Potravinarstvo, vol. 10, 2016, no. 1, p. 499-505
doi:10.5219/649
Received: 4 August 2016 Accepted: 12 October 2016
Available online: 16 October 2016 at www.potravinarstvo.com

ISSN 1337-0960 (online)

SHELF LIFE EXTENSION AND SENSORY EVALUATION OF BIRCH TREE SAP USING CHEMICAL PRESERVATIVES

Maciej Bilek, Vladimír Vietoris, Vojtech Ilko

ABSTRACT
The aim of this study was to assess the stability of the birch tree sap, depending on the addition and concentration of two chemical factors, ie. potassium sorbate and acids: malic, citric or lactic. As in our previous studies we found that the optimal physical parameter to assess the stability of birch sap is turbidity measurement, we used turbidimeter for estimate the effectiveness of shelf life extending. Sensory evaluation was carried out by university sensory panel with 8 skilled people (students and teachers) with pre-selection and basic training of sensory methodology. On the other hand artificial perception measurements were realized by electronic nose. Birch tree sap stability without addition of preservatives, both room temperature and refrigerated, is less than three days. The effectiveness of preservation of birch tree sap depends on the concentration of acids. Independently of storage temperature, samples that received stability during the whole one-month storage period, were those with potassium sorbate and three acids in the highest concentrations, ie. malic acid at 0.3%, citric acid at 0.5% and lactic acid at 0.5%. Unfortunately, concentrations of acids, which allow extension of shelf life at least for one month in a room temperature, are characterized by the worst sensory evaluation rating. Thus, they should be corrected by the use of additives for improving the flavor, such as fruit syrups or herbal extracts. On the other hand, additionally storage in a refrigerated conditions allows one-month-stability for the sample with the highest sensory evaluation rating, ie. with the addition of lactic acid at 0.1% and potassium sorbate, which taste not need to be corrected.

Keywords: birch tree sap; shelf life extending; sensory analysis; beverages; functional food

INTRODUCTION
Birch sap is collected in early spring, usually in the first half of March. It is characterized by pro-health properties, which have been appreciated by the folk medicine. Once, it was recommended, among others, in case of renal disorders, in the anemia, against immunodepressed, in general weakening and in the weakened condition of the skin and hair, in infectious diseases, parasitic infections and even cancer **(Svanberg et al., 2012; Papp et al., 2014; Rastogi et al., 2015)**. This wide range of applications has been confirmed by a number of recent researches conducted, among other, using cell lines **(Moriyama et al., 2008; Peev et al., 2010)**. Very high mineral content in birch tree sap has been demonstrated, including copper, zinc, manganese and magnesium. although it is variable, depending on the individuals **(Bilek et al., 2015b; Bilek et al., 2016b)**. At the same time negligible content of harmful substances in the birch sap has been found, eg. nitrates, considered as one of the most dangerous and the most common factors associated with the products of plant origin **(Bilek et al., 2016c)**.

The results of scientific research, increasing popularity of the behavior based on a folk traditions, as well as popularity of bio-food, low-processed food and independently obtained crops **(Kozelová et al., 2009; Brindza et al., 2011; Kozelová et al., 2013)** contributes to increasing interest in the birch sap **(Godyla, 2014; Stawarczyk, 2015).** Following that, inexperience collectors often acquire significant amounts of sap. Meanwhile, it quickly becomes unsuitable for consumption as a result of the microbiological degradation. This happens after approximately one day at room temperature and after about three days under refrigerated conditions **(Viškelis and Rubinskienė, 2012)**. For this reason, there are many attempts to extend shelf life of the tree saps. The use of pasteurization or thermisation may cause the disappearance of many valuable components of sap, determining the health-promoting properties of this unprocessed raw material **(Yuan et al., 2013)**. In addition, under the influence of the high temperature, decomposition of fructose is observed, resulting in browning of birch sap. Therefore, in the literature, there are several alternatives for thermal methods. Most are based on the use of physical techniques, eg. ultraviolet radiation, ultrafiltration, as well as combination of ultrafiltration and ultraviolet radiation **(Jeong-Jeong et al., 2011, Jeong-Jeong et al., 2013)**. It must be emphasized, however, that the implementation of these arrangements in practice will be associated with the high cost of processing line, as well as with the problem of aseptic bottling. These solutions are also unavailable for the consumers who collect the tree saps own.

The aim of this study was to develop a simple method of extend shelf life of birch tree sap, that would be accessible for any consumers, as well as sensory evaluation of obtained products.

MATERIAL AND METHODOLOGY

Tree sap of silver birch (*Betula pendula* Roth.) was collected in Niwiska village, located on the Kolbuszowa Plateau, accordance with the suggestions of literature **(Yoon et al., 1992)**. Collection has taken place by drilling the hole in the tree trunks at a height of approx. 50 cm, using a drill bit with a diameter of 16 mm, to a depth of 5 cm, on the south side a tree trunk. The tree sap was collected simultaneously from the seven trees. In the evening the collected batches were combined into one, and then frozen at -21 °C.

The birch tree sap was thawed in a water bath on the day of the start of the test. The temperature thereof was controlled and never exceeded 10°C during the thawing. After thawing, the sap was divided into half-liter portions which were preserved as described in the table (Table 1) **(Patent Application P.417738)**.

To preserve the birch sap lactic acid (Chempur, Piekary Slaskie), malic acid (Sigma-Aldrich, St. Louis) and citric acid (Chempur, Piekary Slaskie) was used, as well as potassium sorbate (POCh, Gliwice).

Based on our previous studies **(Bilek et al., 2016a)** we found that the optimal physical parameter to assess the stability of birch sap is turbidity measurement. It was tested using Hanna Instrument HI98703 Turbidimeter.

Sensory analysis

Sensory evaluation was carried out by university sensory panel with 8 skilled people (students and teachers) with pre-selection and basic training of sensory methodology. Samples were stored in regular conditions and served in sequence order. Avoid preservation acids lingering we used demineralized water. All facilities and equipment during experiment were done by ISO EN 8589:2007 standard. For analysis of the results we used non-parametric Friedman's test. Data were processed by R and presented in Table 2 **(R Core Team, 2016)**.

Artificial Perception Measurements

Analysis were realized by electronic nose Heracles II (Alpha MOS, France) in three replications per sample. Data were processed by native software ALPHA soft v.14. For visualization of the results we used PCA technique.

Statistical analysis

Statistical analysis was performed in R-project software, version 3.2.5 (R Foundation for Statistical Computing, Vienna, Austria). We have used One-way ANOVA.

RESULTS AND DISCUSSION

Changes in the turbidity of birch saps preserved are presented in Figures 1 – 6.

To extend the shelf life of birch sap we used the preservatives, ie. citric, malic and lactic acids and the potassium salt of sorbic acid. They are considered one of the safest food additives **(Rogozińska and Wichrowska, 2011)**. We intentionally excluded the use of sodium salt of benzoic acid, posing health risks **(Jędra et al., 2008)**.

Birch tree sap stability without addition of preservatives, both room temperature and refrigerated conditions, is less than three days. Independently of storage temperature, samples that received stability during the whole one-month storage, were those with potassium sorbate and acids in the highest concentrations, ie. malic acid at 0.3%, citric acid at 0.5% and lactic acid at 0.5%. On the other hand, sap containing sorbate but with lower concentration of acids, as well as sap with addition of acids exclusively were much less stable (Figure 1, Figure 2 and Figure 3). And in turn, in refrigerated conditions increased stability has been achieved. For saps with the concentrations at 0.1 and 0.25% of lactic and citric acid shelf-life extension in a monthly test was obtained in refrigerated conditions. Only saps with malic acid concentrations at 0.1% and 0.2% in a reduced temperature were characterized by low stability, ie. about 24 days (Figure 4, Figure 5 and Figure 6). On the other hand, stability of sap preserved solely by the addition

Table 1 A method of preserving and storing the birch tree sap.

Room temperature (21°C)			Refrigerated conditions (4°C)		
Citric acid	0.1% 0.25% 0.5%		Citric acid	0.1% 0.25% 0.5%	
Citric acid	0.1% 0.25% 0.5%	Potassium sorbate 0.03%	Citric acid	0.1% 0.25% 0.5%	Potassium sorbate 0.03%
Lactic acid	0.1% 0.25% 0.5%		Lactic acid	0.1% 0.25% 0.5%	
Lactic acid	0.1% 0.25% 0.5%	Potassium sorbate 0.03%	Lactic acid	0.1% 0.25% 0.5%	Potassium sorbate 0.03%
Malic acid	0.1% 0.2% 0.3%		Malic acid	0.1% 0.25% 0.5%	
Malic acid	0.1% 0.2% 0.3%	Potassium sorbate 0.03%	Malic acid	0.1% 0.25% 0.5%	Potassium sorbate 0.03%

of acids, depending on the type of acid and its concentration, reached from 9 to 12 days stability in refrigerated conditions.

Shelf life extension obtained by the using of potassium sorbate and acids in the highest concentrations may be compared to results reported by other authors. **Jeong-Jeong et al. (2013)** applied to control the turbidity of tree saps spectrophotometry technique by the measuring the absorbance at a wavelength 420 and 590 nm. The results indicate that only birch sap for which both the ultrafiltration and the ultraviolet radiation was used were stable, irrespective of the storage conditions. In this way Jeong-Jeong obtained shelf life extension approx. 20 days, and in turn, our method using two chemical factors, ie. potassium sorbate and the highest concentration of food acids, extended the stability of tree saps at least one month, also irrespective of the temperature of storage conditions.

In the sensory evaluation of birch tree sap with the addition of malic acid statistically significant positively evaluation in the case of overall and harmony has been

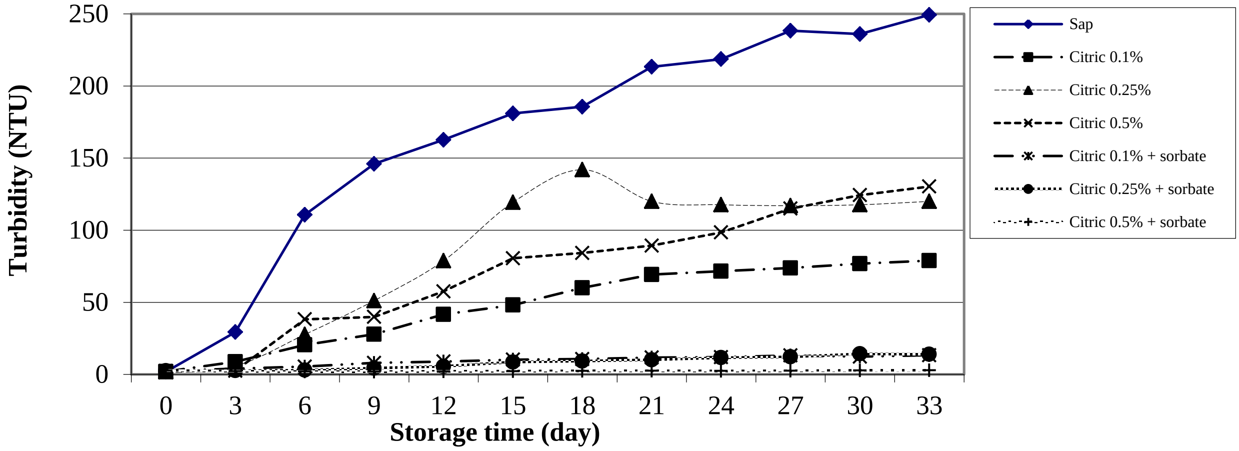

Figure 1 Turbidity changes for birch sap using citric acid-based shelf life extension method (room temperature).

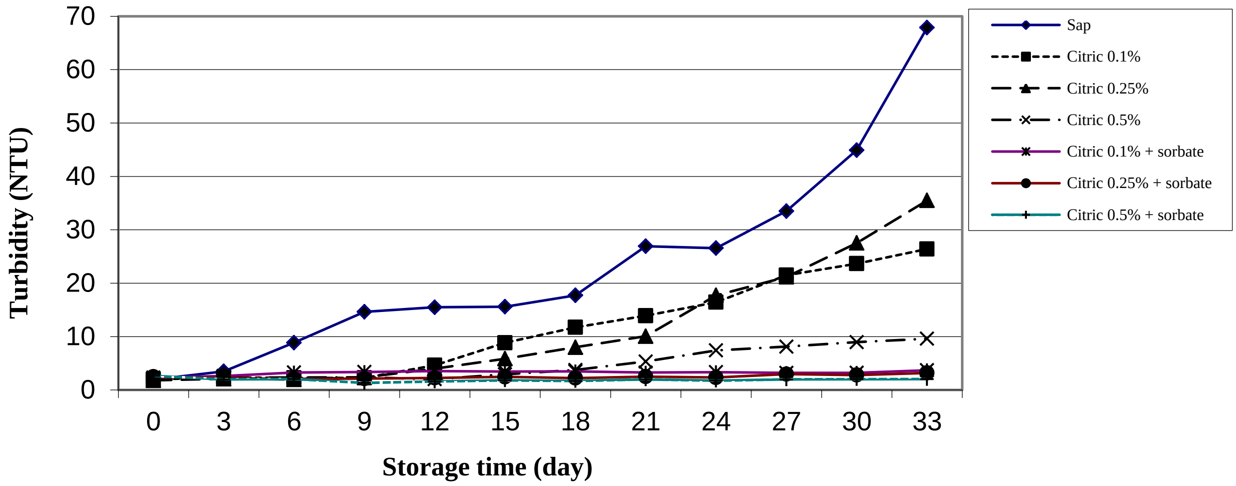

Figure 2 Turbidity changes for birch sap using citric acid-based shelf life extension method (refrigerated conditions).

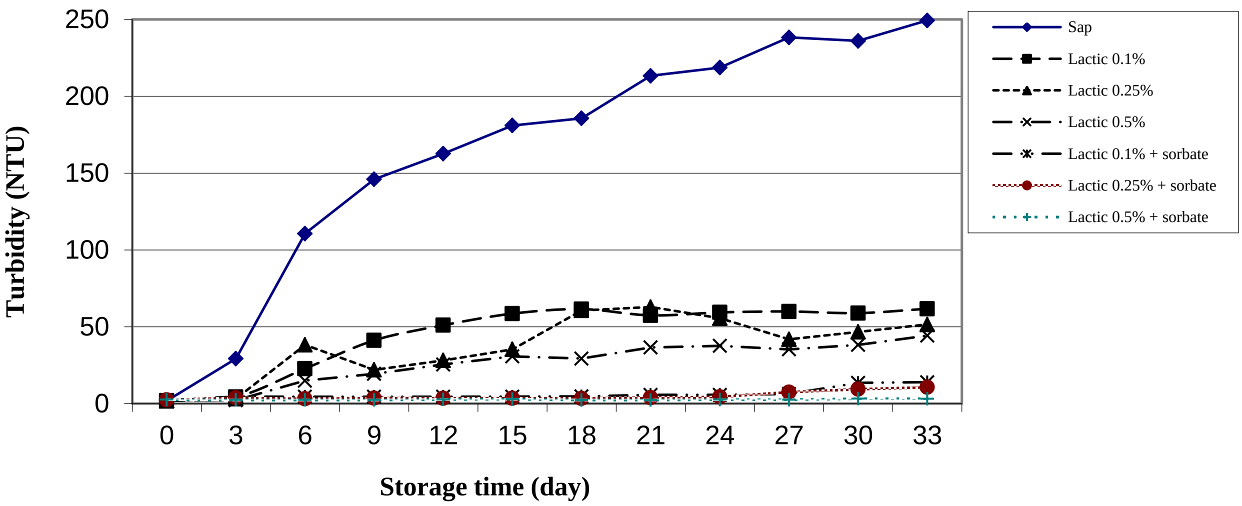

Figure 3 Turbidity changes for birch sap using lactic acid-based shelf life extension method (room temperature).

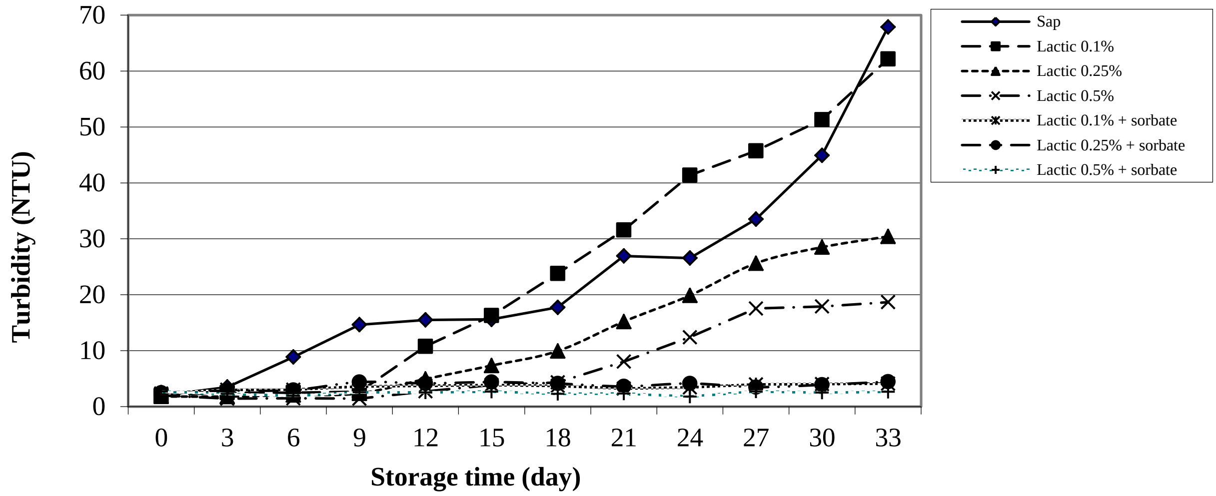

Figure 4 Turbidity changes for birch sap using lactic acid-based shelf life extension method (refrigerated conditions).

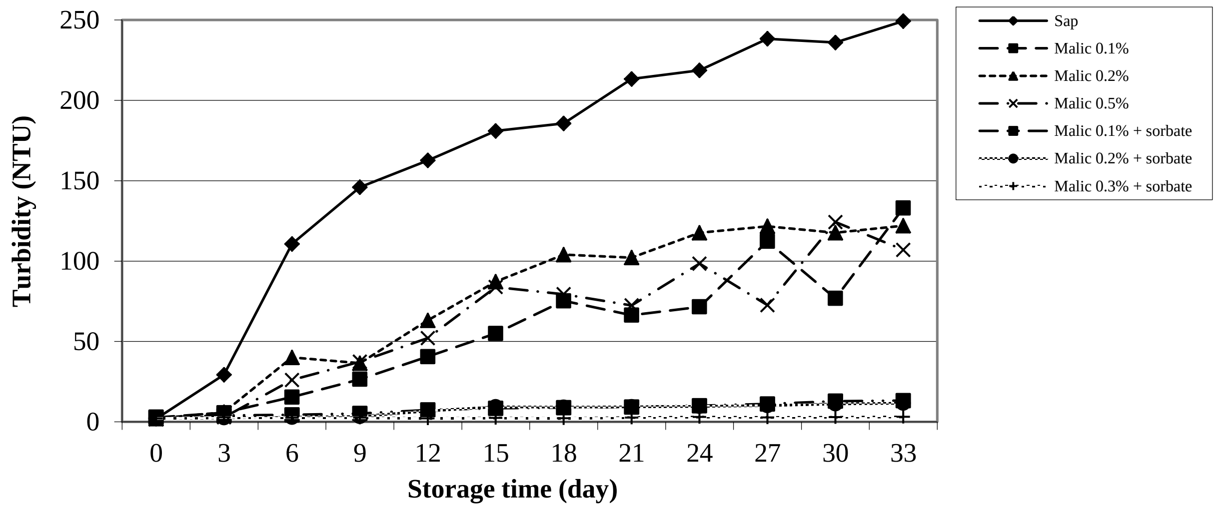

Figure 5 Turbidity changes for birch sap using malic acid-based shelf life extension method (room temperature).

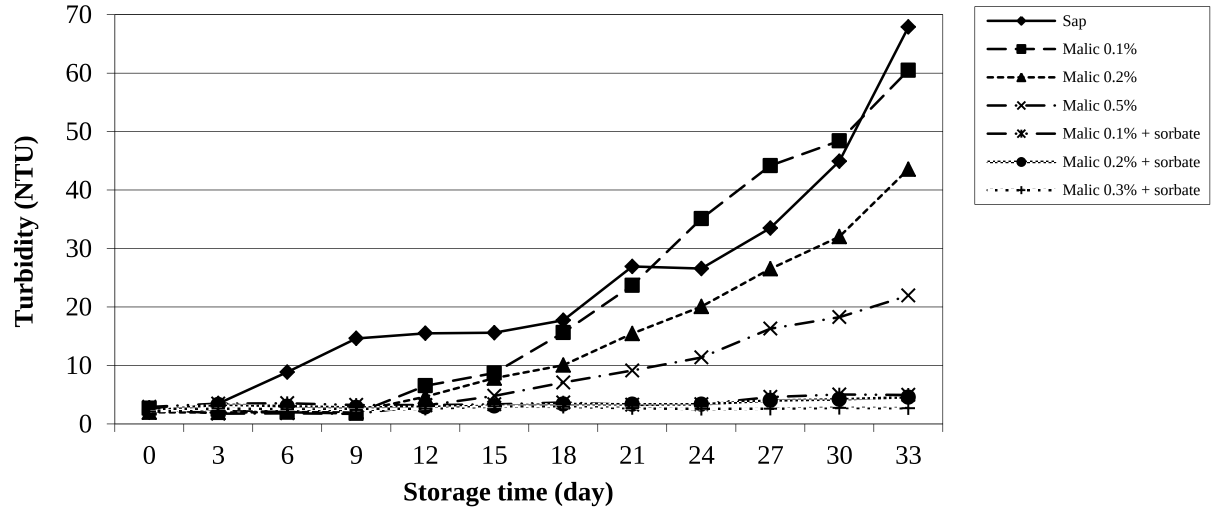

Figure 6 Turbidity changes for birch sap using malic acid-based shelf life extension method (refrigerated conditions).

achieved for the concentrations at 0.1%, and in turn statistically significant negatively evaluation for the sap with addition of malic acid at concentration 0.5%, also for overall and harmony. In the case of sour statistically significant differences have not been reported (Table 2).

In the sensory evaluation of birch tree sap with the addition of citric acid there were no statistically significant differences in the case of sour, and on the other hand for harmony and overall statistically significant negatively evaluation was obtained for the saps with citric acid at the concentration 0.5%.

Table 1 Statistical differences in sensory data of preserved birch tree sap (Sums of Ranks).

Samples		Sour	Harmony	Overall
Citric acid	0.1%	30	22	26
	0.25%	31	30	29
	0.5%	44	58*	55*
Citric acid and potassium sorbate	0.1%	35	22	23
	0.25%	32	27	28
	0.5%	37	48	48
Lactic acid	0.1%	31	23	23
	0.25%	30	35	34
	0.5%	47	56*	58*
Lactic acid and potassium sorbate	0.1%	27	17**	19**
	0.25%	32	29	29
	0.5%	43	50	47
Malic acid	0.1%	27	15**	16**
	0.2%	33	34	31
	0.3%	38	55*	58*
Malic acid and potassium sorbate	0.1%	37	30	28
	0.2%	35	28	29
	0.3%	40	48	48

Note: * Statistically significant negatively evaluation.
** Statistically significant positively evaluation.

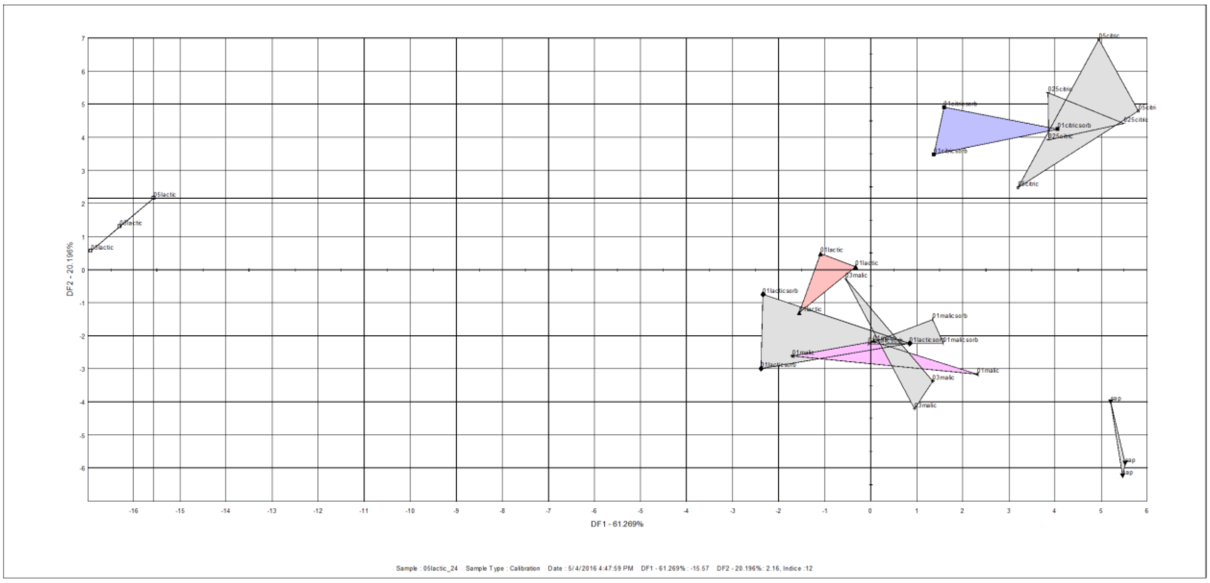

Figure 7 Similarity of the samples classified by electronic nose (own data).

However, in sensory evaluation of tested samples with the lactic acid for sour, there was no statistical differences, while for the harmony and overall there was a statistically significant positively assessment of the sap with the addition of lactic acid in a concentration of 0.1% and with the addition of potassium sorbate, and statistically significant negatively assessment for sap with the addition of lactic acid at 0.5%. Among the samples that were evaluated by the sensory team statistically significantly positively, highest stability has a sample containing sorbate and lactic acid at a concentration 0.1%, ie. approx. 18 days at room temperature and at least a month in the refrigerated condition

How is described in Material and methodology we used for similarity birch saps classification electronic nose. There is relation between aroma and flavour and we would investigate any relations among organoleptic attributes of the samples. We also study interaction between saps characteristics and tasteless, odour less preservation agents (acids). We conclude that prevented birch saps with our selected concentration is possible split to four groups. First group is preserved sap by 0.5 lactid acid (located on opposite quadrant of the plot) typical for very intensive smell of lactic tones. And conservated birch sap was very stable. Another group is represented by pure sap (right bottom corner located). Small triangle of this sample detect small evaporation of volatile compounds (low interactions). Third banding group are represented samples of citric acid preservation (0.1, 0.25, 0.5). This group is characterized by high evaporation level (triangle size). Last group are combination of low level of lactic and malic acid preservated saps with different level of stability. By sensory tests this groups is prefered to others. All positions of the sample are possible see on Figure 7.

Sensory properties of samples preserved sorbate and the highest concentrations of acids can be improved using functional additives, such as herbal extracts or fruit juices **(Ivanišová et al., 2010)**. They will not only correct the taste but also significantly increased antioxidant capacity, which for birch sap is low **(Bilek et al., 2015a)**. Health benefits will therefore be improved, which is expected by the consumers of food products of plant origin **(Vietoris et al., 2016)**.

CONCLUSION

1. The negative sensory evaluation obtained for the most stable samples could be corrected by the use of additives for improving the flavor such as fruit syrups or herbal extracts. Then, it will be possible to prepare a stable, easy to obtain birch sap-based beverage.

2. We conclude that obtained correlation between sensory preference and increasing ratio of the preservation agents to keep sap stability is low. Investigation of preservation and sensory improvements are just in the beginning. This will be promising way to enlarge usage and awareness about saps application and keep Central European heritage.

REFERENCES

Bilek, M., Pytko, J., Sosnowski, S. 2016a. Shelf life of birch tree sap. *Polish Journal Sustainable Development*, in press.

Bilek, M., Siembida, A., Stawarczyk, K., Cieślik, E. 2015a. Radical scavenging activity of tree saps from podkarpackie region. *Żywność. Nauka. Technologia. Jakość*, vol. 101, no. 4, p. 151-161. http://dx.doi.org/10.15193/ZNTJ/2015/101/063

Bilek, M., Stawarczyk, K., Gostkowski, M., Olszewski, M., Kędziora, K.M., Cieślik, E. 2016b. Mineral content of tree sap from the Subcarpathian region. *Journal of Elementology*, vol. 21, no. 3, p. 669-679. http://dx.doi.org/10.5601/jelem.2015.20.4.932

Bilek, M., Stawarczyk, K., Kuźniar, P., Olszewski, M., Kędziora, K. M., Cieślik, E. 2016c. Evaluation of inorganic anions content in the tree saps. *Journal of Elementology*, vol. 21, no. 4, p. 1277-1288. http://dx.doi.org/10.5601/jelem.2015.20.4.1048

Bilek, M., Stawarczyk, K., Łuczaj, Ł., Cieślik, E. 2015b. Content of selected minerals and inorganic anions in tree saps from Podkarpacie region. *Żywność. Nauka. Technologia. Jakość*, vol. 100, no 3, p. 138-147. http://dx.doi.org/10.15193/zntj/2015/100/046

Bilek, M., Stawarczyk, K., Sosnowski, S. The method of obtaining a beverage with enhanced shelf life and pro-health properties based on tree sap, especially birch tree sap. Republic of Poland, Patent Application P. 417738.

Brindza, J., Vietoris, V., Kucelová, L., Fil, M., Ostrovský, R., Gondová, E. 2011. Morphology and sensory evaluation of traditional products from different landraces of pumpkin (Cucurbita spp.). *Potravinarstvo*, vol. 5, no. 2, p. 1-8. http://dx.doi.org/10.5219/137

Godyla, S. 2015. Consumers' attitude to the birch tree sap. *Think*, vol. 20, p. 7-16.

Ivanišová, E., Fikselová, M., Vietoris, V., Mellen, M. 2009. Antioxidant effects of herbal extracts and their food application. *Potravinarstvo*, vol. 3, no. 4, p. 34-37. http://dx.doi.org/10.5219/75

Jędra, M., Starski, A., Gawarska, H., Sawilska-Rautenstrauch, D. 2008. Occurrence of benzene in beverages. *Bromatologia i Chemia Toksykologiczna*, vol. 41, no. 3, p. 382-388.

Jeong, J. S., Jeong, H. S., Woo, S. H., Shin Ch. S. 2013. Consequences of ultrafiltration and ultraviolet on the quality of white birch (*Betula platyphylla* var. *japonica*) sap during storage. *Australian Journal of Crop Science*, vol. 7, no. 8, p. 1072-1077.

Jeong, J. S., Lee, C. H., Kim, H. Y., Hwang, I. G., Shin, C. S., Park, E. S., Lee, J., Jeong, H. S. 2011. Characeteristic of Goroshoe (Acer mono Max.) Sap with Different Collection Times After Ultra Filtration. *The Korean Society of Food Science and Nutrition*, vol. 40, no 5, p. 753-758. http://dx.doi.org/10.3746/jkfn.2011.40.5.753

Kozelová, D., Vietoris, V., Fikselová, M. 2013. Quality and availability of organic foods by Slovak consumers. *Potravinarstvo*, vol. 7, no. 1, p. 146-150. http://dx.doi.org/10.5219/306

Kozelová, D., Zajác, P., Matejková, E., Zeleňáková, L., Lopašovský, L., Mura, L., Čapla, J., Vietoris, V. 2011. Perception of bio-food labeling by consumers in Slovakia. *Potravinarstvo*, vol. 5, no. 1, p. 33-38. http://dx.doi.org/10.5219/107

Moriyama, M., Naru, E., Misaki, Y., Hayashi, A. 2009. Effect of birch (*Betula platyphylla Sukatchev* var. *japonica Hara*) sap on cultured human epidermal keratinocyte differentiation. *International Journal of Cosmetic Science*, vol. 31, p. 159-161. http://dx.doi.org/10.1111/j.1468-2494.2008.00466_3.x

Papp, N., Czégényi, D., Hegedűs, A., Morschhauser, T., Suave, C. L., Cianfaglione, K., Pieroni, A. 2014. The uses of Betula pendula Roth among Hungarian Csángós and Székelys in Transylvania, Romania. *Acta Societatis Botanicorum Poloniae*, vol. 83, no. 2, p. 113-122, http://dx.doi.org/10.5586/asbp.2014.011

Peev, C., Dehelean, C., Mogosanu, C., Feflea, F., Corina, T. 2010. Spring drugs of Betula pendula Roth.: Biologic and pharmacognostic evaluation. *Studia Univ. VG, SSV*, vol. 20, no. 3, p. 41-43.

R Core Team, 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria [online] s.a. [cit. 2016-04-06] Available at: https://www.R-project.org/

Rastogi, S., Pandey, M. M., Rawat, A. K. S. 2015. Medical plants of the genus Betula – Traditional uses and a phytochemical-pharmacological review. *Journal of Etnopharmacology*, vol. 159, p. 62-83, http://dx.doi.org/10.1016/j.jep.2014.11.010

Rogozińska, I., Wichrowska, D. 2001. The most popular food shelf life additives using in modern food technology. *Inżynieria i Aparatura Chemiczna*, vol. 50, no. 2, p. 19-21.

Stawarczyk, M. 2015. Tree saps. *Aptekarz Polski*, vol. 102, no. 2, p. 17-21.

Svanberg, I., Sõukand, R., Łuczaj, Ł., Kalle, R., Zyryanova O., Dénes, A., Papp, N., Nedelcheva, A., Šeškauskaitė, D., Kołodziejska-Degórska, I., Kolosova, V. 2012. Uses of tree saps in northern and eastern parts of Europe. *Acta Societatis Botanicorum Poloniae*, vol. 81, no. 4, p. 343-357. http://dx.doi.org/10.5586/asbp.2012.036

Vietoris, V., Kozelová, D., Mellen, M., Chreneková, M., Potclan, J. E., Fikselová, M., Kopkáš, P., Horská, E. 2016.

Analysis of Consumer Preferences at Organic Food Purchase in Romania. *Polish Journal of Food and Nutritional Sciences*, vol. 66, no. 2, p. 139-146. http://dx.doi.org/10.1515/pjfns-2015-0028

Viškelis, P., Rubinskienė, M. 2011. The chemical composition of birch sap. Sodininkystė ir Daržininkystė, vol. 30, no. 3-4, p. 75-81.

Yoon, S. L., Jo, J. S., Kim, T. O. 1992. Utilization and Tapping of the Sap from Birches and Maples. *Mokchae Konghak*, vol. 20, no. 4, p. 15-20.

Yuan, T., Li, L., Zhang, Y., Seeram, N. P. 2015. Pasteurized and sterilized maple sap as functional beverages: Chemical composition and antioxidant activities. *Journal of Functional Foods*, vol. 5, no. 4, p. 1582-1590. http://dx.doi.org/10.1016/j.jff.2013.06.009

Acknowledgments:

This work was supported by AgroBioTech Research Centre built in accordance with the project Building „AgroBioTech" Research Centre ITMS 26220220180.

Contact address:

Maciej Bilek, University of Rzeszów, Faculty of Biology and Agriculture, Department of Food and Agriculture Production Engineering, Zelwerowicza 4, 35-601 Rzeszów, Poland, E-mail: mbilek@ur.edu.pl.

Vladimír Vietoris, Slovak University of Agriculture, Faculty of Biotechnology and Food Science, Department of Storage and Processing Plant Products, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia, E-mail: vladimir.vietoris@uniag.sk.

Vojtech Ilko, University of Chemistry and Technology Prague, Faculty of Food and Biochemical Technology, Department of Food Analysis and Nutrition, Technická 5, 166 28 Prague, Czech Republic, E-mail:ilkov@vscht.cz.