Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 1, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

RESEARCH REGARDING THE INFLUENCE OF THE HARVESTING PERIOD UPON THE QUALITY AND STORAGE CAPACITY OF SOME APPLE VARIETIES

Lenuta CHIRA, Adrian CHIRA, Elena DELIAN, Ligia ION, Amalia IONESCU

University of Agronomic Sciences and Veterinary Medicine, Bucharest, 59 Marasti Blvd, District 1, 011464, Bucharest, Romania, Phone: +400212243617, Emails: lenutachira@yahoo.com, achira63@yahoo.com, elenadelian@yahoo.com, ionngylygia@yahoo.fr

Corresponding author: achira63@yahoo.com

Abstract

The research studies were carried out during the 2019 – 2021 period with 4 apple varieties, harvested at 3 degrees of maturity. After 190 days of storage, the overall losses, consisting of weight decreases and losses through rotting, presented lower values in the case of Sirius apples harvested at moment I (8.6%) and Golden Orange (11.7%) respectively., Ciprian (11.4%) and Fuji (8.9%), harvested at time 3. The apples of the Ciprian and Fuji varieties harvested earlier (moment I) saw a loss in quality of 63.2 – 86.5%, due to the occurrence of the scald. For cold storage, it is recommended that Sirius fruit be harvested 140 days after blossoming. The Golden Orange variety must be harvested about 145 days after blossoming and the Ciprian and Fuji varieties after 150 days after blossoming.

Key words**:** *losses, cold storage, storage capacity, harvesting period*

INTRODUCTION

Fruit quality is the essential factor that determines their commercial value, the storage behavior as well as the economic efficiency of their valorisation.

The research carried out so far has shown the influence of various factors on fruit quality such as: pedoclimatic, agrotechnical, the degree of maturation at harvest, etc.[2] and [4].

Global research has highlighted the particular importance of the ripeness of apples in storage, their quality and behaviour in storage [1], [3] and [7].

The storage of apples with an appropriate degree of ripeness leads to significant quality depreciation, and the storage process becomes uneconomical [5] and [6].

As a result, the practice of storage requires prior knowledge of the capacity and shelf life of apples according to their degree of ripeness, in order to ensure their valorisation by instalments [8].

In this context, the purpose of the paper was to study the influence of harvesting period on the quality and storage capacity of some apple varieties in Romania.

MATERIALS AND METHODS

The study used apples from the Sirius, Golden Orange, Ciprian and Fuji varieties, from the 2019, 2020 and 2021 harvests from a private plantation located in the Voinesti - Dambovița area, Romania.

The apples were harvested at 3 stages of ripening:

1. – 130 days after blooming when a sum of temperature degrees of about 2,100°C was reached, and starch was present on 95% of the surface of the cross section of Sirius apples, on 97% of the surface of the Golden Orange variety and on 98% of the surface for Ciprian and Fuji varieties.
2. - 140 days after blooming when a sum of temperature degrees of about 2,300°C was reached and the fruits of the Sirius variety had the starch present on 75% of the surface of the cross section, Golden Orange on 80%, Ciprian on 85% and Fuji on 87% of the section area.
3. - 150 days after blooming, when a sum of 2,400°C temperature degrees has been

reached, the starch being present on 50% of the cross-sectional area of Sirius apples, on 60% of the Golden Orange apples section, 70% of Ciprian apples section and 75% of the cross section of Fuji apples.

Each experimental variant consisted of about 150 kg of apples, divided into 3 repetitions.

The fruits were stored in the cold storage room of a private company in the Voinești - Dambovița area, at an average temperature of 2-3°C and a relative humidity of 85-90%.

The measurements and analysis made after harvesting and at the end of the storage period tracked the following:

-the evolution of the main physic-chemical characteristics of the fruits (starch index, dry soluble matter, total sugar, total titratable acidity and the content of ascorbic acid). The starch index was determined by using the test of Iodine into Potassium iodine solution. The content of the soluble dry matter was measured using the Atago electronic refractometer. The total sugar content was measured by iodometric method-Schoorl variant. The total titratable acidity was measured by titration with a NaOH 0.1N solution. The content or ascorbic acid was measured using the iodometric method.

-establishing the weight losses and quality depreciation, by quantity and percentage;

-determining the temperature and relative air humidity in the environment in which the apples were stored, using the Hanhart thermo hygrometer.

RESULTS AND DISCUSSIONS

The delay in harvesting the fruits and as a result keeping them on the trees under the influence of environmental conditions favored the evolution of the ripening process.

The biochemical processes that take place in the fruits during their maturation, determine the modification of the chemical composition and the realization of the characteristic properties of the fruits (Table 1).

Table 1. The main physic - chemical parameters of apple fruits, harvested at different harvesting period

Variety	Harvesting period	Analyses time	Soluble dry matter %	Total sugar %	Total titratable acidity (acid malic) %	Ascorbic acid mg/100 g	Sugar/acidity ratio
SIRIUS	1	at harvest	12.30	9.15	0.72	10.15	12.71
	1	end of storage	12.55	10.05	0.40	4.50	25.12
	2	at harvest	13.50	10.30	0.70	9.82	14.71
	2	end of storage	13.00	10.20	0.35	3.60	29.14
	3	at harvest	13.70	10.70	0.70	7.85	15.28
	3	end of storage	13.25	10.10	0.35	3.50	28.85
GOLDEN ORANGE	1	at harvest	12.10	9.25	0.47	12.40	19.68
	1	end of storage	12.30	9.30	0.15	5.15	62.00
	2	at harvest	13.70	10.35	0.50	13.10	20.70
	2	end of storage	13.85	10.30	0.20	6.40	51.50
	3	at harvest	14.25	11.80	0.45	12.05	26.22
	3	end of storage	14.95	10.90	0.15	6.80	72.66
CIPRIAN	1	at harvest	11.00	7.25	0.30	5.42	24.16
	1	end of storage	13.50	10.20	0.25	5.30	40.80
	2	at harvest	12.10	9.70	0.30	6.45	32.33
	2	end of storage	14.70	9.80	0.15	4.30	65.33
	3	at harvest	12.65	9.45	0.25	6.35	37.80
	3	end of storage	15.40	11.50	0.20	2.40	57.50
FUJI	1	at harvest	11.15	8.50	0.25	7.30	34.00
	1	end of storage	13.20	9.90	0.18	1.70	55.00
	2	at harvest	11.90	9.90	0.25	5.80	39.60
	2	end of storage	14.10	10.00	0.15	1.95	66.66
	3	at harvest	12.55	9.60	0.20	4.55	48.00
	3	end of storage	13.30	10.25	0.17	1.45	60.29

Source: Own determination.

Thus, for the fruits harvested later (moment 3), the following were found, compared to those harvested earlier (moment 1):
- the increase in the total carbohydrate content for the 4 varieties studied, on average 1.21 times;
-the decrease in titratable acidity, on average 1.04 times and of the ascorbic acid 1.14 times;
-increasing the sugar/acidity ratio by 1.31 times.

The physiological state of the fruits during storage, as well as their chemical composition had an influence on the storage behaviour.

The weight losses (Table 2) determined by experimental variants ranged from 5.4% to 11.9%.

Applying the analysis of variance to the results obtained, the following degrees of significance were established, compared to the average value of weight loss:

-In the case of the apples from Ciprian and Fuji varieties, the values of weight loss, at the 3 moments of harvest, were lower compared to the average value, the differences being significant;

- The Golden Orange apples, harvested at time 1, had significantly higher weight losses, compared to the average value, and those harvested at times 2 and 3 were significantly higher;

- The Sirius apples, harvested at time 1, had a weight loss value close to the average values and, as a result, the differences are insignificant. Variants harvested at times 2 and 3 had significantly lower losses.

According to the presented results, the highest weight losses were found in the earlier harvested variants, respectively the 1st harvest time (6.5% - 11.9%), and the lowest, in the later harvested variants, respectively the 3rd harvest time (5.4% -9.2%).

Also, the Golden Orange variety, kept at 85% - 90% relative air humidity, had the highest weight loss, which had repercussions on the appearance of the fruit, and the apples of the varieties Ciprian and Fuji had the lowest weight loss compared to other options.

The rot losses showed similar values in the case of the 3 harvest moments, for the Golden Orange, Ciprian and Fuji varieties.

However, for the Sirius variety, large differences were found between the 3 harvest variants. Thus, the fruits harvested at time 1 showed 1.3% rotten fruit, compared to those harvested at time 3, which had 9.0% rotten fruit.

The total losses made up of weight loss and loss because of rotting showed values between 8.6% and 15.5%. For the 4 varieties studied, the situation was as follows:

-the fruits of the Sirius variety, harvested at time 3, had the highest total losses, the differences from the average being highly significant. The higher value of the total losses, in this case, is due to the internal decomposition, which determined the total depreciation of 6% of the stored fruits. Compared to the average value of total losses, the fruits harvested at time 2 had significantly lower losses, and those harvested at time 1, distinctly significantly lower.

-the fruits of the Golden Orange variety had the highest total losses in the case of earlier harvesting. Thus, at the 1st harvesting time, distinctively significantly higher values were found, and for those harvested at the 2nd and 3rd, the values were significantly higher compared to the average value of the total losses.

- for the Ciprian variety, the fruits from the 3 variants showed significantly lower values, compared to the average of the total losses.

- the apples from the Fuji variety harvested at time 1 had total losses equal to the average value. At the time of harvest 2 the total losses were significantly lower, and at time 3 they were significantly lower compared to the average.

Of these, the lowest total losses in the case of the Sirius variety harvested at time 1 and the Golden Orange, Ciprian and Fuji varieties harvested at time 3 are the lowest.

During storage, the fruits were also affected by some physiological disorders that caused their depreciation. In this regard, mention should be made of the scald, which was manifested by the browning of the fruits' epidermis, thus affecting their commercial value.

Table 2. Total and qualitative losses of the apple fruits harvested at different harvesting periods, after 190 days of storage

Variety	Harvest period	Weight losses		Rotten losses %	Total losses		Physiological disorders %
		%	Signification grade		%	Signification grade	
SIRIUS	1	7.3	-	1.3	8.6	°°	1.8
	2	6.7	°	3.6	10.3	°	0.7
	3	6.5	°	9.0	15.5	**	-
GOLDEN ORANGE	1	11.9	**	2.4	14.3	**	-
	2	10.1	*	2.8	12.9	*	-
	3	9.2	*	2.5	11.7	*	-
CIPRIAN	1	6.5	°	4.7	11.2	°	63.2
	2	6.2	°	4.8	11.0	°	8.7
	3	5.8	°	5.6	11.4	°	2.9
FUJI	1	6.9	°	4.5	11.4	-	86.5
	2	6.7	°	4.1	10.8	°	19.7
	3	5.4	°	3.5	8.9	°°	14.5
Average value		7.4	-	4.1	11.5	-	16.5

Source: Own determination.

Legend: ** = distinctively significantly positive;
* = significantly positive;
°° = distinctly significantly negative;
° = significantly negative;
- = insignificant

This physiological disorder did not manifest itself in the fruits of the Golden Orange variety, and in the Sirius variety it had a small extension (0.7% - 1.8%).

However, the Ciprian and Fuji varieties showed a high percentage of fruits affected by this physiological disorder. The variants harvested at time 1 showed 63.2% and 86.5% affected fruits, respectively, while the variants harvested later showed only 2.9% and 14.5% affected fruits.

During the storage period, the ripening processes of the fruit continue with the hydrolysis of the polyglucides and the accumulation of the resulting monoglycosides, the decrease of the titratable acidity and of the ascorbic acid.

The fruits harvested at time 1, after 190 days of storage, showed an increase in total carbohydrates by an average of 1.15 times, compared to the value determined at storage. In the variants harvested at time 3, the increase in the value of total carbohydrates is only 1.03 times, as a result of the fact that during storage the starch content of the fruit was lower.

For the varieties with a shorter maturation period (Sirius and Golden Orange), in which the starch in the fruit has been hydrolyzed to a greater extent, at the time of storage, the total carbohydrates show a decrease at the end of the storage period.

The titratable acidity of the fruit decreased during the storage period 1.71 times on average for the fruit harvested at time 1 and 1.77 times for those harvested at time 3. The ascorbic acid decreased 2.39 times and 2.16 times, respectively.

The sugar / fruit ratio was on average 45.6 for the variants harvested at time 1, respectively 46.8 at time 2 and 54.8 at time 3 of harvesting.

The level of the main chemical characteristics as well as the appearance of the fruits influenced their commercial value. Thus, the determination of sensory properties at the end of the storage period led to different results, as shown in Table 3.

The fruits harvested at time 1 had inadequate sensory properties (Table 3), being marked with the lowest score (11.3 points out of max. 20 points).

Table 3. The commercial value of apple fruits after 190 days of storage

Variety	Harvesting period 1 -points-	Harvesting period 2 -points-	Harvesting period 3 -points-
SIRIUS	13.2	17.9	17.9
GOLDEN ORANGE	11.1	17.2	17.3
CIPRIAN	10.7	15.5	18.4
FUJI	10.4	14.4	16.7
Average value	11.3	16.2	17.6

Source: Own determination.

The apples in these variants showed an advanced degree of dehydration, acid taste, unbalanced, green background color and a very little developed complementary color. The physiological disorder also affected 63.2% - 86.5% of the fruits of the Ciprian and Fuji varieties.

The highest score was obtained for the variants harvested at time 3 (17.6 points).

Out of the 4 varieties studied, only 2 (Ciprian and Fuji) had an appropriate degree of maturation. The Sirius and Golden Orange varieties were overripe, which was characterized by low firmness, intense yellow background color and low acidity.

Correlating the results regarding storage losses, sensory properties and changes in major chemical components, it can be concluded that for proper storage, with minimal losses, apple harvesting should be sequenced as follows:

-the Sirius variety 140 days after blooming, the starch being present on approximately 75% of the surface of the cross section;

-the Gold Orange variety 145 days after blooming, when the starch is present on about 80% of the cross-sectional area;

-the Ciprian and Fuji varieties 150 days after blooming, when the starch is present on about 75% of the surface of the cross section of the fruit.

CONCLUSIONS

After 190 days of storage, the highest weight losses were found in the fruits harvested earlier, respectively the 1st time of harvesting (6.5% - 11.9%), and the lowest in the variants harvested later, respectively the 3rd time of harvesting (5.4% - 9.2%).

The total losses including weight losses and losses through rotting were lower for Sirius harvested at time 1 (8.6%) and Golden Orange, Ciprian and Fuji harvested at time 3 (11.7%, 11.4% and 8.9% respectively).

The Ciprian and Fuji apples, harvested earlier (harvest period 1), saw a loss in quality by 63.2% - 86.5%, due to the manifestation of a physiological disorder (scald).

After 190 days of storage, the best sensory properties were highlighted in the fruits of the harvesting variant 3 (on average 17.6 points).

As a result of the study, it is recommended that the fruits of the Sirius variety, intended for storage, be harvested 140 days after blooming, when the starch is present on approximately 75% of the surface of the cross section of the fruit. The Golden Orange variety should be harvested approximately 145 days after blooming, when the starch is present on approx. 80% of the surface of the section, and the varieties Ciprian and Fuji after 150 days from blooming, when the starch is present on approx. 75% of the cross-sectional area of the fruit.

REFERENCES

[1]Chira, L., Chira, A, Delian, E., Ion, L., Constantin, N., 2019, Aspects regarding the storage behaviour of some apple varieties which are more or less known in Romania. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 19(1), 101-104.

[2]Chira, L., Chira, A., Ion, L., 2021, Research regarding the economical efficiency and qualitative aspects of some new apple varieties during storage under modified atmosphere, Scientific Papers, Series "Management, Economic Engineering in Agriculture and Rural Development", Vol. 21(1), 125-133.

[3]Chițu, V., Chitu, E., Petrescu, S., Filipescu L., 2007, The influence of harvest period upon the apple storage

capacity. Scientific Papers, ICDPP, Vol. XXIII, 109-114.
[4]Fante, C.A., Vilas Boas, A.C., Aguiar Paira, V., Freitas Pires, C.R., De Oliviera Lima, L.C., 2014, Modified atmosphere efficiency in the quality maintenance of Eva apples, Food Science and Technology, Vol. 34(2), 84-90.
[5]Ishii, M., Kusada, I., Yamane, H., 2018, Quantitative decision method of appropriate apple harvest time using color information. Electronic and Communications in Japan, Vol.101(2), 61-72.
[6]Sypula, M., Pietron, A., Struzyk, A., 2018, Changes in qualitative characteristics of apples stored in modified atmosphere packaging. Engineering for rural development, vol. 17, 1308-1314.
[7]Vielma, S.M., Matta, B.F, Silval, J.L.,2008, Optimal harvest time of various cultivars in Northern Mississippi. Journal of American Pomological Society, Vol. 62(1), 13-20.
[8]Viskelis, P., Rubinskiene Marina, Sasnauskas, A., Bobinas, C., Kvikliene Nomeda, 2011, Changes in apple fruit quality during a modified atmosphere storage. Journal of Fruit and Ornamental Plant Research, Vol. 19 (1), 155-165.