INTRODUCTION

Growing interest in natural food ingredients exhibiting beneficial effects on human health has been an important factor in expanding the studies of less common horticultural plants in recent years (Jordheim et al., 2007; Gruenwald, 2009; Kraujalytë et al., 2012). Plants belonging to the genus Viburnum have more than 230 species of shrubs and trees, which are grown mainly as decorative plants. The majority of the genus Viburnum species are endemic. For example, V. opulus, the most common species in Europe, occurs in western, central, eastern, and north eastern European regions, and it also grows in northern Asia; V. opulus var. sargentii is native to the Far East in Korea, Northern China, and Japan (Bae et al., 2010; Česoniene et al., 2010; Kraujalytë et al., 2012). There are several common English names of V. opulus used in various literature sources: European cranberry bush, snowball tree, guelder rose, squawbush, cramp bark (Velioglu et al., 2006; Zayachkivska et al., 2006; Česoniene et al., 2010; Kraujalytë et al., 2012).

The fruits have been used to treat high blood pressure, heart troubles, tuberculosis, shortness of breath, stomach pain, digestive troubles, duodenal ulcers and bleedings, kidney and bladder affections, coughs, and colds (Velioglu et al., 2006; Zayachkivska et al., 2006; Bae et al., 2010; Česoniene et al., 2010; Kraujalytë et al., 2012). They also have been used in foods in Europe and Asia, mainly as an ingredient in sauces, jellies, marmalades, and drinks (Velioglu et al., 2006; Rop et al., 2010; Kraujalytë et al., 2012).

V. opulus fruits contain high amounts of polyphenolics (Česoniene et al., 2008; Rap et al., 2010; Kraujalytë et al., 2012), ascorbic acid (Česoniene et al., 2008; Česoniene et al., 2010; Rop et al., 2010; Kraujalytë et al., 2012) and L-malic acid (Çam and Hişil, 2007; Kraujalytë et al., 2012). Berry juice was reported to be rich in chlorogenic acid, amounting to 54% of the total phenolic content (Velioglu et al., 2006; Kraujalytë et al., 2012), which is higher than in some more widely consumed juices and nectars (Çam & Hişil, 2007; Kraujalytë et al., 2012). The berries have been also reported as a source of flavonoids, including (+)-catechin and (−)-epicatechin, quercetin glycosides (Velioglu et al., 2006; Kraujalytë et al., 2012) and proanthocyanidins (Zayachkivska et al., 2006; Kraujalytë et al., 2012). Several anthocyanins have been identified in...
V. opulus berries with cyanidin-3-glucoside being the most important representative of this class of compounds (Deineka et al., 2005; Velioglu et al., 2006; Jordheim et al., 2007; Kraujalytë et al., 2012). In addition, they contain carotenoids (Gavrilin et al., 2007; Ėesonienë et al., 2008; Kraujalytë et al., 2012). The high concentration of phenolics is correlated with strong radical scavenging capacity of V. opulus extracts (Çam and Hişıl, 2007; Ėesonienë et al., 2008; Kraujalytë et al., 2012). Plant phenolic compounds are responsible for the organoleptic and health promoting properties of plant products (Kraujalytë et al., 2012). Phenolics, the products of secondary metabolism of plants, are also partly responsible for the colour and the taste of the plant (Duthie et al., 2000; Yao et al., 2004; Karaçelik et al., 2015).

The genus Cucurbita within the family Cucurbitaceae comprises five domesticated species, three of which, C. pepo L., C. maxima Duchesne, and C. moschata Duchesne, represent economically important species cultivated worldwide. The other two domesticated species, C. huber and C. ficifolia Bouché, have more limited cultivation (Loy, 2011).

Cucurbita moschata is a seasonal crop that has been used traditionally both as human and animal feed. C. moschata is eaten as a vegetable and cultivated for its young shoots, fleshy, edible flowers, and above all, for its fruits. There are numerous culinary uses of this crop, either as a vegetable or as an ingredient in food preparations like pies, soups, stews, breads (Noelia et al., 2011).

The nutritional value of pumpkin fruits is high but varies from one species or cultivar to another. Thus, in the fresh mass of the fruit, the total concentration of carotenoids, a major contributory factor in the high nutritional value of pumpkins, ranges from 2 to 10 mg·100 g⁻¹, the content of vitamins C and E accounting for 9–10 mg·100 g⁻¹ and 1.03–1.06 mg·100 g⁻¹, respectively (Assous et al., 2014).

Pumpkin fruit is also a valuable source of other vitamins like K, B1, B2, and B6 as well as minerals, for example, K, F, Mg, Fe, and Se (Assous et al., 2014).

The main advantage of using vacuum treatments such as sous vide (SV) and cook-vidé (CV) is the absence of oxygen and the use of temperatures below 100 °C, causing less damage to thermolabile compounds, which can improve the final quality. Moreover, lower temperatures promote higher flavor retention of fresh produce, lower production of acrylamide, and higher retention of pigments (Iborra-Bernad et al., 2014).

CV has been applied in haute cuisine restaurants from the beginning of its development. CV emplys cooking in boiling water at temperatures below 100 °C by lowering the pressure to reach the vapour pressure of water. The low pressure is maintained during the total cooking time by the continuous function of a pump. There have been few studies on the application of this technique in cooking vegetables and fruit with water. Unlike SV treatments, CV products are cooked in direct contact with water boiling at temperatures lower than 100 °C, by increasing the surface heat transfer coefficient (Iborra-Bernad et al., 2014; Martínez-Hernández et al., 2013).

Vacuum-based cooking treatments have been observed to induce higher microbial reduction (mainly sous vide microwaving) for kailan-hybrid broccoli, compared to conventional cooking (Martínez-Hernández et al., 2013). Moreover, vacuum-based cooking showed better sensory scores (mainly sous vide microwaving) and allowed to reach a moderate softening of the broccoli stem accompanied by a pleasant juiciness with a slight and nice crispness. Cooking treatments, in general, increase the total phenolic concentration and the correlated total antioxidant capacity, especially for microwaved samples. However, increased total phenolic content and antioxidant capacity was not observed among conventional and vacuum-based treatments; in contrast, the total vitamin C concentration after cooking decreased, showing that vacuum boiling had the best retention, compared to conventional boiling, which showed the lowest concentration (Martínez-Hernández et al., 2013).

The aim of the study was to examine the suitability of heat treatment methods on retention of bioactive compound concentrations in pumpkin–guilder rose sauce.

**MATERIALS AND METHODS**

**Ingredients.** Pumpkin–guilder rose sauce was made from pumpkin puree and gueelder rose juice in concentrations (74.5% puree and 13.1% juice) with addition of salt, sugar, and citric acid according to the recepe showed in Table 1. All of the additives before adding to the essential ingredients were finely chopped to homogeneous consistency.

The prepared pumpkin–guilder rose sauces were vacuum cooked under two modes:

1. 0.6 bar pressure, temperature 85 ± 1°C for 15 min;
2. 0.2 bar pressure, temperature 75 ± 1°C for 15 min.

Freshly prepared (no thermal treatment) and sauce samples cooked in atmospheric conditions were also prepared for

| Table 1 |

**PUMPKIN–GUELDER ROSE SAUCE RECIPE**

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Quantity as percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumpkin puree</td>
<td>74.5</td>
</tr>
<tr>
<td>Guilder rose juice</td>
<td>13.1</td>
</tr>
<tr>
<td>Salt</td>
<td>0.7</td>
</tr>
<tr>
<td>Sugar</td>
<td>10</td>
</tr>
<tr>
<td>Citric acid</td>
<td>0.5</td>
</tr>
<tr>
<td>Dried garlic powder</td>
<td>0.2</td>
</tr>
<tr>
<td>Dried rosemary</td>
<td>0.2</td>
</tr>
<tr>
<td>Pepper</td>
<td>0.2</td>
</tr>
<tr>
<td>Cumin</td>
<td>0.2</td>
</tr>
<tr>
<td>Bay leaves</td>
<td>0.2</td>
</tr>
<tr>
<td>Allspice</td>
<td>0.2</td>
</tr>
</tbody>
</table>
comparison. Samples cooked at atmospheric pressure were boiled in a water bath at temperature 95 ± 1°C for 15 min.

**Total carotenoids.** Carotenoid concentration was determined by a spectrophotometric method (UV/VIS spectrophotometer, Jenway 6705, Bibby Scientific Ltd., UK), at 440 nm described by (Kampuse et al., 2012). The concentration of carotenoids (mg·100 g⁻¹) was calculated by equation (1):

\[
X = \frac{0.208 \times 25 \times KE}{36 \times a}
\]

where: coefficients 0.208 and 36 define the relationship between \( K_2Cr_2O_7 \) and carotenoid concentration;

\( KE \) – carotene equivalent from graduation curve;

\( a \) – sample weight, g (Kampuse et al., 2015).

**Vitamine C.** Concentration of L-ascorbic acid, the reduced form of ascorbic acid, was determined by the iodine method T-138-15-01:2002 (Segliņa, 2007).

**Total phenol content.** Total phenolic concentration was determined according to the Folin–Ciocalteu method (Yu et al., 2003) with modifications:

1. To 0.5 ml of extracted sample, 2.5 mL 0.2N Folin–Ciocalteu reagent was added, which was diluted ten times with distilled water;

2. After 5 min, 2.0 ml 7.5% NaCO₃ was added;

3. The resulting solution was mixed and allowed to stand for 30 min at 18 ± 1 °C in the dark;

4. Absorbance was read at 760 nm using a JENWAY 630 Spectrophotometer (Priečiņa et al., 2014).

Total phenolic concentration was expressed as milligrams of gallic acid equivalent per 100 g per dry weight (GAE mg·100 g⁻¹).

**Antiradical scavenging activity.** The antiradical scavenging activity of extracts was determined by reaction with stable 2,2-diphenil-1-pircylhydrazyl (DPPH) free radical according to Yu et al. (2003) with modifications:

1. To 0.5 ml of extracted sample, 3.5 ml freshly made DPPH solution (4 mg of DPPH reagent was dissolved in 100 ml pure ethanol) was added;

2. The mixture was shaken and kept in the dark at 18 ± 1 °C for 30 min;

3. Absorbance was measured at 517 nm using a JENWAY 630 Spectrophotometer (Priečiņa et al., 2014).

The antiradical scavenging activity was expressed as micromolar equivalents of Trolox per 100 g dry weight (mM TE·100 g⁻¹).

**Total anthocyanins.** 20.00 g samples were taken in two replicates, to which 40 ml of previously prepared ethyl alcohol + 1.5 HCl solution was added. The mixture was ground in a blender for 1 min, filtered through filter paper, and precipitated three times by washing with 3*10 ml etanol and 1.5 ml HCl solution (total 30 ml). The resulting extract was further analyzed with a Jenway 6705 spectrophotometer at wavelength 535 nm. The samples were diluted with ethyl alcohol+1.5M HCl solution to achieve an absorption coefficient within the range of 0.6 to 0.8. Anthocyanins concentration of the sample was calculated using equation (2) (Moor et al., 2005):

\[
C = \frac{A \times v \times 1000}{980 \times m}
\]

where: A – absorption coefficient

\( v \) – extract total volume (90)

\( d \) – dilution

\( m \) – sample weight (g) (Moor et al., 2005).

For analysis of total carotenoids, anthocyanins, phenols and antiradical scavenging activity, two product replicates and two chemical replicates were used, except for vitamin C, where one chemical replicate was used. Mean concentrations were calculated.

**RESULTS**

Several pumpkin sauces (experimental samples) were prepared using different cooking methods and two guelder rose hybrids and one variety and the properties of the sauces were compared. Freshly mixed samples, and those cooked under atmospheric conditions and in vacuum under two different modes were compared. All of concentrations were calculated per dry matter, as the most effective comparison method for samples with different moisture content.

The highest concentration of total carotenes was found in control samples (cooked under atmospheric pressure in a water bath), which reached up to 8.78 mg·100 g⁻¹ dry weight; fresh sauce samples that were not cooked had the smallest total carotene content (Table 2). The highest guelder rose of carotines was observed in S3 samples prepared under vacuum (6.61 mg·100 g⁻¹ dry weight), while the sample preparation under vacuum cooking did not significantly affect the total carotines concentration, compared to the control samples.

Statistically no significant difference was found between the total carotene concentration of the hybrids/variety, but was observed between the type of treatment (\( p < 0.05 \)).

In contrast to the total carotene concentration, where cooking under vacuum had a positive effect in product, the concentration of ascorbic acid (Fig. 1) was significantly lower in all samples after heat treatment. There was a significant difference in the concentration of vitamin C among the sauce samples (\( p < 0.05 \)). The S1 samples with hybrid 2-30-K fruits had the highest ascorbic concentration, but af-
After the heat treatment the concentration was preserved better in the S3 samples with variety ‘Krasnaya Grozdj’ fruits (Fig. 1). Also a significant difference was found between fresh and heat-treated samples, and between control samples and vacuum cooked samples ($p < 0.05$), but there were no significant differences between the vacuum cooking modes ($p > 0.05$). Table 2 shows total phenol concentration in sauce samples. As in the concentration of the other compounds, there was difference in total phenol concentration between treatments, with the lowest in the control samples, and somewhat less difference in vacuum cooked samples.

There was also a significant difference between the treatment methods on the ascorbic acid concentration ($p < 0.05$). There was a significant difference in concentration of total phenols between fresh samples and samples treated under heat, but not between vacuum cooking modes. Sauces prepared under vacuum had higher total phenol concentration. Treatment S2 prepared at 0.6 bar had a higher total phenol content (889.704 GAE mg·100 g$^{-1}$ dry matter) than in the fresh sample (983.119 GAE mg·100 g$^{-1}$ in dry matter), while in other samples the total phenol concentration after heat treatment was lower (Table 2). There was a significant difference between the total phenolic concentration depending on the hybrid/variety of guelder rose were used; S1 sauces had the highest total phenol concentration and variety ‘Krasnaya Grozdj’ sauce S3 had the lowest ($p < 0.05$). The largest antiradical activity changes (Table 2) were found in control samples, and cooking under vacuum had less affect, although there was no significant difference between the two vacuum processing modes ($p < 0.05$). The biggest change occurred in samples S3: fresh sauce sample antiradical activity was 246.96 mMTE·100 g$^{-1}$ dry matter, while samples prepared at 0.2 bar had only 152.51 mMTE·100 g$^{-1}$ dry matter. In the same mode, in sample S1 the antiradical activity was higher (218.36 mMTE·100 g$^{-1}$ dry matter), but no significant difference between these samples was found ($p > 0.05$).

Similarly to the changes of vitamin C (Fig. 1), a significant difference of anthocyanin concentration (Table 1) was observed between fresh and heat-treated samples, and between control samples and vacuum cooked samples ($p < 0.05$), but there were no significant differences between the vacuum cooking modes ($p > 0.05$).

![Fig. 1. The concentration of vitamin C in different pumpkin–guelder rose sauce samples. S1 sauces made from guelder rose fruit hybrid 2 30 K; S2 sauces made from guelder rose fruit hybrid 2 45 K; S3 sauces made from guelder rose fruit variety Krasnaya Grozdj. Type of treatment and sample, marked with the same letter shows that there are no significant differences between the evaluated samples ($p > 0.05$)](image-url)

Table 2 shows total phenol concentration in sauce samples. As in the concentration of the other compounds, there was difference in total phenol concentration between treatments, with the lowest in the control samples, and somewhat less difference in vacuum cooked samples.

### Table 2

<table>
<thead>
<tr>
<th>Type of treatment</th>
<th>Sample</th>
<th>Total carotenes (mg·100 g$^{-1}$)</th>
<th>Total phenols (GAE mg·100 g$^{-1}$)</th>
<th>Anthocyanins (mg·100 g$^{-1}$)</th>
<th>Antiradical activity (mM TE mg·100 g$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh</td>
<td>S1</td>
<td>5.24 ± 0.13c</td>
<td>1385.11 ± 32.39a</td>
<td>28.15 ± 2.66c</td>
<td>203.23 ± 6.14a</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>6.10 ± 0.03c</td>
<td>889.70 ± 26.49a</td>
<td>22.76 ± 0.56c</td>
<td>193.08 ± 28.39a</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>6.61 ± 0.50c</td>
<td>864.70 ± 27.01a</td>
<td>25.64 ± 0.71c</td>
<td>246.97 ± 6.61a</td>
</tr>
<tr>
<td>Control</td>
<td>S1</td>
<td>8.78 ± 0.12a</td>
<td>800.74 ± 36.85b</td>
<td>17.24 ± 0.71d</td>
<td>167.73 ± 13.95b</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>7.80 ± 0.01a</td>
<td>631.92 ± 13.87b</td>
<td>13.12 ± 1.33d</td>
<td>135.04 ± 13.74b</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>8.41 ± 0.01a</td>
<td>646.99 ± 12.97b</td>
<td>13.85 ± 0.13d</td>
<td>167.21 ± 29.48b</td>
</tr>
<tr>
<td>0.6 bar pressure</td>
<td>S1</td>
<td>7.74 ± 0.25a,b</td>
<td>985.377 ± 16.65c</td>
<td>21.38 ± 1.16c</td>
<td>193.26 ± 0.25c</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>7.75 ± 0.08a,b</td>
<td>983.119 ± 45.20c</td>
<td>15.57 ± 0.11e</td>
<td>194.18 ± 7.38c</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>8.10 ± 0.07a,b</td>
<td>805.088 ± 31.16c</td>
<td>14.11 ± 0.12e</td>
<td>187.04 ± 19.01c</td>
</tr>
<tr>
<td>02 bar pressure</td>
<td>S1</td>
<td>7.54 ± 0.31b</td>
<td>1080.96 ± 41.12c</td>
<td>20.07 ± 0.57e</td>
<td>218.36 ± 6.02c</td>
</tr>
<tr>
<td></td>
<td>S2</td>
<td>7.77 ± 0.99b</td>
<td>836.14 ± 21.49c</td>
<td>16.31 ± 0.09e</td>
<td>180.24 ± 18.70c</td>
</tr>
<tr>
<td></td>
<td>S3</td>
<td>7.95 ± 0.75b</td>
<td>778.81 ± 74.75c</td>
<td>17.04 ± 0.06e</td>
<td>152.52 ± 4.57c</td>
</tr>
</tbody>
</table>

S1 sauces made from guelder rose fruit hybrid 2 30 K; S2 sauces made from guelder rose fruit hybrid 2 45 K; S3 sauces made from guelder rose fruit variety Krasnaya Grozdj. The same added letter to numbers show that there are no significant differences between the evaluated samples ($p > 0.05$) depending on the type of treatment.
served depending on the type of the heat treatment ($p < 0.05$). In samples prepared under vacuum a higher content of anthocyanins was found than in the control samples, but less than in fresh sauce samples, while no significant difference between the vacuum processing modes was found.

A significant difference in the average anthocyanin concentration was between sauce samples prepared with different hybrids/variety of guelder rose fruits. The highest concentration of anthocyanins was found in hybrid 2-30-K fresh sample S1 2 (8.15·100 g$^{-1}$ dry matter), also processing (0.6 bar – 21.37 mg·100 g$^{-1}$ dry matter) (Table 1).

**DISCUSSION**

The results of the study on higher total carotene content in sauce samples cooked in atmospheric conditions than in raw sauce samples are not supported by the literature, and explanation of the changes that occurred in the chemical composition of sauces is lacking.

Product processing under vacuum compared to conventional heat treatment is much less aggressive on plant-based product cells containing bioactive compounds, including anthocyanins, as lower processing temperatures are used (Iborra-Bernad et al., 2015; Martínez-Hernández et al., 2013), while processing at temperature above 70 °C is able to significantly reduce both vitamin C and anthocyanin and other bioactive compound concentration of the products (Galoburda et al., 2012).

In a previous study (Martínez-Hernández et al., 2013) on innovative cooking techniques for improving the overall quality of Kailan-Hybrid broccoli, it was also concluded that vacuum-based cooking treatments generally showed better microbial, physical and sensory quality, preserving, or even improving, antioxidant concentration compared to conventional methods (Martínez-Hernández et al., 2013).

**CONCLUSIONS**

It can be concluded that there was no significant difference in the chemical composition of the sauces depending on the vacuum treatment regime, but this type of treatment provides better preservation of concentrations of vitamin C, total phenols, anthocyanins and antiradical activity of the product compared with product boiling at atmospheric pressure.

The best experimental results were obtained by vacuum cooking at 0.2 bar pressure of sauces prepared with variety ‘Krasnaya Grozdj’. This sample had the highest vitamin C concentration (39.71 mg·100 g$^{-1}$ dry matter).

**ACKNOWLEDGEMENTS**

*Studies have been carried out with the National Research Programme “Sustainable Agricultural Resources of High Quality and Healthy Food Production in Latvian (AgroBioRes) (2014–2017)”, Project No. 4 “Local agricultural resource, sustainable use of high-quality and healthy food product development (FOOD) framework”.*

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Received 13 November 2016
Accepted in the final form 23 November 2017


TERMISKĀS APSTRĀDES METOŽU IETEKME UZ ŅĪRBJU–IRBEŅU (VIBURNUM OPULUS) MĒRČU UZTURVIELO SASTĀVU

Pētījuma mērķis ir izpētīt termiskās apstrādes metožu piemērotību ņīrļju–irbeņu mērču bioaktīvo savienojumu saglabāšanās spējai. Šīm nolūkām izvēlēti augļu hibridi 2-30-K; 2-45-K un irbeņu šķirme ‘Krasnaja Grozd’. Izmantojot šo ogu sulas, tika izveidoti ņīrļju–irbeņu mērču paraugi, kur ņīrļju biezėņu un irbeņu ogu sulas attiecība 74,3 : 13,1 un veikta to termiskā apstrāde atmosfēras spiedienā (tradicionālā varīšana) un vakuumā attīrājot režīmos 0,6 bar 85 °C un 0,2 bar 75 °C temperatūrā, visi paraugi salīdzināti ar termiski neapstrādātu ņīrļju–irbeņu šķirmes paraugu. Veicot ņīrļju–irbeņu mērču ķīmisko izvērtējumu, tika novērota labāka C vitamīna saglabāšanās 0,2 bar spiedienā vārītā irbeņu šķirnes ‘Krasnaja Grozd’ mērču paraugu salīdzinājumā ar svaigā paraugu esošā C vitamīna daudzumu, pārējāsī no sausuma. Vakuumā varīšanas katlā sagatavošies mērču paraugi sausnā videjā uzzraudzītā lieāku kopējo fenolu, antiradikālās aktivitātes un ņīrļju–irbeņu mērču anticīnu saturu slēkšanu. Šīs izmaiņas sakrīt ar literatūras sniegto informāciju par labāku bioaktīvo savienojumu saglabāšanos augu valsts produktos, kas sagatavoī augu valsts produktos, kas sagatavoī vakuumā pie zemākām termiskās apstrādes temperatūrām.

Received 13 November 2016
Accepted in the final form 23 November 2017