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Birch sap concentrate as a potential modern food product

Maciej Bilek[1], Jarosław Wawer[2], Wojciech Szwerc[3], Katarzyna Słowik[3], Stanisław Sosnowski[1]

[1] *Department of Food and Agriculture Production Engineering, Faculty of Biology and Agriculture, University of Rzeszów, Poland ,Zelwerowicza 4, PL 35 601 Rzeszów, Poland*
[2] *Department of Physical Chemistry, Faculty of Chemistry, Gdańsk University of Technology, Poland Narutowicza 11/12, PL 80 233 Gdańsk, Poland*
[3] *Chair of Chemistry, Faculty of Pharmacy, Medical University of Lublin, Poland Chodźki 4a, PL 20 093 Lublin, Poland*
e-mail: mbilek@ur.edu.pl, jarwawer@pg.edu.pl, wojciech.szwerc@umlub.pl, ssos@ur.edu.pl

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Abstract. This paper presents birch sap concentrate obtained by the reverse osmosis method. It is characterized by sweet taste, high content of minerals and no risk to consumers in terms of content of heavy metals standardized in the European Union food legislation. This beverage has all the features of a modern food product, i.e. it has an attractive taste, is obtained using new technology, meets the clean label requirements and can be classified as a superfoods product.
Key words: birch tree sap, reversed osmosis, new technologies, clean label products, nutritional value.

INTRODUCTION

The consumption of raw tree sap is deeply rooted in the tradition of many countries in Europe, Asia and North America [31, 37]. Unfortunately, this form of use of the birch tree sap – and tree saps in general – is limited by their perishable character. It is valid usually about one day at room temperature and a few days under refrigeration conditions [8]. Birch sap can also be processed, most often into birch syrup, [26] or into pasteurized, sweetened beverages [21]. Regardless of the character of these technological treatments, the processing is always high-temperature, which changes the original composition of birch sap. Meanwhile, folk medicine and the results of the latest scientific research have indicated numerous pro-health benefits of raw unprocessed birch sap [29, 32, 39]. For this reason, we have started to develop non-perishable, unpasteurized birch sap-based beverages.

The addition of the citric acid and honey as taste-improving additives seems to be the most promising method of extending the shelf life of birch sap under refrigeration conditions [7, 36]. Another option is the introduction of food acids (such as citric, lactic and malic acid) into birch tree sap and the simultaneous addition of a chemical preservative, e.g. potassium sorbate, which extends the shelf life to at least one month, regardless of the temperature conditions of storage [10, 17]. In case of such a composition, however, it is necessary to introduce sweetening, taste-improving additives that are necessary to balance the acidic taste of citric acid [30, 35]. From the nutritional point of view, the most preferred addition seems to be lactic acid, which, according to the food law in the category of liquid foodstuffs, can be used as an additive to fruit nectars. However, in the wide production practice, this substance is also used as an addition to carbonated beverages, wine, beer and a very wide range of fruit and vegetable preserves [22]. As a natural product of processes occurring in the human body, it enjoys a wide acceptance of consumers, also in the groups very radically oriented against highly-processed food [28]. It should also be emphasized that lactic acid not only enhances the taste, but also has a number of health-promoting properties. Among others it promotes the absorption of minerals, such as calcium and iron, supports the action of antioxidant compounds and has a bactericidal effect [22].

As it has been presented, the formation of non-pasteurized birch sap-beverages requires the introduction of at least two additives, i.e. food acid and a sweetening additive. Meanwhile, the consumer trend, gaining more and more followers and trending the aspect of modern food industry promotes the *clean label* idea. Basically, it postulates the maximal limitation of food additives use, especially of chemical preservatives and added sugar [33]. However, in case of birch sap, the possibility of implementation of the *clean label* idea on a scale other than industrial [6, 20] seems to be difficult. New possibilities, however, have been opened by a recently described simple apparatus for the concentration of birch

tree sap using reversed osmosis (RO) [38]. Until now, this new technology has been used in food industry as one of the stages of birch syrup production [25].

Thanks to the aforementioned solution, the healthy composition of birch sap is preserved. Also, a product with a distinctly sweet taste is gained, in contrast to birch tree sap, the taste of which is unattractive to consumers and defined as similar to water [23]. It should be particularly emphasized that the improvement of organoleptic properties, i.e. obtaining a clear taste so desired by the modern consumer, is therefore not achieved due to the addition of the taste-improving additives, but through the use of a reverse osmosis process and a significant increase in the concentration of naturally occurring sugars.

The aim of this study was to assess the health-promoting properties as well as health safety of the birch sap concentrate, obtained by the reverse osmosis.

MATERIAL AND METHODS

Birch sap collection. Tree sap of silver birch (*Betula pendula* Roth.) was collected in Łukawiec village (50.097559, 22.168178), in accordance with the suggestions of commonly available indications [40], i.e. the collection took place by the drilling technique, using a drill bit with the diameter of 16 mm, to the depth of 4-5 cm, on the southern sides of tree trunks. The tree sap was collected simultaneously from four trees, placed in one container and then frozen.

Measurements of the physical and chemical parameters of birch sap as well as of the products of the reverse osmosis process. Thawed birch sap was concentrated using the apparatus described in detail in our previous publication [38]. The physical parameters of birch sap, concentrate and permeate were tested using the HI 9811-5 multiparameter meter, the HI 96801 digital refractometer and the RadWag Mac 50 moisture analyzer, using analytical methodologies recommended by the manufacturers. The content of heavy metals and minerals in the birch tree sap, concentrate and permeate was determined in accordance with the previously described analytical procedures [15, 16].

RESULTS AND DISCUSSION

Physical and chemical parameters of the birch sap as well as of the products of the reverse osmosis process. The results of the physical parameters testing of the birch sap and reverse osmosis products are summarized in Table 1.

Table 1. Physical parameters of the birch sap and of the products of reverse osmosis (RO) process

Parameter	*Birch sap*	*Birch sap concentrate*	*Permeat*
Refraction value [°Brix] ±SD (n=3)	0.9±0.0	2.6±0	0±0
Electrolytical conductivity [µS/cm] ±SD (n=3)	610±0	1530±0	10±0
pH ±SD (n=3)	6.8±0	6.4±0	5.6±0
Dry matter [%] ±SD (n=3)	0.849±0.012	2.557±0.071	0.016±0.002

The content of minerals is considered as the most important nutritional feature of birch sap. The content of copper, zinc and manganese is very high from the point of view of the nutritional norms. The content of other important minerals, such as calcium or magnesium, is low [5, 11, 13, 14].

The concentrations of minerals in the tree sap and in the RO products obtained in the present work are presented in Table 2.

Table 2. The content of minerals in the birch tree sap and in the products of the reverse osmosis process

Mineral	*Birch sap*	*Birch sap concentrate*	*Permeat*
Sodium [mg dm^{-3}] ±SD (n=9)	0.73±0.01	18.8±1.7	0.381±0.004
Potassium [mg dm^{-3}] ±SD (n=9)	90.7±1.6	302.6±6.2	4.04±0.1
Copper [µg dm^{-3}] ±SD (n=7)	11.76±0.55	199.3±1.3	<LOQ
Zinc [mg dm^{-3}] ±SD (n=9)	1.2±0.034	4.71±0.091	0.02±0.002
Calcium [mg dm^{-3}] ±SD (n=7)	30.8±2.1	129.42±0.028	0.39±0.015
Magnesium [mg dm^{-3}] ±SD (n=9)	23.88±0.21	49.1±0.58	0.222±0.005
Manganese [mg dm^{-3}] ±SD (n=9)	1.043±0.017	4.489±0.062	0.016±0.001
Iron [µg dm^{-3}] ±SD (n=7)	15.46±0.89	271±23	<LOQ

<LOQ, below the quantification limit

As it was presented in Table 2, the concentrate is characterized by a significantly increased content of nutritionally important mineral components towards birch sap. This is particularly evident in relation to the latest nutrition standards [24] (Fig. 1).

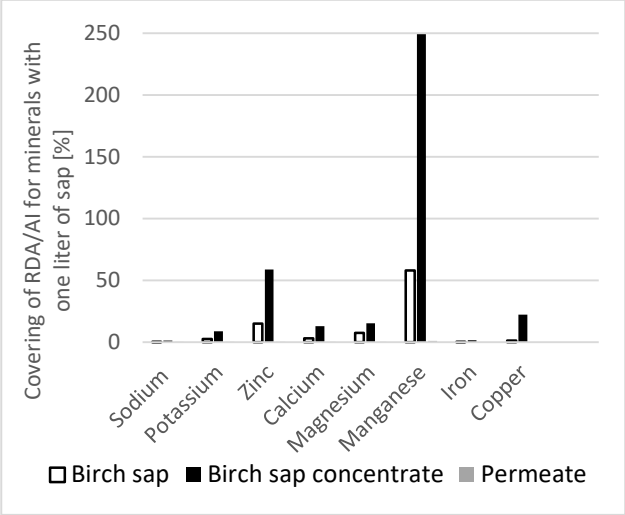

Fig. 1. The percentage implementation of nutritional norm for an adult woman for minerals in one liter of birch tree sap and the products of the reverse osmosis process. Recommended Dietary Allowance norm for zinc, calcium, magnesium, iron and copper, Adequate Intake norm for manganese, sodium and potassium.

The content of heavy metals is the determinant of the health safety of birch sap consumption. In our earlier studies, we did not find concentrations of heavy metals in birch sap which would be dangerous in relation to the maximum levels for various raw materials of plant origin [4, 12, 15].

Table 3. The content of heavy metals in birch tree sap and the products of the reverse osmosis process

Heavy metal	*Birch sap*	*Birch sap concentrate*	*Permeat*
Lead [µg dm^{-3}] ±SD (n=9)	<LOQ	<LOQ	<LOQ
Cadmium [µg dm^{-3}] ±SD (n=9)	<LOQ	0.806±0.016	<LOQ
Nickel [µg dm^{-3}] ±SD (n=9)	52.61±0.98	56.84±0.14	<LOQ
Chromium [µg dm^{-3}] ±SD (n=9)	<LOQ	<LOQ	<LOQ

<LOQ, below the quantification limit

As shown in Table 3, the content of lead, cadmium and chromium both in the birch tree sap and the permeate is below the limit of quantification of the apparatus used. The content of cadmium can be quantified only in the birch sap concentrate, but it does not exceed the maximum level allowed by the European Union legislation for food category "Vegetables and fruit, excluding leaf vegetables, fresh herbs, fungi, stem vegetables, pine nuts, root vegetables and potatoes", i.e. 50 µg dm^{-3} wet weight [18]. However, attention must be paid to the relatively high content of nickel in the birch sap tested, higher than those recorded in our earlier works [15]. For this heavy metal there is no maximum level established in the European food law, although the results obtained can be referenced to the maximum level set by the Polish law for drinking water at 20 µg dm^{-3} [34]. Fortunately the content of this heavy metal does not increase in the birch sap concentrate compared to the sap. The high concentration of nickel recorded in the sap collected in the village of Łukawiec confirms our earlier thesis that birch tree sap should always be examined in terms of heavy metals content before processing and consumption [15].

Birch sap concentrate as a modern food product, obtained using the so called new technology. In this work birch sap concentrate has been presented. It is characterized by sweet taste and meets all the latest trends in the food industry as well as the image of modern foodstuff with high nutritional value. In addition to meeting the health safety requirements [18] and implementing the above-mentioned *clean label* idea [33], the concentrate described is obtained using a relatively new technology in the field of food industry, i.e. reverse osmosis [39].

The popularity and practical application of new technologies in food industry has been gradually increasing, while the foodstuffs obtained through them have enjoyed rising sales [1, 27]. The presented birch sap concentrate is characterized by a very high content of minerals. This fact can be regarded as a distinctive feature of the new product. This simple, tradition-based soft drink with a natural composition, could serve as an interesting product for consumers who value unprocessed foods with high nutritional value. Therefore, the product described here has a good chance to be successful in the superfoods category. And just as other superfoods, the product could be promoted in marketing campaigns [19]. Another strong point of a marketing campaign of the described concentrate could be a reference to the Slavic tradition of birch sap tapping, still alive in contemporary culture [37]. Moreover, the birch sap concentrate could become one of the important so-called BIO products from ecologically clean areas. This would not only increase the prestige of the product, but also the health safety of consumers,

particularly important in the case of birch sap, susceptible to the impact of agricultural and industrial pollution [4, 9]. It should also be emphasized that the availability of birch tree sap is very short and depends on the high variability of atmospheric phenomena in March each year [2, 3]. All this clearly indicates that the production of the described concentrate should be treated only as a chance to create additional, seasonal production of food factories. It can not be considered as their main business line.

CONCLUSIONS

1. The reverse osmosis of birch tree sap allows to obtain a concentrate with sweet taste, high content of minerals and no risk to consumers in terms of heavy metal content standardized in the European Union food legislation.
2. The concentrate obtained has all the features of a modern food product, i.e. it has attractive taste, is obtained using new technology, meets the *clean label* requirements and can be classified as a superfoods product.

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