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Selected Physical Parameters and Daily Volume of Silver birch sap Collected from the Cardinal Directions of the Tree Trunk

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Abstract: The collection, sale and processing of non-wood forest products are becoming a significant factor in stimulating regional development and improving the economic situation especially of poor rural communities. The fashion for a healthy lifestyle is also conducive to the growth of interest in such goods. Among them, birch sap is indicated as one of the most promising non-wood forest resources of central Europe, with very wide possibilities of its practical use, e.g. in the food, pharmaceutical and cosmetics industry.

The potential increase in birch sap commercial use prompts to undertake research on both the principles of its collection and the impact of various factors on its quality. In this presentation, we decided to investigate how the daily volume and selected sap parameters change depending on the location of the holes in relation to the cardinal directions.

The research was conducted in April 2018, in the eastern part of Poland, in a stand with a dominant share of silver birch (*Betula pendula* Roth) at the age of approx. 100 years, in a fresh broadleaved forest habitat. On each of the 6 selected trees, 4 holes were drilled at a height of 1 m, positioned according to the cardinal directions (N-E-S-W). Sap was collected twice, one week apart, always after 24 hours of leak. In each case, the daily volume of the obtained sap was determined, and then the selected properties of the sap were tested: electrolytic conductivity (proving, among others, the content of pro-health minerals), refractometric index (proving the approximate content of sugar), pH and the percent of dry matter.

As a result of the research, it was found that the location of boreholes in the tree trunk in relation to the cardinal directions (N-E-S-W) does not affect the efficiency of the birch sap leak intensity as well as on most of tested physical sap properties: refraction, pH value and percentage of dry matter. However, a slight effect on the electrolytic conductivity was found. Therefore it can be summarized that the cardinal directions does not affect the usefulness of the sap for the production of birch syrup, but may affect a nutritional value.

Keywords: non-wood forest products; forest utilization; silver birch sap

1. Introduction

According to FAO definition, non-wood forest products (NWFPs) consist of goods of biological origin other than wood, derived from forests, other wooded land and trees outside forests [1]. The use of non-wood forest resources is not only of historical significance today [2]. Millions of people in the world still obtain a significant part of their basic, daily needs by using numerous forest resources [3,4]. The collection, sale and processing of NWFPs are becoming a significant factor in stimulating regional development [5,6]. Particularly the increasing social demand for food products collecting from the forests is being observed currently. Among them, birch sap is indicated as one of the most promising non-wood forest resources of central Europe, with very wide possibilities of its practical use, e.g. in the food, pharmaceutical and cosmetics industry [7,8].

The potential increase in birch sap use prompts to undertake research on both the principles of its collection and the impact of various factors on its quality. So far, very detailed studies on the usability and chemical composition of sap have been carried out, however, they did not take into account typical forest conditions, including regionalization, habitat conditions, and tree parameters. The aim of this paper was to investigate how the daily volume and selected sap parameters (electrolytic conductivity, refractometric index, pH value and the percent of dry matter) change depending on the location of the holes in the tree trunk in relation to the cardinal directions.

1. Material and Methods

The research was conducted in April 2018, in the eastern part of Poland (Lubartów Forest District, Regional Directorate of State Forest in Lublin), in a stand with a dominant share of silver birch (*Betula pendula* Roth) at the age of approx. 100 years, in a fresh broadleaved forest habitat. The Hartig's method was used to designate sample trees representing the stand. This method is based on taking trees ordered by increasing diameter at breast height (DBH) and categorizing them into three classes of the same cross-sectional area [9]. Then, two sample trees of average DBH value from each class were selected. On each of the 6 selected trees, 4 holes were drilled at a height of 1 m, positioned according to the cardinal directions (N-E-S-W). Sap was collected twice, one week apart, always after 24 hours of leak. In each case, the daily volume of the obtained sap was determined [10], and the samples for further testing were immediately frozen. The following properties of the sap were tested:

- electrolytic conductivity (proving, among others, the content of pro-health minerals) - using Conductometer HI 9811-5, HANNA;
- refractometric index (proving the approximate content of sugar) - using Refractometer HI 96801, HANNA;
- pH value (corresponding to, inter alia, organic acid content) - using pH meter HI 9811-5, HANNA;
- the percent of dry matter (corresponding to, inter alia, the sugar content) – using analytical balance and laboratory dryer.

All parameters (except daily leak volume) were measured in triplicate and then averages were calculated. Statistical analyses were performed with the use of STATISTICA 13.1 software [11]. The impact of the location of the boreholes on the trunk (the cardinal direction) on the values of the studied variables characterizing the physical parameters of birch sap (daily leak volume, refractometric index, pH value, electrolytic conductivity and percentage of dry matter) was checked using the Friedman test (Friedman One-Way Repeated Measure Analysis of Variance by Ranks), which is a non-parametric alternative to the one-way repeated measures ANOVA test. The multiple pairwise-comparison procedures were carried out with the use of Dunn's post-hoc test, investigating the significant differences in the mean values of the examined features (physical parameters of birch sap) for all combinations of pairs of the independent variable (cardinal directions). The relationship between various physical parameters of birch sap was investigated using the Spearman's rank correlation coefficient.

3. Results

During the two collection periods, a total amount of 49.281 dm^3 of birch sap was obtained, including: from the N direction - 16.766 dm^3, S - 10.970 dm^3, W - 10.567 dm^3, E - 10.978 dm^3. On average, the daily amount of collected tree sap was 1.026 dm^3/24h (the highest in the N direction - 1.397 dm^3/24h, while the smallest in W - 0.881 dm^3/24h) (Table 1).

Table 1. Descriptive statistics of the birch sap parameters in relation to the location *of the sap collection points* (cardinal directions).

Cardinal directions	Number of observations	Mean	Median	Minimum	Maximum	Standard deviation	Coefficient of variation [%]	ANOVA Friedman
The impact of the cardinal direction (location of the hole on the trunk) on the daily volume of the birch sap [ml]								
S	12	914,17	883,00	590,00	1556,00	269,05	29,43	p = 0,334
W	12	880,58	496,00	25,00	2696,00	875,64	99,44	
N	12	1397,17	969,00	340,00	2620,00	814,24	58,28	
E	12	914,83	791,00	30,00	2284,00	719,86	78,69	
The impact of the cardinal direction (location of the hole on the trunk) on the refractometric index [°Brix]								
S	12	0,73	0,80	0,30	1,00	0,25	33,85	p = 0,233
W	12	0,62	0,70	0,10	0,90	0,22	36,09	
N	12	0,74	0,82	0,20	1,17	0,29	39,83	
E	12	0,71	0,80	0,17	1,20	0,30	41,64	
The impact of the cardinal direction (location of the hole on the trunk) on pH value								
S	12	5,38	5,40	3,73	6,70	0,85	15,76	p = 0,341
W	11	4,88	4,90	3,60	5,73	0,67	13,75	
N	12	5,39	5,47	4,33	6,70	0,70	12,94	
E	12	5,61	5,67	4,50	7,37	0,80	14,21	
The impact of the cardinal direction (location of the hole on the trunk) on the electrolytic conductivity [µS/cm]								
S	12	654,44	651,67	440,00	876,67	128,40	19,62	p = 0,025 *
W	11	537,88	623,33	90,00	703,33	174,96	32,53	* *
N	12	531,11	553,33	240,00	783,33	142,90	26,91	*
E	12	580,00	556,67	400,00	853,33	130,34	22,47	* *
The impact of the cardinal direction (location of the hole on the trunk) on the percent of dry matter								
S	12	0,649	0,753	0,203	0,989	0,292	45,07	p = 0,873
W	12	0,571	0,695	0,041	0,837	0,281	49,22	
N	12	0,680	0,767	0,137	1,094	0,343	50,40	
E	12	0,646	0,724	0,142	1,124	0,298	46,17	

The highest coefficient of variation was observed at the W direction (99.44%), and the lowest at the S direction (29.43%). Based on the Friedman ANOVA analysis, no statistical significance was found between the cardinal direction from which the sap was collected and the daily sap volume ($p=0.334$), despite the observed differences in the volume of sap obtained. A similar trend was observed for the refractometric index, which was not statistically confirmed ($p=0.233$). The values ranged on average from 0.62°Brix (W direction) to 0.74°Brix (N), on average 0.70°Brix. The coefficient of variation ranged from 33.85% (S) to 41.64% (E) (Table 1). On average, the pH value was 5.33 (the highest in the E direction - 5.61, the lowest in W - 4.88). The coefficient of variation ranged from 12.94% (N) to 15.76% (S). Similarly, no statistical significant difference was found between the location of the hole on the trunk and the pH of the samples (p=0.341) (Table 1). In the case of electrolytic conductivity, the values ranged from 531 μS/cm in the N direction to 654 μS/cm in the S, on average 577 μS/cm. The lowest variability was shown in the S direction (19.62%), and the highest in the W direction (32.53%). Statistical significant differences were demonstrated between the location of the hole on the trunk and the electrolytic conductivity (p=0.025). The arrangement of homogeneous groups showed two homogeneous groups. Statistical differences exist between the N and S directions (Table 1). On average, the percentage of dry matter was 0.636%, the highest in the N direction (0.680%), and the lowest in the W direction (0.571%). The coefficients of variation are at a similar level (from 45.07% on S to 50.40% on N). These differences were not statistically confirmed (p=0.873) (Table 1). The relationship between the refractometric index and the percentage of dry matter (r=0.9588), pH value (r=0.6350) and electrolytic conductivity (r=0.3760) was demonstrated. A correlation was also found between the percentage of dry matter and pH value (r=0.6499) as well as electrolytic conductivity (r=0.3096).

4. Discussion and Conclusions

The obtained results do not confirm the influence of the location of the drill in the tree trunk (in relation to the cardinal directions) on the sap leak efficiency and on most of the physical properties tested. However, many authors report a relationship between the sap yield and the location of the holes in relation to the cardinal directions and their number in individual trees. According to Kostroň [12], in the initial period of the leakage, the earliest and highest production of birch sap can be observed from the holes located on the south side of the tree trunk (it is probably caused by the sun exposure of the trunk). At a later stage, the greatest leakage is observed from the north, and the leak of sap from that direction ends at the latest. The highest efficiency is recorded from the northern boreholes, then east and west, and the lowest from the south [12]. This is also confirmed by Dinulescu [13]. Kostroň [12] also stated that the stand exposure influences the sap leak efficiency. The largest leak can be observed on the mild northern slopes, the smallest - on the southern slopes. According to Janistyn [14], the content of chemical compounds also varies depending on the location of the boreholes in relation to the cardinal directions. Grochowski [15] and Kostroň [12] report that as the number of holes increases, the total sap yield from the trunk increases, but the leakage from individual holes decreases.

The conducted research allows for the following conclusions.

- The location of boreholes in the tree trunk in relation to the cardinal directions (N-E-S-W) does not affect the efficiency of the birch sap leak intensity.
- The location of boreholes in the tree trunk in relation to the cardinal directions has no influence on physical sap properties such as: refraction, pH value and percentage of dry matter; however, a slight effect on the electrolytic conductivity was found. Therefore it can be summarized that the cardinal directions does not affect the usefulness of the sap for the production of birch syrup, but may affect a nutritional value. To confirm it, research using instrumental analysis techniques must be applied, because not only minerals content, but also organic acids and inorganic anions can affect the electrolytic conductivity.

5. References

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