

# Tomatoes



## What's New and Beneficial About Tomatoes

- Did you know that tomatoes do not have to be a deep red color to be an outstanding source of lycopene? Lycopene is a carotenoid pigment that has long been associated with the deep red color of many tomatoes. A small preliminary study on healthy men and women has shown that the lycopene from orange- and tangerine-colored tomatoes may actually be better absorbed than the lycopene from red tomatoes. That's because the lycopene in deep red tomatoes is mostly trans-lycopene, and the lycopene in orange/tangerine tomatoes is mostly tetra-cis-lycopene. In a recent study, this tetra-cis form of lycopene turned out to be more efficiently absorbed by the study participants. While more research is needed in this area, we're encouraged to find that tomatoes may not have to be deep red in order for us to get great lycopene-related benefits.
- Tomatoes are widely known for their outstanding antioxidant content, including, of course, their oftentimes-rich concentration of lycopene. Researchers have recently found an important connection between lycopene, its antioxidant properties, and bone health. A study was designed in which tomato and other dietary sources of lycopene were removed from the diets of postmenopausal women for a period of 4 weeks, to see what effect lycopene restriction would have on bone health. At the end of 4 weeks, women in the study started to show increased signs of oxidative stress in their bones and unwanted

changes in their bone tissue. The study investigators concluded that removal of lycopene-containing foods (including tomatoes) from the diet was likely to put women at increased risk of osteoporosis. They also argued for the importance of tomatoes and other lycopene-containing foods in the diet. We don't always think about antioxidant protection as being important for bone health, but it is, and tomato lycopene (and other tomato antioxidants) may have a special role to play in this area.

- There are literally hundreds of different tomato varieties. We usually choose our favorite varieties by some combination of flavor, texture, and appearance. But a recent study has shown that we may also want to include antioxidant capacity as a factor when we are choosing among tomato varieties. Surprisingly, researchers who compared conventionally grown versus organically grown tomatoes found that growing method (conventional versus organic) made less of an overall difference than variety of tomato. While all tomatoes showed good antioxidant capacity, and while the differences were not huge, the following four varieties of tomatoes turned out to have a higher average antioxidant capacity regardless of whether they were grown conventionally or organically: New Girl, Jet Star, Fantastic, and First Lady. It's only one study, of course, and we're definitely not ready to recommend these four varieties at the exclusion of all others. But these findings are fascinating to us, and they suggest that specific types of nutrient benefits may be provided by specific varieties of tomatoes. Also, if you're seeking good antioxidant protection and you're in the grocery standing in front of a New Girl, Jet Star, Fantastic, or First Lady tomato, you would probably be well-served to place it in your shopping cart.
- Intake of tomatoes has long been linked to heart health. Fresh tomatoes and tomato extracts have been shown to help lower total cholesterol, LDL cholesterol, and triglycerides. In addition, tomato extracts have been shown to help prevent unwanted clumping together (aggregation) of platelet cells in the blood - a factor that is especially important in lowering risk of heart problems like atherosclerosis. (In a recent South American study of 26 vegetables,

tomatoes and green beans came out best in their anti-aggregation properties.) But only recently are researchers beginning to identify some of the more unusual phytonutrients in tomatoes that help provide us with these heart-protective benefits. One of these phytonutrients is a glycoside called esculeoside A; another is flavonoid called chalconaringenin; and yet another is a fatty-acid type molecule called 9-oxo-octadecadienoic acid. As our knowledge of unique tomato phytonutrients expands, we are likely to learn more about the unique role played by tomatoes in support of heart health. Tomatoes are also likely to rise further and further toward the top of the list as heart healthy foods.

## Health Benefits

Tomatoes are a treasure of riches when it comes to their antioxidant benefits. In terms of conventional antioxidants, tomatoes provide an excellent amount of vitamin C and beta-carotene; a very good amount of the mineral manganese; and a good amount of vitamin E. In terms of phytonutrients, tomatoes are basically off the chart, and include:

- Flavonones
  - naringenin
  - chalconaringenin
- Flavonols
  - rutin
  - kaempferol
  - quercetin
- Hydroxycinnamic acids
  - caffeic acid
  - ferulic acid
  - coumaric acid
- Carotenoids
  - lycopene
  - lutein
  - zeaxanthin

- beta-carotene
- Glycosides
  - esculeoside A
- Fatty acid derivatives
  - 9-oxo-octadecadienoic acid

Specific antioxidant nutrients found in tomatoes, whole tomato extracts, and overall dietary intake of tomatoes have all been associated with antioxidant protection. Sometimes this protection comes in the form of reduced lipid peroxidation (oxygen damage to fats in cell membranes or in the bloodstream). Sometimes this protection comes in the form of better antioxidant enzyme function (for example, better function of the enzymes catalase or superoxide dismutase). Better antioxidant protection has also been shown using broad measurements of oxidative stress in different body systems. We've seen studies involving tomato and specific antioxidant protection of the bones, liver, kidneys, and bloodstream.

## **Cardiovascular Support**

Reduced risk of heart disease is an area of health benefits in which tomatoes truly excel. There are two basic lines of research that have repeatedly linked tomatoes to heart health. The first line of research involves antioxidant support, and the second line of research involves regulation of fats in the bloodstream.

No body system has a greater need for antioxidant protection than the cardiovascular system. The heart and bloodstream are responsible for taking oxygen breathed in through the lungs and circulating it around throughout the body. In order to keep this oxygen in check, antioxidant nutrients are needed in an ample supply. Earlier in this Health Benefits section, we gave you a close-up look at some of the best-researched antioxidants in tomatoes. It's worth noting here that conventional vitamin antioxidants like vitamin E and vitamin C are sometimes overlooked in tomatoes because of their unique phytonutrient composition. Yet vitamin E and vitamin C provide critical antioxidant support in the cardiovascular system, and they are an important part of the contribution made by tomatoes to our heart health. It's the carotenoid lycopene, however, that

has gotten the most attention as tomatoes' premier antioxidant and heart-supportive nutrient. Lycopene (and a related group of nutrients) has the ability to help lower the risk of lipid peroxidation in the bloodstream. Lipid peroxidation is a process in which fats that are located in the membranes of cells lining the bloodstream, or fats that are being carried around in the blood, get damaged by oxygen. This damage can be repaired if it is kept at manageable levels. However, chronic and/or excessive lipid peroxidation in the bloodstream leads to trouble. Overly damaged fat components sound an alarm to the body's immune and inflammatory systems, and the result is a series of processes that can lead to a gradual blocking of blood vessels (atherosclerosis) or other problems.

The second line of research linking tomatoes with heart health involves regulation of fats in the blood. Dietary intake of tomatoes, consumption of tomato extracts, and supplementation with tomato phytonutrients (like lycopene) have all been shown to improve the profile of fats in our bloodstream. Specifically, tomato intake has been shown to result in decreased total cholesterol, decreased LDL cholesterol, and decreased triglyceride levels. It's also been shown to decrease accumulation of cholesterol molecules inside of macrophage cells. (Macrophage cells are a type of white blood cell that gets called into action when oxidative stress in the bloodstream gets too high, and the activity of macrophages—including their accumulation of cholesterol—is a prerequisite for development of atherosclerosis.) Many phytonutrients in tomatoes are likely to be involved with the improvement of our blood fat levels. Two little-known phytonutrients—one called esculeoside A and the other called 9-oxo-octadecadienoic acid—are currently under active investigation by researchers as tomato phytonutrients especially important in blood fat regulation.

Yet another area of increasing interest in tomatoes and heart health involves blood cells called platelets. The excessive clumping together of platelet cells can cause problems for our bloodstream in terms of blockage and unwanted clotting, and prevention of this excessive clumping is important for maintaining heart health. Numerous phytonutrients in tomatoes have been shown to help prevent excessive clumping of our

platelet cells. (This ability is usually referred to as an "antiaggregatory effect.") In combination with the other heart benefits described above, this platelet-regulating impact of tomatoes puts them in a unique position to help us optimize our cardiovascular health.

## **Supports Bone Health**

Bone health is another area of growing interest in tomato research. Interestingly, the connection of tomato intake to bone health involves the rich supply of antioxidant in tomatoes. We don't always think about antioxidant protection as being important for bone health, but it is; and tomato lycopene (and other tomato antioxidants) may have a special role to play in this area. In a recent study, tomato and other dietary sources of lycopene were removed from the diets of postmenopausal women for a period of 4 weeks to see what effect lycopene restriction would have on bone health. At the end of 4 weeks, women in the study started to show increased signs of oxidative stress in their bones and unwanted changes in their bone tissue. We expect to see follow-up studies in this area that will hopefully determine exactly what levels of tomato intake are most helpful in protecting bone tissue.

## **Anti-Cancer Benefits**

While not well researched for all cancer types, tomatoes have repeatedly been shown to provide us with anti-cancer benefits. The track record for tomatoes as a cancer-protective food should not be surprising, since there is a very large amount of research on tomato antioxidants and a more limited but still important amount of research on tomato anti-inflammatory nutrients. Risk for many cancer types starts out with chronic oxidative stress and chronic unwanted inflammation. For this reason, foods that provide us with strong antioxidant and anti-inflammatory support are often foods that show cancer prevention properties.

Prostate cancer is by far the best-researched type of cancer in relationship to tomato intake. The jury verdict here is clear: tomatoes can definitely help lower risk of prostate cancer in men. One key tomato nutrient that has received special focus in prostate cancer prevention is alpha-tomatine.

Alpha-tomatine is a saponin phytonutrient and it's shown the ability to alter metabolic activity in developing prostate cancer cells. It's also been shown to trigger programmed cell death (apoptosis) in prostate cancer cells that have already been fully formed. Research on alpha-tomatine has also been conducted for non-small cell lung cancer, with similar findings.

Along with prostate cancer and non-small cell lung cancer, pancreatic cancer and breast cancer are the two best-studied areas involving tomatoes and cancer risk. Research on tomatoes and breast cancer risk has largely focused on the carotenoid lycopene, and there is fairly well documented risk reduction for breast cancer in association with lycopene intake.

## Other Health Benefits

While not as thoroughly researched as these other areas of antioxidant support, cardiovascular support, and anti-cancer benefits, several other health benefit areas are important to mention with respect to tomatoes. Diets that include tomatoes have been linked with reduced risk of some neurological diseases (including Alzheimer's disease) in multiple studies. Tomato-containing diets have also been linked in a few studies with reduced risk of obesity.

## Description

The tomato is the fruit of the plant *Lycopersicon esculentum*. (Botanically speaking, tomato is not only a fruit, but also a berry since it is formed from a single ovary.) Originally, tomato was named after the food family to which it belongs - the *Solanaceae* (sometimes called "solanoid" or "nightshade") family. The botanical name *Solanum lycopersicum* for tomatoes has now largely been replaced by the name *Lycopersicon esculentum*. (The genus/species name *Lycopersicon esculentum* is also sometimes used to refer to tomatoes.)

The French sometimes refer to the tomato as pomme d'amour, meaning "love apple," and in Italy, tomato is sometimes referred to as "pomodoro" or

"golden apple," probably referring to tomato varieties that were yellow/orange/tangerine in color.

Regardless of its name, the tomato is a wonderfully popular and versatile food that comes in over a thousand different varieties that vary in shape, size, and color. There are small cherry tomatoes, bright yellow tomatoes, Italian pear-shaped tomatoes, and the green tomato, famous for its fried preparation in Southern American cuisine.

Only the fruits of this plant are eaten since the leaves often contain potentially problematic concentrations of certain alkaloids (see Individual Concerns section below). Tomatoes have fleshy internal segments filled with slippery seeds surrounded by a watery matrix. They can be red, pink, yellow, orange/tangerine, green, purple, brown, or black in color.

Beefsteak and beef master tomatoes are among the largest-sized varieties. Roma tomatoes are more of an intermediate size, while cherry and grape tomatoes are small and rounded. The term "heirloom tomatoes" has become somewhat confusing as it can have a variety of different meanings. In the most traditional sense, "heirloom" refers to seeds from tomato cultivars that get handed down over time from family to family. Obviously, seeds handed down in this way do not make it possible for tomato production on a very large commercial scale. Yet there are definitely "commercial heirloom" tomatoes in the marketplace (sometimes produced from cross-breeding and sometimes produced through open pollination.)

Although tomatoes are fruits in a botanical sense, they don't have the dessert quality sweetness of other fruits. Instead they have a subtle sweetness that is complemented by a slightly bitter and acidic taste. They are prepared and served like other vegetables, which is why they are often categorized as such, including in our A-Z List of the World's Healthiest Foods. Cooking tempers the acid and bitter qualities in tomatoes and brings out their warm, rich sweetness.

There are few food sensations that better mark the summer and early fall months than the sweet juiciness of a vine-ripened tomato. Although tomatoes are available year-round across the U.S., some of the most



delicious tomato flavors come from fresh tomatoes that have been planted in late spring or early summer and ripen from July through September.

# History

Although tomatoes are often closely associated with Italian cuisine, they are actually originally native to the western side of South America, in the region occupied by Columbia, Ecuador, Peru, Chile, and the western half of Bolivia. The Galapagos Islands off the coast of Ecuador are also believed to be part of tomatoes' native area. The first type of tomato grown is thought to have more resembled the smaller-sized cherry tomato than the larger varieties.

The tomato does not appear to have been first cultivated in South America, however, but rather in Mexico, most likely in Aztec civilizations and probably in the form of small yellow fruits. The word "tomato" may actually originate from the Nahuatl (Aztec) word "*tomatl*" meaning "the swelling fruit." It wasn't until the 1500's that Spanish explorers and colonizers brought tomato seeds from Mexico back to Spain and introduced this food to European populations.

Although the use of tomatoes spread throughout Europe (including Italy) over the course of the 1500's, tomatoes did not enjoy full popularity then and were seen by many people as unfit to eat. Part of this "food inappropriateness" was associated with the status of the tomato plant as a nightshade plant and its potential poisonousness in this regard. (It's true, of course, that tomatoes belong to the *Solanaceae* or nightshade family of plants, along with potatoes, sweet and hot peppers, eggplant, tomatillos, tamarios, pepinos, pimientos, paprika, and cayenne. It's also true that tomatoes contain alkaloids —substances that even in small doses can be associated with adverse reactions in sensitive individuals. But it's also true that the levels of alkaloids found in nightshade foods are well-tolerated by many individuals in diets worldwide. For more on nightshades, please see our article "What are nightshades and in which foods are they found?")

Today tomatoes are enjoyed worldwide—to the tune of about 130 million tons per year. The largest tomato-producing country is China (with approximately 34 million tons of production), followed by the United States, Turkey, India, and Italy.

In the U.S., cultivation of tomato varieties is usually determined by their final destination: (1) consumption in fresh form by consumers or (2) use in processing by manufacturers of tomato products. Tomato processors need varieties that have a greater proportion of soluble solids in order to make products like tomato paste more efficiently. Between 80-90% of all commercial tomato cultivation in the U.S. is cultivation for eventual use in processing. (Processing tomatoes are needed for the manufacturing of pasta sauces, pizza sauces, and tomato pastes. Both processing and fresh market tomatoes may be used in the production of salsa—although fresh market tomato salsas or homemade salsas—like our Fresh Tomato Salsa—are the salsas that we like best on account of their minimal processing.) California and Florida produce about two-thirds of all commercially grown fresh market tomatoes in the U.S. During the winter months, because Florida tomatoes are generally shipped to other states along the east coast of the U.S., imported Mexican tomatoes make up a high percentage of commercially grown fresh tomatoes along the west coast.

## References

- Aldrich HT, Salandanan K, Kendall P et al. Cultivar choice provides options for local production of organic and conventionally produced tomatoes with higher quality and antioxidant content. *J Sci Food Agric.* 2010 Dec;90(15):2548-55. 2010.
- Anthon GE, LeStrange M, and Barrett DM. Changes in pH, acids, sugars and other quality parameters during extended vine holding of ripe processing tomatoes. *J Sci Food Agric.* 2011 May;91(7):1175-81. 2011.
- Bai Y and Lindhout P. Domestication and Breeding of Tomatoes: What have We Gained and What Can We Gain in the Future? . *Ann Bot.*

2007 October; 100(5): 1085-1094. Published online 2007 August 23. 2007.

- Borguini RG and Torres EAFDS. Tomatoes and Tomato Products as Dietary Sources of Antioxidants. *Food Reviews International*. Philadelphia: 2009. Vol. 25, Iss. 4; p. 313-325. 2009.
- Cao XL, Corriveau J, and Popovic S. Bisphenol A in Canned Food Products from Canadian Markets. *Journal of Food Protection*. Des Moines: Jun 2010. Vol. 73, Iss. 6; p. 1085-1089. 2010.
- Dilis B and Trichopoulou A. Antioxidant Intakes and Food Sources in Greek Adults. *The Journal of Nutrition*. Bethesda: Jul 2010. Vol. 140, Iss. 7; p. 1274-1279. 2010.
- Dogukan A, Tuzcu M, Agca CA et al. A tomato lycopene complex protects the kidney from cisplatin-induced injury via affecting oxidative stress as well as Bax, Bcl-2, and HSPs expression. *Nutr Cancer*. 2011;63(3):427-34. 2011.
- Etminan M, Takkouche B, and Caamano-Isorna F. The role of tomato products and lycopene in the prevention of prostate cancer: a meta-analysis of observational studies. *Cancer Epidemiol Biomarkers Prev*. 2004 Mar;13(3):340-5. 2004. 2004.
- Friedman M, Levin CE, Lee SU et al. Tomatine-containing green tomato extracts inhibit growth of human breast, colon, liver, and stomach cancer cells. *J Agric Food Chem*. 2009 Jul 8;57(13):5727-33. 2009.
- Gonzali S, Mazzucato A, and Perata P. Purple as a tomato: towards high anthocyanin tomatoes. *Trends Plant Sci*. 2009 May;14(5):237-41. Epub 2009 Apr 8. 2009.
- Herbette S, de Labrouhe DT, Drevet JR et al. Transgenic tomatoes showing higher glutathione peroxydase antioxidant activity are more resistant to an abiotic stress but more susceptible to biotic stresses. *lant Sci*. 2011 Mar;180(3):548-53. Epub 2010 Dec 14. 2011.
- Ishida BK, Chapman MH. A comparison of carotenoid content and total antioxidant activity in catsup from several commercial sources in the United States. *J Agric Food Chem*. 2004 Dec 29;52(26):8017-20. 2004. PMID:15612790.

- Jacob K, Garcia-Alonso FJ, Ros G et al. Stability of carotenoids, phenolic compounds, ascorbic acid and antioxidant capacity of tomatoes during thermal processing. *Arch Latinoam Nutr.* 2010 Jun;60(2):192-8. 2010.
- Kim YI, Takahashi H, Goto T et al. 9-oxo-10(E),12(E)-octadecadienoic acid derived from tomato is a potent PPAR agonist to decrease triglyceride accumulation in mouse primary hepatocytes. *Molecular Nutrition & Food Research*, 2010; DOI: 10.1002/mnfr.201000264. 2010.
- Lazarus SA, Bowen K, Garg ML. Tomato juice and platelet aggregation in type 2 diabetes. *JAMA.* 2004 Aug 18;292(7):805-6. 2004. PMID:15315994.
- Lee ST, Wong PF, Cheah SC et al. Alpha-tomatine induces apoptosis and inhibits nuclear factor-kappa B activation on human prostatic adenocarcinoma PC-3 cells. *PLoS One.* 2011 Apr 26;6(4):e18915. 2011.
- Lippi G and Targher G. Tomatoes, lycopene-containing foods and cancer risk. *Br J Cancer.* 2011 Mar 29;104(7):1234-5. Epub 2011 Feb 22. 2011.
- Mackinnon ES, Rao AV, and Rao LG. Dietary restriction of lycopene for a period of one month resulted in significantly increased biomarkers of oxidative stress and bone resorption in postmenopausal women. *J Nutr Health Aging.* 2011 Feb;15(2):133-8. 2011.
- Mathieu S, Dal Cin V, Fei Z et al. Flavour compounds in tomato fruits: identification of loci and potential pathways affecting volatile composition. *J Exp Bot.* 2009 January; 60(1): 325-337. Published online 2008 December 16. 2009.
- Moneruzzaman KM, Hossain ABMS, Sani W et al. Effect of Stages of Maturity and Ripening Conditions on the Biochemical Characteristics of Tomato. *American Journal of Biochemistry and Biotechnology Year: 2008 Vol: 4 Issue: 4 Pages/record No.: 336-344.* 2008.
- Nohara T, Ono M, Ikeda T et al. The Tomato Saponin, Esculeoside A. *J Nat Prod.* 2010 Sep 20. [Epub ahead of print]. 2010.

- Palozza P, Parrone N, Catalano A et al. Tomato lycopene and inflammatory cascade: basic interactions and clinical implications. *Curr Med Chem*. 2010;17(23):2547-63. 2010.
- Reboul E, Borel P, Mikail C et al. Enrichment of Tomato Paste with 6% Tomato Peel Increases Lycopene and  $\beta$ -Carotene Bioavailability in Men. *J Nutr*. 2005 Apr;135(4):790-4 2005. 2005.
- Salem S, Salahi M, Mohseni M et al. Major dietary factors and prostate cancer risk: a prospective multicenter case-control study. *Nutr Cancer*. 2011;63(1):21-7. 2011.
- Sesso HD, Liu S, Gaziano JM et al. Dietary lycopene, tomato-based food products and cardiovascular disease in women. *J Nutr* Jul;133(7): 2336-41. 2003. 2003.
- Shieh JM, Cheng TH, Shi MD et al.  $\alpha$ -Tomatine suppresses invasion and migration of human non-small cell lung cancer NCI-H460 cells through inactivating FAK/PI3K/Akt signaling pathway and reducing binding activity of NF- $\kappa$ B. *Cell Biochem Biophys*. 2011 Jul;60(3):297-310. 2011.
- Silaste ML, Alfthan G, Aro A, et al. Tomato juice decreases LDL cholesterol levels and increases LDL resistance to oxidation. *Br J Nutr*. 2007 Dec;98(6):1251-8. 2007. PMID:17617941.
- Slimestad R and Verheul M. Properties of chalconaringenin and rutin isolated from cherry tomatoes. *J Agric Food Chem*. 2011 Apr 13;59(7):3180-5. Epub 2011 Mar 4. 2011.
- Talvas J, Caris-Veyrat C, Guy L et al. Differential effects of lycopene consumed in tomato paste and lycopene in the form of a purified extract on target genes of cancer prostatic cells. *Am J Clin Nutr*. 2010 Jun;91(6):1716-24. Epub 2010 Apr 14. 2010.
- Tan HL, Thomas-Ahner JM, Grainger EM et al. Tomato-based food products for prostate cancer prevention: what have we learned? . *Cancer Metastasis Rev*. 2010 Sep;29(3):553-68. 2010.
- Torres-Urrutia C, Guzman L, Schmeda-Hirschmann G et al. Antiplatelet, anticoagulant, and fibrinolytic activity in vitro of extracts from selected fruits and vegetables. *Blood Coagul Fibrinolysis*. 2011 Apr;22(3):197-205. 2011.

- Visioli F, Riso P, Grande S et al. Protective activity of tomato products on in vivo markers of lipid oxidation. *Eur J Nutr.* 2003;42(4):201-6. 2003.
- Willcox JK, Catignani GL, Lazarus S. Tomatoes and cardiovascular health. *Crit Rev Food Sci Nutr* 2003;43(1):1-18. 2003.
- Wood M. Tangerine Tomatoes Top Reds in Preliminary Lycopene Study. *Agricultural Research.* Washington: Feb 2011. Vol. 59, Iss. 2; p. 15. 2011.