Veringa D *et al.* (2023)
Notulae Botanicae Horti Agrobotanici Cluj-Napoca
Volume 51, Issue 1, Article number 13027
DOI:10.15835/nbha51113027
Research Article

The effect of storage conditions on some tomato varieties, during the postharvest period

Daniela VERINGA[1]*, Ionel Lucian DUMITRESCU[1], Marian BOGOESCU[1,2]

[1]*Research and Development Institute for Processing and Marketing of Horticultural Products - HORTING, 5N Drumul Gilăului Street, District 4, 041715 Bucharest, Romania;*
*daniela.veringa@horting.ro (*corresponding author); lucian.dumitrescu@horting.ro*
[2]*The Academy of Agricultural and Forestry Sciences, 61 B-dul Marasti, District 1, 011464 Bucharest, Romania; marianbogoescu@gmail.com*

Abstract

In this study, an analysis was made of how the variety and storage conditions influence the keeping of tomatoes in the fresh conditions, in the post-harvest period. The fruits of three varieties of tomatoes were stored in different technological conditions: at ambient temperature (20-22 °C), with and without air ionization; at a temperature of 10-12 °C, with and without modified atmosphere; and at a temperature of 3-5 °C. The firmness of the pulp and some biochemical components were analysed, respectively the soluble dry matter, the total sugar, the acidity and vitamin C. For the studied varieties the mass losses were appreciated and losses due to rotten during the analysed period. The observations made during the storage of tomatoes in different conditions confirmed that, in general, tomatoes are relatively easily alterable products, the storage period being between 5 days and 15 days. The experimental research carried out showed the fact that the fresh storage time of tomatoes varies significantly depending on the storage conditions but also depending on the tomato variety investigated. The main problem was represented by the large volume of losses due to rotting recorded in one of the varieties regardless of the storage conditions and also the very large differences in losses due to rotting existing between the varieties within the same storage conditions.

Keywords: biochemical components; ionized air; storage; tomatoes

Introduction

Among the vegetable species, compared to the area cultivated with cabbage, the areas cultivated with tomatoes in the field and in protected areas has the largest share in Romania. The importance of this crop lies in the fact that tomatoes can be eaten both fresh and processed in different ways (Stan *et al.*, 2003). Applied cultivation technology must aim not only to obtain high yields, but also quality, and technological links must take into account the destination of production (Alexe *et al.*, 2013; Alexe *et al.*, 2015).

To assess the quality as well as the nutritional value of fruits, not only the physical and sensorial characteristics (size, shape, colour, specific gravity, structure-texture firmness, aroma, taste, etc.) or technological characteristics (storage capacity, resistance in transport and handling, the presence of disease or

Received: 15 Feb 2023. Received in revised form: 02 Mar 2023. Accepted: 27 Mar 2023. Published online: 30 Mar 2023.
From Volume 49, Issue 1, 2021, Notulae Botanicae Horti Agrobotanici Cluj-Napoca journal uses article numbers in place of the traditional method of continuous pagination through the volume. The journal will continue to appear quarterly, as before, with four annual numbers.

pest attacks, the remanence of some control substances, etc.) but also the biochemical properties are taken into account: water content, dry matter, sugar, acids, cellulose, vitamins, pigments, mineral salts, etc. (Salunkhe and Kadam, 1998). The chemical composition of tomatoes depends, for each variety, on the soil chemistry (Neata, 2002; Anton *et al*., 2011; Cioroianu *et al*., 2011; Alexe *et al*., 2015) and the technological links applied to culture. In addition, when creating new varieties and hybrids, it must be taken into account that they respond differently both to environmental conditions and to the technological chains applied to the cultivation and valorisation of the products (Draghici and Pele, 2012; Alexe *et al*., 2015).

The storage capacity depends on the post-harvest quality of the products intended for storage and the storage conditions. The chemical composition of tomatoes, which largely depends on soil chemistry, influences the level of biochemical processes during storage and thus their storage capacity. In this paper are presented some aspects regarding the influence of variety and storage technology, on the storage capacity of three varieties of tomatoes usually used for tomatoes can production ('Pontica', 'Viorica', 'Vipon'). Tomatoes were cultivated at the Research and Development Institute for Vegetable and Floriculture Vidra, Romania.

Materials and Methods

The research protocol established a number of 15 experimental variants depending on the tomato variety and storage conditions. The experimental variants are presented in Table 1.

Table 1. Experimental scheme for storing tomatoes

Variant	Variety	Storage conditions *)
V1	'Pontica'	20-22 °C
V2		20-22 °C / IR
V3		10-12 °C
V4		10-12 °C / MA
V5		3-5 °C
V6	'Viorica'	20-22 °C
V7		20-22 °C / IR
V8		10-12 °C
V9		10-12 °C / MA
V10		3-5 °C
V11	'Vipon'	20-22 °C
V12		20-22 °C / IR
V13		10-12 °C
V14		10-12 °C / MA
V15		3-5 °C

*) Legend: MA = modified atmosphere; IR = ionized radiation

Prior to storage, biometric measurements were performed, taking into account: average fruit weight, height, diameter and shape index. During the experiments, the initial level and the evolution of some biochemical components during storage were analysed, namely soluble dry matter, total sugar, acidity and vitamin C. In Figure 1 it is shown the physical appearance of the three tomato varieties studied at the optimum harvesting period.

Figure 1. The aspect of tomatoes from the studied varieties

Results

The biometric data of the three tomato varieties are presented in Table 2. It can be seen that they are different for all the evaluation criteria, respectively: size, shape and weight of the fruits. The table shows that for the 'Viorica' variety, the fruits were larger and heavier on average by 10.8 g/piece than the 'Pontica' variety and by 22.2 g/piece than the 'Vipon' variety.

Table 2. Biometric data of three varieties of tomato

No	Variety	Length/height [mm]	Width/diameter [mm]	Shape index	Average mass [g/pc]
1	'Pontica'	56.1	55.5	1.01	99.5
2	'Viorica'	63.3	56.7	1.12	110.3
3	'Vipon'	60.8	51.6	1.18	88.1

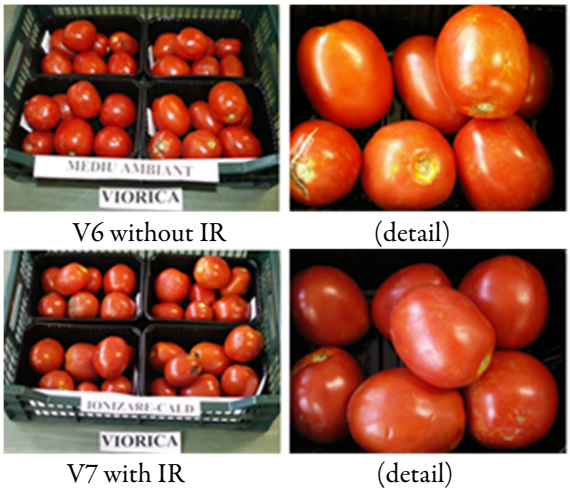
Data on the evolution of losses during storage of tomatoes are presented in Table 3. The storage periods were, for all varieties, 5 days in the case of storage at 20-22 °C, 10 days for storage at 10-12 °C and 15 days at a temperature of 3-5 °C. At ambient temperature, the tomatoes registered after 5 days of storage, mass losses of 2.66 to 4.48%, losses due to rotten of 8.94 to 36.72% and total losses of 11.60 to 41.20%, depending on the variety. The V6 variant for 'Viorica' variety had the lowest values of mass losses, due to rotten and total (Figure 2), and the V1 variant of the 'Pontica' variety had the highest losses.

At ambient temperature with air ionized the tomatoes recorded after 5 days of storage, mass loss of 3.57 to 7.52%, loss due to rotten of 11.16 to 29.13% and total loss of 15.23 to 36.65%, depending on the variety. In the V2, V7 and V12, with air ionized variants, the mass losses were higher than in ambient conditions without ionization. The level of losses due to rotten was also higher in the V7 and V12 variants of the 'Viorica' and 'Vipon' varieties. However, the positive effect of air ionization was highlighted in the V2 variant of the 'Pontica' variety by lower losses due to rotten and total than in the case of storage at ambient temperature without ionization.

At a temperature of 10-12 °C the tomatoes recorded after 10 days of storage, weight losses from 1.11 to 2.08%, losses due to rotten from 4.54 to 13.11% and total losses from 5.97 to 15.19%, in depending on the variety. The V13 variant with tomatoes from the 'Vipon' variety presented the lowest mass losses, but the V8 variant with tomatoes from the 'Viorica' variety had the lowest losses due to rotten, being the best variant for storing tomatoes by refrigeration (Figure 3). The worst refrigeration storage results were obtained by 'Pontica' tomatoes, which had the highest mass losses and losses due to rotten.

Table 3. Losses during storage

Variant	Variety	Storage conditions	Storage period [days]	Mass losses [%]	Losses due to rotten [%]	Total losses [%]
V1	'Pontica'	20-22 °C	5	4.48	36.72	41.20
V2		20-22 °C +IR	5	7.52	29.13	36.65
V3		10-12 °C	10	2.08	13.11	15.19
V4		10-12 °C+MA	10	0.30	14.20	14.50
V5		3-5 °C	15	4.53	19.42	23.95
V6	'Viorica'	20-22 °C	5	2.66	8.94	11.60
V7		20-22 °C +IR	5	3.57	11.66	15.23
V8		10-12 °C	10	1.43	4.54	5.97
V9		10-12 °C+MA	10	0.10	0	0.10
V10		3-5 °C	15	2.29	7.20	9.49
V11	'Vipon'	20-22 °C	5	3.23	10.94	14.17
V12		20-22 °C +IR	5	3.89	27.26	31.15
V13		10-12 °C	10	1.11	10.99	12.10
V14		10-12 °C+MA	10	0.08	0	0.08
V15		3-5 °C	15	2.60	6.95	9.55



V6 without IR (detail)

V7 with IR (detail)

Figure 2. Appearance of tomatoes stored at room temperature (20-22 °C)

Figure 3. Appearance of tomatoes V8 – refrigerated storage

As a result of the increasing of CO_2 concentration, under conditions of modified atmosphere that was achieved in airtight storage containers, containers which were then stored in spaces with a temperature of 10-

12 °C, after 10 days there were mass losses of 0.08-0.30% and losses due to rotten of 0-13.11%, depending on the variety.

The CO_2 concentration of the air in the storage containers was maintained at around 10% throughout the storage period of the tomatoes. Under these conditions, all 3 variants, respectively V4, V9 and V14, registered after a storage period of 10 days, extremely small mass losses (less than 1%). At the same time, the losses due to rotten were among the lowest, being below the level of the other working variants. The lowest values of mass losses and losses due to rotten were recorded for variants V9 and V14 of 'Viorica' and 'Vipon' varieties. The tomatoes of the two varieties kept very well under the given conditions, without any losses or depreciations that would affect their appearance and quality in any way (Figure 4).

Figure 4. Appearance of tomatoes – (10-12 °C) refrigerated storage + modified atmosphere

At a temperature of 3-5 °C, the tomatoes stored for 15 days had between 2.29% and 4.53% mass losses and between 6.95% and 19.42% losses due to rotten, depending on the variety. Even in these conditions, the 'Viorica' and 'Vipon' varieties, respectively the V10 and V15 variants, presented lower losses than the V5 variant of the 'Pontica' variety, a variety that registered the highest volume of mass losses and losses due to rotten in all the storage conditions tested (Figure 5).

Figure 5. Appearance of tomatoes – (3-5 °C) refrigerated storage

The regression equation of the total losses on the storage options is shown in Figure 6, and that of the losses due to rotten in Figure 7. The highest total losses were recorded in the V1 storage variant for the 'Pontica' variety and the lowest in the V4 variant for the 'Viorica' and 'Vipon' varieties (see Figure 6). The equation that most faithfully describes the variation of rotten losses depending on the storage variant, is the one for the 'Pontica' variety, the equation of regression being: y=3.0521x2-23.266x+58.74 (see Figure 7).

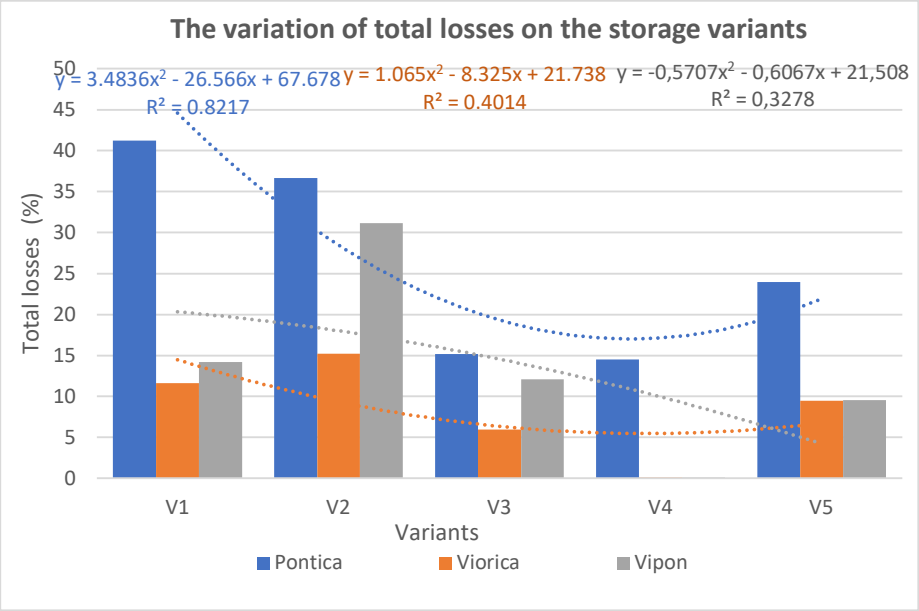


Figure 6. The regression equation of total losses on the storage variants

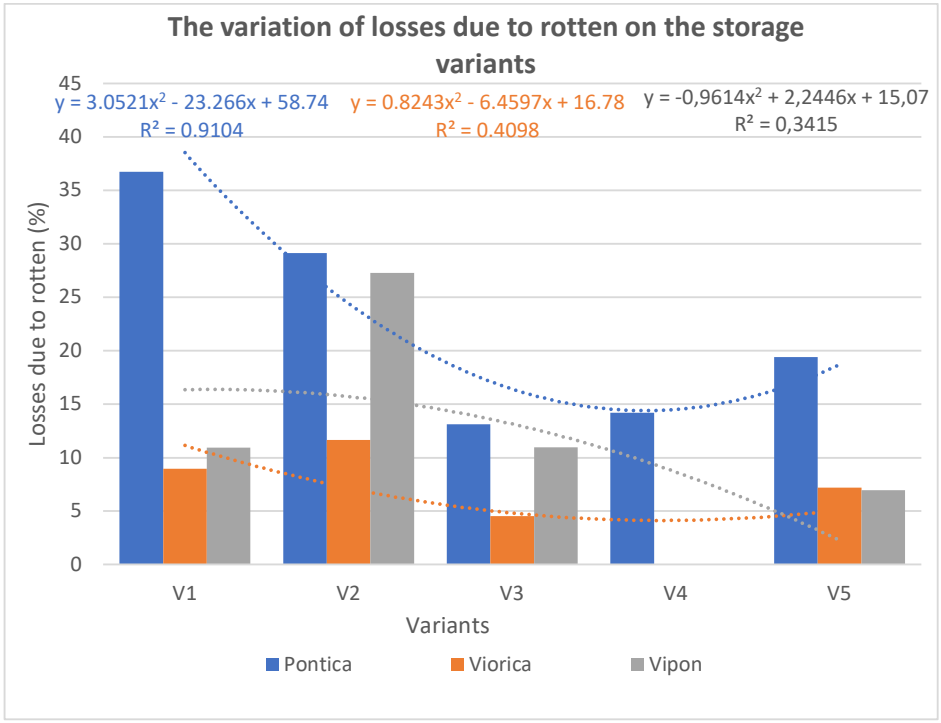


Figure 7. The regression equation of losses due to rotten on the storage variants

The results regarding the initial level and the evolution of some chemical components during the storage of tomatoes are presented in Table 4. Initially, at storage, the tomatoes had a content of 4.3-4.8% soluble dry matter, 0.45-0.51% titratable acidity, 1.26-1.72% total sugar and 33.98 -37.78 mg/100 g vitamin C, depending on the variety. The 'Pontica' variety had the highest content in titratable acidity and total sugar, and the 'Viorica' variety had the highest content of soluble dry matter and vitamin C.

The dry matter content showed both decreases and increases during the storage of tomatoes depending on the storage option. Thus, tomatoes of the 'Pontica' and 'Vipon' varieties showed especially increases, while the tomatoes of the 'Viorica' variety registered mainly decreases of dry matter. The analysis of the variation of indicators established by the research protocol shows that the dry matter content increased slightly for all storage conditions, but in the case of refrigeration, the increase of dry matter content is more pronounced. Tomatoes acidity decreased in all varieties, but in different proportions depending on the storage conditions, all varieties generally maintaining the same evolution. The data show that the smallest decreases in acidity are recorded for tomatoes stored with modified atmosphere, and the largest for those stored under non-modified atmosphere refrigeration conditions.

The evolution of the total sugar content during storage was also different for each variety. Thus, if in the 'Vipon' variety, the sugar content increased in all storage variants, but in different proportions depending on the storage conditions. For the other two varieties ('Pontica' and 'Viorica'), it recorded both increases and decreases, depending on the storage option. Increases were observed mainly in the ambient storage variants and decreases in the cold storage conditions.

Table 4. Initial level and evolution of chemical components during storage

Variant	Variety	Storage conditions [°C]	Soluble dry matter [%]	Acidity [%]	Total sugar [%]	Vitamin C [mg/100 g]
-	'Pontica'	AT	4.3	0.51	1.89	33.98
V1		20-22 °C	4.4	0.45	1.67	41.08
V2		20-22 °C +IR	5.3	0.28	2.18	38.71
V3		10-12 °C	4.6	0.35	1.63	38.44
V4		10-12 °C +MA	4.6	0.49	1.33	38.06
V5		3-5 °C	4.8	0.32	1.57	42.74
-	'Viorica'	AT	4.8	0.45	1.72	37.78
V6		20-22 °C	4.3	0.38	1.77	23.45
V7		20-22 °C +IR	4.4	0.41	1.67	32.93
V8		10-12 °C	4.6	0.32	1.38	39.70
V9		10-12 °C +MA	4.4	0.32	1.48	38.08
V10		3-5 °C	5.4	0.29	1.43	40.01
-	'Vipon'	AT	4.3	0.51	1.26	35.25
V11		20-22 °C	5.1	0.25	2.24	30.50
V12		20-22 °C +IR	4.0	0.32	1.93	36.17
V13		10-12 °C	4.4	0.32	1.48	39.19
V14		10-12 °C +MA	4.9	0.42	1.94	37.33
V15		3-5 °C	4.6	0.26	1.52	40.99

NOTE: AT = Ambient Temperature

The vitamin C content had a different evolution for each of the three tomato varieties. Thus, in the 'Pontica' variety it showed increases in all storage options, while in the 'Viorica' and 'Vipon' varieties there were also increases and decreases depending on the storage option, keeping warm generally favouring the decrease of vitamin C content. The reduction of the vitamin C content in case of storage at ambient temperature and its increase in case of refrigeration or refrigerated storage are also highlighted by the average data obtained.

Regarding the variation of sugar content shown in Figure 8, it can be seen that the highest increase in sugar concentration was recorded in the 'Vipon' variety V1 storage variant, followed by the 'Pontica' variety stored in the V2 variant. Regarding the variation of the vitamin C content (Figure 9), it can be seen that the biggest increase is in the case of storage in the V5 variant.

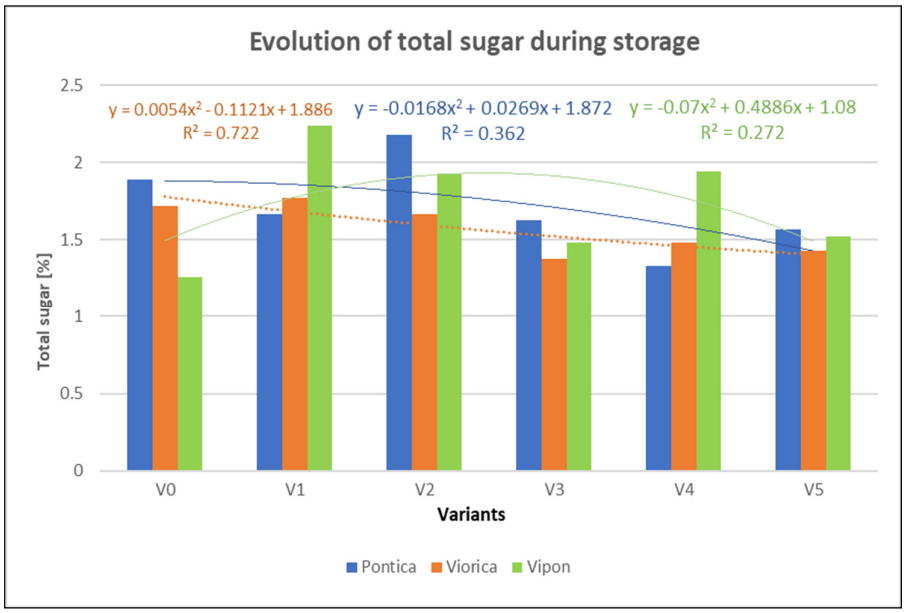


Figure 8. Variation in total sugar content

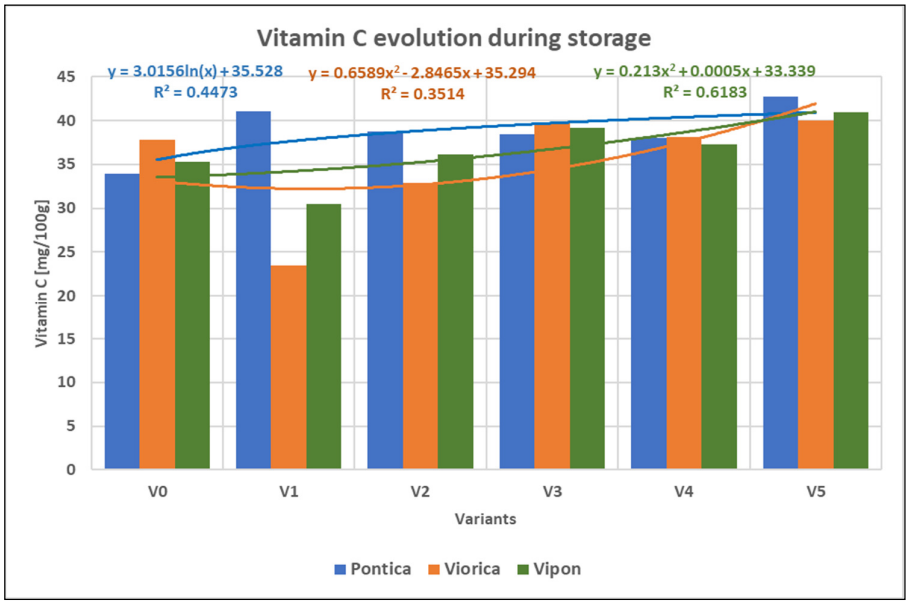


Figure 9. Vitamin C content variation during storage

Regarding the firmness of the tomatoes (presented in Table 5), initially, in all three varieties there were small differences between them, which indicated the existence of close degrees of maturity of the fruits introduced in the experiments. The initial firmness was thus 85.95-100.30 penetrometric units, depending on the variety, the 'Viorica' variety having a slightly higher firmness compared to the other varieties studied. The decrease in the firmness of the tomatoes was in the proportion of 8-48%, depending on the storage option. The evolution of firmness was also different, from one variety to another. Thus, for the Pontica variety, the tomatoes remained firm after 5 days of storage at ambient temperature, but in the presence of ionized air they softened the most. In the 'Viorica' variety in which the tomatoes were initially firmer, there were decreases in firmness with small variations (between 25-33%) depending on the storage conditions. Lower values were recorded for

storage variants V4 and V5. In the 'Vipon' variety, the reduction in firmness was lower for storage at higher temperatures and greater for storage at low temperatures.

Table 5. The evolution of tomato firmness during storage

Variant	Variety	Storage conditions [°C]	Storage period [days]	Firmness [PU]*	Decrease in firmness [%]
-	'Pontica'	AT	-	100.30	-
V1		20-22 °C	5	108.33	-8
V2		20-22°+IR	5	145.36	-45
V3		10-12 °C	10	119.72	-19
V4		10-12 °C +MA	10	113.60	-13
V5		3-5 °C	15	123.15	-23
-	'Viorica'	AT	-	85.95	-
V1		20-22 °C	5	114.31	-33
V2		20-22°+IR	5	109.56	-27
V3		10-12 °C	10	112.65	-31
V4		10-12 °C +MA	10	108.45	-26
V5		3-5 °C	15	107.50	-25
-	'Vipon'	AT	-	98.30	-
V6		20-22 °C	5	100.81	-3
V7		20-22°+IR	5	110.88	-13
V8		10-12 °C	10	124.95	-27
V9		10-12 °C +MA	10	145.25	-48
V10		3-5 °C	15	128.90	-31

*PU-penetrometric unit = 0.1 mm

Conclusions

From the observations made during the storage of tomatoes in different conditions, it emerged that in general tomatoes are easily perishable vegetables during fresh storage, the maximum storage time being from 5 to 15 days, depending on the storage conditions. The main problem during storage was the large volume of losses caused by rotting. In one of the varieties, high losses were recorded regardless of the storage conditions. It was also found that there were very large differences in losses due to rot between varieties stored under the same conditions. At the same time, it was found that in almost all storage conditions, 'Viorica' tomatoes proved to be the most resistant, presenting the lowest level of mass losses and losses due to rotting. The 'Vipon' variety recorded similar results to the 'Viorica' variety under modified atmosphere refrigeration conditions and at low temperatures. During storage, a decrease in firmness was found in all variants, but in different proportions depending on the storage variant. Among the varieties studied, it turned out that in almost all storage conditions, the 'Viorica' variety proved to be superior to the other varieties, presenting a low level, especially of losses due to rotting.

Authors' Contributions

Conceptualization: DV, ILD and MB; Data curation: DV and ILD; Funding acquisition: DV; Investigation: DV and ILD; Methodology: DV, ILD and MB; Project administration: DV; Supervision: ILD and MB; Validation: DV and ILD; Writing - original draft DV; Writing - review and editing: ILD.

All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

Acknowledgements

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

References

Alexe C, Vintila M, Lamureanu G (2015). Biochemical quality of tomatoes depending on growing technology. In: Proceedings of the 43rd International Symposium on Agricultural Engineering, Actual Tasks on Agricultural Engineering. Opatija, Croatia, 24-27 February 2015, pp 763-774.

Alexe C, Vintila M, Popescu S, Lamureanu G, Chira L (2015). The influence of culture technology upon the physical quality of some early tomatoes varieties. Scientific Papers-Series B, Horticulture 59:171-175.

Alexe C (2015). Preliminary results regarding the influence of cultivation technology on some physical indicators in summer-autumn tomatoes. Rev. Hortus 14:227-230.

Anton I, Dorneanu A, Bireescu G, Sirbu C, Stroe V, Grigore A (2011). Foliar fertilization effect on production and metabolism of tomato plants. Research Journal of Agricultural Science 43(3):3-10.

Cioroianu T (2011). Assessment of quality tomatoes grown in solar by applying organic and mineral fertilization – Amanda hybrid. Book of Abstracts 'Sesiunea Omagială Agrochimia, Prezent şi viitor, a Filialei Naţionale Romane CIEC', pp 72-80.

Constanta A, Lamureanu G, Chira L, Pricop S (2013). The influence of culture technology upon the temporary storage capacity of tomatoes. Journal of Horticulture, Forestry and Biotechnology 17(3):91-95.

Draghici EM, Pele M (2012). Evaluation some new hybrids for cultivation in conventional system in spring climatic conditions of Romania. International Journal of Agriculture Sciences 4(7):299.

Neata G (2002). Agro-chemistry and soil biology. Printech Publishing House, Bucharest.

Salunkhe DK, Kadam SS (1998). Handbook of vegetable science and technology: production, composition, storage, and processing. CRC Press.

Stan N, Munteanu N, Stan T (2003). Vegetable growing (volume III). Ion Ionescu de la Brad Publishing House, Iasi.

Notes:

- Material disclaimer: The authors are fully responsible for their work and they hold sole responsibility for the articles published in the journal.
- Maps and affiliations: The publisher stay neutral with regard to jurisdictional claims in published maps and institutional affiliations.
- Responsibilities: The editors, editorial board and publisher do not assume any responsibility for the article's contents and for the authors' views expressed in their contributions. The statements and opinions published represent the views of the authors or persons to whom they are credited. Publication of research information does not constitute a recommendation or endorsement of products involved.