

Evaluation of pumpkin–rowanberry marmalade quality after different drying times

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Historically, marmalades may have originated as an early effort to preserve fruit for consumption in the off-season. Marmalades are basically products with fruit purée and sugar–acid–pectin gel. The aim of the current research was to determine the chemical and physical properties and to investigate the degree of acceptance of pumpkin–rowanberry marmalade.

The experiments were carried out at the Faculty of Food Technology of the Latvia University of Agriculture. The marmalade was made from *Cucurbita maxima* pumpkin and sweet rowanberry *Sorbus aucuparia* cultivar ‘Nevezhinskaya’ purées. Different drying times in oven at a temperature of 50 ± 2 °C were examined and compared with marmalade drying in air ambiance at room temperature. The moisture, total carotene, ascorbic acid content, hardness, colour, and the degree of acceptance of marmalade samples were determined as quality evaluation.

The results of the research have shown a large variability in the physical and chemical parameters among the marmalades after different drying times. The moisture content of marmalade samples decreased by 9.1 to 33.5 %, and hardness increased from 1.85 to 9.54 N. According to sensory evaluation, consumers liked pumpkin–rowanberry marmalade samples after drying in the air ambiance at room temperature.

Keywords: marmalade, total carotene content, hardness, colour, degree of acceptance

Introduction

Sweets constitute a group of food for which human beings have always had some inborn preference because the majority of sweet fruits or edible parts of plants found in nature are not poisonous. The group of sweets includes honey, candies, jellies and marmalades, candied fruits, sweets made of cacao, and others [1]. Historically, marmalades, jams and jellies may have originated as an early effort to preserve fruit for consumption in the off-season. The processing of different fruits into juice, marmalade or jam has been important for ensuring fruit availability all the year round. Marmalades are mostly products from fruit purée and sugar–acid–pectin gel or low-methoxyl pectin–calcium gels. Pectin is traditionally used in a wide range of fruit-based products in which it acts as a gelling agent [2–4]. For the production of marmalade, fresh fruits or intermediary products, such as fruit pulps or slurries, are boiled with the addition of sugar and other ingredients (gelling agents, starch syrup, and acids) [5].

Berries are among the most suitable fruits for processing into jams and jellies because of their quality, acidity, colour, high pectin content, flavour, and aroma. If a fruit does not have enough pectin, commercial pectin has to be used, when a mixture of the required pectin with a similar portion of sugar should be added after the concentration process to avoid heat damage to the pectin molecules. Sugar and other minor ingredients help to develop the texture of jams and marmalades because of the formation of a gel between sugars and pectin substances along with fruit acidity [2, 3].

Consumers demand high-quality healthy products in various innovative forms and for competitive prices [5]. Therefore, it is very important to choose the raw material with a high content of bioactive compounds. There is still a lot of potential to improve the product quality using new, non-traditional fruits and vegetables as raw materials for the production of marmalades. Such raw materials are also pumpkins and sweet rowanberries.

Pumpkin is one of the vegetables that meet the requirements of healthy nutrition; it is a gourd-like squash of the genus *Cucurbita* and the family *Cucurbitaceae*. It is a tasty and valuable vegetable crop containing a lot of biologically active substances and distinguished for dietary qualities. The name ‘pumpkin’ is commonly used for cucurbits of some species similar in botanical characteristics. In Central Europe and other countries, pumpkins belonging to *Cucurbita pepo* L. (called also ‘squash’), *Cucurbita maxima* Duch. (called ‘winter squash’) and *Cucurbita moschata* Duch. ex Poir species are mostly grown. Since pumpkin species and cultivars differ in the nutritional and technological value of fruits, breeders and scientists seek genotypes of the highest nutritional value and suitability for human nutrition [6, 7].

The yellow-orange characteristic colour of pumpkin is due to the presence of carotenoids which have a major role in nutrition as provitamin A and as an antioxidant [8]. The main carotenoids present in winter squash (*Cucurbita maxima*) are α -carotene and β -carotene. Winter squash fruit contains 0.4–7.5 mg 100 g⁻¹ of α -carotene and 1.4–8.4 mg 100 g⁻¹ of β -carotene, depending on a cultivar [9]. *Cucurbita moschata* is used in the traditional medicine of

several countries to control diabetes as well as for treating worms and parasites [10]. They are consumed in various ways such as fresh or cooked; also they are stored frozen or canned [11].

The rowanberries *Sorbus* belong to the subfamily *Maloideae* of the family *Rosaceae*, and their berries have been promoted as a health-food or a source of health-promoting components. Wild rowanberries have been traditionally used to make purées, juices or wine, and they make an excellent jelly because of the high content of pectin, but their wider use as food ingredients has been less popular because of their bitter taste. Sweeter and less astringent than wild rowanberries are different cultivars of sweet rowanberries and hybrids with other species. The first sweet rowanberry clones were selected in the Sudety mountain area, in the current Czech Republic area in the 19th century. A breeding program for sweet rowanberries was started by Michurin in Russia at the beginning of the 20th century, resulting in interesting hybrids of the rowanberry (*Sorbus aucuparia* L.) with the *Aronia*, *Malus*, *Mespilus*, or *Pyrus* species. Sweet rowanberries have been bred particularly for northern conditions and have shown excellent winter-hardiness in Russia and Finland [12, 13]. 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, 98 mg of vitamin C per 100 g, and 2.5 mg of total carotenoids per 100 g [14]. A comparison of data on sugar content in wild rowanberries indicated that cultivars of the sweet rowanberries were sweeter – sugar content in their fruits was considerably (1.2–2.1 times) higher [15].

The stability of many bioactive compounds is dependent on the pre-treatment of the raw material, processing operations of the product, and storage conditions. In many fruits, carotenoids and flavonoids, located mainly in epidermal tissues, are removed by peeling operations which can greatly reduce the concentrations of bioactive compounds in processed products. Removal of seeds can result in a loss of phenolics (e. g., ellagitannins) [16]. Drying in the hot air is mostly performed at a temperature ranging between 50 and 90 °C; it must be chosen very carefully for drying fruits and berries. These reactions cause not only browning and the loss of pigments [17], but also the loss of important nutrients. High temperature causes the loss of important nutrients, non-enzymatic browning, some enzymatic and other reactions [18]. At a temperature just above 50 °C, the degradation of several phenolic compounds occurs [19], but at 60–63 °C anthocyanin degradation begins [20]. During the thermal processing, 50–70 % losses of ascorbic acid can occur. The losses of this vitamin are used as an indicator of food quality. On the other hand, carotenoids after thermal processing are more easily extracted from plant tissues due to tissue softening and the destruction of the membrane–protein complex [16].

Colour and texture are very important quality parameters of marmalades. The colour is one of the most important parameters to which consumers are sensitive when selecting foods. Colour stability of fruit and fruit products is influenced by many factors. At least three

factors can cause colour deterioration: the loss of red anthocyanin pigment, formation of brown pigments, and discoloration through various factors such as heavy metal contaminations. The fruit cultivar, temperature, pH, presence of oxygen and the time of processing were found to exert a great influence on colour stability of fruit products [21, 22]

The aim of the current research was to determine the chemical and physical properties and to investigate the degree of acceptance of pumpkin–rowanberry marmalade after different times of drying at a temperature of 50 ± 2 °C.

Materials and methods

The object of the research was pumpkin–rowanberry marmalade. The principal technological scheme of its preparation and drying is shown in Fig. 1. The pumpkin *Cucurbita maxima* and sweet rowanberry *Sorbus aucuparia* cultivar ‘Nevezhinskaya’ purées were the main raw material for the preparation of the marmalade. The rowanberry purée was made from frozen and defrosted rowanberries.

The dimensions of one piece of pumpkin–rowanberry marmalade was 90 mm × 70 mm × 20 mm and the mass 100 ± 5 g. Part of marmalade samples were dried at room temperature, i. e. 22 ± 2 °C, for 24 h as a control sample, and other samples were dried in convection oven HS 30 with air ventilation at a temperature of 50 ± 2 °C for 24, 48 and 56 h. Chemical (moisture, total carotene and ascorbic acid content), physical (hardness, colour $L^*a^*b^*$ values) and sensory analyses of the marmalade samples were carried out.

Moisture content was analyzed by the gravimetric method at a temperature of 97 ± 1 °C [23] using an oven TR60 (Naberthern) and analytical scales BP-210s (Sartorius) in three replications. The total carotene content was analysed by the spectrophotometric method at 440 nm [24] with petroleum ether (boiling temperature range 80–110 °C) and measured with a UV-VIS-NIR spectrophotometer UV-3100PC (Shimadzu) in 10 mm cuvettes. A total of 2–3 grams of homogenized marmalade was placed in a conic retort (100 ml) and 96 % ethanol (20 ml) was added, and then samples were stirred with a magnetic stirrer for 20 min. Then petroleum ether (25 ml) and water (1 ml) were 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 the graduating curve with $K_2Cr_2O_7$. The measurements were carried out in two replications for each sample.

The hardness (cutting force in N) of marmalades was determined with a Texture Analyser TA.XT.plus (Stable Micro Systems Ltd., Surrey, UK) and the measuring probe A/BC (butter cutter, can be used for soft samples; it is supplied together with the Texture Analyser) [25]. The maximum force required for sample compression was calculated as an average of 10 measurements.

The colour of marmalades was measured in the CIE $L^*a^*b^*$ colour system using a ColorTec-PCM/PSM

(Accuracy Microsensors Inc., USA). Ten random areas were measured, and the mean values were reported for each sample. In colour measurement, CIELAB coordinates show the degree of brightness (L), the degree of redness (+a) or greenness (-a), and the degree of yellowness (+b) or blueness (-b), respectively [26, 27].

In order to assess the consumer's acceptability of pumpkin–rowanberry marmalade hardness, the ranking

test (ISO 8587:2006 Sensory analysis – Methodology – Ranking) was used. The sensory analysis of pumpkin–rowanberry marmalade was performed at the 16th International Exhibition 'Riga Food 2011'. In the evaluation, 61 consumers (48 females and 13 males) took part; their mean age was 32 years.

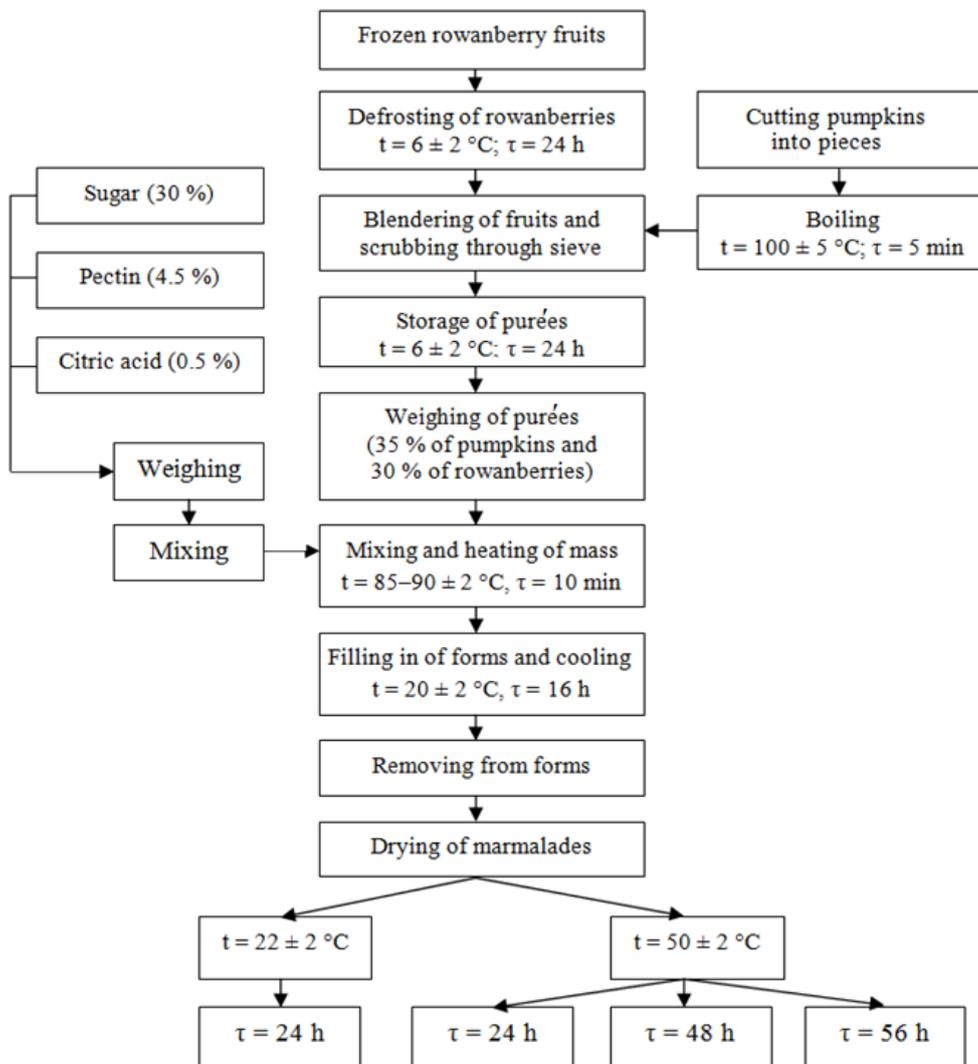


Fig. 1. The principal technological scheme of pumpkin–rowanberry marmalade preparation and drying

The results were processed by mathematical and statistical methods. The data were analysed using the statistical analysis of variance (ANOVA) and the Friedman test; significance was defined at $p < 0.05$.

Results and discussion

The chemical and physical parameters of the pumpkin–rowanberry marmalades dried at a temperature of 50 ± 2 °C for 24, 48 and 56 h and the values of control samples (marmalade dried at room temperature for 24 h – further in the text designated as marmalade samples dried at 50 ± 2 °C for 0 h) are given in Table 1.

The moisture content of pumpkin–rowanberry marmalade samples was found to have decreased by 7 %,

22 % and 26 % according to the drying time of samples, and there was a significant difference ($p = 0.000$) in the moisture content among the samples.

The total carotene content of pumpkin–rowanberry marmalade after drying at room temperature for 24 h was 3.31 ± 0.16 mg 100 g⁻¹ DW (see Table 1). After 24 hours of marmalade drying at 50 ± 2 °C, the total carotene content decreased by 14.6 %, but after the further drying there were no significant ($p = 0.06$) changes. Therefore, we can conclude that drying the samples at 50 ± 2 °C causes a fast decrease of carotenes content as soon as after 24 hours, but the further drying at the same temperature does not decrease the content of these pigments.

Table 1. Changes of pumpkin–rowanberry marmalade quality parameters during the drying of samples

Parameter	Drying time, h			
	0	24	48	56
Moisture, %	43.76 ± 0.12 ^a	39.80 ± 0.19 ^b	31.27 ± 0.05 ^c	29.11 ± 0.13 ^c
Total carotene content, mg 100 g ⁻¹ DW	3.31 ± 0.16 ^a	2.83 ± 0.07 ^b	2.82 ± 0.21 ^b	2.86 ± 0.04 ^b
Ascorbic acid content, mg 100 g ⁻¹ DW	14.75 ± 0.48 ^a	5.45 ± 0.21 ^b	3.68 ± 0.66 ^c	2.18 ± 0.46 ^c
Hardness, N	1.85 ± 0.09 ^d	5.82 ± 0.21 ^c	7.57 ± 0.63 ^b	9.54 ± 0.62 ^a

* Values marked with the same subscript letters in rows are not significantly different ($p > 0.05$).

Pumpkin–rowanberry marmalade samples showed a significant ($p = 0.000$) loss of ascorbic acid content during drying, which was 63–85 % depending on the drying time. The results indicated vitamin C oxidation during marmalade treatment and drying, because the product was subjected to heat treatment in the presence of air.

The hardness of the pumpkin–rowanberry marmalades varied from 1.85 to 9.54 N. The hardness of pumpkin–rowanberry marmalades after sample drying at 50 ± 2 °C for 24, 48 and 56 h increased 3, 4 and 5 times, respectively. Pearson’s correlation analysis was carried

out to compare the quality indicators of the pumpkin–rowanberry marmalades, and a negative correlation was determined between moisture and hardness ($p = 0.000$, $r = -0.968$). The hardness of marmalade samples was highly dependent on drying time, and the major reason for hardening was water vapour during drying.

The drying time of marmalade samples at 50 ± 2 °C for 24, 48 and 56 h significantly ($p = 0.000$) affected also the colour of pumpkin–rowanberry marmalade. The results of colour L* a* b* measurements are shown in Table 2.

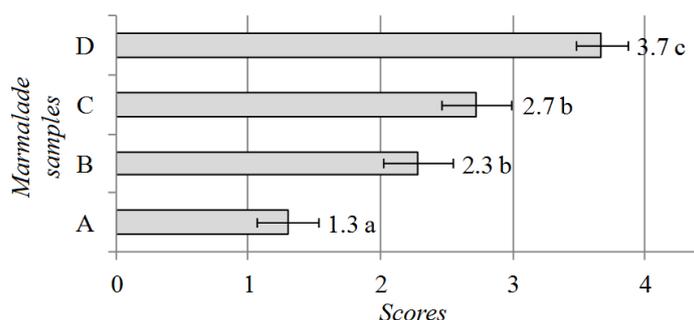
Table 2. The colour of pumpkin–rowanberry marmalades in CIE L* a* b* system

Drying time of marmalade	Colour values		
	L*	a*	b*
0 hours	36.31 ± 0.84 ^a	5.60 ± 0.55 ^b	29.25 ± 1.19 ^b
24 hours	36.02 ± 0.37 ^a	6.60 ± 0.32 ^a	33.42 ± 1.44 ^a
48 hours	33.38 ± 0.74 ^b	6.82 ± 0.27 ^a	29.66 ± 1.82 ^b
56 hours	32.66 ± 0.54 ^c	6.92 ± 0.29 ^a	28.00 ± 1.92 ^b

* Values marked with the same subscript letters are not significantly different ($p > 0.05$, Duncan).

The results showed that marmalade samples before drying were the lightest ($L^* = 36.31 \pm 0.84$), and during drying at 50 ± 2 °C they became darker, a little redder and yellowish. The darkest and the reddest colours were detected in the marmalade samples dried at 50 ± 2 °C for 56 hours. These colour changes seem to show the emerging of brown colour, the loss of colour quality.

The results of the analysis of variance (ANOVA) indicate that $F_{cal} = 101.0 > F_{crit} = 7.81$, so there are significant differences in the degree of hardness among the pumpkin–rowanberry marmalade samples. The results of hardness evaluation scores of the marmalades are summarized in Fig. 2.

**Fig. 2.** The pumpkin–rowanberry marmalade hardness ranking test results

* Values marked with the same subscript letters are not significantly different ($p > 0.05$).

Drying time of pumpkin–rowanberry marmalade samples at 50 ± 2 °C: A – 0 h; B – 24 h; C – 48 h; D – 56 h.

Results of the sensory evaluation of the pumpkin–rowanberry marmalade hardness showed that consumers found the softest sample to be marmalade dried at room temperature, while the hardest were samples dried at 50 ± 2 °C for 56 hours (see Fig. 1). Among marmalade

samples dried at 50 ± 2 °C for 24 and 48 hours, there were no significant differences ($p > 0.05$).

The summary of consumers’ questionnaires showed that the majority (i. e. 54 % of the respondents) preferred the softest pumpkin–rowanberry marmalade (i. e. samples

dried at room temperature), while some consumers (17 % of the respondents) liked the marmalade which was the hardest (see Fig. 3). Marmalades of a medium hardness

(dried at $50 \pm 2^\circ\text{C}$ for 48 hours) had the lowest acceptability.

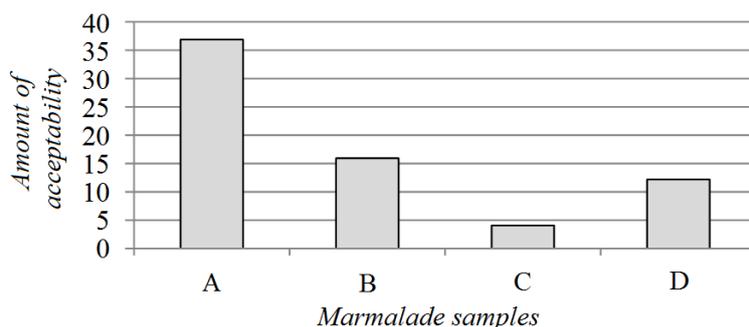


Fig. 3. The ranking of test results of pumpkin–rowanberry marmalade hardness
Drying time of pumpkin–rowanberry marmalade samples at $50 \pm 2^\circ\text{C}$: A – 0 h; B – 24 h; C – 48 h; D – 56 h.

The majority of consumers considered the marmalades dried at room temperature ($22 \pm 2^\circ\text{C}$) to be suitable for the preparation of pumpkin–rowanberry marmalade because of their softer texture.

Conclusions

1. The results of the research show a large variability ($p = 0.000$) of the physical and chemical parameters among pumpkin–rowanberry marmalades dried for different times. The moisture content varied from 29.11 to 49.60 % and hardness from 1.85 to 9.54 N.
2. The highest content of carotenes ($3.31 \text{ mg } 100 \text{ g}^{-1} \text{ DW}$) and ascorbic acid ($14.75 \pm 0.48 \text{ mg } 100 \text{ g}^{-1} \text{ DW}$) was detected in the marmalade dried at room temperature.
3. Consumers preferred the marmalade sample with the softest texture. Therefore, drying the product for 24 hours at room temperature could be recommended as the best way of the production of soft marmalades.

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ĮVAIRIAI DŽIOVINTO MOLIŪGŲ IR ŠERMUKŠNIŲ MARMELADO KOKYBĖS VERTINIMAS

S a n t r a u k a

Istoriškai marmeladai gaminami norint išsaugoti vaisius ir juos vartoti ne sezono metu. Marmeladai iš esmės yra vaisių tyrės ir cukraus, rūgšties ir pektino gelio produktas. Šio darbo tikslas – nustatyti įvairiai džiovinto moliūgų ir šermukšnių marmelado chemines ir fizikines savybes bei priimtinumą vartotojams.

Ekspimentai buvo atlikti Latvijos Žemės ūkio universiteto Maisto technologijos fakultete. Marmeladas pagamintas iš moliūgų *Cucurbita maxima* ir šermukšnių *Sorbus aucuparia* atmainos „Nevezhinskaya“ saldžios tyrės. Skirtingą laiką 50 ± 2 °C temperatūroje džiovinto marmelado savybės buvo lygintos su marmelado, džiovinto kambario temperatūroje, savybėmis. Marmelado mėginių kokybė vertinta nustačius drėgmės, bendro karotino, askorbo rūgšties kiekį, kietumą, spalvą ir priimtinumą vartotojams.

Tyrimų rezultatai parodė, kad skirtingą laiką džiovinto marmelado fizikiniai ir cheminiai parametrai labai svyruoja. Marmelado mėginių drėgmės kiekis sumažėjo nuo 9,1 iki 33,5 %, o kietumas padidėjo nuo 1,85 iki 9,54 N. Kambario temperatūroje džiovintas moliūgų ir šermukšnių marmeladas buvo priimtinausias vartotojams.