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STUDIES REGARDING THE BEHAVIOUR OF 'MONEYMAKER' TOMATOES DURING THEIR MARKETING IN FRESH STATE

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Abstract

The consumption of fresh tomatoes, both in Romania and worldwide, has an important place as far as the vegetable category is concerned. This paper presents the results of the studies carried out for the technological and economic characterization of the 'Moneymaker' tomato in the marketing process in fresh state. The duration of maintaining the quality depends on the ripening stage at harvesting and on the temperature level during storage. The limit period for fresh fruits marketing is 7-9 days at a temperature of 23-24 ^{0}C and of 18-22 days at a temperature of 7-10^{0}C. It was also ascertained that over 97% of the output of the 'Moneymaker' tomato corresponds to the specific quality standard. The fruits harvested in greenhouse or solarium have a homogenous structure by quality categories, the value of quality category coefficient (Q) having values between 2.64 and 2.60.

Key words**:** *postharvest, quality preservation, storage period.*

INTRODUCTION

Tomatoes are among the most consumed vegetables worldwide, and variety is one of the main factors that define the quality of production and the destination of its valorization (Chira & Chira, 2022; Nirupama et al., 2020).
The spread of this species is due to its adaptability to different cropping systems and different processing conditions. Tomato fruits have a great diversity and superior quality characteristics that meet consumer requirements (Dobrin et al., 2019; Ilie & Mihalache, 2022; Hatami et al., 2013).
Given that the 'Moneymaker' ensured the possibility of delivering uniform batches of high quality tomatoes for most of the year, it was considered necessary to carry out research for technological and economic characterization in the conditions of the Vidra vegetable basin in Ilfov County.
In the literature, the 'Moneymaker' is characterized more from an agro-productive point of view. For the technological characterization of tomatoes, the assessment criteria and factors influencing fruit quality during storage are mentioned in numerous papers (Winsor, 1979: Thole et al., 2021).
Particular attention is paid to the scientific substantiation of the changes that occur in the fruit marking process: colour, flesh firmness and chemical components that determine the nutritional value of the fruit, as mentioned in many scientific studies (Brashlyanova et al., 2014; Kabir et al., 2020; Al-Dairi et al., 2021; Pinela et al., 2022; Thole et al., 2020).
The aim of the present research was to investigate 'Moneymaker' tomato storage period and some quality changes related to the culture systems, as well as the preservation conditions.

MATERIALS AND METHODS

The biological material has been represented by 'Moneymaker' tomatoes obtained from different growing systems (greenhouse and solarium) from a private farm located in the Vidra vegetable basin, Ilfov County (Figure 1).
A specific cultivation technology was applied in greenhouse (cycle 1) and the solarium (cycle 1 and cycle 2), respectively (Table 1).

Table 1. Tomato growing conditions, harvesting period and storage conditions

Harvesting period	Growing system	Environmental room		Refrigerated room	
		Temperature (T)(^{0}C)	Relative Humidity (RH) (%)	T (^{0}C)	RH (%)
1.02. – 22.02	Greenhouse Cycle 1	23-24	65-70	7-8	95-100
27. 07 - 13.08	Solarium Cycle 1	23-24	70-85	9-10	90-95
28.09 – 11.10 First harvest	Solarium Cycle 2 partial protected	20-21	80-85	8-9	90-95
23.10 – 18.11 Second harvest	Solarium Cycle 2 partial protected	19-20	80-85	7-8	90-95

It should be noted that in solarium culture, cycle 2, the total protection of the crop with polyethylene film was not ensured.

Figure 1.'Moneymaker' tomato (own source)

At the harvesting time and at the end of the storage period the following parameters have been determined: the main physical-chemical, such as water content (%), dry total matter (%), dry soluble matter (%), firmness (kgf/cm^2), total titratable acidity (%) and the content of ascorbic acid (mg/100 g fresh weight).
The water content and total dry matter have been determined by using a ventilation oven, at 105^{0}C. The content of soluble dry matter was measured by using the Atago electronic refractometer (Figure 2).
The total titratable acidity was measured by titration with a sodium hydroxide (NaOH) 0.1N solution. The content or ascorbic acid was measured using the iodometric method. The pulp firmness was determined by using the hand-held Effegi penetrometer, having an 11mm piston in diameter (Figure 3).

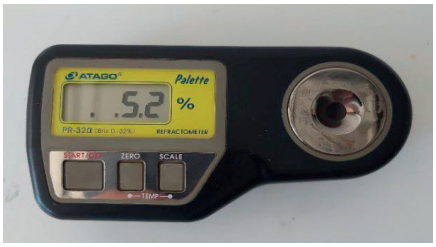

Figure 2. Determination of soluble dry matter, using the Atago refractometer (own source)

Also, the shape index has been calculated (height/medium diameter ratio).

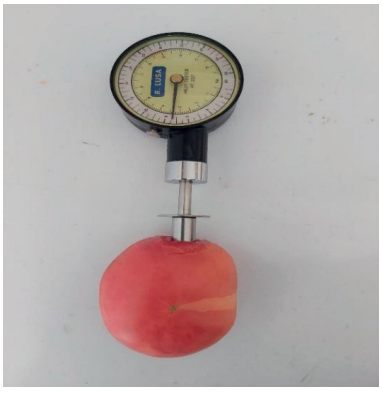

Fig. 3. Determination of fruit firmness, using the hand-held Effegi penetrometer (own source)

The temperature level and the air relative humidity in the storage environment have been measured using the Hanhart thermo hygrometer.
It is known that tomatoes can be harvested at different ripening stages, depending on the destination of the crop, as follows: F0 - green ripening, F1 - when 10-30% of the skin is pinkish-yellow, F2 - when 30-50% of the skin

is pinkish-yellow, F3 - when 50-90% is red, F4 - when 100% is red and F5 - when the fruit contains at least 4.5% soluble dry matter (technological maturity). In the present work there were carried out two harvesting phases: F1 and F3.

The tomatoes fruits were then stored under different environmental conditions, as we can see in (Table 1).

There were used 3 replicates, each represented by 3kg of tomatoes, which were stored in the environmental and refrigerated room, respectively, in the Technology Laboratory of the Faculty of Horticulture Bucharest (Figure 4 and Figure 5).

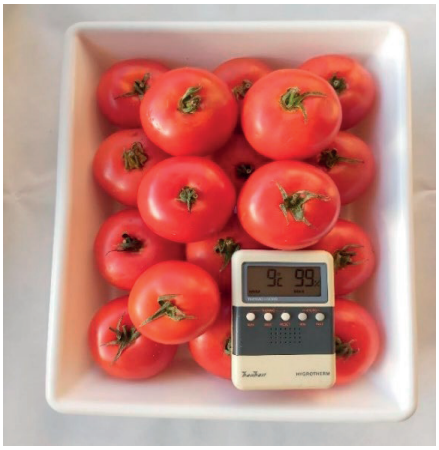

Fig. 4. Tomato fruits stored in the cooling room (own source)

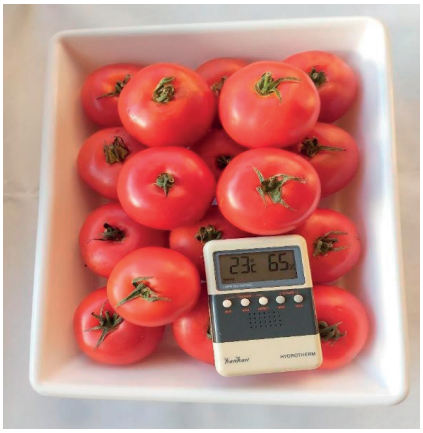

Fig. 5. Tomato fruits stored in the enviromental conditions (own source)

The economic efficiency of tomato valorization was determined by establishing the structure of production by quality category (Q) using the formula:

Q = Kq/100, where K = 3 for extra quality; 2 for quality 1; 1 for quality 2 and 0 for those intended for industrialisation, and q is the percentage of the quality category.

RESULTS AND DISCUSSIONS

1. The quality of tomato fruit at harvest

The results of the physical-chemical analysis carried out on tomato fruits are presented in Tables 2 and 3. It can be seen as a good homogenity in the case of this cultivar.

Table 2. The main physical characteristics of tomato fruits at harvest time

Growing system	Maturation phase	Shape index	Caliber (40-47 mm)		Caliber (47-57mm)	
			Diameter (mm)	Weight (g)	Diameter (mm)	Weight (g)
Greenhouse Cycle 1	F1	1.02	45	41	57	74
	F3	1.02	45	41	57	74
Solarium Cycle 1	F1	1.03	43	40	52	75
	F3	1.03	43	40	52	75
Solarium Cycle 2 first harvest	F2	1.10	47	52	56	81
Solarium Cycle 2 second harvest	F1	1.08	46	50	48	69

Table 3. The main chemical characteristics of tomato fruits at harvest time

Growing system	Water (%)	Total dry matter (%)	Soluble dry matter (%)	Ascorbic acid (mg/100g FW)	Total titratable acidity (%)
Greenhouse	94.07	5.93	5.4	17.03	0.43
Cycle 1	94.07	5.93	5.6	24.33	0.45
Solarium	94.48	5.52	5.3	30.79	0.37
Cycle 1	94.75	5.25	5.1	30.79	0.36
Solarium Cycle 2 first harvest	94.71	5.29	5.1	35.95	0.40
Solarium Cycle 2 second harvest	93.26	6.74	5.4	39.75	0.30

Thus, in terms of the shape index, the values determined were close to 1, which meets the requirements for the spherical shape, a characteristic feature of this cultivar.

The size of the tomatoes at harvest was average, with diameter values between 43 mm and 57 mm and a weight of 40-81 g.

The water content of tomatoes ranged from 93.26% to 94.75%, while total dry matter ranged from 5.25% to 6.74%. The soluble dry matter content ranged from 5.1 to 5.6%.

The ascorbic acid content ranged from 17.03 mg/100 g FW to 39.75 mg/100 g FW and the total titratable acidity (as malic acid) ranged from 0.3% to 0.45%. The results obtained fall within the specific values defining good quality tomato fruit (Dobrin et al., 2019; Abiso et al., 2015).

2. Duration of tomato quality maintenance after harvesting

The results obtained, presented in Table 4, confirm that the duration of the interval from harvesting to reaching the stages of eating maturity (F4/F5) is directly influenced by the degree of ripeness of the tomatoes at harvest.

Harvested from greenhouses or solariums at the F1 stage, tomatoes reach consumption maturity after 5 days at 23-24^{0}C and after 14-15 days at temperatures ranging from 7 to 10^{0}C.

In the case of tomatoes harvested at F3 stage, the fruit reached consumption maturity in 2 days at 23-24^{0}C and 5-7 days at 7-10^{0}C. After reaching consumption maturity (F4), the tomatoes continue to maintain their specific quality for fresh processing for a period that depends mainly on the temperature values during storage. If we consider the time interval from harvesting to the possible limit for fresh processing, the influence of the ripening stage at harvest is not so evident.

Thus, tomatoes harvested in the F1 phase, which have reached the maturity for consumption in 5 days at 23-24^{0}C, can still be used in good conditions after another 3-4 days, so the total period is 8-9 days.

If harvested at the F3 stage, tomatoes reach eating maturity in 2 days, but they can also be harvested in good condition after another 5-6 days, the total period in this case being 7-8 days. Basically, the two periods with tomatoes harvested in F1 and F3 phases are almost equal until the consumption limit is reached.

At temperatures of 7-10^{0}C, the total period from harvest to consumption was extended to 20-22 days.

In cycle 2, tomatoes harvested at F1 stage and kept at 20-21^{0}C were harvested after 6 days and those kept at 8-9^{0}C after 13 days. Tomatoes obtained at the 2nd harvest were harvested after 8 and 14 days respectively.

Table 4. The storage period of tomato fruits, depending on temperature levels and harvesting maturation phase

Growing system	Maturation phase at harvest	Temperature level during storage (^{0}C)	The period from harvest until full maturation F4/F5 (days)
Greenhouse	F1	23-24 7-8	5 F4 8 F5 14 F4 22 F5
	F3	23-24 7-8	2F4 7F5 5F4 20F5
Solarium Cycle 1	F1	23-24 9-10	5F4 9 F5 15F4 20F5
	F3	23-24 9-10	2F4 8F5 7F4 18F5
Solarium Cycle 2 (first harvest)	F1	20-21 8-9	6F4 10F5 13F4 17F5
Solarium Cycle 2 (second harvest)	F1	19-20 7-8	8F4 12F5 14F4 19F5

3. Changes seen in ripening tomato fruit after harvesting

Tomatoes are climacteric fruits, that continue their ripening process after harvesting, with changes in their physical-chemical characteristics. Thus, at ripening, flesh firmness had values between 4 and 7.6 kgf/cm^2 (Table 5). After tomatoes storage in different temperature conditions, due to solubilization of pectic substances, firmness decreased by 19-47% at 23-24^{0}C reaching values of 2.8-4 kgf/cm^2. The most relevant reduction in firmness was recorded in tomatoes harvested in stage 2 of the solarium - cycle 2 (from 7.6 to 3 kgf/cm^2) in 26 days at 7-8^{0}C.

This was followed by greenhouse-grown tomatoes harvested at F1 stage and kept at 8-10^{0}C for 22 days (from 6.7 to 3.38 kgf/cm^2), and then by those in the glasshouse, cycle 2, harvested at the same stage (from 6.5 to 3.4 kgf/cm^2).

It was observed that irrespective of the type of crop, tomatoes harvested in the F1 phase and stored at 8-10^{0}C for more than 20 days lose firmness to a greater extent than those harvested in the F3 phase, even when the storage period was the same.

The weight losses determined during storage were higher in tomatoes harvested at F1 stage (from 4.7 to 5.7%) at approximately the same temperature (8-10^{0}C) and storage time (20-22 days). The same influence of ripening phase was found at 23-24^{0}C (4.1% to 4.7% at F1 phase and 2.9-3.2% at F2 phase) (Table 6).

The daily weight losses were reduced as the shelf life was extended (Thole et al., 2020).

Table 5. The evolution of tomato fruit firmness depending on the harvesting maturation phase and temperature level during storage

Growing system	Maturation phase at harvest	Firmness at harvest time (kgf/cm^2)	Temperature (^{0}C)	Storage period (days)	Firmness at the end of storage (kgf/cm^2)	Firmness loss (%)
Greenhouse	F1	6.7	7-8	22	3.38	50.7
	F1	6.7	23-24	8	4.00	40.0
	F3	4.6	7-8	20	14.17	10.8
		4.6	23-24	5	3.73	19.0
Solarium Cycle 1	F1	6.5	9-10	20	4.20	35.0
		6.5	24-24	9	3.40	47.0
	F3	4.0	9-10	18	3.20	25.0
		4.0	23-24	8	2.80	30.0
Solarium Cycle 2 (first harvest)	F1	7.6	8-9	13	5.7	25.0
		7.6	20-21	6	4.8	36.0
Solarium Cycle 2 (second harvest)	F1	7.3	7-8	14	3.0	58.0
		7.3	19-20	8	3.4	53.0

Table 6. The weight losses of tomato fruits during storage period

Growing system	Maturation phase/ Temperature (^{0}C)	Weight losses (%)				Storage period (days)
		after 24 h	after 48 h	after 72 h	End of storage	
Greenhouse	F1/7-8	0.4	0.7	1	4.5	22
	F2/7-8	0.2	0.4	0.5	2.5	20
	F1/23-24	0.7	1.0	0.6	4.1	8
	F3/23-24	0.2	0.8	1.2	2.9	5
Solarium Cycle 1	F1/9-10	0.6	0.9	1.0	5.7	20
	F3/9-10	0.4	0.6	0.9	4.3	18
	F1/23-24	0.6	1.1	1.5	4.7	9
	F3/23-24	0.3	0.9	1.6	3.2	8
Solarium Cycle 2 (first harvest)	F1/8-9	0.2	0.4	0.7	2.9	13
	F1/20-21	0.7	1.0	1.8	6.2	6
Solarium Cycle 2 (second harvest)	F1/7-8	0.3	0.5	0.7	4.1	14
	F1/19-20	0.2	0.6	1.4	5.4	8

Regarding the results obtained on the evolution of the main physical-chemical characteristics that define the quality of tomatoes, from the data presented in Table 7, during ripening, after harvesting there were specific morphological, physical and biochemical changes. Thus, during storage there was a slight increase in the total dry matter content, due to water loss through transpiration and concentration of the cell juice.

Tomatoes stored at 23-24^{0}C showed a slight decrease in total titratable acidity, due to more intense oxidation processes at higher temperatures, compared to 7-8^{0}C, where a slight decrease was determined.

Ascorbic acid content increased more during storage mainly in greenhouse tomatoes harvested at F1 phase and stored at 23-24^{0}C (29.19 mg/100g compared to 17.03 mg/100 g at harvest) according to the previous published results (Al-Dairi et al., 2021).

4. The economic efficiency of the valorization of 'Moneymaker 'tomatoes

The quality structure of the production of the 'Moneymaker' tomato grown in the two cropping systems is shown in Table 8.

It results that in all cropping systems, out of the total production, 97.9-99.2% falls within the requirements of the quality standard for fresh tomatoes.

The coefficient of the quality categories, which characterizes the homogeneity of the cultivar in terms of quality, in the three cropping systems, varied between 2.46 and 2.60 (Table 8). The close values of this coefficient indicate the homogeneity of the quality of the cultivar in all cropping systems.

Table 7. The main physical-chemical characteristics of tomato fruits at the end of the storage period

Growing system	Maturation phase at harvest	Storage temperature (^{0}C)	Storage period -day)	Water (%)	Total dry matter (%)	Soluble dry matter (%)	Ascorbic acid (mg/100g)	Total titratable acidity (%)
Greenhouse	F1	23-24	8	92.85	7.15	6.4	29.19	0.41
	F1	7-8	22	93.87	6.13	6.0	25.26	0.46
	F3	23-24	5	94.05	5.95	5.7	20.27	0.34
	F3	7-8	20	93.90	6.09	5.6	20.53	0.43
Solarium	F1	23-24	9	93.95	6.05	5.8	39.67	0.34
	F1	9-10	20	93.96	6.04	5.8	28.96	0.39
	F3	23-24	8	94.3	5.7	5.5	27.21	0.35
	F3	9-10	18	93.88	6.12	5.9	30.29	0.34

Table 8. The quality structure of tomato fruits in the valorisation process

Growing system	Selling period	Quality structure (%)				Total according quality standard	The coefficient of the quality category
		Extra	First quality class	Second quality class	Industry class		
Greenhouse Cycle 1	20.03-1.07	72.0	12.0	15.2	0.8	99.2	2.55
Greenhouse Cycle 2	25.09-31.12	76.0	9.7	13.4	0.9	99.1	2.60
Solarium	10.06-30.09	67.2	13.8	16.9	2.1	97.9	2.46

CONCLUSIONS

Maintaining the quality of the tomatoes after harvesting until they are ready for consumption can be ensured for:

- 5 days at 23-24^{0}C and RH 70-85% for those harvested at F1 phase;
- 2 days at 23-24^{0}C and RH 70-85% for those harvested at F3 phase;
- 14-15 days at 7-10^{0}C and RH 90-95% for those harvested in F1phase;
- 5 days at 7-10^{0}C and RH 90-95% for those harvested in F3 phase.

Once tomatoes have reached the maturity for consumption, they can be used for a longer period, reaching a total of :

- 7-9 days at 23-24^{0}C and RH 70-85%;
- 18-22 days at 7-10^{0}C and RH 90-95%.

Changes in the physical-chemical characteristics during storage do not adversely affect the possibility of consuming them fresh within the specified shelf-life.

The daily weight loss decreased as the shelf life was extended.

Economic quality indicators of the 'Moneymaker' tomato show that:

- 97.9-99.2% of the total production meets the quality standard for fresh tomatoes;
- the coefficient of the quality categories (Q) had values between 2.46 and 2.60, indicating the homogeneity of the quality structure in the three cropping systems.

REFERENCES

Al-Dairi, M., P.B. Pathare, A. Al-Mahdouri (2021). Effect of storage conditions on postharvest quality of tomatoes: a case study at market-level. *J. Agric. Marine Sci., 26 (1)*, pp. 13-20.

Al-Dairi, Pankaj B. Pathare, Rashid Al-Yahyai (2021). Chemical and nutritional quality changes of tomato during postharvest transportation and storage. *Journal of the Saudi Society of Agricultural Sciences*, *Volume 20, Issue 6,* September 2021, Pages 401-408.

Abiso E., Satheesh N., Hailu A (2015). Effect of storage methods and ripening stages on postharvest quality of tomato (*Lycopersicom esculentum* Mill) cv. *Chali. Annals Food Sci.Technol., 6 (1),* pp.127-137.

Brashlyanova, B., Zsivamovits, G., & Ganeva, D. (2014). Texture quality of tomatoes as affected by different storage temperatures and growth habit. *Emirates Journal of Food and Agriculture*, *26*(9), 750 – 756.

Chira, A., & Chira, L. (2022). Managementul Calității și Siguranței Produselor Agroalimentare (The Quality and Food Safety Management of Agrofood Products). Ex Terra Aurum Publishing House, 27 – 33, ISBN 978-606-072-243-4.

Dobrin, A., Nedeluț, A., Bujor, O., Moț, A., Zugravu, M., & Bădulescu, L. (2019). Nutritional quality parameters of the fresh red tomato varieties cultivated in organic system. *Scientific Papers, Series B, Horticulture*, *LXIII* (1), 439-443.

Ilie, V., & Mihalache, M. (2022). Research on the quality of tomatoes growth with vermicompost fertilization, solarium cultivation. *Current Trends in Natural Sciences*, *11*(21), 271-278.

Hatami M., Kalantari S.,Delshad M. (2013). Responses of Different Maturity Stage of Tomato Fruit to Different Storage Conditions. *VII International Postharvest Symposium 2012*, pp. 857-864.

Kabir, N.S., Rasool, K., Lee, W., H., Cho, S., I., & Chung, S.O. (2020). Influence of delayed cooling on the quality of tomatoes stored in a controlled chamber. *Agriculture and Food*, *5*(2), 272 – 285.

Nirupama P., Neeta B.G., Rao T.V.R. (2020). Effect of post harvest treatments on physicochemical characteristics and shelf life of tomato (*Lycopersicon Esculentum* Mill.) fruits during storage. *Am.-Eurasion J. Agric. Environm. Sci., 9 (5)*, pp.470 – 479.

Pinela. J., Petropoulos, S.A., & Barros L (2022) Editorial: Advances in tomato and tomato

compounds research and technology. *Frontier Nutrition, 9*:1018498.

Thole, V., Vain, P., Yang, R.Y., Barros da Silva, J.A., Enfissi, E.M.A. & al. (2020). Analysis of tomato post-harvest proprieties: fruit colour, shelf life and fungal susceptibility. *Current Protocol Plant Biology*, *5*(2), 108-116.

Thole, V., Vain, P., & Martin, C. (2021). Effect of elevated temperature on tomato post-harvest proprieties. *Plants*, *10* (11), 2359-2367.

Winsor, G.W. (1979). Some factors affecting the quality and composition of tomatoes. *Acta Horticulture*, *93*, 335-346.