THE CHEMICAL AND PHYSICAL PROPERTIES OF SWEET ROWANBERRIES IN POWDER SUGAR

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Abstract
The rowanberries (*Sorbus aucuparia*) are small orange-red "fruits" of a rowan tree. These berries have been described as an important source of flavonoids, and their antioxidant activity affects reactive oxygen species and lipid peroxidation; therefore they are suitable for production of health-food products. The aim of this experiment was to prepare new product – rowanberries in powder sugar, and to determine chemical and physical properties of samples. The experiments were prepared in the Faculty of Food technology of Latvia University of Agriculture and in the Customs laboratory of National Customs Board of State Revenue Service. The berries of cultivars 'Moravica' and 'Michurinskaya Krasnaya', and hybrid of rowanberry × hawthorn 'Granatnaya' were used for investigations. The rowanberries 'Granatnaya' in powder sugar were packed in carton and plastic (biodegradable PLA and conventional PP) boxes and kept three weeks at room temperature. The content of ascorbic acid and total carotenoids, the firmness of experimental products and the weight losses of packed samples were analysed. For determination of the organic acid and ascorbic acid content high performance liquid chromatography was used, and the content of total carotenoids was determined by spectrophotometric method. Texture analyser TA.XT.plus was used for measurement of the firmness of samples. The results showed that sweet rowanberries are good raw material for preparation it's in powder sugar. The analysis of firmness showed that the rowanberries in powder sugar had a fairly hard texture, influenced by the presence of sugar layer. We observed the weight losses during 18 days storage of packed samples in carton boxes.
Key words: rowanberries in powder sugar, firmness, ascorbic acid, total carotenoids

Introduction
The rowanberries (*Sorbus aucuparia* L.) are small orange-red "fruits" of a rowantree (also known as mountain ash), which grow in the northern part of Europe. The rowanberries (*Sorbus*) belong to the subfamily *Maloideae* of the family *Rosaceae* and their berries have been promoted as a health-food or can be a source for health-promoting components. The ripe wild rowanberries are picked in the autumn and they are eatable, but very tart in flavour. Sweeter and less astringent than wild rowanberries are different cultivars of sweet rowanberries and hybrids with other species. The hybrid cultivars were developed by cross-breeding rowan with *Malus, Pyrus, Aronia* and *Mespilus* (Hukkanen et al., 2006; Poyrazoğlu, 2004).
The berries consist mostly of water, and the main components in the dry matter are carbohydrates, primarily sugars, and non-volatile organic. Organic acids are important intermediate products of metabolism (Viljakainen et al., 2001). According to food composition and nutrition tables, sweet rowanberry *S. aucuparia* L. var. *edulis* contains 1600-2420 mg of organic acids per 100 g of edible portion, int.al. 10 mg of parasorbic acid, 98 mg of vitamin C per 100 g and 2.5 mg of total carotenoids per 100 g. (Souci et al., 2008)
Packaging protects goods from damage, allows efficient transportation and distribution, offers convenience and prolongs shelf life. Berries are live organisms and, even after harvest, they continue to respire and transpire. If there is not enough oxygen, fermentation occurs, and small amounts of alcohol, acetaldehyde, and other volatile compounds are produced; therefore, packaging materials for fruits should not create too high a barrier to oxygen. On the other side berries are high-moisture products and loss of moisture under normal storage conditions causes wilting and shrivelling of product. Developments in polymer chemistry have resulted in the production of packaging films such as low-density polyethylene (LDPE), polystyrene (PS), polyvinyl chloride (PVC), polyvinylidene chloride (PVDC), and ethylene vinyl alcohol (EVOH). These films have a range of water vapour and gas barrier, and heat-sealing characteristics that enable them to be used for shelf-life extension of products (Gontard et al., 2010;

Smith et al., 2005). Promising alternatives of polymer packaging are biopolymers, produced from regularly renewable raw materials. There are three main forms of renewable bio packaging: polylactic acid (PLA), polyhidroxyalkanoates (PHA) and thermoplastic starch (TPS) (Weber et al., 2002). Although many biobased packaging materials do not provide a high water vapour barrier, and moisture loss or gain is therefore a critical parameter for foods packaged in such materials. There was reported and expected that PLA will be suitable for fruits packaged in atmospheric air as these products do not require any specific gas barrier (Holm, 2010).
The aim of this experiment was to prepare new product – sweet rowanberries in powder sugar, to determine chemical and physical properties of samples and the possible storage time in different packaging materials.

Materials and Methods

Experimental design

Experiments were carried out at the Faculty of Food technology, Latvia University of Agriculture, and the Customs laboratory of National Customs Board, State Revenue Service. The object of this investigation was berries of two sweet rowanberries cultivars 'Moravica' and 'Michurinskaya Krasnaya', and hybrid of rowanberry × hawthorn 'Granatnaya' (hybrid of *S. aucuparia* × *Crataegus sanguine*) grown in Latvia. The berries were picked in the Pure Horticultural Research centre (HRC) collection of genetic resources in September 2010. Part of samples after harvesting was packed in plastic bags, frozen, and kept at -18±2 °C along 3 months.
The samples of experimental product – sweet rowanberries in powder sugar, were prepared from fresh rowanberries and from stored frozen rowanberries followed by thawing. The frozen berries (1 kg) were thawed overnight in refrigerator at +4°C. All rowanberries were dipped in the solution of starch and then coated with powder sugar layer. The coating process with powder sugar was repeated once. The samples of rowanberries 'Granatnaya' in powder sugar were packed in carton (80±5 g in each box) and plastic (biobased PLA and conventional PP) boxes (60±5 g in each box), and stored 18 days at room temperature. The content of organic acids and ascorbic acid and total carotenoids, the firmness of all experimental products and the weight losses of packed samples were analysed.

Chemical and physical analysis

The determination of the organic acids and vitamin C content was based on methods reported by Romero-Rodriguez et al. (1992) and Vanques-Oderiz et al. (1994) by adding some modifications. Samples of experimental products (100 g) were homogenised by a manual blender (Braun). The portion of samples (5–10 g) was weighed into a volumetric flask (50 ml) and 0.001 M sulphuric acid (~ 30 ml) was added for determination of organic acid content, and 0.1% oxalic acid (~ 30 ml) – and ascorbic acid content was determined. Mixture was stirred mechanically for 15 minutes and the solution filtered through a paper filter (DP 503 125, Albet) in 50 ml volumetric flask and filled to mark with correspondent acid solution. Acid extract was then filtered through a membrane filter with pore size 0.2 μm (Sartorius) prior to injection into the chromatographic system. Calibration curve was acquired after two repeated HPLC runs of 5 standard solutions of reference materials. Quantifications of the organic acids and ascorbic acid content of experimental products were performed in duplicate and were based on peak area measurements.
The extract of experimental products was analysed and content of organic acids and vitamin C (ascorbic acid) determined using HPLC Prominence (Shimadzu, Japan) equipped with Ostion LG-KS H^+ column (250x8 mm, particle size 10 μm) and an autosampler SIL-20A. Working conditions: the mobile phase – ultra-pure water acidified to pH 2.2 with sulphuric acid. The flow rate was 0.4 ml min^{-1}, column temperature – 30 °C, detection with a UV/VIS detector SPD-20A (Shimadzu) was at 215 nm for organic acids and at 245 nm for vitamin C, and injection volume of

samples – 10 µl. Data were acquired and processed using Shimadzu LabSolutions software (LCsolution Version 1.21 SP1).
The content of total carotenoids was analyzed by the spectrophotometric method at 440 nm (Ермаков, 1987) with petroleum ether (boiling temperature range 80–110 ºC) and measured with UV-VIS-NIR spectrophotometer UV-3100PC (Shimadzu) in 10 mm cuvettes. One to two grams of homogenized rowanberries in powder sugar were placed in a conic retort (100 ml) and 96% ethanol (20 ml) was added, and then samples were stirred by a magnetic stirrer for 20 min. Then petrol ether (25 ml) and water (1 ml) was added and stirring was continued for one more hour. After 3–4 hours the top (yellow) layer was used for the detection of total carotenoids. The carotene equivalent (KE) was found, using graduating curve with $K_2Cr_2O_7$.
The firmness of all experimental products was measured by texture analyser TA.XT.plus (Stable Microsystems Ltd., Surrey, England) and software Texture Exponent 32. The texture analyser was equipped with a load cell of 50 kg. Samples of rowanberries in powder sugar were positioned under the needle type P/2. The results were expressed as maximum force in Newtons (N), and the maximum force required for sample compression was calculated as an average of 15–20 measurements.
The weight losses of packed samples were determined by weighing on the analytical balances Sartorius SB-210s with precision ±0.0001 g. The results were analyzed before storage (0 days) and after 4, 6, 8, 10, 12, 14 and 18 storage days, and reported as averages of those three determinations.
Data analysis
All values of parameters were expressed as means and standard deviations and calculated using SPSS for Windows (Version 11.0).

Results and Discussion
In this study 6 samples of sweet rowanberries in powder sugar were prepared consisting of 53±6% of berries and 47±6% of starch-sugar layer.
The content of organic acids and ascorbic acid (vitamin C) is a very important parameter that determines the quality of berry products. The amount of organic acids (citric, malic, succinic, and sorbic) of rowanberries in powder sugar is given in Table 1. Malic acid was the dominant compound compared with other organic acids in all investigated samples. The content of malic acid in samples prepared from frozen rowanberries was on 7.5–8.2% less than of those made from fresh rowanberries. We observed that during frozen storage of rowanberries 'Michurinskaya Krasnaya' the content of succinic and sorbic acid increased.

Table 1

The organic acids content (mg $100g^{-1}$) of rowanberries

Cultivar of berries	Citric acid	Malic acid	Succinic acid	Sorbic acid
'Moravica' fresh	26±3*	769±17	65±2	7±1
'Moravica' frozen	25±12	706±28	66±12	6±2
'Michurinskaya Krasnaya' fresh	91±1	1242±28	202±6	10±1
'Michurinskaya Krasnaya' frozen	70±2	1150±31	222±5	12±1

* - values expressed as mean and standard deviation

The ascorbic acid content of sweet rowanberries is reported in Figure 1, and the highest content of vitamin C was detected in the samples of experimental products made from fresh berries.

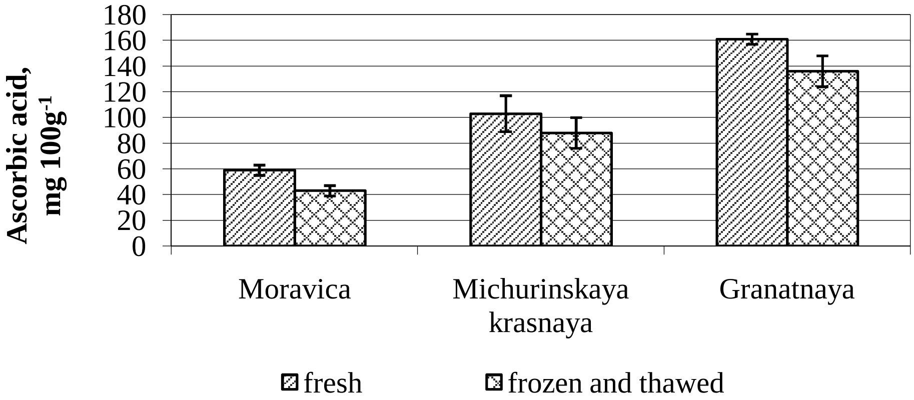

Figure 1. The vitamin C content of rowanberries in powder sugar

The total carotenoid content of sweet rowanberries in powder sugar is reported in Figure 2. The content of total carotenoids was less about of 13 and 16% in samples made from frozen and thawed rowanberries than in rowanberries prepared from fresh berries (cultivars 'Michurinskaya Krasnaya' and 'Moravica', respectively).

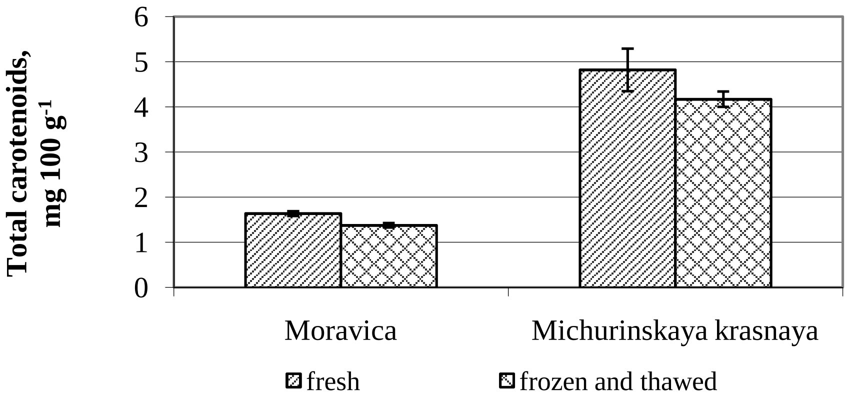

Figure 2. The total carotenoid content of rowanberries

The results of textural analyses of experimental products are showed in Figure 3. The results of the experiment showed that the rowanberries in powder sugar had a fairly hard texture, improved by the presence of sugar layer.

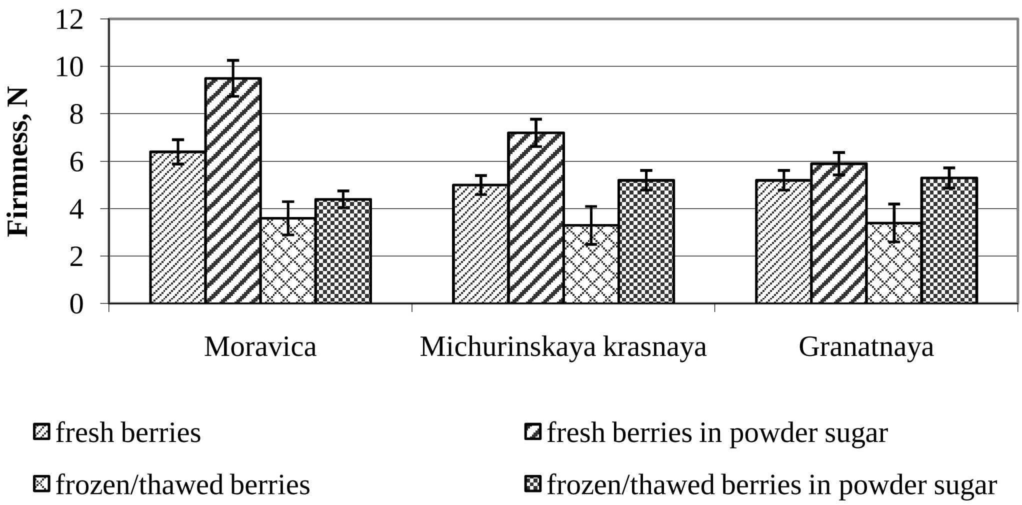

Figure 3. Comparison of firmness of rowanberries and rowanberries in powder sugar

The weight losses during storage of rowanberry samples in powder sugar packed in carton boxes are reported in Figure 4. The weight loss of samples packed in plastic boxes during the firsts 4 storage days was 1.6–2.2 % and during 6 days storage – 9.6–11.6%. The weight loss of samples packed in cardboard boxes during the firsts 4 storage days was determined 9.9–11.4 % and during 6 days – 21.3–23.5%, and during 18 days – 29.1–32.5%. The sugar coating of experimental sample' berries packed in plastic boxes (PLA and PP) after 6 days storage moistened, therefore the storage was not followed up.

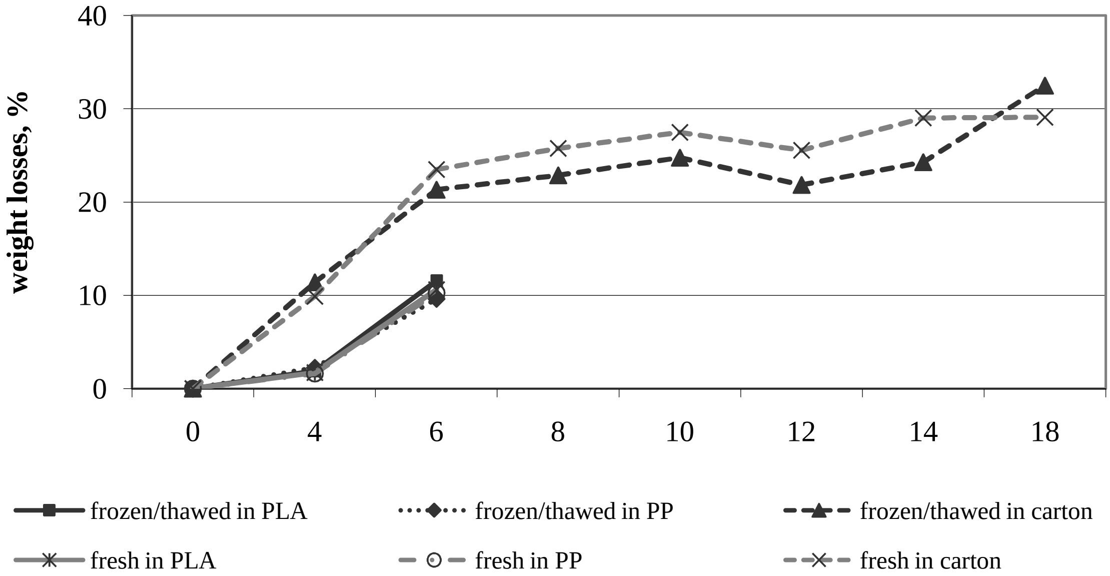

Figure 4. The weight loses of rowanberries 'Granatnaya' in powder sugar

The firmness of experimental products during storage is showed in Figure 5.

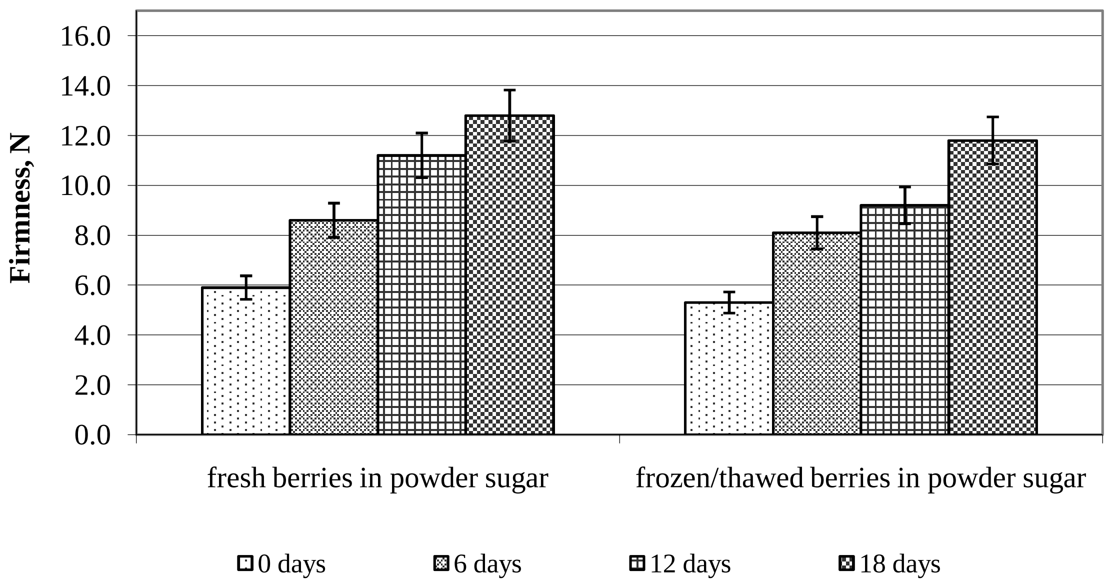

Figure 5. The firmness changes of rowanberries in powder sugar during storage time

After 18 days storage in carton boxes the firmness of experimental products – 'Granatnaya' in powder sugar, were increased from 6.3 up to 10.3–12.1 N (samples from fresh berries) and from 7.6 up to 8.9–9.8 N (samples from frozen and thawing berries).

Conclusions

1. Both fresh and frozen stored rowanberries followed thawing are as good raw material for their processing in powder sugar. The new product contains ascorbic acid, organic acids, and carotenoids. Malic acid is the main component of organic acids – in 'Moravica' in powder sugar – 706–769 mg 100 g^{-1} and in 'Michurinskaya Krasnaya' in powder sugar – 1150–1242 mg 100 g^{-1}.
2. The rowanberries in powder sugar had a fairly hard texture, improved by the presence of sugar layer. Plastic boxes (PLA and PP) are not recommendable for storage of berries in powder sugar more than 6 days; whereas in carton boxes the storage time may be 12 days.

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