Research article

Turbidity changes of birch tree sap after addition of commonly available chemicals

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Abstract: *The problem signalled both by the popularizers of birch tree sap consumption, as well as in many scientific articles and sap collection manuals is short shelf life, hindering the wider use. The loss of shelf life is manifested by the appearance of a characteristic turbidity and simultaneously intensifying unpleasant odor. Most of birch sap shelf life extension methods, that inhibit turbidity, are non-thermal methods, based on the physical techniques, ex. ultraviolet radiation, ultrafiltration, and also combination of this two methods. The aim of this study was to assess the stability of the birch tree sap, depending on the concentration of commonly available chemicals used to extend shelf life of plant origin food products. At room temperature, the sample with addition of ethanol at the concentrations of 10% and 15%, as well as with the addition of citric acid in combination with potassium sorbate were stable during the all turbidity testing period. Additionally, in the refrigerated condition, 27-day stability has been obtained for the sap with the addition of ethanol at the concentration of 5% and 15-day with the addition of citric acid in concentration of 0,5%. This stable solutions obtained, however, are not suitable for direct consumption. They can only be used as a stable base for the preparation of beverages, after the addition ex. herbal extracts, fruit juices and syrups, honey.*

Keywords: *silver birch; birch tree saps; turbidity, functional beverages.*

Introduction

Growing popularity of tree saps, especially birch sap, is observed in the last few years. It can be explained in two ways. The online communities that promote healthy lifestyle and the consumption of natural, unprocessed natural products are developed intensively. This is the reason why the information about the nutritional value of tree sap and the ways of their acquisition appear on the Internet [1, 2]. On the other hand, online communities are also inspired by the scientific sources, especially the ethnographic data, that points to the numerous erstwhile medical applications of tree saps [3, 4], many of which were confirmed by the modern researches [5 ,6].

The problem signalled both by the popularizers of birch tree sap consumption [1,2], as well as in many scientific articles [7, 8] and sap collection manuals [9] is their short shelf life, hindering the wider use. The loss of shelf life is manifested by the appearance of a characteristic turbidity and simultaneously intensifying unpleasant odor [7]. Rapidly microbially degraded of birch tree sap is facilitated due to its chemical composition, i.e. approx. 0.5-1% of simple sugars [10] and approx. 0,1-0,5% of minerals [11], and may be considered as a very good medium for the microbes [7, 8]. Progressing microbial decomposition of birch sap causes danger to the health of consumers, due to the presence of very rich and rapidly expanding microflora, that harmfulness to human has not been evaluated yet [8, 12].

Therefore, numerous attempts to extending the shelf life of birch tree sap, have been taken. Most authors avoid, at the same time, pasteurization or thermisation, because thermal methods may cause the disappearance of many valuable components of sap, that are determining the health-promoting properties [13]. Attention is also drawn that under the influence of high temperature, decomposition of fructose is observed, which is manifested by browning of the sap [14]. Therefore, most of presented methods that inhibit turbidity are non-thermal methods based on the physical techniques, ie. ultraviolet radiation [15], ultrafiltration [16] and also combination of this two methods [8]. But it should also be noted emphatically, that these solutions are cost-intensive for the food industry, as well as unavailable for the consumers who collect the tree saps on their own and want to extend sap shelf life using the methods available in the household.

And this is why a simple method of inhibiting turbidity of tree saps are presented by the popularizers of birch sap consumption. From the food technology point of view, they rely on the addition of chemicals that increases the shelf life, such as citric acid or ethanol. Refrigerated condition is also featured [1]. These recommendations, however, we do not find the information what concentrationof these substances should be used, as well what is the stability of obtained beverages.

The aim of this study was to assess the stability of the birch tree sap, depending on the concentration of commonly available chemicals used to extend shelf life of plant origin food products.

Experimental

Materials

Tree sap of silver birch (*Betula pendula* Roth.) was collected in Niwiska village, located on the Kolbuszowa Plateau. 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, using the silicone hose with a diameter of 16 mm sealed with duct tape, and plastic bottles, previously disinfected with ethanol at a concentration of 70%. A collection was carried out continuously, and the tree sap of seven individuals was combined in the evening and then frozen at -21°C.

Before the turbidity testing, birch tree sap was thawed in a water bath and the temperature thereof was controlled and never exceeded 10°C during the thawing. After thawing, the sap was divided into half-liter bottles, previously disinfected with ethanol at a concentration of 70% and then preserved as described in the table (Table 1). To inhibit turbidity of birch sap commonly available substances were used, ie. citric acid, ethanol, potassium sorbate and sodium benzoate (Table 1), not to exceeding the levels permitted by the regulation of Minister of Health of 22 November 2010 [17].

Table 1. Test material and methods for inhibit turbidity of birch tree sap

Sample	**Storing conditions**	
	Room temperature (21°C)	**Refrigerated condition (4°C)**
1-2	Birch sap	
3-4	Birch sap, citric acid 0,1%	
5-6	Birch sap, citric acid 0,25%	
7-8	Birch sap, citric acid 0,3%	
9-10	Birch sap, citric acid 0,5%	
11-12	Birch sap, etanol 2,5%	
13-14	Birch sap, etanol 5%	
15-16	Birch sap, etanol 10%	
17-18	Birch sap, etanol 15%	
19-20	Birch sap, potassium sorbate 0,03%	
21-22	Birch sap, potassium sorbate 0,025%, sodium benzoate 0,015%	
23-24	Birch sap, potassium sorbate 0,03%, citric acid 0,5%	
25-26	Birch sap, potassium sorbate 0,025%, sodium benzoate 0,015%, citric acid 0,5%	

Methods

Stability of birch tree sap has been evaluated in the 27-days turbidity testing, and a study was carried out in three-day intervals. For stability studies turbidity parameter has been selected, which in our previous work [18] was chosen as the first and fastest changing parameter in relation to the changes that are occurring in the tree sap. Turbidity is a parameter that increases during the storage as the first, in contrast to other physical and chemical parameters such as pH, electrolytic conductivity, refraction, or the measurement of absorbance, which, in relation to the turbidity, are changing for several days later. The turbidity was tested using a Hanna Instrument 98703 turbidimeter, working on the scattered light principle in the range 400-600 nm. Each measurement was performed three times and the results were presented in figures as mean values with standard deviation shown as error bars.

Results and Discussion

Obtained results for turbidity testing are presented as figures 1-3.

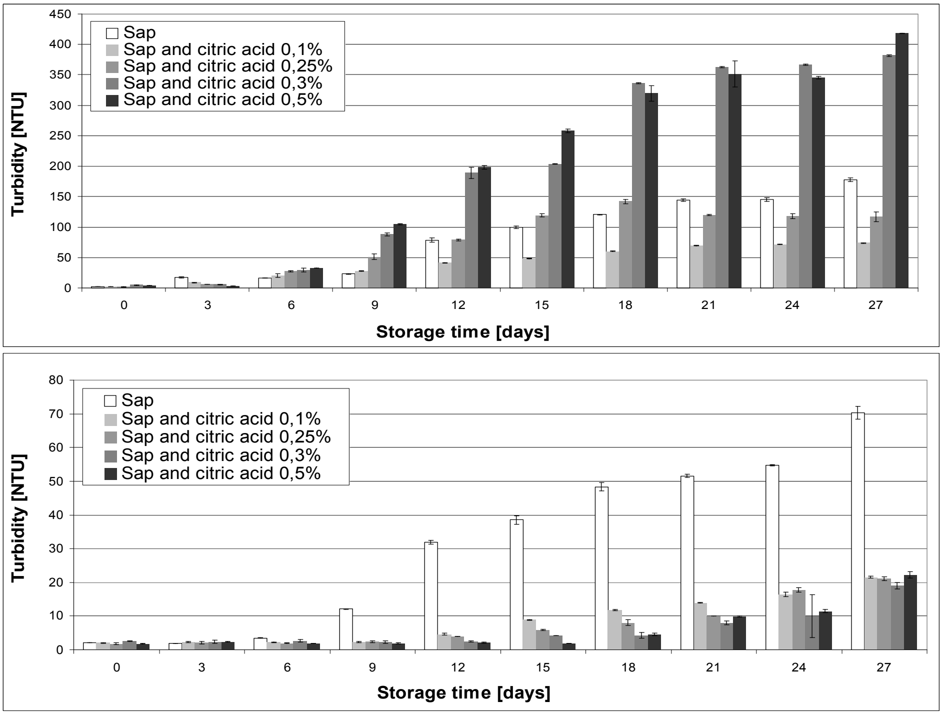

Figure 1. Turbidity changes during the testing of birch sap with addition of various concentration of citric acid (top – room temperature, bottom – refrigerated condition)

Birch tree sap with no shelf life additives and storing in the room temperature is characterized by a very low stability, as it was signaled in the work of Jeong-Jeong et al. [8] and Viškelis and Rubinskienė [7]. We have confirmed these observations in this study (Figure 1).The use of refrigerated condition marginally inhibit turbidity of birch sap (Figure 1). In the present study, no increase of turbidity was observed up to the third day of testing. Viškelis noted that the pH of birch sap at a temperature of 2°C does not change until the fifth day of the test [7], but on the other hand Jeong-Jeong described that during the third day of the test increase in absorbance can be seen, at a wavelength of 420 and 590 nm [8].

The addition of citric acid at room temperature only in a concentration of 0.5% inhibited turbidity for about three days. Lower concentrations of citric acid did not stop the changes of this parameter. It should be emphasized that further turbidity of tree sap was the fastest for the concentrations of 0.3% and 0.5%, and the slowest for a concentration of 0.1%. When additional refrigerated condition were applied, significant inhibit turbidity of birch sap has been obtained, ie. 9 days for the concentrations of 0.1% and 0.25%, 12 days for the concentration of 0.3%, and 15 days for the concentration of 0.5%.

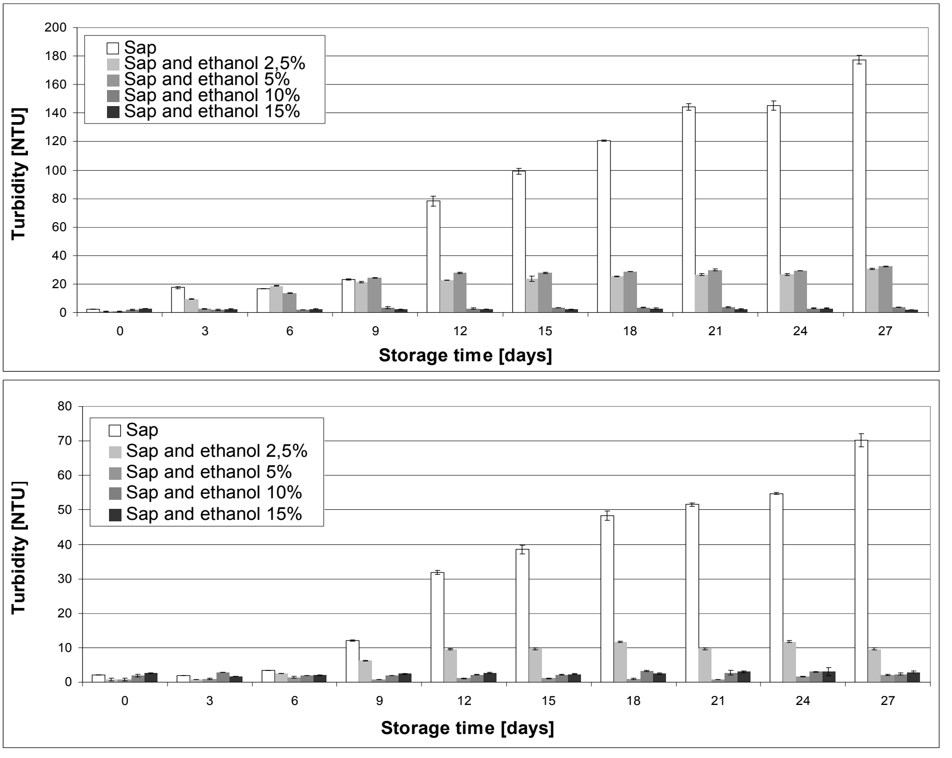

Figure 2. Turbidity changes during the testing of birch sap with addition of various concentration of ethanol (top – room temperature, bottom – refrigerated condition)

Use of ethanol resulted in a much more effective inhibit turbidity of birch sap (Figure 2). At room temperature, using a concentration of 10% and 15%, we achieved a stability in the entire of turbidity testing. Using a concentration of 5% stability was at least three days, and in the case of concentration of 2.5% increase in turbidity was observed in the second measurement of the turbidity testing, that is, after three days of storage. Sample in the refrigerated condition with the ethanol concentration of 2.5% reached three days stability, whereas for concentrations of 5%, 10% and 15% increase of turbidity was not observed throughout the period of the testing (Figure 2).

The use of preservatives, i.e. sodium benzoate and potassium sorbate brings result only in combination with the citric acid. Paradoxically, using the combination of citric acid at a concentration of 0.5% and both mentioned preservatives, turbidity increased at room temperature was observed on the 12th day of turbidity testing, while in the case of the combination of citric acid and potassium sorbate there was no increasing turbidity during the all testing (Figure 3). This observation is very important from the food safety point of view, because citric acid and potassium sorbate, are considered as one of the safest food additives [19]. For this reason, this method can be regarded as an optimal and certainly worth recommending [20].

For the birch sap with potassium sorbate or potassium sorbate in combination with sodium benzoate added increase in turbidity was observed just after three days of the testing. The use of additional refrigerated condition delayed the turbidity of this samples an additional three days, whereas those with citric acid at a concentration of 0.5% and with the addition of potassium sorbate or potassium sorbate in combination with sodium benzoate were stable throughout the turbidity testing.

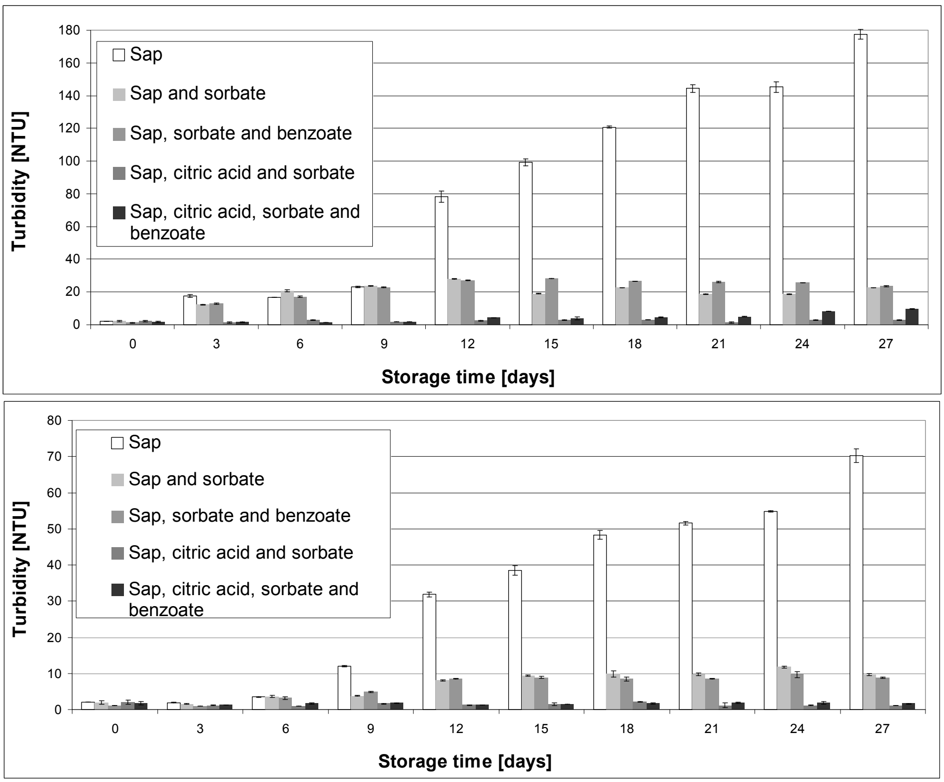

Figure 3. Turbidity changes during the testing of birch sap with addition of various preservatives (top – room temperature, bottom – refrigerated condition)

Previous attempts to extend the shelf life of tree sap have been undertaken using physical methods. Jeong-Jeong [8] used a combination of ultrafiltration and ultraviolet radiation techniques. Thus, he obtained a 20-day inhibit turbidity of *Betula platyphylla* tree sap, regardless of storage temperature, ie. 4°C and 25°C.

In this work much longer, at least a 27-day inhibit turbidity of birch sap has been obtained. In the refrigerated condition this involved the addition of ethanol in the concentrations 5%, 10% and 15% as well as addition of citric acid 0,5% with potassium sorbate 0,03% and citric acid 0,5%, potassium sorbate 0,025% and sodium benzoate 0,015%. At room temperature no changes are observed in the samples with addition of ethanol at the concentrations of 10% and 15%, as well as with the addition of citric acid with combination of potassium sorbate.

This stable solutions obtained, however, are not suitable for direct consumption due to unfavorable taste values. Thus, they can only be used as a stable base for the preparation of beverages. In previous published works devoted to additives used to improving the taste of beverages, which at the same time are giving the health benefits, herbal extracts [21], fruit juices [22], fruit syrups [23] as well as honey [24] are mentioned and, therefore, may be used as additives for birch sap. Both substances used to inhibit turbidity, as well as the additions suggested as flavors, are commonly available. This makes possible for consumers collecting birch sap on their own to get a drink of increased stability and taste adjusted to own preferences. Due to the high mineral content, characteristic for the birch sap, as well as non-thermal methods, preserving the initial composition of the sap, it is possible to obtain a tasty beverage with functional properties.

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