Research article

The usefulness of birch saps from the area of Podkarpacie to produce birch syrup

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Abstract: *In northern European countries, as well as in North America tree saps of maples and birches are used for the production of syrups. Birch syrups are characterized by a specific aromatic taste and can be used as an addition to sweets, desserts, salads and meats. Attention is paid to the health benefits of birch syrups, mainly for high mineral content. The aim of this study was to evaluate the usefulness of birch saps obtained from the area of Podkarpacie for birch syrup production. HPLC-ELSD system was used for analysing the sugar content in the birch tree saps from four localization. All the examined saps contained the monosaccharides as fructose and glucose. The presence of sucrose was found in eight per twenty tested saps. There weren't statistical differences between the studied sites for the averages of total sugar concentration in the tree saps samples. The highest average amount of total sugar was found in the D sites (11.74 g/dm*^{3}*), whereas the lowest in the C sites (7.66 g/dm*^{3}*). Silver birch tree saps from the area of Podkarpacie offer perspectives to used for syrup production according to the US and Finnish criteria of profitability.*

Keywords: *Silver birch, birch tree saps, birch syrups, functional food.*

Introduction

In East Asia as well as in Central and Eastern Europe tree saps are collected primarily for immediate consumption [1]. They can also be used for the production of pasteurized beverages, which are usually acidified with the citric acid and enriched by the addition of sugars [2]. Whereas in northern European countries, mainly in Finland, as well as in North America, i.e. in Canada and the

United States, tree saps of maples (*Acer* sp.) and birches (*Betula* sp.) are used for the production of syrups. This is an important branch of the industry [3].

Syrups, which are obtained from the saps of maple trees, because of high sucrose content, are most commonly used to sweeten as a substitute of sugar or as a material for the production of granulated sugar [3]. In recent years also birch syrups are gaining mass popularity. They are characterized by a specific aromatic taste and can be used as an exclusive addition to sweets, desserts, salads and meats [3, 4]. In addition to their taste, attention is paid to the health benefits of maple and birch syrups, mainly for high mineral content [5].

The usefulness of tree saps for syrup production is naturally determined by the content of sugars: sucrose, in the case of maple saps (approx. 10-50 g/dm^3), and on the other hand, fructose and glucose for birch saps (approx. 10 g/dm^3) [6, 7]. However, efforts are being made to fertilising the soil to increase the sugar content in the tree saps to improve the profitability of the plantation and, at the same time, reduce production costs [8, 9]. Cost effectiveness of the syrup production is determined by the character of the sap concentration process. Once only long term evaporation of the tree sap was applied to obtain a product with the desired sugar content approx. 70° Brix [10, 11]. However, while such a procedure is suitable for the maple syrup production, during birch syrup production the formation of coloured reaction products of thermal decomposition of fructose are observed and a syrup has the taste unacceptable for consumers [2, 3, 12, 13]. For these reasons in birch syrup production two-step procedure is common. The first stage is reverse osmosis process, so that the tree sap is concentrated to a solution of approx. 10-20% of total sugar, and the second stage is evaporation under reduced pressure, which allows to obtain the final product with the sugar concentration approx. 70% [2, 4, 11]. This procedure is characterized by the best cost-efficient and reduced of the formation of fructose thermal decomposition products [3].

In order to reduce birch syrup production costs new technologies are created. Thanks to them, it is now possible collection large amounts of tree saps with dozens of trees at the same time, while reducing their damage and ensuring their use for saps collecting in the future [4, 12]. Methods for limiting microbial contamination are also expanded to minimize tree sap fermentation during collection process, both in the case of maple and birch tree saps [10, 14, 15]. Therefore, the routine control procedures for maple and birch syrup manufacturing process were created [16], providing not only microbiological control, but also supervision over the environmental conditions, which have an impact on the quality and health safety of syrups related to potential contamination with heavy metals and chloride ions [17-19].

The aim of this study, based on sugar content, was to evaluate the usefulness of birch tree saps obtained from the area of Podkarpacie for birch syrup production.

Experimental

Materials

Birch tree saps gathering sites were localized in Niwiska in the area of Podkarpacie. Tree sap collection was conducted within one day, approximately the noon hours. Saps were tapped from the 20 individuals of silver birch trees (*Betula pendula* Roth.) in four different localizations: a plot in the neighbourhood of a cultivated field (site A); a plot localized around 20 m away from an active farm (within this plot, a small stream containing wastes from the nearby farm was observed) (site B); a remote forest site, 1.5 km away from any infrastructure (site C); a pasture situated 50 m away from a farmland and 20 m away from a rarely used country road (site D). The tapped trees were localized not further than 15 m apart from each other within each of localizations.

Methods

We established a protocol for samples collection based on previously published methods, characterized by a minimizing of microbiological degradation in the tree saps samples [6]. Spots of tapping were selected on the south side of a trunk, 50 cm above the ground. Before sap collection, a fragment of bark was removed from a tree with a sterile chisel, additionally disinfected with Octenisept. Collecting spots was sterilized with 70% ethanol for 30 s. Holes (10 mm diameter, 4-6 cm deep, 30º angle) were bored with a sterile, autoclaved drill and cleaned of wooden shavings with a sterile scalpel. Collection of a sap started 5 min. after a beginning of flow, only after an area surrounding a hole was sterilized with 96% ethanol and flamed. Saps were gathered into sterile and flamed test-tubes, which were again flamed before closing. Holes in tree trunks were sealed with Koro-Derma pruning ointment.

After sterile collecting, samples were immediately frozen and transported to a laboratory, where their analysis was performed directly after thawing. Undiluted samples were degassed for 10 min and sterilized with syringe filters, MCE 0.45 µm prior to chromatographic analysis. High-performance liquid chromatography system controlled with Varian Workstation software version 6.9.1, consisting of two high pressure Varian LC 212 pumps, an autosampler Varian ProStar 410, an evaporative light scattering detector Varian ELSD 385 LC and an integrating module Varian Star 800, was used for analysing the sugar content in the birch tree saps according to the previously published method. The Cosmosil Sugar-D, 4.6 x 250 mm chromatographic column was used for chromatographic separation. Optimum parameters of the chromatographic analysis were determined. Isocratic flow; mobile phase composition: acetonitrile:water (80:20 v/v); mobile phase flow rate: 1 ml per min.; injection volume: 25 µl; temperature inside the column thermostat: 35ºC; the autosampler tray temperature: 4ºC. The following ELSD detector parameters were used: the flow rate of gas of 1.2 L per min., the nebulizer temperature of 80ºC and the evaporator temperature of 80ºC [6].

Statistical analysis was performed as a one-way analysis of variance (one-way ANOVA), with a tree species being a differentiating factor, using Statistica v.

10.0. To find means that are significantly different from each other, a post-hoc analysis with Tukey's honest significance test was used. The differences were deemed statistically significant with a cutoff level alpha = 0.05.

Results and Discussion

The results of the determination of monosaccharides and sucrose content in the birch tree saps of 20 individuals are summarized in Table 1.

Fructose and glucose are monosaccharides that were presented in the tree saps all of the individuals. The mean concentrations for five individuals from each sites are shown in Figure 1. The mean concentration of fructose and glucose in the studied birch tree saps at different sites did not differ statistically. The highest mean concentration was observed at the D site both for fructose and glucose, and the lowest one for the C site, simultaneously for fructose and glucose. The presence of sucrose in the studied tree saps was found in eight per twenty tested individuals. Statistical analysis of sucrose content in the birch tree saps showed significant differences between the sites of their collection. In the tree saps of all of the individuals from the B sites, there was no presence of sucrose, and at the same time, among other sap gathering sites statistically significant differences in the concentrations of sucrose has not been demonstrated.

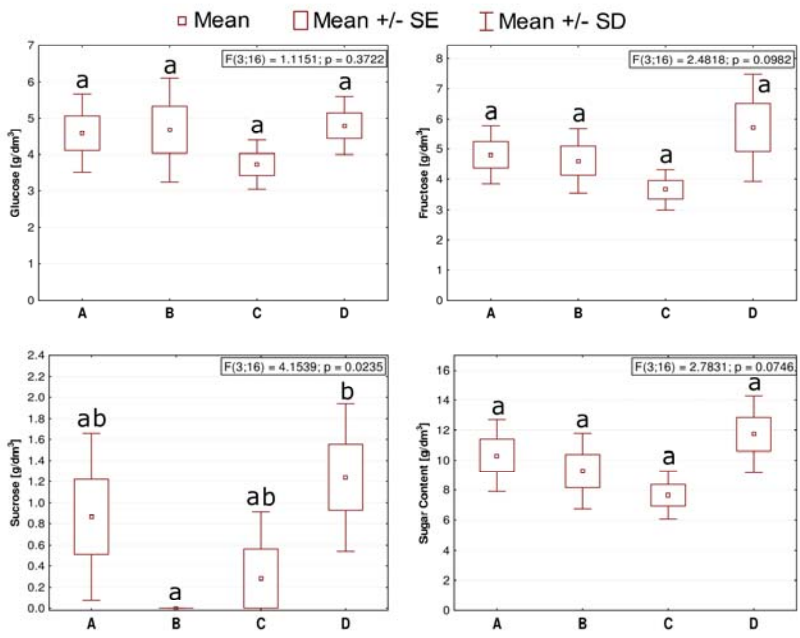

Figure 1. Monosaccharides, sucrose and total sugar content in the saps from silver birch trees. A – a site close to the field; B – a site close to the farm; C – a site in the middle of the forest, D – a site close to the pasture (for details see Materials). Same letters indicate lack of statistically significant differences between studied sites ($\alpha = 0.05$)

Table 1. The concentrations of monosaccharides and sucrose in the birch tree sap samples and a total sugar content

Sampling site	Fructose content [g/dm^3] ±SD, (n = 3)	Glucose content [g/dm^3]±SD, (n = 3)	Sucrose content [g/dm^3] ± SD, (n = 3)	Total sugar [g/dm^3]
A	4.52 ± 0.01	4.40 ± 0.04	1.46 ± 0.01	10.38
	6.56 ± 0.06	6.47 ± 0.08	1.43 ± 0.01	14.46
	4.83 ± 0.02	4.12 ± 0.02	n.d.	8.95
	4.39 ± 0.08	4.19 ± 0.03	n.d.	8.58
	3.89 ± 0.10	3.78 ± 0.01	1.44 ± 0.00	9.11
B	3.99 ± 0.10	4.21 ± 0.07	n.d.	8.20
	4.15 ± 0.02	3.94 ± 0.09	n.d.	8.09
	4.62 ± 0.09	4.41 ± 0.01	n.d.	9.03
	6.47 ± 0.03	7.17 ± 0.05	n.d.	13.64
	3.83 ± 0.09	3.58 ± 0.01	n.d.	7.41
C	4.04 ± 0.06	4.19 ± 0.05	n.d.	8.23
	3.90 ± 0.02	3.93 ± 0.02	1.41 ± 0.02	9.24
	3.22 ± 0.09	3.41 ± 0.07	n.d.	6.63
	4.39 ± 0.02	4.39 ± 0.01	n.d.	8.78
	2.73 ± 0.05	2.71 ± 0.03	n.d.	5.44
D	5.97 ± 0.01	5.07 ± 0.00	1.66 ± 0.01	12.70
	4.04 ± 0.03	3.48 ± 0.04	1.52 ± 0.04	9.04
	5.07 ± 0.08	4.78 ± 0.10	1.57 ± 0.07	11.42
	4.84 ± 0.01	5.12 ± 0.04	n.d.	9.96
	8.61 ± 0.02	5.53 ± 0.02	1.43 ± 0.01	15.57

n.d. – not detected

There weren't statistical differences between the studied sites for the averages of total sugar concentration in the tree sap samples (Figure 1). The highest average amount of total sugar was found in the D sites (11.74 g/dm^3), whereas the lowest at the C sites (7.66 g/dm^3).

The usefulness of Polish tree saps to produce syrup was evaluated in our previous studies with respect to the saps of six species, i.e. silver birch (*Betula pendula* Roth.), downy birch (*Betula pubescens* Ehrh.), European hornbeam (*Carpinus betulus* L.), Norway maple (*Acer platanoides* L.), boxelder (*Acer negundo* L.) and white willow (*Salix alba* L.) [6]. We have established that

Polish maple saps have lower sugar content than maple saps, used to produce syrup in North America [7]. Only silver birch tree sap, with the average sugar content of 9.00 g/dm^3, had the perspective for syrup production [6], like birch tree sap obtained in Finland (9.30 g/dm^3) [20]. Silver birch species is considered to be the most favourable for the production of birch syrup [2], and at the same time, this species is commonly found in the area of Podkarpacie [21].

In the present study, the average total sugar content in the silver birch tree saps from the A sites was 10.30 g/dm^3, the B sites – 9.27 g/dm^3, the C sites 7.66 g/dm^3 and the D sites 11.74 g/dm^3. In accordance with the procedures which were adopted for the Finnish birch syrup production, birch syrup is characterized by a most preferred taste qualities when it is produced from the sap having sugar content about 1° in Brix scale [11], which is approximately equal to a 10.0 g of total sugar per 1 dm^3 of sap. However, in the United States, birch syrup production is still profitable when birch sap has an average sugar content 0.74° in Brix scale, which is approx. 7.0-8.0 g of total sugar per 1 dm^3 of birch tree sap [3, 12]. Thus, silver birch tree saps from the area of Podkarpacie offer perspectives to used their for the syrup production. Saps collected from the all of tested sites met the United States criteria of profitability for syrup production, and three of them – Finnish requirements.

The potential production of birch syrup from the tree saps collected from the ecological area of Podkarpacie region seems to meet consumers demand for safe products based on “clean label” idea [22], as well as characterized by a high nutritional value and health benefits [23, 24]. Birch syrup is a food product which does not require the use of additives [11], and the widely accepted method of its manufacture, does not reduce the health-related value of primary raw material, which is birch sap [2, 4].

In the birch tree saps, which were taken from the area of Podkarpacie, high concentrations of minerals, particularly copper (average 0.15-0.39 mg/dm^3) and zinc (average 0.88-1.85 mg/dm^3) have been reported. The content of these minerals in one litter of tree sap implemented several tens of percent of daily demand for these elements [17]. In the birch syrup, which is about one hundred times concentrated sap [3], also the content of other minerals such as calcium, magnesium and potassium will be high (approx. a few grams per dm^3), so the nutritional value of the products to which a birch syrup is added, will significantly increase. Furthermore, in the syrup production process tree saps of many individuals are used, thus in the final product which is the birch syrup, the mineral content is averaging. This is particularly important in the context of the large inter-individual mineral content variability, which has been demonstrated for tree saps in our previous studies [17].

In countries where the production of birch syrup is developed on a large scale, the products to which a birch syrup is added are e.g., candies and chocolates, as well as cake toppings, which consist of a combination of a birch syrup and honey or birch syrup and caramel [3]. With the addition of the mineral-rich birch syrup, these products acquire the character of functional foods, which is now the subject of great interest among consumers [25].

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