CHEMICAL COMPOSITION OF HIGHBUSH BLUEBERRY CULTIVARS
KRŪMMELLEŅU ŠĶIRŅU ĶĪMISKAIS SASTĀVS

Solvita Kampuse[1], Elga Šnē[1], Dace Šterne[2], Inta Krasnova[3]
[1] Faculty of Food Technology, Latvia University of Agriculture (LLU), Liela Street 2, Jelgava, Latvia,
e-mail: skampuse@inbox.lv
[2] Faculty of Agriculture, LLU, Jelgava, Latvia
[3] The Latvia State Fruit Growing Institute, Graudu 1, Dobele, Latvia

Abstract
The breeding of blueberries has expanded so far that now the number of the highbush blueberry cultivars has reached several hundreds, and sixty of them are particularly widespread. The chemical composition and suitability for the processing of highbush blueberries has been researched quite extensively, mostly in the USA, but there are no such studies and data for blueberries grown in Latvia. Therefore the aim of this investigation was to compare the biochemical composition of different highbush blueberry cultivars grown in Latvia.

The experiments were done at the Faculty of Food Technology, Latvia University of Agriculture (LLU), Jelgava, and at the Latvia State Fruit Growing Institute, Dobele during the year 2008. The samples of highbush blueberry cultivars were collected from the blueberry collection of Institute of Agrobiotechnology (LLU). The contents of titratable acids, soluble solids, ascorbic acid, total phenols, and anthocyanins of frozen fruits of the highbush blueberry cultivars 'Northland', 'Spartan', 'Barkeley', Duke', 'Chippewa', 'Bluecrop', 'Jersey', 'Blueray', 'Chandler', and 'Bluejay' were analysed.

The cultivars ‘Northland’ and 'Chippewa' had the highest anthocyanin content (on average 297.59 and 288.83 mg 100 g^{-1}, respectively), the highest phenol content was detected in highbush blueberry cultivar 'Spartan' (on average 381.14 mg 100 g^{-1}), the highest content of ascorbic acid was in cultivar ‘Bluejay’ (on average 11.8 mg 100 g^{-1}), the highest titratable acids content in the berries of the cultivar ‘Chandler’ (1.35 %), and the cultivar with the highest soluble solids content was ‘Duke’ (on average 12.99 % soluble solids).

Kopsavilkums
Melleņu audzēšana jau ir izplatījusies tādā apmērā, ka uz doto brīdi krūmmelleņu šķirņu skaits jau ir sasniedzis vairākus simtus un sešdesmit no tām ir plaši izplatītas. Krūmmelleņu ķīmiskais sastāvs un piemērotība pārstrādei tiek intensīvi pētīta – visvairāk ASV, bet pagaidām nav tādu pētījumu un datu par Latvijā audzētajām krūmmellenēm. Pētījuma mērķis bija salīdzināt dažādu Latvijā audzēto krūmmelleņu šķirņu bioķīmisko sastāvu.

Eksperimenti tika veikti Latvijas Lauksaimniecības universitātes Pārtikas tehnoloģijas fakultātē un Latvijas Valsts Augļkopības institūtā 2008. gadā. Krūmmelleņu šķirņu paraugi tika ievākti no Agrobiotehnoloģijas institūta (LLU) kolekcijas. Šķirņu 'Northland', 'Spartan', 'Barkeley', Duke', 'Chippewa', 'Bluecrop', 'Jersey', 'Blueray', 'Chandler' un 'Bluejay' paraugiem tika analizētas titrējamās skābes, šķīstošā sausna, askorbīnskābe, kopējie fenoli un antociāni.

Šķirņu ‘Northland’ un ‘Chippewa’ paraugiem tika konstatēts augstākais antociānu saturs (vidēji 297.59 un 288.83 mg 100 g^{-1}). Augstākais kopējo fenolu saturs noteikts šķirnes 'Spartan' paraugam (vidēji 381.14 mg 100 g^{-1}), augstākais askorbīnskābes saturs bija škirnei ‘Bluejay’ (vidēji 11.8 mg 100 g^{-1}). Augstākais titrējamo skābju saturs bija šķirnes ‘Chandler’ (1.35 %) paraugam, un šķirne ar augstāko šķīstošās sausnas saturu bija ‘Duke’ (vidēji 12.99 % šķīstošās sausnas).

Key words: *Vaccinium corymbosym*, ascorbic acid, soluble solids, phenols, anthocyanins, titratable acids

Introduction

The highbush blueberries (family *Ericaea*, genus *Vaccinium corymbosym*) are a relatively novel shrub berry crop. In the early 1900’s two enthusiasts - Elizabeth White and Dr. Frederick Coville - aspired to domesticate the wild blueberries. Their efforts and selection work by plant breeders and and pathologists has created nowadays plump, juicy, sweet and easy-to-pick cultivated blueberries.

The major growing areas of highbush blueberries are in the United States (in more than 38 states) and in some provinces in Canada; gradually they are being propagated all around the world - South America, Australia and New Zealand, and Europe (US Highbush Blueberry Council, 2009).

The popularity and demand of blueberries is growing increasingly due to the demand for their bioactive compounds (polyphenolics, pectic acids, ascorbic acid, carotenes and others) and their antioxidant activity (Sinelli *et.al.,* 2008).

Blueberries contain polyphenols in high quantities: the antocyanins (cyanidin, delphinidin, malvidin, peonidin, petunidin), flavonoids (cathechin and epicatechin, myricetin, quercetin and kaempferol), phenolic acids (ellagic acid, benzoic and cinnamic acid) and others. The content and composition of polyphenolics depends on the growing conditions, cultivating methods, maturity at harvest and other conditions (Giovanelli *et.al.* 2009; Giovanelli *et.al.* 2002; US Highbush Blueberry Council, 2009). Giovanella *et.al.* (2009) reported concentrations of total phenolics and total antocyanins, accordingly from 250 to 310 mg $100g^{-1}$ and from 92 to 126 mg 100 g^{-1}. These data are similar with those reported Prior *et.al.* (1998): total phenolics from 233 to 273 mg *100 g^{-1} and antocyanins from 62 to 157 mg 100 g^{-1}.

Antioxidants help to protect the body against free radicals caused damage, diseases and accelerated aging. The USDA Human Nutrition Research Center on Aging (Boston, MA) has stated that blueberries have the highest antioxidant activity among fruits. They used a test called ORAC (oxygen radical absorbance capacity), which determines the antioxidant capacity of foods, and showed that fresh blueberries the ORAC is 2400 per 100 grams and that is more than other fresh fruits and vegetables (for example, the blackberry ORAC is 2000 to 100 g^{-1}, strawberry - 1500 to 100 g^{-1}, apple 400 to 100 g^{-1} (Prior *et.al.,* 1998; Cao *et.al.,* 1998).

Beaudry (1992) has suggested highbush blueberries quality standards: >10 % soluble solids content (SSC), 0.3 – 1.3 % titratable acidity (TA), pH between 2.25 and 4.25 and SSC/TA ratio between 10 and 33.

Saftner *et. al.* (2008) explored the 11 most popular varieties of highbush blueberries (‘Chanticleer’, ‘Duke’, ‘Hannah’s Choice’, ‘Weymouth’, ‘Berkeley’, ‘Bluecrop’, ‘Bluegold’, ‘Coville’, ‘Elliott’ un ’Lateblue’) and concluded that their soluble solids content (SSC) differs from 10.6 – 13.2 %; varieties which SSC is the lowest are ‘Lateblue’, ‘Coville’ and ‘Duke’ (accordingly 10.6; 10.8 and 10.9), but highest are - ‘Chanticleer’ (13.0) and ‘Bluegold’ (13.2). The difference in titratable acidity (expressed as citric acid) among cultivars is large: ‘Coastal’ had only 0.35 % of the acid, whereas ‘Lateblue’ and ‘Elliott’ has a two times larger amount 1.22 – 1.27 %. Fruit pH ranged between 2.5 to 3.4 where the two last of mentioned varieties had a pH 2.5, but the ‘Bluegold’, ‘Bluecrop’, ‘Berkeley’, ‘Hannah’s Choice’ and ‘Chanticleer’ had the highest pH 3.1 – 3.4. All cultivars have these above mentioned Beaudry (1992) standards excepting three - ‘Coastal’, ‘Elliott’ and ‘Lateblue’ (Saftner *et.al.,* 2008).

Another autor (Giovanelli *et.al.,* 2009) studied the blueberries cultivars ‘Goldtraube’, ‘Patriot’, Bluecrop’ and ‘Darrow’. These varieties agree with Beaudry (1992) suggested standards in regard to pH which is 2.90 – 3.15, but the titratable acidity (expressed as citric acid) is higher – from 1.15 (‘Goldtraube’) to 1.47 % (‘Bluecrop’).

Due to their chemical content, blueberries are acknowledged as very healthy food and are sold not only fresh but also in jams, as blueberry juice and they can also be canned, frozen and dried, and producers are still looking for the new processing techniques.

The breeding of blueberries has expanded so far that now the number of the highbush blueberry cultivars has reached several hundreds, and sixty of them are particularly widespread. (Augļi un ogas Latvijā mūsdienu augļu dārzā, 2008).

The chemical composition and suitability for processing for highbush blueberries has been researched quite extensively, mostly in USA, but there are no similar studies and data of blueberries grown in Latvia.

Therefore the aim of this investigation was to compare the biochemical composition of different highbush blueberry cultivars grown in Latvia.

Materials and methods

The experiments were done at the Faculty of Food Technology, Latvia University of Agriculture (LLU), Jelgava, and at the Latvia State Fruit Growing Institute, Dobele. The samples of highbush blueberry cultivars were collected from the blueberry collection (7 years old bushes) of the Institute of Agrobiotechnology (LLU), Jelgava.

The samples were analyzed after freezing. After harvesting the blueberries were sorted, frozen in the freezer PORKKA BF 710 at a temperature of -25±2 °C, then packaged and stored for one month in the freezer chamber VTK 201 U at a temperature of -20±2 °C.

The contents of titratable acids, soluble solids, ascorbic acid, the total phenols, and anthocyanins of frozen fruits of highbush blueberry cultivars 'Northland', 'Spartan', 'Barkeley', Duke', 'Chippewa', 'Bluecrop', 'Jersey', 'Blueray', 'Chandler', and 'Bluejay' were analysed.

The content of *ascorbic acid* was determined by titration with a 0.05-M iodine solution (Moor *et al.*, 2005). 25 g of berries were doused with a 100 ml of 6 % solution of oxalic acid and homogenized for 1 minute. Then the sample was filtered. 2 ml of 1 % solution of starch was added to10 ml of filtrate and the filtrate was titrated until a change of colour, which does not disappear during 30 seconds. The content of ascorbic acid mg per 100 g of berries was calculated from the following equation [1]:

$$C = 400 \cdot \frac{V_{sample}}{V_{s\tan dard}}, \qquad [1]$$

where V_{sample} – volume of the iodine solution titrated in a sample, ml;
$V_{standard}$ – volume of the iodine solution titrated in a standard solution, ml.

Total titratable acids were determined by titration with 0.1 N NaOH (ISO 750:1998) in fresh and frozen berries.

The contents of the soluble solids were determined by refractometer (ISO 2173:2003) in fresh and frozen berries.

Total phenol content was determined by the photometric method with Folin-Ciocalteau reagent (Singleton *et al.*, 1999). For analyses of phenols the Folin-Ciocalteau reagent and 4 ml 7.5 % sodium carbonate was used. After 30 minutes the samples were analyzed with a spectrophotometer at a wave length of 765 nm. As a control solution 1 ml water with 5 ml Folin-Ciocalteau reagent and 4 ml 7.5 % sodium carbonate solution was used. The content of phenols was calculated from formula [2]:

$$X = \frac{C}{a \cdot 10}, \qquad [2]$$

where C – content of phenols, mg 100 g^{-1};
a – the amount of analyzed sample, g.

The results of all analyses were recalculated to 100 g of dry weight.

Total anthocyanins were determined by the spectrophotometric method (Moor *et al.*, 2005). Initially 50 g of berries were homogenized. Then 20 g of this volume was doused with 40 g of ethanol and 1.5 M HCl solution (85:15 by volume) and homogenized for 1 minute. Then the sample was filtered, and light absorption at 535 nm was detected with a spectrophotometer. The sample was diluted until the absorption coefficient was between 0.6 and 0.8. The content mg per 100 g was calculated with the equation [3]:

$$C = \frac{A \cdot v \cdot d \cdot 1000}{980 \cdot m}; \qquad [3]$$

where A – absorption coefficient;
v – volume of the extraction (90);
d – dilution;
m – sample weight in g.

Results and Discussion

The total anthocyanins of highbush blueberry cultivars differed between 59 and 119 mg 100 g^{-1} of fresh weight (Figure 1).

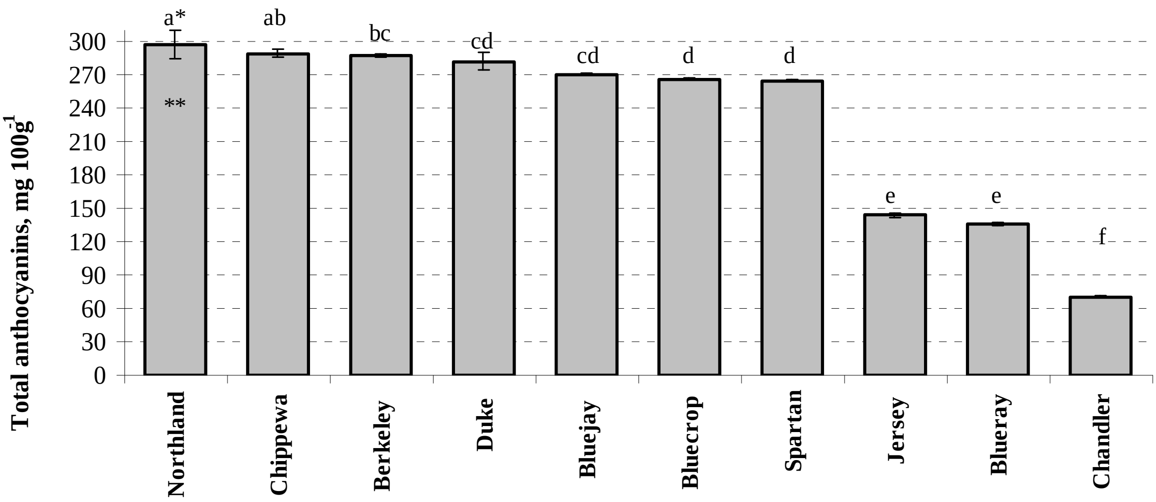

Figure 1. Total anthocyanin content in highbush blueberry cultivars.

**Values, marked with the same letter, are not significantly different at p=0.05.*

*** Bars corresponds the standard error of the mean of the cultivar.*

The cultivars ‘Northland’ and 'Chippewa' had the highest anthocyanin content (on average 297.59 and 288.83 mg 100 g^{-1}, respectively).

The total phenol content of highbush blueberries differed between 226 and 381 mg 100 g^{-1} of fresh weight (Figure 2). This is even higher than reported in the literature (Giovanella *et.al.*, 2009; Prior *et.al*, 1998).

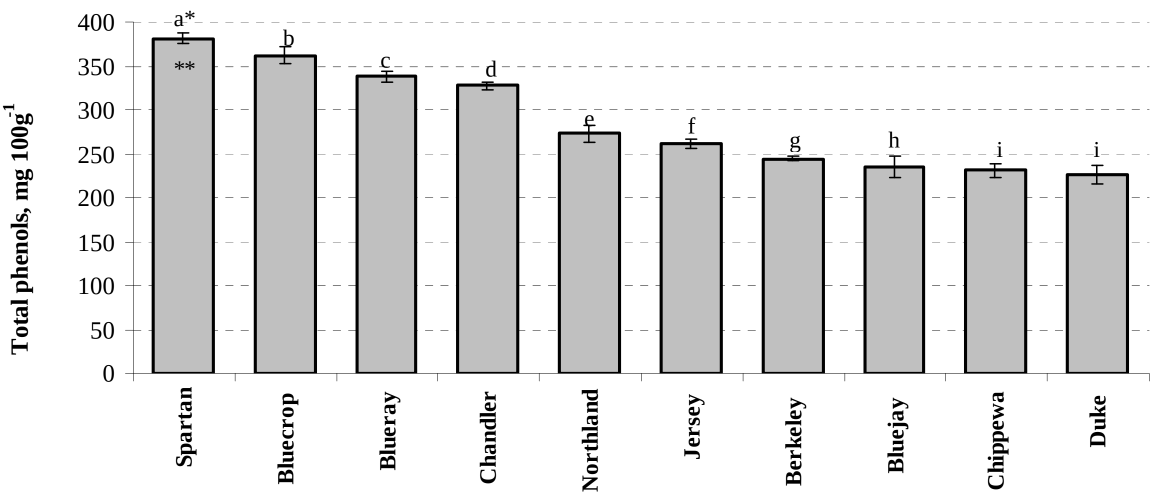

Figure 2. Total phenol content in highbush blueberry cultivars.

**Values, marked with the same letter, are not significantly different at p=0.05.*

*** Bars corresponds the standard error of the mean of the cultivar.*

The highest phenol content was measured in the highbush blueberry cultivar 'Spartan' (on average 381.14 mg 100 g^{-1}).

The ascorbic acid content in the highbush blueberry cultivars was low compared to the other berry crops (currants, strawberries, etc. (Augļi un ogas Latvijā mūsdienu augļu dārzā, 2008; Moor *et al.*, 2005): from 6.9 to 11.8 mg 100 g^{-1} (Figure 3).

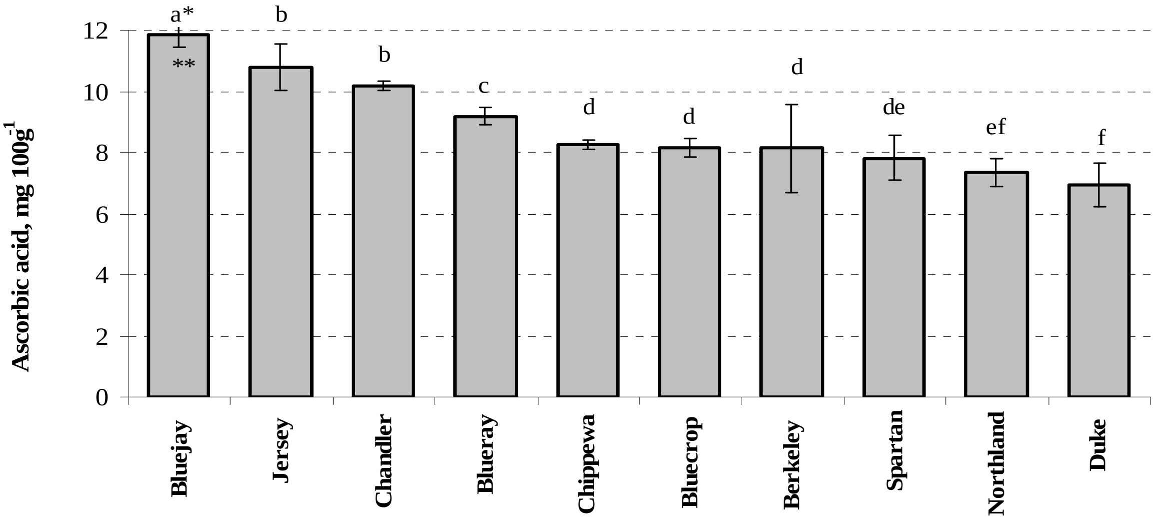

Figure 3. Ascorbic acid content in highbush blueberry cultivars.
**Values, marked with the same letter, are not significantly different at p=0.05.*
*** Bars corresponds the standard error of the mean of the cultivar.*

The cultivar 'Bluejay' had the highest content of ascorbic acid (in average 11.8 mg 100 g^{-1}).
The titratable acids content in highbush blueberries differed between 0.5 and 1.4 %, similarly to that reported in the literature (Beaudry, 1992; Saftner *et.al.*, 2008). There were high differences between the cultivars in titratable acid content (Figure 4).

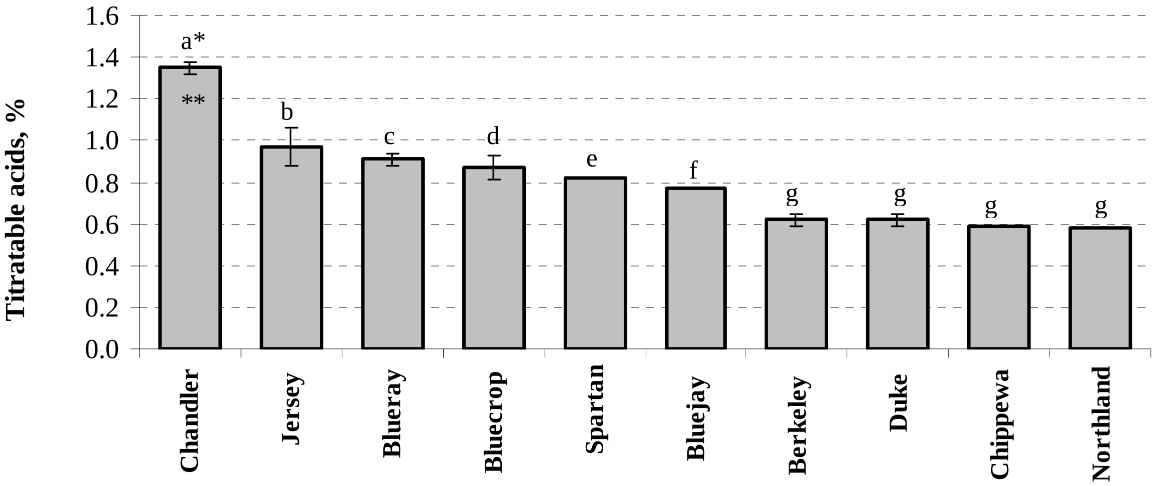

Figure 4. Titratable acid content in highbush blueberry cultivars.
**Values, marked with the same letter, are not significantly different at p=0.05.*
*** Bars corresponds the standard error of the mean of the cultivar.*

The titratable acid content in the berries of the cultivar 'Chandler' (1.35 %) were significantly higher than in all other evaluated cultivars. The titratable acids content in most of the cultivars did not exceed 1 % and is low compared to other berry cultivars. It is important for processing to find blueberry cultivars with the higher acidity therefore the cultivar 'Chandler' could be more suitable for the production of juice and other preserves.

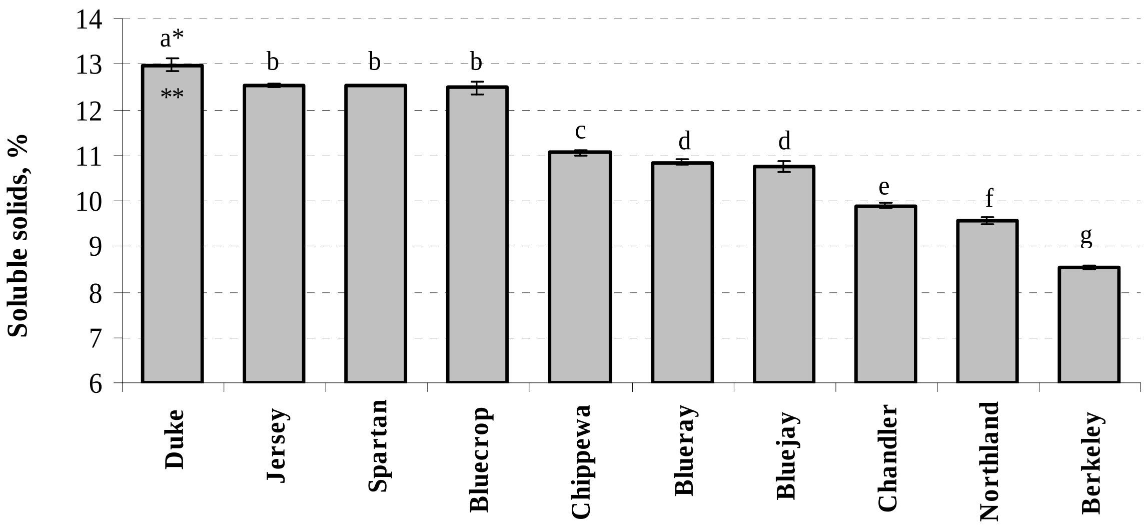

Figure 5. Soluble solids content in highbush blueberry cultivars.

**Values, marked with the same letter, are not significantly different at p=0.05.*

*** Bars corresponds the standard error of the mean of the cultivar.*

The soluble solids content in the evaluated highbush blueberry cultivars differed between 8.5 and 13 % (Figure 5). The cultivar 'Duke' had the highest soluble solids content (on average 12.99 % soluble solids). The soluble solids content in some blueberry cultivars grown in Latvia could be lower than in other growing regions due to more rainfall, less sunshine, and a colder climate. For example, the soluble solids content in the berries of the cultivar 'Berkeley' were only on average 8.5 %, which is significantly lower than that mentioned in the literature (Saftner *et. al.*, 2008).

Conclusions

The cultivars 'Northland' and 'Chippewa' had the highest anthocyanin content (on average 297.59 and 288.83 mg 100 g^{-1}, respectively), the highest phenol content was measured in the highbush blueberry cultivar 'Spartan' (on average 381.14 mg 100 g^{-1}), the highest content of ascorbic acid was in the cultivar 'Bluejay' (on average 11.8 mg 100 g^{-1}), the highest titratable acids content in the berries of cultivar 'Chandler' (1.35 %), and the cultivar with the highest soluble solids content was 'Duke' (in average 12.99 % soluble solids).

In total, the chemical composition of the evaluated highbush blueberry cultivars grown in Latvia were similar to the literature, but there was tendency that blueberries in Latvia had higher phenol content and lower soluble solids content compared to those grown in the other growing regions.

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BIOCHEMICAL COMPOSITION AND ANTIRADICAL ACTIVITY OF ROWANBERRY (*SORBUS L.*) CULTIVARS AND HYBRIDS WITH DIFFERENT *ROSACEAE* L. CULTIVARS

PĪLĀDŽU (*SORBUS* L.) ŠĶIRŅU UN TO HIBRĪDU AR CITIEM *ROSACEAE* L. AUGĻAUGIEM ANTIOKSIDATĪVĀ AKTIVITĀTE UN BIOĶĪMISKAIS SASTĀVS

Kaspars Kampuss[1], Solvita Kampuse[2], Elga Berņa[2], Zanda Krūma[2], Inta Krasnova[3], Inese Drudze[4]

[1] Faculty of Agriculture, Latvia University of Agriculture (LLU), Liela street 2, Jelgava, Latvia
[2]Faculty of Food Technology, LLU, e-mail: skampuse@inbox.lv
[3] The Latvia State Fruit Growing Institute, Dobele, Latvia
[4] Pure Horticultural Research Centre, Abavas 2, Pure, LV-3124, Latvia

Abstract

Rowanberry (*Sorbus aucuparia* L.) is a common yellowish, wild berry that grows in the Northern part of Europe. Rowan has been described as an important source of flavonoids and their antioxidant activity affects reactive oxygen species and lipid peroxidation. The aim of this study was to evaluate the biochemical composition of 8 rowanberry cultivar fruits and the fruits of their hybrids with *Rosaceae* L. cultivars and to establish the correlation of their biochemical composition with antiradical activity. The experiments were done at the Faculty of Food Technology, Latvia University of Agriculture (LLU) and in the Latvia State Fruit Growing institute, Dobele. The content of ascorbic acid, the total phenols, anthocyanins, carotenoids, soluble solids, titrable acids, tannins and the antiradical activity of fresh and frozen rowanberry×hawthorn 'Granatnaya', rowanberry×chokeberry 'Likiornaya', rowanberry *(Sorbus aucuparia)* 'Rosina', rowanberry *(Sorbus aucuparia)* 'Zholtaya', wild rowanberry *(Sorbus aucuparia)*, rowanberry×pear 'Alaya Krupnaya', rowanberry *(Sorbus aucuparia)* 'Rosina Variegata', rowanberry *(Sorbus aucuparia)* 'Krasnaya Krupnaya' were analysed. There were no significant differences between the chemical composition of fresh and frozen rowanberry samples. The highest content of ascorbic acid was in fruits of the rowanberry 'Rosina', 'Rosina Variegata', 'Krasnaya Krupnaya', and 'Zholtaya' (49 – 53 mg 100 g^{-1}). The highest content of carotenoids were detected in rowanberry×hawthorn 'Granatnaya' (13.04 mg 100 g^{-1}), but the highest phenol content was detected in the rowanberry and chokeberry hybrid 'Likiornaya' (484.9 mg 100 g^{-1}). 'Likiornaya' showed also the highest antiradical activity (11.2 g of berries per 1g of DPPH radical).

Kopsavilkums

Pīlādži (*Sorbus aucuparia* L.) ir izplatīts savaļas augļaugs, kas aug Eiropas ziemeļu daļā. Pīlādži ir raksturoti kā nozīmīgs flavonoīdu avots un to antioksidatīvā aktivitāte ietekmē reaktīvo skābekli un lipīdu peroksidāciju. Pētījuma mērķis bija izvērtēt bioķīmisko sastāvu 8 pīlādžu šķirņu un to