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Total polyphenol content and antioxidant activity of *Solanum lycopersicum* L.

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Tomato, the edible berry of the plant tomatoes (*Solanum lycopersicum* L.) is currently one of the most widely used crops worldwide. Tomatoes are considered to be one of the most popular vegetables, although, from a botanical point of view, it is a fruit. It is a rich source of numerous important bioactive substances that have a positive effect on human health. Antioxidant compounds of tomatoes, with their protective properties, have a significant effect on oxidative stress. Seven tomato cultivars, namely Perun, Tornado, Bejbino F1 60S, Darinka F1, Glazier, Tramezzino, and Brioso were analysed in this study, that aimed to determine the total polyphenol content and antioxidant activity of tomatoes. The total polyphenol content has been determined by the Folin-Ciocalteu assay, using an UV-VIS spectrophotometer. The values have ranged from 231.48 mg.kg^{-1} FW to 559.81 mg.kg^{-1} FW. Statistically highest TPC was determined in the cultivar Bejbino F1 60S. Statistically lowest TPC was determined in the cultivar Brioso. The total antioxidant activity (AA) has been determined by the DPPH radical scavenging assay, using an UV-VIS spectrophotometer. The values have ranged from 0.261 to 0.554 mmol TE.kg^{-1} FW. Statistically highest AA was determined in the cultivar Bejbino F1 60S. Statistically lowest AA was determined in the cultivar Darinka F1. Statistical evaluation of the results showed a weak correlation between total polyphenol content and antioxidant activity of tomatoes. These results indicate that content of polyphenols and antioxidant activity of tomatoes are influenced by cultivar.

Keywords: Tomato, polyphenols, antioxidant activity

Introduction

Solanum L., the genus of the family Solanaceae, includes about 1250 to 1700 species. *Solanum* species are present in all temperate, subtropical to tropical zones and are remarkable for their morphological and ecological diversity. *Solanum* is possibly the most important genus in economic terms. Tomatoes (*Solanum lycopersicum* L.) come from America, specifically from the Andean Mountain region, where it was domesticated by the indigenous people (Bergougnoux, 2014). They have easily spread around the world due to the great diversity of their usability

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and its adaptation. As a result, there are currently hundreds of varieties of tomatoes. Current varieties were created by genetic breeding of native, wild species (Nuez and Díez, 2013). Tomato is one of the most important horticultural crops worldwide, with more than 186 million tonnes produced in 2020 (FAOSTAT, 2020). It does not contain toxic substances, is palatable uncooked, can be easily processed into various products, and is even used to make pharmaceuticals. The plants have a high yield of fruit, they are easily grown under containment, indoors, in greenhouses, and in fields (Tzfira, 2007). Tomato is consumed fresh or as a processed product, i.e. ketchup, puree, paste, canned tomatoes, juice, and pasta sauces (Li et al., 2018).

Tomatoes are considered to be one of the most popular vegetables, although, from a botanical point of view, it is a fruit. This species is a good source of various phytochemicals, mainly carotenoids and polyphenols. Tomatoes also contain a large number of other bioactive compounds, such as vitamins, terpenoids, glycoalkaloids, and many others that accumulate in their fruits (Mechlouch et al., 2012; Hafeznia et al., 2014; Perveen et al., 2015; Martí et al., 2016). Tomatoes are the major source of lycopene and a number of other carotenoids, such as α-, β-, and γ-carotene, phytoene, phytofluene, and neurosporene (Perveen et al., 2015). Consumption of tomatoes has been linked to many health benefits, such as prevention of oxidative stress-related diseases, and prevention of cardiovascular diseases (Szabo et al., 2019). Tomatoes are generally recognized for their outstanding antioxidant, anticancer, and antidiabetic properties (Faizan et al., 2021).

Even though phenolic compounds are secondary metabolites, they play a significant role in plant existence. Besides being involved in defense against herbivores and pathogens, in allelopathy processes, mechanical support, and attraction of pollinators and fruit dispersers, they also absorb damaging ultraviolet radiation (Taiz and Zeiger, 2006). Because of this, they tend to accumulate in the dermal tissue of the plant body (Peng et al., 2008). Polyphenol content in plants depends on various factors such as plant genetics and type of cultivar, growing conditions, soil composition, maturity state and post-harvest conditions, and others (Faller and Fialho, 2010).

Therefore, the purpose of this work was to evaluate the antioxidant activity and total polyphenol content in different tomato cultivars and determine the influence of cultivar on these parameters. These results could establish the basis for future research into the elaboration of tomatoes as a natural source of antioxidants and polyphenols.

Material and methodology

Plant material

The researched cultivars of tomatoes (Perun, Tornado, Bejbino F1 60S, Darinka F1, Glacier, Tramezzino, Brioso) were obtained from various locations in Slovakia. Samples have been harvested at the state of complete ripeness.

Extract preparation

25 g of homogenized tomatoes were extracted in 50 mL of 80% methanol by horizontal shaker (Unimax 2010, Heidolph Instrument GmbH, Germany) for 12 h and filtered through Munktell no. 390 filtrating paper (Munktell & Filtrac, Germany).

Total polyphenol content

Total polyphenol content was determined by Folin-Ciocalteau colorimetric method (Lachman et al., 2003). Folin-Ciocalteu phenol reagent (Merck, Germany), 20% Na_2CO_3 (Sigma Aldrich, USA), and distilled water were used. 0.1 mL of extract was pipetted into a 50 mL volumetric flask. 0.85 mL of Folin-Ciocalteau reagent was added, and after 3 minutes, 5 mL of 20% Na_2CO_3 was added. The mixture was stirred, and the flask was filled with distilled water to the mark. Flasks were left for 2 h at laboratory temperature and then measured against blank solution at 765 nm, using a Shimadzu UV-VIS scanning spectrophotometer (Shimadzu, Japan). Total polyphenol content was expressed as mg of gallic acid equivalent (GAE) in 1 kg of fresh weight (FW), based on the calibration curve (R^2 = 0.996).

Antioxidant activity

Antioxidant activity (AA) was measured by DPPH radical scavenging assay (Brand-Williams et al., 1995). DPPH• radical (2,2-diphenyl-1-picrylhydrazyl) (Sigma Aldrich, USA) and methanol (Sigma Aldrich, USA) were used to produce a working DPPH solution. 1 mL of extract was pipetted into 3.9 mL of working DPPH solution, stirred, and left in dark. After 10 minutes, the solution was measured against blank solution at nm, using a Shimadzu UV-VIS scanning spectrophotometer (Shimadzu, Japan). Antioxidant activity was expressed as mmol of Trolox equivalent (TE) in 1 kg of fresh weight (FW), based on the calibration curve (R^2 = 0.994).

Statistical analysis

Statistical analysis was performed using RStudio (2020) software package. A nonparametric Kruskal-Wallis test was performed to find statistically significant information about differences among the tested samples ($p < 0.05$). 7 samples, with 4 measurement replications each were analyzed.

Results and discussion

Regular intake of tomatoes has been linked to decreased risk of chronic diseases. Epidemiological findings confirm the observed health effects are due to the presence of different antioxidant molecules such as phenol compounds, carotenoids, and vitamin C (Frusciante et al., 2007). Antioxidants are important in the prevention of both animal and plant diseases, as they could delay or inhibit oxidation (Martínez-Valverde et al., 2002).

The total polyphenol content and antioxidant activity of tomato cultivars are given in Table 1.

Total polyphenol content

Polyphenols are the most abundant antioxidants in the human diet. Recent data support the role of polyphenols in the prevention of cancer, cardiovascular diseases, and osteoporosis, and implies a contribution to the prevention of diabetes mellitus and neurodegenerative diseases (Abbas et al., 2017).

The total polyphenol content (TPC) in analysed tomato cultivars ranged from 231.48 to 559.08 mg GAE.kg^{-1} FW. Highest TPC was determined in the cultivar Bejbino F1 60S, while the lowest TPC was determined in the cultivar Brioso. According to the results, the order for tomato cultivars based on their TPC could be as follows: Brioso< Darinka F1< Tornado< Perun< Glazier< Tramezzino< Bejbino F1 60S.

Similar values were determined by other authors. Tamasi et al. (2019) reported TPC in tomato cultivars in the range 253.3–508.7 mg GAE.kg^{-1} FW. Carrilo-López and Yahia (2013) reported TPC in Mexican tomatoes in the range of 227–437 mg GAE.kg^{-1} FW. Minutolo et al. (2013) reported TPC in tomato cultivars in the range of 260–421 mg GAE.kg^{-1} FW. García- Valverde et al. (2013) reported TPC in tomato cultivars in the range of 186.92–558.63 mg GAE.kg^{-1} FW. Chandra and Ramalingam (2011) reported TPC in commercially important Indian tomato cultivars in the range of 188.4–266.0 mg GAE.kg^{-1} FW. Chang et al. (2006) reported TPC in tomato cultivars in the range of 340–380 mg GAE.kg^{-1} FW. Slimestad and Verheul (2015) reported 215 mg GAE.kg^{-1} FW in cherry tomato cultivar Jennita. Pék et al. (2010) reported 294 mg GAE.kg^{-1} FW in tomato cultivar Lemance F1. Minoggio et al. (2003) reported lower TPC in different tomato cultivars in the range of 44.3–258.4 mg GAE.kg^{-1} FW. Asensio et al. (2019) reported lower TPC in Spanish traditional tomatoes in the range of 66.71–175.42 mg GAE.kg^{-1} FW. Jacob et al. (2010) reported 23.0 mg GAE.kg^{-1} FW in the tomato cultivar Pera.

Antioxidant activity

Antioxidants acquired from diet play an important part in helping endogenous antioxidants in the neutralization of oxidative stress. The nutrient antioxidant deficiency could be the cause of several chronic diseases (Pham-Huy and Pham-Huy, 2008).

The antioxidant activity (AA) in analysed tomato cultivars ranged from 0.261 to 0.554 mmol TE.kg^{-1} FW (10.95 to 22.40%). The highest AA was determined in the cultivar Bejbino F1 60S, while the lowest AA was determined in the cultivar Darinka F1. According to the results, the order for tomato cultivars based on their AA could be as follows: Darinka F1< Brioso< Glazier< Tramezzino< Tornado< Perun< Bejbino F1 60S.

Table 1 The total polyphenol content and antioxidant activity of tomato cultivars

Cultivar	TPC (mg GAE.kg^{-1} FW ±SD)	AA (mmol TE.kg^{-1} FW ±SD)	AA (%)
Perun	307.69 ±8.50^{d}	0.545 ±0.005^{e}	22.40 ±0.64
Tornado	262.81 ±4.99^{e}	0.508 ±0.008^{d}	20.90 ±0.76
Bejbino F1 60S	559.08 ±5.92^{c}	0.554 ±0.001^{e}	22.75 ±0.47
Darinka F1	247.29 ±6.52^{b}	0.261 ±0.023^{a}	10.95 ±1.37
Glazier	361.69 ±9.54^{e}	0.339 ±0.001^{b}	14.11 ±0.45
Tramezzino	380.47 ±9.69^{f}	0.435 ±0.013^{c}	17.98 ±0.97
Brioso	231.48 ±8.30^{a}	0.274 ±0.023^{a}	11.48 ±1.35

Notes: Results are expressed as a mean of 4 measurement replications ± standard deviation (SD). Different letters indicate significant differences ($p < 0.05$); TPC – total polyphenol content; AA – antioxidant activity; FW – fresh weight; GAE – gallic acid equivalent; TE – Trolox equivalent

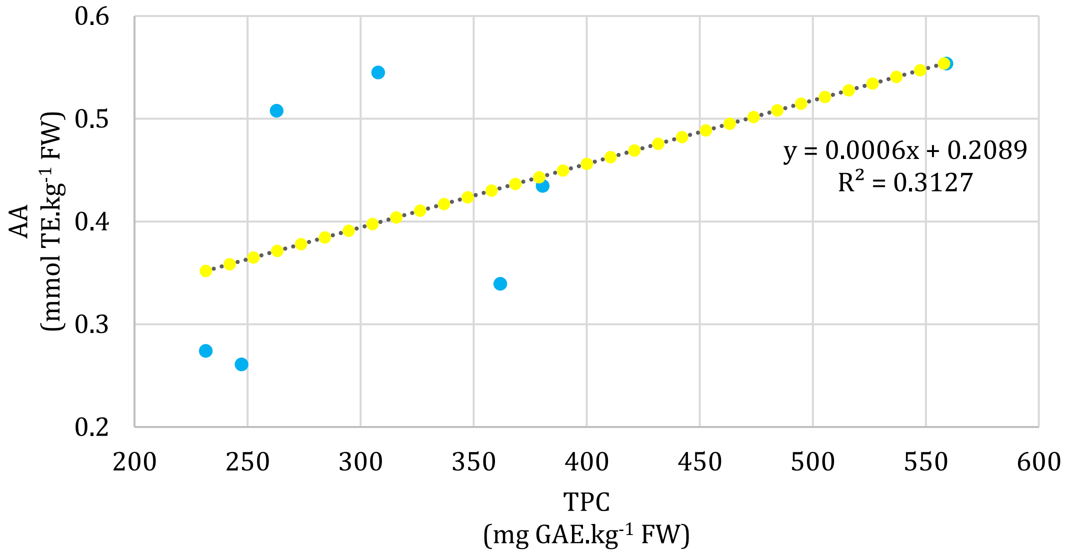

Figure 1 Relationship between total polyphenol content (TPC) and antioxidant activity (AA) of tomato cultivars

Similar values were determined by other authors. Erge and Karadeniz (2011) reported AA in Turkish tomatoes in the range of 0.42–0.58 mmol TE.kg^{-1} FW. Odriozola-Serrano et al. (2008) reported AA in Spanish tomato cultivars in the range of 9.8–26.6%. Gougoulias et al. (2012) reported AA in hydroponically cultured tomato Sandin F1 in the range of 0.07–0.84 mmol TE.kg^{-1} FW. Borguini et al. (2013) determined AA in various tomato extracts in the range of 11.33–72.34%. Tommonaro et al. (2021) determined AA in tomato cultivars in the range of 10.32–49.83%. Tamasi et al. (2019) reported higher AA in tomato cultivars in the range of 0.823–1.780 mmol TE.kg^{-1} FW. Nour et al. (2013) reported higher AA in Romanian tomatoes in the range of 0.81–1.74 mmol TE.kg^{-1} FW. Shahzad et al. (2014) reported higher AA in tomato cultivars in the range of 35.80–37.60%. Chandra and Ramalingam (2011) reported higher AA in commercially important Indian tomato cultivars in the range of 40.6–55.3%. Borguini et al. (2013) determined AA in various tomato extracts in the range of 11.33–72.34%. Tommonaro et al. (2021) determined AA in tomato cultivars in the range of 10.32–49.83%. Kaur et al. (2013) determined 2.5–4.61 mmol TE.kg^{-1} FW of hydrophilic antioxidant activity and 0.17–0.24 mmol TE.kg^{-1} FW of lipophilic antioxidant activity in selected Indian tomatoes.

Statistical evaluation of the results showed a weak positive correlation between total polyphenol content and antioxidant activity of tomatoes (R^2 = 0.3127). Gougoulias et al. (2012) also determined a weak correlation between TPC and AA of tomatoes. De Souza et al. (2021) determined a moderate correlation between TPC and AA of tomatoes. Nour et al. (2013) and Patanè et al. (2019) determined a strong positive correlation between TPC and AA of tomatoes. On the other hand, Fidrianny et al. (2015) determined a strong negative correlation between TPC and AA of various tomato cultivars.

Conclusions

Tomatoes contain a number of health-promoting substances that have a beneficial effect on human health. They are a source of important bioactive substances characterized by antioxidant activity, among other positive effects. Based on this fact, it is important to include frequent consumption of tomatoes into our diet. The total polyphenol content and antioxidant activity of seven tomato cultivars were analysed in this study. Based on the results, we can state that tomatoes are a natural source of antioxidants and polyphenols. Statistical evaluation of the results confirmed significant differences among TPC and AA of individual cultivars. Linear regression revealed a weak positive correlation between TPC and AA of tomatoes.

Conflicts of interest

The authors declare no conflict of interest.

Ethical statement

This article does not contain any studies that would require an ethical statement.

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