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Tomatoes and lycopene in the athletes' diet
Roşiile şi licopenul în dieta sportivilor

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Abstract

Unlike other groups of food, tomatoes have not only a nutritional value, but they also contain a large group of secondary components (such as lycopene), non-nutritive, which give them the extraordinary organoleptic diversity and benefic pharmacological qualities.

While eating fruits and vegetables raw is more nutritional, cooking sweet tomatoes increases the amount of lycopene that our body can absorb.

Because of the antioxidant activity, consuming tomatoes may help to prevent or treat certain health conditions, including high cholesterol, heart disease and certain types of cancer.

Moreover, in sportsmen, a diet rich in tomatoes juice has a potential antioxidant effect and may significantly reduce the serum concentration of 8-oxo-dG (8-Oxo-2'-deoxyguanosine), a sensitive marker of oxidative stress. Also, tomatoes can help ease fatigue from exercise, by lowering TGF-ss, a well-known indicator of exercise-related fatigue, a type of cytokine, a protein molecule used specifically for intercellular communication.

Key words: tomato, lycopene, effects, health, athletes.

Rezumat

Spre deosebire de alte grupe de alimente, roşiile nu au doar o valoare nutritivă, dar conţin şi o serie de componente secundare (cum este licopenul), non-nutritive, care le dau o extraordinară diversitate organoleptică şi calităţi farmacologice benefice.

În timp ce consumul celor mai multe fructe şi legume se recomandă a se face în stare crudă, pentru a le păstra cea mai mare valoare nutritivă, prepararea termică a roşiilor duce la creşterea cantităţii de licopen utilizat digestiv.

Datorită activităţii antioxidante, consumul de roşii poate preveni sau trata unele afecţiuni, cum ar fi hipercolesterolemia, bolile de inimă sau unele tipuri de cancer.

În plus, la sportivi, o dietă bogată în suc de roşii are un potenţial efect antioxidant şi poate reduce semnificativ concentraţia serică de 8-oxo-dG (8-Oxo-2'-deoxyguanosine), un marker sensibil al stresului oxidativ. De asemenea, roşiile ar putea să reducă oboseala consecutivă exerciţiului fizic, prin scăderea concentraţiei de TGF (transforming growing factor), un cunoscut indicator al oboselii de după exerciţiu, un tip de citokină proteică folosită în comunicarea intercelulară.

Cuvinte cheie: roşii, licopen, efecte, sănătate, sportivi.

General considerations

People know a lot about food and nutrition, since Hippocrates, but they still do not know enough. Nowadays, in the most developed world, the increase of non-communicable chronic diseases associated with dietary and lifestyle changes, reduced physical activity and increased urbanization still remains a major challenge for society. For some chronic diseases, such as type 2 diabetes, cardiovascular disease, some cancers, and a range of inflammation-associated conditions, certain phytochemicals and plant-based foods could reduce the incidence and progression (Diamond, 2011). Moreover, athletes might benefit from the antioxidant effects of plants such as tomatoes (Martin et al., 2011; Martin et al., 2013).

Unlike other groups of food, fruits and vegetables have not only a nutritional value, but they also contain a large group of secondary non-nutritive components, which give them the extraordinary organoleptic diversity and beneficial pharmacological qualities. One of the most amazing plants is tomato, also called over the years "love apple", "golden apple," "apple of paradise" or even "devil apple".

Tomatoes are members of the nightshade family (plants which have developed a means of defending themselves against predators). The family is also known as the potato family or *Solanaceae*. This flowering family contains many plants used by humans as food, spice and medicine, and many poisonous plants.

The plants from this family produce a toxic substance (alkaloidal glycosides, or simply alkaloids) to protect themselves from being eaten. The toxin produced is in small amounts, so usually extremely harmful only to small creatures, such as bugs and insects. As far as humans are concerned, these alkaloids can be desirable, toxic, or both, though they have presumably evolved because they have

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reduced the tendency of animals to eat the plants.

The family includes Datura or Jimson weed, Mandragora (mandrake), Atropa belladonna (deadly nightshade), Lycium barbarum (wolfberry), Physalis philadelphica (tomatillo) , Physalis peruviana (Cape gooseberry flower), Capsicum (chili pepper, bell pepper, paprika), Solanum (potato, tomato, eggplant), Nicotiana (tobacco), and Petunia. With the exception of tobacco (Nicotianoideae) and petunia (Petunioideae), most of the economically important genera are contained in the subfamily Solanoideae.

The leaves, stems, and green unripe fruit of the tomato plant contain small amounts of the toxic alkaloid tomatine (a glycoalkaloid with antifungal properties and a higher toxic impact on dogs than on humans) (McGee, 2009; Brevitz, 2004).

They also contain solanine, a toxic alkaloid found in potato leaves and other plants of the nightshade family (Barceloux, 2009; Stimekova, 2006). The use of tomato leaves for tea (tisane) has been responsible for at least one death (McGee, 2009; Barceloux, 2009). However, tomatine levels in foliage and green fruit are generally too low to be dangerous unless large amounts are consumed, for example, as greens. Small amounts of tomato foliage are sometimes used for flavoring without ill effect, and the green fruit is sometimes used for cooking, particularly as fried green tomatoes, a delicacy in restaurants (McGee, 2009). Compared to potatoes, the amount of solanine in green or ripe tomatoes is low (1).

The toxicity of these alkaloids for humans and animals ranges from mildly irritating (allergic reaction, or food sensitivity) to fatal in small quantities, so it is wise for some individuals to avoid them (8).

In 1753, Linnaeus placed the tomato in the genus *Solanum* (alongside the potato) as *Solanum lycopersicum*. In 1768, Philip Miller moved it to its own genus, naming it *Lycopersicon esculentum* (6).

This name came into wide use, but was in breach of the plant naming rules. Technically, the combination *Lycopersicon lycopersicum* (L.) H. Karst. would be more correct, but this name (published in 1881) has hardly ever been used, except in seed catalogs, which frequently used it and still do (7).

The scientific epithet *lycopersicum* means "wolf peach", and comes from German werewolf myths. These legends said that deadly nightshade was used by witches and sorcerers in potions to transform themselves into werewolves, so the tomato's similar, but much larger fruit was called the "wolf peach" when it arrived in Europe (Hammerschmidt & Franklin, 2005).

The Aztecs called the fruit *xitomatl*, meaning "something round and plump". Other Mesoamerican peoples, including the Nahuas (Aztec language), took the name as *tomatl*, from which most western European languages derived their names for "tomato". However, the Italian word, *pomodoro* (from *pomo d'oro* "apple of gold") was borrowed into Polish, and via Russian, into several other languages. Similarly, the now rare German term *Paradeisapfel* (for "apple of paradise") is still heard in the form *paradeiser* in Bavarian and Austrian dialects, and was borrowed into modern Hungarian, Slovenian and Serbian.

Botanically, a tomato is a fruit: the ovary, together with its seeds, of a flowering plant. However, the tomato has a much lower sugar content than other edible fruits, and is therefore not as sweet, although some tomato varieties do taste sweet.

Typically served as part of a salad or main course of a meal, rather than as a dessert, it is considered a vegetable for most culinary uses. One exception is that tomatoes are treated as a fruit in home canning practices: they are acidic enough to process in a water bath rather than a pressure cooker as vegetables require. Tomatoes are not the only food source with this ambiguity: green beans, eggplants, cucumbers, and squashes of all kinds (such as zucchini and pumpkins) are all botanically fruits, yet cooked as vegetables.

The first tomatoes can be traced back to the Andes in Peru, where they grew wild as cherry-sized berries. Aztecs and other peoples in Mesoamerica used the fruit in their cooking. The exact date of domestication is unknown: by 500 BC, it was already cultivated in southern Mexico and probably other areas.

During a long period, the tomato was considered poisonous, and it took nearly 200 years for the tomato to be one of the largest commercial crops in North America, then in Europe.

By the end of the 19th century, in the 1893 U.S. Supreme Court case of "Nix v. Hedden," the tomato was declared a vegetable, along with cucumbers, squashes, beans and peas. In the 20th century, tomatoes were believed to have "medicinal virtues".

The fact that tomatoes were once considered poisonous is a particularly ironic fact in light of recent scientific research supporting their many health benefits.

Freshly picked tomatoes are one of the great fruits of summer, and now they are recognized for their nutritional and health benefits, due to their phytochemicals (chemicals produced by plants that may affect health, but are not essential nutrients). They occur naturally in plants (phyto = "plant" in Greek), and are responsible for color and organoleptic properties, such as the deep purple of blueberries and smell of garlic (Liu, 2004).

Phytochemicals help plants defend themselves against environmental challenges, such as damage from pests or ultraviolet light, and appear to provide humans with protection as well.

Some scientists estimate that there may be as many as 10,000 different phytochemicals having health effects, while others estimate that up to 40,000 phytochemicals will someday be fully catalogued and understood. Over just the last 30 years, many hundreds of these compounds have been identified and are currently being investigated for their health-promoting qualities (Park et al., 2009).

The many phytochemicals work differently. Most of them have *antioxidant* activity and protect our cells against oxidative damage and reduce the risk of developing certain types of cancer (e.g. allyl sulfides from onions, leeks, garlic; carotenoids; flavonoids from fruits and vegetables; polyphenols from tea and grapes).

Others have a *hormonal action* (isoflavones, found in soy, imitate human estrogens and help to reduce menopausal symptoms and osteoporosis).

Another possible action is *stimulation of enzymes* (indoles, from cabbages, stimulate enzymes that make the estrogen less effective and could reduce the risk for breast cancer; other phytochemicals, which interfere with enzymes, are protease inhibitors from soy and beans, and terpenes from citrus fruits and cherries).

Saponins from beans *interfere with the replication of cell DNA*, thereby preventing the multiplication of cancer cells. Capsaicin, found in hot peppers, protects DNA from carcinogens.

The phytochemical allicin from garlic has *antibacterial properties*.

Some phytochemicals bind physically to cell walls, thereby *preventing the adhesion of pathogens to human cell walls*. Proanthocyanidins from cranberry will reduce the risk of urinary tract infections and will improve dental health.

Phytochemicals are classified by their chemical structure and categorized into families based on similarities in their structures: *phenols*, or polyphenols (*anthocyanidins* and *catechins*); *flavonoids* (isoflavones); *organosulfur compounds* (glucosinolates and indoles from brassica vegetables like broccoli, and allylic sulfides from garlic and onions); o*rganic acids* (some powerful antioxidants, like ferulic acid, which is found in whole grains), and *carotenoids*.

Carotenoids are a class of more than 600 naturally occurring pigments synthesized by plants, algae, and photosynthetic bacteria. These richly colored molecules are the sources of the yellow, orange, and red colors of many plants (Yeum & Russell, 2002).

Fruits and vegetables provide most of the carotenoids in the human diet. Carotenoids can be broadly classified into two classes, *carotenes* (alpha-carotene, beta-carotene, and lycopene) and *xanthophylls* (beta-cryptoxanthin, lutein, and zeaxanthin). Alpha-carotene, beta-carotene, and beta-cryptoxanthin are provitamin A carotenoids, meaning they can be converted by the body to retinol (vitamin A). Lutein, zeaxanthin, and lycopene have no vitamin A activity.

Lutein and zeaxanthin are the only carotenoids found in the retina and lens of the eye. The results of epidemiological studies suggest that diets rich in lutein and zeaxanthin may help slow the development of age-related macular degeneration and cataracts, but it is not known whether lutein and zeaxanthin supplements will slow the development of these age-related eye diseases (Krinsky et al., 2003).

Metabolism and bioavailability of carotenoids

Carotenoids in foods are mainly in the *all-trans* form, although cooking may result in the formation of other isomers. The relatively low bioavailability of carotenoids from most foods compared to supplements is partly due to the fact that they are associated with proteins in the plant matrix (Yeum & Russell, 2002). Chopping, homogenizing (puréeing), and cooking carotenoid-containing vegetables in oil generally disrupt the plant matrix, increasing the bioavailability of carotenoids they contain (Dewanto et al., 2002; Van Het Hof et al., 2000). The bioavailability of lycopene from tomatoes is substantially improved by heating tomatoes in oil (Gartner et al., 1997; Stahl et al., 1997).

For dietary carotenoids to be absorbed intestinally, they must be released from the food matrix and incorporated into mixed micelles (mixtures of bile salts and several types of lipids) (Yeum & Russell, 2002). Therefore, carotenoid absorption requires the presence of fat in a meal. As little as 3-5 g of fat in a meal appears sufficient to ensure carotenoid absorption (Van Het Hof et al., 2000).

Because they do not need to be released from the plant matrix, carotenoid supplements (in oil) are more efficiently absorbed than carotenoids in foods (Van Het Hof et al., 2000). Within the cells that line the intestine (enterocytes), carotenoids are incorporated into triglyceride-rich lipoproteins called chylomicrons and released into the circulation (Yeum & Russell, 2002). Triglycerides are depleted from circulating chylomicrons through the activity of an enzyme called lipoprotein lipase, resulting in the formation of chylomicron remnants. Chylomicron remnants are taken up by the liver, where carotenoids are incorporated into lipoproteins and secreted back into the circulation. In the intestine and the liver, provitamin A carotenoids may be cleaved to produce retinol, a form of vitamin A. The conversion of provitamin A carotenoids to vitamin A is influenced by the vitamin A status of the individual (During & Harrison, 2004). Although the regulatory mechanism is not yet clear in humans, cleavage of provitamin A carotenoids appears to be inhibited when vitamin A stores are high.

Carotenoids have many biological *activities*:

- *vitamin A activity*: orange and yellow vegetables like carrots and winter squash are rich sources of alpha- and beta-carotene. Spinach is also a rich source of beta-carotene, although the chlorophyll in spinach leaves hides the yellow-orange pigment (***, 2000).

- *antioxidant activity*: in plants, carotenoids have the important antioxidant function of quenching (deactivating) singlet oxygen, an oxidant formed during photosynthesis (Halliwell & Gutteridge, 1999). Test tube studies indicate that carotenoids can also inhibit the oxidation of fats (i.e., lipid peroxidation) under certain conditions, but their actions in humans appear to be more complex (Young & Lowe, 2001). At present, it is unclear whether the biological effects of carotenoids in humans are a result of their antioxidant activity or other non-antioxidant mechanisms.

- *light filtering*: the long system of alternating double and single bonds common to all carotenoids allows them to absorb light in the visible range of the spectrum (Halliwell & Gutteridge, 1999). Reducing the amount of blue light that reaches the critical visual structures of the eye, where lutein and zeaxanthin are abundant, may protect them from light-induced oxidative damage (Krinsky et al., 2003).

- *intercellular communication*: carotenoids can facilitate communication between neighboring cells grown in culture by increasing the expression of the gene encoding a connexin protein (Bertram, 1999). Connexins form pores (gap junctions) in cell membranes, allowing cells to communicate through the exchange of small molecules. This type of intercellular communication is important for maintaining cells in a differentiated state and is often lost in cancer cells (Stahl et al., 1997).

- *immune system activity*: because vitamin A is essential for normal immune system function, it is difficult to determine whether the effects of provitamin A carotenoids are related to their vitamin A activity or other activities of carotenoids. Although some clinical trials have found that beta-carotene supplementation improves several biomarkers of immune function, increasing intakes of lycopene and lutein - carotenoids without vitamin A activity - have not resulted in similar improvements in biomarkers of immune function (Corridan et al., 2001).

Lycopene

Lycopene, an acyclic isomer of β-carotene, without provitamin-A activity, is a red natural pigment that is synthesized by plants and microorganisms but not by animals. In its natural state, lycopene is a highly unsaturated, long straight chain hydrocarbon containing 11 conjugated and two non-conjugated double bonds. The conjugated bonds allow it to absorb light and "quench" free radicals. A study published in "Archives of Biochemistry and Biophysics" demonstrated that lycopene was the most efficient biological scavenger of singlet oxygen free radicals, which are commonly produced during cellular metabolism. In fact, lycopene may be the most powerful carotenoid quencher of singlet oxygen (Di Mascio et al., 1989), being 100 times more efficient in test tube studies of singlet-oxygen quenching action than vitamin E, which in turn has 125 times the quenching action of (water soluble) glutathione. Singlet oxygen produced during exposure to ultraviolet light is a primary cause of skin aging (Berneburg et al., 1999).

Ingested lycopene travels in the blood and accumulates in the liver, skin, blood serum, adrenal glands, prostate gland and colon.

Lycopene gives tomatoes, apricots, pink grapefruit, rose hips, watermelon, and guava their red color. Lycopene is the most represented carotenoid in tomato, accounting for above 90% of all carotenoids and it is one of the major carotenoids in the Western diet. Tomatoes are considered the richest food sources of lycopene (it has been estimated that 80% of lycopene in the diet comes from tomatoes and tomato products such as tomato sauce, tomato paste, and ketchup). Lycopene can also be taken in supplemental form (Agarwal, 2001).

Some foods that are good sources of lycopene are listed in Table I (4).

Table I

Lycopene content of selected foods

Food	Serving	Lycopene (mg)
Tomato paste, canned	1 cup	75.4
Tomato purée, canned	1 cup	54.4
Tomato soup, canned, condensed	1 cup	26.4
Vegetable juice cocktail, canned	1 cup	23.3
Tomato juice, canned	1 cup	22.0
Watermelon, raw	1 wedge (1/16 of a melon that is 38 cm long x 19 cm in diameter)	13.0
Tomatoes, raw	1 cup	4.6
Ketchup	1 tablespoon	2.5
Pink grapefruit, raw	½ grapefruit	1.7
Baked beans, canned	1 cup	1.3

Like in the other carotenoids, naturally occurring geometrical isomers of lycopene are primarily (95%) in a linear configuration (all-*trans* configuration) with few exceptions. However, *cis*-isomers (a bent shape) of lycopene represent approximately 50% of total lycopene in blood and up to 80% in prostate tissues (Norrish, 2000). The all-trans configuration is a structure that hinders the molecule's absorption through the intestinal walls and into the blood stream, so all-trans-lycopene is isomerized in the body or is less bioavailable.

So, *cis*-isomers are more bioavailable than all-*trans*-lycopene, most likely because of the greater solubility of *cis*-isomers in the bile acid micelles, a shorter chain length to fit into micelles, and the lower tendency to aggregate (Rao & Rao, 2007). Even an "in cell" isomerization has also been hypothesized (Yeum & Russell, 2002). The mechanisms explaining the isomerization of all-*trans* to *cis*-lycopene isomers *in vivo*, and the physiological importance of *cis*-lycopene are not fully understood. During food processing, lycopene may isomerize to *cis*-isoforms with the presence of heat and/or oil, or during dehydration. Moreover, during storage and/or processing, lycopene undergoes further geometrical isomerization, mainly *cis*- to *trans* retro-isomerization. With long heating times or temperatures above 50 °C, degradation proceeds faster than isomerization, the stability of lycopene isomers decreases in the order: 5-*cis* > all-*trans* > 9-*cis* > 13-*cis* > 15-*cis* > 7-*cis* > 11-*cis*. Starting from all-*trans*-lycopene, isomerization is characterized first by the formation and then by the disappearance of the unstable 13-*cis*-isomer. It is clear that isomerization and degradation are competitive and contemporaneous processes.

Lycopene in tomato paste is four times more bioavailable than in fresh tomatoes. For this reason, tomato sauce is a preferable source as opposed to raw tomatoes (Gartner et al., 1997; Kirsh et al., 2006) (2).

In order to gain the benefits of lycopene, the body somehow transforms lycopene molecules through reactions that have yet to be identified, so that lycopenes are able to be absorbed into the blood and transported to tissue, or they must be bent prior to ingestion. Heating red tomatoes and adding oils during processing has the potential of creating a sauce that contains the bent molecular forms of lycopene.

While eating fruits and vegetables raw is the best way to extract the most nutritional content (cooking most fruits and vegetables typically removes a significant amount of the vitamin and mineral content), sweet tomatoes are unique because, unlike most fruits and vegetables, cooking sweet tomatoes actually increases the amount of lycopene that our body can absorb. The amount of lycopene available to the body is increased when tomatoes are processed. Up to 15 minutes of cooking will continue to increase the absorption of lycopene, but there is no increased benefit for longer cooking times (Giovannucci, 2002; Giovannucci et al., 2002).

Heart benefits

Lycopene is a powerful antioxidant that helps protect against heart disease: it reduces health risks associated with high cholesterol - atherosclerosis (lycopene stops LDL cholesterol from being oxidized by free radicals and cannot be deposited in the plaques that narrow and harden the arteries). When taken in doses of 25 mg or more daily, lycopene reduced LDL cholesterol by 10 percent, which was comparable to the effect of low doses of statins in patients with slightly elevated cholesterol levels (Ried & Fakler, 2011). The results concluded that when taken in doses of 25 mg or more daily, lycopene reduced total cholesterol by 7.55mg/dl and LDL cholesterol by 10.35mg/dl. Lycopene helps treat and prevent heart disease also by reducing inflammation and reducing the risk of blood clots, even in low doses.

According to Reid and Fakler, 25 mg of daily lycopene helped reduce blood pressure in research studies, while lower amounts of this nutrient did not improve this condition. More research is needed to confirm the suggested beneficial effects on total serum cholesterol and systolic blood pressure.

Bone benefits

The National Institute of Health reports that, although osteoporosis is most common in post-menopausal women, men experience it as well. Osteoporosis is a bone disease that leads to deterioration of bone tissue and breakdown of bone mass, increasing the chance of hip, wrist and spine fractures. Researchers from Canada investigated the effects of lycopene on osteoporosis and found that subjects with higher levels of lycopene in their systems had lower levels of oxidative stress and bone turnover rate, so lycopene is beneficial for the prevention of osteoporosis (Rao, 2007).

Some studies have demonstrated that oxidative stress is a key modulator of bone cell function and that oxidative status influences the pathophysiology of bone. Endurance exercise is effective for antioxidant enzyme activity enhancement and bone formation enhancement. On the other hand, lycopene is a carotenoid that has a higher antioxidant capability to reduce oxidative stress caused by exercise. In addition, several studies have reported that lycopene is effective for suppressing bone resorption. The results suggest that lycopene intake exhibited a positive effect on bone strength but not on bone mineral density (Kakutani et al., 2011).

Common cold benefits

Lycopene in watermelon may also ease common cold symptoms, as well as asthma and upper and lower respiratory infections caused by rhinovirus. One of the most common symptoms of rhinovirus infection is inflammation of the airways. Researchers at the University of Newcastle in Australia tested the effects of lycopene on cells inflamed and infected by rhinovirus and the results of the study showed that lycopene was able to reduce airway inflammation (Saedisomeolia et al., 2009).

Anticancer benefits

Lycopene has potent anticancer benefits, it stops the growth and development of cancer cells in prostate, breast and endometrial cancer, with the strongest effect on prostate cancer (Peters et al., 2007). Lycopene's anticancer actions stem from its strong antioxidant content. It is not clear whether lycopene itself is protective. Studies suggest that lycopene is one factor involved in reducing the risk of prostate cancer (Haseen et al., 2009; Zuniga et al., 2013). Since tomatoes also contain vitamins, potassium, and other carotenoids and antioxidants, other compounds in tomatoes may account for some of the protective effects first thought to be due to lycopene. These compounds may act alone or in conjunction with lycopene. When researchers look at large population groups with different lifestyles and habits, it is also possible that their findings can be explained by other factors that were not examined (Campbell et al., 2004).

To test whether lycopene is the main cancer-fighting substance in tomatoes, one animal study compared lycopene supplements to powdered tomatoes. The groups of rats that were fed tomato powder were compared to rats receving lycopene. The rats that received tomato powder had a much lower cancer risk, whereas the rats receiving lycopene supplements did not differ significantly from the group that received no special supplements (3).

The results of several prospective cohort studies suggest that lycopene-rich diets are associated with significant reductions in the risk of prostate cancer, particularly more aggressive forms (lycopene improved symptoms and halted the progression of prostate enlargement), and cervical cancer (Giovannucci, 2005). However, dietary lycopene intake was not related to prostate cancer risk in a prospective study on more than 58,000 Dutch men (Schuurman et al., 2002). A meta-analysis that combined the results of 11 case-control and ten prospective studies found that men with the highest intakes of dietary lycopene or tomatoes had modest, 11-19% reductions in prostate cancer risk (Etminan et al., 2004). Another study in a cohort of 29,361 men monitored for 4.2 years found no association between dietary lycopene intake and prostate cancer risk (Kirsh et al., 2006). Additionally, a large prospective study found no association between plasma concentrations of lycopene, or plasma concentrations of total carotenoids, and the overall risk of prostate cancer (Key et al., 2007). While there is considerable scientific interest in the potential for lycopene to help prevent prostate cancer, it is not yet clear whether the prostate cancer risk reduction observed in some epidemiological studies is related to lycopene itself, other compounds in tomatoes or other factors associated with lycopene-rich diets. To date, results of short-term dietary intervention studies using lycopene in prostate cancer patients have been promising (Dahan et al., 2008). Yet, the safety and efficacy of the long-term use of lycopene supplements for prostate cancer prevention or treatment are not known (Dahan et al., 2008). Large-scale, controlled clinical trials would be needed to address these issues.

In a clinical study published in 2008 in "Journal of Nutrition," the authors found that men with benign prostate hyperplasia who took lycopene supplements for six months experienced decreased levels of prostate-specific antigen, a marker of the disease (Schwarz, 2008).

Lycopene and lung function

It has been suggested that exercise-induced bronchoconstriction may involve oxidative stress. Strenuous exercise promotes free radical production, which can lead to many of the pathophysiological changes associated with asthma, including bronchoconstriction, mucus secretion, and microvascular leakage (Mannisto et al., 2004). Lycopene has been shown to have high antioxidative activity. Lycopene supplementation has no effect on airway hyperreactivity and inflammation in young athletes who complain of difficulty in breathing related to physical exertion (Falk et al., 2005; Gallicchio et al., 2008).

Macular degeneration

Although evidence is limited, consumption of lycopene may protect against macular degeneration by antioxidant and light-screening mechanisms. Lycopene and other carotenoids might also be useful in the treatment of glaucoma (Khachik et al., 2002).

Tomatoes, lycopene and physical activity

Reactive oxygen species (ROS) that include oxygen ions, hydroxyl ions and peroxides play an important role in the development of cancer and aging. They react with cell components such as proteins, lipids, and DNA and bring about chemical modifications in the cells, causing what is known as oxidative stress.

Oxidative stress induced DNA damage is measured by the concentration of 8-Oxo-2'-deoxyguanosine (8-oxo-dG) present within the cell.

Many scientific data strongly suggest that tomato juice has a potential antioxidant effect and may significantly protect the nucleotide pool of the DNA from ROS produced in response to extensive physical activity, reducing the elevated level of ROS induced by oxidative stress. The results indicated that a daily intake of tomato juice (150 ml), equal to 15 mg lycopene per day, reduced the serum level of 8-oxodG (a sensitive marker of oxidative stress) after extensive physical exercise (Harms-Ringdahl et al., 2012; Wagner et al., 2010; Rolland Y et al., 2010).

Recently, it has been found that tomatoes can also help ease fatigue from exercise. The key to maximizing the effects of tomato juice is drinking it at the right time. According to a study, drinking tomato juice before or during exercise can help ease fatigue caused by these activities. The key factor in the experiment was TGF-ss (Transforming Growth Factor), a protein produced by the body. This substance is a well-known indicator of exercise-related fatigue. Researchers are aware that the amount of this protein increases remarkably after physical activity. Scientists had mice exercise for one hour and measured the amount of TGF-ss in their blood plasma six hours later. Some mice were given tomato juice an hour before or during the physical activity (0.3 milliliters to 1 milliliter of tomato juice was given to each mouse), while others were given water (8).

The researchers found that post-exercise blood TGF-ss levels increased less in mice that received tomato juice than in those that received water. TGF-ss, which is secreted from immune cells, is a type of cytokine or protein molecule used specifically for intercellular communication. It is believed that the substance is associated with transmitting signals of physical fatigue caused by exercise within the body. The level of TGF-ss is reported to increase in the bloodstream of patients suffering from chronic fatigue syndrome. The results of another animal study showed that mice whose brain was injected with TGF-ss began to move more slowly.

Tomato juice is believed to help ease fatigue not only in runners, but also in people who practice moderate forms of exercise such as walking. It is widely known that active people are less prone to lifestyle-related disease than those who are inactive. It is also widely known that walking for exercise provides many health benefits, such as obesity prevention (Doyle, 2006; Kushi et al., 2006).

Scientists also found that tomatoes contain a substance that is said to be able to activate DNA associated with the burning of fat in our body, namely (13-oxo-ODA), a special type of unsaturated fatty acid. This substance is said to help decrease the amount of neutral fat in the body and prevent metabolic syndrome from setting in (Young-il et al., 2012).

However, tomato juice is not a panacea, it is not a nutritional drink; some tomato juice brands may contain salt.

Dietary supplement and side effects

Lycopene is available as a dietary supplement in mixed formulations or by itself. It is typically available in soft-gel form and is oil based. There are currently no reported side effects from eating foods that are rich in lycopene or taking lycopene dietary supplements (in the standard dosage prescribed). Tomato extract is another form of lycopene supplement that is becoming popular and wide-selling.

Adverse effects of lycopene in humans

There is a dearth of information on the adverse effects of lycopene in humans. High intakes of lycopene-rich foods or supplements may result in a deep orange discoloration of the skin known as lycopenodermia. Because lycopene is more intensely colored than carotenes, lycopenodermia may occur at lower doses than carotenodermia (***, 2000). Lycopenodermia has been observed with high intakes of lycopene-containing foods (i.e. 2 liters of tomato juice daily for several years). Although there was evidence of lycopene and fatty deposits in the liver, there was an absence of measurable hepatic dysfunction. After 3 weeks of consuming a diet free of tomato juice, the orange discoloration faded. Because of the lack of data on the adverse effects or toxicities of lycopene in animals or apparently healthy humans, there is no set tolerable upper intake level for lycopene (McClain et al., 2003).

Conclusions

1. We live in a time where people know that eating better and exercising on a regular basis are important. Healthy eating is not about strict nutrition philosophies, staying unrealistically thin, or depriving ourselves of the foods we love. Rather, it is about feeling great, having more energy, stabilizing our mood, and keeping ourselves as healthy as possible.

2. A healthy nutrition is about eating daily half a plate of vegetables and fruits. They are low in calories and nutrient dense, which means they are packed with vitamins, minerals, and fiber. In fruits like tomatoes, beyond their nutritional components, the presence of other non-nutritional factors (i.e. carotenoids such as lycopene) has an important antioxidant function. The amount of lycopene available to the body is increased when tomatoes are combined with fat and heated during processing (tomato juice).

3. Due to its antioxidant activity, lycopene found in tomatoes may help prevent or treat certain health conditions, such as: heart diseases, infertility, diabetes, age-related macular degeneration and cataracts, skin aging, osteoporosis, and many types of cancer. Besides, tomatoes can help ease fatigue from exercise in athletes.

4. However, tomato juice is not a panacea, it is not a nutritional drink, some tomato juice brands may contain salt; lycopene does not replace conventional treatment for cancer or other medical conditions.

5. Overall, it is not possible to say conclusively that tomatoes or lycopene have any definite effect on the above medical conditions, or whether this is clinically significant. Complex interactions between multiple nutrients may contribute to the properties of tomatoes. Large randomized controlled trials will be needed to further investigate these issues. In the interim, tomatoes and other lycopene-containing fruits can still contribute to our recommended five daily portions of fruit and vegetables.

Conflicts of interest

Nothing to declare.

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