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THE INFLUENCE OF STORAGE CONDITIONS UPON ASCORBIC ACID CONTENT IN JONATHAN AND GOLDEN APPLES

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Abstract: *In this work it has searched the influence of storage conditions upon ascorbic acid content, in Jonathan and Golden apples. The study of ascorbic acid content and pH evolutin for 16 weeks has been carried out using, as biological material, apple samples from Jonathan and Golden varieties, coming from the orchards in the area of Fălticeni. The apples were kept in containers of glass and wood, constituting, for each sample, variants of experiences, in the presence and in the absence of oxygen, at following thermal thresholds: 4°C, 8°C and 15°C. In order to keep the apples in the presence of oxygen, they were placed in wooden boxes. To store apples in an oxygen-free environment, it used glass containers where the fruits were introduced along with a small candle lit, and then the lid of the container was tightly closed. The extinguish of the candle has confirmed that the oxygen in the container was used. The chemical investigations have been carried out on freshly harvested material (week 0) and then every two weeks, for a total of 16 weeks. At the end of the analysed interval (after 16 weeks of storage), the ascorbic acid content has registered different rates of diminution, depending on storage temperature and length, as well as on variety (sucrose concentration and pH). The lower degradation of ascorbic acid in apples from Golden variety, during storage, is due both to higher sucrose content of those ones, and to higher pH values compared to apples from Jonathan variety.*

Keywords: ascorbic acid, apples, oxygen, pH, storage, temperature.

1. Introduction

The industrial processing and cooking of food raw materials such as: cutting, grinding, blanching, scalding, boiling, addition of chemicals etc. can negatively influence the quality of these products, resulting in significant loss of hydro- and fat-soluble vitamins [1, 2, 3, 4, 5, 6].
The addition of anthocians, sugars and even starch seems to have a protecting action on vitamin C [6].
The drying methods, exposing the food to air, lead to the loss of vitamin C because of oxidation. But, the freeze drying, which is carried out in the absence of oxygen, does not cause loss of vitamin C [7].
The storage conditions can also influence the level of some raw material vitamines causing, sometimes, significant decrease in the concentration of these biocatalysers within finished product [6].
In some juices the ascorbic acid degradation is predominantly aerobic (due to the presence of dissolved oxygen), but in absence of oxygen the ascorbic acid decomposition continues anaerobicaly, being especially influenced by temperature [8]. The loss of acid ascorbic is fast in the early stage of fruits juice storage, coincident with the consumption of dissolved oxygen, and then becomes gradual [7].
In the case of ascorbic acid (vit. C) the reduction of this vitamine in vegetable products is caused by the presence and activity of ascorbic oxydase enzyme, which has a large spread in plants, catalysing the oxidation of ascorbic acid to dehydroascorbic acid [9].
The mean storage length of fruits, in modern conditions, may be: days in strawberries and

cherries, 1-2 weeks in blueberries, currants, up to a month at apricots, watermelons, melons, peaches, up to 1-2 months at plums, 3-4 months at quince, up to 5-6 months at pears, 3-8 months at apples, 8-13 months at nuts in shell [10].
In this work it has studied the influence of temperature and oxygen upon ascorbic acid content of some apple samples, belonging to Jonathan and Golden varieties, stored for 16 weeks.

2. Experimental

The research has been carried out using, as biological material, apples from Jonathan and Golden varieties, coming from the orchards in the area of Fălticeni. It has studied the evolution of ascorbic acid content and pH for 16 weeks. The apples were kept in containers of glass and wood, constituting, for each sample, variants of experiences, in the presence and in the absence of oxygen, at following thermal thresholds: 4°C, 8°C and 15°C.
In order to keep the apples in the presence of oxygen, they were placed in wooden boxes.
To store apples in an oxygen-free environment, it used glass containers where the fruits were introduced along with a small candle lit, and then the lid of the container was tightly closed. The extinguish of the candle has confirmed that the oxygen in the container was used.
The chemical investigations have been carried out on freshly harvested material (week 0) and then every two weeks, for a total of 16 weeks.
The ascorbic acid content of apples was determined through a method based on reduction by the ascorbic acid of 2.6-Dichlorphenol-indophenol (2.6-DCFIF) to the corresponding leucoderivate [11].
The dosing of sucrose in apples was based on evaluation of reducing sugars before and after inverting [12]. The pH values were determined with a digital pH-meter type Hanna.

3. Results and discussion

Table 1 plays the acid ascorbic values of Jonathan apples during storage of samples under certain conditions.

Table 1
Ascorbic acid values in apples from Jonathan variety

Determination	**Ascorbic acid (mg/100g)**					
Storage temperature	**T=4°C**		**T=8°C**		**T=15°C**	
Test variants	**+O_2 ***	**–O_2****	**+O_2**	**–O_2**	**+O_2**	**–O_2**
Week 0	11.08					
Week II	9.90	11.08	9.90	9.90	8.31	7.04
Week IV	7.92	9.50	7.20	7.28	7.22	6.01
Week VI	6.33	6.41	6.17	7.20	6.01	4.03
Week VIII	6.30	5.54	5.14	5.94	5.14	3.90
Week X	5.14	4.75	3.72	5.46	4.19	3.90
Week XII	4.52	4.56	3.16	4.03	4.03	3.72
Week XIV	3.16	3.32	3.18	3.70	3.29	3.30
Week XVI	2.29	2.61	1.98	2.05	1.48	1.80

+O_2 * = storage in the presence of oxygen**; –O_2** =** storage in the absence of oxygen

As seen in the table 1, at temperature of 4°C in the presence of oxygen, the ascorbic acid content in apples of Jonathan variety has recorded different discounts, depending on the length of storage.

Thus, the greatest reductions of acid ascorbic concentration were registered in the ranges II-IV and IV-VI (20%), followed by ranges X-XII and VIII-X (12-18.4%).

At the same temperature of storage, but in the absence of oxygen, the greatest reduction in the content of ascorbic acid was in the range IV-VI weeks (32.5%), followed by range XII-XIV (27.2%).

At the end of the analysed interval (after 16 weeks of storage) the ascorbic acid content has decreased by 79.3%, compared to the blank (week 0), in apples stored at 4°C in the presence of oxygen, and by 76.4%, compared to blank, in apples kept at the same temperature, but in the absence of oxygen.

At temperature of 8°C, in the presence of oxygen, the largest reduction of ascorbic acid content was within the range XIV-XVI weeks (37.73%), followed by ranges II-IV and VIII-X weeks (27.2%).

At temperature of 8°C, but in the absence of oxygen, the biggest reductions of the ascorbic acid content were within the interval XIV-XVI weeks (44.6%), followed by intervals II-IV and X-XII weeks (over 26%). At the end of the analysed interval (after 16 weeks of storage) the ascorbic acid content has decreased by 82.1%, compared to the blank (week 0), in apples stored at 8°C in the presence of oxygen, and by 81.5%, compared to the blank, in apples kept, at the same temperature, but in the absence of oxygen. At temperature of 15°C, in the presence of oxygen, the greatest reduction of the ascorbic acid content was in the range XIV-XVI weeks (55%), followed, in order, by the range 0-II (25%) and the ranges XII-XIV weeks (18.36%) and II-IV weeks (13%). At the same temperature, but in the absence of oxygen, the biggest reductions in the levels of ascorbic acid content were within intervals XIV-XVI (45.45%), 0-II (36.5%) and IV-VI (33%).

At the end of the analysed interval (after 16 weeks of storage) the ascorbic acid content has decreased by 86.6%, compared to the blank (week 0), in apples stored at 15°C, in the presence of oxygen, and by 83.75%, compared to the blank, in apples kept, at the same temperature, in the absence of oxygen. Compared to week 0 (fresh sample), the pH of the Jonathan apple has recorded an increase with 13% in the 8th week and with 7% at the end of the test (after 16 weeks).

Table 2 plays the acid ascorbic values of Golden apples during storage of samples under certain conditions. As seen in the table 2, at temperature of 4°C, in the presence of oxygen, the ascorbic acid content in apples of Golden variety has recorded the largest decreases within intervals XII-XIV and XIV-XVI weeks (20.3-21.6%), followed, in order, by intervals II-IV, IV-VI and VI-VIII (12.53-14.45%). At the same temperature of storage, but in the absence of oxygen, the greatest reduction of the ascorbic acid content was in ranges IV-VI and XIV-XVI weeks (32.8-34%), followed by range XII-XIV (11.32%). At the end of the analysed interval (after 16 weeks of storage), the ascorbic acid content has decreased by 72.63%, compared to the blank (week 0), in apples stored at 4°C in the presence of oxygen, and by 68.16%, compared to the blank, in apples kept, at the same temperature, lack of oxygen. At temperature of 8°C, in the presence of oxygen, the largest reduction of ascorbic acid content was within range VIII-X weeks (30%), followed by ranges XII-XIV (26.77) and X-XII (20.75%). At temperature of 8°C, but in the absence of oxygen, the biggest reductions of the ascorbic acid content were within range XIV-XVI (29.72%), followed, in order, by ranges X-XII (22.4%), VIII-X and XII-XIV (over 20%). At the end of the analysed interval (after 16 weeks of storage), the ascorbic acid content has decreased by 76.31%, compared to the blank (week 0, in apples stored at 8°C in the presence of oxygen, and by 74.12%, compared to the blank, in apples, kept at the same temperature, but in the absence of oxygen.

At temperature of 15°C, in the presence of oxygen, the largest reduction of ascorbic acid content was within range XIV-XVI weeks (36.82%), followed by range X-XII (34.4%) and ranges XII-XIV, VIII-X and 0-II (16-19%). At the same temperature, but in the absence of oxygen, the largest decreases of ascorbic acid content were in the range X-XII (32.3%), followed by range XIV-XVI (27%), and the ranges 0-II and VIII-X (20-25%).

At the end of the analysed interval (after 16 weeks of storage), the ascorbic acid content has decreased by 82.58%, compared to the blank (week 0), in apples stored at 15°C in the presence of oxygen, and by 79.10%, compared to the blank, in apples kept, at the same temperature, in the absence of oxygen. Compared to week 0 (fresh sample), the pH of the Golden apples has recorded an increase by 7% in the weeks VIII-XII, and by 10% at the end of the test (after 16 weeks).

Table 2
Ascorbic acid values in apples from Golden variety

Determination	**Ascorbic acid (mg/100g)**					
Storage temperature	**T=4°C**		**T=8°C**		**T=15°C**	
Test variants	**+O_2**	**–O_2**	**+O_2**	**–O_2**	**+O_2**	**–O_2**
Week 0	**10.05**					
Week II	9.50	9.58	9.50	9.58	8.07	8.07
Week IV	8.31	9.42	8.23	8.57	7.52	7.99
Week VI	7.12	6.33	8.02	8.20	6.33	7.21
Week VIII	6.09	6.01	7.20	7.51	6.09	6.01
Week X	5.30	5.59	5.06	5.98	5.06	4.51
Week XII	4.40	5.30	4.01	4.64	3.32	3.05
Week XIV	3.45	4.70	3.25	3.70	2.77	2.88
Week XVI	2.75	3.10	2.38	2.60	1.75	2.10

+O_2 = storage in the presence of oxygen**; –O_2 =** storage in the absence of oxygen

The acid ascorbic content in potato tubers, stored 90 days under house cellar conditions, has decreased by over 60% in tubers stored in wooden boxes, and by 20% in tubers stored in tightly closed glass jars [13].

Comparing the data from the two tables, it notice that, under the same conditions of storage, the apples of Golden variety have recorded a lower reduction of ascorbic acid content than apples of Jonathan variety. The differences between the two varieties, as to sucrose content and pH values, could explain the difference as to ascorbic acid reduction during storage.

After 168 hours storage of some natural juices, under refrigeration conditions, the highest vitamin C losses have registered in sucrose free juice samples, and the least ones in juice samples with 10% sucrose [14, 15].

From the figure no. 1 it can remark a very closed corelation between the ascorbic acid variation (mg/100g) and the storage time. The table no. 3 renders the regression function for the variation of ascorbic acid values in apples from Jonathan and Golden variety.

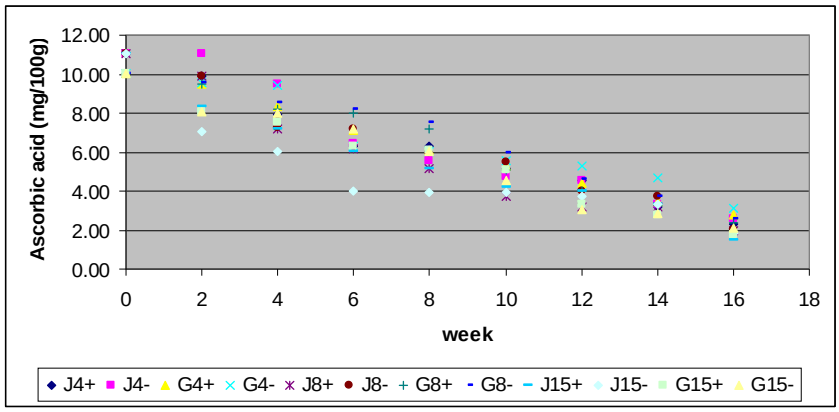

Figure 1. The variation of the ascorbic acid content in function of week storage
G = Golden variety, J = Jonathan variety
4, 8, 15 coresponds to the storage temperature of T=4°C, T=8°C, T=15°C, respectively
+ and - coresponds to the storage in the presence of oxygen ($+O_2$), respectively to the storage in the absence of oxygen ($-O_2$)

Table 3
Regression function for the variation of ascorbic acid values depending of the storage time in apples from Jonathan and Golden variety

Apples variety	Test variants, storage temperature	Regression function	R^2
Jonathan variety	$+O_2$, T=4°C	$y = -0.0022x^3 + 0.0652x^2 - 1.0435x + 11.272$	$R^2 = 0.9888$
	$-O_2$, T=4°C	$y = 0.0016x^3 - 0.0184x^2 - 0.6534x + 11.627$	$R^2 = 0.9615$
	$+O_2$, T=8°C	$y = -0.0006x^3 + 0.0426x^2 - 1.095x + 11.325$	$R^2 = 0.9873$
	$-O_2$, T=8°C	$y = -0.0026x^3 + 0.0738x^2 - 1.0732x + 11.233$	$R^2 = 0.9831$
	$+O_2$, T=15°C	y = -0.0044x3 + 0.1226x2 - 1.4334x + 11.009	$R^2 = 0.9936$
	$-O_2$, T=15°C	$y = -0.0077x^3 + 0.2224x^2 - 2.1676x + 10.98$	$R^2 = 0.9884$
Golden variety	$+O_2$, T=4°C	$y = 0.0008x^3 - 0.0147x^2 - 0.4252x + 10.171$	$R^2 = 0.9977$
	$-O_2$, T=4°C	$y = -0.0003x^3 + 0.0148x^2 - 0.5923x + 10.423$	$R^2 = 0.9302$
	$+O_2$, T=8°C	$y = 0.0019x^3 - 0.0524x^2 - 0.1178x + 9.9411$	$R^2 = 0.9861$
	$-O_2$, T=8°C	$y = 0.0008x^3 - 0.0335x^2 - 0.143x + 9.9786$	$R^2 = 0.9936$
	$+O_2$, T=15°C	$y = -0.0014x^3 + 0.0341x^2 - 0.7068x + 9.8068$	$R^2 = 0.9846$
	$-O_2$, T=15°C	$y = 0.0014x^3 - 0.0318x^2 - 0.3325x + 9.6602$	$R^2 = 0.9779$

$+O_2$ = storage in the presence of oxygen**; $-O_2$ =** storage in the absence of oxygen

According to Banu et al. (2003), the oxidation of vitamin C depends on pH values, being very fast at pH<4,5. It seems that the lower degradation of ascorbic acid in apples from Golden variety during storage is due both to higher sucrose content of those ones (4.56%), and to higher pH values (6.20-6.82), compared to apples from Jonathan variety (sucrose=2.37%, pH = 4.4-5.2), as seen in the figure no. 2.

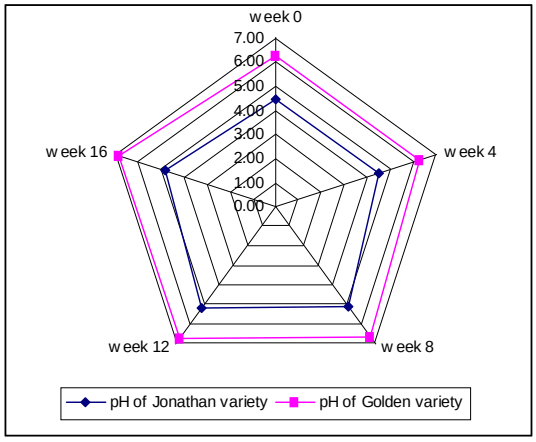

Figure 2. The variation of pH values depending of the storage time in apples from Jonathan and Golden variety

4. Conclusions

The storage of apples from Jonathan and Golden varieties, under certain conditions of temperature and aeration, has influenced the content of ascorbic acid.

At the end of the analysed interval (after 16 weeks of storage), the ascorbic acid content has registered different rates of diminution, depending on storage temperature and length, as well as on variety (sucrose concentration and pH).

In Jonathan variety samples, the greatest decrease of ascorbic acid content has registered after 16 weeks of storage at 15°C: by 86.6% (compared to the blank - week 0) in apples stored in the presence of oxygen, and by 83.75% in apples kept in the absence of oxygen.

In Golden variety samples the greatest decrease of ascorbic acid content has registered after 16 weeks of storage at 15°C: by 82.58% (compared to the blank - week 0) in apples stored in the presence of oxygen, and by 79.10% in apples kept in the absence of oxygen.

Under the same conditions of storage, the apples of Golden variety have recorded a lower reduction of ascorbic acid content than apples of Jonathan variety. It seems that the lower degradation of ascorbic acid in apples from Golden variety, during storage, is due both to higher sucrose content of those ones, and to higher pH values compared to apples from Jonathan variety.

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