Isothiocyanates, Isoflavones, and Phytosterols: Cruciferous Vegetables and Soy Foods

By: Keith Herman
Date: January 21, 2022

This is part four of why the phytonutrients in plants are so beneficial to our health. Two of the nutrients we will look at in this article are found predominantly in cruciferous vegetables and soy. Cruciferous vegetables are often called the most powerful food for protecting from cancer, and some argue we should avoid soy because it increases the risk of certain cancers. Truth or myth? Let's see where the weight of the evidence points.

Cruciferous Vegetables

Cruciferous vegetables are extremely healthy foods. The name "cruciferous" comes from the Latin cruciferae meaning "cross bearing," as the four petals resemble a cross. They include broccoli, cauliflower, kale, Brussels sprouts, broccoli rabe (rapini), mustard greens, collard greens, Swiss chard, bok choy, arugula, broccolini, cabbage, horseradish, wasabi, kohlrabi, radish, rutabaga, turnips, turnip greens, and watercress. They are rich in many nutrients, including fiber, beta-carotene, lutein, zeaxanthin, potassium, magnesium, vitamin C, vitamin E, vitamin K, and folate.

Cruciferous vegetables are unique in that they are a rich source of a sulphur-containing compound called glucosinolates. This compound provides the pungent aroma and spicy or bitter flavor. When cruciferous vegetables are chopped or chewed the glucosinolates convert to isothiocyanates and indoles. Sulforaphane (an isothiocyanate) and indole-3-carbinol (an indole) are the most frequently studied of these compounds and sulforaphane has surfaced as a particularly potent anticancer agent. In animal and lab studies, these compounds inhibit the development of cancer by protecting cells from DNA damage, inactivating carcinogens, inducing apoptosis (self-destruction of cancer cells), and inhibiting the formation of tumor blood vessels and the migration of tumor cells. They also have anti-inflammatory, antiviral and antibacterial effects. For hormone-related cancers, some research indicates glucosinolates may shift estrogen to a weaker form or inhibit the expression of estrogen-responsive genes.

Due to these amazing properties you would think every health care organization would specifically recommend eating cruciferous vegetables. As I explained in my article on the seven healthiest foods,[1] the World Cancer Research Fund recommends eating a plant-based diet high in fiber but does not yet specifically recommend cruciferous vegetables. This is because human studies show an inconsistent[2] link between cruciferous vegetables and a reduced cancer risk.[3] This may be partly due to genetic differences. Those missing certain detoxifying genes, or with less active forms, are less able to metabolize certain toxins and therefore have a higher risk of some cancers, especially among those who smoke tobacco.

Another major factor not getting enough attention is inactivation of an important enzyme, called

myrosinase, during cooking. Myrosinase is responsible for converting glucosinolates to isothiocyanates and indoles. Myrosinase is physically separated from glucosinolates in intact cruciferous vegetables, so you need to break the plant cells apart by chewing or chopping for the chemical reaction to occur.[4]

However, myrosinase is heat sensitive and therefore cooking cruciferous vegetables before chopping them vastly reduces the amount of isothiocyanates and indoles created. If you are going to eat cooked cruciferous vegetables, it is best to chop them before you cook them. Lightly cooking them for less than 5 minutes can also reduce the inactivation of the myrosinase. For example, if you are eating broccoli, don't cook it until it is mushy. Leave a little crunch when you bite it which means the cell walls are still intact. The best option is to eat a small amount of raw cruciferous vegetable with the cooked ones so there is some myrosinase unaffected by heat. Studies show that adding just a ½ teaspoon of powdered brown mustard seed (the standard mustard powder in the spice aisle), whether cooked or uncooked, can ensure a high conversion of the glucosinolates.[5] Daikon radish root (even if cooked up to a temperature of 176 Fahrenheit) appears to provide the same benefit.[6] Frozen vegetables are blanched before being frozen, so there will be no active myrosinase in frozen broccoli to convert the glucosinolates. This may be why fresh kale suppresses cancer cell growth so much more than frozen kale.[7] Be sure to use mustard seed, daikon radish root, or a little fresh cruciferous vegetable when eating your frozen or cooked cruciferous vegetables.[8]

Broccoli sprouts are the superstar in this area. They contain ten to one hundred times more glucosinolates than mature broccoli plants, which are already high in glucosinolates.[9] In a 12-week randomized clinical trial, researchers gave 291 participants from a region of China with substantial air pollution a broccoli sprout-derived beverage providing a standardized dose of sulforaphane and glucosinolate.[10] Exposure to air pollution has been associated with lung cancer and cardiopulmonary diseases. Drinking the broccoli-sprout beverage increased the urinary excretion of a known carcinogen, benzene, and a toxicant, acrolein. Excretion of benzene was higher in participants with the "GSTT1-positive" detoxifying gene.

Soy Isoflavones

Isoflavones are in a class known as phytoestrogens. Phytoestrogens are plant-derived compounds with a similar chemical structure to human estrogen, but they bind to the body's estrogen receptors differently and function differently. Isoflavones seem to act as tumor suppressors most often. Soybeans and soy products such as tofu, tempeh, miso, and soy milk are the richest sources of isoflavones.

There is a common misconception phytoestrogens increase the risk of hormone sensitive cancers such as breast and prostate cancer. The current research indicates a high intake of soy foods early in life may decrease the risk of breast cancer as an adult.[11] Soy also seems to improve survival and decrease cancer reoccurrence among women a year or more after a breast cancer diagnosis,[12] and it may improve the side effects of breast cancer treatment.[13]

There is another misconception that phytoestrogens in soy feminize men by lowering testosterone and increasing estrogen. This has been extensively studied and the evidence shows that phytoestrogens do not have a negative effect on male reproductive hormones.[14] Population studies analyzing soy consumption find either no effect or a decreased risk of prostate cancer.[15] Randomized controlled trials indicate soy protein powder and soy isoflavone supplements have no effect on PSA levels or hormones related to the risk of prostate cancer.[16]

The 2020-2025 Dietary Guidelines for Americans consider fortified soy milk and soy yogurt to be a

healthy alternative to dairy due to their similar nutritional profiles (high in protein, calcium, and vitamin D). Soybean isoflavones may improve the elasticity of arteries and reduce blood pressure. Soy also lowers LDL cholesterol, but this may not be related to the isoflavones.[17] In 1999, the FDA approved the health claim that “25 grams of soy protein a day, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease.” There are no health claims allowed for dairy foods and heart disease, as the saturated fat may increase the risk of heart disease.

Plant Sterols

Plant sterols, also known as phytosterols, are found in small amounts in vegetables, fruits, whole grains, nuts, and seeds. They block the absorption of cholesterol in the small intestine and lower LDL cholesterol. Supplements with 2 to 3 grams of phytosterols have been shown to reduce LDL cholesterol by 8 to 10%.[18] The National Cholesterol Education Program (NCEP) recommends 2 grams of phytosterols a day to lower LDL cholesterol and reduce the risk of heart disease.[19]

A Portfolio of the Heart Healthiest Foods and Nutrients

David Jenkins, the inventor of the glycemic index, tested the cholesterol lowering effects of a NCEP Step II vegetarian diet with added components recognized by the FDA to lower cholesterol, including 2 grams of phytosterols, 20 grams of viscous soluble fiber from oats, barley and psyllium husk, 45 grams of protein from soy foods, and 45 grams of nuts. He called this the “Portfolio Diet” as it includes a portfolio of cholesterol-lowering foods. In just one month the Portfolio diet reduced LDL cholesterol by 28.6%, similar to a statin drug (lovastatin) (30.9%).[20] The participants average LDL cholesterol went from 179 to 127. There is a 12-15% decrease in deaths from cardiovascular disease for each 38.7 mg/dL reduction in LDL cholesterol.[21]

Have you checked your LDL cholesterol recently?

About the Author: Keith Herman is an estate planning attorney who is passionate about nutrition and helping others live their healthiest lives. He is a certified nutrition coach and personal trainer.

#HealthyEating

#HealthyLifestyle

#Wellness

References

[1] https://www.linkedin.com/pulse/7-foods-guaranteed-make-huge-improvements-your-health-keith-herman/

[2] Studies showing a reduced risk of breast cancer recurrence are more consistent.

Farvid, et al. “Postdiagnostic Fruit and Vegetable Consumption and Breast Cancer Survival: Prospective Analyses in the Nurses’ Health Studies.” Cancer research vol. 80,22 (2020): 5134-5143.

Thomson CA, et al. Vegetable intake is associated with reduced breast cancer recurrence in tamoxifen users: a secondary analysis from the Women’s Healthy Eating and Living Study. Breast Cancer Res Treat. 2011 Jan;125(2):519-27.

Cruciferous vegetable intake after diagnosis of breast cancer and survival: a report from the shanghai breast cancer survival study. In: Proceedings of the 103rd Annual Meeting of the American Association for Cancer Research; 2012 Mar 31-Apr 4; Chicago, IL. Philadelphia (PA): AACR; Cancer Res 2012;72(8 Suppl):Abstract nr LB-322.

[3] https://www.aicr.org/resources/blog/healthtalk-i-hear-a-lot-about-cruciferous-vegetables-but-what-else-does-this-include-besides-broccoli-do-the-others-offer-the-same-health-benefits/

[4] Glucosinolates in cooked cruciferous vegetables can also be broken down by bacterial myrosinase in the colon produced by our microbiome, but to a much smaller degree.

[5] Okunade O, et al. Supplementation of the Diet by Exogenous Myrosinase via Mustard Seeds to Increase the Bioavailability of Sulforaphane in Healthy Human Subjects after the Consumption of Cooked Broccoli. Mol Nutr Food Res. 2018 Sep;62(18):e1700980.

[6] Dosz EB, et al. Modifying the processing and handling of frozen broccoli for increased sulforaphane formation. J Food Sci. 2013 Sep;78(9):H1459-63.

[7] Olsen H, et al. Antiproliferative effects of fresh and thermal processed green and red cultivars of curly kale (Brassica oleracea L. convar. acephala var. sabellica). J Agric Food Chem. 2012 Aug 1;60(30):7375-83.

[8] Dosz EB, et al. Modifying the processing and handling of frozen broccoli for increased sulforaphane formation. J Food Sci. 2013 Sep;78(9):H1459-63.

[9] Fahey JW, et al. Broccoli sprouts: an exceptionally rich source of inducers of enzymes that protect against chemical carcinogens. Proc Natl Acad Sci U S A. 1997 Sep 16;94(19):10367-72.

Ghawi SK, et al. The potential to intensify sulforaphane formation in cooked broccoli (Brassica oleracea var. italica) using mustard seeds (Sinapis alba). Food Chem. 2013 Jun 1;138(2-3):1734-41.

[10] Egner PA, et al. Rapid and sustainable detoxication of airborne pollutants by broccoli sprout beverage: results of a randomized clinical trial in China. Cancer Prev Res (Phila). 2014 Aug;7(8):813-823.

[11] Messina M. Impact of Soy Foods on the Development of Breast Cancer and the Prognosis of Breast Cancer Patients. Forsch Komplementmed. 2016;23(2):75-80.

[12] Shu, Xiao Ou et al. “Soy food intake and breast cancer survival.” JAMA vol. 302,22 (2009): 2437-43.

[13] Study Finds, Soy Foods and Cruciferous Vegetables May Reduce Side Effects of Breast Cancer Treatment. AICR Blog. January 10, 2018. Available at Nomura SJO, et al. Dietary intake of soy and cruciferous vegetables and treatment-related symptoms in Chinese-American and non-Hispanic White breast cancer survivors. Breast Cancer Res Treat. 2018 Apr;168(2):467-479.

Study Finds, Soy Foods and Cruciferous Vegetables May Reduce Side Effects of Breast Cancer Treatment

[14] Reed KE, et al. 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.

Messina M. Soybean isoflavone exposure does not have feminizing effects on men: a critical examination of the clinical evidence. Fertil Steril. 2010 May 1;93(7):2095-104.

[15] Soy and Cancer: Myths and Misconceptions. AICR Blog by Karen Collins. February 19, 2019. Available at

https://www.aicr.org/resources/blog/soy-and-cancer-myths-and-misconceptions/Applegate CC, et al. Soy Consumption and the Risk of Prostate Cancer: An Updated Systematic Review and Meta-Analysis. Nutrients. 2018;10(1):40. Published 2018 Jan 4.

[16] Soy and Cancer: Myths and Misconceptions. AICR Blog by Karen Collins. February 19, 2019. Available at https://www.aicr.org/resources/blog/soy-and-cancer-myths-and-misconceptions/

[17] Demonty I, et al. Role of isoflavones in the hypocholesterolemic effect of soy. Nutr Rev. 2003 Jun;61(6 Pt 1):189-203.

[18] Gylling H, et al; European Atherosclerosis Society Consensus Panel on Phytosterols. Plant sterols and plant stanols in the management of dyslipidaemia and prevention of cardiovascular disease. Atherosclerosis. 2014 Feb;232(2):346-60.

Maki KC, et al. Lipid effects of a dietary supplement softgel capsule containing plant sterols/stanols in primary hypercholesterolemia. Nutrition. 2013 Jan;29(1):96-100.

[19] Expert Panel on Detection. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA 2001;285:2486–2497.

[20] Jenkins DJA, et al. Effects of a Dietary Portfolio of Cholesterol-Lowering Foods vs Lovastatin on Serum Lipids and C-Reactive Protein. JAMA. 2003;290(4):502–510.

[21] Khan SU, et al. Cardiovascular mortality after intensive LDL-Cholesterol lowering: Does baseline LDL-Cholesterol really matter? Am J Prev Cardiol. 2020 May 1;1:100013.