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# Sugar Concentration in Frozen Sap

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## Introduction

Native Americans are the first people credited with processing syrup from the sap of maples trees, and the processes used to make maple syrup today are derived from their techniques (Henshaw, 1890). One of these procedures that the Native Americans used that is still utilized today is the freezing of sap. By allowing the sap to sit in below freezing temperatures, the water in the sap separates out and freezes on the top and is then able to be removed from the sap (Henshaw, 1890). This process helps to cut down on the amount of heat and time that is needed to evaporate the sap into syrup. A problem, however, is that it is possible that the ice that is removed form sap may hold a significant amount of sugar, making the removal of the ice counterproductive in maximizing syrup making efficiency. In our study, we measured the sugar concentration and volume of the ice that was frozen off of sap, as well as the sugar concentration and volume of the sap itself, in two different sized containers that would commonly be used in today's sugar bush. We then analyzed our results and discussed whether or not the freezing of sap appears to be beneficial in the maple syruping process.

## Purpose

To determine if disposing of ice that forms on sap recovered from sugar maple trees is an efficient method of increasing sugar concentration of the remaining ice, or if this practice is wasteful.

## Methods

One five-gallon pail was filled with 15.142 liters (four gallons) of water and then 303.363 grams (0.6688 pounds) of sugar was added. The pail was placed outside to to freeze for varying amounts of time and removed once each day. Any ice in the bucket was broken up and placed in a separate bucket and placed inside to melt. The sugar concentration and amount of ice melt was measured and recorded the next day. The ice melt was poured back into the pail to refreeze and the pail was again placed outside. One 50-gallon barrel was used for a larger test. The barrel was filled with 181.7 liters (48 gallons) of water. 3640 grams (8.025 pounds) of sugar was mixed into the water. The barrel remained outside during the entire experiment and any ice that appeared on the surface was melted inside and after samples were taken, disposed of. Three samples were taken by a pipet from each container's remaining sap and three for the ice melt and were then stored. The volume of the ice melt was measured by pouring the ice melt into a large graduated cylinder. This was repeated 20 times. After the final samples were taken all the samples were removed from storage and the sugar concentration was measured using a refractometer.

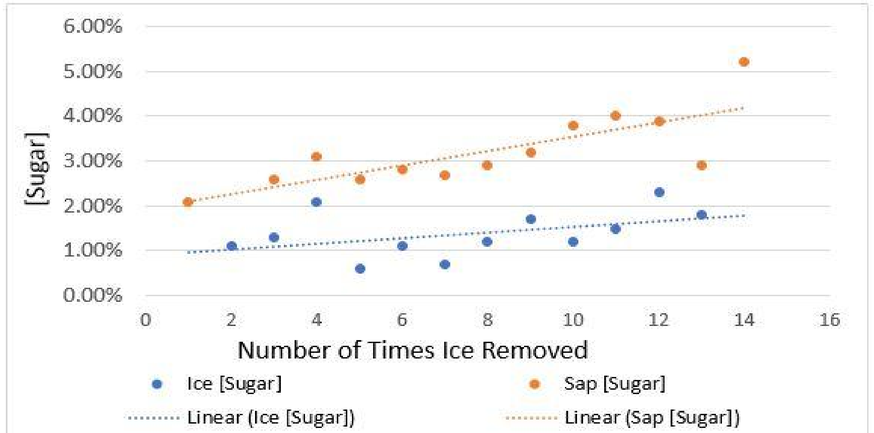


**Figure 1**. Sugar concentration in the sap and the ice of the barrel with 181.7 L of sap over time. Data collected from Febuary 7th to March 3rd. Days with no ice formation were ommitted. n= 14

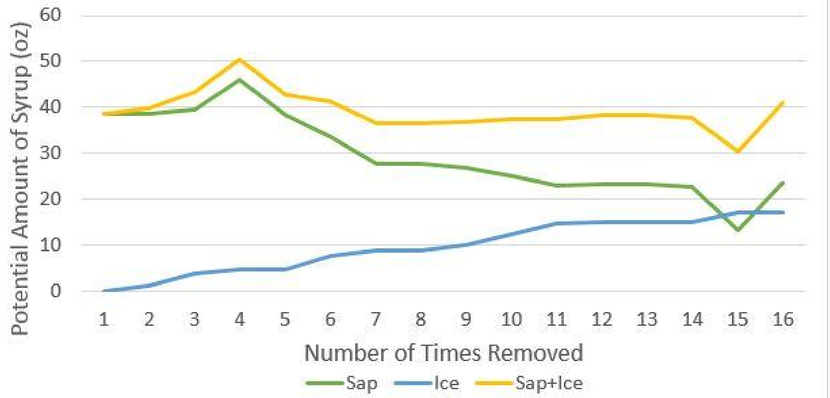


**Figure 2.** Amount of syrup that can be made with the remaining sap, from the ice removed from the barrel, and the total that can be made from the sap and the ice, over time. Data collected from Febuary 7th to March 3rd. Days with no ice formation were ommitted. n= 14

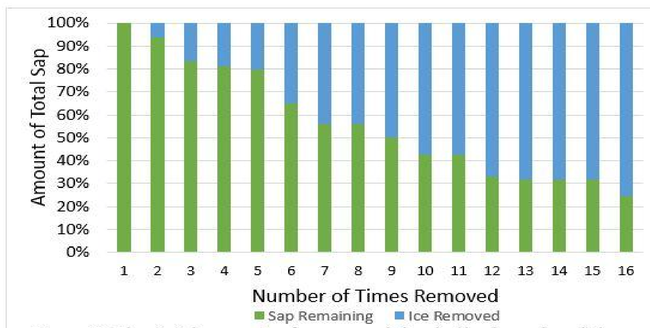


**Figure 3.** The total amount of sap remaining in the barrel and the total amount of ice removed from the barrel over number of times removed. Data collected from Febuary 7th to March 3rd. Days with no ice formation were ommitted. n= 14

## Results

As seen in figure 1, the overall concentration of the sap increased as ice was removed. Figure 3 displayes how many times the ice was removed and what portion of the inital sap was removed as ice. When examining the mound of syrup that can be made from the remaining sap, there seems to be an overall decrease after an inital spike. It must be noted that during the time of the experiment there was a period of 10 days where the temperatures were too warm out to form new ice. During a few of these days remaining ice around the inside of the bucket was loosened enough to removed and was measrued.

## Discussion

Figure 1 shows an overall increase of sugar concentration in the sap as ice was removed. Despite this we calculated that over time, removing ice can lead to a decrease in the amount of syrup that can be made, as displayed by figure 2. We removed approximately 75% of the original sap as ice over the 25 day period of data collection, as shown in figure 3. Potential errors in this experiment include the possibility that bacteria may have gotten into the sap and skewed the sugar concentration. Towards the end of the experiment the sap did become more cloudy. There is also the issue of rain. On the 13th day of data collection it rained and this may have affected the sugar concentrations after this. If this experiment is repeated we would recommend stirring up the sap after the ice is removed and then take the samples, as we believe there is a possibility that the concentration of sugar may have been greater at the bottom. It would also be beneficial to redo this experiment over a time frame where it was below freezing more consistently. While this data may help tree tappers make decisions about removing ice from pails of sap on sugar maple trees, we strongly reccomend this experiment be repeated before any definite conclusions are drawn.

## Works Cited:

Henshaw, H. (1890). Indian Origin of Maple Sugar. *American Anthropologist, 3*(4), 341-352. Retrieved from http://www.jstor.org/stable/658239