DOI: 10.22616/FoodBalt.2019.042

*SHORT COMMUNICATION*

# SUGGESTIONS FOR CONSUMERS ABOUT SUITABILITY OF DIFFERENTLY COLOURED TOMATOES IN NUTRITION

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**Abstract**

Tomatoes (*Solanum lycopersicum* L.) are known as very popular vegetable due to high nutritional value and are among the most commonly used vegetables in the world. Tomato varieties differ not only in fruit size, but also in colour. The aim of the present study was to evaluate how the colour of tomatoes influences the nutritional value. Chemical composition (vitamin C, lycopene, β-carotene, soluble solids, total acidity) and taste index were determined in 27 tomato cultivars grown in plastic film greenhouse without additional lighting. Red, pink, brown, orange and yellow tomato fruits were studied. The obtained results showed that there were significant differences in the mean values between analysed parameters according to the colour of fruit. The content of lycopene changed as follows: pink>red>brown>orange>yellow, but content of β-carotene: orange>pink>brown>red>yellow. The highest content of total acids (855.7±234.2 mg 100 $g^{-1}$) as well as vitamin C (18.43±4.74 mg 100 $g^{-1}$) was observed in orange tomatoes, but regarding taste index differently coloured tomatoes can be arranged as follows: brown>orange>pink>red>yellow. The smaller and bigger size tomatoes are recommended for consumers as tastier comparing with medium size tomatoes.

***Keywords***: taste, chemical composition, lycopene, β-carotene, vitamin C

## Introduction

In recent years, the interest of healthy and tasty products has been increased. It is connected with consumer's interest about products, including vegetable, containing biological active substances, such as vitamins, phenolic compounds a well as antioxidants (Dhandevi, Rajesh, 2015).

Tomatoes (*Solanum lycopersicum* L.) are very popular vegetable in Europe, but due to modernization of production processes, the quality of final products does not always meet consumer's requirements. They pay attention also on sensory properties of products, including taste and colour (Fernqvist et al., 2013).

In Latvia, tomato occupies an important place in the vegetable sector with 43% from total vegetable production in greenhouses in 2017 (Informative material of Ministry of Agriculture). The consumption of fresh tomatoes was on average 1 kg monthly per household member in 2017 (Central Statistical Bureau of Latvia, 2017).

Tomatoes is known as good source of phenolic, flavonoids, lycopene, ascorbic acid and other bioactive compounds (Toor, Savage, 2005), but the nutritional value may vary depending on several factors such as cultivar, growth conditions, harvesting time and conditions, as well as storage (Hernandez-Suarez et al., 2008). The colour of tomatoes depends on its chemical composition, especially on the content of pigments, but the content and ratio of sugars and organic acids gives the tomatoes taste. (Tieman et al., 2017, Zhang et al., 2015). Tomato flavour is a balance of acidity and content of sugars, but colour of fruits depends on content of pigments, which also can influence tomato flavour. Orange and yellow tomatoes are less acidic and have delicate taste, whereas red and black tomatoes cultivars have different taste qualities.

Tomatoes colour, its weight and taste qualities are very important indices for consumers. It is known, that red coloured tomatoes are better preferred for consumers, but very often in the supermarkets we could find tomatoes with other colours – yellow, orange, brown and black (Cooperstone et al., 2017; Borghesi et al., 2011). Fruit colour is one of the main factors, which determines consumer choice (Breksa et al., 2015; Stommel et al., 2005). Tomato fruit colour is connecting with content of different colour pigments - chlorophylls, carotenes, lycopene, and their proportions in the fruit (Borghesi et al., 2016; Zhao et al., 2012). The content of chlorophylls characterized by green colour of tomato fruits, but carotenes give an orange and lycopene – red colour (Fangman et al., 2018, Park et al., 2018).

The aim of the present study was to evaluate how the colour influences the nutritional value of tomatoes grown in plastic film greenhouse without additional lighting.

## Materials and Methods

Investigations were carried out at the Latvia University of Life Sciences and Technologies, Institute of Soil and Plant Sciences. 27 tomato plant varieties with five colours of tomato fruits (red, pink, brown, orange and yellow) were grown in the plastic film greenhouse without additional lighting from 1st of May till 1st of September 2018. All fruits were harvested at full ripening stage. In the experiment the following red fruit varieties were included – 'Gaurmandia F1', 'Aurea F1', 'Berberana F1', 'Amaneta F1', 'Pozano F1', 'Nectar F1', 'Sunstream F1', 'Bellastar F1', 'Lancelot F1', 'Conchita F1', 'Gardener delight F1' and 'Elegance F1'; pink varieties 'Dimeros F1', 'Fuji Pink F1' , 'Pink wonder F1', 'Cipars F1', 'Rhianna F1', 'DRK936 F1' and 'Rosastar F1'; orange varieties

'Beorange F1', 'Organza F1', 'Apressa F1' and 'Oranjstar F1'; yellow varieties 'Gualdinjo F1' and 'Bolzano F1', and brown varieties 'Chocomote F1' and 'Black cherry F1'.

*Tomato sampling*

Physiologically ripe tomatoes were harvested, cleaned, washed and dried up. Five tomatoes from each cultivar were selected for chemical analysis, weighed and then homogenized. From the obtained puree samples were taken on triplicate to measure content of vitamin C, total acids and soluble solids, as well as content of β-carotene and lycopene.

*Chemicals and spectral measurements*

All the reagents used were with the analytical grade from Sigma Aldrich, Germany. UV spectrophotometer UV-1800 (Shimadzu Corporation, Japan) was used for the absorbance measurements, but content of total soluble solids was determined refractometrically. The content of vitamin C and total acids were determined titrimetrically.

*Determination of vitamin C content*

Vitamin C content in tomato samples was determined titrimetrically using 2.6-dichlorphenolindophenol. For determination 2±0.0001 g of tomatoes puree was quantitatively transferred in 100 mL tubes, added 30 mL of 1% HCl and 5% $HPO_3$ mixture (1:1 v/v) and mixed thoroughly for 30 min. After that solution was centrifuged for 10 min at 5000 rpm. For determination 10 mL ($V_a$) of supernatant was titrated with 0.0005 molar solution of 2.6 dichlorphenolindophenol ($V_{titr}$).
The content of vitamin C was calculated according to the equation (1):

$$\text{Vitamin C (mg 100 g}^{-1}\text{)} = \frac{V_{titr} \times 0.044 \times V_{total} \times 100}{V_a \times weight} \quad (1)$$

where:
$V_{titr}$ – volume of 2.6 dichlorphenolindophenol, mL;
$V_{total}$ – total volume of supernatant, mL;
$V_a$ – volume of supernatant for titration, mL.

*Determination of titratable acidity*

Titratable acidity was determined titrimetrically with a solution of sodium hydroxide 2±0.0001 g of tomatoes puree was quantitatively transferred in 100 mL tubes, added 40 mL of distilled water and mixed... After 30 minutes solutions were centrifuged for 10 min at 5000 rpm. For determination 10 mL of the supernatant was titrated with 0.1 M NaOH in presence of indicator phenolphthalein and results expressed as g of citric acid 100 $g^{-1}$ tomato sample.

*Determination of total soluble solids*

The total soluble solids content (expressed as BRIX degree) was measured with a refractometer (A.KRÜSS Optronic Digital Handheld Refractometer Dr301-95), calibrated at 20 °C with distilled water.

*Determination of lycopene content*

For extraction, a sample of tomato puree (0.5±0.0001 g) was weighted in a glass test tube. Then 10 mL of solvent (tetrahydrofuran, THF) was added to it and the test tubes were held for 30 min with occasional shaking at room temperature and finally centrifuged for 10 min at 5000 rpm. The absorbance of supernatants was analysed spectrophotometrically by absorption measurements at 350 to 700 nm and calculated in accordance with Nagata and Yamashita (1992).

*Determination of β-carotene*

For extraction a representative portion of tomato puree (0.5±0.0001 g) was weighted in a glass test tube. Then 10 mL of solvent (ethanol, 97%) was added to it and the test tubes were held for 30 min with occasional shaking at room temperature and finally centrifuged for 10 min at 5000 rpm. The absorbance of supernatants was analysed spectrophotometrically by absorption measurements at 350 to 700 nm and calculated in accordance with Nagata and Yamashita (1992).
*Taste index* was calculated using the equation proposed by Narvez et al (1999) and Nielsen (2003).

*Statistical analysis*

Data were expressed as mean of triplicate assay ± standard deviation. The One-way analysis of variance (ANOVA) was used to determine the significance of differences and value of $p<0.05$ was regarded as statistically significant.

## Results and Discussion

Fruit colour is one of the most important food quality parameters affecting consumer choice Data on the values of different coloured tomato fruit quality parameters (content of vitamin C, total acidity as well as calculated taste index) are summarized in Table 1.

Table 1

**Quality parameters of analysed tomatoes**

| Tomato colour | Vitamin C mg 100 $g^{-1}$ | Titratable acidity* mg 100 $g^{-1}$ | Taste index |
|---|---|---|---|
| Red | 13.18±6.17 | 759.8±55.1 | 1.15 |
| Pink | 14.12±3.41 | 811.7±74.1 | 1.18 |
| Orange | 18.43±4.74 | 855.7±23.2 | 1.25 |
| Brown | 11.23±2.16 | 805.8±58.5 | 1.26 |
| Yellow | 13.64±2.54 | 598.1±22.2 | 0.95 |

*Titratable acidity expressed as mg 100 $g^{-1}$ of citric acid.

Data processing showed, that there are significant differences ($p<0.05$) in analysed quality parameters. In this study we have found that content of vitamin C was from 11.23±2.16 mg 100 $g^{-1}$ (brown tomatoes) till 18.43±4.74 mg 100 $g^{-1}$ (orange tomatoes). Results regarding total acidity changes in the following sequence: orange>pink>brown>red>yellow.
It means that for consumers who like milder tomatoes, yellow fruit is recommended. The levels of vitamin C and total acidity are in agreement with research data reported in scientific literature (Peihoto et al., 2018, Pinela et al., 2016), but less than others (Asensio et al., 2019, Vinha et al., 2013). Taste index is parameter, which characterizes the quality and taste of tomatoes. When comparing the obtained results among the

coloured tomatoes, it can be observed that taste index, which is calculated using the values of the Brix degree and total acidity, changes from 0.95 (yellow tomatoes) till 1.26 (brown tomatoes).

To compare the quality of different coloured tomatoes several measures were used. Significant differences ($p<0.05$) were observed among content of dry matter and soluble solids in tomato samples. The dry matter ranged from 5.42±0.69 (yellow tomatoes) till 8.25±1.01 g 100 $g^{-1}$ (brown tomatoes) and these results are similar with our previous studies (Duma et al., 2015).

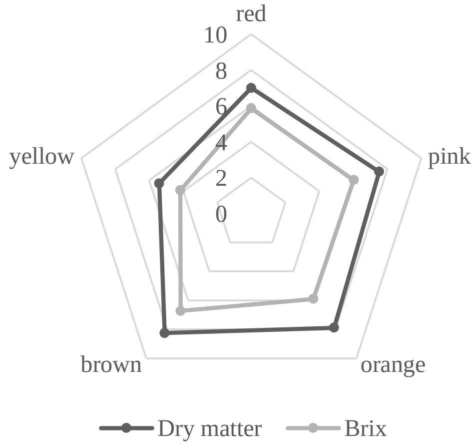


**Figure 1. Content of dry matter (%) and total soluble solids (°Brix) in differently coloured tomatoes**

Plant variety, degree of maturation a well as growing conditions could effect the content of total soluble solids (TSS). The TSS values which are determined by refractometer, are used as an index of total sugars in fruits (Vinha et al., 2013) and if Brix degree is in range of 4.8–8.8, that the quality of tomatoes is high. Our results showed that soluble solids values ranged from 4.18±0.18 (yellow fruits) till 6.73±0.32 Brix degree (Figure 1). There were not significant differences between total soluble solids in red (5.87±1.61), pink (6.03±1.08) and orange (5.90±1.26) tomatoes. These mean values found in the present study are consistent with some data reported in the literature (Coyago-Cruz et al., 2019; Duma et al, 2015), but higher than reported by Vinha et al., 2013.

Tomatoes are known as important source of carotenes, especially lycopene that is well known antioxidant (Böhm, 2012). The highest level was found in the pink tomatoes (4.063±1.248 mg 100 $g^{-1}$, but less in yellow (0.037±0.001) and orange (0.361±0.175 mg 100 $g^{-1}$) tomatoes (Figure 2). The pink, red and brown tomatoes may be interesting for consumers as rich sources of antioxidant lycopene.

The values of β-carotene varies according to orange> pink>brown>red>yellow (Figure 2).

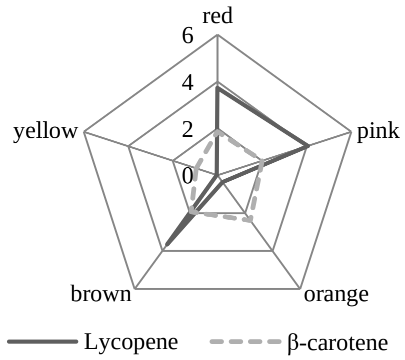


**Figure 2. Content of lycopene (mg 100 $g^{-1}$) and β-carotene (mg 100 $g^{-1}$) in differently coloured tomatoes**

The obtained results regarding lycopene content are similar with other results (Coyago-Cruz et al., 2019), but Asensio et al. 2019 reported-carotene values between 1.37 and 6.41 mg $kg^{-1}$ which are lower than our results.

Consumers often pay attention not only to the colour of tomato fruits, but also to the size. When comparing the results of fruits mass and taste index, it is observed that higher taste index is for smaller or bigger tomatoes (Figure 3).

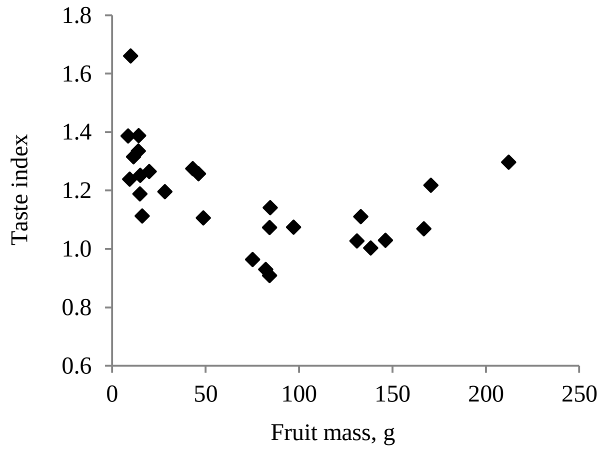


**Figure 3. Connections between taste index and fruit mass**

Therefore, tomatoes with average mass up to 50 g or larger than 150 g could be recommended as tasty tomatoes despite of tomatoes' colour.

## Conclusions

For consumers who like milder tomatoes, yellow fruits are recommended due to less acidity, but pink, red and brown tomatoes may be interesting for consumers as rich sources of well-known antioxidant lycopene. Despite the tomato colour, less tasty are medium sized tomatoes.

## Acknowledgment

Study was supported by European Regional Development Fund project "New control methods for energy and ecological efficiency increase of greenhouse plant lighting systems (uMOL)", Grant Agreement Nr. 1.1.1.1/16/A/261.

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