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PHYSICO-CHEMICAL PROPERTIES OF TWO CHERRY TOMATO VARIETIES IN RELATION TO THE GREENHOUSE ENVIRONMENTAL FACTORS

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Abstract

To prevail on the agricultural market, greenhouse grown cherry tomatoes need to meet certain quality standards. The quality can be assessed by determining several chemical and physical characteristics. The aim of the current study is to analyse such parameters of two cherry tomato varieties (Cheramy and Flaviola) in relation to their flowering stage and to the growing conditions within the greenhouse: air temperature, relative humidity and CO_2 concentration. The soluble solids, titratable acidity and dry matter were determined. Furthermore, the β-carotene, lycopene and ascorbic acid contents were analysed. Tomato fruit size and firmness were also assessed. The current study illustrates a limited correlation between the environmental factors and the quality parameters. Thus, future research should be pursued for a better understanding of the effect of these climatic conditions on greenhouse grown tomatoes.

Key words: *tomato, cherry tomato, quality, greenhouse*

INTRODUCTION

Today's horticultural market imposes high quality standards for its products (Coyago-Cruz et al., 2019). These quality standards refer to a series of physiological and chemical properties often described in literature (Schwarz et al., 2017).

Controlling the environmental conditions helps in achieving the commercial and nutritional quality parameters (Doan & Tanaka, 2022). Thus, indoor cultivation is the standard for obtaining both high yield and high-quality tomatoes. Manipulation of these climatic conditions requires proper space and equipment, however. The use of greenhouses is a viable solution to ensure higher yields and high-quality crops (He et al., 2022).

The aim of the current paper is to study the effect of three environmental conditions (air temperature, relative humidity and CO_2 concentration) on the quality parameters of two greenhouse-grown cherry tomatoes (*Solanum lycopersicum*). For this, several physico-chemical properties will be assessed: fruit weight, longitudinal and equatorial diameter and firmness. Furthermore, the total soluble solids and titratable acidity will be measured. These will also help identify the taste and maturity indices. Moreover, the dry matter and ascorbic acid will be assessed. Pigment synthesis is important for both the ripening and red coloring of the fruit (Felföldi et al., 2022). Thus, β-carotene and lycopene contents were analysed, both pigments having important nutritional properties (Junior et al., 2022). This also translates to several health benefits (Lazzarini et al., 2022; Meng et al., 2022).

The current study addresses whether the environmental factors influence the quality parameters of the greenhouse cherry tomatoes.

MATERIALS AND METHODS

The research was conducted in the Research Greenhouse and the Research Center for Studies of Food and Agricultural Products Quality within the University of Agronomic Sciences and Veterinary Medicine of Bucharest (USAMV) campus. Two cherry tomato varieties ('Cheramy' and 'Flaviola') were selected for the current study. Cheramy RZ F1 is a Dutch hybrid from Rijk Zwaan (Rijk Zwaan, 2022). Flaviola F1 is a Romanian hybrid developed within the Buzău Vegetable Research Station (Jerca et al., 2021). The two varieties were sown on September 15th, 2021. The plants were transplanted to coconut-based Jiffy growbag, each variety being cultivated in a separate greenhouse compartment. Throughout the study, the plants were watered and fertilized daily according to a standard recipe. The 'Cheramy' varieties are illustrated in Figure 1. The analyses were performed on tomatoes harvested starting with the fourth inflorescence (fourth harvesting week) - February 28th, 2022. Tomatoes were randomly harvested from the compartments and analysed once every two weeks, with the last harvesting week being the fourteenth - May 3rd, 2022.

Figure 1. 'Cheramy' tomato plants in the Research Greenhouse at USAMV of Bucharest

Equatorial and longitudinal diameter (cm) were used as metrics for evaluating the marketable tomato fruit size, being assessed using a digital calibre and the weight (g) measured with a digital scale. Furthermore, the firmness ($N/cm^2*9.84$, where 9.84 is the firmness factor) was analysed using a digital penetrometer, TR Turoni equipped with 3 mm diameter tip (Massantini et al., 2021). Soluble solids (% °Brix) were assessed using the Krüss DR301-95 refractometer (Bezdadea-Cătuneanu et al., 2017).

The titratable acidity was determined by homogenising the samples with distilled water and titrated with 0.1 N NaOH until they reached a pH of 8.1. The results were calculated according to the method proposed by Saad et al., 2014.

The ascorbic acid content was determined following the method of Stan et al., 2020.

Taste and maturity indexes were calculated after Mendez (2011).

Dry matter was determined by drying the fresh tomatoes at 105°C for 24 hours, with results expressed in % fresh weight (FW).

The carotenoids pigments content was quantified according to the petroleum ether extraction method as follows: fresh sample was ground using mortar and a small quantity of sea sand. The sample was washed repetitively with the extraction solvent until the residue was colorless. The absorbance of the etheric extract was measured at 452 and 472 nm against a petroleum ether blank, using Specord 210 Plus UV/VIS spectrophotometer. The total carotenoids content was calculated following Rodriguez-Amaya et al. (2004) and lycopene content following Pelissari et al. (2016). The results were expressed as mg/100 g of FW.

To determine the influence of the environmental factors on the quality parameters, correlation analyses were performed using Microsoft Excel. This software was also used to determine the standard deviation of the analysed samples. Five repetitions per sample were used to determine the average weight, longitudinal and equatorial diameter, the firmness and the total soluble solids. Furthermore, three repetitions were used to obtain the average titratable acidity, ascorbic acid, β-carotene and lycopene contents of the tomato varieties.

RESULTS AND DISCUSSIONS

The average weekly temperature before harvesting the tomatoes varied between 15.6°C and 23°C (Figure 2).

Optimal growing conditions are obtained at temperatures between 15.5 and 28°C (Tahery et al., 2021). While this threshold was surpassed a few times during the day in the later harvesting weeks, the air temperature only reached values above 30°C a few times. Therefore, while not achieving the optimal temperature at all times, the plants did not suffer from cold or heat stress.

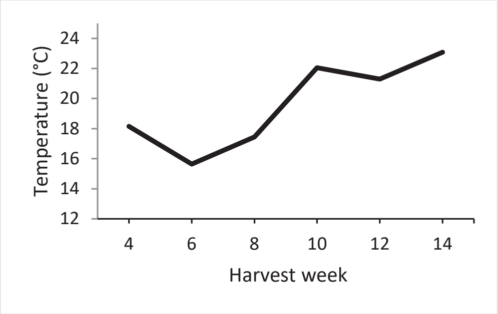

Figure 2. Average weekly greenhouse air temperature prior to harvesting

The seven-day average relative humidity prior to the harvest of the tomatoes varied between 44% and 78.2% (Figure 3), correlated with the indoor greenhouse air temperature.

Figure 3. Average weekly greenhouse relative humidity prior to harvesting

While the optimal relative humidity is considered to be around 65%, the growing conditions were favourable for the tomato plants (Tahery et al., 2021).

The average weekly CO_2 concentration prior to harvesting the tomatoes varied between 373 ppm and 594 ppm (Figure 4).

Figure 4. Average weekly greenhouse CO_2 concentration prior to harvesting

For greenhouse crops, research shows optimal CO_2 enrichment values of up to 1000 ppm (Li et al., 2018). The average CO_2 concentration recorded through the current study was lower than optimal, plant growth being negatively affected.

Given the phenotypical characteristics of the two varieties, larger weights were recorded for the Cheramy tomatoes throughout the study (Figure 5).

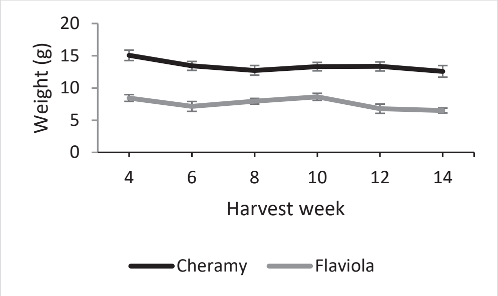

Figure 5. Average weight of the two varieties. Vertical bars represent the standard error of the mean

The lowest average weights for both varieties were measured in the fourteenth harvesting week: 12.57 g for 'Cheramy' and 6.5 g for 'Flaviola'. On the other hand, while the largest weight was recorded at 15.06 g in the first week for 'Cheramy', an average of 8.62 g per fruit was measured in the tenth week for 'Flaviola'.

The average longitudinal and equatorial diameters were relatively consistent throughout the study. Thus, the larger differences in longitudinal diameter between the harvesting weeks were registered for 'Flaviola' (Figure 6).

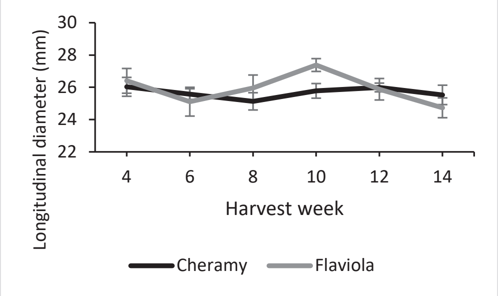

Figure 6. Average longitudinal diameter of the two varieties. Vertical bars represent the standard error of the mean

Similarly, a significant dip within the equatorial diameter was recorded for 'Flaviola' in the twelfth and fourteenth harvesting week (Figure 7).

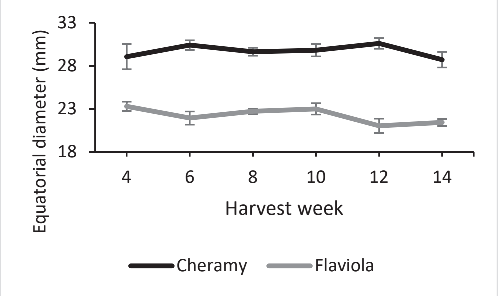

Figure 7. Average equatorial diameter of the two varieties. Vertical bars represent the standard error of the mean

This might be due to several factors, among which might be the variety’s phenotype or the greenhouse whitefly infestation which affected 'Flaviola’s' plant vigour in a more significant manner compared to 'Cheramy'.

The tomatoes’ firmness varied between the harvesting weeks for both varieties (Figure 8).

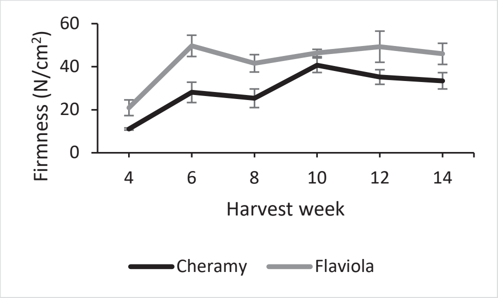

Figure 8. Average firmness of the two varieties. Vertical bars represent the standard error of the mean

Overall, due to the intrinsic characteristics, the 'Flaviola' tomatoes were firmer compared to the 'Cheramy' variety due to the higher resistance recorded.

The total soluble solids were found in higher percentage within the 'Flaviola' tomatoes (Figure 9). However, the analysis performed in the fourteenth harvesting week revealed a higher percentage for 'Cheramy', peaking at 7.84%.

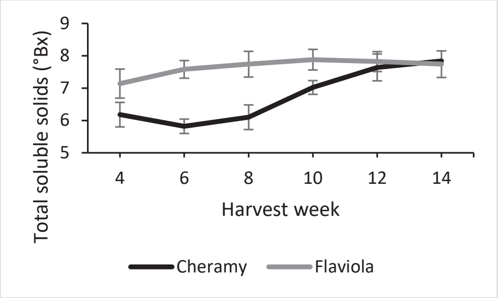

Figure 9. Average total soluble solids of the two varieties. Vertical bars represent the standard error of the mean

For 'Cheramy', the results reveal slightly higher values compared to the findings of Dobrin et al., 2019. However, total soluble solids values are in line with the determinations of Khan et al., 2017.

A significant positive correlation $R^2 = 0.8864$, with the linear regression $y = 0.2737x + 1.4007$ was identified between temperature and total soluble solids for the 'Cheramy' variety (Figure 10).

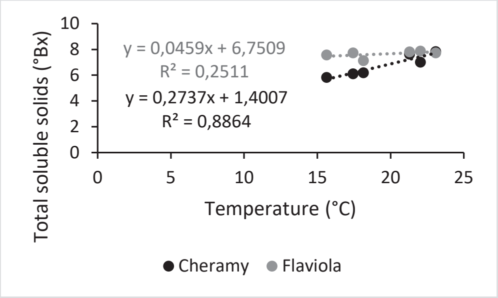

Figure 10. Correlation between the greenhouse temperature and total soluble solids for both varieties

This illustrates the direct influence of air temperature on the sugar content of the tomatoes. Thus, a higher temperature is synonymous with a higher concentration of soluble solids.

The lowest titratable acidity was recorded for 'Flaviola' in the fourth harvesting week (0.29% citric acid), closely followed by 'Cheramy' with 0.34%. While the largest value for 'Cheramy' was recorded in the eighth week (0.95%), 'Flaviola' registered the two largest values within the sixth and eighth weeks at 0.7% (Figure 11).

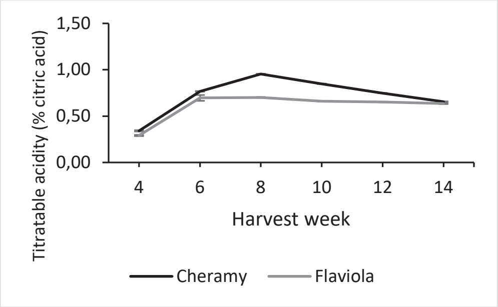

Figure 11. Average titratable acidity of the two varieties. Vertical bars represent the standard error of the mean

Using the previous two quality parameters, the taste and maturity indices were calculated. Because of the low titratable acidity in the fourth week, the largest taste index registered for 'Flaviola' was 1.52. 'Cheramy' tomatoes had a more consistent taste index, averaging at 1.24 throughout the whole study (Figure 12). This is lower than the 1.29 average taste index assessed for 'Flaviola'.

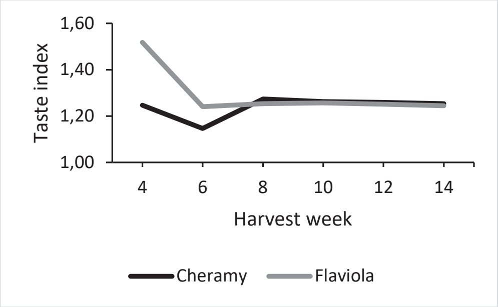

Figure 12. Taste index of the two varieties

The maturity index varies more between the varieties in the first harvesting weeks, reaching a similar value in the fourteenth week: 11.97 for 'Cheramy' and 12.19 for 'Flaviola' (Figure 13).

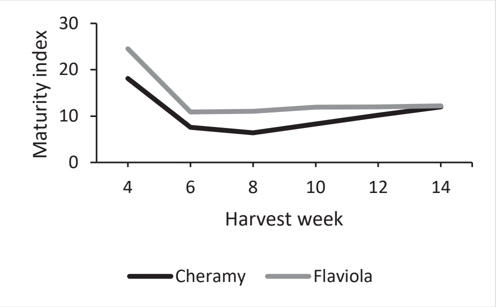

Figure 13. Maturity index of the two varieties

Both the taste and maturity indices are in line with those determined in other studies (Dobrin et al., 2019; Figàs et al., 2018).

The dry matter percentage varied slightly between the varieties and the harvest weeks (Figure 14).

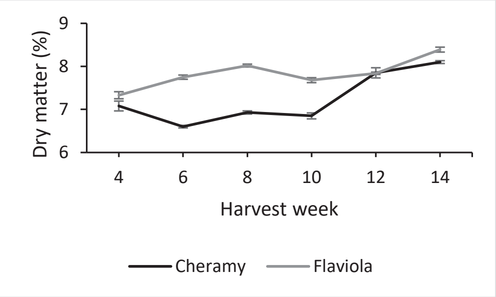

Figure 14. Average dry matter of the two varieties. Vertical bars represent the standard error of the mean

The findings are in line with the values determined through previous studies for the 'Cheramy' variety (Dobrin et al., 2019). Other studies reveal similar values for the tomato dry matter percentage (Felföldi et al., 2022).

No significant correlation was identified between temperature and dry matter (Figure 15).

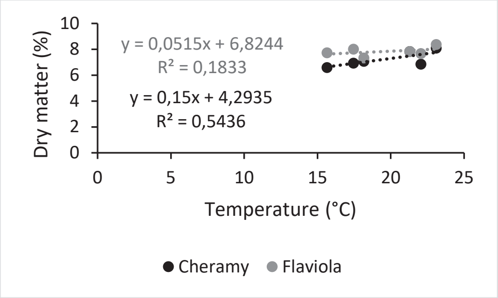

Figure 15. Correlation between greenhouse temperature and dry matter for both varieties

As such, the largest percentage for both varieties were registered in the fourteenth week: 7.97% for 'Cheramy' and 8.3% for 'Flaviola'.

The antioxidant value of tomato (rendered by the content of vitamin C, carotene and lycopene) could be significantly influenced by the crop system and variety (Murariu et al., 2021).

The ascorbic acid varied significantly between the harvesting weeks (Figure 16). For 'Cheramy', the ascorbic acid content varied between 10.23 and 27.56 mg/100 g FW. These represent larger variations compared to 'Flaviola' which ranged from 13.47 to 23.5 mg/100 g FW. The average ascorbic acid is comparable with the results found in the literature (Khan et al., 2017).

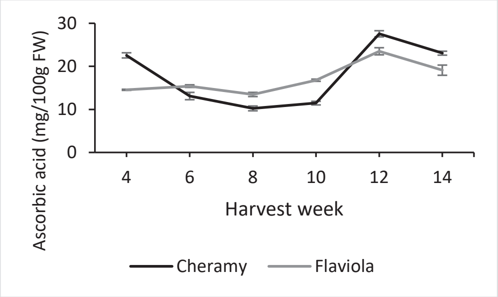

Figure 16. Average ascorbic acid content of the two varieties. Vertical bars represent the standard error of the mean

β-carotene also varied between harvesting weeks, the values being inconsistent with the development stage (Figure 17).

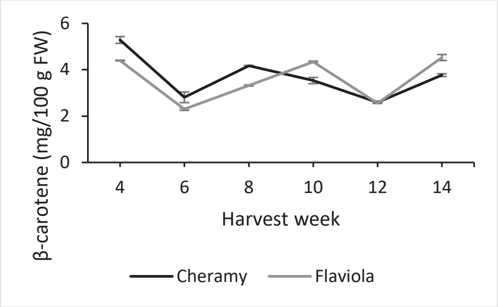

Figure 17. Average β-carotene content of the two varieties. Vertical bars represent the standard error of the mean

The β-carotene content is higher compared to the results of previous studies (Felföldi et al., 2022; Junior et al., 2022).

Analysing the correlation between the temperature and the β-carotene content, no significant interaction was determined (Figure 18).

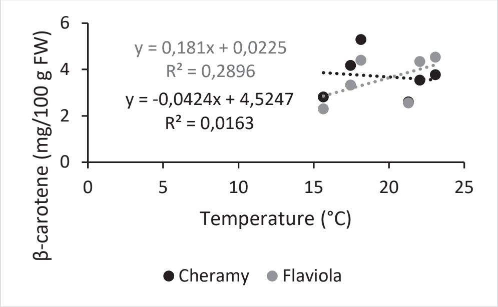

Figure 18. Correlation between the greenhouse temperature and the β-carotene content for both varieties

Similarly, large variations between the harvest weeks could be observed for the lycopene content (Figure 19).

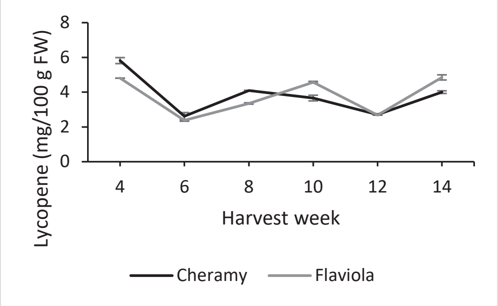

Figure 19. Average lycopene content of the two varieties. Vertical bars represent the standard error of the mean

The tomato lycopene content is lower compared to previous research results (Felföldi et al., 2022), but also higher compared to other studies (Junior et al., 2022). Furthermore, an in depth look at β-carotene and lycopene contents reveals similar values between both the varieties and the harvesting weeks. This is in line with previous findings (Dobrin et al., 2019).
Similarly to β-carotene, no significant correlation was identified between the air temperature and the lycopene content (Figure 20).

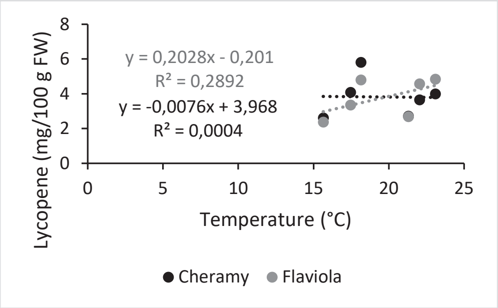

Figure 20. Correlation between the greenhouse temperature and the lycopene content of both varieties

The studied nutritional parameters are in close relationship with the commercial quality of tomatoes (Marti et al., 2016). Monitoring the environmental conditions is essential to reach optimal quality values for greenhouse grown tomatoes. This is further demonstrated by previous studies which concluded that there is no significant difference within the nutritional parameters between organically and conventionally grown tomatoes (Vélez-Terreros et al., 2021).
A well-coordinated cultivation technique is necessary in order to achieve the optimal phytochemical content in tomatoes (Lima et al., 2022). Thus, tomato quality directly translates to the health benefits obtained by consuming the fruits (Meng et al., 2022).

CONCLUSIONS

Environmental factors play a significant role within the plants' growth and development. While the current study only illustrates a particular correlation between the climatic conditions and quality parameters, the interaction between them is proved through previous studies. Future research should focus on a more in-depth review of the environmental factors' effect on the nutritional quality parameters. Furthermore, the differences between plant varieties should be considered for further research.

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