CHANGES OF BIOCHEMICAL COMPOUNDS IN SEABUCKTHORN MARC DURING STORAGE

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Abstract

Seabuckthorn fruits contain functionally active compounds: vitamins, minerals, fiber, organic acids, and phenolic compounds, important for human health. As a result of juice pressing marc is left which consists of fatty acids, carotenes, insoluble fiber in a relatively large amount. Since the tendency of using finely ground wheat bread is rising, it is possible to increase its nutritive value by adding seabuckthorn marc. The aim of this work was to determine the changes of different fatty acids, carotenes, phenolic compounds and vitamin E of seabuckthorn mark during storage. The research was carried out at the Experimental Fruit and Berry Processing Center of Latvia State Institute of Fruit Growing during 2005, Latvia. It was found that the content of fatty acids reduced for 4.3 to 21.6%, the content of vitamin E – for 54.5%, the content of phenolic compounds – for 44.9% but the content of carotenes – for 32.7%.

Key words: seabuckthorn marc, fatty acids, phenolic compounds

Introduction

Seabuckthorn are one of the most valuable plant crops because they contain vitamin, organic acids, fiber, pectic compounds, carotenes, polyunsaturated fatty acids and other components (Kawecki *et al.*, 2004; Jamyansan and Badgaa, 2005; Lebeda, 2003). In the process of obtaining seabuckthorn juice, as a leftover remains marc, which contains 8–10% biologically active compounds important for the human organism, including natural antioxidants – vitamin C and E, carotenoids, minerals and polyphenols (Tsybikova *et al.*, 2003; Novruzov, 2005). The marc is used for the production of pulp and seed oil (Singh, 2005; Singh and Mörsel, 2005). In Germany the marc after pressing is dried and the oil is extracted by hexane, liquid gas or similar way (Heilscher, 2003). In Mongolia oil is extracted from the dry marc of the seabuckthorn by Kazantsevis and Ohina method at 50–65 °C (Avdai and Chimed-Ochir, 2003).

The marc is possible to be utilized as a raw material for the production of palmitoleic acid methyl ester concentrate (Klaas and Meurer, 2004). A new use was researched in the Institute of Technology of Mogilev where fresh pressed seabuckthorn marc was used for the making beverages (Timofeeva, 1996). However in Russia the uses of marc are wider: in baking of bread and manufacturing of vitamin mixtures for farm animals and birds (Zolotareva, 2004; Tsybikova *et al*., 2003; Koshelev *et al*., 2003). Similar research was done in Estonia using seabuckthorn marc to increase the nutritive value of wheat bread (Lõugas *et al*., 2005).

The seabuckthorn marc can be used in bread, confectionery production and in other cereal products to increase their nutritive value (Singh, 2005; Gailite and Strautniece, 2005).

The storage of seabuckthorn marc after juice pressing can be different: it can be dried immediately and stored dry or put into the refrigerator and stored at the temperature of -18 °C. Biochemical content of the dry marc changes during storage. The changes can significantly influence its nutritive value. Therefore the aim of this work was to determine the changes of different fatty acids, total carotenes, phenolic compounds and vitamin E during storage of dry seabuckthorn marc.

Materials and Methods

The research was carried out at the Experimental Fruit and Berry Processing Center of Latvia State Institute of Fruit Growing during 2005. The research material – fruits of different seabuckthorn (*Hippophae rhamnoides* L.) cultivars, widely grown in Latvia, was harvested at "Baltplant" Ltd, Dobele region and was stored frozen at minus 18 °C until analyzing. The juice was pressed from thawing fruits with a press "Voran 60K". The marc was dried by compulsory air circulation for 24 hours at the temperature +4 °C; crushed in mill and stored in plastic bags in a dark place at temperature +5 °C for three months. The biochemical composition of seabuckthorn marc was analyzed during storage.

The content of vitamin E in samples was established by a modified method. The method is based on the extraction of carotenoides with petroleum benzene. The same solvent was used for the determination both of carotenoides and vitamin E.

Five (5) g of sea buckthorn berries were crushed and put into a 100 ml retort. Ten (10) ml of 96% ethanol were added and the solution was mixed for 5 minutes. After adding of twenty five (25) ml of petroleum benzene mixing was continued 4 hours. Then thirty (30) ml of H_2O was added and mixed for 15 minutes. The sample was filtered. The sediment was rinsed with ten (10) ml of 96% ethanol and two times with H_2O. After the separation of both layers the upper one was used for analyses. Yellow petroleum benzene layer was put in twenty five (25) ml retort and refilled till the mark.

Two (2) ml of petroleum benzene were taken and put into twenty five (25) ml retort. Ten (10) ml of ethanol were added and mixed. Then one (1) ml of 0.5% 2,2'-dipiridyl solvent was added in ethanol and mixed; one (1) ml of 0.2% $FeCl_3$ solvent added in ethanol and the retort was placed in a dark place. After 15 minutes ethanol was added to the retort till the mark. The absorbance of light was measured with a spectrophotometer at 500 nm. At the same time a control substance was prepared in the same way as the analyzed substance, only instead of the analysis two (2) ml of petroleum benzene were taken. The content of vitamin E was found by using a graduation curve and calculated by using the formula:

$$X = \frac{c \times 12.5 \times 100}{a}, \text{ mg } 100\text{g}^{-1} \quad (1)$$

where:

c – the content of vitamin E by using a graduation curve, mg/25ml;
12.5 – factor of sample dilution;
a – weight of sample, g.

Analysis for determination of carotenoides:

Two (2) ml of petroleum benzene solvent were taken and put in twenty five (25) ml retort, refilled till the mark. The absorbance was read at 450 nm. Petroleum benzene was used as control.

For the analyzes of total phenolic compounds (mg $100g^{-1}$) the Folin-Ciocelteu method (Singelton, 1999) was used, for fatty acids (% of total fatty acids) standard method ISO 5508:1990 was used.

Dates were statistically elaborated using SPSS for Windows and MS Excel.

Results and Discussion

The biochemical compositions of seabucthorn pulp and seed oil are substantially different. The palmitic ($C_{16:0}$) and palmitoleic ($C_{16:1}$) acids dominate in the pulp oil, whereas linoleic ($C_{18:2}$) and linolenic ($C_{18:3}$) acids dominate in the seed oil (Jamyansan and Badgaa, 2005). Since the seabuckthorn marc contains both oils, then its content of fatty acids depends of the proportion between these ingredient contents.

At the beginning of the research there were established higher contents of $C_{18:2}$ and $C_{18:3}$ fatty acids (respectively 32.3±2.3 and 25.8±1.8%) in the sample (Figure 1). However, the contents of $C_{16:0}$ and $C_{16:1}$ fatty acids were less than on average in pulp oil (respectively 15.4±1.1 and 12.5±0.9%). It means that the samples of marc contain a higher amount of seeds than the skin and pulp part. The samples contained 2.1±0.1% $C_{18:0}$, 11.4±0.8% $C_{18:1}$ and 0.4±0.03% $C_{20:0}$ in average (Tab. 1), that conforms to data given in literature (Jamyansan and Badgaa, 2005; Korovina and Fefelov, 2005). After 60 days of marc storage the considerable losses were established for $C_{16:1}$, $C_{20:0}$ and $C_{16:0}$ fatty acids (respectively 21.6; 20.0 and 14.9%). The content of $C_{18:1}$ fatty acid decreased by 10.2%, but $C_{18:0}$, $C_{18:3}$ and $C_{18:2}$ respectively by 9.5; 7.0 and 4.3%.

Table 1

Changes of fatty acids during storage

*Fatty acids	Storage time, days		
	0	**30**	**60**
Palmitic ($C_{16:0}$)	15.4 ±1.1	14.9±1.0	13.1±0.9
Palmitoleic ($C_{16:1}$)	12.5±0.9	11.7±0.8	9.8±0.7
Stearic ($C_{18:0}$)	2.1±0.1	1.8±0.1	1.9±0.1
Oleic ($C_{18:1}$)	12.7±0.8	12.0±0.8	11.4±0.9
Linoleic ($C_{18:2}$)	32.3±2.3	33.4±2.3	30.9±2.1
Linolenic ($C_{18:3}$)	25.8±1.8	24.6±1.7	24.0±1.7
Arahinic ($C_{20:0}$)	0.4±0.03	0.37±0.03	0.32±0.02

** % of total fatty acids*

The content of total carotenes in whole dried fruits is in average 20.43 mg 100 g^{-1} (Novruzov, 2005). It still substantially depends on the initial content of carotenes in the fruits, as well as on the processing technology (Heilscher, 2003). Several researches testify that the content of carotenes in seabuckthorn oil in a dark place at temperature +5 °C after three month storage decrease from 42.5 to 47.5% (Novruzov, 2005; Bekker *et al.*, 2005).

At the beginning of our research the content of total carotenes in seabuckthorn marc was on average 37.0 mg 100 g^{-1} (Figure 1).

This research did not show disparity in the content of total carotenes after 30 storage days ($p>0.05$). Disparity was established after 60 storage days ($p<0.05$) where the content of total carotenes decreased to 32.05 mg 100 g^{-1}. The content of total carotenes decreased for 32.7% during whole storage time (90 days), which is comprisable with the data in literature.

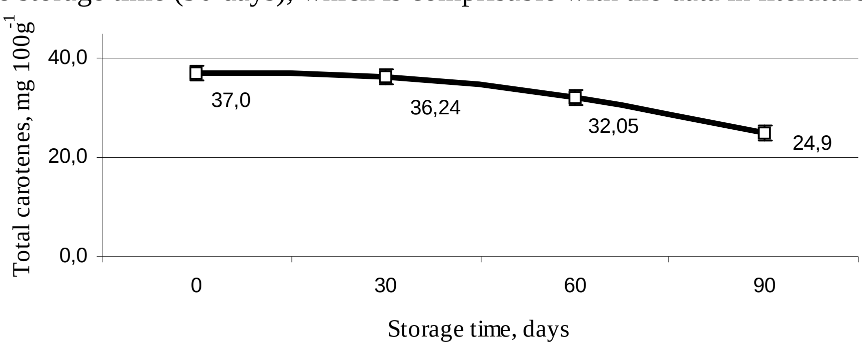

Figure 1. Changes of total carotenes content during storage

Fruits of seabuckthorn contain different phenolic compounds that are represented mainly by flavonols, leuoanthocyanins, catechins, chlorogenic acid etc. The total content of phenols depends on the cultivar and varies from 828.7 to 1099.6 mg 100 g^{-1} (Novruzov, 2005). As this researcher indicates, the content of phenolic compounds is influenced not only by cultivar but also species, grooving place and stage of ripeness. In the beginning of the research there were 2256.4 mg 100 g^{-1} of total phenolic compounds in dry seabuckthorn marc (Figure 2). With probability 95% there was established a disparity ($p=0.028<0.05$) after 30 storage days. Relevant decrease was established after three-month storage reaching 1243.3 mg 100 g^{-1}.

The content of total phenols in seabuckthorn marc decreased for 44.9% during the whole storage time.

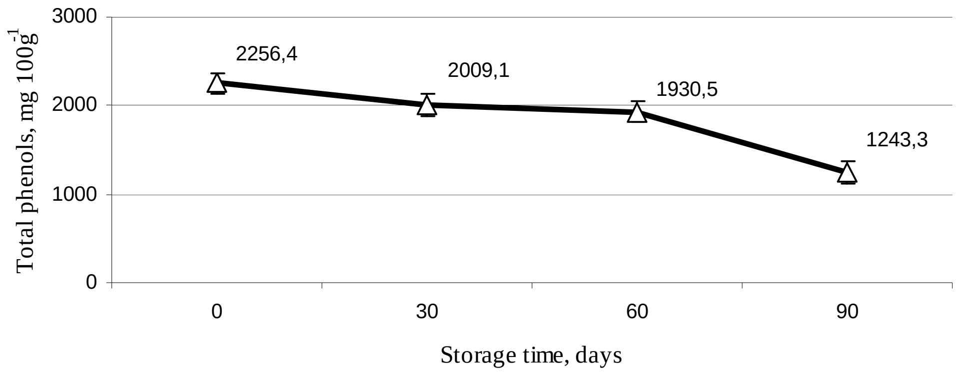

Figure 2. Changes of total phenolic content during storage

Summarizing the research data from China and Italy, the content of vitamin E in pulp oil may be 54.3–248.2 mg 100 g^{-1} (Rongsen, 2005; Antonelli *et al.*, 2005). Depending on the extraction way and technology the content of vitamin E is different, in addition it is significantly influenced by the growing environment of the crop. For example in *subsp. sinensis* (growing place Jiaoko County, Shaxi, China) in wet soil the content of vitamin E in pulp oil and seed oil was higher (respectively 220 and 688 mg 100 g^{-1}) than in dry badlands (respectively 150–170 mg 100 g^{-1}) (Wei and Guo, 1996). Similar results were shown by research from Mongolia: the pulp oil contained 330.4 mg $100g^{-1}$, but seeds oil 260.0 mg 100 g^{-1} of vitamin E.

The beginning of our research there was 559.5 mg 100 g^{-1} of vitamin E in seabuckthorn marc. The content of vitamin E relevant by decreased during all storage time. In addition the decrease was on average about 85 mg 100 g^{-1} in first two months, but in the third month on average 134 mg 100 g^{-1} (Figure 3). At the end of research the content of vitamin E was decreased by 54.5% (to 254.39 mg 100 g^{-1}).

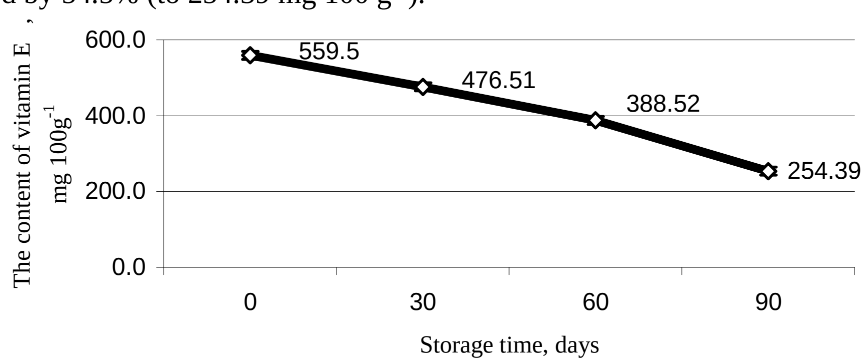

Figure 3. Changes of vitamin E content during storage

Conclusions

The obtained data show that it cannot be recommended to store dry seabuckthorn marc, because during storage its nutritive value significantly decreases, along with the possibility to use it for the nutritive improvement of other products, e.g., wheat bread. The highest losses of fatty acids during 60 storage days were established for $C_{16:1}$, $C_{20:0}$ and $C_{16:0}$ fatty acids (respectively 21.6; 20.0 and 14.9%). The content of total carotenes in seabuckthorn marc decreased by 32.7%; the content of total phenolic compounds – by 44.9% but the content of vitamin E decreased by 54.5% during 90 days.

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