4-26-2018

Calcium concentration in tree sap of five species of Minnesota trees as an indicator of sugar sand

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Introduction

Tree sap can be collected from a variety of species in Minnesota. When the sap of sugar maple trees and other maples is cooked into syrup, a cloudy mixture of minerals precipitates out. This precipitate, called sugar sand, gives syrup an unpleasant taste and can clog up machinery if improperly managed (Ball, 2007). Calcium, present in tree sap, is a major component of sugar sand (Warren, 1911). Thus, calcium concentration is an indicator of how much sugar sand would precipitate out if sap is processed into syrup. Previous literature has shown that sugar maple sap has the highest calcium concentration (Leaf, 1964), followed by box elder (Bilek, Stawarczyk *et al*., 2016) , red maple (Luczaj, L. *et al*., 2014), and birch (McCormick, 1997) Ironwood sap had no previous research conducted. The purpose of this study was to determine the possible variations in the predicted amount of sugar sand in syrup produced from different species of trees by measuring the calcium concentration in the trees' sap. In addition, we aimed to determine the pattern of change in concentration of calcium over the course of the season. We hypothesized that the calcium concentrations in sap would match that of the previous research, with sugar maple sap having the highest concentration, then box elder, red maple, and paper birch. Since no previous ironwood research existed, we could not make any hypothesis concerning calcium concentration in its sap.

Methods

At Saint John's University in Collegeville, Minnesota, two trees each of the five following species were tapped from March 21 to March 29: sugar maple (*Acer saccharum*), box elder (*Acer negundo*), red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), and ironwood (*Ostrya virginiana*). Trees were tapped with 5/16 spiles using standard procedures. Sap volume was recorded and calcium concentration of the sap measured using a ion-selective calcium electrode.

Results

- Box elder sap had the highest average calcium concentration at 29 mg/L followed by sugar maple at 17.15 mg/L and red maple at 15.42 mg/L, measured from the March 22, 23, and 24 collection dates. Box elder sap had a significantly higher concentration of calcium compared to both sugar maple and red maple, which were not significantly different from each other (Figure 1).
- Over the three day period from March 22-24 that the sap was measured, box elder sap calcium concentration decreased and both sugar maple and red maple increased (Figure 2).
- Paper birch and ironwood produced no sap in the March 21-29 collected period.

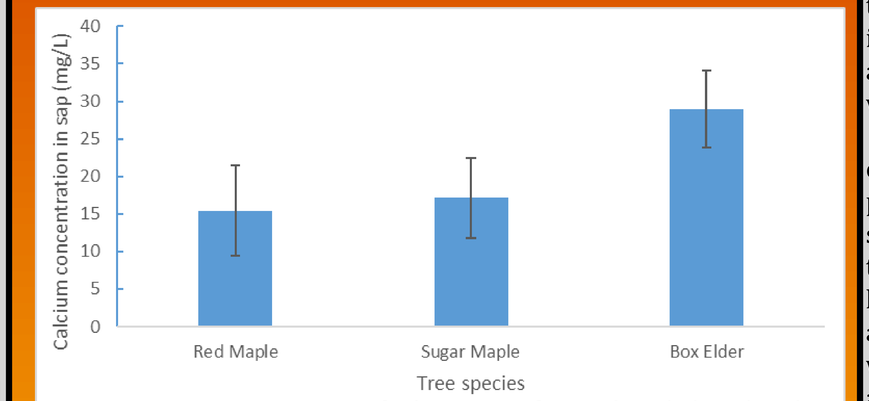

Figure 1. Average concentration of calcium in sap from red maple (*A. rubrum*), sugar maple (*A. saccharum*), and box elder (*A. negundo*) from March 22-24. Error bars represent standard deviation (95% CI).

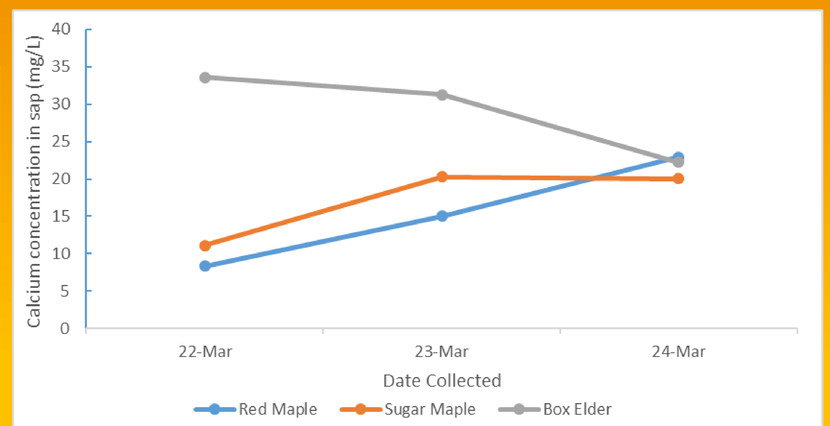

Figure 2. Daily average concentration of calcium in sap from red maple (*A. rubrum*), sugar maple (*A. saccharum*), and box elder (*A. negundo*) from March 22-24.

Discussion

Results refuted our hypothesis that sugar maple sap would have the highest concentration of calcium, followed by box elder and red maple. Box elder was actually highest, and sugar maple and red maple, both about the same concentration, were lower than box elder. We were not surprised that the paper birch did not produce any syrup, since previous research had shown that they tend to produce later in the season than maples (Jones & Alli, 1987). Also, ironwood producing no sap could be due to either the inability for the species to produce sap or to them only producing sap later in the season. We refrained from making any conclusions about trends in calcium concentration from sap over the course of the season since we had only three days of data. Fluctuations in these concentrations are more likely due to daily temperature variations than from a seasonal trend.

Since box elder sap has the highest concentration of calcium, we would expect that they would also produce the largest amount of sugar sand. This could mean that, for people considering alternative sources of syrup besides sugar maples, they might wish to avoid box elder if they are concerned about maintenance of equipment, since using box elder sap could potentially produce require more cleaning per volume of sap boiled than red maple and sugar maple, which had lower concentrations. However, red maple could be a good alternative to sugar maple for limiting the sugar sand produced, since it contained around the same amount of calcium. On the other hand, if someone were interested in using tree sap as a dietary supplement, box elder might be a consideration, although, as noted below, box elder does not have a very palatable taste.

Box elder on average produced the most amount of sap, often overflowing the gallon containers used to collect each day. Sugar maple produced an intermediate amount of sap and red maple produced the smallest. If someone were interested in obtaining large quantities of sap, they might wish to consider box elder, but bearing in mind that it could have the most sugar sand precipitate out if boiled into syrup. In addition, box elder sap, when taste-tested, had a rather unpleasant woodsy taste that overpowered any sweetness it possessed. Red maple and sugar maple had more pleasant tastes, so we would recommend these rather than box elder for making syrup, perhaps suggesting sugar maple over red maple due to its higher sap volume per tree.

One may note that, although sap was collected on days from March 21 to March 29, only results from March 22-24 are displayed. This is due to human error. The sap was all tested on one day, but unfortunately, after the first three days, the electrode was dropped and stopped functioning. Multiple attempts were made to make the electrode work again, but nothing succeeded. Thus, only three days' worth of results were able to be collected. Other sources of error could include days skipped in collecting sap, unpredictability in the accuracy and precision of the calcium electrode, and daily variability in outside temperature.

Literature Cited

Ball, D. (2007). The Chemical Composition of Maple Syrup. Journal of Chemical Education 84(10), 1647-1650.
Bilek, M., Stawarczyk, K., Gostkowski, M., Olszewski, M., Kędziora, K. M., & Cieślik, E. (2016). Mineral content of tree sap from the Subcarpathian region. Journal of Elementology, 21(3), 669-679.
Jones, A. & Alli, I. (1987). Sap yields, sugar content, and soluble carbohydrates of saps and syrups of some Canadian birch and maple species. Canadian Journal of Forest Research 17, 263-266.
Leaf, A. (1964). Pure Maple Syrup: Nutritive Value. Science 143, 963-964.
Luczaj, L., Bilek M., & Stawarczyk K. (2014). Sugar content in the sap of birches, hornbeams and maples in southeastern Poland. Central European Journal of Biology 9(4), 410-416.
McCormick, L. (1997). Variation in mineral content of red maple sap across an atmospheric deposition gradient. Communications in Soil Science and Plant Analysis, 28(3-5), 365-379.
Warren, W. (1911). "Sugar sand" from maple sap, a source of malic acid. Journal of the American Chemical Society 33, 1205-1211.