

The Tomato-Prostate Cancer Connection By Sharon Palmer, RD

Suggested CDR Learning Codes: 2000, 2020, 2090, 2100, 4040, 4170, 5150, 8090; Level 2

Armed with a \$400,000 grant from the National Institutes of Health (NIH), scientists from the University of Illinois and Ohio State University have been tracing how tomato compounds help reduce the risk of prostate cancer in humans. Using isotopic labeling of the three tomato carotenoids—lycopene, phytoene, and phytofluene—they're tracking the absorption and metabolism of these substances in the body, hoping to unlock the mysteries of how tomatoes seem to protect against prostate cancer.¹

The prospect that something as simple as eating tomatoes can help fend off prostate cancer is exciting. After all, the American Cancer Society estimates there will be almost 240,000 new cases of prostate cancer in the United States in 2013, resulting in about 30,000 deaths.²

"Most men are going to get prostate cancer if they live long enough," says John Erdman, PhD, professor emeritus of the department of food science and human nutrition at the University of Illinois who's been studying the effects of tomatoes on prostate cancer since the mid-1990s and is the co-lead researcher on the NIH-funded study. "Many men between 40 and 50 develop early-stage prostate cancer, and it may continue to develop over 20 years. It's important to reduce the growth of the tumor. If you can control this by diet so that the tumor doesn't get large enough to cause problems, you've saved a lot of lives."

This continuing education course reviews the nutrients tomatoes contribute to the diet and the research showing associations between tomato consumption and a reduced risk of prostate cancer. The practical applications of these findings, including strategies for increasing clients' intake of cancer-protective nutrients, also are presented.

Tomato Lovers

While, botanically speaking, the tomato (*Lycopersicon esculentum*) is a fruit, the USDA classifies it as a vegetable. Although the name derives from *tomati*, the word used by Mexican natives who consumed them since prehistoric times,³ tomatoes likely originated in South America, where Spanish explorers helped introduce them to other parts of the world.

As tomatoes were cultivated in countries spanning the world, they became an important element in many traditional dishes—from Mexican salsas to South Asian curries to Italian red sauces. Although the tomato is now the second most popular vegetable in the United States, behind the potato,⁴ it has only been widely embraced here during the the last two centuries. Previously, colonial Americans believed it to be poisonous because it is a member of the nightshade (*Solanaceae*) family, which includes many poisonous plants.

The advent of preservation through canning tomatoes led to an important, economical way to enjoy them all year long. About 75% of the entire tomato crop goes to processed products such as ketchup, canned tomatoes, paste, and tomato or pasta sauce.⁵

Nutrient Buzz

Tomatoes contain a variety of nutrients that may be responsible for tomatoes' cancer-protective properties, including vitamins A and C, fiber, and potassium, as well as carotenoids, which give tomatoes their red, yellow, and orange colors.⁵ The most abundant carotenoid found in tomatoes is lycopene, followed by phytoene, phytofluene, zeta-carotene, gamma-carotene, beta-carotene, neurosporene, and lutein.⁶

While lycopene is present in other fruits such as watermelon and guava, tomatoes account for 80% of the lycopene in the American diet. Research shows that single daily servings of processed tomato products produce significant increases of lycopene concentrations in blood and buccal mucosal cells in healthy adults.⁷ And evidence indicates that the lycopene from processed tomatoes is more bioavailable than that of fresh tomatoes. Processing breaks down the tomato cell matrix and promotes isomerization of lycopene from all-trans isomers to the more bioavailable form of cis-isomers.⁸

Erdman believes the cancer protection provided by tomatoes isn't merely due to lycopene. Compared to lycopene alone, more effective benefits have been linked with the whole tomato, which contains a full range of carotenoids and nutrients. "The work we've done so far with tomato powder is positive. We strongly feel that there are lots of goodies in tomatoes well beyond lycopene—for example, other carotenoids," he says.

According to Nancy Engelmann Moran, PhD, a postdoctoral researcher from Ohio State University who worked with Erdman and produced the isotopically labeled carotenoids for the study, tomato products are more effective than isolated lycopene because of other carotenoids such as phytoene and phytofluene, the colorless precursors to lycopene.

How do tomato products work to fight cancer? While lycopene has strong antioxidant capacity that may provide cancer protection, there may be other factors at play. "The metabolic products of carotenoids are vitamin A-like; we think they directly affect gene expression in a number of different pathways," Erdman says. "There also could be anti-inflammatory effects, alterations in cancer cell cycle, and/or there might be effects from an antioxidant response, but we don't think it's just antioxidants."

"Lycopene does seem to offer benefits both as an antioxidant and through direct impact on cancer cell growth and development," says Karen Collins, MS, RD, CDN, nutrition advisor for the American Institute for Cancer Research (AICR). "However, an important distinction is that research provides greater support for including tomatoes as part of a healthful diet and doesn't really support the use of lycopene supplements to reduce risk of prostate cancer."

Science on Tomatoes and Prostate Cancer

The tomato-prostate cancer connection is rooted in a body of observational population studies. "There's very good, strong, epidemiological support for increased consumption of tomato

products and lower incidence of prostate cancer,” Erdman says. “Animal models are fairly conclusive. We can’t make a direct correlation to humans, but a number of animal models have shown strong results.”

A small number of intervention trials focusing on tomato products has been performed, with positive results measuring improvements in prostate-specific antigen (PSA) concentrations 9-12 and increased cell death in carcinomas.¹³

Research published in ***Cancer Prevention Research*** also investigated the effects of lycopene on prostate cells and found that proteins most affected by lycopene exhibit cancer-protective properties, such as antioxidant activity and growth inhibition.¹⁴ A 2006 review in ***Current Opinion in Clinical Nutrition & Metabolic Care*** concluded that daily consumption of tomatoes or tomato products may protect DNA damage associated with prostate cancer pathogenesis.¹⁵

A meta-analysis focusing on the intake of tomatoes, tomato products, or lycopene, which included 11 case-control studies and 10 cohort studies or nested case-control studies, found that, compared with those who infrequently consumed tomato products, those who consumed high amounts of raw tomatoes had an 11% reduced risk of prostate cancer, and those with a high intake of cooked tomato products experienced a 19% lower risk.¹⁶

In the 2011 update of a summary of research on tomatoes/lycopene and disease risk, prostate cancer was identified as the subject of substantial research attention. Britt Burton-Freeman, PhD, director of the Center for Nutrition Research at the Illinois Institute of Technology, reviewed 86 studies related to tomato and lycopene intake and prostate cancer in her summary, reporting that, overall, the data supported a protective relationship between tomato and tomato-based foods consumption and a lower prostate cancer risk, but that lycopene supplementation doesn’t improve disease status, as measured by PSA levels.¹⁷

A 2013 study coauthored by Erdman and published in ***Cancer Prevention Research*** pointed out tomatoes’ bioactive, cancer-fighting, and health-protective qualities. In the study, mice that had been genetically engineered with an aggressive form of prostate cancer were fed one of four diets: one rich in tomatoes, another rich in soy, a third rich in both tomatoes and soy, and finally one containing neither soy nor tomatoes. The study found that mice fed the combination diet had the least risk of developing the disease followed by mice that were fed the tomato-rich diet. In fact, only 45% of the mice fed the combination diet and only 61% of the mice fed the tomato-rich diet developed disease.¹⁸

Tomatoes always have been a food that tastes better in combination with other ingredients: simmered with onions, olive oil, and basil in a sauce or eaten in a salad with green vegetables, for example. So it’s interesting to discover that antioxidant-rich foods, when combined with tomatoes, may have added cancer-protective effects.

Erdman found such effects when combining tomato powder with both broccoli powder and soy germ in rat studies.¹⁸⁻²⁰ “Research is definitely still ongoing and with mixed results in this area. But it does continue to show benefits in laboratory studies of animals, especially when

tomato powder is combined with broccoli powder, showing decreased development of prostate cancer,” Collins says.

Though human research is needed, Erdman reports many barriers. “It’s very difficult to do a clinical trial for prostate cancer. These studies take a lot of time and money,” he explains.

Additionally, he says a good biomarker to measure cancer risk is lacking. “PSAs are a hot debate in prostate cancer; levels can change if something has gone awry, such as an infection,” he notes. “A reduction in PSA isn’t proven to reduce the risk of prostate cancer.”

“This is a very challenging area,” Collins adds. “Prostate cancer studies are difficult to interpret because this disease takes so long to develop, with some types being very aggressive and others slow growing and possibly non-life threatening. Impact of tomato consumption may vary based on type and stage of this cancer, synergy with other foods, and the proportion consumed as processed tomatoes, which cause greater increase in body levels of lycopene,” she explains. “In interpreting studies on tomatoes and prostate cancer risk, we need to consider that they might provide particular benefit against very early formation of the disease because of compounds that are antioxidants and act in other ways to enhance normal controls on cell growth. Or they might act in later stages, impacting whether or not a slow-growing cancer becomes more advanced and aggressive.”

However, the evidence is promising enough for health organizations to promote the benefits of consuming tomato products for prostate cancer protection. In a comprehensive scientific analysis of cancer prevention and causation, an expert panel of scientists for the AICR reviewed more than 4,000 trials, studies, and reports to create the organization’s ***Second Expert Report — Food, Nutrition, Physical Activity, and the Prevention of Cancer: a Global Perspective***. The report noted a substantial amount of evidence on tomato products, and that food containing lycopene probably does protect against cancer, in particular providing a convincing decreased risk of prostate cancer.²¹

Studies also have shown that consuming tomato products can be an optimal whole-foods strategy for boosting prostate cancer protection, without any adverse effects on gastrointestinal health, total serum cholesterol, blood pressure, or total body weight. In an intervention trial published in the June 2013 issue of ***The British Journal of Nutrition***, African American male study participants were asked to consume one serving of tomato product each day during the intervention. Plasma levels of lycopene among male participants rose by 53% and 40% when measured at the one-month and three-month marks, respectively.²²

Incorporating Tomato Products Into the Diet

While there is more to learn about how tomatoes protect against prostate cancer, most experts agree it’s a good idea to recommend eating more of them as part of the overall strategy to increase fruit and vegetable intake.

“The research is still unclear, and it doesn’t support overdosing on tomatoes or overrelying on tomatoes as a strategy in itself,” Collins says. “This should be part of an overall health-promoting strategy that includes regular physical activity, maintaining a healthy weight, eating

a diet with an abundance of plant foods, and limiting red meat—especially meat cooked at high temperatures or to very well-done doneness, when carcinogens especially form.”

However, Collins does recommend that men incorporate lycopene-rich foods such as tomatoes into the diet, adding, “Regular consumption probably lowers risk of prostate cancer based on conclusions from the AICR expert report. The recommendation for tomatoes is as part of a healthful diet, including a wide variety of vegetables, fruits, whole grains, and beans. No food can supply all the protective compounds, and to take greatest advantage of synergy with nutrients and phytochemicals from other foods, variety is key.”

“One can’t say that you can treat or prevent prostate cancer with tomatoes, but two to three servings per week from an epidemiological standpoint appears to be enough,” Erdman says.

It generally isn’t difficult for people to consume two to three weekly servings of tomatoes or related products considering how popular tomatoes are in American diets. The following tips can help guide your patients and clients to increase their tomato intake:

Fresh Tomatoes

- Slice tomatoes for breakfast and serve them as a side with eggs, hash browns, or toast.
- Include fresh tomato slices in sandwiches, pitas, and wraps.
- Dice tomatoes for salsas and dips such as bruschetta.
- Add tomatoes to salads, tacos, pilafs, and pasta dishes.
- Try heirloom tomatoes from the farmers’ market or your own garden, which are delicious served au naturel.
- Prepare sliced tomatoes with basil and a drizzle of olive oil and black pepper.
- Pack cherry tomatoes for a portable snack or sack lunch component.
- Bake or broil tomato halves with a splash of olive oil and herbs.
- Grill fresh tomato halves or use cherry tomatoes on kebabs.
- Add cherry tomatoes to fresh vegetable platters.

Processed Tomatoes

- Stock the pantry with various (no-salt-added) tomato products, such as canned tomatoes, diced tomatoes, tomato sauce, pasta sauce, tomato soup, salsa, and ketchup.
- Serve tomato soup with meals.

- Make tomato-based vegetable soups with canned tomatoes—serve it hot in the winter and cold (think gazpacho) in the summer.
- Cook a pot of chili using canned tomatoes, beans, and diced vegetables.
- Serve whole grain pasta dishes with tomato sauce.
- Prepare traditional Mexican favorites such as enchiladas and tacos using tomato sauce or prepared salsa.
- Make baked pasta dishes such as lasagna with tomato sauce.
- Use the slow cooker to create a savory stew that includes canned tomatoes.
- Enjoy (no-salt-added) tomato or vegetable juice as a beverage.
- Bake a stewed tomato casserole with canned tomatoes, breadcrumbs, and herbs.
- Pour tomato sauce over favorite dishes such as chicken cacciatore, meatloaf, or Swiss steak.
- Try a creamy tomato-based curry with brown rice.
- Create a healthful pizza with whole grain crust, tomato sauce, and lots of veggies.
- Add canned tomatoes to grain dishes such as rice, couscous, quinoa, or bulgur.
- Enjoy sun-dried tomatoes as a snack or use in salads, vegetable platters, and cooking.

—*Sharon Palmer, RD is a plant-based diet expert, the author of **The Plant-Powered Diet** and **Plant-Powered for Life**, the editor of the **Environmental Nutrition** newsletter, and a contributing editor at **Today's Dietitian**.*

Nutrient Content of Canned Tomatoes

Tomatoes, red, ripe, canned, packed in tomato juice, no salt added (1 cup):

Calories: 41
 Total fat: 0.3 g
 Sodium: 24 mg
 Carbohydrates: 9.6 g
 Dietary Fiber: 2.4 g
 Protein: 1.9 g
 Vitamin A: 281 IU (6% Daily Value [DV])
 Vitamin C: 22.3 mg (37% DV)
 Vitamin E (alpha tocopherol): 1.6 mg (8% DV)
 Vitamin K: 7 mcg (9% DV)

Thiamin: 0.1 mg (7% DV)
Riboflavin: 0.1 mg (8% DV)
Niacin: 1.7 mg (9% DV)
Vitamin B6: 0.3 mg (13% DV)
Folate: 19 mcg (5% DV)
Pantothenic acid: 0.3 mg (3% DV)
Choline: 16.8 mg
Calcium: 74 mg (7% DV)
Iron: 2.3 mg (13% DV)
Magnesium: 26 mg (7% DV)
Phosphorus: 46 mg (5% DV)
Potassium: 451 mg (13% DV)
Zinc: 0.3 mg (2% DV)
Copper: 0.2 mg (8% DV)
Manganese: 0.2 mg (9% DV)
Lycopene: 6,641mcg

— Source: USDA National Nutrient Database for Standard Reference, Release 26

References

1. Stones M. Tomato compounds enlisted in fight against prostate cancer. Nutra Ingredients-USA.com website. <http://www.nutraingredients-usa.com/Research/Tomato-compounds-enlisted-in-fight-against-prostate-cancer>. December 2, 2010. Accessed March 16, 2012.
2. What are the key statistics about prostate cancer? American Cancer Society website. <http://www.cancer.org/cancer/prostatecancer/detailedguide/prostate-cancer-key-statistics>. Accessed October 8, 2013.
3. The tomato had to go abroad to make good. Aggie Horticulture website. <http://aggiehorticulture.tamu.edu/archives/parsons/publications/vegetabletravelers/tomato.html>. Accessed October 8, 2013.
4. Power up on tomatoes, the easy vegetable. Tomato Products Wellness Council website. <http://www.tomatowellness.com/static/uploads/Powerupontomatoes.pdf>. Accessed October 8, 2013.
5. Vegetable crops. Purdue University Department of Horticulture and Landscape Architecture website. <http://www.hort.purdue.edu/rhodcv/hort410/tomat/to00001.htm>. Accessed January 4, 2012.
- 6 Khachik F, Carvalho L, Bernstein PS, Muir GJ, Zhao DY, Katz NB. Chemistry, distribution, and metabolism of tomato carotenoids and their impact on human health. *Exp Biol Med (Maywood)*. 2002;227(10):845-851.

7. Allen CM, Schwartz SJ, Craft NE, Giovannucci EL, De Gross VL, Clinton SK. Changes in plasma and oral mucosal lycopene isomer concentrations in healthy adults consuming standard servings of processed tomato products. **Nutr Cancer**. 2003;47(1):48-56.
8. Shi J, Le Maguer M. Lycopene in tomatoes: chemical and physical properties affected by food processing. **Crit Rev Biotechnol**. 2000;20(4):293-334.
9. Chen L, Stacewicz-Sapuntzakis M, Duncan C, et al. Oxidative DNA damage in prostate cancer patients consuming tomato sauce-based entrees as a whole-food intervention. **J Natl Cancer Inst**. 2001;93(24):1872-1879.
10. Bowen P, Chen L, Stacewicz-Sapuntzakis M, et al. Tomato sauce supplementation and prostate cancer: lycopene accumulation and modulation of biomarkers of carcinogenesis. **Exp Biol Med (Maywood)**. 2002;227(10):886-893.
11. Grainger EM, Schwartz SJ, Wang S, et al. A combination of tomato and soy products for men with recurring prostate cancer and rising prostate specific antigen. **Nutr Cancer**. 2008;60(2):145-154.
12. Edinger MS, Koff WJ. Effect of the consumption of tomato paste on plasma prostate-specific antigen levels in patients with benign prostate hyperplasia. **Braz J Med Biol Res**. 2006;39(8):1115-1119.
13. Kim HS, Bowen P, Chen L, et al. Effects of tomato sauce consumption on apoptotic cell death in prostate benign hyperplasia and carcinoma. **Nutr Cancer**. 2003;47(1):40-47.
14. Qiu X, Yuan Y, Vaishnav A, Tessel MA, Nonn L, van Breemen RB. Effects of lycopene on protein expression in human primary prostatic epithelial cells. **Cancer Prev Res (Phila)**. 2013;6(5):419-427.
15. Ellinger S, Ellinger J, Stehle P. Tomatoes, tomato products and lycopene in the prevention and treatment of prostate cancer: do we have the evidence from intervention studies? **Curr Opin Clin Nutr Metab Care**. 2006;9(6):722-727.
16. Etminan M, Takkouche B, 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;13(3):340-345.
17. Burton-Freeman B. Summary of research on tomatoes/lycopene and disease risk, 2011 update. <http://tomatowellness.com/report2011/index.html>. Accessed March 12, 2012.
18. Zuniga KE, Clinton SK, Erdman JW Jr. The interactions of dietary tomato powder and soy germ on prostate carcinogenesis in the TRAMP model. **Cancer Prev Res (Phila)**. 2013;6(6):548-557.

19. Canene-Adams K, Lindshield BL, Wang S, Jeffery EH, Clinton SK, Erdman JW Jr. Combinations of tomato and broccoli enhance antitumor activity in dunning r3327-h prostate adenocarcinomas. **Cancer Res**. 2007;67(2):836-843.
20. Zuniga KE, Erdman JW Jr. Combined consumption of soy germ and tomato powders results in altered isoflavone and carotenoid bioavailability in rats. **J Agric Food Chem**. 2011;59(10):5335-5341.
21. Food, nutrition, physical activity, and the prevention of cancer: a global perspective. World Cancer Research Fund/American Institute for Cancer Research website. <http://www.dietandcancerreport.org>. Accessed March 20, 2012.
22. Park E, Stacewicz-Sapuntzakis M, Sharifi R, Wu Z, Freeman VL, Bowen PE. Diet adherence dynamics and physiological responses to a tomato product whole-food intervention in African-American men. **Br J Nutr**. 2013;109(12):2219-2230.

Examination

1. The National Institutes of Health recently funded a study that will do which of the following?

- A. Test the effects of tomato consumption on prostate-specific antigen levels in men
- B. Track the metabolism and absorption of tomato carotenoids in humans
- C. Trace the absorption of lycopene in rats
- D. Measure the levels of lycopene in foods

2. Tomatoes contain which of the following important nutrients?

- A. Vitamins A and C, fiber, potassium, and carotenoids
- B. Lycopene, vitamin E, and magnesium
- C. Anthocyanins and vitamin C
- D. Protein, potassium, and lycopene

3. The cancer-protective effects of tomatoes appear to be related only to their lycopene content.

- A. True
- B. False

4. According to research, foods that may have synergistic cancer-protective effects with tomatoes include which of the following?

- A. Potatoes and oranges
- B. Pasta and carrots
- C. Broccoli and soy
- D. Squash and apples

5. A meta-analysis focusing on the intake of tomatoes, tomato products, or lycopene found that those who consumed a high intake of cooked tomato products had what percentage lower risk of prostate cancer when compared with those who infrequently consumed tomato products?

- A. 5
- B. 7
- C. 11
- D. 19

6. New studies indicate that tomatoes may fight prostate cancer through which of the following mechanisms?

- A. Reducing oxidative stress and inflammation, and altering gene expression
- B. Reducing body weight
- C. Lowering blood cholesterol levels
- D. Lowering insulin levels

7. Based on the current scientific evidence, at least how many weekly servings of tomato products may you recommend to patients and clients for possible prostate cancer prevention?

- A. One
- B. Two
- C. Four
- D. Five

8. Processed tomato products may be a better option than fresh tomatoes for prostate cancer prevention for which of the following reasons?

- A. They're easier to digest.
- B. They're lower in minerals that may interfere with lycopene absorption.
- C. They're less expensive than fresh tomatoes.
- D. The lycopene in processed tomato products is more bioavailable.

9. Which of the following is the best advice you can give patients and clients about eating tomato products to help fight prostate cancer?

- A. Eat as many tomato products as possible.
- B. Include two to three servings of tomato products per week as part of an overall healthful diet and lifestyle even though the research isn't conclusive.
- C. The research is unclear, so don't try to cure prostate cancer by eating tomato products.
- D. Avoid tomato products because they're not proven to cure prostate cancer.

10. How do tomato products help patients and clients increase their intake of cancer-protective carotenoids?

- A. They have the highest source of carotenoids in the plant kingdom.
- B. They increase plasma lycopene levels without side effects.
- C. There is an FDA-approved health claim regarding their link to cancer protection.