# Tomato-the chemistry of "golden apple"

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## ABSTRACT

Food is expected to meet basic physiological needs, but also to exert a positive influence on the health and protection of cells from negative environmental factors. Tomatoes are a good source of vitamins and minerals and also have antioxidant properties. The main antioxidants in tomatoes are carotenoids, ascorbic acid and phenolic compounds. Lycopene is responsible for the red color of tomatoes and is considered to be an antioxidant with high biological activity. Studies have shown that lycopene protects the skin from ultraviolet (UV) rays and thus provides some protection against skin cancer.

*Keywords: Tomato, chemical composition, lycopene, polyphenolic compounds*

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## Introduction

Tomato (*Solanum lycopersicum*) is a vegetable, whose fruit is used for nutrition at botanical maturity but also as a green, after acidification (Madhavi and Salunkhe, 1998). Ripe fruit is used in the diet as a salad, a supplement to various dishes and raw material for various processing. Cultured tomato varieties originate from wild relatives, which are still part of spontaneous vegetation in the Andes region of South America. Migrations of Native American populations to the Central American and Mexican regions of the Andean region conveyed wild forms of tomatoes, where they were cultivated and used for eating in the early seventh century. In the cultivation of tomatoes, a significant role was played by the tribe Astecs who called it "xtomatl". The name “tomati“ derives from this name, which was generated by other Native American tribes of Central America and is the root of the word „tomato“ in many languages. At the beginning of the sixteenth century, it is believed that tomatoes were transferred to Europe, first to Spain, Italy and Portugal, and then to other parts. It was initially grown as an ornamental plant and was not used for eating since its fruits were thought to be poisonous. The first description of the tomato plant was given by the Italian botanist Mattioli in 1544, calling it "pomi d'oro" (golden apple) indicating that the first-born plants had yellow fruits. From that description, the current Italian name for tomato "pomodoro" also originates. New forms of larger red fruits are likely to have spread to France, which is why the French have called them "pomme d'amour" (apple of love). Newly arrived vegetables have been called "paradiesapfel" in Germany, which means paradise apple. The current scientific name for the Lycopersicon esculentum tomato was suggested by the English botanist Miller in 1768, which would translate into a wolf's edible apple (Matotan, 2008). Tomatoes for eating in Europe are thought to be first used in Italy in the mid-sixteenth century, and then spread to other Mediterranean countries and later to northern Europe.

## Chemistry of tomato

The chemical compounds present in tomatoes greatly affect the biological properties and organoleptic properties. The chemical composition of tomato fruits depends on factors such as variety, maturity and environmental conditions in which they are grown (Abushita et al., 1997; Davies and Hobson, 1981; Giovanelli et al., 1999; Thompson et al., 2000). It has been shown that ripening processes and storage temperatures can greatly influence the final nutrient composition (Madhavi and Salunkhe, 1998). The average chemical composition of tomato fruits is: 94% water, 4% carbohydrates, 0.9% protein, 0.2% fat, 0.6% minerals and 0.2% pectin (Hernández Suárez et al., 2008). It has low calories and a high content of vitamins C and A, which have a beneficial effect on the immune system and break down fat. Nutritional composition of tomato is shown in Table 1.

**Table 1.** Nutritional composition of tomatoes

| **Nutritional composition per 100g** | **Mass** |
|---|---|
| Water | 93g |
| Proteins | 1,3g |
| Fats | 0,3g |
| Carbohydrates | 5,8g |
| Cellulose | 1,1g |
| Minerals | |
| K | 353mg |
| P | 35,8mg |
| Ca | 14,9mg |
| Mg | 16,4mg |
| Fe | 0,4mg |
| Na | 7,5mg |
| Zn | 0,3mg |
| Mn | 0,2mg |
| Vitamins | |
| Vitamine C | 18,9mg |
| Vitamine E | 0,8mg |
| Carotene (provitamine A) | 0,7mg |
| Vitamine K | 0,1mg |
| Vitamine PP | 0,5mg |
| Vitamins B1, B2, B3, B5, B6 | 0,82mg |
| Folates (vitamine B9) | 22,3µg |
| Essential aminoacids | 0.9g |

Tomatoes and its products are good sources of carotenoids (especially lycopene), ascorbic acid (vitamin C), vitamin E, folate, chavonoids and potassium (Beecher, 1998; Leonardi et al., 2000). Other ingredients are protein and dietary fiber (Davies and Hobson, 1981).

Lycopene, a plant pigment belonging to the carotenoid group, is responsible for tomato red color (Nguyen and Schwartz, 1999) and is considered an antioxidant with high biological activity. This pigment possesses the ability to inhibit the proliferation of breast, lung, and endometrial cancer cells (Heber and Lu, 2002). Studies have shown that lycopene protects the skin from ultraviolet (UV) rays and thus provides some protection against skin cancer. The content of lycopene in tomatoes varies considerably, so research has shown that grown tomatoes contain higher levels of lycopene (5.2 to 23.6 mg / 100 g fresh weight (SM)) (Abushita, 1997) than tomatoes in greenhouse (0.1 and 10.8 mg / 100 g SM) (Leonardi et al., 2000). In tomatoes with yellow fruits, lycopene is present in traces. The tomato fruit also contains other colored substances (β-carotene and xanthophylls), which are responsible for the color of the non-red tomato. From a chemical point of view, the carotenoids are tetraterpenic and belong to the lipid class in terms of physical and chemical properties (Lajšić and Grujić-Injac, 1998). They can be divided into two groups: carotene - dissolved in non-polar solvents and oxidizing products of carotenoids - xanthophylls - which dissolve in polar solvents and occur in the form of alcohols, aldehydes, ketones, esters (Lajšić and Grujić-Injac, 1998). These plant pigments participate in the process of photosynthesis, and they have a provitaminic role in the human body (Kadian and Garg, 2012) and an antioxidant role (Padovani and Amaya-Farfán, 2006). Another essential compound in tomatoes is flavonoid zeaxanthin. Zeaxanthin protects the eyes from the disease

of yellow spot degeneration (ARMD (Age-Related Macular Degeneration), which occurs in the elderly, caused by the action of harmful UV rays.

In addition to carotenoids, which play an antioxidant role, many other compounds that exhibit antioxidant activity, such as polyphenolic compounds and vitamin C, are also present in Table 2. Table 2 shows the average content of compounds showing antioxidant activity (Frusciante et al., 2007).

**Table 2.** Content of compounds exhibiting antioxidant activity in tomato samples

| **Compound** | **Content (mg/100 g tomato)** |
|---|---|
| Lycopene | 1.86-14.62 |
| β-carotene | 0.11-1.07 |
| Luteine | 0.08-0.34 |
| Fenolic acids | 2.85-4.68 |
| Flavonoids | 1.15-8.16 |
| Vitamine C | 2.20-21 |
| Vitamine E | 0.11-1.84 |

The content of these compounds varies in seeds, husks and meat. George et al. (2004) found that the content of polyphenolic compounds was higher in the shell than in the meat of tomatoes (10.4-40.0 mg / 100 g and 9.2-27.0 mg / 100 g). Naringenin, chalconaringenin, quercetin, kaempferol, myricetin, *p*-hydroxybenzoic, cinnamon, salicylic, protocatechin, coumaric, vanillin, caffeic, chlorogenic, ferulic and synaptic acid were isolated from tomato samples (Slimestad and Verheul, 2009).

*Cis*-3-hexenal, hexanal, *cis*-3-hexenol, β-ionone, β-damascenone, 1-penten-3-one, 3-methylbutanal, 2-isobutylthiazole are responsible for the aroma of this vegetable (Yilmaz, 2001).

Tomatoes have found a wealth of vitamins, minerals and other nutrients. It contains 17 times more iron than milk, twice as much as eggs and even three times as much as fish. Ripe fresh tomatoes contain 2-3 times more vitamin C (as much as 21% of the recommended dose per 100 grams) than green. It has very few calories (15 kcal per 100 grams of food) and is therefore an integral part of most diet menus. Cherry tomato is a variety of tomato cerasiforme that has been only used for decorative purposes until numerous positive effects on the organism are discovered. It is mostly small, of various shapes (across round and oval to pear-shaped) and colors (green, red, orange, black).

## References

Abushita, A. A., Hebshi, E. A., Daood H. G., & Biacs, P. A. (1997). Determination of antioxidant vitamins in tomatoes. Food Chemistry, 60, 207-212.

Beecher, G. R. (1998). Nutrient content of tomatoes and tomato products. Proceedings of the Society for Experimental Biology and Medicine, 218, 98-100.

Davies, J. N., & Hobson, G. E. (1981). The constituents of tomato fruit—the influence of environment, nutrition, and genotype. CRC Critical Reviews in Food Science and Nutrition, 15, 205-280.

Frusciante, L., Carli, P., Ercolano, M. R., Pernice, R., Di Matteo, A., Fogliano, V., & Pellegrini, N. (2007). Antioxidant nutritional quality of tomato. Molecular Nutrition & Food Research, 51, 609-617.

George, B., Kaur, C., Khurdiya, D.S., & Kapoor, H.C. (2004). Antioxidants in tomato (*Lycopersium esculentum*) as a function of genotype. Food Chemistry, 84, 45-51.

Giovanelli, G., Lavelli,V., Peri, C., & Nobili, S. (1999). Variation in antioxidant components of tomato during vine and post-harvest ripening. Journal of the Science of Food and Agriculture, 79, 1583-1588.

Heber, D., & Lu, Q-Y. (2002). Overview of mechanisms of action of lycopene. Experimental Biology and Medicine, 227, 920–923.

Hernández Suárez, M., Rodríguez, E. M., & Díaz Romero, C. (2008). Chemical composition of tomato (*Lycopersicon esculentum*) from Tenerife, the Canary Islands. Food Chemistry, 106, 1046-1056.

Kadian, S. S., & Garg, M. (2012). Pharmacological effects of carotenoids: A review. International Journal of Research in Pharmaceutical Sciences, 3, 42-48.

Lajšić, S., & Grujić-Injac, B. (1998) Hemija prirodnih proizvoda, Univerzitet u Novom Sadu, Tehnološki fakultet.

Leonardi, C., Ambrosino, P., Esposito F., & Fogliano, V. (2000). Antioxidative activity and carotenoid and tomatine contents in different typologies of fresh consumption tomatoes. Journal of Agricultural and Food Chemistry, 48, 4723-4727.

Madhavi, D. L., & Salunkhe, D. K. (1998). Production, composition, storage, and processing. New York.

Matotan, Z. (2008). Plodovito povrće. Bjelovar: Neron.

Nguyen, M. L., & Schwartz, S. J. (1999). Lycopene: chemical and biological properties. Food Technology, 53, 38-45.

Padovani, R. M., &Amaya-Farfán, J. (2006). Procurement of β-carotene, lycopene, lutein and zeaxanthin in households of Brazil's urban areas. Segurança Alimentar e Nutricional, 13, 49-63.

Slimestad, R., & Verheul, M. (2009). Review of flavonoids and other phenolics from fruits of different tomato (*Lycopersicon esculentum* Mill.) cultivars. Journal of the Science of Food and Agriculture, 89, 1255-1270.

Takeoka, G. R., Dao, L., Flessa, S., Gillespie, D. M., Jewell, W. T., Huebner, B, Bertow, D., & Ebeler, S. E. (2001). Processing effects on lycopene content and antioxidant activity of tomatoes. Journal of Agricultural and Food Chemistry, 49, 3713–3717.

Thompson, K. A., Marshall, M. R., Sims, C. A., Wei, C. I., Sargent, S. A., & Scott, J. W. (2000). Cultivar, maturity, and heat treatment on lycopene content in tomatoes. Journal of Food Science, 65, 791–795.

Yilmaz, E. (2001). The chemistry of fresh tomato flavor. Turkish Journal of Agriculture and Forestry, 25, 149-155.