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

BEHAVIOUR OF THE SWEET PEPPER AT SHORT-TERM STORAGE, DEPENDING ON CROP FERTILIZATION SCHEDULE

Mariana TOMA (SINGH)[1, 2], Simona POPESCU[1], Constanţa ALEXE[1], Adrian CHIRA[2]

[1]Institute of Research and Development for Processing and Marketing of Horticultural Products - "Horting";
5N Drumul Gilaului, District 4, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, District 1, Bucharest, Romania

Corresponding author email: mtoma.horticulture@gmail.com

Abstract

The scientific paper presents the impact of some technological production sequences (nutrition regime) and capitalization (storage conditions) on the quality and its maintenance capacity during short-term storage of sweet pepper. Two pepper varieties "Minthos" and "Boni" were supplied by an experimental vegetables farm. They were fertilized with different amounts of fertilizers, both varieties in three variants. The experimental storage was conducted at the Institute of Research and Development for Processing and Marketing of Horticultural Products "Horting" Bucharest in two technological variants: at ambient temperature (T=23-25^{0}C, RU=70-75%) and at refrigerant temperature (T=10°C, RU=80-85%) for the period of 10 and 20 days, respectively. Organoleptic properties, biochemical compounds, quantitative and qualitative losses during storage were analysed. Best results regarding the quality and storage capacity were obtained at "Minthos" variety. Best fertilization variant was represented by 200:150:80 kg NPK/ha. Cold storage was considered the most efficient option for peppers short-term storage.

Key words: *biochemical compounds, Capsicum annuum, organoleptic properties, storage losses.*

INTRODUCTION

Sweet peppers come from South and Central America and belong to the Solanaceae family. They were introduced into Europe for the first time at the beginning of the 16th century. The name "pepper" was given by Europeans when Christopher Columbus brought the plant to Europe. The terms bell pepper, sweet pepper, mild pepper or capsicum are often used for any of the large bell-shaped peppers, regardless of their color (green, yellow, orange, red, purple, brown or black). They are widely used because of their nutritional value, aroma, strong pungency and colour (Yaldiz et al., 2010). Due to their importance gradually increased, the peppers became ones of the most consumed vegetable crops worldwide (Téllez-Pérez et al., 2012). In addition, the food industry employs them widely as colouring and flavouring agents in sauces, soups, processed meats, lunches, sweetmeats and alcoholic beverages (Bogusz Junior et al., 2011). Sweet peppers are distinguished by a high content of vitamin C which is higher than of many other types of fruits and vegetables (www.greenfood.ro/ardeiul/).

Pepper is considered the second source of vitamin C after parsley, 200 g of pepper offering the daily amount needed by an adult. In addition to vitamin C, pepper also contains vitamin A, this combination representing a «deathly cocktail» for free radicals. These vitamins do not allow cholesterol deposit and, therefore, protect the body against heart diseases, offering protection against tumors, glaucoma and arthritis, as well (Ciofu et al., 2003).

The achievement and up keeping of the horticultural products quality depend on a blend of factors that interfere in all the cropping technology and capitalization, starting with variety selection and crop manage-ment until harvesting, conditioning and delivery (Jobling, 2012; Gherghi et al., 1977; Ryall and Lipton, 1972). The vegetables varieties have different particularities as regard a shorter or longer period of storage (Jamba and Carabulea, 2002; www.concordfoodcoop.documents/ncg_ produce_storage_guide_for_web.pdf.37;www. halfyourplate.ca/wpcontent/uploads/2014/12/ cpma_fruits_and_vegetables_storage_guide_final2. pdf). The shor - term storage capacity of

the peppers depends not only on the variety, but also on the quality of the raw material intended for storage (Tsegay et al., 2013; Lim et al., 2007; Lill and King, 1999; Popescu, 1978) and on the storage conditions (Raffo et al., 2008; Abdel-Maksoad et al., 1975; www.agrimedia.ro/articole/recoltarea-conditio-narea-si-pastrarea-legumelor; www.vegetablegardenplanner.com/how to-store/bell-pepper; www.naturefresh.ca/how-to-store-vegetables; www.chilipeppermadness.com/preserving-chili-peppers/how-to-store-pepper).

The chemical composition of peppers which determines the level of biochemical processes during storage and, therefore, the storage capacity is strongly influenced by the fertilization regime (Hameed et al., 2015; Bosland and Votava, 2000).

The doses of mineral or organic fertilizers influence the chemical composition of the fruits whith effects on the storage capacity (Ion, 2004; Salunkhe and Kadam, 1998; Meir et al., 1995).

As concern the capitalization technologies, it is recommended to apply those technological storage procedures that will determine the inhibition of the physiological and biochemical processes of fruits, leading to the up keeping of their commercial value for a longer period (Titisina et al., 2019; Burzo et al., 2005; Lill and King, 1999; Burzo, 1986).

The purpose of the present paper is to evaluate the achievement and quality mainte-nance of *Minthos* and *Boni* sweet pepper varieties, depending on the fertilization schedule and storage conditions.

MATERIALS AND METHODS

The sweet peppers were supplied by an experimental vegetable farm situated in Dobrogea, Romania. The technological conditions of culture and quality achievement were verified.

Tri-factorial experience was organized, with the following experimental factors:

A: variety:

- A_1: Minthos;
- A_2: Boni;

B: nutrition level: three graduations of fertilization have been applied, as is follows:

- B_1: 100 N + 100 P_2O_5 +50 K_2O kg a.s./ha;
- B_2: 200 N + 150 P_2O_5+80 K_2O kg a.s./ha;
- B_3: 300 N + 200 P_2O_5 +70 K_2O kg a.s./ha

C: storage conditions:

- C_1: warm (ambient temperature): T=23 - 25ºC ;RU=70-75%;
- C_2: cold (refrigerant temperature): T=10ºC, RU=80-87%

Where: T=temperature (ºC); RU=relative (air) humidity (%).

Minthos F1 is an early sweet pepper hybrid recommended for protected or open field cultivation. The plant has a high resistance to stress and good fruiting capacity. The fruits have an average weight of 200 g, are large, glossy, waxy, with a particular commercial aspect (www.wikipedia.org/wiki/bell_pepper; www.syngenta.ro/minthos-f1; www.zki.ro/blog/sortimentul-de-ardei-gras-de-tip-blocky/). Their color changes gradually from light green to yellow and then red to physiological maturity (Figure 1).

Boni is a sweet pepper heirloom with indeterminate growth, intended for open field cultivation. It is resistant to TMV (Tobacco mosaic virus) and is noticed for its good overall stressors resistance. It tolerates well the variations of temperature, drought and sunburn. *Boni* is a stable variety, with uniform aspect (truncate,) and an average weight of 140-180 g, fleshy, sweet, with a light yellow-red ripening at physiological maturity (*xxx*-2003; www.seminte-demetra.ro/product/boni/; www.royalsluis.com/hun/catalog/paprika/boni) as is shown in the Figure 2.

Figure 1. *Minthos* sweet pepper

Figure 2. *Boni* sweet pepper

The organoleptic determinations and bio-chemical analyses of the main components were made at two key moments:

- immediately after harvesting, just before storage;

- at the end of the storage period.

As regard the biochemical compounds, were analysed: the soluble dry matter using refractometric method (expressed in Brix/ refractometric degrees) soluble carbohydrates using Bertrand titrimetric method (expressed in percentage), titratable acidity (expressed in malic acid/100 g) and vitamin C using titrimetric method (expressed in mg/100 g). Also, the fruits weight losses (quantitative losses) and their depreciation (qualitative losses) during storage were quantified.

The evaluation of the organoleptic quality was achieved by carrying out the fruits sensory testing, using a grading scale from 1 to 100. Tasting sheets were used which included a number of three criteria of appreciation (aspect, firmness, taste), with different share in the general notation, depending on their importance: the aspect represents 15%, firmness 35%, and taste 50%. Depending on the score obtained, five quality classes are distinguished, as follows: very good (80-100 points), good (60-79 points), satisfactory (40-59 points), sufficient (20-39 points) and insufficient (0-19 points).

During storage, a daily control of the thermo-hydric factors in the storage rooms was carried out, in order to ensure the accomplishement of optimum conditions for up keeping the peppers quality. At the same time, the capacity to keep up the peppers quality was evaluated, including the monitoring of different storage pathogens.

RESULTS AND DISCUSSIONS

a. Organoleptic quality

The results of the organoleptic evaluation are presented in the Figures 3-5, pointing out that:

- immediately after harvest, *Minthos* obtai-ned a higher score than *Boni*, due to its attrac-tive aspect, good firmness and pleasant taste. The best variant of fertilization was B_2 (93.20 points), followed by B_3 (91.35 points) and B_1 (89.5 points). *Minthos* peppers at all fertiliza-tion variants obtaneid "very good" grading.
- after 10 days of warm storage (ambient temperature) the sensory properties of *Minthos* peppers remained at high parameters at B_2, getting “very good” grading. At B_1 and B_3 the score was quite lower and they got “good” grading, due to the aspect, taste and firmness depreciation. Storing the peppers at 23-25ºC conducted of getting fewer points than fresh crops.
- after 20 days of cold storage (refrigerant temperature), *Minthos* peppers maintained their nice aspect, great firmness and pleasant taste, recieving “very good” grading. The best fertilization variant was B_2 with 88.20 points.
- immediately after harvest, *Boni* peppers got a little bit lower score than *Minthos,* but high enough to receive “very good” grading at all fertilization variants (Table1).
- after warm storage, the sensory properties of *Boni* peppers remained at high parameters only at B_2, getting “very good” grading (81.33 points). B_1 and B_3 got a quite lower score and they received “good” grading.
- after cold storage of *Boni* peppers, B_2 and B_3 received “very good” grading, while B_1 received only “good” grading.

b. Biochemical composition

Analyzing the data presented in the Figures 6-9, it is found that the values of the biochemical indicators for *Minthos* variety and its evolution during storage varied upon the fertilizer’s doses applied to the crop.

Thus, the content in the soluble dry matter, expressed in Brix/refractometric degrees (ºR) was between 5.6% (B1) and 6.6% (B2).

Best values were obtained at B2, as regard the carbohydrates content, (4.35%) and vitamin C (198.68 mg/100 g), as well.

At harvest, B1 obtained the smallest values as regard all analyzed biochemical compounds.

High temperature during warm storage determined the intensification of biochemical processes in fruits, so that, after 10 days of warm storage, the content of the soluble dry matter increased, while the soluble carbohydrates and malic acid decreased in a higher rate, in comparison with other storage methods.

Lower temperature during cold storage conducted in slowing down the biochemical processes of the peppers. Thus, the soluble dry matter increased by 5, 86%, compared to the time of harvest, while the carbohydrates content

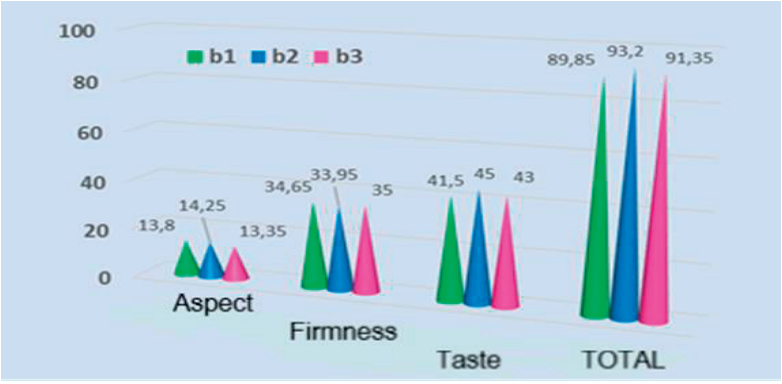

Figure 3. Sensory evaluation of *Minthos* after harvest

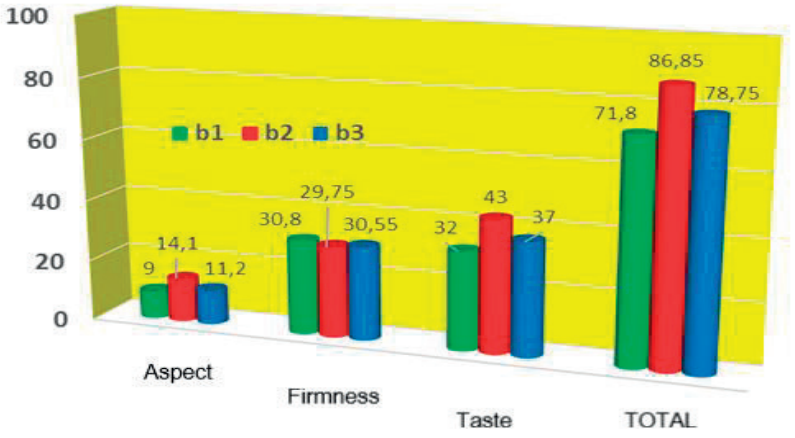

Figure 4. Sensory evaluation of *Minthos pepper* after ambient storage

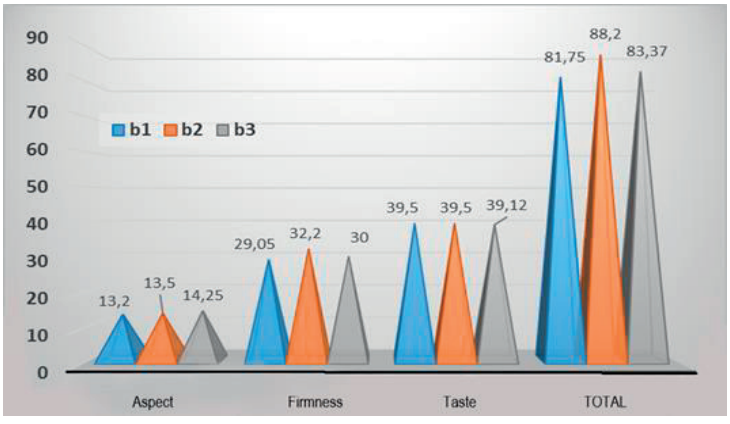

Figure 5. Sensory evaluation of *Minthos* pepper after cold storage

Table 1. Sensory evaluation of *Boni* sweet pepper

Determination time Total score/indicator score/ grading	Sensory evaluation/fertilization variant		
	B_1	**B_2**	**B_3**
At harvest			
- total score	**83.33**	**87.99**	**86.33**
- aspect	10.50	12.00	11.00
- firmness	29.50	32.66	30.33
- taste	43.33	43.33	45.00
- grading	very good	very good	very good
After ambient storage			
- total score	**70.07**	**8133**	**79.00**
- aspect	12.50	13.00	11.00
- firmness	26.80	35.00	28.00
- taste	30.77	33.33	40.00
- grading	good	very good	good
After cold storage			
- total score	**79.00**	**86.66**	**84.66**
- aspect	11.00	14.00	11.00
- firmness	28.00	32.66	30.33
- taste	40.00	40.00	43.33
- grading	good	very good	very good

decreased by 1.19%; titratable acidity decreased by 3.85% and vitamin C decreased by 9.5%, compared to harvesting time.

In the Table 2 are shown the biochemical indicators values of *Boni* peppers and their evolution during warm and cold storage.

B_2 was the best variant of pepper fertilization which determined the greatest biochemical values. The dynamics of biochemical processes development follows near some characteristics as in the case of *Minthos* sweet pepper (Figures 6-9).

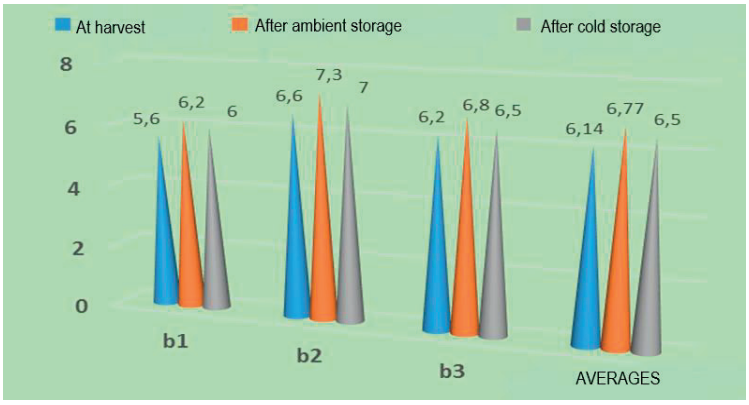

Figure 6. *Minthos* soluble dry matter content (^{0}R)

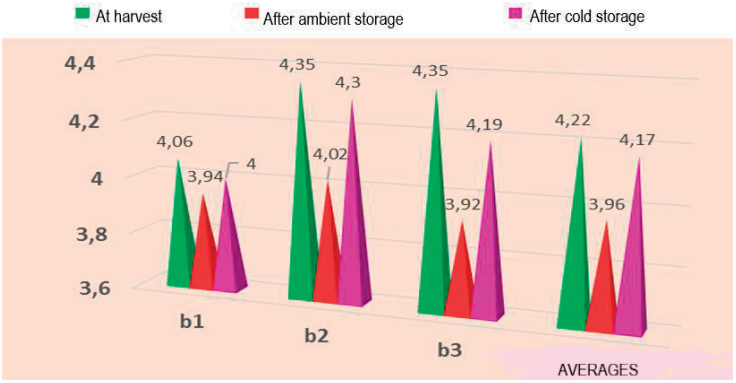

Figure 7. *Minthos* carbohydrates content (%)

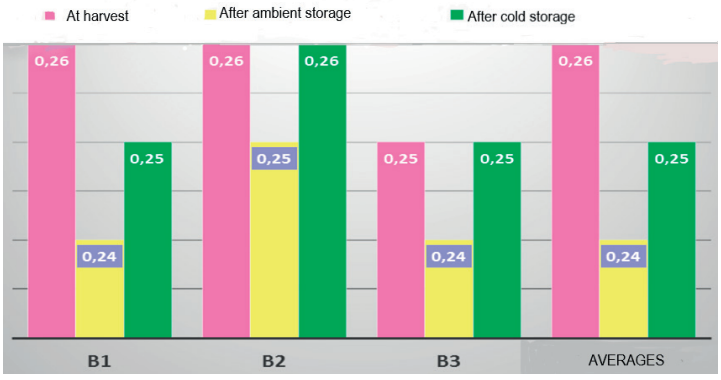

Figure 8. *Minthos* titratable acidity (malic acid/100 g)

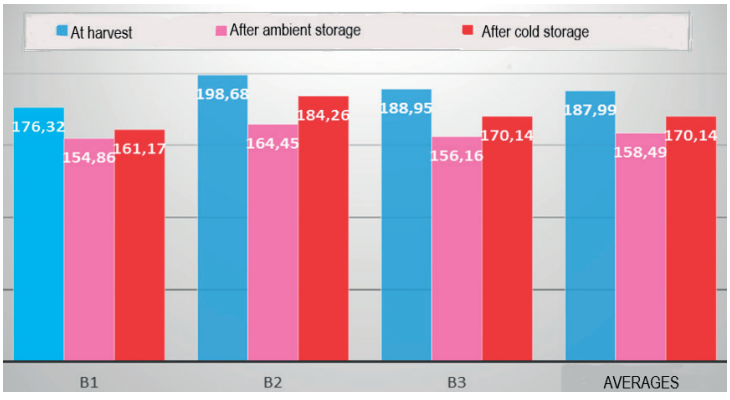

Figure 9. *Minthos* vitamin C content (mg/100 g)

Table 2. Main biochemical compound at harvest and after storage of *Boni* sweet pepper

Determination time/ Biochemical indicator	Variant			
	B_1	**B_2**	**B_3**	**Averages**
At harvest				
- soluble dry matter (^{0}R)	4.90	5.60	5.20	5.24
- carbohydrates (%)	3.49	3.99	3.61	3.70
-titratable acidity (malic acid/100 g)	0.26	0.27	0.26	0.26
-vitamin C (mg/100 g)	199.82	208.94	204.82	204.53
After ambient storage				
- soluble dry matter (^{0}R)	5.20	6.0	5.80	5.66
- carbohydrates (%)	2.99	3.34	3.24	3.19
- titratable acidity (malic acid /100 g)	0.24	0.25	0.25	0.25
- vitamin C (mg/100 g)	164.12	175.34	176.28	171.92
After cold storage				
-soluble dry matter (^{0}R)	5.00	6.0	5.5	5.50
-carbohydrates (%)	3.26	3.76	3.50	3.51
- titratable acidity (malic acid /100 g)	0.26	0.25	0.25	0.25
- vitamin C (mg/100 g)	180.93	191.16	188.76	186.95

c. Quantitative and qualitative losses

From the research carried out, it appears that the **best fertilization variant** of *Minthos* and *Boni* sweet peppers, concerning their storage losses, in both technological methods, **was B_2**, followed by B_3 (Table 3).

At **cold storage**, *Minthos* pepper total losses were: 11.33% at B_1, 9.92% at B_3 and 9.17% at B_2, the average losses being of 10.14%.

The values of *Boni* pepper total losses at cold storage were: 13.64% at B_1, 11.15% at B_3 and 10.26% at B_2, the average losses being of 11.69%. B_2 recorded the smallest losses to both sweet pepper varieties.

Pepper losses during **warm storage** (ambient temperature) for 10 days are high at all three variants of fertilization, due to the weight loss and deterioration, as well. Thus, the total losses are very high at the variant B_1 (16.44% - *Minthos* and 19.11% - *Boni*), followed by the variant B_3 (14.39% - *Minthos* and 18.26% - *Boni*). The variant B_2 recorded quite less losses (12.87% - *Minthos* and 17.92% - *Boni*).

The variety level are: 14.57% total losses, 3.55% weight losses and 11.02% depreciation losses of *Minthos* variety and 18.43% total losses, 4.43% weight losses and 14.01% depreciation losses of *Boni* variety.

The causes which determine very high percentages of pepper losses are the infections installed prior to harvest, produced by the *Xanthomonas vesicatoria* (bacterial spot) and the attack produced by *Erwinia carotovora* and *Botrytis cinerea* (two fungi which produce wet rot, respectively dry drying) during harvest and transport.

By using the refrigeration storage method, the pathogens development was slowed down and the total losses were greatly reduced, at all three variants of fertilization.

Table 3. Pepper losses during short - term storage

Variety	Fertilization variant	Total losses		Weight losses		Depreciation losses	
		10°C	23°C	10°C	23°C	10°C	23°C
Minthos	B_1	11.33	16.44	1.68	4.96	9.65	11.48
	B_2	9.17	12.87	0.43	2.53	8.74	10.34
	B_3	9.92	14.39	0.33	3.16	9.59	11.23
	Average	**10.14**	**14.57**	**0.82**	**3.55**	**9.33**	**11.02**
Boni	B_1	13.64	19.11	2.00	5.64	11.64	13.47
	B_2	10.26	17.92	1.09	3.48	9.17	14.44
	B_3	11.15	18.26	1.83	4.15	9.32	14.11
	Average	**11.69**	**18.43**	**1.64**	**4.43**	**10.04**	**14.01**

CONCLUSIONS

The quality of the sweet peppers and their maintenance capacity have varied according to the fertilizer doses applied to the crop and to the environmental storage conditions, especially, the temperature.

Among the fertilization variants, the variant B_2 promoted the best quality and storage capacity.

Of two storage methods (ambient tempera-ture and refrigerated room) better results were obtained in case of the second method, at which the smallest losses during storage were recorded, because low temperatures inhibit or slow down the fungi & molds growing rate - specific to each species of vegetables and slow down the rate of biochemical processes during their storage. Therefore, the depreciation losses were greatly reduced.

The content of sweet peppers as regard the main biochemical indicators (soluble dry matter, soluble carbohydrates, organic acids, vitamin C) varied according to the crop fertilization schedule.

The best results were obtained at variant B_2 - the sweet peppers were fertilized in the dose of 200 N + 150 P_2O_5 +80 K_2O kg/ha.

During storage, the peppers biochemical composition recorded variations. Thus, as the soluble dry matter content increased, the soluble carbohydrates & vitamin C content and acidity level decreased. The intensity of these processes differed according to the storage conditions.

The biodegradations of carbohydrates and organic acids are influenced by the storage temperature which is one of the essential factors that regulate the speed of ripening processes.

As higher the storage temperature is, as pronounced the biodegradation appears.

REFERENCES

Abdel-Maksoad, M., Abou-Aziz, A.B., Abdel-Kader, A.S., Abdel Samei, K.A. (1975). Effect of Temperature on quality and decay percentage of *California Wonder* pepper fruit grown in Gharbia and Menofia governatore during storage. Egypt. J. Hort., 2, 157-165.

Bogusz Junior, S., De Marchi Tavares de Melo, A, Zini, C.A, Godoy, HT. (2011). Optimization of the extraction conditions of the volatile compounds from chili peppers by headspace solid phase micro-extraction. J. Chromatogr. A; 1218:3345-3350.

Bosland, P.W., Votava, E.J. (2000). Peppers: vegetable and spice capsicum. Crop production science in horticulture. Wallingford, U.K. CAB international Publishing: 145-147.

Burzo, I. (1986). Physiology and technology of preserving horticultural products. Bucharest, RO. Technical Publishing House: 35-43,151-162.

Burzo, I., Delian, E., Hoza, D. (2005). Physiology of crop plants. Vol. IV: Physiology of fruit trees, shrubs and grasses plant. Bucharest, RO. Elisavaros Publishing House: 386-394.

Ciofu, R. (coordinator), Stan, N., Popescu, V., Chilom, P., Apahidean, S., Horgos, A., Berar, V., Laurer, F.K., Atanasiu, N. (2003). Treatise of vegetables growing, Bucharest, RO. Ceres Publishing House: 562-571; 646-674.

Gherghi, A. (1977). Methods for maintain quality and reduce losses during storage of fruits and vegetables. Bucharest, RO. Scientific papers ICVLF, vol. VIII: 27-3.

Hameed, R, Malik, A.U, Sattar, A., Show, K., Riaz, R. (2015). Evaluating the effect of different storage conditions on quality of green chillies (*Capsicum annuum* L.), DOI: 10.4038/tar. v24i4.8024, Autaste, Pakistan.

Ion, V. (2004). Biological agriculture. Bucharest, RO. Alma Mater Publishing House: 76-89.

Jamba, A., Carabulea, B. (2002). Technology of preservation and industrialization horticultural products, Chisinau. Moldavian Republic. Cartea Moldovei Publishing House: 308-317.

Jobling, J. (2012). Correct cool chain management is essential for all fruits and vegetables. Postharvest Laboratory Information Sheet. Sydney, Australia.

Lill, R.E., King, G.A. (1999). Postharvest physiology of fruit and vegetable. Hort. Rev. 11:413-452.

Lim, C.S., Kang, S.M., Cho, L.J. (2007). Bell Pepper (*Capsicum annuum* L.) Fruits are Susceptible to Chilling Injury at the Breaker Stage of Ripeness. Hortscience 42(7):1659-1664. Jinju, South Korea.

Meir, S., Rosenberger, Y., Aharon, Z. Grinberg, S., Fallik. E. (1995). Improvement of the postharvest keeping quality and colour development of bell pepper (cv. 'Maor') by storage in CA at reduced temperature. Postharv. Biol. Technol. 5: 303-309.

Popescu, V. (1978). The influence of the environmental factors upon the growth and fruiting of sweet peppers, cultivated in the greenhouse – Doctoral Thesis, NAIB Bucharest, RO.

Raffo, A., Baiamonte, I., Paoletti, F. (2008). Changes in antioxidants and taste-related compounds content during cold storage of fresh-cut red sweet peppers. European Food Research Tech. 226(5), 1167-1174.

Ryall, A. L., Lipton, W.J. (1972). Handling, transporting and storage of fruits and vegetables, Vol. I, Vegetables and Melons. Westport Conn, Avi Publishing.

Salunkhe, D.K., Kadam, S.S. (1998). Handbook of Vegetable Science and Technology: Production, Composition, Storage and Processing. CRC Press203-225.

Téllez-Pérez, C., Sabah, M.M., Montejano-Gaitán, J.G.,

Sobolik, V., Martínez, C.A., Allafa, K. (2012). Impact of instant controlled pressure drop treatment on dehydration and rehydration kinetics of green Moroccan pepper (*Capsicum annuum* L.), the 20th International Congress of Chemical and Process Engineering, Czech Republic.

Titisina, M., Popescu, S., Moise, D. (2019). Different aspects regarding the dehydration of *Yellow superior* sweet pepper cultivar, organically grown, International Symposium "Agricultural and mechanical engineering" ISB-INMA TEH", Bucharest, RO.

Tsegay, D., Tesfaye, B., Mohammed, A., Yirga, H., Bayleyegn, A. (2013). Effects of harvesting stage and storage duration on postharvest quality and shelf life of sweet bell pepper (*Capsicum annuum* L.) varieties under passive refrigeration system. Montpellier, FR.

Yaldiz, G, Ozguven, M, Sekeroglu, N. (2010). Variation in capsaicin contents of different *Capsicum* species and lines by varying drying parameters. Ind. Crops Prod. 32:434-438.

xxx – Official catalogue of heirlooms and hybrids of Romanian crops. (2003). Printexim Publishing house, Bucharest, RO.

www.agrimedia.ro/articole/recoltarea-conditionarea-si-pastrarea-legumelor.

www.chilipeppermadness.com/preserving-chili-peppers/how-to-store-peppers.

www.concordfoodcoop.coop/documents/NCG_Produce_Storage_Guide_for_Web.pdf 37.

www.greenfood.ro/ardeiul.

www.halfyourplate.ca/wpcontent/uploads/2014/12/cpma_fruits_and_vegetables_storage_guide- final2.pdf.

www.naturefresh.ca/how-to-store-vegetables.

www.royal-sluis.com/hun/catalog/paprika/boni-paprika.

www.seminte-demetra.ro/product/boni/.

www.syngenta.ro/mintos-f1.

www.tisgdv.de/tis_e/ware/gemuese/paprika.

www.vegetablegardenplanner.com/how-to-store/pepper.

www.wikipedia.org/wiki/Bell_pepper.

www.zki.ro/blog/Sortimentul-de-ardei-gras-blocky.