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STUDIES REGARDING THE INFLUENCE OF THE PERIOD BETWEEN HARVESTING AND THE BEGINNING OF STORAGE UPON THE QUALITY OF SOME PEAR VARIETIES

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Abstract

The 3-year research on Alexander Lucas and Santa Maria pear varieties followed the influence of the time interval from harvest to storage of the fruit on quality characteristics, weight loss, quality depreciation and storage length. The results showed that in both varieties harvested at the optimal time and put into storage 24 hours after harvest (V1), the quality characteristics, weight loss, quality deterioration and storage length were significantly higher (better) than for the variants in which the fruit was kept for 6 days (V2) and 12 days (V3) at 10-14 C before being put into the cooling room. Thus, the weight losses at the end of storage varied between 9.2-9.6% in V3 (fruit stored 12 days after harvest) compared to 6.4-7.2% in V1 (fruit put into storage after 12 hours), as the storage period was longer in V1. The qualitative losses at the end of storage ranged from 5-5.8% in fruit placed in the cooling room 24 hours after harvest, compared to 7.6-8.2% in fruit where storage in the cooling room was delayed by 12 days. The optimal storage period of the pear fruits, stored as soon as possible after harvesting, belonging between 90 days for the summer variety Santa Maria and 115 days for the winter variety Alexander Lucas, in cold storage room.

Key words**:** *harvesting period, storage period, weight losses, organoleptic assessment*

INTRODUCTION

The quality and shelf life of pears are influenced by a number of factors in the preharvest and postharvest periods [1, 2]. Among these factors, the time period between harvesting and storage plays a determining role on the keeping capacity and quality of the fruit at the end of storage [3, 4]. In practice, at farm level, the time between harvesting and placing in cold storage is influenced by logistical aspects (organisation of transport, distance to the warehouse, possibility fruit conditioning).

It is known that pears continue to ripen after harvesting, this evolution being greatly influenced by the temperature at which the fruit is kept before being placed in cold storage and especially by the period of time between harvesting and placing in cold storage [5]. The storage conditions also influence the shelf life and quality of the pears [6]. Thus, under modified atmosphere or controlled atmosphere conditions, the storage time increases and the quality of the fruit reaches optimum values, but at the end of storage a post-ripening period of 6-8 days at a temperature of 16-20 °C is needed to achieve an organoleptic quality that is well appreciated by consumers [7, 8, 9, 10].

MATERIALS AND METHODS

The research was carried out on Alexander Lucas and Santa Maria pear varieties, from the 2020, 2021 and 2022 harvests, grown in a private farm, Voinești area, Dâmbovița fruit basin.

The characters of the two studied varieties are presented below as follows:

- ***The Santa Maria pear variety*** (Photo 1) was developed in Italy at the University of Florence and was introduced to the market in 1951.

The tree has high vigour and a medium to late flowering period. It is a summer variety, with fruit that ripens after 15 August and has an average weight of 160-230 grams, with a diameter of over 6 cm. The colour of the fruit

is greenish-yellow, but on the side exposed to the sun it turns red.

Photo 1. Santa Maria pear variety
Source: Original.

The taste of the fruit is sweet (approx. 90 Brix) and flavoured. The pulp is white in colour, fine, juicy and free of sclereids. The fruit can be stored for up to 2 months in ambient conditions and up to 5 months in a controlled atmosphere.

-***The Alexander Lucas pear tree*** (Photo 2) originated in France, where it was identified by chance in 1870 in a forest in Blois. The tree is of medium vigour and has an early-mid flowering period.

Fig. 2. Alexander Lucas pear variety
Source: Original.

It is a winter variety, with fruit ripening after 15 October and an average weight of 160-350 grams, with a diameter of 7-9 cm. The colour of the fruit is green, which changes to yellowish, with shades of red on the side exposed to the sun. The taste of the fruit is pleasant, with a balanced sugar/acidity ratio, and the flesh of the fruit is white, juicy, crunchy, with sclereids in the central area. The fruit is harvested before it is ripe. The fruit can be kept for 2 months in ambient conditions and up to 5 months in a controlled atmosphere.

The fruit was harvested at the optimum time, determined on the basis of previous years' production experience, which ensured good keeping capacity. In the study, only extra quality fruit was used, assessed according to the rules of the standard in force (Reg. EU 543/2011).

They were placed in storage at different time intervals after harvesting, the variants studied being the following:

V1 - fruit placed in cold storage 24 hours after harvest;

V2 - fruit placed in the cold room after a 6-day holding period at 10-140C and 65-70% relative humidity (Photo 3 and 4);

V3- fruit placed in the cold room after a holding period of 12 days at 10-14 0C and 65-70% relative humidity.

Photo 3. Pear fruits from V2 and V3 variant, before cold storage
Source: Original.

Each variant was made up of 3 repetitions, each of 50 kg. Fruit storage was done in the cold room of the Horticultural Products Technology Laboratory of the Faculty of Horticulture Bucharest.

The storage temperature varied between 1 and 20C, and the relative air humidity between 86-90%, ensured by packaging the fruits with LDPE film, 15 microns thick.

Photo 4. Pear fruits from V2 and V3 variant, in cold storage
Source: Original.

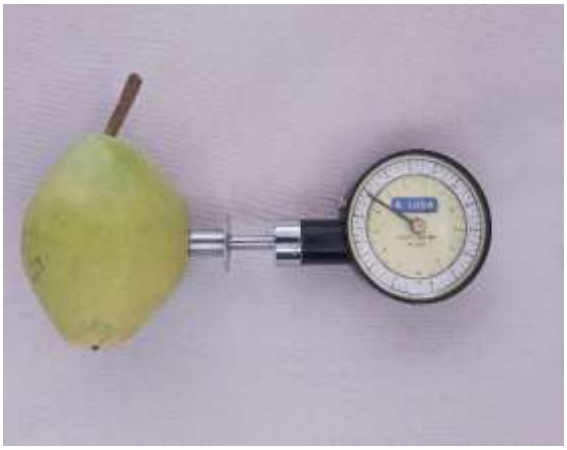

Photo 5. Fruit firmness testing, using the Effegi penetrometer
Source: Original.

Photo 6. Soluble dry matter determination, using the Atago refractometer
Source: Original.

The main physico-chemical characteristics of the fruit (average weight, pulp firmness, soluble dry matter, total titratable acidity and ascorbic acid) were determined at harvest and at the end of storage.

The pulp firmness was analysed by using the Effegi penetrometer with 11 mm diameter plunger (Photo 5).

The value of the soluble dry matter was determined using the Atago electronic refractometer (Photo 6).

The total titratable acidity (expressed in malic acid) was determined by titration with NaOH 0.1 N solution. The value of ascorbic acid was determined using the iodometric method.

At the end of storage, the organoleptic capacity of the fruit was assessed on the basis of a score according to STAS 6441/88.

The storage conditions with regard to temperature and relative air humidity were determined using the Hanhhart thermohygrometer.

The weight losses and quality depreciation were determined by weighing and expressed in percentage.

The shelf-life of pears, expressed in days, was considered to be completed when the fruit still had commercial value, expressed as a total loss (in weight and quality depreciation) of between 10% and 17%.

RESULTS AND DISCUSSIONS

The physico-chemical characteristics of fruit at harvest

As previously mentioned, the fruit was harvested at the optimal harvest time, determined based on observations made in previous years, which provided the best storage capacity.

From the data presented in Table 1, the differences between the two varieties can be seen. Thus, the average fruit weight, a variety-dependent characteristic, ranged from 185 g in Santa Maria to 230 g in Alexander Lucas, with flesh firmness values ranging from 5.5 to 6.2 kgf/cm^2.

The soluble dry matter content, determined by a refractometer, varied between 7.8% in the Santa Maria variety and 8.6% in the Alexander Lucas variety, and the titratable

acidity had very similar values, between 0.24% and 0.28%.

The ascorbic acid content had a lower value of 6.86 mg/100 g in the Santa Maria variety, while in the Alexander Lucas variety, the value was higher at 7.48 mg/100 g.

The values determined for both varieties fall within the specific parameters for the optimum harvesting time recommended to ensure good storage capacity.

The evolution of the physico-chemical characteristics of the fruit during storage, depending on the time of introduction into the cold room

Fruit firmness, an important property which can be used to characterise the degree of ripeness of pears, has decreased continuously since harvest due to the transformation of insoluble protopectin into soluble pectin.

Firmness declined at a more pronounced rate in the time between harvest and the start of cold storage.

From the results presented in Table 2, related to the analyses carried out after 45 days of storage (the shortest storage period for Santa Maria - Variant 3), it can be seen that the firmness of the pulp decreased, compared to the value at the time of harvesting, in a high proportion in V3 (on average by 50% - 54%, depending on the variety) and in a lower proportion in V1 (on average by 19% - 21% depending on the variety).

Table 1. The main physio - chemical characteristics of the pear fruits at harvest

VARIETY	Average Weight - g -	Firmness Kgf/cm2	Soluble dry matter %	Total titratable acidity (ac malic) %	Ascorbic acid mg/100 g
ALEXANDER LUCAS	230	6.2	8.6	0.28	7.48
SANTA MARIA	185	5.4	7.8	0.24	6.86

Source: Own determination.

Table 2. The influence of the time period between harvesting and beginning of storage, upon the fruit firmness, after 45 days of storage in cold environment

VARIETY	VARIANT					
	A	B	A	B	A	B
ALEXANDER LUCAS	4.9	21	3.9	37	3.1	50
SANTA MARIA	4.4	19	3.5	35	2.5	54

Source: Own determination.

Legend: A = Firmness value, in kgf/cm^2; B = Decreasing of the fruit firmness (%) in comparison with the harvesting time.

The decrease in firmness during the 45 days was on average 0.02 - 0.03 kgf/cm^2/day when the fruit was placed in storage 24 hours after harvest (V1) and 0.06 - 0.07 kgf/cm^2/day when the fruit was kept for 12 days in an ambient environment before being placed in cold storage.

Soluble dry matter showed a continuous increase for both varieties and in all variants from the time of harvest due to the transformation of starch content into soluble carbohydrates. The evolution was different depending on the experimental variant. Thus, in the case of V1, the soluble dry matter content increased more, up to values between 13.8% in Santa Maria and 14.8% in Alexander Lucas. The increases were lower in the fruits of variety 3, with values between 12.6% in the Santa Maria variety and 13% in the Alexander Lucas variety.

Total titratable acidity, expressed as malic acid, at the end of storage had lower values compared to the time of harvesting, depending on the variant and length of storage. Thus, the highest values for both varieties were recorded at V1 (0.16 - 0.18%), while the lowest values were at V3, respectively 0.11% in the Alexander Lucas variety and 0.09% in the Santa Maria variety.

Ascorbic acid decreased sharply during storage and reached 4.12 mg/100 g (V1) for Alexander Lucas and 3.86 mg/100 g (V1) for

Santa Maria. In the case of fruit stored under V3 conditions, the decrease was more pronounced, i.e. by 62.5% compared to the initial value in the Alexander Lucas variety and by 61.5% in the Santa Maria variety.

From the analysis of the main physico-chemical characteristics of the fruit at the end of storage, it appears that fruit stored in cold storage 24 hours after harvest (V1) are superior in terms of nutritional value compared to fruit whose introduction to storage was delayed by 6-12 days, i.e. V2 and V3 (Table 3).

The fruit quality determined by organoleptic assessment

Following the assessment of fruit quality at the end of the storage period, by organoleptic assessment, from the results presented in Table 4 it can be seen that in both varieties, the fruit stored 24 hours after harvest (V1) had superior characteristics and were classified as Extra quality, as they obtained 30 points in the Santa Maria variety and 32 points in the Alexander Lucas variety.

Table 3. The main physio – chemical characteristics of the pear fruit at the end of storage period

VARIETY	VARIANT	Soluble dry Matter -%-	Total titratable Acidity -%-	Ascorbic acid -mg/100g-
ALEXANDER LUCAS	V1	148	0.18	4.12
	V2	14.2	0.14	3.40
	V3	13.0	0.11	2.80
SANTA MARIA	V1	13.8	0.16	3.86
	V2	13.0	0.12	3.12
	V3	12.6	0.09	2.64

Source: Own determination.

Table 4. The quality of the fruits, determined by organoleptic assessment

Characteristic analysed	Grading	Variety/ variant					
		ALEXANDER LUCAS			SANTA MARIA		
		V1	V2	V3	V1	V2	V3
Size	3……..1	3	3	2	3	3	2
Shape	3……..1	3	3	3	3	3	3
Skin colour	4……..1	4	4	2	4	3	2
Skin state	4……..1	4	3	2	4	3	1
Pulp colour	3……..1	3	3	2	3	3	2
Pulp firmness	3……..1	3	2	1	2	2	1
Pulp juiciness	3……..1	3	2	1	2	2	1
Taste	3……..1	6	6	4	6	6	4
Aroma	7……..1	3	3	2	3	3	2
Total points	4……..1	32	29	19	30	28	18
Quality class	Extra 30 – 34	x			x		
	First Quality 20 – 29		x			x	
	Second Quality 10 - 19			x			x

Source: Own determination.

This result was ensured by a suitable external appearance, juicy flesh and a characteristic taste and flavor. Fruits placed in storage after 6 days (V2) were slightly penalized for the characteristics: skin state, pulp firmness, pulp juiciness taste and aroma and fell into the first quality category as they scored 28 points (Santa Maria variety) and 29 points (Alexander Lucas variety) respectively.

Delaying the introduction to storage by 12 days (V3) resulted in a lower organoleptic quality (second quality category), with 18

points for Santa Maria and 19 points for Alexander Lucas.

The fruit of this variety showed some commercial defects, with small browned surfaces on the skin, the taste and flavor less characteristic, making these fruits no longer of commercial value to consumers.

The quantitative and qualitative losses of the pear fruits, during the storage period.

The weight losses were influenced by the temperature and relative humidity of the air in the storage space.

Thus, the highest losses were recorded at V3, because the higher temperature and lower relative humidity in the period before the introduction to storage favoured the sweating and respiration processes.

The values obtained varied between 9.2% for Alexander Lucas and 9.6% for Santa Maria, but after different storage periods (65 days and 45 days respectively), as shown in Table 5.

The introduction of the fruit into storage immediately after harvest (V1) as well as the optimal values of temperature and relative humidity in the cooling room resulted in much lower weight losses, respectively 6.4% for Alexander Lucas and 7.2% for Santa Maria, but after a much longer storage period compared to V3 (50 days for Alexander Lucas and 45 days for Santa Maria).

The qualitative losses were also higher in V3 and lower in V1, because the vulnerability (susceptibility) of pears to disease attack increases as they ripen.

Microorganisms also find optimal conditions for growth in the time between harvest and storage.

Thus, the qualitative losses ranged from 5% (Santa Maria) to 5.8% (Alexander Lucas) at V1 and from 7.6% (Santa Maria) to 8.2% (Alexander Lucas) at V3, but as mentioned above, after different storage periods.

Table 5. The weight and qualitative losses of the pear fruits, during the storage period

Variety	Variant	Storage Period -days-	Weight Losses -%-	Qualitative Losses -%-	Total Losses -%-
ALEXANDER LUCAS	V1	115	6.4	5.8	12.4
	V2	85	7.8	7.0	14.4
	V3	65	9.2	8.2	17.4
SANTA MARIA	V1	90	7.2	5.0	12.2
	V2	70	8.0	6.4	14.4
	V3	45	9.6	7.6	17.2

Source: Own determination.

The total losses during the storage period, resulting from adding the weight and qualitative losses, were very similar for all 3 variants for both varieties, but after very different storage periods (about 15-20 days between varieties, at the same grazing variant).

Thus, the values varied between 12.2% - 12.4% in V1 and 17.2% - 17.4% in V3, which once again highlights the advantage of storing the fruit as soon as possible after harvest.

The fruits storage period

In practice, the size of the losses definitely determines the storage period of a batch of fruit. In this respect, comparing the storage periods in which losses (quantitative or qualitative) of 7-10% were recorded, it can be seen that the fruit storage period was shorter by 45-50 days in V3 and 20-30 days in V2, compared to V1 (Table 5).

It is shown that by delaying storage by 6-12 days, the fruit storage period was reduced by 22% (V2) - 50% (V3) compared to fruit stored immediately after harvest (V1).

CONCLUSIONS

The pear fruits of the Alexander Lucas and Santa Maria varieties, harvested at the optimal time and stored in cold storage 24 hours after harvesting, kept much better compared to fruits whose storage was delayed by 6-12 days.

Fruit firmness during storage decreased, compared to the time of harvest, with values ranging from 50% to 54% when storage was

delayed by 12 days and only 19-21% for fruit put into storage 24 hours after harvest.

The main chemical components of the fruit such as soluble dry matter, total titratable acidity and ascorbic acid, at the end of storage, had higher values, which determine a better taste quality, in the fruits that were introduced immediately to storage, compared to the variants in which storage was delayed by 6-12 days.

Following the organoleptic assessment of the fruit at the end of storage, they were classified as Extra quality, in the variants where the fruit was stored immediately after harvesting, respectively quality I and quality II when storage was delayed by 6-12 days.

The weight losses of the end of storage varied between 9.2 - 9.6% at V3, compared to 6.4-7.2% at V1, but after a longer period of fruit storage.

The qualitative losses at the end of storage ranged from 5-5.8% in fruit placed immediately after harvest, compared to 7.6-8.2% in fruit where storage was delayed by 12 days.

The obtained values of total losses showed the advantage of introducing the fruit into storage as soon as possible after harvest.

As a result of delaying storage by 6-12 days after harvest, the shelf life of the fruit was reduced by 22% (V2) - 50% (V3), compared to the variant where the fruit was stored immediately after harvest (V1).

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