THE INFLUENCE OF SOME STORAGE CONDITIONS UPON ASCORBIC ACID CONTENT IN WHITE AND RED CABBAGE

MARCEL AVRAMIUC[1*]

Keywords: ascorbic acid, cabbage, oxygen, pH, storage, temperature.
Abstract: In this work it has searched the influence of storage conditions upon ascorbic acid content in cabbage. The ascorbic acid content and pH evolution for 16 weeks has been carried out using, as biological material, cabbage samples from two varieties: white cabbage (Brassica oleracea var. capitata L. f. alba DC.) and red cabbage (Brassica oleracea var. capitata L. f. rubra (L.) Thell). The cabbage samples 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. The ascorbic acid content of cabbages was determined through a method based on reduction by the ascorbic acid of 2.6-Dichlorphenol-indophenol (2.6-DCFIF) to the corresponding leucoderivate. The investigations have been carried out on freshly harvested material (week 0) and then every two weeks, for a total of 16 weeks. Compared to fresh harvested cabbage, at the end of the analysed interval (after 16 weeks of storage), the ascorbic acid content has registered different rates of diminution in the both varieties, depending on storage temperature, on storage length, and on variety. The ascorbic acid in white cabbage has registered losses, compared to red variety, so much the bigger as the temperature was higher and the storage duration was longer.

INTRODUCTION

The risk of cancer and cardiovascular illnesses can be reduced by consumption of fruit and vegetables, rich in antioxidant compounds such as: vitamins C and E, carotenoids and phenolic compounds (Cortés et al., 2007; Block et al., 2001; Burns et al., 2003; Gardner et al., 2000; John et al., 2002; Sánchez-Moreno et al., 2003).

The storage conditions can influence the level of vitamines in some raw material causing, sometimes, significant decrease in the concentration of these biocompounds within finished product (Banu et al., 2003).

According to Ball (2006), 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.

The loss of acid ascorbic is fast in the early stage of fruits juice storage, coincides with the consumption of dissolved oxygen, and then becomes gradual (Zerdin et al., 2003; Ball, 2006).

The concentration of ascorbic acid decreases during storage, depending on storage conditions, such as temperature, oxygen content and light (Alwazeer et al, 2003; Blasco et al., 2004; Del Caro et al., 2003; . Esteve et al., 1995; Murata et al., 2002; Polydera et al., 2003; Torregrosa et al., 2006; Zerdin et al., 2003; Cortés et al., 2007).

In this paper it has studied the influence of temperature and storage length upon ascorbic acid content in white and red cabbage.

MATERIALS AND METHODS

In this paper, the biological material was represented by two types of cabbage (white and red), coming from a small vegetable farm around Suceava town, selected to meet the quality parameters necessary to storage, such as: well made, with a head weight between 0.7-1.5 kg, no damage and no attack by insects or parasites, clean, odorless and taste.

Fresh raw material was analyzed, determining the **pH** (**6.95** in **white cabbage,** and **7.15** in **red cabbage**), and the content of **ascorbic acid** (**34.7 mg %** in **white cabbage**, and **56.2 mg %** in **red cabbage**)**.**

It has studied the evolution of ascorbic acid content and pH during 16 weeks. The both cabbage types 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 samples in the presence of oxygen, they were placed in wooden boxes. To store cabbages in an oxygen-free environment, it used glass containers where the samples 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 cabbages was determined through a method based on reduction by the ascorbic acid of 2.6-Dichlorphenol-indophenol (2.6-DCFIF) to the corresponding leucoderivate (Artenie and Tănase, 1980; Indyk and Konings, 2000).

The pH values were determined with a digital pH-meter type Hanna.

Four replicates for each determination represented the data of experiments, which were statistically processed, the analysis of variance being used to calculate differences between results. The differences at $p < 0.05$ were considered significant.

RESULTS AND DISCUSSIONS

Table 1 plays the ascorbic acid and pH values during storage of white cabbage samples under certain conditions.

Table 2. Ascorbic acid and pH values in white cabbage

Determination	Ascorbic acid (mg/100g)						pH
Storage temperature	T=4°C		T=8°C		T=15°C		
Test variants	$+O_2$ *	$-O_2$**	$+O_2$*	$-O_2$**	$+O_2$*	$-O_2$**	$+O_2$*
Week 0	34. 7						6.95
Week II	34.70	33.70	30.58	32.60	25.85	25.85	-
Week IV	31.50	32.64	29.00	31.50	22.70	20.74	6.82
Week VI	30.65	31.75	27.10	31.50	20.35	19.30	-
Week VIII	27.60	31.60	24.50	30.33	18.30	18.76	6.50
Week X	26.85	30.33	23.00	28.00	17.95	18.20	-
Week XII	24.40	26.80	22.80	24.16	15.30	17.45	6.43
Week XIV	22.90	24.20	18.15	21.30	13.04	15.44	-
Week XVI	21.34	23.86	17.15	20.70	9.73	14.60	6.10

$+O_2$ *=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 white cabbage has recorded different decreases, depending on storage length.

Thus, the greatest reductions of acid ascorbic concentration were registered between weeks VI-VIII (10%), followed by weeks II-IV (9.23%), and X-XII (9.13%). At the same temperature of storage, but in the absence of oxygen, the greatest reduction in the content of ascorbic acid was between weeks X-XII (11.64%), followed by XII-XIV (9.71%), and VIII-X (4,02%).

At the end of the analysed interval (after 16 weeks of storage) the ascorbic acid content has decreased by 38.5%, compared to the blank (week 0), in white cabbage stored at 4°C in the presence of oxygen, and by 31.3%, compared to blank, in white cabbage 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 XII-XIV weeks (20.4%), followed by ranges 0-II (11,88%), and VI-VIII weeks (9.6%). At temperature of 8°C, but in the absence of oxygen, the biggest reductions of the ascorbic acid content were within the interval X-XII weeks (13.72%), followed by interval XII-XIV weeks (11.04%) and VIII-X weeks (7.69%).

At the end of the analysed interval (after 16 weeks of storage) the ascorbic acid content has decreased by 50.6%, compared to the blank (week 0), in cabbage stored at 8°C in the presence of oxygen, and by 40.4%, compared to the blank, in cabbage 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 0-II weeks (25.51%), followed, in order, by the range XIV-XVI (25.39%) and the ranges X-XII weeks (14.77%) and II-IV weeks (12.19%). At the same temperature, but in the absence of oxygen, the biggest reductions in the levels of ascorbic acid content were within intervals 0-II weeks (25.51%), II-IV weeks (19.77%) and XII-XIV weeks (11.52%).

At the end (after 16 weeks of storage), the ascorbic acid content has decreased by 72%, compared to the blank (week 0), in white cabbage stored at 15°C, in the presence of oxygen, and by 58%, compared to the blank, in white cabbage kept, at the same temperature, but in the absence of oxygen.

In the Table 2 are reproduced the ascorbic acid and pH values of red cabbage samples during storage.

Table 2. Ascorbic acid and pH values in red cabbage

Determination	Ascorbic acid (mg/100g)						pH
Storage temperature	T=4°C		T=8°C		T=15°C		
Test variants	$+O_2$ *	$-O_2$**	$+O_2$*	$-O_2$**	$+O_2$*	$-O_2$**	$+O_2$*
Week 0	56.2						7.15
Week II	54.20	54.00	51.80	52,60	45.45	46.60	-
Week IV	51.40	53.40	49.10	48.50	42.00	44.92	7.15
Week VI	49.24	51.80	47.20	46.80	37.30	43.10	-
Week VIII	47.08	48.56	43.60	44.80	36.90	39.20	7.10
Week X	47.08	47.20	44.20	44.20	34.75	38.50	-
Week XII	45.90	45.90	42.00	43.15	32.40	37.45	6.89
Week XIV	42.20	44.20	39.30	41.25	30.50	37.05	-
Week XVI	38.60	41.30	33.50	40.10	28.42	36.60	6.70

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

As seen in the Table 2, at temperature of 4°C in the presence of oxygen, the ascorbic acid content in red cabbage has recorded different decreases, depending on storage length.

Thus, the greatest reductions of acid ascorbic values were registered between weeks XIV-XVI (8.54%), followed by weeks XII-XIV (8.07%), and II-IV (5.17%). At the same temperature of storage, but in the absence of oxygen, the greatest reduction of the ascorbic acid content was between weeks VI-VIII and XIV-XVI (over 6.2%), followed by 0-II (4%), and IV-VI (3%).

After 16 weeks of storage, the ascorbic acid content has decreased by 31.3%, compared to the blank (week 0), in red cabbage stored at 4°C in the presence of oxygen, and by 26.5%, compared to blank, in red cabbage 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 (14.76%), followed by ranges 0-II and VI-VIII (over 7.6%), and XII-VIV weeks (6.43%). At temperature of 8°C, but in the absence of oxygen, the biggest reductions of the ascorbic acid content were between weeks II-IV (7.8%), followed by interval 0-II weeks (6.41%), and VI-VIII and XII-XIV weeks (over 4.3%).

After 16 weeks of storage, the ascorbic acid content has decreased by 40.4%, compared to the blank (week 0), in red cabbage stored at 8°C in the presence of oxygen, and by 28.7%, compared to the blank, in red cabbage 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 0-II weeks (19.13%), followed, in order, by the range IV-VI (11.2%) and the ranges II-IV weeks (7.6%) and X-XII and XIV-XVI weeks (over 6.7%). At the same temperature, but in the absence of oxygen, the biggest reductions in the levels of ascorbic acid content were within intervals 0-II weeks (17.1%), VI-VIII weeks (9.05%) and IV-VI weeks (4.06%).

After 16 weeks of storage, the ascorbic acid content has decreased by 49.4%, compared to the blank (week 0), in red cabbage stored at 15°C, in the presence of oxygen, and by 36.8%, compared to the blank, in red cabbage kept, at the same temperature, but in the absence of oxygen.

The pH of the white cabbage has recorded a variable diminution during storage (Tab. 1, Fig. 1). Thus, in the range 0-IV weeks the pH decreased by 1.88% (0.13 units), within IV-VII weeks by 4.7% (0.32 units), within VIII-XII weeks by 1.08% (0.07 units), and within XII-XVI weeks by 5.14% (0.33 units). After 16 weeks of storage, the pH of white cabbage has decreased by 12.24% (0.85 units), compared to fresh raw material.

Like in white variety, the pH of red cabbage has recorded some diminutions during storage (Tab. 2, Fig. 1). Thus, in the range 0-IV weeks of storage the pH has not suffered any change, compared to the blank sample (fresh raw material). Between IV-VIII weeks the pH has decreased by 0.7% (0.05 units), between VIII-XII weeks by 3% (0.21 units), and between XII-XVI weeks by 2.76% (0.19 units). After 16 weeks of storage, the pH of red cabbage has decreased by 6.3% (0.45 units), compared to fresh raw material.

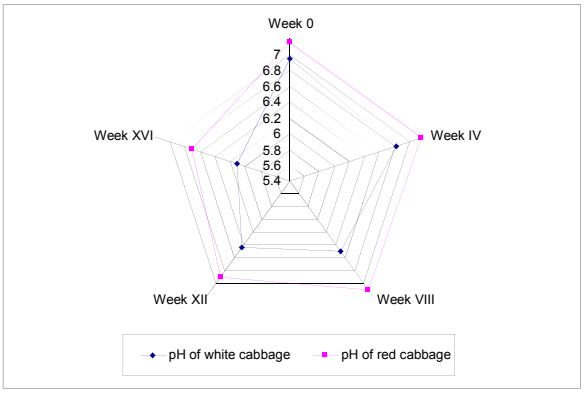

Fig. 1. The comparative evolution of pH values in white and red cabbage, depending on storage time

In the table 3 there are reproduced the r^2 values for correlations between ascorbic acid contents and storage lengths.

Table 3. Correlations between ascorbic acid contents at 4,8 and 15ºC, and storage lengths

Storage temperature	4°C (+O_2)	4°C (−O_2)	8°C(+O_2)	8°C(−O_2)	15°C(+O_2)	15°C(−O_2)
r^2 WC	0.9853	0.9251	0.9748	0.9358	0.9035	0.7659
r^2 RC	0.9650	0.9871	0.9555	0.9324	0.8862	0.8175

WC = white cabbage; RC = red cabbage; $+O_2$ = storage in presence of oxygen; $-O_2$ =storage in absence of oxygen

As seen from Table 3, the biggest r^2 values were, both in white and in red cabbage, at 4**°C** and 8**°C** (in presence of oxygen) and at 4**°C** in red cabbage (in absence of oxygen). The lowest values of r^2 were at 15°C in the both varieties (in absence of oxygen).

Analysing and comparing the data in the previous tables, one can see that, both in white and in red cabbage, the greatest reductions of acid ascorbic content have been in the presence of oxygen at 15°C, followed, in order, by 8°C, and by 4°C. It also notices that, after 16 weeks of storage, the acid ascorbic percentage reductions were bigger in white cabbage samples compared to red ones, in the three intervals and temperature thresholds analysed, as follows:

- at 4°C, by 7.2% in the presence of oxygen, and by 4.8% in the absence of oxygen;
- at 8°C, by 10.2% in the presence of oxygen, and by 11.7% in the absence of oxygen;
- at 15°C, by 22.6% in the presence of oxygen, and by 21.2% in the absence of oxygen.

According to Kennedy et al. (1992), in some juices the decomposition of ascorbic acid occurs in the presence of dissolved oxygen, being predominantly aerobic, but can continue in the absence of dissolved oxygen, by an anaerobic pathway, mainly influenced by temperature. The ascorbic acid is unstable at alkaline pH, and its stability is higher in the pH range 3.0–4.5 than in the range 5.0–7.0 (Borenstein, 1965; Ball, 2006).

In the present paper, both in white and red cabbage before storage (freshly harvested material) and during storage, the pH values were in the range 7.15–6.1.

Stored 90 days under house cellar conditions (whose mean temperature values has decreased from 17.3ºC to 10.8ºC), the acid ascorbic content in potato tubers was reduced by over 60% in tubers stored in wooden boxes, and by 20% in tubers stored in tightly closed glass jars (Avramiuc et al., 2008). Within experiments from this work, 12 weeks of cabbage storage at 15ºC (84 days) has led to a reduction by 56% in the presence of oxygen, and by 49.8% in the absence of oxygen, in white variety, and by 42.4% in the presence of oxygen, and by 33.5% in the absence of oxygen, in red variety.

According to Banu et al. (2003), the addition of anthocians, sugars and even starch seems to have a protecting action on vitamin C.

Knowing that the red variety contains anthocians, it can explain why the ascorbic acid in white cabbage has registered losses, compared to red variety, so much the bigger as the temperature was higher and the storage duration was longer.

CONCLUSIONS

The storage of white and red cabbage 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 (anthocians presence).

In white cabbage samples, the greatest decrease of ascorbic acid content has registered after 16 weeks of storage at 15°C: by 72% (compared to the blank - week 0) in cabbage stored in the presence of oxygen, and by 58% in cabbage kept in the absence of oxygen.

In red cabbage samples the greatest decrease of ascorbic acid content has registered after 16 weeks of storage at 15°C: by 49.4% (compared to the blank - week 0) in cabbage stored in the presence of oxygen, and by 36.8% in cabbage kept in the absence of oxygen.

The ascorbic acid in white cabbage has registered losses, compared to red variety, so much the bigger as the temperature was higher and the storage duration was longer.

REFERENCES

Alwazeer D., Delbeau C., Divies C., Cachon R., 2003 - Int J Food Microbiol 89:21–29
Artenie V., Tănase E, 1980 - *Practicum de biochimie generală.* Centrul de Multiplicare al Universităţii "Al. I. Cuza" Iaşi.
Avramiuc M., Fărtăiş L., Herghelegiu Ioana, 2008 - *The ascorbic acid content variation in potato tubers, during storage under house cellar conditions.* Cercetări Agronomice în Moldova, Vol. XLI, No. 4 (136), 2008
Ball G.F.M., 2006 - *Vitamins in Foods, Analysis, Bioavailability, and Stability*. CRC Press, Taylor & Francis Group 6000, Broken Sound Parkway NW, Suite 300, Boca Raton, FL 33487-2742, p. 292-305
Banu C., Iordan M., Nour V, Musteaţă G., 2003 - *The processing of raw materials and the loss of biologically active substances*. Ed. „TEHNICA" UTM. Chişinău, p. 91-93
Blasco R., Esteve M.J., Frígola A., Rodrigo M., 2004 - Lebens Wissen Technol 37:171–175
Block G., Norkus E., Hudes M., Mandel S., Helzlsouer K., 2001 - Am J Epidemiol 154:1113–1118
Borenstein, B., The comparative properties of ascorbic acid and erythorbic acid, Food Technol., 19 (11), 115, 1965
Burns J, Frase P.D., Bramley P.M., 2003 - Phytochem 62:939–947
Cortés Clara , Esteve J. María, Frígola Ana, 2007 **-** *Effect of refrigerated storage on ascorbic acid content of orange juice treated by pulsed electric fields and thermal pasteurization***,** European Food Research and TechnologyZeitschrift für Lebensmittel- Untersuchung und -Forschung A© Springer-Verlag 200710.1007/s00217-007-0766-x Original Paper
Del Caro A., Piga A., Vacca V., Agabbio M., 2003 - Food Chem 84:99–105
Esteve M.J., Farré R., Frígola A., 1995 - J Agric Food Chem 43:2058–2061
Gardner P.T., White T.A.C., McPhail D.B., Duthie G.G., 2000 - Food Chem 68:471–474
Indyk, H. and Konings, E., Eds, 2000 - *Official Methods of Analysis of AOAC International*, 17th ed., AOAC International, Gaithersburg, MD, p. 45-60
John J.H., Ziebland S., Yudkin P., Roe L.S., Neil Haw, 2002 - Lancet 359:1969–1974
Kennedy, J.F., Rivera, Z.S., Lloyd, L.L., Warner, F.P., and Jumel, K., 1992 - *L-Ascorbic acid stability in aseptically processed orange juice in TetraBrik cartons and the effect of oxygen*, Food Chem., 45, 327
Murata M., Shinoda Y., Homma S., 2002 - Int Congr Ser 1245:459–460
Polydera A.C., Stoforos N.G., Taoukis .PS., 2003 - J Food Eng 60:21–29
Sánchez-Moreno C., Plaza L, de Ancos B., Cano P., 2003 - J Sci Food Agric 83:430–439
Torregrosa F., Esteve M.J., Frígola A., Cortés C., 2006 - J Food Eng 73:339–345
Zerdin K., Rooney M.L., Vermuë J., 2003 - Food Chem 82:387–395

1. Faculty of Food Engineering, Stefan cel Mare University of Suceava
* avramiucm@fia.usv.ro