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INFLUENCE OF GENOTYPES AND THE STORAGE TIME ON PEARS QUALITY INDICATORS

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Abstract

In order to study the changes in the quality of the fruits during the storage time, the late ripening seven Romanian genotypes and two international cultivars used as control. Genotypes were refrigerated for different periods of time under conditions of 4°C and 75% humidity. Fruit quality indicators: flesh firmness, skin color, pH, total dry weight, total soluble solids content, titratable acidity, total polyphenols content and vitamin C were evaluated starting at the time of fruit harvesting and continuing in the interval 60, 90 and 120 days after harvesting. All tested pear genotypes retained a hight level of quality after 60 days. The degradation of organic acids and vitamin C, the increase followed by decrease in the level of sugars and total dry weight per mass unit in fruits was influenced by the duration of storage. In the Romcor cultivar, firmness and the average weight decreased significantly compared to the other genotypes. The obtained results were significantly influenced by the genetic characteristics and the time of storage.

***Key words**: biochemical characteristics, pear quality, postharvest storage.*

INTRODUCTION

Pear trees are a tree species of interest for fruit cultivation that belongs to the genus *Pyrus*, family *Rosaceae* and are native to Europe, North Africa and Asia (Kaviani et al., 2023). In Europe, Africa, Asia, North America, South America and Australia, due to the appreciation of nutritional value, *Pyrus communis* L. (European pear) is the main species found in the marketing chain (Thakur & Dalal, 2008). In 2021, the reported world production of European pear (*Pyrus communis* L.) was about 23 million (Prange & Wright, 2023).
The storage, quality, biochemical value, taste and aroma of fruits are affected by various factors, including genetic factors (Nafiye et al., 2023), ecological conditions, cultural systems and harvesting periods (Kader, 2002). Improper handling during pre-harvest, harvest, sorting, packaging, storage, transport or marketing operations has significant repercussions on the appearance and commercial quality of fruit producing mechanical damage, water loss, deformation, fungal decay and fermentation (Sánchez et al., 2012). Summer pears cannot be stored. Autumn pears can be stored for a shorter period of time compared to winter pears (Nótári & Ferencz, 2014). Fruit harvesting and storage operations constitute an important stage of fruit growing. The fruit of the pear is harvested by hand, requiring competence and skill (Soltész, 2007). Another important feature of storage is that the fruit can be kept fresh for a longer period of time, so the market and consumption period can be extended.
The time of harvesting is a particularly significant factor in the formation of the taste of pears. In immature fruits, although the storage capacity is longer, the possibilities to develop the appropriate organoleptic characteristics are generally reduced, while the storage time of overripe fruits is usually very short because the susceptibility to decay increases (García, 2001). Although the dynamics of fruit pulp firmness and refractive index values are particularly important for consumer acceptance (Kader, 2002), in pear, both characteristics are not considered factors to depict the stage of ripeness before pear harvest in terms of harvest date and postharvest treatment (Gamrasni et al., 2015). The biochemical value of fruits can fluctuate

significantly, creating differences in taste (Jeppsson & Johansson, 2000; Kader, 2002).
The total soluble solids content of fruits has an increasing dynamic during storage (Engin & Mert, 2020). The ideal time to harvest the fruit is in the early hours of the morning, just after the dew has cleared from the fruit, or in the evening when the temperatures are a little cooler. The procedure of storage at the minimum acceptable temperature has a crucial role in extending the shelf life of pears (Porritt, 1964). If pears are stored at a higher temperature, fruit senescence and losses due to fungal activities will shorten the storage period, and if stored at a lower temperature, the fruit may develop certain chilling disorders or freeze (Kidd et al., 1927). Preference for lower temperatures varies with cultivar genetic background, early pear cultivars have a shorter requirement, 0-20 days, while later ripening cultivars require longer durations (>40 days) (Gerasopoulos & Richardson, 1999). Chilling is the main method used to maintain the commercial value of fresh fruit after harvest. The range of average storage temperatures for European pear cultivars varies between -1.0 and +0.25°C. In contrast, recommendations for Asian pear varieties range from 0 to +0.5°C, so slightly higher than European pear storage temperatures (Prangeand Wright, 2023). According to Wiseman et al. (2016), pears can be stored at temperatures between -0.5 to 4°C under controlled atmospheric conditions (1 to 2% O_2 and 0.5% CO_2) or in air where they can be stored depending on the cultivar up to 8 months. Higher temperature ranges can accelerate pear metabolism and pathogen activities and accelerate moisture loss, causing greater decay, softening and weight loss during storage. Thus the respiration rate of climacteric fruits such as pears is accentuated (Biale, 1964 cited by Brandes & Zude-Sasse, 2019). The higher the fruit respiration rate, the shorter the shelf life (Brash et al., 1995). Low post-harvest temperatures can slow respiration rate, water loss, ripening and senescence processes and fungal decay of horticultural products (Oliveira et al., 2013).
The indications regarding the recommended temperature for the storage period of the pears, in the vast majority, refer to controlled atmosphere conditions. Controlled atmosphere storage is based on changing and maintaining a gas composition of the air different from that in the natural state (78 kPa N_2, 21 kPa O_2 and 0.03 kPa CO_2). The main benefit of controlled atmosphere is caused by reducing the concentration of O_2 as much as possible without producing undesirable anaerobic metabolism. The decrease in the level of O_2 can inhibit the respiratory metabolism of the fruits and if it is low enough, it can even inhibit the biosynthesis of ethylene during ripening (Prange, 2022). According to Prange and Wright (2023), storage recommendations differ for each variety and each pear-growing region. For example, for 17 varieties of European pears, there are 34 recommendations. The expansion of the varietal pipeline of cultivars in the database is a reflection of changes in the pear industry.
The aim of the present study was to evaluate the biochemical composition of pears refrigerated at 4°C and 75% humidity for 120 days.

MATERIALS AND METHODS

The experiment location and plant material

The research was conducted in 2023 year, in an experimental plot of the Research Institute for Fruit Growing Piteşti-Mărăcineni, in randomized blocks with three repetitions (5 tree per each replicate) and were studied the late ripening seven Romanian genotypes: \`Isadora\`, \`Romcor\`, \`R39P51xParamis\`, \`Aniversare\`, \`P20R41P30\`, \`SP06C2P5\`, \`Monica\`, and two international cultivars \`Packham's Triumph\` and \`Socrovisce\` used as control. The fruit samples were harvested at the tehnical harvest maturity and were sorted, classified and packed directly in the containers. At harvest, fruit are placed into either wooden or plastic binsand then transported immediately to storage were cooled 4°C and 75% humidity for 60, 90 and 120 days.

Soil Description

The experimental scheme was located on a brown-clay soil, flat with a loamy and loamy texture in the first 60-70 cm, and in depth the texture becomes sandy. Soil samples were collected at two depths (0- 20 cm and 20-40 cm), with an agrochemical probe. The soil thus harvested was air-dried and analyzed in the agrochemical laboratory. The soil is characterized by a moderately acidic reaction, a low humus content and a low supply of nitrogen and phosphorus.

Biochemical analyzes and laboratory determinations

The indicators studied were recorded at the optimal time for harvesting the fruits and continuing in the interval 60, 90 and 120 days after harvesting, on a sample of 10 pear fruits.

The *average weight* of the fruit was determined by weighing using the Kern EW digital balance.

Weight loss. Pear weight was measured with a balance (±0.01 g) before treatment and after storage, respectively, and the mass loss was calculated as % weight loss = (AB)/B × 100 (Hosseini et al., 2017).

The *firmness* of the fruit was determined for each sample with a Bareiss HPE II Fff penetrometer, a non-destructive test. The measurement was performed on the two parts of the fruits according to ECPGR, Pear (*Pyrus communis*) recommendations, 2022.

The external *fruit colour* was measured with a colorimeter Konica Minolta CR 400, based on system Hunter L, a*, b* on both sides of the fruit (L corresponds to brightness, a* and b* chromaticity coordinates from green to red and from blue to yellow, respectively).

The biochemical characteristics of the fruit were determined in a sample of approximately 10 pears per repetition.

Total soluble solids (TSS) content was measured with Atago Palette PR32 digital refractometer (0-32°Brix).

Total dry matter was determined by the gravimetric method by measuring water loss to constant weight according to AOAC International (2002).

The *content of organic acids* (TA), expressed as % malic acid, was analysed by the titrimetric method using a 0.1 N NaOH solution in the presence of phenolphthalein as an indicator (AOAC, 2000).

The *content of ascorbic acid* (*vitamin C*) expressed in mg/100 g of fresh fruit was determined by the titrimetric method (PN-A-04019: 1998).

The determination of *total polyphenols* was carried out spectrophotocolorimetrically, with the Folin-Ciocâlteu reagent (Singleton et al., 1999) and the results were expressed as milligrams per kilogram of gallic acid equivalent (mg GAE/kg FW). For the extraction of polyphenols, methanol (70%) was used as a solvent, according to Singleton and Rossi (1965 cited by Ereifej et al., 2016).

Statistical analysis

Statistical analysis was performed using an IBM SPSS 14 program (SPSS Inc., Chicago, IL, USA). All results were analyzed by Anova and using the Duncan Multiple Range test. The differences were considered statistically significant at $p < 0.05$.

RESULTS AND DISCUSSIONS

Biochemical quality and commercial value under storage conditions or for fresh consumption are particularly important in cultivar selection for fresh fruit. The period of ripening significantly influences the period of preservation of pears in a fresh state. Also, shelf life and susceptibility to decay differ between pear varieties. The fruits of the hair genotypes were stored at 4°C and 75% humidity and qualitatively analysed starting at the time of harvest and continuing at 60, 90, 120 days after harvest. Fruit decline was low (<2%) in the first 60 days. Continued storage at 4°C for up to 120 days resulted in highly accelerated degradation, fresh

Table 1. Fruit characteristic - weight (g), firmness (HPE units), pH, TA (%), dry weight (%), water (%) - of the pear genotypes

Genotypes	Storage time (days)	Weight (g)	Firmness (HPE units)	pH	TA (%)	Dry weight. (%)	Water (%)
Aniversare	At harvest	187.25±45.59^{a}	80.48±3.66^{a}	3.78±0.04^{b}	0.42±0.06^{a}	13.07±0.28^{c}	86,93±0.28^{a}
	60 days	186.44±45.39^{a}	76.85±4.61^{b}	3.86±0.08^{b}	0.39±0.03^{ab}	13.62±0.74^{c}	86,38±0.74^{b}
	90 days	185.45±45.3^{a}	68.56±8.31^{b}	4.14±0.06^{a}	0.32±0.02^{b}	14.68±0.06^{b}	85,32±0.06^{c}
	120 days	182.33±44.53^{a}	67.43±0.64^{b}	4.22±0.12^{a}	0.16±0.01^{c}	16.87±0.58^{a}	83,13±0.58^{d}
Romcor	At harvest	155.82±26.29^{a}	79.18±2.00^{a}	3.73±0.26^{a}	0.73±0.00^{a}	14.61±0.52^{b}	85.39±0.52^{a}
	60 days	154.13±26.01^{a}	38.80±5.69^{b}	3.93±0.29^{a}	0.50±0.02^{b}	15.25±0.33^{b}	84.75±0.33^{a}
	90 days	152.39±25.32^{a}	31.12±1.39^{c}	4.25±0.28^{a}	0.11±0.01^{c}	17.57±0.21^{a}	82.43±0.21^{b}
	120 days	-	-	-	-	-	-
Isadora	At harvest	212.25±26.75^{a}	80.60±2.03^{a}	4.29±0.06^{b}	0.18±0.01^{a}	15.69±0.23^{d}	84.31±0.23^{a}
	60 days	211.23±26.62^{a}	76.41±2.47^{b}	4.52±0.22^{ab}	0.13±0.02^{b}	16.72±0.40^{c}	83.28±0.40^{b}
	90 days	210.19±26.34^{a}	75.85±3.66^{b}	4.65±0.21^{a}	0.11±0.01^{c}	18.77±0.31^{b}	81.23±0.31^{c}
	120 days	208.77±25.96^{a}	71.86±2.32^{c}	4.78±0.13^{a}	0.10±0.00^{c}	19.58±0.61^{a}	80.42±0.61^{d}
Monica	At harvest	238,09±53.25^{a}	79.83±1.94^{a}	3.90±0.03^{c}	0.32±0.02^{a}	16.52±0.40^{c}	83.48±0.40^{a}
	60 days	236.49±52.89^{a}	76.14±2.06^{b}	4.13±0.10^{b}	0.24±0.01^{b}	17.07±0.38^{bc}	82.93±0.38^{ab}
	90 days	235.00±53.31^{a}	73.93±3.54^{b}	4.22±0.09^{b}	0.21±0.02^{b}	17.61±0.18^{ab}	82.39±0.18^{bc}
	120 days	232.96±53.33^{a}	70.46±4.39^{c}	4.43±0.14^{a}	0.11±0.01^{c}	18.34±0.91^{a}	81.66±0.91^{c}
Packham's Triumph	At harvest	169.02±15.31^{a}	65.53±3.01^{a}	4.61±0.17^{b}	0.13±0.02^{a}	15.57±0.60^{b}	84.43±0.60^{a}
	60 days	167.93±15.21^{a}	43.59±12.97^{b}	4.75±0.08^{ab}	0.11±0.01^{b}	16.11±0.60^{ab}	83.89±0.6a^{b}
	90 days	167.07±15.35^{a}	40.37±9.10^{b}	5.03±0.21^{a}	0.10±0.00^{c}	16.93±0.35^{a}	83.07±0.35^{b}
	120 days	-	-	-	-	-	-
P20R41P30	At harvest	137.93±28.54^{a}	69.54±1.00^{a}	4.76±0.42^{b}	0.21±0.02^{a}	14.24±0.36^{b}	85.76±0.36^{a}
	60 days	136.69±28.28^{a}	68.41±5.73^{a}	5.02±0.03^{ab}	0.18±0.01^{b}	14.26±0.94^{b}	85.74±0.94^{a}
	90 days	135.10±28.05^{a}	58.41±7.29^{b}	5.36±0.13^{a}	0.11±0.01^{c}	17.06±0.51^{a}	82.94±0.51^{b}
	120 days	-	-	-	-	-	-
R39P51x Paramis	At harvest	122.98±34.96^{a}	82.75±7.64^{a}	4.21±0.03^{a}	0.32±0.02^{a}	13.79±0.14^{c}	86.21±0.14^{a}
	60 days	122.38±34.79^{a}	80.62±4.67^{a}	4.32±0.07^{a}	0.27±0.04^{b}	16.17±1.29^{b}	83.83±1.29^{b}
	90 days	121.37±34.50^{a}	72.89±4.58^{b}	4.41±0.19^{a}	0.18±0.01^{c}	16.30±0.53^{b}	83.70±0.53^{b}
	120 days	119.09±33.76^{a}	70.08±3.53^{b}	4.39±0.21^{a}	0.14±0.02^{d}	20.20±0.48^{a}	79.80±0.48^{c}
SP06C2P5	At harvest	151.97±10.40^{a}	81.45±5.45^{a}	3.74±0.17^{a}	0.51±0.01^{a}	15.06±0.31^{c}	84.94±0.31^{a}
	60 days	150.34±10.29^{a}	57.79±9.71^{b}	3.88±0.13^{a}	0.49±0.03^{a}	15.77±0.26^{b}	84.23±0.26^{b}
	90 days	148.32±10.01^{a}	42.39±9.05^{c}	4.07±0.19^{a}	0.35±0.04^{b}	16.59±0.33^{a}	83.41±0.33^{c}
	120 days	-	-	-	-	-	-
Socrovisce	At harvest	165.54±32.61^{a}	79.03±3.17^{a}	3.63±0.29^{b}	0.73±0.00^{a}	14.98±0.29^{c}	85.02±0.29^{a}
	60 days	164.56±32.42^{a}	74.13±4.23^{b}	4.08±0.16^{a}	0.51±0.02^{b}	16.56±0.25^{b}	83.44±0.25^{b}
	90 days	163.81±32.52^{a}	71.52±4.91^{b}	4.19±0.34^{a}	0.48±0.01^{b}	16.84±0.12^{b}	83.16±0.12^{b}
	120 days	162.7±32.30^{a}	70.20±0.62^{b}	4.31±0.11^{a}	0.24±0.06^{c}	20.64±0.21^{a}	79.36±0.21^{c}

*Duncan test. Mean values with the same letter do not present significant differences ($p \leq 0.05$) ($n=3$).

weight loss and pH increase, as well as accelerated decreases in bioactive compounds beneficial to human health.

Sensory characteristics of pears are reported in Table 1.

Average weight and Weight loss

Fresh weights decreased during storage in all cultivars studied, although no statistically significant differences were noted (Table 1). However, the percentage of weight loss increases significantly with the increase of storage time in the genotypes (Figure 1). According to the analysis of variance test, the weight loss was significantly influenced by the genetic background of the cultivar. Significant differences in terms of weight loss percentage were shown by \`Aniversare\` \`R39P51xParamis\` and \`Socrovisce\` genotypes. The percentage of weight loss was different from one cultivar to another. Thus, a variation of this indicator between 1.16% (\`Packham's Triumph\`) and 3.14% (\`R39P51xParamis\`) was obtained. The \`SP06C2P5' genotype achieved the highest weight loss up to 60 days and was followed by the 'Romcor' genotype, the difference between the two genotypes being low. In genotype \`R39P51xParamis\`, the difference between the percentage of weight loss at 60 days and 120 days was higher compared to the other varieties that were kept until this date (from 0.49% to 1.86%). Ochoa-Velasco and Guerrero-Beltrán (2014) noted a superior weight loss in pears with red fiber compared to pears with white fiber probably due to the fact that the red fiber is juicier and more fragile in texture. Among the genotypes analyzed, the fruits of the `Romcor` variety deteriorated the fastest in terms of quality up to 90 days of storage (2.18% up to 90 days).

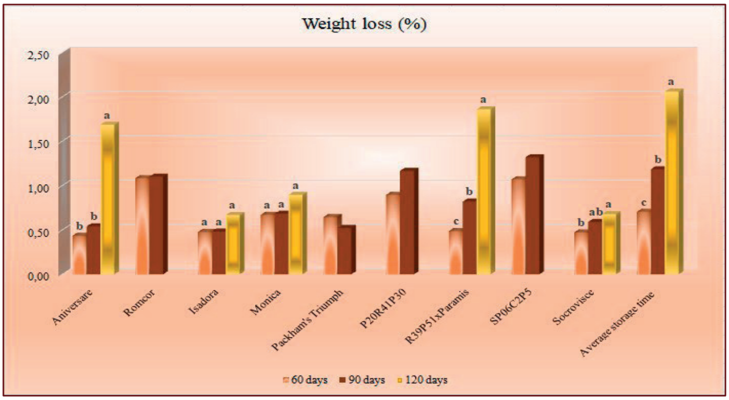

Figure 1. Influence of storage period on weight loss (%) of pears by cultivar (n=3)

Firmness Pears (*Pyrus communis* L.) are eaten in a firm and crisp stage immediately after harvest or storage. Fruit pulp firmness is an indicator used in agriculture or commerce to predict the optimal time to harvest pears (Wang & Sugar, 2015). Control of earlier and later ripening pears revealed a whole range of changes in this quality indicator, from crisp texture at fruit harvest to butter pulp at the end of shelf life (Brandes & Zude-Sasse, 2019). The fruit firmness at harvest was maximum 82.75 HPE units (R39P51xParamis) and it gradually declined as the period of storage advanced (Table 1). The lowest values were recorded for the genotypes 'Romcor' (31.12 HPE units), 'Packham's Triumph' (40.37 HPE units) and SP06C2P5 (42.31 HPE units) at 90 days of storage (the maximum period for these genotypes). The change in flesh firmness may be due to modification of the chemical structure of the cell wall (Sakurai & Nevins, 1997)

Colour: Traditionally, the pear cultivars have green, yellow, or russet-brown skins. Red coloration of pear skin is known to depend mainly on the composition and concentration of anthocyanin (Steyn et al., 2004). In recent years, red pear cultivars have rapidly become more popular for their attractive skin colour and potential nutritional value (Zhang et al., 2012). At European pears (*P. communis* L.), red coloration decreases toward harvest and anthocyanin accumulation reaches maximum about midway between anthesis and harvest (Steyn et al., 2004). A large variation in colour changes was observed between genotypes and storage time (Table 2). The limits of variation of the chromatic coordinate L were 67.90 for the 'R39P51xParamis' genotype and 43.52 for the 'Isadora' genotype. The values of the chromatic coordinate a* were between -14.74 (for 'Packham's Triumph' - 60 days of storage) and 14.28 (for the 'R39P51xParamis' genotype - 90 days of storage). Hunter's L, a*, b* values increased during the first 60 or 90 days of storage followed by a decrease in some genotypes. The effect of storage time on skin colour changes has been reported in several studies (Arzani et al., 2008; Hosseini et al., 2017).

Table 2. Fruit colour characteristic of the pear genotypes

Genotypes	Storage time (days)	*L*	a*	b*
Aniversare	At harvest	49.67±4.54^{ab}	-3.88±2.23^{b}	22.93±2.28^{ab}
	60 days	46.12±3.83^{b}	-2.22±1.28^{b}	21.17±1.58^{b}
	90 days	51.64±4.40^{a}	-4.84±3.89^{a}	22.75±1.90^{ab}
	120 days	51.97±4.98^{a}	3.43±4.88^{a}	24.55±1.26^{a}
Romcor	At harvest	60.15±7.30^{a}	-6.60±5.51^{a}	26.77±2.55^{a}
	60 days	58.47±5.99^{a}	-9.13±4.59^{a}	27.59±3.17^{a}
	90 days	61.09±2.27^{a}	-3.87±2.11^{a}	28.72±1.90^{a}
	120 days	-		
Isadora	At harvest	60.37±4.38^{b}	-12.51±3.35^{d}	29.46±3.13^{b}
	60 days	65.40±4.77^{a}	-8.82±1.36^{c}	30.53±1.34^{ab}
	90 days	68.30±4.22^{a}	-5.56±1.32^{b}	31.99±0.98^{a}
	120 days	67.90±3.38^{a}	-2.41±1.59^{a}	32.33±0.96^{a}
Monica	At harvest	60.66±10.60^{a}	17.10±9.49^{a}	23.63±5.37^{a}
	60 days	60.34±9.97^{a}	6.51±12.87^{a}	24.90±4.21^{a}
	90 days	58.92±9.87^{a}	10.02±12.91^{a}	24.30±3.99^{a}
	120 days	57.87±9.42^{a}	8.44±11.91^{a}	23.30±4.17^{a}
Packham's Triumph	At harvest	55.65±1.40^{a}	1.85±3.13^{a}	27.11±1.77^{a}
	60 days	61.61±4.02^{a}	-14.74±46.85^{a}	28.37±2.64^{a}
	90 days	56.59±8.54^{a}	2.35±2.15^{a}	25.90±4.88^{a}
	120 days	-		
P20R41P30	At harvest	56.89±1.97^{a}	2.19±2.09^{a}	27.41±1.84^{a}
	60 days	61.61±6.02^{a}	2.27±2.21^{a}	25.46±1.53^{b}
	90 days	59.64±5.98^{a}	2.97±2.48^{a}	25.03±1.87^{b}
	120 days	-		
R39P51x Paramis	At harvest	43.52±5.04^{a}	4.56±7.84^{b}	18.14±3.29^{a}
	60 days	49.15±8.13^{a}	10.88±6.73^{ab}	22.86±5.38^{a}
	90 days	48.02±9.30^{a}	14.28±8.76^{a}	21.51±5.41^{a}
	120 days	48.11±8.25^{a}	13.0±10.72^{ab}	21.03±4.99^{a}
SP06C2P5	At harvest	51.49±2.33^{a}	-4.18±2.06^{b}	24.62±0.85^{a}
	60 days	51.15±1.51^{a}	8.07±2.00^{a}	24.80±1.09^{a}
	90 days	48.06±3.44^{b}	9.56±1.62^{a}	22.74±2.59^{b}
	120 days	-		
Socrovisce	At harvest	46.74±1.90^{b}	2.60±1.37^{b}	22.20±1.40^{b}
	60 days	51.58±3.02^{a}	3.46±2.08^{b}	23.88±1.12^{a}
	90 days	51.82±2.44^{a}	4.37±2.03^{b}	24.73±1.11^{a}
	120 days	50.85±1.49^{a}	7.39±2.37^{a}	23.60±1.54^{a}

*Duncan test. Mean values with the same letter do not present significant differences ($p \leq 0.05$) (n=3).

TA and pH

pH indicates the acidity or alkalinity of a sample and is a crucial measure for evaluating the quality and ripeness of fruits, including pears (Taghinezhad et al., 2023). It is a quick and simple method used to highlight the level of organic acids in fruits or vegetables. Fruit acidity followed a linear downward trend throughout the storage period. In general, fruit acidity tends to decrease with ripening while a concomitant increase in sugar content occurs and may be due primarily to the use of organic acids in respiration (Raffo et al., 2002; Yaman & Bayoindirli, 2002). During storage, fruits could utilize acids and therefore organic acid content decreases with prolonged storage (Bhattarai & Gautam, 2006). In the Figure 2 a regression of the TA expressed as malic acid is observed in all analysed genotypes influenced by the storage time at the temperature of 4°C and 75% humidity. The content of organic acids in the fruits varied from 0.10% (`Isadora` at 120 days and `Packham's Triumph` at 90 days) and 0.73% (`Romcor` and `Socrovisce` at harvest). In the `Romcor` variety, a massive decrease in the content of organic acids can be observed up to 90 days (0.83%).

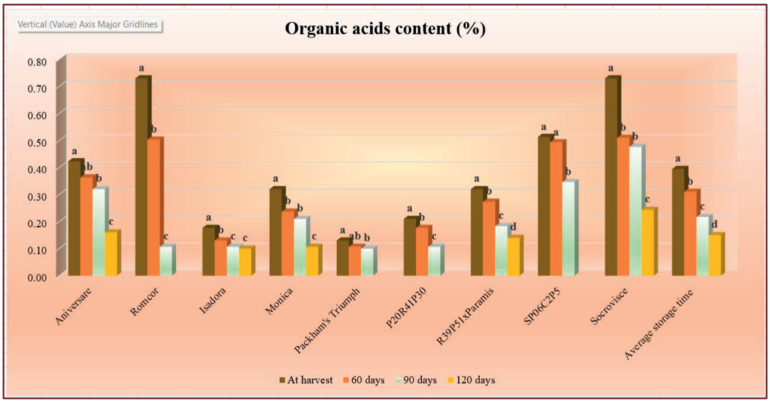

Figure 2. The influence of the storage period on the content of organic acids (%) in pears according to the genotypes (n=3)

TSS

Sugars and organic acids in fruits are substrates that are consumed in fruit respiration during storage (Yaman & Bayoindirli, 2002) by reducing into pyruvic acid, citric acid (Öztürk & Ağlar, 2019). Thus, the change in TSS level is a natural phenomenon encountered during fruit ripening and is correlated with hydrolytic changes in starch content during ripening and storage (Nandane et al., 2017). Previous research has shown that in pears, at the time of harvest, sorbitol was the dominant sugar, followed by fructose, glucose and sucrose. After two months of storage, fructose was dominant, followed by glucose, sorbitol and sucrose. During 2023-2024, stored pears showed an increase in TSS to a maximum value followed by a sharp decrease at the end of shelf life (Figure 3). At genotype \`R39P51xParamis\` a sudden drop in TSS is observed in the last 30 days from 17.17% Brix to 12.10% Brix. Similar results were obtained by Mahajan and Dhatt (2004). The maximum TSS content was recorded at 90 days of storage for all analysed genotypes. TSS varied between 17.17% Brix (\`R39P51xParamis\` at 90 days) and 11.3% brix (at \`Monica\`, 120 days). The progression of TSS during the shelf life is considered to be dependent on respiratory behaviour at the time of collection and may be affected by the storage atmosphere and treatment during the shelf life (Brandes & Zude-Sasse, 2019).

Vitamin C content

Losses of vitamin C during storage were variable from cultivar to cultivar. Among the analysed genotypes, \`Monica\` and \`R39P51xParamis\` stood out with a higher content of ascorbic acid (30.31 mg/100 g FW and 9.80 mg/100 g FW, respectively). The vitamin C content of pears showed a gradual decreasing trend during storage in all studied genotypes. If the vitamin C content at harvest recorded the values of 10.31 mg/100 g FW in the \`Monica\` genotype at the end of the storage period, it decreased to the value of 3.46 mg/100 g FW (Figure 4). The decrease in ascorbic acid level during storage can be attributed to the oxygen released by ascorbic acid, the conversion of dehydroascorbic acid (Sumnu & Bayindirli, 1995). Higher storage temperatures may be responsible for higher oxidation resulting in higher dehydroascorbic acid content (Lee & Kader, 2000).

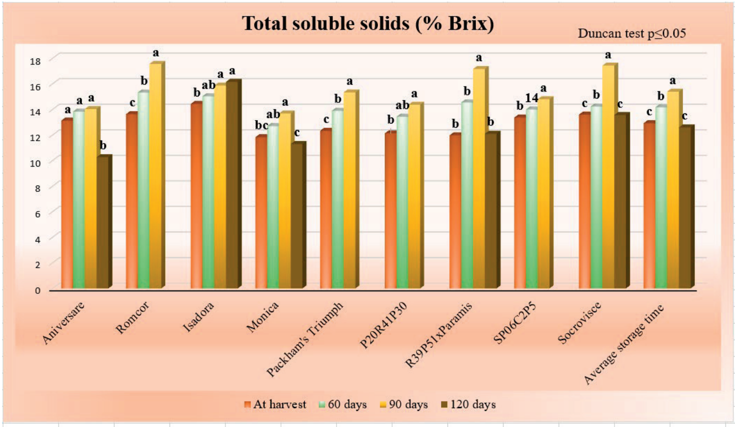

Figure 3. Influence of storage period on total soluble solids content (% Brix) of pears by cultivar (n=3)

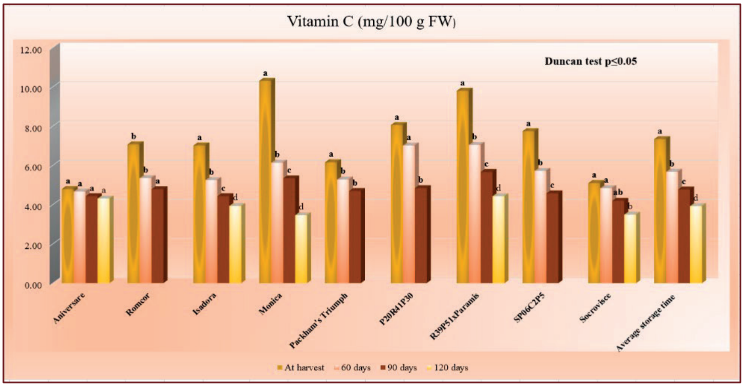

Figure 4. Influence of storage period on vitamin C content (mg/100 g FW) of pears according to cultivar (n=3)

Total polyphenol content (TPH)

The initial content of polyphenolic compounds in pear juice was significantly influenced by the genetic background of the cultivar. From figure 5 it can be seen that the `Isadora` and `Monica` pear varieties had a content of polyphenolic compounds significantly higher than the other varieties (3894.20 mg GAE/kg FW, 3818.84 mg GAE/kg FW respectively). Compared to the two cultivars used as control (`Packham's Triumph` and `Socrovisce`), only the genotypes `P20R41P30` and `SP06C2P5` were characterized by a lower content polyphenolic. Although the fruits of `Romcor` cultivar deteriorated the fastest in terms of quality, the content of total polyphenols obtained after 90 days of storage was significantly lower in genotypes `SP06C2P5` (720.29 mg GAE/kg FW) and `P20R41P30` (1010.15 mg GAE/kg FW) compared to `Romcor` (1710.14 mg GAE/kg FW). At the end of the shelf life of the fruit, the total polyphenol content drops sharply. The data are consistent with those in the specialized literature (Arzani et al., 2008).

Following the tests performed on the fruit quality indicators of the nine pear genotypes during the storage period (Table 2), the existence of positive or negative, statistically significant correlations between most of the compounds studied was found (Table 3).

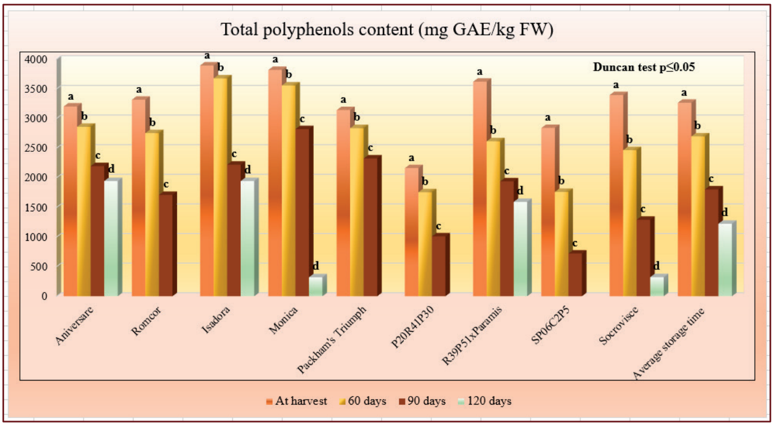

Figure 5. Influence of storage period on total polyphenols content (mg GAE/kg FW) of pears according to cultivar (n=3)

The results obtained indicated a significant negative linear interdependence between fruit weight and weight loss (r=0.330), between fruit weight and firmness (r=0.161). The relationship between fruit weight loss and TSS is negative, distinctly significant (r=-0.471). There was also a distinctly significant negative correlation between fruit pH and polyphenol content (r=-0.315) and a positive linear interdependence between water content and total polyphenols (r=0.313).

Table 3. Correlation between the values of the quality indicators studied in the fruits of the `Isadora`, `Romcor`, `Monica`, `Aniversare`, `P20R41P30`, `R39P51xParamis`, `SP06C2P5` `Packham's Triumph` and `Socrovisce` pear cultivars during the storage period

	Weight (g)	*Weight loss (%)*	*Firmness (HPE units)*	TSS (%Brix)	pH	TA (%)	Water (%)	Dry matter (%)	Vitamin C (mg/100 g FW)	*Total polyphenols (mg GAE/kg FW)*	L	a	b
Weight (g)	1												
Weight loss (%)	-0,330*	1											
Firmness (HPE units)	0,161*	0,196	1										
TSS (%Brix)	-0,088	-0,471*	-0,326**	1									
pH	-0,158	-0,321	-0,177	0,116	1								
TA (%)	-0,220*	0,054	0,158	-0,015	-0,715**	1							
Water (%)	-0,222*	-0,122	0,132	-0,175	-0,286**	0,460**	1						
Dry matter (%)	0,222*	0,122	-0,132	0,175	0,286**	-0,460**	-1,000**	1					
Vitamin C (mg/100 g FW)	0,054	-0,004	0,308**	-0,336**	-0,144	0,182	0,473**	-0,473**	1				
Total polyphenols (mg GAE/kg FW)	0,313**	-0,148	0,378**	-0,160	-0,315**	0,261*	0,503**	-0,503**	0,581**	1			
L	0,189*	-0,283	-0,091	0,122	0,434**	-0,362**	-0,241*	0,241*	-0,156	0,014	1		
A	0,052	0,335*	0,039	-0,103	-0,083	0,021	-0,107	0,107	0,101	-0,133	-0,387**	1	
B	0,094	-0,269	-0,162**	0,194*	0,313**	-0,264**	-0,254*	0,254*	-0,247*	0,017	0,872**	-0,458**	1

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

A positive linear relationship was obtained between water content and vitamin C or total polyphenols (r=-0.473, respectively r=0.503). TA content correlates negatively, distinctly significantly with total dry matter (r=-0.460). The relationship between the pH of the fruits and the acid content is negative, of very high intensity (r=-0.715).

CONCLUSIONS

After 60 days of keeping pears at 4°C and 70% humidity, the quality parameters of fruit indicate a downward trend that is maintained up to 90 and 120 days, respectively. The obtained results were significantly influenced by the genetic characteristics and the time of storage.

At the end of the shelf life of the fruit, the total sugar and polyphenol content drops sharply.

Among the studied genotypes, 'Romcor' collapsed in the range of 60-90 days of storage (fruit firmness after 90 days reached the value of 31.12 HPE units). Under these storage conditions, the genotypes 'Isadora', 'Aniversare' and 'R39P51xParamis' kept the best (up to 120 days).

Prolonged storage of pears at a temperature of 4°C significantly reduces the biochemical quality of the fruits. This storage method is indicated for a maximum period of 60-90 days depending on the genotype.

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