071733.

Muley A, Fernandez R, Ellwood L, Muley P, Shah M. Effect of tree nuts on glycemic outcomes in adults with type 2 diabetes mellitus: a systematic review. JBI Evid Synth. 2021 May;19(5):966-1002. doi: 10.11124/JBIS-RIR-D-19-00397.

Naghshi S, Sadeghian M, Nasiri M, Mobarak S, Asadi M, Sadeghi O. Association of Total Nut, Tree Nut, Peanut, and Peanut Butter Consumption with Cancer Incidence and Mortality: A Comprehensive Systematic Review and Dose-Response Meta-Analysis of Observational Studies. Adv Nutr. 2021 Jun 1;12(3):793-808. doi: 10.1093/advances/nmaa152.

Ni J, Nishi SK, Babio N, Ros E, Basterra-Gortari FJ, Corella D, O C, Martínez JA, Alonso-Gómez ÁM, Wärnberg J, Vioque J, Romaguera D, López-Miranda J, Estruch R, Tinahones FJ, Santos-Lozano JM, Serra-Majem L, Cano-Ibáñez N, Tur JA, Fernández-García JM, Pintó X, Delgado-Rodríguez M, Matía-Martín P, Vidal J, Vázquez C, Daimiel L, Fernández-Aranda F, Ruiz-Canela M, Mestres Solà C, Portolés O, Sala-Vila A, Garcia-Rios A, Compañ-Gabucio LM, Gómez-Gracia E, Zulet MA, Chaplin A, Casas R, Martínez-Diz S, Tojal-Sierra L, Gómez-Pérez AM, Toledo E, Rios S, Ortega-Azorín C, de la Torre R, Peña-Orihuela PJ, Garcia-de la Hera M, Sayón-Orea C, Malcampo M, Salas-Salvadó J; PREDIMED-Plus investigators. Higher versus lower nut consumption and changes in cognitive performance over two years in a population at risk of cognitive decline: a cohort study. Am J Clin Nutr. 2023 Aug;118(2):360-368. doi: 10.1016/j.ajcnut.2023.05.032.

Nishi SK, Viguiliouk E, Blanco Mejia S, Kendall CWC, Bazinet RP, Hanley AJ, Comelli EM, Salas Salvadó J, Jenkins DJA, Sievenpiper JL. Are fatty nuts a weighty concern? A systematic review and meta-analysis and dose-response meta-regression of prospective cohorts and randomized controlled trials. Obes Rev. 2021

Nov;22(11):e13330. doi: 10.1111/obr.13330.

Pan L, Sui J, Xu Y, Zhao Q. Effect of Nut Consumption on Nonalcoholic Fatty Liver Disease: A Systematic Review and Meta-Analysis. Nutrients. 2023 May 19;15(10):2394. doi: 10.3390/nu15102394.

Parilli-Moser I, Domínguez-López I, Trius-Soler M, Castellví M, Bosch B, Castro-Barquero S, Estruch R, Hurtado-Barroso S, Lamuela-Raventós RM. Consumption of peanut products improves memory and stress response in healthy adults from the ARISTOTLE study: A 6-month randomized controlled trial. Clin Nutr. 2021 Nov;40(11):5556-5567. doi: 10.1016/j.clnu.2021.09.020.

Şahin M, Arioglu-Tuncil S, Ünver A, Deemer D, Lindemann SR, Tunçil YE. Dietary Fibers of Tree Nuts Differ in Composition and Distinctly Impact the Fecal Microbiota and Metabolic Outcomes In Vitro. J Agric Food Chem. 2023 Jun 28;71(25):9762-9771. doi: 10.1021/acs.jafc.3c01415.

Sapp PA, Kris-Etherton PM, Arnesen EA, Chen See JR, Lamendella R, Petersen KS. Peanuts as a nighttime snack enrich butyrate-producing bacteria compared to an isocaloric lower-fat higher-carbohydrate snack in adults with elevated fasting glucose: A randomized crossover trial. Clin Nutr. 2022 Oct;41(10):2169-2177. doi: 10.1016/j.clnu.2022.08.004.

Semmler G, Bachmayer S, Wernly S, Wernly B, Niederseer D, Huber-Schönauer U, Stickel F, Aigner E, Datz C. Nut consumption and the prevalence and severity of non-alcoholic fatty liver disease. PLoS One. 2020 Dec 31;15(12):e0244514. doi: 10.1371/journal.pone.0244514.

Soriano-Hernandez AD, Madrigal-Perez DG, Galvan-Salazar HR, Arreola-Cruz A, Briseño-Gomez L, Guzmán-Esquivel J, Dobrovinskaya O, Lara-Esqueda A, Rodríguez-Sanchez IP, Baltazar-Rodriguez LM, Espinoza-Gomez F, Martinez-Fierro ML, de-Leon-Zaragoza L, Olmedo-Buenrostro BA, Delgado-Enciso I. The protective effect of peanut, walnut, and almond consumption on the development of breast cancer. Gynecol Obstet Invest. 2015;80(2):89-92. doi: 10.1159/000369997.

Strait DS, Weber GW, Neubauer S, Chalk J, Richmond BG, Lucas PW, Spencer MA, Schrein C, Dechow PC, Ross CF, Grosse IR, Wright BW, Constantino P, Wood BA, Lawn B, Hylander WL, Wang Q, Byron C, Slice DE, Smith AL. The feeding biomechanics and dietary ecology of Australopithecus africanus. Proc Natl Acad Sci U S A. 2009 Feb 17;106(7):2124-9. doi: 10.1073/pnas.0808730106.

Su Q, Yu B, He H, Zhang Q, Meng G, Wu H, Du H, Liu L, Shi H, Xia Y, Guo X, Liu X, Li C, Bao X, Gu Y, Fang L, Yu F, Yang H, Sun S, Wang X, Zhou M, Jia Q, Zhao H, Song K, Niu K. NUT CONSUMPTION IS ASSOCIATED WITH DEPRESSIVE SYMPTOMS AMONG CHINESE ADULTS. Depress Anxiety. 2016 Nov;33(11):1065-1072. doi: 10.1002/da.22516.

Tamargo A, Martin D, Navarro Del Hierro J, Moreno-Arribas MV, Muñoz LA. Intake of soluble fibre from chia seed reduces bioaccessibility of lipids, cholesterol and glucose in the dynamic gastrointestinal model simgi®. Food Res Int. 2020 Nov;137:109364. doi: 10.1016/j.foodres.2020.109364.

van den Brandt PA, Schouten LJ. Relationship of tree nut, peanut and peanut butter intake with total and cause-specific mortality: a cohort study and meta-analysis. Int J Epidemiol. 2015 Jun;44(3):1038-49. doi: 10.1093/ije/dyv039.

Wang C, Gu K, Wang F, Cai H, Zheng W, Bao P, Shu XO. Nut consumption in association with overall mortality and recurrence/disease-specific mortality among long-term breast cancer survivors. Int J Cancer. 2022 Feb 15;150(4):572-579. doi: 10.1002/ijc.33824.

Zhang D, Dai C, Zhou L, Li Y, Liu K, Deng YJ, Li N, Zheng Y, Hao Q, Yang S, Song D, Wu Y, Zhai Z, Cao S, Dai Z. Meta-analysis of the association between nut consumption and the risks of cancer incidence and cancer-specific mortality. Aging (Albany NY). 2020 Jun 2;12(11):10772-10794. doi: 10.18632/

Seafood

Alhassan A, Young J, Lean MEJ, Lara J. Consumption of fish and vascular risk factors: A systematic review and meta-analysis of intervention studies. Atherosclerosis. 2017 Nov;266:87-94. doi: 10.1016/j.atherosclerosis.2017.09.028.

Berry MJ, Ralston NV. Mercury toxicity and the mitigating role of selenium. Ecohealth. 2008 Dec;5(4):456-9. doi: 10.1007/s10393-008-0204-y.

Braun DR, Harris JW, Levin NE, McCoy JT, Herries AI, Bamford MK, Bishop LC, Richmond BG, Kibunjia M. Early hominin diet included diverse terrestrial and aquatic animals 1.95 Ma in East Turkana, Kenya. Proc Natl Acad Sci U S A. 2010 Jun 1;107(22):10002-7. doi: 10.1073/pnas.1002181107.

Caini S, Chioccioli S, Pastore E, Fontana M, Tortora K, Caderni G, Masala G. Fish Consumption and Colorectal Cancer Risk: Meta-Analysis of Prospective Epidemiological Studies and Review of Evidence from Animal Studies. Cancers (Basel). 2022 Jan 27;14(3):640. doi: 10.3390/cancers14030640.

Catanesi M, Caioni G, Castelli V, Benedetti E, d'Angelo M, Cimini A. Benefits under the Sea: The Role of Marine Compounds in Neurodegenerative Disorders. Mar Drugs. 2021 Jan 8;19(1):24. doi: 10.3390/md19010024.

Chen C, Huang H, Dai QQ, Ren J, Cai HH, Hu WJ, Zhang XJ, Zhong WT, Li XY. Fish consumption, long-chain omega-3 fatty acids intake and risk of stroke: An updated systematic review and meta-analysis. Asia Pac J Clin Nutr. 2021;30(1):140-152. doi: 10.6133/apjcn.202103_30(1).0017.

Curhan SG, Eavey RD, Wang M, Rimm EB, Curhan GC. Fish and fatty acid consumption and the risk of hearing loss in women. Am J Clin Nutr. 2014 Nov;100(5):1371-7. doi: 10.3945/ajcn.114.091819.

Donoso A, González-Durán J, Muñoz AA, González PA, Agurto-Muñoz C. "Therapeutic uses of natural astaxanthin: An evidence-based review focused on human clinical trials". Pharmacol Res. 2021 Apr;166:105479. doi: 10.1016/j.phrs.2021.105479.

Esatbeyoglu T, Rimbach G. Canthaxanthin: From molecule to function. Mol Nutr Food Res. 2017 Jun;61(6). doi: 10.1002/mnfr.201600469.