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BEHAVIOUR OF DELTA CULTIVAR NECTARINES DURING THE VALORIZATION PROCESS ACCORDING TO THE FERTILIZATION OF THE CULTURE

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Abstract

The researchers performed at the Research and Development Institute for Processing and Marketing of the Horticultural Product-Bucharest. They had as object the study of some qualitative indicators (firmness, organoleptic appreciation, chemical composition, weight and qualitative losses) of Delta cultivar nectarines at harvest as well as their evolution during the valorisation process. The nectarines – Delta cultivar (an extra-early cultivar, created by the researchers from Research Station for Fruit Growing Constanta, in collaborate with Rutgers University, New Jersey – S.U.A.), provided from experimental plots of R. S. F. G. Constanta. They were fertilized in different manners, with organic or chemical fertilizers, applied on soil and/or foliar. The nectarines were stored in three variants: at the ambient temperature (26-28^{0}C), in cold conditions (T = 2-4°C) and cold + modified atmosphere conditions, for 5, 25 and 30 days, respectively. It was found that the quality of the nectarines and their storage capacity varies according to the fertilisation regime and the conditions in the storage environment, especially the temperature and the gaseous composition of the air. Among the fertilisation variants, the V4 variant (soil + foliar chemical fertilisation) induces the best quality and storage capacity. Foliar fertilisers ensure not only an input of macro-and micro elements but also other organic substances which stimulate the metabolism of chlorophyll assimilation, the energetic delivery and finally, the fruit quality. Of the three storage methods (ambient temperature, cold room and cold room + modified atmosphere), the best results were obtained within the third method, which recorded the smallest losses during storage.

Key words: *firmness, qualitative losses, storage capacity.*

INTRODUCTION

Due to a new and valuable sort which is adequate to ecological conditions, both the peach tree and the nectarine tree can ensure the consumption of fresh fruits for more than three month (Lamureanu et al., 2012). The studies show that the new nectarine cultivars obtain in the south-eastern of Romania have a good quality of the fruits, high and constant productivity of the trees and enriched the actual sortiment as for fresh consumption as for canneries (jam, nectar, stewed fruit) too (Margineanu et al., 2011).

Nectarines are extremely perishable, which raises serious problems concerning the maintaining of their quality during the valorization process, from the moment they are harvested until they reach the consumer.

The quality of the nectarines at harvest varies according to the technology which was applied to the culture, the climatic conditions, the cultivar and the maturity phase, while the evolution of this quality during storage depends on an ensemble of factors, beginning with the harvesting, the conditioning and the technological conditions in the storage environment (Gherghi et al., 1977) and especially on the temperature and the gaseous composition (Alexe et al., 2012). If the storage of the fruit is done while respecting adequate conditions (optimum storage temperatures or the specific modified atmosphere for a species or cultivar) the biochemical processes are inhibited, thus

maintaining the quality of the products (Alexe et al., 2010).
Nectarine cultivars display different particularities as far as their storage and valorisation for a longer period of time (Jampa and Carabulea, 2002).
The chemical composition of nectarines, which determines the level of the biochemical processes occurring during storage and thus the storage capacity, is highly influenced by the fertilisation regime. The doses in which the organic or mineral fertilisers are applied influence the chemical composition of the fruit, affecting the storage capacity as well (Salunke, 1974; Ion, 2004). The presence of several nutrients enhances, in a synergic manner, the effect of each of these nutrients, contributing to an adequate growth and development of the fruit (Ionita, 2012).
The aim of this paper is to study the effects of the fertilising regime on the physical and chemical particularities of the nectarines of the Delta cultivar as well as their evolution during storage, which is a very important stage in the valorisation process.

MATERIALS AND METHODS

The Delta cultivar was obtained at R.S.F.G. Constanta following the collaboration with Rutgers University, New Jersey, U.S.A and was patented in 1991. The tree is autofertile, of medium vigour (Figure 1), resistant to diseases and pests, precocious and productive (25-30 kg/tree), while the production, which is constant every year, is destined to be consumed as fresh (Braniste et al., 2007).

Figure 1. Nectarin of the the Delta cultivar

The fruits, having a spherical-elongated shape, are of medium size (90-100 grams), which is fairly good for an extra-early cultivar (the maturity phase occurs in the third decade of the month of June and the first decade of the month of July). The pulp is yellow, juicy, with a balanced, sour-sweet taste. The skin is smooth, the main colour being yellow, while the covering one is ruby-red on most of the surface (Figure 2).

Figure 2. Nectarines of the Delta cultivar

In the period 2007-2011 the threes were fertilised according to three variants, which were compared to the witness variant (V1), as follows:
- V2-organic fertilisation (with fermented manure);
- V3-chemical fertilisation of the soil (with NPK complex fertilisers, the ratio being of 15:15:15);
- V4-ground + foliar chemical fertilization (ground with NPK complex fertilizers 15:15:15 and foliar feeding with Murtonik 20:20:20 + micronutrients: Mn, Fe, Cu, Zn, B, in the form of chelation).

Immediately after harvesting the fruit were transported to the Research and Development Institute for Processing and Marketing of the Horticultural Product, where they were stored in 3 variants:
- ambient temperature (T = 26-28 ^{o}C, RH = 65-70%) in 1 kg packages-*keep warm*;
- refrigeration room (T = 2-4°C, RH = 83-87%), in packs of 1 kg covered with perforated polyethylene film-cold storage;
- refrigeration room (T = 2-4°C, RH = 92-96%), in 1 kg hermetic packages, so that the composition of the atmosphere inside has modified, by the reducing of the O_2 content and

the increasing the CO_2 content and also of air relative humidity - storage in modified atmosphere - MA.

The duration of the storage (days) varied according to the technological variant, being of 5 days for the warm storage, 25 days for the cold storage and 30 days for the AM storage.

Before entering the storage period and at its end the fruit were analysed in order to establish the firmness, the organoleptic characteristics and the biochemical features of the main components (dry soluble substance, soluble carbohydrates, titratable acidity). Moreover, the weight losses (quantitative) and those cause by alteration (qualitative) suffered by the fruit throughout the storage period were established.

The firmness was determined by means of an OFD mass penetrometer which measures in penetrometric units (1PU=0.1 mm) the depth that the conical needle (length=24 mm, base diameter = 4 mm) reaches within the pulp of the fruit.

The measurements were carried out on a number of 25 fruit/variant, each fruit being penetrated in 4 different points in the equatorial area.

The appreciation of the organoleptic quality was achieved by means of carrying out a sensorial testing of the fruit and the method was that of evaluating on a scale from 1 to 100. Tasting sheet were used comprising three appreciation criteria: aspect, texture, taste. Each of the three criteria holds a different weight within the general scoring, according to their importance. Thus, the "aspect" represents 15%, the "texture" 35% and the "taste" 50%. According to the scores there are five different quality classes as follows:

Grades (quality classes	Points
Very good	80 – 100
Good	60 – 79
Acceptable	40 – 59
Mediocre	20 – 39
Unsuitable	0 – 19

The methods for determining the biochemical components were the following: refractometry, using an ABBE refractometer to determine the soluble substance, the Bertrand titrimetric method for determination of the soluble carbohydrates, the titrimetric method for the determination of the titratable acidity.

During storage the thermo-hydric factors in the cold room were checked every day in order to ensure that the optimum conditions for maintaining the quality were respected. In addition, the capacity of maintaining the fruit's quality was evaluated, including the apparition and development of certain storage diseases.

RESULTS AND DISCUSSIONS

1. Firmness

The results presented in Table 1 reveal the fact that at harvest the firmness of the nectarines ranges from 68.79 PU at the V4 fertilising variant (chemical fertilisers applied on soil + foliar) to 93.57 PU at the V3 variant (chemical fertilisers applied on the soil), the average per cultivar being of 83.56 PU.

Table 1. The firmness of the nectarines of the Delta cultivar upon harvesting and after storage

Moment of evaluation	Variant				Average/ cultivar
	V1	V2	V3	V4	
At harvest	91.28	80.59	93.57	68.79	83.56
After warm storage	153.40	150.11	175.62	144.11	155.81
After cold storage	110.91	129.35	126.35	127.95	123.64
After AM storage	99.35	119.78	123.66	125.53	117.08

During warm storage for 5 days the firmness rapidly declines due to the alteration of the pectin substances and the cellular membranes, reaching values ranging from 144.11 PU at the V4 variant to 176.62 PU at the V3 variant, the average per cultivar being of 155.81 PU.

Cold storage slowed down the structural and cellular alteration of nectarines, after 25 days the average firmness being of 155.81 PU, meaning 110.91 PU at the V1 variant, 126.35 PU at the V3 variant, 127.95 PU at the V4 variant and 129.35 PU at the V2 variant.

The enriching of the atmosphere in carbon dioxide allowed for the nectarines to be stored for 30 days while maintaining the firmness at an average level of 117.08 PU, varying between 99.35 PU at the V1 variant and 125.53 PU at the V4 variant.

2. The organoleptic quality

At harvest, following the organoleptic test, the nectarines obtained a high score (89.95) due to their lovely aspect, their high degree of firmness and their pleasant and balanced taste, thus entering the "very good" fruit quality class (Table 2).

Table 2. The organoleptic appreciation of the nectarines of the Delta cultivar

Organoleptic appreciation-score + grade	Moment of evaluation			
	At harvest	After warm storage	After cold storage	After AM storage
Total	89.95	83.75	70.07	56.16
Aspect	13.80	13.20	12.50	11.25
Firmness	34.65	29.05	26.80	27.41
Taste	41.50	41.50	30.77	27.50
Qualifying	Very good	Very good	Good	Acceptable

After 5 days of warm storage the parameters of the organoleptic properties of the nectarines remained fairly reasonable, the score being of 83.75 points and the grade "very good". After 25 days of cold storage, the nectarines, though maintaining their pleasant aspect, lose their firmness and especially their taste, which explains why the total score relatively drops to 70.07 and the adequate grade is now "good". During AM storage the nectarines of the Delta cultivar lost their aspect, their firmness and especially their taste, the latter becoming bland and floury. Because of the very low score (56.16 points), the fruit received the grade "acceptable". In some cases the nectarines stored in AM conditions displayed physiological disorders, manifested through shiny, grey spots or the cracking of the skin (a rather scarce phenomenon present at nectarines stored in cold conditions as well). This demonstrates the fact that the period in which the fruit had the capacity to maintain their quality was surpassed, which means that the duration of the storage in the atmosphere enriched in carbon dioxide was too long.

3. Biochemical composition

The data presented in Table 3 show that the fertilising variant with organic fertilisers (V2) as well as the variant with chemical fertilisers applied on the soil + foliar (V4) have the largest input when it comes to enriching the fruit in dry soluble substance (11.10% and 11.24%, respectively) and soluble carbohydrates (8.57% and 8.32%, respectively). From this point of views, the V1 variant-witness occupies the last position, having, however, the highest content of malic acid (0.93%).

During storage the biochemical content of the nectarines modifies but at a different intensity according to the conditions in the storage place. The high temperature during storage favours the undergoing of biochemical processes within the fruit at a greater intensity, so that after 5 days of warm storage the content of dry soluble substance greatly increases (V1=12.39%, V2=12.73%, V3=11.53%, V4=12.19%, average=12.21%), while the soluble carbohydrates (V1=5.70%, V2=6.56%, V3=7.09), V4=6.81%, average =6.54%) and the malic acid (0.79%, 0.63%, 0.66% and 0.64%, respectively) decrease considerably in comparison to the other storage methods.

The lower temperature during cold storage leads to the slowing down of the rhythm of these biochemical processes, so that the dry soluble substance increases up to 11.50% within 25 days, while the content of soluble carbohydrates and titratable acidity decreases, reaching 7.76% and 0.71%, respectively – average value/cultivar.

Table 3. The main chemical components of the nectarines of the Delta cultivar

Biochemical indicator	Variant				
	V1	V2	V3	V4	Average/cultivar
At harvest:-soluble dry substance (^{0}R)	9.77	11.10	10.74	11.24	10.71
-soluble carbohydrates-%	6.95	8.57	8.16	8.32	8.00
-acidity (malic acid/100g)	0.93	0.68	0.71	0.68	0.75
Warm: -soluble dry substance (^{0}R)	12.39	12.73	11.53	12.19	12.21
-soluble carbohydrates-%	5.70	6.56	7.09	6.81	6.54
-acidity (malic acid /100g)	0.79	0.63	0.66	0.64	0.68
Cold: -soluble dry substance (^{0}R)	11.72	11.49	11.38	11.42	11.50
-soluble carbohydrates-%	6.67	8.25	8.01	8.11	7.76
-acidity (malic acid /100g)	0.88	0.66	0.69	0.62	0.71
AM: -soluble dry substance (^{0}R)	11.08	11.25	11.07	10.99	11.09
-soluble carbohydrates-%	6.51	8.08	7.96	7.81	7.59
-acidity (malic acid /100g)	0.87	0.67	0.67	0.62	0.71

The effect of the low temperature, that of slowing down the metabolism, adds up to that of the carbon dioxide, which has a larger concentration in the case of storage in a modified atmosphere. During this type of storage the content of dry soluble substance does not increase very much as compared to the initial moment (11.09%) and, at the same time, the content of soluble carbohydrates and titratable acidity insignificantly drops (7.59% and 0.71%, respectively).

4. Quantitative and qualitative losses

The losses recorded during warm storage (ambient temperature) for 5 days are presented in Table 4.

Table 4. Losses recorded during warm storage of the nectarines

Variant	Losses-%		
	total	weight	depreciation
V1	45.71	14.97	30.74
V2	36.89	13,32	23.57
V3	43.13	13.63	29.50
V4	31.79	14.36	17,43
Average per cultivar	**39.38**	**14.07**	**25.31**

It was noticed that the total losses are significant in all 4 variants of fertilisation and they are caused by weight losses and especially by depreciation. The following total losses were recorded: 45.71% at the V1 variant, 36.89% at the V2 variant, 43.13% at the V3 variant and 31.79% at the V4 variant. The average values of these indicators per cultivar are: 39.38% total losses, 14.07% weight losses and 25.31% alteration losses. The V4 variant recorded the smallest amount of losses, followed by the V2 variant.

The causes which determine the high percentages of losses by alteration are the late infections caused by the *Monilinia laxa* and the *M. fructigena* fungi, which occur before harvesting and the attacks of the *Rhizopus stolonifer* and *Botrytis cinerea*, which occur during harvesting and manipulation.

By using the cold storage method (Table 5) the developing of these fungi and moulds is slowed down, so that the total losses were greatly reduced at all fertilisation variants. The values were the following: 34.28% at the V1 variant, 10.17% at the V2 variant, 22.06% at the V3 variant and 5.67% at the V4 variant, the average per cultivar being of 18.04% total losses.

Table 5. Losses recorded during cold storage of the nectarines

Variant	Losses-%		
	total	weight	depreciation
V1	34.28	1.50	32.78
V2	10.17	1.30	8.87
V3	22.06	1.43	20.63
V4	5.67	1.33	4.34
Average per cultivar	**18.04**	**1.39**	**16.65**

It is obvious that, similar to warm storage, the V4 variant records the smallest losses (5.67%), followed by the V2 variant (10.17%).

Using the AM storage method led to a great decrease in both the weight and the depreciation losses, the values of the total losses per cultivar being of 6.46%, meaning 12.17% at the V1 variant, 6.47% at the V2 variant, 6.99% at the V3 variant and only 0.23% at the V4 variant.

Table 6. Losses recorded during AM storage of the nectarines

Variant	Losses-%		
	total	weight	depreciation
V1	12.17	0.31	11.86
V2	6.47	0.33	6.14
V3	6.99	0.31	6.68
V4	0.23	0.23	-
Average per cultivar	**6.46**	**0.29**	**6.17**

There were no depreciation losses at the V4 variant and the weight losses were very small (0.23%) in comparison to the other storage variants.

CONCLUSIONS

The different fertilization of the trees is reflected in the degree of firmness of the fruit at harvest, but not in their evolution during storage. The greatest firmness at harvest is recorded by the fruits which were chemically fertilized at soil + foliar (68.79 PU). The evolution of the firmness during storage is especially influenced by the storage conditions. Through warm storage the nectarines easily lose their firmness because of their rapid ripening. In the case of cold storage the intensity of the ripening process is decreased so that the fruit maintain their structural and textural firmness for a longer period of time (25 days). By enriching the atmosphere within the storage space in carbon dioxide the metabolic processes become even slower and the firmness of the fruit is maintained for a longer period of time (30 days).

The organoleptic quality of the Delta cultivar nectarines is better appreciated (89.95 points) at harvest, the fruit having a yellow, juicy pulp, with a balanced, sour-sweet taste. During storage the quality decreases faster than it does at other studied cultivars (Cora), so that it is indicated that the valorization process be carried out faster because the storage capacity of this cultivar is lower.

The fertilization of the nectarine tree culture with the Murtonik foliar fertilizer (20:20:20 + microelements: Mn, Fe, Cu, Zn, B-chelation) resulted in the enriching of the fruit in dry soluble substance (11.24%) and soluble carbohydrates (8.32%). Moreover, the usage of organic fertilisers led to the obtaining of nectarines with a high content of these biochemical compounds (11.10% and 8.57%, respectively). During storage the content of dry soluble substance increased, while that of soluble carbohydrates and malic acid decreased, the intensity varying according to the temperature and the gaseous composition of the air in the storage place. The AM storage recorded the best results regarding the slowing down of the rhythm of the metabolic processes.

The quantitative and qualitative losses recorded during the storage of the nectarines are greatly influenced by the fertilising regime applied to the culture. In the case of supplementing the chemical fertilization of the soil with the Murtonik foliar fertiliser the weight losses and especially those caused by attacks from diseases were substantially smaller as compared to those recorded in the case of the control. From this point of view, good results were also obtained in the case of fertilising the culture with organic fertilizers, which contain minerals which enhance the quality of the fruit and their resistance to diseases during storage.

The maintaining of the nectarines′ quality during valorization is also influenced by the environmental conditions ensured during this process and especially by the temperature. Bu using the cold method the metabolic processes and the developing of fungi and moulds are greatly slowed down, so that the losses were significantly reduced at all variants of fertilization. The average reduction per cultivar was of 54.19% in the case of total losses, 90.12% in the case of quantitative losses and 34.21% in the case of depreciation losses. Using the AM storage method led to an important decrease in both weight losses (97.93%) as well as in depreciation losses (75.62%).

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