

THE INFLUENCE OF THE STORAGE INTERVAL ON QUALITY OF THE APPLE STORED UNDER CONTROLLED STORAGE CONDITION

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Abstract

Apples, fruits that are characterized by taste qualities, nutritional, prophylactic and therapeutic value can be consumed in fresh condition for a long time when are stored under suitable conditions. Thus, it was aimed to identify the main organoleptic and physico-chemical changes on the apples preserved within the *Cerasus Grup* Cotnari deposit by collecting samples represented by six apples varieties (*Golden Reinders*, *Golden Delicious*, *Gala*, *Jonared*, *Idared* și *Braeburn*) in two different intervals, respectively: November 2018 and January 2019. In terms of weight losses, it was noted that these ranged between the minimum value of 5,8% for *Gala* variety and maximum of 15% for *Golden Reinders* variety. The value of the firmness decreases, the differences between the two collecting samples periods being between 0,7 kgF/cm² (for *Jonared* variety) and a significant difference of 1,9 kgF/cm² for *Braeburn* variety. Compared to the reference values that indicate an adequate storage at the values of firmness between 5 to 7 kgF/cm², it evidences indicates the urgency of the removal of the *Braeburn* variety from storage to marketing, which has a firmness value of 5,7 kgF/cm² in January. The pH values were within the reference limits between 3,6 – 5 in both quality control intervals. There was a slight decrease on the pH values for all the varieties analyzed, an aspect closely correlated with the increase of the percentage of sugars by a 1% as a result of the hydrolysis of the starch and its transformation into reducing carbohydrates during storage compared with the values obtain for the sampling from November. The results obtain for the vitamin C content for samples collected in November indicate a fall in the reference values (7 – 12 mg/100 g) for all varieties analyzed excepting the *Golden Reinders* variety which is lower (5,28 mg/100 g). Most varieties evidence a decrease on vitamin C content by 2 mg/100 g in January, excepting the *Golden Reinders* and *Gala* varieties, who maintain their values constant. The results of the organoleptic and phytosanitary evaluation, pH values, iodine tests well as weight losses and firmness values have shown a major importance during the valorification of the stored fruits because they can indicate exactly the optimal moment for marketing in terms of economic efficiency. drafted in English (10-15 rows, with special reference to research results).

Key words: apple quality, controlled storage condition, vitamin C

The group of *Pomaceae*, which also includes the apple, has a good storage capacity compared to the other categories of fruits such as the groups of the *Drupaceus* or the one of fruit bushes (Murariu O. *et al*, 2014; 2017). Their resistance to long term storage is justified by the genetic attribute presented by *Malus domestica* species as well as by the structural, textural, chemical properties and the intensity of physiological process (Murariu O. *et al*, 2018). The *Malus domestica* species has the ability to ripe inclusively after harvesting, which creates the possibility to harvest the fruits designed for longer storage period before reaching the stage of consumption maturation, with maturing during storage. In the literature it is mentioned that the storage life of the different varieties of apples differs according to the difference of the amount of

starch that is present in pericarp and mesocarp and also by the storage temperature, which when is optimal increases the storage period (Jamba A. *et al*, 2002, Goncearov *et al*, 2004).

The research results indicate that the influence of ecological factors (temperature, atmospheric precipitation, geographical location of orchards) can contribute to a normal development, an improvement of chemical properties, an increased resistance to diseases during the post – harvest period, and at the same time can improve the quality of the product and the storage capacity of apples (Sumedrea *et al*, 2018), provided that all parameters are observed and monitored (Petcu *et al*, 2007). It has been founded that the autumn – winter apples varieties harvested from the southern part of the country accumulate a higher amount of dry matter and sugars compared to the fruits

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harvested from the orchards located in the northern part where the climatic condition (atmospheric precipitation and air temperature) are more satisfying for fruit growth and development, their resistance to physiological disorders and storage diseases. Also a major factor is the weather conditions of the last weeks until harvest. Thus, in the geographical areas where the temperature during the harvest period reaches below 5°C, it increases the possibility of affecting the fruits of the “cold diseases” during the storage period, and the fruits obtained in the high temperature areas increase the possibility of their attack on the scald.

Jamba A *et al.*, (2002) recommends the immersing of the apples harvested in 4% calcium chloride solution, followed by drying and storage in order to provide protection against parasitic diseases. Also, another important factor in the protection of the *Pomacee* is the application of the latest fungicide treatments to combat the diseases caused by the fungi that develop during the period of keeping the fruits fresh. The practice shows that fruits treated with Merpan (50%; 80%), Delan (70%); Ditan (40M) at the end of July or the beginning of the august had a good resistance in storage conditions. Also, it should be noted that in case that some fruits present blows, attack of pests, physiological disorders or diseases are not stored. Also, it should be noted that all diseases can be stopped by a higher CO₂ concentration, low of O₂ which leads to the storage of fruits in controlled (AC) or modified atmosphere (AM) (Petcu *et al.*, 2014). In order to ensure the need of fresh fruits of consumers, regardless of the season, it is resorted to keeping them under specific conditions.

The main purpose of the current research consists in highlighting the conditions of storage in normal atmosphere (3...4°C, Ur = 90 – 95%) on the different varieties of apples stored within the fruit stored at SC Cerasus Group SRL.

MATERIAL AND METHODS

The objectives of this study consisted in the evaluation of the physico – chemical and phytosanitary characteristics of some varieties of apple kept in the storage with normal atmosphere after one month, respectively 4 months of storage. Thus, there were made the following determinations: - evaluation of physical properties (average weight, diameter and firmness); - evaluation of some chemical constituents (total dry matter content – SUT; H₂O; soluble dry matter SUS (sugars); vitamin C; malic acid content (g/100 g – titrable acidity); pH – value and determination of gluco – acidimeters index.

The biological material was represented by six varieties of apples (*Golden Reinders*, *Golden*

Delicious, *Gala*, *Jonared*, *Idared* și *Braeburn*) harvested from the orchards of Cotnari area, Iasi county, which were kept in the storage of Cerasus Group from Cotnari, Iași.

This deposit was set up by a local producer, being provided with six cells (5 for storage and one for shipping, a conditioning – sorting – packing room, with a storage capacity of 820 tons for apples and 150 – 180 tons of cherries) having as object of activity the commercialization of fruits.

The samples were collected from storage containers by quarters method from the batches of apples that were harvested during the august – september period of 2018 year.

The working methodology complied with the actual standard. The determination of the average weight consisted of weighing the entire sample and the value resulted being divided by the total number of products that make up the sample.

The diameter was determined by measuring the diameter in the equatorial area of the fruits.

The pH value was determined by using the pre-calibrated *Hanna Instruments*.

The content in SUT and H₂O was determined by the classic drying method in the oven and the vitamin C content was determined by extracting it with oxalic acid 2% and volumetric titration with 2,6 – *dichlorophenolindophenol*.

The titrable acidity was determined by titration with 0,1N NaOH in the presence of *phenolphthalein*, the results being expressed in g malic acid/ 100 g produce.

The soluble dry matter was determined on the juice extracted from the samples using the hand press and the refractive index readed was expressed as a percentage of sucrose with the Zeiss refractometer.

The gluco – acidimetric ratio was calculated by dividing the SUS value content to the acidity value.

The phyto-sanitary evaluation consisted in the direct observation of the external appearance, of the integrity of the pericarp and mesocarp, on the presence of physiological disorders and diseases by direct comparison with the descriptive sketch.

RESULTS AND DISCUSSIONS

The average weight values, diameter, firmness and pH-values for all varieties analyzed highlight low values in January vs. November.

The size of the apple fruit is assessed by two different parameters, such as weight and diameter. These indicators are important in order to establish the optimal period of harvest, the mode of transport, the storage period and the type of packaging.

The average weight of the 6 varieties analyzed in November showed values that fell within the delimited range of variation lower of

176 g (for the *Braeburn* variety) and higher of 279,8 g for the *Jonared* variety.

Depending on the specific weight, apples are grouped as follows: large fruits 180 – 220 g (*Golden Reinders*, *Golden Delicious* in november, *Gala*, *Jonagored*, *Idared*), medium to large fruits 170 – 190 g (*Braeburn* in January) and medium fruits 130 – 160 g (*Golden Delicious* in January, *Braeburn* in January). The values obtained were correlated with the data from the literature and it was observed that only some varieties, such as *Braeburn* fall within the limits of standard values; and in this case of *Gala* and *Jonagored* varieties, surplus values were registered, compared to the standard values. In the case of *Golden delicious* variety, the reduced weight (161 g) can be determined by the poor management system of fruit crops, as well as by non – compliance with the optimal storage parameters (*Table 1*).

The values obtained in January for the average weight ranged between the minimum limit of 155.3 g (*Braeburn* variety) and the maximum limit of 254,2 g (*Jonagored*). The resulting weight losses between the two different analysis intervals ranged from a minimum of 6% for the *Gala* variety to a maximum of 12; 12,3 and 15% for *Braeburn*, *Golden Delicious* and *Golden Reiders* varieties.

In *table 1* is presented the diameters of the apples varieties investigated in the two intervals of storage, with values between 65 mm for *Braeburn*

variety and 84 mm for the *Idared* variety. All varieties analyzed correspond to the calibration requirements (minimum 60 mm) (*table 1*).

Weight and diameter losses, respectively, may be due to metabolic processes during storage.

The firmness value decreases, the differences between the two harvesting periods being between 0.7 kgF/ cm² (*Jonared*) and a significant difference of 1.9 kgF/ cm² for *Braeburn*. Compared to the reference values that highlight an appropriate retention for firmness values between 5 – 7 kgF/ cm², it is imperative to expedite the removal from the storage the *Braeburn* variety, which has a firm value of 5.7 kgF/ cm² in January. Therefore, analyzing the results of the apples firmness, it is found that in both intervals of analysis the apples were still suitable for storage and transport, with the exception of the *Idared* variety (in January) which have to be given for consumption or processing.

The acidity provides information on the degree of ripeness and quality of the fruit.

The pH values were within the reference limits between 3.6 to 5 in both quality control intervals. There is a slight decrease in pH for all varieties analyzed, which is closely correlated with an increase in the percentage of sugars of 1% due to the hydrolysis of the starch and its transformation into reducing carbohydrates during storage compared to the values obtained in November.

Table1

Results regarding the physical parameters of apples varieties during storage analysed in November and January

Varieties	Average weight (g)		Horizontal fruit Diameter (mm)		Firmness (kgF/ cm ²)		pH value	
	N	I	N	I	N	I	N	I
<i>Golden Reinders</i>	224.4	190.2	76	69	7.8	6.7	3.9	3.9
<i>Golden Delicious</i>	183.4	161	72	65	7.1	5.6	4.3	4.2
<i>Gala</i>	210.8	198.4	77	74	7.3	6.2	4.29	4.18
<i>Jonagored</i>	279.8	254.2	82	78	7.1	6.5	4.6	3.9
<i>Idared</i>	242	219.5	84	72	6.4	4.8	3.8	3.6
<i>Braeburn</i>	176	155.3	70	65	7.5	5.7	3.9	3.8

The titrable acidity provides information of the freshness, ripeness and health of the fruit. The indicator may be in surplus during the leverage period and deficient at oversaturation.

The titrable acidity varies between the minimum limit of 0.4 g malic acid/ 100 g apple for the *Golden Reiders*, *Golden Delicious* and *Gala* varieties in January and the maximum 0.8 g malic acid/ 100 g for the *Idared* variety in november. All the results obtained fall within the limits of the

reference values established by the literature (0.27 – 1.02 malic acid/ 100 g apple) (*table 2*).

The titrable acidity values recorded in January are lower compared to the results obtained in november. This decrease in acidity may be due to the early harvest of the fruit, as well as to the unsuitable atmospheric composition, the high storage temperature and the long shel life.

The vitamin C content varies depending on the variety and the way that products are harness; fresh fruits having a maximum content in vitamin

C at harvest (Irimia L., 2013; Murariu O.C. *et al* 2014; 2017; 2018). The results obtained for the vitamin C content in November indicate a fit in the reference values (2 – 10 mg/ 100 g)(Davey *et al*, 2000) for all varieties analyzed except the Golden Reiders variety which is lower (5.28 mg/ 100 g).

Most varieties show a decrease in vitamin C content of 2 mg/ 100 g in January, with the exception of *Golden Reiders* variety which keep their values constant losses that may be due to the long storage period and the evolution of the maturation process (table 2)..

Tabelul 2

Results regarding the chemical characteristics apples varieties during storage analysed in November and January

Varieties	Vitamin C (mg/100 g)		Titrable acidity (g malic acid/ 100 g)		Soluble dry matter (%)		Gluco – acidimetric index		Total dry matter (%)	
	N	I	N	I	N	I	N	I	N	I
<i>Golden Reinders</i>	5.6	5.3	0.6	0.4	12.0	12.8	20.0	32.0	13.4	15.2
<i>Golden Delicious</i>	7.0	5.4	0.5	0.4	13.4	14.2	26.8	35.5	11.6	13.4
<i>Gala</i>	7.1	7.0	0.5	0.4	10.5	12.8	21.0	32.0	13.4	13.6
<i>Jonagored</i>	7.1	5.3	0.7	0.6	12.4	13	17.7	21.6	13.1	13.7
<i>Idared</i>	7.0	5.5	0.8	0.7	11.6	12.4	14.5	17.7	15.0	15.4
<i>Braeburn</i>	8.8	7.0	0.7	0.6	11.0	12.2	15.7	20.3	12.8	13.1

Table3

Results regarding the quality and disease presence of apples varieties during storage analysed in November and January

Varieties	Storage period	Extra	Cal I	Cal II	<i>Venturia inequalis</i>	<i>Monilinia fructigena</i>	<i>Botrytis cinerea</i>	<i>Alternaria</i>	Bitter stain	Internal crash	Pericarpal defects
<i>Golden Reinders</i>	N	97.5	-	-	-	-	-	-	-	-	P
	I	96.8	-	-	-	-	-	-	-	-	P
<i>Golden Delicious</i>	N	-	87.3	-	-	-	-	-	-	-	-
	I	-	87	-	-	-	-	-	-	p	-
<i>Gala</i>	N	-	88.9	-	-	-	-	-	-	-	-
	I	-	89.7	-	-	-	-	-	p	-	-
<i>Jonagored</i>	N	98	-	-	-	-	-	-	-	-	-
	I	97.2	-	-	-	-	-	-	-	-	p
<i>Idared</i>	N	90.7	-	-	-	-	-	-	-	-	-
	I	91.7	-	-	-	-	-	-	-	-	-
<i>Braeburn</i>	N		86.4	-	-	-	p	-	-	-	-
	I		88.2	-	-	-	-	-	-	-	-

Literature indicates that the dynamically controlled atmosphere maintains the post-harvest quality of apple by reducing the rate of respiration and ethylene production. The physiological disorders produced by ethylene, such as scalding, are completely suppressed. Also, the resistance and color of apple are higher due to storage in the controlled atmosphere. In conclusion, the controlled atmosphere maintains the physico – chemical and organoleptic quality of apples, but the high concentration of CO₂ and low concentration of O₂ causes damage to the fruit.

Soluble dry matter content is most higher with the degree of ripening of the apples is more advanced. In table 2 it is showed the results obtained in the two periods on the soluble dry matter content. The analyzed varieties registered values between 10.5% for *Gala* variety in November and 14.2 for *Golden delicious* in January. All values obtained for soluble dry matter was higher in January. The increase of soluble dry matter content is due to the ripening of the fruit. During the ripening process the sugar content increases and the taste of apple was sweeter.

Apples are in optimal taste balance and can be eaten fresh at a certain value of soluble dry

matter/ acidity ratio. The value of the index is characteristic of each astringent, sweet and sour variety (table 2). The gluco – acidimetric index values show values between the minimum of 14,5 (*Idared* in november) and the maximum of 35.5 (*Golden delicious* in January). This values indicate that apples have a sweet taste. It should be noted that the results recorded in January are higher compared to those recorded in November, due to the maturation process which is characterized by increased sugar content and decreased acidity.

In table 2 are presented the values of total dry matter obtained for the samples analyzed in November and January. The total dry matter content varied between the minimum of 11.6% for the *Golden delicious* in November and the maximum of 15.4% for *Idared* in January. It is observed that almost all the values obtained in November and January respectively are lower than the reference value (15%) (Moțoc D. *et al*, 1971) excepting the *Golden Reiders* variety and the *Idared* variety in both ranges which showed values close to the reference values.

The results regarding the disease presence on apples was followed by visual examination of the apples, which consisted of direct observation of the integrity of the pulp, the external appearance. The presence of gray rot (*Botrytis cinerea*), stings caused by various insects, internal crash and post – harvested physiological disorders were observed (table 3). Consequently, after the visual assessment, the presence of gray rot (*Botrytis cinerea*) in the *Braeburn* variety in November, physiological disorders, namely, bitter spot in the *Gala* variety in January, stings in the varieties *Golden Reinders* (samples from November and January) and *Jonagored* (in January).

Depending on the total score of organoleptic evaluation, the apples are classified by quality, as follows: Extra quality: 90 – 100 points; First quality: 65 – 90 points; Second quality: 31 – 65 points and Lower quality: less than 30 points.

In the case of the organoleptic examination carried out in November, the total score varies between 86.4 points for the *Braeburn* variety and 98 points for the *Jonagored* variety and in January the score varies between 87 points for the *Golden delicious* variety and 97.2 points for the *Jonagored* variety. Analyzing the obtained results, it is observed that the *Jonagored* variety registered the highest score, both in November (98 points) and in January (97.2 points).

CONCLUSIONS

Consequently, apples provide a convenient matrix through which nutrients and other health –

related food components can be provided to humans. Apples are a good source of vitamin C.

Results indicates that the normal atmosphere with controlled condition from deposit maintains the post – harvest quality of apples by reducing the rate of respiration and ethylene production. The physiological disorders produced by ethylene, such as scalding, are completely suppressed. Also, the resistance and color of apple are higher due to storage in the controlled conditions.

In conclusion, the controlled conditions maintain the physico – chemical and organoleptic quality of apples, but the high concentration of CO₂ and low concentration of O₂ causes damage to the fruits. Thus, further research is needed to improve the technology of the dynamically controlled atmosphere, to minimize the level of CO₂ and O₂, as well as the injuries produced during long – term storage.

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REFERENCES

- Davey M.W., Montagu M., Inze D., Sanmartin M., Kanellis A., Smirnof N., Benzie J., Strain J., Favell D., Fletcher J., 2000 – *Plant L – ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing*, Journal of the Science of Food and Agriculture, 80:825 – 860.
- Goncearov M., Petcu C., Antoniu S., 2004 - *Hazard analysis critical control points - a modern concept regarding food quality and safety*, Scientific Papers: Veterinary Medicine, Timișoara, 37:868-872.
- Irimia L.M., 2013 - *Cotrolul și expertiza calității legumelor, fructelor și produselor derivate*, Ed. I.I. de la Brad lași.
- Jamba A., Carabulea B., 2002 – *Tehnologia păstrării și industrializării produselor horticole*, Editura Cartea Moldovei, Chișinău.
- Moțoc Dumitru, Dimitriu M., 1971 – *Biochimia produselor alimentare*, Ed. Didactică și Pedagogică București.
- Murariu O.C., Irimia L.M., Robu T., 2017- *Analiza și controlul calității produselor din fructe și legume – Îndrumător de lucrări practice*, Ed. I.I. de la Brad lași.
- Murariu O.C., Irimia L.M., Robu T., Murariu F., Arsenoia V., 2018 – *The influence of storage condition on some bioactive compounds of berrie fruits and those human health promoting*, Lucrări Științifice.Seria Horticultură, 61 (2):222 – 228.
- Murariu O.C., Irimia L.M., Robu T., 2017- *Analiza și controlul calității produselor din fructe și legume – Îndrumător de lucrări practice*, Ed. I.I. de la Brad lași.

- Murariu O.C., Ișan E., Robu T., Irimia L.M., Ratu R.N., Murariu F.**, 2018 – *Evaluation of the presence of pesticides residues and its metabolites from raw materials used as sources for ensuring a healthy nutrition for athletes*, Proceeding of ICU, 185 – 191.
- Murariu O.C., Irimia L.M., Anghel R., Murariu F.**, 2014 – *Research on the apples quality marked in the Moldova area from the physico – chemical and sensorial point of view*, *Lucrări Științifice. Seria Horticultură*, 57(1):195 – 198.
- Petcu C.D., Savu C., Mitrănescu E., Chirilă S.**, 2007 - *The implementation of the integrated quality and food safety management system in the food industry units*, *Lucrări Științifice Medicină Veterinară, Timișoara*, vol. XL, pg. 545-51.
- Petcu C.D., Șulea C., Dumitrache M.**, 2014 - *Audit of Producers/Users of Compressed Air and other Industrial Gases used in the Food Industry*, *Quality-Access to Success*, 15 (130).
- Ranganna S.**, 2008 – *Handbook of analysis and quality control of fruits and vegetable products*, by Tata Mcgraw – Hill Publishing.
- Sumedrea D., Florea A., Sumedrea A., Asănică A., Coman R., Militaru M., Chițu E., Butac F., Marin FC., Calinescu M.**, 2018 – *Influence of different storage methods on apples chemical properties*, *Agriculture for Life – Life for Agriculture*, Bucharest, 1(1):316-321.