Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 1, 2020
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

THE QUALITATIVE AND QUANTITATIVE CHARACTERISTICS OF SOME ROMANIAN TOMATO VARIETIES IN GREENHOUSE CONDITIONS

Adriana BĂDULESCU[1], Alina FLOREA[1], Dorin SUMEDREA[1], Florina ULEANU[2]

[1]National Research and Development Institute of Biotechnology in Horticulture Ştefăneşti-Argeş, Sreet Bucharest - Piteşti, No.37, Ştefăneşti, 117715, Romania
[2]University of Pitești, Street Târgu din Vale, No. 1, Pitești, Romania

Corresponding author email: badulescuadriana18@yahoo.com

Abstract

Tomato (Solanum lycopersicum L.), known to belong to the Solanaceae family, is considered one of the most important vegetable in the world since the fruits are widely consumed either fresh or processed. The ripe fruits are a valuable source of vitamin C, carotenoids and minerals such as iron and phosphorous that is daily required for a healthy diet. Fruit growth and ripening are the result of multiple physiological and metabolic processes that occur during the plant development. Knowledge of the physiological characteristics of tomato plants is necessary to improve the cultivation technology under greenhouse conditions. This work highlights the evolution of the quality study of tomato's fruits varieties as regard the fruit indicators (plant height, number of inflorescences, diameter, fruit length, biometric indicators (weight, diameter, weigh fruit) and biochemical (dry mater content % Brix, acidity).The following varieties obtained at NRDIBH Stefanesti were studied: Argeş 11, Argeş 20, Argeş 16, Argeş 123, compared to the control variety Notorius.

Key words*: tomato, fruit quality, weight, dry substance, acidity.*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.), known to belong to the *Solanaceae* family, is considered one of the most important vegetable in the world since the fruits are widely consumed either fresh or processed.
In the world, tomato is one of the most consumed vegetables and one of the most produced agricultural products. According to FAO, in 2018, Romania produce 742.899 tons of tomatoes.
The interest in consuming high quality fresh or processed tomatoes continues to increase. In Romania, the annual average of tomatoes consumption per capita was recorded in 2015 as 38.6 kg/inhabitant (Soare et al., 2017), which is a relevant indicator for the vegetable market.
Tomato is considered an important antioxidant source in human nutrition. Compounds with essential antioxidant properties in tomato fruit include phenolics, carotenoids and pigments (Coyago-Cruz et al., 2019). Beside the high nutritional value, the ripe tomato fruits are a valuable source of vitamin C, carotenoids and minerals such as iron and phosphorous that are daily required for a healthy diet (Mubarok et al., 2019; Nour et al., 2013).
Fruit growth and ripening are the result of multiple physiological and metabolic processes that occur during the plant development (Bertin & Génard, 2018; Li et al., 2019). Leaves are considered to be the main providers of carbon for fruit growth (Hetherington et al., 1998).

MATERIALS AND METHODS

Four tomato hybrids patented by the National Research and Development Institute of Biotechnology in Horticulture Ştefăneşti (INCDBH) were investigated: 'Arges 11', 'Arges 20', 'Arges 16', 'Arges 123', compared to the control 'Notorius' cultivar. 'Arges 11' hybrid is a tomato with determined growth, big fruit (average weight 180 g), and ideal for consumption in fresh and preserved condition (Badulescu & Uleanu, 2017). 'Arges 20' hybrid is characterized by determined growth, very big fruits (average weight 220 g), suitable for consumption in fresh or preserved state. 'Arges 16' are tomato hybrids with undetermined growth, which produce big elongated fruits

(180-200 g) and 'Arges 123' which produce big fruits (average weight 270 g) (Bădulescu & Uleanu, 2017). 'Notorius' variety was chosen as a Control cultivar. The selected tomato hybrids were cultivated in protected systems (greenhouse) that provided controlled conditions for plant growth.
The following bioindicators regarding the growth and fruiting processes were determined: the number of inflorescence per plant, the number of fruits in inflorescence, the average length of a fruit, the average diameter of the fruit, the production (Badulescu & Tita, 2014) and the biochemical indicators: acidity and soluble solids content.
The total soluble solids (TSS) was determined with KRUSS GMbH mobile optronic refractometer model DR 101-60, in Brix % of fruit juice. The total acidity was determined by the titrimetric determination method (Tudor-Radu et al., 2016).
For the statistical interpretation of the results, the data were included in an Excel database and then statistically interpreted with the SPSS 14.0 program, which uses the Duncan test (multiple t test) for a 5% statistical assurance.

RESULTS AND DISCUSSIONS

The statistical analysis of the fruit took into account the following biometrics: inflorescence number, number of fruit blossom, fruit average height, the diameter of a fruit, production, total acidity and dry matter.
Average height of plants. In general a normal distribution is symmetric when the asymmetry value of the coefficient is equal to zero.
The sample average was 76.4933 the values being between the minimum value of 59.00 and the maximum value of 86.00.
The histogram of all the plant height values is asymmetrical to the left, (the values are higher than the average), being different from the normal distribution, a sign that there are significant influences between the varieties studied about of plant height (Figure 1).
Analyzing indicators of dispersion or genetic and experimental diversity, in terms of inflorescence number, the mean sample was 3.8267, the values being between 2 and 6 (Figure 2). The histogram of the number of fruits in the inflorescence is bimodal, a sign that the sample is no longer homogeneous due to the influence of the different varieties studied, regarding the number of fruits in the inflorescence (Figure 3).
In the case of the number of fruits from the average inflorescence it was 8.4467, with a standard deviation of 2.03, the values being between the minimum value 4 and the maximum value 12.0 (Figure 3).
The diameter of the fruit, expressed in mm, of an average of 8.4467 mm with a standard deviation of 2.03505 (Figure 4). If fruit weight, average was 197.9427 kilograms with a standard deviation of 37.18824 (Figure 6).

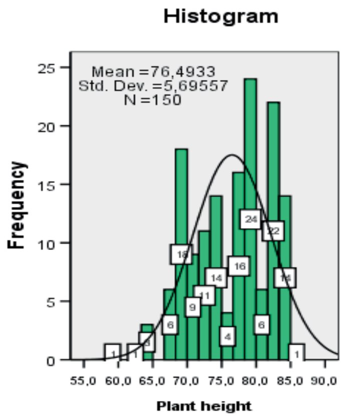

Figure 1. Histogram of the distribution by absolute frequency classes of plant height, in the studied varieties (mm)

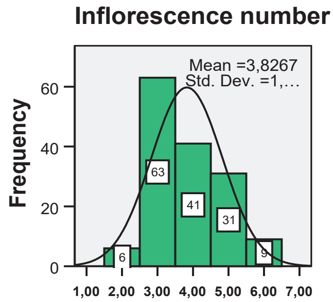

Figure 2. Histogram of the distribution by absolute frequency classes of the number of inflorescences per plant, in the studied varieties

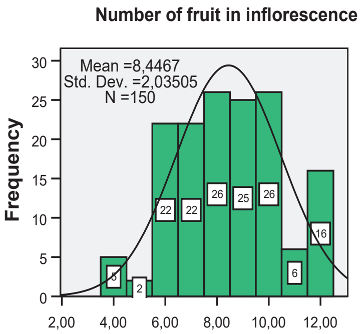

Figure 3. Histogram of the distribution by classes of absolute frequency of the number of fruits in the inflorescence, at the studied varieties

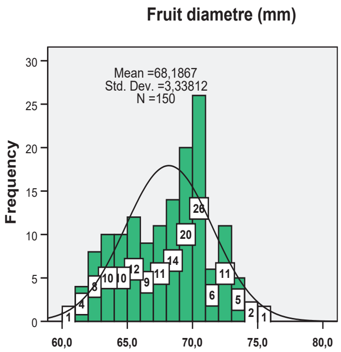

Figure 4. Histogram of the distribution by absolute frequency classes of the diameter of the fruits, for the studied varieties

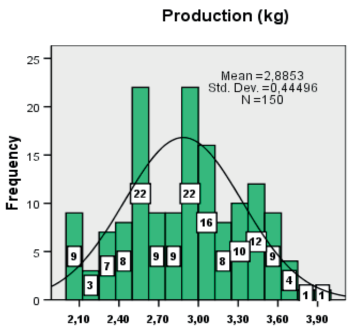

Figure 5. Histogram of the distribution by classes of absolute frequency of fruit production, for the studied varieties

The histogram of the average mass of the fruits deviates significantly from the normal distribution, being asymmetrical to the right (predominating values lower than the average) sign that there are significant influences between the studied varieties (Figure 6).

The values measurements at the production, at the 5 varieties of tomatoes studied on a sample of 150 samples are between the minimum value of 2.0 and the maximum value of 3.90, with a maximum oscillation of 1.90 (Figure 5).

For acidity, the sample average was 3.3073, with a standard deviation with 0.30, values ranging from a minimum of 2.50 to a maximum of 4.20 (Figure 7). It is observed that the histogram deviates from the normal distribution, having asymmetry to the right (the values lower than the average predominate), sign that there are significant differences between the values of the acidity of the fruits recorded by the 5 varieties.

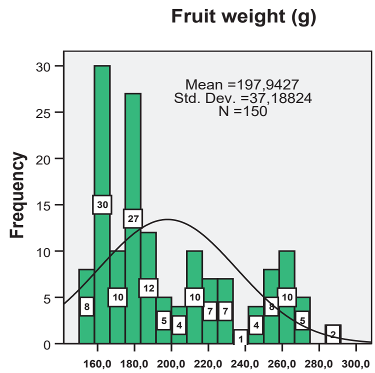

Figure 6. Distribution histogram by frequency classes absolute of the average fruit mass, in the studied varieties

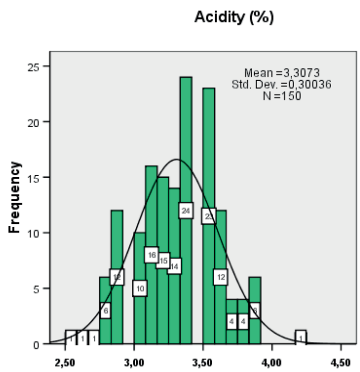

Figure 7. Histogram with the distribution of fruit acidity values, in the studied varieties

As total soluble solids, the sample average was 3.8487 with values between 2.80 and 5.00 with a standard deviation of 2.20 (Figure 8).

The histogram of all the values analyzed regarding the dry substance in the 5 varieties studied is asymmetric to the left, the coefficient of asymmetry being -0.633, which means that the values above the average predominate (Figure 8), and the sample is no longer homogeneous due to the influence of the variety regarding the dry matter (% Brix), (Figure 8).

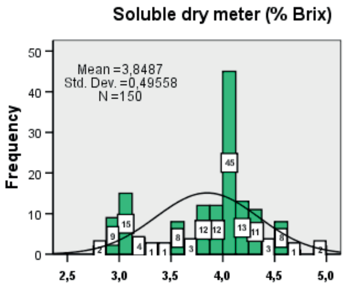

Figure 8. Histogram of the distribution by frequency classes of the total soluble solids in fruit (% Brix), in the studied varieties

Table 2 and graph below (Figure 9) shows the correlations between indicators studied, we highlight the following:

- Between the average fruit weight and production there is a positive correlation (r = 0.250**) significant. The weight of the fruit implies a high production.
- Is a significant negative correlation between the fruit weight and number of inflo-rescence (r=-0.711**), which explains the fact that, as the number of fruit per plant is higher, the lower the average weight of a fruit;
- Number of fruits in inflorescence correlate significant negative with fruit weight, production and total soluble solids (r=-0.742**; r=-0.247**; r=-0.127**; r=-0.220**), negative acidity significant (r = -0.129 **), and then we have a decrease in the percentage of the tomato juice.
- It is known that, as total soluble solids (% Brix) has higher values as the total acidity (%) will have lower values (Gurteg Singh, 2017). Soluble dry matter correlate positive and distinct significant negative with acidity, indicating that there is a relation between these parameters balanced.

Table 1. Indicators sample central tendency (mean, median and mode) and indicators value dispersion around the average (maximum amplitude, limits, standard deviation and asymmetric coefficient)

Statistics		Plant height	Inflores cence number	Number of fruits in inflorescente	Fruit diameter (mm)	Fruit lenght (mm)	Fruit weight (g)	Production (kg)	Total acidity (%)	TSS (% Brix)
N	Valid	150	150	150	150	150	150	150	150	150
Mean		76.4933	3.8267	8.4467	68.1867	70.4060	197.9427	2.8853	3.3073	3.8487
Median		78.0000	4.0000	8.0000	68.9000	74.9000	183.0000	2.9000	3.3000	4.0000
Mode		79.00	3.00	8.00(a)	67.90	75.90	179.00(a)	2.90	3.40	4.10
Std. Deviation		5.69557	1.00165	2.03505	3.33812	10.50128	37.18824	.44496	.30036	.49558
Skewness		-.414	.477	.005	-.272	3.783	.764	.000	.004	-.633
Std. Error of Skewness		.198	.198	.198	.198	.198	.198	.198	.198	.198
Kurtosis		-.577	-.592	-.584	-.813	32.107	-.698	-.813	-.067	-.399
Std. Error of Kurtosis		.394	.394	.394	.394	.394	.394	.394	.394	.394
Range		27.00	4.00	8.00	14.50	101.70	136.00	1.90	1.70	2.20
Minimum		59.00	2.00	4.00	60.90	56.90	154.00	2.00	2.50	2.80
Maximum		86.00	6.00	12.00	75.40	158.60	290.00	3.90	4.20	5.00

(a) Multiple modes exist. The smallest value is shown.

Table 2. Matrix of correlation (Pearson "r" correlation coefficients "r") of the main physical and biochemical indicators (average for the five tomato cultivars studied).

		Plant height	Inflorescence number	Number of fruits in inflorescence	Fruit diameter (mm)	Fruit weight (g)	Production (kg)	Total acidity (%)	TSS (% Brix)
Plant height	Pearson Correlation	1	.367(**)	.289(**)	.303(**)	-.382(**)	.081	.021	-.244(**)
Inflorescence number	Pearson Correlation	.367(**)	1	.433(**)	.579(**)	-.614(**)	-.220(**)	-.212(**)	-.433(**)
Number of fruits in inflorescence	Pearson Correlation	.289(**)	.433(**)	1	.603(**)	-.742(**)	-.247(**)	-.129	-.220(**)
Fruit diameter (mm)	Pearson Correlation	.303(**)	.579(**)	.603(**)	1	-.711(**)	-.208(*)	.005	-.216(**)
Fruit weight (g)	Pearson Correlation	-.382(**)	-.614(**)	-.742(**)	-.711(**)	1	.431(**)	.250(**)	.384(**)
Production (kg)	Pearson Correlation	.081	-.220(**)	-.247(**)	-.208(*)	.431(**)	1	.452(**)	.441(**)
Total acidity (%)	Pearson Correlation	.021	-.212(**)	-.129	.005	.250(**)	.452(**)	1	.530(**)
TSS (% Brix)	Pearson Correlation	-.244(**)	-.433(**)	-.220(**)	-.216(**)	.384(**)	.441(**)	.530(**)	1

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

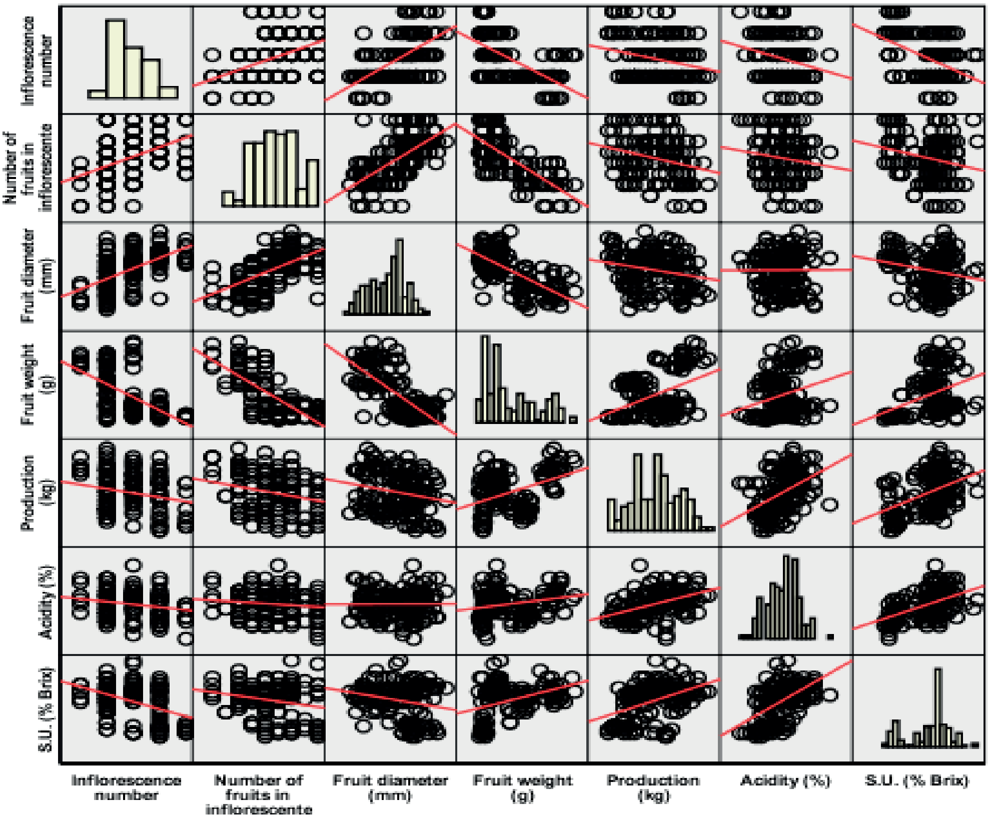

Figure 9. Matrix of correlations between biometric and biochemical indicators, for studied tomato cultivars

Table 3. Morphometry of tomato varieties

Varieties	Plant height (cm)	Inflorescence number	Number of fruit in inflorescence	Fruit diameter (mm)
Arges 11	75.1b	4.03b	10.00a	70.84a
Arges 20	70.23c	3.03c	7.00c	65.31c
Arges 16	80.10a	4.03b	9.07b	69.63b
Arges 123	75.83b	3.03c	6.13d	64.65c
Control (Mt)	81.23a	5.00a	10.00a	70.51ab

Duncan. Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 30,000

The plant height shown that all studied varieties are shorter than Control ('Notorius' variety), which could be an advantage in the field. The number of inflorescence varied between 3.03% on 'Argeș 20' and 'Arges 123' and 5.00% on 'Notorius' variety (Table 3, Figure 10).

Table 4. Physical and biochemical properties of studied tomato varieties

Varieties	Fruit weight (g)	Produc-tion (kg)	Total acidity (%)	TSS (% Brix)
Arges 11	179.03c	2.9c	3.5a	4.3a
Arges 20	215.20b	2.5d	3.10b	3.81c
Arges 16	175.10c	3.13b	3.42a	4.0b
Arges 123	260.30a	3.40a	3.5a	4.11b
Mt	160.08d	2.49d	3.02b	3.1d

Duncan
Means for groups in homogeneous subsets are displayed.
a Uses Harmonic Mean Sample Size = 30,000.

The fruit weight varied between 175.10 g on 'Argeș 16' and 260.30 g ('Arges 123'), being cultivar characteristic that influence significantly tomato production (Table 4).

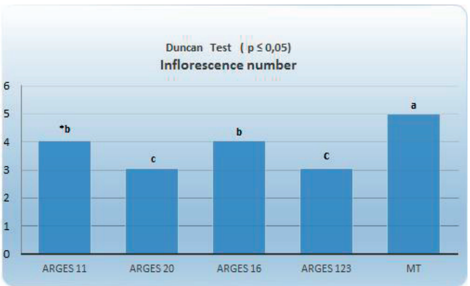

Figure 10. Inflorescence number of the fruit on the tomato varieties

The fruit diameter was higher in varieties 'Arges 11' and 'Notorius' (control), with significant differences compared to all the other varieties to 5% statistical assurance. The lowest values of this indicator were registered variety 'Arges 123' (Figure 11).

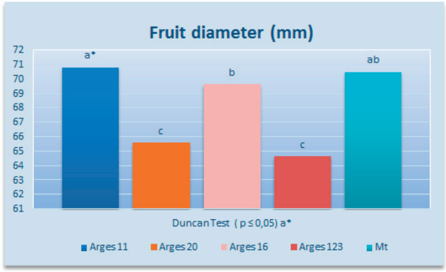

Figure 11. Fruit diameter of the fruit on the tomato varieties

The average weight is a characteristic that expresses the size of the fruit, the index of commercial importance, especially for fresh fruits market. Analyzing the average weight of the fruit from 5 varieties of tomato is found that all varieties belongs to tomato large fruits group, like St. Pierre or Mirsini F1 (Mandru et al., 2019). The variety 'Arges 123' has the heaviest fruit (260.30 g), its average weight being significantly different from all other varieties, for statistical assurance 5% (Figure 12). The smallest fruit varieties were recorded at 'Arges 16' and 'Notorius' (Control), that influence strongly the production.

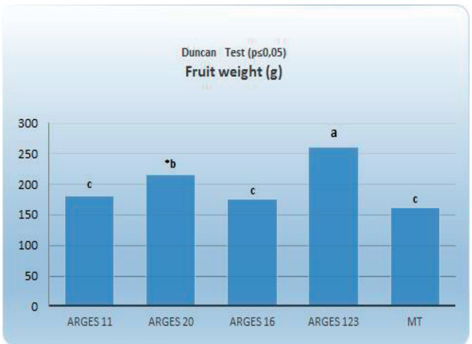

Figure 12. Fruit weight of the fruits on the tomato varieties

Analysing the production were significant differences between genotypes studied (Figure 13). The variety 'Arges 123' recorded the highest yield (3.4 kg/plant), with significant differences compared to the other varieties. The small amount of tomato fruit varieties were recorded to ‘Notorius’ and ‘Arges 20’ (control), the differences between the two varieties were statistically insignificant for a statistical assurance 5%, (Figure 13).

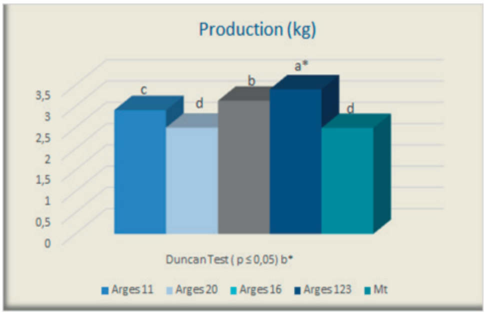

Figure 13. Production of the fruits on the tomato varieties

The content of organic acids (total acidity %) in fruits and vegetables depends on several factors, including differences in genotypic, climatic conditions pre-harvest and post-harvest handling procedures (Lee & Kader, 2000). It is known that during periods of heavy rainfall or cooler areas, total acidity values become larger (Gherghi, 1972).

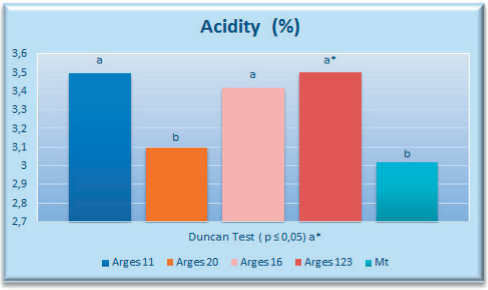

Figure 14. Acidity of the fruits on the tomato varieties

The fruits acidity between 3.02% on ‘Notorius’ and 3.5 % on ‘Arges 11’ variety The highest values of this indicator showed varieties ‘Arges 11’, ‘Arges Arges 123’ and ‘Arges 16’, and the smaller varieties ‘Notorius’, ‘Arges 20’ (control), the differences between the two classes is significant (Figure 14).

The dry matter content depends on the cultivar, the growing technology, and the environmental factors during the growing season (Helyes, 2007). János Ágoston, following the studies done on tomatoes intended for both fresh consumption and industrialization, states that the varieties intended for fresh consumption should fall between 3.5-4.5% Brix values, while destined for industrialization must exceed the value of 5% Brix (J. Agoston, 2017).

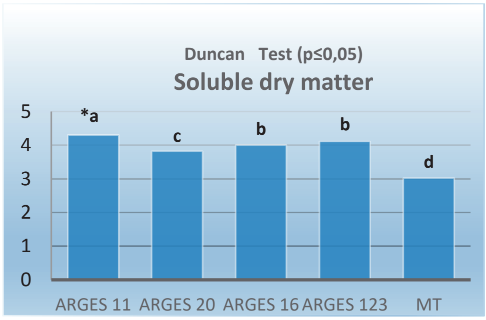

Figure 15. Soluble dry matter of the fruits on the tomato varieties

From the point of view of the content of tomato fruit dry matter (% Brix) was studied varieties within the normal limits of variation of this index ranging from 4.11 to ‘Arges 123’ and 3.1 from variety ‘Notorius’ (control).

The results on the soluble dry matter (% Brix) showed significant statistically differences between genotypes, and the mean there of was classified into four classes of statistical significance homogeneous. The highest value of dry matter (Figure 15) was recorded in the variety ‘Arges 11’ (4.3%), which differs significantly from the varieties Arges 20, ‘Arges 16’, ‘Arges 123’ and ‘Notorius’ - Mt (3.81%, 4.0%, 4.11%, 3.1%).

CONCLUSIONS

The following conclusions were drawn from the study:

All the studied varieties had large fruits with a mean weight over 175.10 g and a diameter of more than 64 mm;

Average fruit weight was significantly correlated and distinct positive with production (r = 0.250 **). Fruit weight entails a high production

Soluble dry matter was correlates significantly with acidity (r = 0.530**), indicating that there is a relation between these parameters balanced.

‘Arges 123’ variety presented the best results for the production of fruit soluble dry matter and acidity.

The low solids content (% Brix) and acid recorded in the control variety ('Notorius').

REFERENCES

Ágoston, J., Tóth-Horgosi, P., Kiss, T., Tóthné Taskovics, Z. (2017). Assessment of nutrient content of tomato hybrids for processing. Acta Universitatis Sapientiae Agriculture and Environment, 9: 63-69.

Bădulescu, A., Tita, I. (2014). New varieties tomato obtained and cultivated at INCDBH Ştefăneşti, *Current Trends in Natural Sciences*. Vol. 3(5):61-65.

Bădulescu, A., Uleanu, F. (2017) New valuable genotypes of tomato added in culture to INCDBH Stefanesti-Arges, *Current Trends in Natural Sciences*. Vol. 6(12):83-87.

Bertin, N., Génard, M. 2018. Tomato quality as influenced by preharvest factors, *Scientia Horticulturae*, 223:264-276, https://doi.org/10.1016/j.scienta.2018.01.056.

Coyago-Cruz, E., Corell, M., Moriana, A., Mapelli-Brahm, P., Hernanz, D., Stinco, C.M., Beltrán-Sinchiguano, E., Meléndez-Martínez, A.J. (2019) Study of commercial quality parameters, sugars, phenolics, carotenoids and plastids in different tomato varieties, *Food Chemistry*, 277:480-489. https://doi.org/10.1016/j.foodchem.2018.10.139.

Gherghi A., Millim K., Burzo I. (1972). *Păstrarea şi valorificarea fructelor şi legumelor*, Ed. Ceres Bucureşti.

Gurteg Singh, Pushpinder Singh Aulakh, Harinder Singh Rattanpal (2017). Correlation studies on fruit traits of some mandarin genotypes grown under sub-tropical conditions of India. *J Krishi Vigyan*, 6(1):40-44. DOI: 10.5958/2349-4433.2017.00046.0.

Helyes, L., Dimény, J., Pék, Z., Lugasi, A. (2006). Effect of the variety and growing methods as well as cultivation conditions on ingredient of tomato (*Lycopersicon lycopersicum* (L.) Karsten) fruit. *Acta Horticulturae* 712, 511-516.

http://www.fao.org/faostat/en/#data/QC

Hetherington S.E., Smillie R.M., Davies W.J. (1998). Photosynthetic activities of vegetative and fruiting tissues of tomato. *J. of Exp. Botany,* 49(324): 1173–1181.

Lee K.S., Kader A.A. (2000). Preharvest and postharvest factors influencing vitamin C contenof horticultural crops. *Postharvest Biology and Technology*, 20(3), 207e220.

Li, J., Gao, Y., Zhang, X., Tian, P., Li, J., Tian, Y. (2019). Comprehensive comparison of different saline water irrigation strategies for tomato production: Soil properties, plant growth, fruit yield and fruit quality, *Agricultural Water Management*, 213:521-533, https://doi.org/10.1016/j.agwat.2018.11.003.

Mandru I., Costache M., Sovarel G., Croitoru M., Hoza D., Cristea S. (2019) Research on fruits quality of different tomato (Lycopersicon esculentum Mill.) cultivars in Vidra area, Ilfov County. *Scientific Papers. Series A. Agronomy*, Vol. LXII(2):140-143.

Mubarok, S., Farhah, F.F., Anas, Suwali,N., Kurnia, D., Kusumiyati, Suminar, E., Ezura, H. (2019). Data on the yield and quality of organically hybrids of tropical tomato fruits at two stages of fruit maturation, *Data in Brief*, 25:104031, https://doi.org/10.1016/j.dib.2019.104031.

Nour V., Trandafir I., Ionica M.E. (2013). Antioxidant Compounds, Mineral Content and Antioxidant Activity of Several Tomato Cultivars Grown in Southwestern Romanian. *Not. Bot. Horti Agrobo* 41(1): 136-142.

Tudor-Radu, M., Vîjan, L.E., Tudor-Radu, C.M., Tiţa, I., Sima, R., Mitrea, R. (2016) Assessment of Ascorbic Acid, Polyphenols, Flavonoids, Anthocyanins and Carotenoids Content in Tomato Fruits. *Not Bot Horti Agrobo*, 44(2):477-483. DOI:10.15835/nbha44210332.

Soare, E., Chiurciu, I.A., David, L., Dobre, I. (2017) Tomato market trends in Romania. *Scientific Papers. Series "Management, Economic Engineering in Agriculture and rural development",* Vol. 17(2):341-348.