

# Maple Syrup Digest

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## Reducing Maple Sap Spoilage Variation in Sap Sugar Content Across States Bottle Maple Sap

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*The Newsletter of the North American Maple Syrup Council*



## MAPLE SYRUP DIGEST

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## President's Message

We seem to be having a more traditional Maple Season this year. In my area we have over 3 feet of snow. I can't get anywhere in the bush without snowshoes after never needing them last season and tapping a month later than usual.

Despite the quirks in our weather patterns, our industry is about to produce the first agricultural crop of the year. Please everyone, let's strive to make the highest quality syrup possible. I will repeat myself as it can't be said enough —let's make the highest quality syrup we can. Many of you have heard me say selfishly "if you make great syrup, it only helps me". And that is true! If we all produce quality syrup, everyone in the industry benefits.

At our last delegate meeting held on January 14, 2025, upon recommendation of the Research Committee, the delegates approved funding (\$50,000 US or \$70,000 Cdn) a proposal from Centre Acer to explore "defoamer usage". This project now will involve both Canada and the United States.

The findings can be used on both sides of the border when dealing with related government agencies (CFIA & FDA). This is important work. We need to establish understanding around this issue, to demonstrate that defoamer is a processing aid, and not an additive to maple syrup. The NAM-SC change in funding proposals allows the Council to be more responsive to emerging needs inside the Industry.

The political landscape may change with the implementation of tariffs and counter measures; in no way does this change our collective responsibility that we all work together to make the highest quality product possible. The Maple Belt transcends our borders and we truly are in this Industry together.

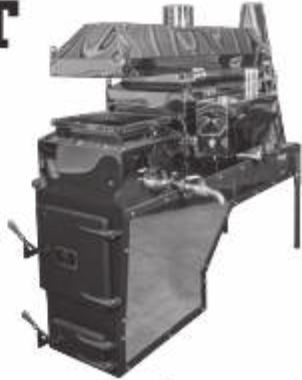
Michigan will host the International Conference this fall in Port Huron, Michigan October 22nd to 25th; they have reported that arrangements are on track and registration will be available by summer.

The next in-person delegate meeting is May 16th in Croghan NY. This will be held in conjunction with the Hall of Fame ceremony the following day, inducting David Hamilton and Tim Wilmot. Everyone is encouraged to attend either day or both.

Brian Bainborough  
NAMSC President

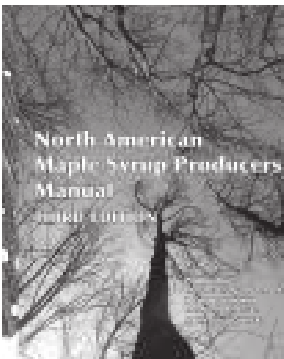
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Cover: Veteran owned ,Rocky Acres Maple Farm, Brandon, NY (see page 33)

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# Reducing Maple Sap Spoilage

Catherine Monserrate Ph.D., 2025  
Cornell University

## Overview

**M**aple sap is a perishable product that will spoil when stored improperly or for extended periods of time. As it exits the tree, it is contaminated with bacteria, yeast, and molds, which can spoil the sap by consuming its resources (e.g. sugars) or by releasing byproducts (e.g. enzymes, acids, aromas) resulting in color, texture, flavor and odor changes in the sap. Flavors and textures developed in spoiled sap can persist in maple syrup and other value-added products; therefore, proper care of maple sap is essential to produce quality products.

## Composition of Maple Sap

Maple sap contains water, sucrose, organic acids (malic, succinic, and oxalic), minerals, phenolics, and flavonoids (Yuan et al. 2013). Its composition can differ throughout the season and in different locations. Throughout a season, total phenolics and mineral concentrations increase in maple syrup. While across locations, the pH, syrup color, and mineral content can differ (Nimalaratne et al. 2020). A variation in sap composition particularly pH, sugars, and minerals impact microbial activity and subsequently shelf-life (Jay et al. 2005).

## Spoilage and Quality Decline

### What is sap spoilage?

Maple sap spoilage can appear as sour, fermented, or musty flavors and odors, cloudy appearance, or formation of a clear to opaque, viscous, string-like texture known as “ropy” sap. The type of spoilage that occurs depends on the microorganisms present. Sour off flavors are associated with bacteria (Lagacé et al. 2015), fermentation is associated with yeast (Whitfield, 1998), musty flavors are associated with bacteria and fungi (Whitfield, 1998), and ropy sap is associated with bacteria (Lagacé et al. 2018). Due to the variety and complexity of spoilage, broad-spectrum approaches are used to reduce microbial contamination and growth.

### How can spoilage be reduced?

Sap spoilage can be minimized by both maintaining optimal storage conditions, particularly at low temperatures and proper sanitation of collection and storage materials. Temperature control is essential in reducing spoilage. In maple sap and many other food products, two types of bacteria are prominent - cold-loving, psychrophilic bacteria and moderate-temperature loving, mesophilic bacteria. Cold-loving bacteria grow between 32 to 68 °F, while moderate-temperature loving bacteria grow best between 77 to 104 °F. (van Lier et al. 1997). Both types are known to grow in maple sap (Lagacé et al. 2006a; Lagacé et al. 2018) and both have

significantly lower growth rates below 40 °F (van Lier et al. 1997). It is recommended to store sap below 40 °F to maintain quality.

Another key component of temperature storage is consistency. Temperature fluctuations will increase the rate of sap spoilage. For instance, sap stored at 73 °F for eight hours followed by 39 °F for 16 hours spoiled at the same rate as sap stored consistently at 59 °F (Lagacé et al. 2018).

In addition to temperature management, cleaners and sanitizers can be used to remove and inactivate microorganisms growing on surfaces (McDonnell and Russell, 1999). Cleaning refers to the physical removal of material from a surface while sanitizing is an inactivation of the microorganisms on a surface. Sodium hypochlorite and peracetic acid are effective sanitizers for sap collection and storage materials, including the removal of biofilms (Lagacé et al. 2006b). To avoid off-flavors in sap and syrup, sanitizers can be removed by rinsing prior to sap collection. All sanitizers used in sugarbushes must be approved for use on food contact surfaces by the Environmental Protection Agency (EPA) and have an EPA registration number.

### How to determine if sap is spoiled?

Sap spoilage can appear in numerous forms. The key indicators that can be used to detect sap spoilage are off-appearance, off-odors, and/or a decline in pH.

To illustrate the quality decline and off-odor development that can occur, sap (2.1 °Brix) was harvested in cleaned and sanitized food grade buckets from sugar maples (*Acer saccharum*) in the Arnot Forest Sugarbush. Sap was evaluated for quality decline (off-appearance and off-odors, °Brix, and pH) and microbial contamination during storage at 41 °F (5 °C) and 50 °F (10 °C) for up to 12 days. The data presented shows trends that occur when sap is stored at warmer temperatures and the difference in spoilage rate between storage temperatures.

The sap was clear and free of debris at collection, and appearance was consistent throughout storage, even as sap spoiled (Figure 1). By 6 days, sap stored at 50 °F developed a slightly sour aroma.

Similarly, sap stored at 41 °F developed a sour aroma by 12 days of storage. In both storage conditions, no other aromas, textures, or cloudiness were perceived.

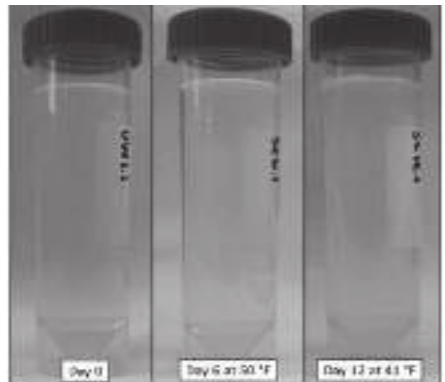


Figure 1. Visual appearance of maple sap stored immediate after harvest (left) and following development of off-odors at 50 °F (6 days; middle) or at 41 °F (12 days; right).

While sourness is a common indicator of spoilage, spoilage can appear in any of the forms previously mentioned.

To evaluate the **quality** of maple sap, take note of the initial appearance and aroma of the sap. Continue to monitor the sap each day and record any changes. Dispose of sap if any of the following appear: a sour, fermented, or musty flavor or odor, a cloudy appearance, or a ropy texture.

The **°Brix** will decline over time as bacteria use sugars, a carbohydrate, as a resource (Sperber and Doyle, 2009). However, measuring changes in °Brix is not a reliable indicator of spoilage in raw sap. In this study, the °Brix was unchanged throughout 6 days at 50 °F and 12 days at 41 °F (data not shown). In a study by Lagacé et al. (2018), °Brix declined within three days of storage in concentrated maple sap (8 °Brix) stored at warmer temperatures (59 °F and 73 °F). In saps with lower sugar concentrations or those stored at a lower temperature, the sugar consumption by bacteria may not be detectable with a refractometer until later stages of spoilage.

A decline in **pH** can be used to indicate sap spoilage. This is because some bacteria consume resources in sap and leave acids as a byproduct (Whitfield, 1998). However, the pH in fresh sap can range from 6 to 7.4 and it differs across seasons and locations (Nimalaratne et al. 2020). To use pH as a quality indicator, measure and record the initial pH of the sap with a pH meter or pH test strips. Continue to monitor the pH throughout sap storage. Raw or unconcentrated sap stored at or below 50 °F can be evaluated daily, while sap stored above 50 °F should be monitored more frequently. Concentrated sap (8 °Brix) stored at or below 40 °F can be evaluated daily, while this sap stored above 40 °F should be monitored more frequently, based on findings from Lagacé et al. (2018). If a decline greater than 0.5 units in pH occurs, as shown in Figure 2, that is an indication that the sap may be spoiled. In the example presented in Figure 2, a significant decline in pH was observed the same day in which a sour aroma developed in sap.

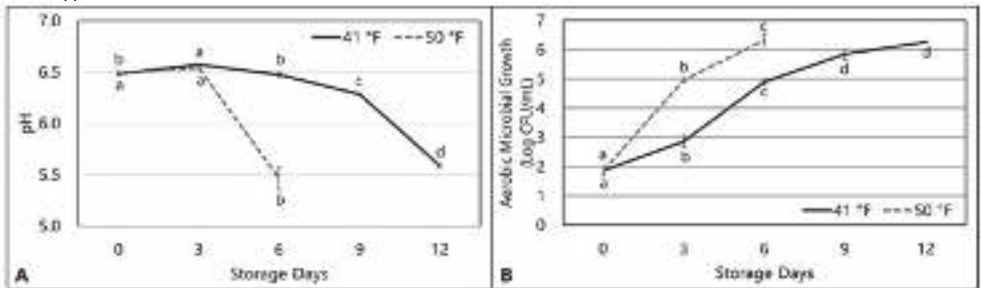


Figure 2. pH (A) and aerobic microbial growth (B), measured through a total aerobic plate count, of maple sap during storage at 41 °F and 50 °F. Vertical bars represent the standard error (n=6). Different letters indicate significant differences at  $P < 0.0001$  level of probability. Sap was collected from the Arnot Forest Sugarbush in Van Etten, NY during the 2024 maple season.

**Microbial growth** is assessed by counting the number of microorganisms present in a defined area at a known concentration. This concentration, commonly referred to as the microbial load, serves as a valuable indicator of spoilage or as an indication of a properly sanitized surface. The microbial load can be measured using an aerobic plate count method, with results expressed as the number of colony forming units (CFU) or viable microbial cells (Maturin and Peeler, 2001). In microbiology, a food product is generally considered spoiled the microbial load reaches 6 log CFU/mL, which is equivalent to 1 million colonies. However, obtaining an aerobic plate count requires time, often taking several days to weeks, as bacteria, yeast, and molds must grow on nutrient media before colonies can be counted.

In this study, the microbial load of sap increased from 1.9 log CFU/mL on Day 0 to 6.3 log CFU/mL by Day 6 at 50 °F and Day 12 at 41 °F (Figure 2b). To an extent, the rate of spoilage will accelerate as temperature increases, particularly within the “Danger Zone” – the temperature range between 40 °F and 140 °F where bacterial growth is more rapid (USDAFSIS, 2020). Initial microbial load also influences sap shelf-life, with higher initial microbial loads leading to faster spoilage. Sap collected in clean, sanitized buckets or tubing will have a lower microbial load, resulting in a longer shelf-life compared to sap collected from unclean equipment.

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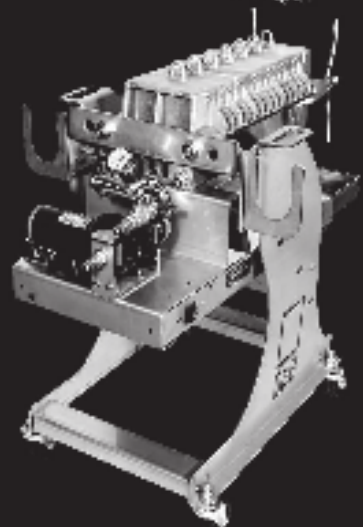


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# Variation in Sap Sugar Content Across States

T.D. Perkins<sup>1</sup> and M.L. Isselhardt<sup>2</sup>

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2 University of Vermont Extension Maple Program, Underhill, Vermont

Sap sugar concentration varies from tree-to-tree, from one location to another, within a season, from one season to the next, and even within individual sap runs. These changes arise from several factors, primarily due to genetic and environmental factors including soil nutrition, weather, and tree size/stature and health. Typically, the level of sucrose in sap averages around 2.0°Brix over a season, but can range much lower and higher (Perkins et al. 2022). Sugar maple trees generally produce slightly sweeter sap than red maple (van den Berg 2022, Perkins et al. 2024).

Within any individual season, sap sugar levels tends to peak early then trend downward as the season progresses, with slight upward excursions sometimes occurring after freeze periods (Perkins 2022). It should be noted that the sugar that is transformed into syrup was once produced during the process of photosynthesis over previous growing seasons. Once produced, and if not used immediately by the tree to support its normal function, the sugar is converted to starch (a more suitable material for long-term storage through enzymatic activity). The timing and rate of conversion of starch back to sugar is limited to some degree by temperature which could also impact the SSC

in maple sap (Sauter 1973). In general, there are no significant differences in sap sugar concentrations between gravity or vacuum collection (Wilmot et al. 2007), but producers using vacuum will see lower values after several days of prolonged thaws (Perkins 2022).

Some seasons tend to have somewhat higher or slightly lower sugar in sap than average. The exact causes for this are unknown, however regional influences such as conditions during the growing season, drought, seed production, tree nutrition, and other factors are all likely to be involved (Rademacher et al. 2023), although the strength of these relationships have not been well determined.

Similarly, there is little information about how sap sugar varies across the maple producing region. Raap et al. (2019) in a study of a limited number of sites found that sap levels were negatively related to previous growing season temperature, meaning that higher temperatures from May to October preceding the sap flow season was associated with reduced sap sugar. These results were contrasted by another study (Duchense et al. 2014) that found that sap sugar concentration appeared to increase following higher temperatures in the previous growing season.

The U.S.D.A. National Agricultural Statistics Service (NASS) conducts an annual survey of maple producers in several states. From 2013-2015, the survey asked about the ratio of sap to syrup (SSR or the number of gallons of sap required to make a gallon of syrup). A low SSR means more sugar in the sap (a higher sap sugar concentration), thus requiring fewer gallons of sap to make a gallon of syrup, whereas a high SSR means a lower sap sugar concentration.

NASS published SSR values) for ten of the higher syrup producing states. There is no information available for how many producer responses were used to generate the reported values. Likewise, no information is available to understand the methods producers that used to determine their SSR to respond to NASS's request. In addition, finished syrup can have slightly different density requirements in different states, which would somewhat affect the reported SSR values. Given the lack of consistency in sampling methods (precision/accuracy of instrument, number and timing of samples taken to generate the estimate and to what degree the producer calibrated and properly used their instruments, we can only take the results at face value in the subsequent analysis.

Figure 1 shows the SSR for each state for 2013, 2014, and 2015. Across all states and all three years, SSR ranged from a low of 34 gal/gal to a high of 52 gal/gal, with an average of 44.6 gal/gal across all years and states. Interestingly, 6 of 10 states in 2013 had exactly the same SSR value of 46 gal/gal. NASS

verified those values in their database, but provided no further clarification.

It may simply reflect the fact that SSR was in fact similar across a wide geographic range, or that as a new survey question respondents picked a general round number. Despite this, we see similar trends and relationships in the subsequent two years. Therefore, the data from 2013, although unusual, was retained in this analysis. In 2013, ME and WI clearly had lower SSC than all the other states assessed. These two states remained at the lower end of the SSR spectrum for the next two years, but the margin was far less pronounced. OH and PA tended to have slightly higher values than other states. Most of the other states grouped at similar SSR levels each year, with just slight variations.

In most cases, absolute changes in SSR from one year to the next averaged 6.3%, but occasionally changes in SSR of up +20% (ME from 2013 to 2014) and -13% (NH from 2014 to 2015) were found. Some states (MA, NY, MI) exhibited relatively stable or minor changes in SSR across the three years.

The year 2013 had an average SSR of 43.8, with 2014 and 2015 coming in at 45.7 and 44.4. Averages mask the fact that two states (ME and WI) had considerably lower SSR (sweeter sap) than the other states that year. Similarly, CT and PA had relatively high SSR (less sweet sap) values in 2015 compared to the other states. In 2013 and 2014, 8 of 10 states had SSR levels higher than 43 gal/gal. In 2015, 7 of 10 states had

SSR at approaching or below 43 gal/gal, suggesting a “sweeter” sap year across a broad area of the maple producing belt.

Of some note, there was only a low relationship ( $r^2 < 0.20$ ) between SSR and syrup yield, suggesting that, in general, sap volume over a season has a much stronger impact on syrup yield. Therefore, high SSR is probably less important to syrup production than is commonly thought, except in extremely low sap sugar content seasons in some areas.

In examining these results, northern states appeared to have slightly lower SSR (sweeter sap), while more southern states tended to have lighter SSC (less sweet sap). When we examined the relationship between latitude (using the geographic center of each state) and SSR, we found there was a reasonably robust relationship ( $r^2 = 0.78$ , Figure 2). This suggests that latitude (how far north a state is from the equator) is strongly related to SSR, with a reduction of about  $0.1^\circ$  Brix per degree of latitude southward. Admittedly, state geographic center doesn't necessarily represent the climatic center or the center of distribution of maple production in these states. Further examination would be necessary to explore this relationship better. Whether this is just a spurious correlation or there is some physiological relationship between SSR and climate is unknown, but the question has relevance to climate change and requires further study.

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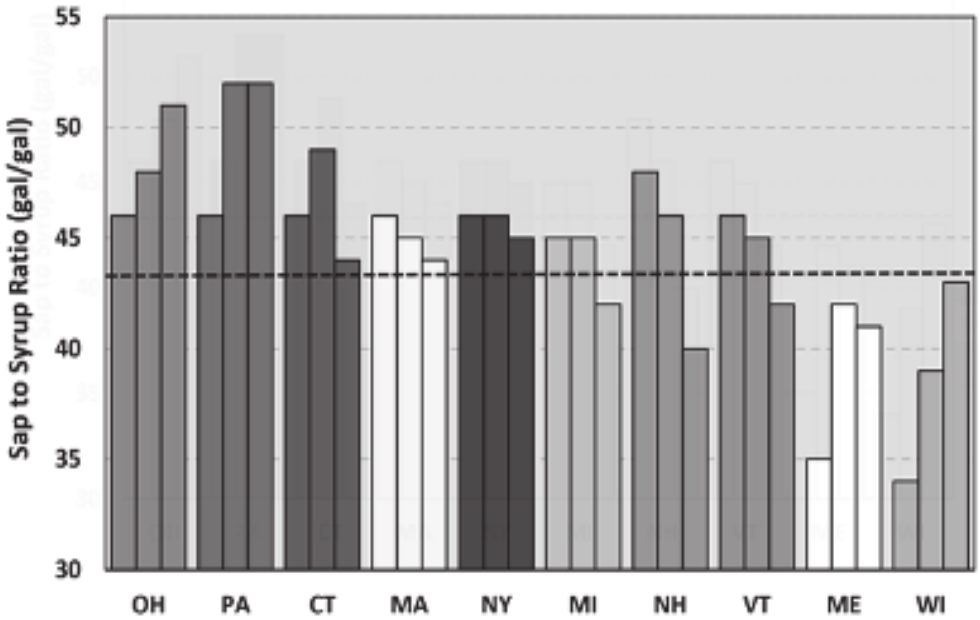


Figure 1. Average annual sap-to-syrup ratio (SSR) for ten states from 2013-2015. The bars for each state group represent 2013, 2014, and 2015, respectively, from left to right. The dashed line represents 2° Brix point level at which 43 gal of sap are required to make 1 gal of syrup at 65.5° Brix according to the Jones Rule of 86. Minimum maple syrup density in the U.S. is currently 66.0° Brix, but is higher in some states.

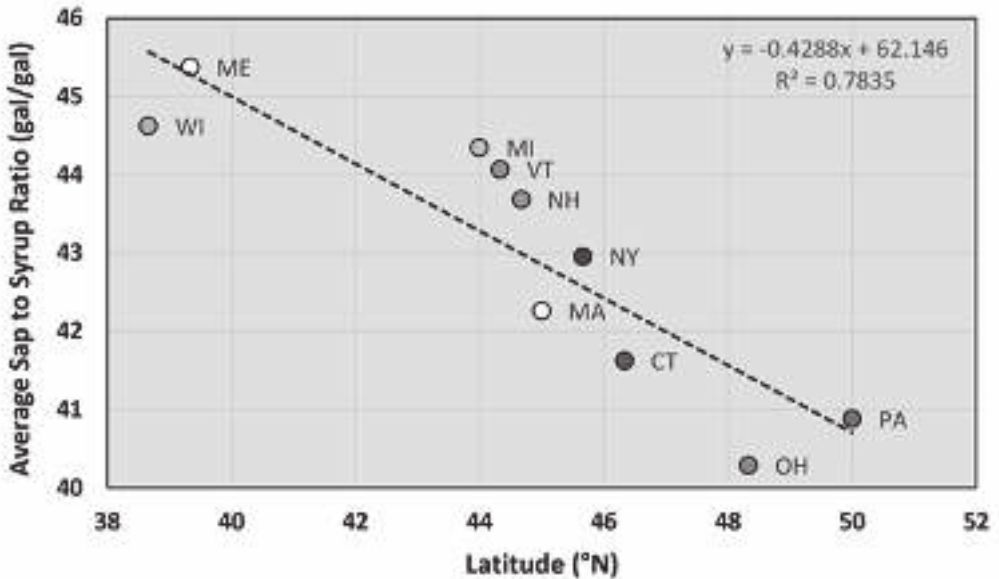
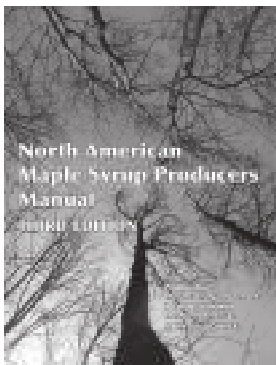


Figure 2. Average sap to syrup ratio for each state from 2013-2015 by geographic center (latitude) of each state. The dashed line represents the linear regression.



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# Tapping Below the Lateral Line for a Sustainable Use of Maple Resource

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d Proctor Maple Research Center, University of Vermont, Underhill, Vermont, USA

Each year, several tens of millions maple trees are tapped in North America for maple syrup production. Over the years, tapping techniques have evolved with a focus on efficiency, profitability, and long-term resource protection. Traditionally, tapping has been done by drilling into the maples in the spring to collect sap and using a tubing system, above the lateral tube to ensure a sufficient slope for the natural flow of sap into the lateral tube. This practice also aimed to prevent sap from flowing back into the taps as temperatures dropped at the end of the day. However, in recent years, some producers have seen the benefit of tapping maples below the lateral line for multiple reasons. The main reason is to access a larger area of healthy wood on the trunk. This is because the maple tree produces a compartmentalization zone inside the trunk following tapping, which isolates the wound left by the tap hole. This internal zone then becomes unproductive for future taps

as sap can no longer circulate normally. In sugarbushes where maple growth is slow, years of tapping above the lateral line have multiplied, or the size and/or number of taps per year were high, the availability of healthy wood for tapping becomes limited, and the likelihood of tapping into compartmentalized, non-productive wood is higher, which penalizes sap collection. By opting for a tapping pattern that respects the necessary spacing of taps from year to year based on their size and number, the likelihood of tapping into compartmentalized wood is minimized. If, in addition, the tapping area is expanded by allowing tapping below the lateral line, the exploitation of the trunk surface is further optimized, ensuring the sustainability of sap collection.

All this, of course, is provided that tapping below the lateral line is as effective as above it. Tapping below the lateral line could create low points where sap can stagnate in the tubing,

possibly promoting microbial growth and penalizing sap collection. This is particularly the case when this sap can return into the tap hole due to the suction caused by negative temperatures. To investigate the effectiveness of tapping below the lateral line, Centre ACER, in collaboration with maple syrup advisors from MAPAQ and the Club d'encadrement technique en acériculture de l'Est, recently conducted and published a study (Rademacher

et al. 2024. Tapping below the lateral line does not reduce maple sap yield or quality. *Trees, Forests and People*, 18: 100712).

As part of this study, sap was collected under high vacuum with 5/16" diameter tubing in two sugarbushes where taps were made at different heights above and below the lateral line for two harvest years (Fig. 1).

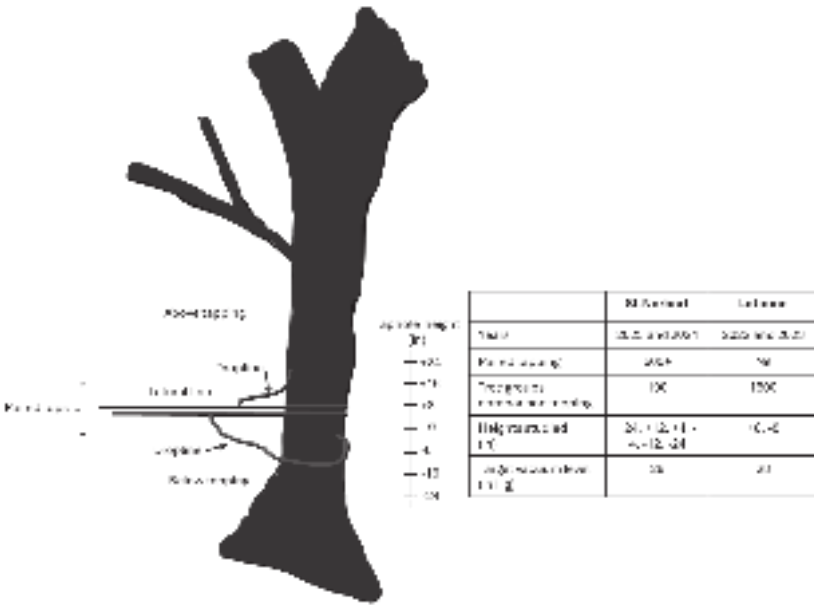


Figure 1. Illustration (not to scale) of the experimental setup at the Centre ACER sugarbush in St-Norbert d'Arthabaska (paired tapping) and the one associated with Club d'encadrement technique en acériculture de l'Est in Lejeune (individual tapping), showing the distribution of tap heights and other conditions of the experiment.

For some systems, one independent line connected taps above the lateral line and another connected taps on the same trees below the lateral line in a pairwise setup. For other systems, a line reached taps above the lateral line for a group of trees (control) while another line of the same system and completely comparable to the control line reached taps below the lateral line for a different but comparable group of trees in a control and treatment setup. The heights of the taps relative to the lateral line were measured (Fig. 2a) and varied depending on the line, the sugarbush (St-Norbert or Lejeune), and the production season (2022 to 2024). All

taps made below the lateral line were done carefully, forming a loop with the drop line to ensure a certain slope for the sap to exit the spout (Fig. 2b). For monitoring the setup, the volume of sap collected daily from each line was measured using calibrated water meters, as well as the °Brix of the sap. Additionally, sap samples were taken in St-Norbert at different times of the season to measure its pH and microbial contamination level by Adenosine Triphosphate (ATP) bioluminescence. These latter measurements were made to evaluate the quality of the sap from the different treatments.

a)



b)



Figure 2. Measurement of tap height relative to the lateral line (a) and tapping below the lateral line by forming a loop with the dropline (b).

The results showed a very slight increase and decrease in the average volume of sap collected for taps placed at extreme heights, 24 In above and below the lateral line. However, the statistical analysis shows that these differences are marginal and that overall, there is no clear trend of the effect of tap height on the volume of sap collected above

and below the lateral line (Fig. 3a). In these experiments, it was mainly found that maintaining the vacuum at the desired high level of roughly 28 InHg had was more important for the volume of sap collected than the relative tapping height, which confirms the importance of high-level vacuum from previously studies (Lagacé et al. 2019).

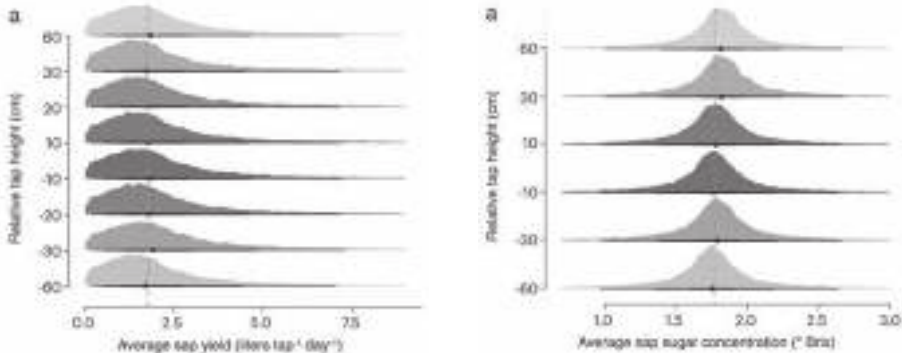


Figure 3. Results on the volume of sap collected (a) and the °Brix of sap (b) based on the different tap heights relative to the lateral line. Black dots show the average treatment effect at all treatment heights and the gray dashed line shows the global mean.

Similarly, the statistical analysis showed a slight increase in the °Brix of the sap for taps placed above the lateral line without this difference being statistically significant (Fig. 3b). The measured differences were small and within the precision of the refractometer and were also consistent with the previously reported trend of a slight increase in sugar concentration depending higher up on the trunk (Rademacher et al. 2023).

Regarding the effect of tap height on sap quality, the results (not shown) of

microbial counts by ATP bioluminescence and sap pH showed once again that there is little change in sap quality (both ATP and pH) whether tapping above or below the lateral line. It should be noted, however, that the results were obtained for taps placed below the lateral line, forming a loop with the drop of these taps and a high vacuum level. It can be assumed that the loop may have influenced the results obtained without being able to categorically confirm it, as no results were obtained with taps without a loop with the drop line. This effect would need to be confirmed

by other trials. Equally, the results may well differ with lower or no vacuum, as this would possibly increase backflow into the tap hole. Under the tested conditions, however, tapping below the lateral line does not significantly affect the quality of the sap collected.

The results of this study show that there is no significant effect of tapping below the lateral line in terms of productivity at the tap (sap volume and °Brix) or sap quality (ATP and pH). Other parameters are, however, highlighted in the study and should be considered when tapping below the lateral line. For example, the length of the drop must be sufficient to reach the parts of the trunk below the lateral line and form a loop with the drop line. Additionally, extra care must be taken when tapping below the lateral line to prevent poor tapping resulting from non-ergonomic operator positioning. A quality tap hole is essential for maintaining high levels of vacuum and optimal sap collection. Finally, the height of the lateral tube and the thickness of the snow cover during the tapping period will impact the decision to tap below the lateral line. For some seasons, it will be more prudent not to tap below the lateral line for these reasons. Overall, the results of this study indicate that there are no major negative consequences to tapping below the lateral line and suggest the possibility of increasing the tapping area to optimize the sustainable exploitation of the maple resource. This project was funded with the participation of the Quebec Ministry of Agriculture, Fisheries and Food through the Canadian Partnership for Sustainable Agriculture.

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**NAMCS Semi Annual Meeting May 16, 2025**  
**Hall of Fame Induction Ceremony May 17, 2025**  
**at International Maple Museum Centre, Croghan,**  
**New York**

**T**he International Maple Museum Centre will be hosting the NAMSC Semi Annual meeting on Friday, May 16, 2025 and the International Maple Hall of Fame Induction Ceremony on Saturday May 17 for David Hamilton(Indiana) and Tim Wilmot(Vermont) into the Maple Hall of Fame.

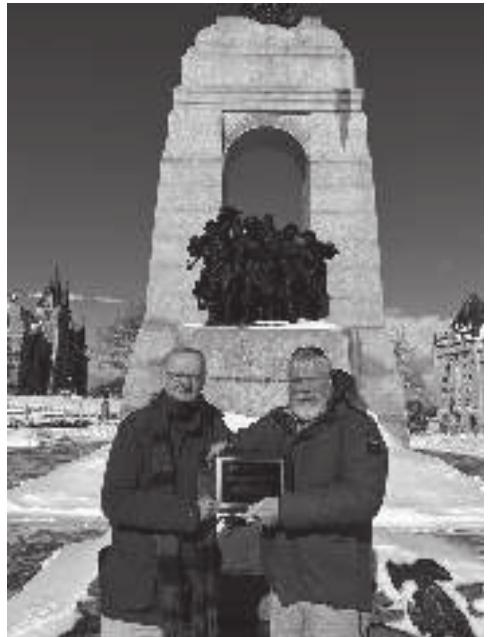
Induction into the Hall of Fame is the highest recognition afforded to individuals in the maple industry and is a profound and honorable experience for

these gentlemen. The ceremony is intimate and sincere (and not long!) and everyone is invited to attend. Please plan to join us at the International Maple Museum and Hall of Fame as they celebrate this event. There will be a Pancake Breakfast from 6:30 am – 9:00, followed by the inductioceremony at 9:30. This will be followed by a luncheon at 11:30 am. International Maple Museum Centre is located at 9756 State Route 812, Croghan, New York 13327 (315) 346 1107

**2024 Richard Hass Award**  
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**T**he Richard G Haas award recognizes distinguished service for research in the Maple industry. NAMSC acknowledges all the efforts Dr Miller has accomplished while at Carleton University and his work bettering the Maple Industry.

Pictured to the right:  
Dr David Miller receiving the Richard G Haas award from NAMSC president , Brian Bainborough in front of the national war memorial monument in Ottawa.



# Exploring the Beginnings of Reverse Osmosis in the Maple Syrup Industry

Matthew M. Thomas

The greatest, most impactful innovation in the production of maple syrup over the last 50 years is unquestionably the introduction of reverse osmosis (RO) technology in the concentration of maple sap. Curious minds may wonder why RO was invented in the first place and how it came to the maple syrup industry.

In the 1950s, the United States government encouraged scientists to develop innovative new methods for large-scale desalination of salt water. In response, university researchers experimented with a variety of designs and materials, arriving at workable design that pushed pressurized salt water through a semi-permeable membrane, working as a kind of filter to prevent the salt in solution from passing through the membrane, producing clean water as a result. The first commercial membranes were developed and patented by UCLA researchers Sidney Loeb and Srinivasa Sourirajan in 1959.

Not long after, Sourirajan expanded on his research with a new position with the National Research Council (NRC) in Ottawa, Ontario. As a leading expert in the young, but promising technology of reverse osmosis, Sourirajan often visited with other labs and scientists who were beginning their own investigations into the potential of RO. At one such visit to a laboratory at Dart-

mouth College in 1965, Sourirajan met with a group that included graduate student Dean Spatz. In an October 2022 interview with the author, Spatz shared that he had been experimenting with ideas for using RO to clean wastewater from mining activities but became curious about reversing the application and considering its potential as a tool for concentrating solids in solutions. With such thinking in mind, at this meeting Spatz asked Sourirajan if he thought RO could be used to concentrate maple sap as part of the maple syrup making process, to which Dr. Sourirajan responded, that he did not see why not. This exchange led both Spatz in the Dartmouth lab and Sourirajan in the NRC lab, to conduct independent experiments with concentrating sugar solutions using table top RO units.

In 1966, Spatz obtained a few gallons of fresh maple sap and ran it through a small RO in the Dartmouth lab, discovering the membranes worked great and exactly as expected in concentrating the sap. Unbeknownst to Spatz, that same year in Ottawa, Sourirajan ran his own RO experiments, also successfully concentrating a sugar solution, which was published in the spring of 1967. Curiously, this single experiment and publication was as far as Sourirajan went with applications of RO to sap concentration. However, he did go on to be a world leader in the advancement of RO

technology.

At the same time Spatz and Sourirajan were conducting their own independent parallel experiments, scientists at the US Department of Agriculture's maple research program at the Eastern Utilization Research and Development Division (Eastern Regional Lab) in Wyndmoor, Pennsylvania had also arrived at the idea of using RO for concentrating maple sap. In the spring of 1966, under the direction of Dr. C.O. Willits, director of the maple program at the Eastern Regional Lab, maple sap was concentrated from 2.5% to 10% sugar using a small, table-top RO set up in their laboratory.

Concluding that the technology was viable for sap concentration, the Eastern Regional Lab determined that their RO unit needed to be scaled up and field tested in a real-life sugarbush setting. As early as 1966, even before conducting their first field tests, the scientists at the Eastern Regional Lab were claiming that the adoption of RO technology "should lead to full automation of the maple syrup industry".

A large, portable, eight membrane RO machine was built and tested in the 1968 season at the sugarhouse of Lloyd Sipple in Bainbridge, New York. Wanting to try the system with a greater volume of sap, over the following two years the Eastern Regional Lab team moved to a larger sugarbush at Mountain Meadow Farms in Sommerset County, Pennsylvania. At the end of the 1970 season the Eastern Regional Lab prototype RO was sold to Mountain Meadow Farms

where it was used for a few more years before the farm exited the maple syrup business.

Despite the new technology being experimental and having a significant learning curve for working with maple sap, the field tests were unquestionably successful. Using relatively low pressure on the membranes, their tests were able to achieve a 50% removal of water from sap. Less anticipated or understood were the problems of bacterial buildup and growth, heat effects from operation of the machine, and changes to sap chemistry over the course of the season which resulted in loss of operational efficiency. There was still much to learn about effective membrane flushing and the best cleaning agents.

The Eastern Regional Lab made great research strides with RO leading to aggressive efforts to promote RO technology as the future of maple industry. Unfortunately, with the retirement of Dr. Willits in 1969, the Eastern Regional Lab began to phase out maple research and their RO research ceased at the end of the 1970 season. Apart from a few small test cases, government and university research into RO for the maple industry in the United States and Canada, stopped for the remainder of the 1970s.

In contrast to the outcome of RO research at the Eastern Regional Lab, upon his graduation from Dartmouth University, Dean Spatz took his connection to RO to the next level. In 1969, Spatz moved to Minnesota and started the company Osmonics, Inc., building

RO machines for water purification and industrial filtration. As the Osmonics company was getting started, Rex Alwin a Minnesota maple producer, engineer, and later president of the North American Maple Syrup Council, convinced Spatz to allow him to test one of Osmonics' new small single membrane machines. Alwin later presented the results of his test at the Eighth Conference on Maple Products in October 1971. The successful tests in the Alwin sugarbush convinced Spatz to begin marketing Osmonics' RO technology to the maple syrup industry with advertisements in the *Maple Syrup Digest* appearing as early as 1976.

Through the 1970s, a small handful of larger syrup producers installed Osmonics RO units in their sugarbushes, such as the Great Mountain Forest sugarbush in Norfolk, Connecticut; the Pouliot sugarbush near Saint-Philemon, Québec; and the David Near sugarbush at Shelby, Michigan. Reverse osmosis units in the 1970s, with their long horizontal 4" membranes, were noisy, expensive, often over heated, and could only concentrate sap in one cycle from 2% to 6%.

Also in the 1970s, many larger syrup producers began shifting from wood to fuel oil for their evaporators. A rapid increase in fuel prices during the energy crisis of the 1970s increased the focus on alternative fuels and fuel saving technologies like RO. However, for the bulk of the 1970s, Osmonics was the only commercial manufacturer of RO for use in the maple syrup industry. The RO market for the maple industry

began to grow in the 1980s with the introduction of RO units from Electrohome of Kitchener, Ontario; Memtek of Ottawa, Ontario; and Springtech of Wilmington, VT. New RO designs saw a shift to smaller quieter, machines with vertical, higher-pressure membranes that were built specifically for the maple industry.

Research into the effectiveness and cost of commercial RO, as well as its effect on syrup quality, resumed in the 1980s with studies by Morseli and Sendak in Vermont and Gaston Allard in Québec. Interestingly, multiple early studies using blind taste testing when questioning the effect of RO on syrup flavor found no difference in taste compared to non-RO made syrup.

By the end of the 1980s and into the 1990s, RO units had come down in price and the technology had proven itself for larger commercial maple syrup producers. Reverse osmosis was becoming standard industry equipment and all major equipment manufacturers at that time, brands like Leader, Dominion & Grimm, Small Brothers, and G.H. Grimm, got on board with their own RO designs or partnered with existing RO makers to offer the technology to their customers. Reverse osmosis had earned its place in the process of modern syrup making and was here to stay.

Dr. Matthew M. Thomas is a maple industry historian. You can read more maple history articles like this at his website, [www.maplesyruphistory.com](http://www.maplesyruphistory.com).



Figure 1  
Dr. Willits of the USDA Eastern Regional Lab examining an experimental RO membrane (source: February 1969 Maple Syrup Digest).



Figure 2  
USDA Eastern Regional Lab's prototype eight membrane RO unit, field tested from 1968 to 1970 (source: Moore and Willits 1970 ARS report 73-66 ).

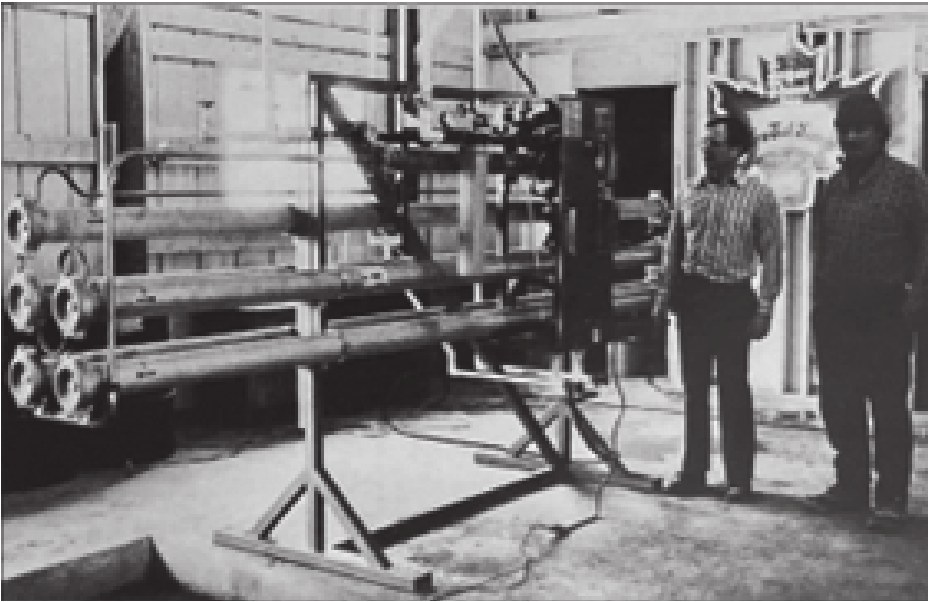
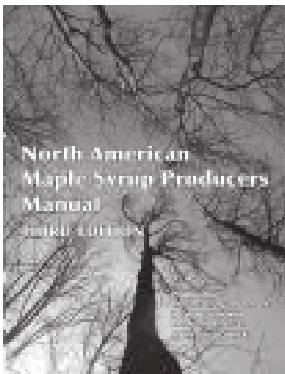


Figure 3

Example from the 1980s of a large commercial RO machine built by Osmonics, Inc. for use in the maple syrup industry (source Osmonics sales brochure -collections of the author).



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## Homeward Bound Adirondacks

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veterans from Veterans Service Organization (Homeward Bound Adirondacks) in which Ron works to help heal veterans with PTSD through nature so they boil with other combat veterans to aide in their recovery and to help to fight the mission to end veteran suicide and educate them on production of male syrup and any veterans who helps in the production take home syrup and positive camaraderie!!

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## Great Lakes! Great Maple! 2025 North American Maple Syrup Conference October 22 – 25, 2025



Debbie Thomas

**O**n behalf of the North American Maple Syrup Council and Michigan Maple Syrup Association we would like to invite you to join us at our Annual Meeting/Trade Show.

The event will be held at the Blue Water Convention Center located in Port Huron, Michigan. Port Huron sits on the St Clair River, which is the border between Ontario, Canada and Michigan. Enjoy a stroll along the river boardwalk, or relax and watch up close and personal as the massive freighters glide by.

Anticipated events:

Dine on the Lady Huron II as she sails on the St Clair River and Lake Huron, which is the 2nd largest lake in America.

Network with friends, old and new, who share a passion for all things maple.

Join in on the NAMSC meetings on Wednesday, giving you access to international leaders in the maple syrup industry while plugging into the most current issues they are addressing.

Attend technical sessions on current research and topics of interest

Visit quality vendor displays and research exhibits highlighting what's new in maple syrup equipment and supplies.

Bid on items in the Research Fund Silent Auction and Quilt Raffle.

Explore the regions sugar-houses and a wide variety of local attractions.

Participate in our Syrup/Confections Contest—bring your best syrup and specialty products for a friendly competition among all our states and provinces.

Enter our Great Lakes! Great Maple! Photo Contest—put together your best shots for these categories: People In and around the Sugar Bush, Animals Around the Sugar Bush, Sugar Bush Landscapes and Maple Products.

Savor delicious local foods at our kick-off event, "A Taste of Michigan Banquet" on Wednesday night.

Not into Maple? That's ok! Join in the fun of our special companion sessions and tours.

Don't miss our GRAND FINALE on Saturday evening: the Great Lakes!

Great Maple! Banquet and award ceremony, the silent auction and raffle results, and more.

We will be staying at the Double Tree by Hilton, Port Huron, Michigan- Blue

Water Convention Center. To save-money on your room rate you can book your room now - be sure and tell them you are attending the NAMSC Convention!



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**Syrup producers take note:** There are suppliers promoting and selling *seedlings* of high-content parent trees. This is bad biology; seedlings are highly variable! Only cloning (tissue culture or cuttings) will reliably pass on the high sugar content trait to offspring! This selection was discovered by H. Cedric Larsson, and we propagate via tissue culture, which is cloning.

Email us to reserve trees for Spring 2025: [trees@slngrow.com](mailto:trees@slngrow.com)

# Bottled Maple Sap

Catherine Monserrate Ph.D. and Adam Wild, 2025,  
Cornell University

## Overview of Bottled Sap and its Potential Uses

Producing maple syrup (66.0 to 68.9 °Brix) from maple sap with approximately 2 °Brix requires extensive energy and labor. A lower input option is to market maple sap as a commercial beverage for consumers (Figure 1). On average, about 44 gallons of sap are required to produce one gallon of maple syrup. One gallon of syrup has a gross value of about \$120 if sold in 16 oz retail containers. If instead of being processed into syrup, the maple sap was processed into 16 oz bottles of drinkable sap sold at \$3 each, \$1,056 of revenue could be generated from the same 44 gallons of sap; this represents a 780% increase in sales revenue.

Maple sap is harvested in eastern North America during thawing temperatures from January to April each year. For maple syrup production, sap is typically processed into syrup soon after harvest as sap is a perishable product susceptible to bacteria, yeast, and mold contamination across the season (Lagacé et al. 2002).

To preserve maple sap quality, care must be taken to ensure it has not spoiled or interacted with any potential contaminants, including lead and sanitizer residues. Once maple sap is harvested, it can be processed and packaged using multiple techniques, each of which ensure the product maintains quality and safety for consumers. This article reviews the benefits of maple sap



Figure 1. Shelf-stable maple sap beverage. Photo by Ailis Clyne.

as a bottled beverage while covering preservation and packaging methods, regulatory guidelines, and overview of commercial production procedures.

### Maple Sap Composition and Market Potential as a Functional Beverage

Freshly harvested maple sap contains sugars, mainly sucrose, glucose and fructose, minerals, amino acids, organic acids, and phenolic compounds (Yuan et al. 2013; Lagacé et al. 2015; Table 1). Sap composition has been shown to change across the harvest season with a decline in pH and sucrose, and an increase in invert sugars (glucose and fructose), organic acids, and minerals from the beginning to end of each season (Lagacé et al. 2015).

In sap that was preserved through pasteurization, the content of sucrose, minerals, amino acids, and total phenolics (antioxidants) were maintained or increased. Simultaneously, invert sugars decreased slightly and malic acid increased slightly (Yuan et al. 2013). In a separate study, a commercially pasteurized maple sap was evaluated over 12-months of storage under refrigeration (4 °C or 39.2 °F). Sucrose, fructose, and glucose declined slightly after four-months of storage, while pH, amino acids, and total phenolic levels were maintained across the study (Torrey et al. 2023). Quality decline should be considered when establishing “Best By” dates for any preserved maple sap. Pasteurization and other preservation methods are described in detail in the Preservation Methods section below.

Table 1. Average composition of maple sap collected throughout the harvest season of twenty-one sugarbushes in Quebec, Canada

Analysis <sup>1</sup>	Average	SD <sup>2</sup>
pH	7.13	0.52
°Brix	2.03	0.50
Sugar (%)		
Sucrose	2.10	0.43
Glucose	0.03	0.041
Fructose	0.03	0.056
Acids (µg/g)		
Acetic	24.2	24.2
Fumaric	7.9	14.2
Lactic	18.0	42.0
Malic	305.2	387.8
Pyruvic	10.4	14.1
Succinic	39.3	61.3

<sup>1</sup>Data from Lagacé et al. 2015; <sup>2</sup>SD = Standard Deviation from the Average

The stability of maple sap after processing and during storage provides insight into its potential use as a functional beverage. Functional beverages are a category of the beverage industry that provide health benefits either naturally or through formulation. The health-benefiting components may include macro- and micro-nutrients, prebiotics, probiotics, dietary fiber, and antioxidants, among other substances (Temple, 2022). For instance, some bottled waters are fortified with functional ingredients, including vitamins, minerals, antioxidants, or amino acids (Dini, 2019).

Coconut water is a common functional beverage that provides a useful com-

parison. It contains antioxidants and minerals, particularly potassium and magnesium (Santos et al. 2013). Compared to coconut water, raw maple sap has lower antioxidant capacity, as measured by the diphenylpicrylhydrazyl (DPPH) assay and presented as IC50 values (Table 2). The lower the IC50 value, the higher the antioxidant capacity or antioxidant strength. Coconut water was reported to have higher calcium, potassium, magnesium, and sugar concentrations compared to maple sap (Santoso et al. 1996; Yuan et al. 2013; Table 2). Maple sap contains higher sodium content and can be fortified with other minerals or concentrated to increase antioxidant, mineral, and other desirable attributes.

Table 2. Average antioxidant and mineral profiles of maple sap and coconut water

Commodity	Free radical scavenging (DPPH IC <sub>50</sub> , µg/ml)	Calcium (mg/100g)	Potassium (mg/100g)	Magnesium (mg/100g)	Sodium (mg/100g)	Total sugars (g/100g) <sup>3</sup>
Fresh maple sap <sup>1</sup>	587.3 ± 151.2	4.0 ± 1.96	2.7 ± 1.70	0.68 ± 0.24	5.53 ± 1.26	2.28
Postbottled maple sap <sup>1</sup>	567.5 ± 97.5	4.0 ± 1.54	2.7 ± 2.10	1.18 ± 0.35	4.24 ± 0.99	2.3
Coconut water <sup>2</sup>	150 to 390.2	27.35	203.7	5.4	1.73	5.23

<sup>1</sup>Data from Yuan et al. 2013; <sup>2</sup>Data from Santos et al. 2013 (minerals of young coconuts) and Santoso et al. 1996 (minerals of mature coconuts); <sup>3</sup>Total sugars are the sum of sucrose, glucose, and fructose.

## Sap Collection and Storage

It is generally understood that sap is contaminated with microorganisms, namely bacteria, yeasts, and molds once it leaves the tree. These organisms will reproduce and consume resources (sugars, amino acids, and other nutrients) within maple sap until the sap is processed and stabilized.

The shelf-life of fresh maple sap is dependent on its cleanliness (i.e. low levels of microbial contamination), storage temperature, and storage time. Sap should be collected in cleaned and sanitized food grade materials, including tubing, buckets, releasers, and holding tanks. Sap should be stored consistently below 40 °F until processing and should be discarded if off-odors or off-flavors develop. In depth guidelines for cleaning and sanitation procedures are available through Good Manufacturing Practices courses or the North American Maple Syrup Producers Manual (Perkins et al. 2022).

If sap is stored improperly or for an extended period, spoilage will occur. Sap spoilage can present as sour, fermented, or musty flavors and odors, cloudy appearance, and/or formation of a clear to opaque, viscous, string-like liquid known as “ropy” sap.

## Overview of Preservation

Preservation is the process of extending the shelf-life of a product by reducing or inhibiting microbial spoilage and reducing quality changes. Depending on the preservation method, sap can be

stored for a few days (short-term storage) or months (long-term storage). Treatments for short-term storage include refrigeration (<40 °F) or thermal (heat) processing followed by refrigeration. Long-term storage treatments include freezing, thermal processing, chemical treatments, pressure treatments, and aseptic processing, among others (Chiozzi et al. 2022). A combination of techniques can be used to preserve a product.

Each preservation method has the goal of reducing or eliminating microbial growth and spoilage. There are two types of microorganisms to be aware of, foodborne pathogens and spoilage microorganisms. Foodborne pathogens such as *Clostridium botulinum*, *Escherichia coli* 0157:H7, *Salmonella*, and *Listeria monocytogenes* cause an estimated 48 million cases of illness per year (FDA, 2023). Although no foodborne pathogen outbreaks have been reported in maple sap, sap is a suitable environment for pathogens to grow. Spoilage microorganisms can spoil the sap by consuming its resources (e.g. sugar, amino acids) and/or by releasing byproducts (e.g. enzymes, acids, aromas) resulting in color, texture, flavor and odor changes in the sap. Multiple spoilage microorganisms, particularly bacteria and yeast, are known to survive and grow in maple sap (Filteau et al. 2012).

To control microbial growth, food products are first classified based on their pH and water activity. These factors are used to determine the relevant pathogens and spoilage microorganisms that

must be controlled. Maple sap is classified as a low-acid food, meaning the pH is greater than 4.6 and the water activity (aw) is greater than 0.85 (Part 113, 2011)). Depending on the preservation method, sap can retain its low-acid food classification or acid can be added to change the classification to an acidified food. An acidified food is a low-acid food that has been treated to have a pH below 4.6 and a water activity that remains above 0.85 (Part 114, 2000). Beverages classified as low-acid foods include carrot and beet juices, dairy-based drinks, and some plant-based milks. They are either pasteurized and sold under frozen or refrigerated conditions with a short shelf-life or are sold as a shelf-stable product following aseptic or retort processing. Acidified beverages include sports drinks, some juices, and fruit flavored teas. They can be sold refrigerated, frozen, or as a shelf-stable product following a pasteurization regime. Acidified foods require a lower temperature heat treatment compared to low acid foods; they can be produced and sold as shelf-stable products using small-scale equipment. There are FDA-required processing, filing, and training for both low acid and acidified foods that are sold as shelf-stable products. More information on acidified and low-acid foods can be found on the FDA website under “Acidified and Low-Acid Canned Foods Guidance Documents and Regulatory Information” (FDA, 2021) or through Better Process Control Schools.

The pH is a measure of how acidic or basic a product is on a 1 to 14 scale, with acidic products having a pH below 7 and basic products having a pH

above 7.

Products with a pH of 4.6 or greater are susceptible to *Clostridium botulinum* growth, a bacterium that can produce a deadly toxin and heat-resistant spores. *C. botulinum* is controlled by inhibiting its growth through acidification or, in low acid products, by destroying it and its spores. Both processes are described below.

**Water activity** is a measure of the free or available water in a product. When sugar dissolves in water, it physically bonds with the water molecules making the water unavailable for microorganisms to use for growth. The more bound the water, the lower the water activity. The water activity scale ranges from 0 to 1, with maple syrup at approximately 0.85 (Frasz and Miller, 2015) single-strength (not from concentrate) fruit juices at 0.97 to 0.99 (Schmidt and Fontana, 2020), and pure water at 1.00. Low-acid and acidified beverages and foods have a water activity above 0.85 according to regulatory definitions, and thus support survival and growth of both pathogens and spoilage microorganisms. Products with a water activity below 0.85 do not support the growth of pathogens (Ransom and NACMCF, 2005), but do support pathogen survival and spoilage microorganisms, mainly yeasts and molds, which can grow down to a water activity of 0.60.

### **Preservation Methods**

Here we review common preservation methods used in the food industry that are applicable for maple sap. Some me-

thods such as pasteurization, acidification, and carbonation can take place in a home kitchen or small-scale commercial kitchen, while others, such as retort or aseptic processing require specialized equipment that are not available in homes or typical maple syrup operations. For any preservation method used, it is recommended to submit a sample to a Process Authority for a product review. If the product is to be sold, a scheduled process by a Process Authority is required. More information is available in the Regulation Requirements section below.

**Thermal treatments** are used to destroy pathogens and spoilage microorganisms. One type of thermal treatment is **pasteurization**, a mild thermal processing technique designed to destroy pathogens and reduce the number of

heat-sensitive spoilage microorganisms (Jay et al. 2005).

It is commonly used to extend the shelf-life of refrigerated products. A more severe thermal treatment, commercial sterility, is designed to destroy all pathogens and most spoilage microorganisms. When combined with proper packaging and often other treatments, it results in a shelf-stable product. Maple sap can be thermally treated by heating the liquid in a pot, vat, or kettle (Figure 2). It must be held at or above a preestablished temperature for a set period, as defined in each scheduled process by a Process Authority. Pasteurization and commercial sterility are common processes in the food and beverage industry with a wide range of temperatures and times to reach proper microbial destruction.

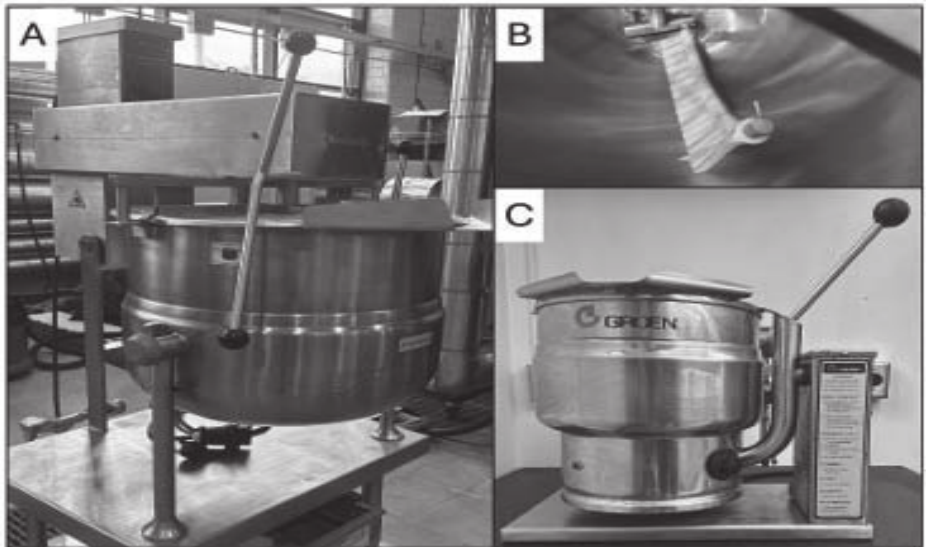


Figure 2. Open Kettle examples, Lee Scraped Surface Open Kettle (A, B) and Groen Steam-Jacketed Kettle (Courtesy of the Seneca Foods Foundation Pilot Plant).

**Acidification** is the process of lowering a product’s pH through the addition of food grade acids. While this step alone is not sufficient to produce a shelf-stable beverage (Jennifer et al. 2020), it is a key step to lower the thermal treatment 5 parameters (temperature and time) required to produce a shelf-stable maple sap. For instance, to achieve commercial sterility, maple sap can be acidified to 4.00 pH and heated to 180 °F for a processing time of 10 minutes. Alternatively, it can be acidified to 3.90 pH and heated for 6 minutes at 180 °F with the same result (Pflug, 2003). A longer and higher heating time will lead to more cooked flavors while adding more acid to lower the pH can result in a sour flavored beverage. Maple sap undergoing pasteurization can also be acidified to extend the shelf-life of refrigerated product. Once acidified, sap must be thermally treated by heating the liquid to a set temperature for a defined time period followed by hot

packing the sap in food grade, heat-resistant containers, such as glass, PET bottles, or aluminum cans with vinyl coatings (Figure 3). Multiple food grade acids are available for acidification. In maple sap, malic, lactic, and citric acid were evaluated for palatability. Lactic acid was rated as the most neutral flavored acid in acidified and pasteurized maple sap samples (Ott et al. 2022). Among the acids, lactic acid has the lowest acid dissociation constant (pKa) values, meaning it is the weakest of the three acids. With this, higher amounts of lactic acid are needed to lower the pH of a product compared to malic and citric acids, respectively. Interestingly, citric acid is the most common of the three acids used in commercial beverages (Table 3). This is likely due to the higher sugar concentration in beverages that balance the tartness from citric acid.

Table 3. Food grade acids flavor, strength, and common uses in the food and beverage industry.

	Citric acid	Malic Acid	Lactic Acid
Flavor	Tart <sup>1</sup>	Smooth tartness <sup>2</sup>	Acid <sup>1</sup> , mildly sour, astringent (bitter) <sup>2</sup>
Use in Beverages	Coconut water, tea, energy drinks, sports drinks	Fruit juices, sodas, Energy drinks, teas	Teas, Sodas

<sup>1</sup>Da Conceicao Neta et al. (2007), <sup>2</sup>Hartwig and McDaniel (1995)

Maple sap can be concentrated prior to acidification but care must be taken when concentrating to higher levels. In preliminary experiments it was found that maple sap concentrated above 10 °Brix was resistant to pH changes meaning that it will take more acid to lower the pH when the sap is concentrated than when the sap is not concentrated. In maple sap, the factor or factors interfering with pH have not been evaluated. More information on acidification and advice for selecting a pH meter can be found through university extension programs, including Oklahoma State University (McGlynn, 2003a and 2003b).

**Carbonation** is a process in which carbon dioxide is dissolved into the sap under pressure, creating an effervescent sensation in the final product. Producing a shelf-stable carbonated maple beverage involves acidification and

thermal treatments, with the addition of a carbonation procedure. First, the sap must be acidified to a pH below 4.6 to reduce microbial growth and reduce the thermal treatment requirements, as previously described. Once acidified, the sap is carbonated by refrigerated forced carbonation, a method common in the sparkling beverage industry in which carbon dioxide is pumped into a pressurized kegerator. The procedure should take place at refrigerated temperatures (38 °F) where carbon dioxide is more stable. The carbon dioxide will dissolve into the sap in the form of carbonic acid and over time an equilibrium will be reached between the sap and the container headspace. While the carbonic acid will lower the pH of the product, carbonic acid is not considered an acceptable acidification method.



**Figure 3.** Acidified and thermally treated maple sap bottled using a water jacketed tank. This same unit is used for bottling maple syrup and similar bottling units are common in maple syrup production facilities. Photo by Ailis Clyne.



**Figure 4. Carbonated Beverage Counter Pressure Can Filler (Courtesy of XpressFill Systems LLC)**

Following carbonation, the sap is bottled using counter-pressure filling equipment under refrigeration, generally at a pressure of 10 to 12 pounds square inch (PSI; Figure 4).'

Suitable packaging options include PET bottles or cans with vinyl coatings as they can withstand the internal pressure from carbonation (Robertson, 2013). To achieve microbial stability, the carbonated sap must undergo

thermal treatment in a water bath or tunnel pasteurizer. Due to the added pressure from carbonation, these beverages require lower thermal treatment temperatures but longer treatment times to minimize the risk of bottle rupture caused by the buildup of pressure. More information on the science of carbonation and guidelines for producing carbonated beverages can be found through Song et al. (2020).

**Retort processing** is a method used to produce commercially sterile products through in-container sterilization (Jimenez et al. 2023). The process involves filling and sealing containers, followed by applying thermal processing under pressure. For maple sap, which has a pH of 6 to 7.4 (Nimalaratne et al. 2020), retort processing requires a processing time of 60 to 90 minutes at temperatures of 250 °F or higher. This is the same principle be=

hind home pressure canning; however, multiple types of retorts exist including batch, continuous, steam, shower, and water immersion still retorts (Jimenez et al. 2024; Figure 5). Additionally, packaging must withstand the high temperatures for extended periods of time. Common packaging options include metal cans, glass bottles, retort pouches, aluminum foil pouches, and retort-tolerant semirigid containers (Jimenez et al. 2024).

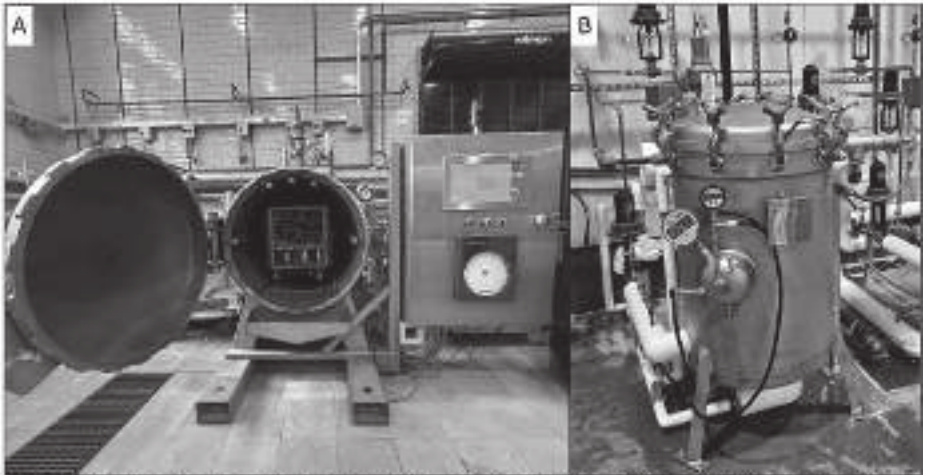


Figure 5. Small-scale retort examples, small batch agitated retort (A; Courtesy of the Seneca Foods Foundation Pilot Plant) and Dixie RDSW-3SS Retort (B; Courtesy of Dixie Canner Co.).

The high costs for retort equipment and maintenance, safety evaluations, and personnel costs make it impractical for most small-scale processors. Additionally, this low-acid product has stricter regulatory requirements to ensure that pathogens like *C. botulinum* are properly controlled. The regulatory requirements include following a scheduled process and the requirements specified in Title 21 of the Code of Federal Regulations (CFR) Part 113 (Part 113, 2011).

By regulation, products for sale may not be produced in a home canner. Small-scale producers may consider partnering with a co-manufacturer, also referred to as co-packers, to reduce costs, although this option often involves high minimum order quantities. Information on co-manufacturers can be found in resources such as Holcomb (2016).

Aseptic processing is another method

for producing shelf-stable products, where the product is commercially sterilized, cooled, and then transferred into presterilized containers within a sterile environment and aseptically hermetically sealed with a presterilized closure (Nelson, 2010). Among processing methods, aseptic is the most complex (FDA, 2005) but can be ideal for maintaining original product flavor and nutrition (Betta et al. 2011). Since pure maple sap is a low-acid product, it would require a processing time of at least 7 minutes at 250 °F in an ultra-high-temperature (UHT) pasteurizer to control for *C. botulinum* (Ott, 2022). However, the specific time and temperature parameters must be determined by a Process Authority, as these values depend on the aseptic processing technique, product, and packaging used. Packaging options include metal cans, paperboard or plastic containers, thermoform containers, plastic or glass bottles, and plastic or foil bags (FDA, 2005; Chiozzi et al. 2022). Each packaging option must undergo proper sterilization, such as sterile water for metal cans or a hydrogen peroxide treatment in paperboard or plastic containers, as defined in your scheduled process (FDA, 2005). Aseptic processing allows for flexibility in packaging options, as the assembled package does not require further heat treatment after filling.'

Aseptic processing equipment is designed for high production rates, often producing 30,000 or more units at a time. For these reasons, like retort processing, aseptic manufacturing is generally impractical for small-scale producers. Use of a comanufacturer may

be necessary to produce shelf-stable maple sap using aseptic processing.

### Regulation Requirements

Commercial production of a shelf-stable maple sap beverage requires a scheduled process from a Process Authority. A refrigerated product is likely to require at least review by a Process Authority, while acidified, carbonated, retorted, or aseptically processed maple sap will require a scheduled process. Scheduled processes are required for most food or beverage products manufactured for sale in which refrigeration or additional steps such as thermal treatment are necessary to ensure a safe, stable product.

The Cornell Food Venture Center offers scheduled process services. A scheduled process is a document specific to a particular food product that states the process for making the product and all parameters that must be controlled in order to make the product safe. The guidelines presented in this document are for informational purposes only and are **not scheduled processes**; it is the responsibility of each maple producer or food facility to ensure compliance and adhere to regulatory requirements.

Maple sap is classified as a low-acid food; if acid is added to it, maple sap is classified as an acidified food. Shelf-stable low-acid (Part 113, 2011) and acidified foods (Part 114, 2000) are subject to additional regulatory requirements outlined in the Code of Federal Regulations. These include but are not limited to Current Good Manufacturing Prac-

tices, record keeping, approved containers and closures, and scheduled processes. All processing of low acid shelf-stable products, including both retort and aseptic processing and packaging, must follow federal regulations described in 21 CFR Part 113 (Part 113, 2011).

In New York State, maple sap beverages for sale must be produced in a kitchen with a 20C Food Processing Establishment License from New York State Department of Agriculture and Markets. Food facilities and maple producers located outside of NYS should check with their state department or state regulatory agency prior to commercial production.

### **Production Overviews**

Below are overviews of three production methods for maple sap beverages. These methods were chosen based on the ease of incorporation into an existing maple production facility utilizing equipment maple producers already own. If the product is to be sold, you must follow state and federal regulatory requirements. The outlines below are for informational purposes only and are not a replacement for a Scheduled Process.

### **Production Overview for Refrigerated Pasteurized Maple Sap**

To produce a refrigerated maple sap beverage using pasteurization you will need a heat source, pot or kettle, temperature probe, and hot-fill food grade containers, such as glass, PET bottles, cans with vinyl coatings, or a food

grade drum.

1. Harvest fresh maple sap and freeze or store below 40 °F until processing.
2. Heat the sap in a pot, vat, kettle, or syrup bottling unit until the sap is at or above 165 °F. Hold it at this temperature for a minimum of 15 seconds.
3. Cool sap so that the product temperature cools from 165 °F to 70 °F within 2 hours, and ideally to below 41 °F within a total of 6 hours.
4. Bottle the sap and immediately cap and seal.
5. Store bottled sap at or below 40 °F for up to 10 days. The estimated Best By date is for 5 to 10 days. A Process Authority may require a laboratory shelf-life study to grant a shelf-life of >5 days, as shelf-life of this product is dependent on current Good Manufacturing Practices (cGMPs) and the thermal treatment.

### **Production Overview for Acidified Shelf-Stable Maple Sap**

To produce a shelf-stable maple sap beverage using acidification and commercial sterilization you will need a heat source, pot, kettle, or syrup bottling unit, temperature probe, pH meter, and hot-fill food grade containers, such as glass, PET bottles, cans with vinyl coatings, or a stainless-steel drum

1. Harvest fresh maple sap and freeze or store below 40 °F until processing.
2. Adjust the pH of the maple sap to below 4.20. This can generally be accomplished by adding 0.05 to 2.0% powdered citric, malic, or lactic acid. Acidic fruit juices may also be added.

Ensure the acid is fully dissolved in the solution and measure the pH when the sap is at room temperature (68 to 72 °F). Note that the sap may need to be acidified to a lower pH depending on the heating requirements of the pressurized package.

3. Cool the acidified sap to below 40 °F.
4. Add the acidified sap into a cleaned and sanitized kegerator. Assemble the kegerator and carbon dioxide tank according to manufacturer's instructions.
5. To begin carbonating, allow the carbon dioxide gas to flow into the kegerator and monitor the PSI levels. Adjust the PSI levels until they are between 20 to 25 PSI.
6. Allow carbonation to proceed in a 40 °F environment.
7. Once the desired carbonation level is reached, dispense the carbonated beverage directly from the kegerator or bottle the beverage under 10 to 12 PSI.
8. Beverages dispensed from the kegerator should be consumed within 1 to 2 weeks or before quality declines.
9. Bottled beverages can be pasteurized in a water bath or tunnel pasteurizer at so that the internal temperature is at least 160 °F. Hold it at this temperature for at least 32 minutes.
  - a. This time and temperature regime is an example. Shelf-stability for products processed at lower temperature and/or shorter times, and for products with pH values above 3.90, will need to be confirmed with a microbial shelf-life study.
10. Allow the product to cool and check for an airtight seal.
11. Store bottled sap at or below room temperature. The estimated Best By date for carbonated beverages in plastic

bottles is 6 to 12 months (Del Nobile et al. 1997)

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## Future Generations University announces Jayne Engle, PhD, as President

The Board of Trustees of Future Generations University, with great pleasure, announces Jayne Engle, PhD, as its next president effective February 24, 2025. Board Chair Daniel Taylor says, "Jayne brings superbly fitted credentials with fieldwork that spans Haiti and Eastern Europe, as well as work with Indigenous communities in Canada. She brings leadership experience in nonprofits and was a senior executive of the J.W. McConnell

Foundation in Canada. Her academic degrees blend Urban and Regional Planning (McGill University PhD, and University of Pittsburgh MURP) plus she has an MBA from Temple University."

Dr. Engle learned of Future Generations while completing field work in Haiti for her doctoral degree where she met Future Generations University students. Observing first-hand the impact the University had on community development in the region, she monitored the university's scope and method around the world. Happily, she discovered more connections to the institution: her family's ancestral farm is adjacent to Future Generations University's campus at the headwaters of the Potomac River.

Her appointment commences February 24, 2025, and succeeds Francis L. Day,

who continues as trustee on the university board. The Board of Trustees gratefully extends their appreciation to Fran: "Our university has been privileged to have had Fran Day as our President. She came to the presidency from the Board of Trustees following her role as] vice president when the university was founded two decades earlier." To see the full announcement and read Jayne Engle's letter of welcome and biography, visit [www.future.edu](http://www.future.edu).

About Jayne Engle, PhD: Dr. Jayne Engle is the incoming President and CEO of Future Generations University (starting February 2025). Her background spans practice, research, and teaching in a wide range of geographic and cultural contexts, including sites of societal transition: a Peace Corps tour of duty in Eastern Europe after the fall of the Soviet Union and PhD fieldwork in Haiti after the catastrophic 2010 earthquake She's held multiple leadership roles in community planning and economic development, philanthropy, and innovation ecosystems, including with the J.W. McConnell Foundation and Dark Matter Labs. She co-founded Seven Generation Cities with the Mi'kmaw Native Friendship Centre, an initiative co-led with Indigenous community leaders, municipalities and other civil society partners aiming to transform civic and social infrastructure for the long term, centering principles of Truth and Reconciliation, and Indigenous ways of knowing, alongside multiple knowledge and wisdom systems. Dr. Engle holds a PhD from McGill University, where she is ad

junct faculty. Two publications that reveal the transdisciplinary and collaborative nature of her work are Sacred Civics: Building Seven Generation Cities (2022; Open Access), and Stories of Tragedy, Trust and Transformation? A case study of education-centered community development in post-earthquake Haiti (2018).

## About Future

### Generations University

Together with the University's global community of partner organizations, Future Generations University gathers practitioners, students, academics, and

community leaders to advance the well-being of people and the planet. The University promotes research, learning, and action towards inclusive and sustainable change worldwide. Headquartered in the heart of Appalachia, Future Generations University's scenic campus is located on top of North Fork Mountain in West Virginia at the headwaters of the Potomac River. [www.future.edu](http://www.future.edu).

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# New York State Maple Confections Notebook: 6th Ed. Making Quality Maple Value Added Products, Cornell Maple Program, County CCE, SARE and the New York State Farm Viability Institute

## 7.2 Maple Taffy

**Maple taffy** is a non-crystallized form of maple sugar. The syrup is heated to a temperature of 23 – 26 °F (13 – 14 °C) above the boiling point of water. Then it is allowed to cool for a few minutes without disturbance, before being poured into serving containers. A very light misting of water helps eliminate bubbles on the surface. The product should be cooled as quickly as possible which can be accomplished by placing the serving containers gently into a freezer, being careful not to agitate the syrup which could cause crystals to form. Maple taffy should be served at room temperature and can be eaten with a fork or wooden taffy spoon. Individual servings can be packaged in small plastic cups with snap on covers. The taffy will last indefinitely when frozen.

### Ingredients

- 2 cups maple syrup
- 3/4 cup light corn syrup, or 1 cup inverted maple syrup
- 2 tablespoons cornstarch
- 2 tablespoons butter

### Directions

1. Butter a 15x10x1 inch baking pan. Combine the ingredients in a pot or saucepan equipped with a candy thermometer. Cook over medium heat until it reaches a boil.

2. Cook over medium-low heat, without stirring, until it reaches 265 – 285 °F depending on the invert level of your choice of maple syrup\*.

3. Once the desired finish temperature is reached, immediately remove from heat. Allow to cool for a few minutes, then pour the mixture into the prepared baking pan. Cool mixture in a freezer until it can be handled easily.

3. Once the mixture reaches a safe handling temperature, use buttered hands to twist and pull the candy until it turns a creamy color and is stiff and quite difficult to pull.

4. Pull into strands about 1/2 inch thick. If you prefer, cut each strand of taffy into bite-size pieces with buttered scissors or a knife. Wrap each piece in clear plastic wrap or place on parchment paper. Consume the taffy once finished or store in a cool dry place in a tightly covered container. Taffy can be stored indefinitely in a freezer.

\*A note on finish temperature  
Temperature will need to be adjusted based on the invert sugar level in your choice of maple syrup. Cook to a higher finish temperature if the syrup is high in invert sugar (>2%), or a lower finish temperature if the syrup has low invert sugar levels (<2%). If the taffy is too hard, reduce the finish temperature

for your next batch. If it is too soft, increase the finish temperature. Temperature adjustments should be gradual (2 – 5 °F).

## 7.6 Maple Granola

### Ingredients

1 large box (42 oz) old fashioned oatmeal  
1 cup each: chopped walnuts, pecans, almonds, coconut  
1 cup each: chopped dates, cranberries, raisins  
1/2 cup wheat germ  
1/2 cup oat bran  
1/2 cup wheat bran  
1 cup canola oil  
1 cup maple syrup  
1 cup molasses  
1 cup honey  
3 Tbsp vanilla  
1 Tbsp cinnamon  
1 tsp salt

### Directions

Preheat oven to 350 °F. In a large roasting pan, combine oatmeal, wheat germ, oat bran, wheat bran, cinnamon and salt. Mix in the chopped nuts, but reserve the dried fruit. Stir in oil, maple syrup, molasses, honey, and vanilla until dry ingredients are evenly coated. Bake for 30 minutes, stirring every ten minutes to cook evenly. Add in the dried fruits after removing from the oven.

Increase or reduce oil and sugars according to your personal tastes. Granola can be stored frozen in freezer bags. Yields 32 servings.

## 7.12 Maple Ice Cream

Catherine Belisle, Ph.D. (2022)

### Background

The volume of syrup used in the following recipes is the maximum amount of sugar that can be added to the mix without causing significant textural changes to the ice cream. Sugar decreases the freezing point of ice cream and thus slows the rate of ice crystallization. If a higher concentration of maple syrup is added to the ice cream mixture, the solution will not freeze properly or the finished ice cream will melt very quickly. Ice cream machines incorporate air while they freeze the ice cream mix. This incorporation of air causes an increase in volume known as "overrun". Overrun is increased by the presence of nonfat dry milk solids, egg yolks, and emulsifying agents. Fat decreases the percent overrun in ice cream, especially when present as large fat globules or clumps.

### Hard Maple Ice Cream

#### Ingredients

½ gallon Cornell Dairy hard ice cream mix (no added vanilla, 12% fat) 2200 mL Dark maple syrup (approximately ½ gallon)

#### Directions

1. Combine ice cream base and maple syrup. Mix well until homogenous.
2. Add mixture into an ice cream machine and allow ice cream to aerate and form.
3. Deposit ice cream into containers and freeze for 24 hours before serving.

Recipe yields 1.5 gallons of hard ice cream.

### **Sensory Evaluation**

The quality of frozen desserts is evaluated by the texture (mouthfeel), consistency (hardness or softness), and body. A good quality frozen dessert will have a smooth, creamy texture, a consistency that is neither too hard nor too soft, and body that is not too watery and compact nor too viscous and spongy when the product begins to melt. This hard maple ice cream recipe was evaluated by 95 panelists at the Cornell Sensory Evaluation Center. Overall, 64% of panelists liked the ice cream moderately to extremely and 45% of panelists “would purchase” the ice cream. This ice cream was noted for its creaminess and strong maple flavor.

### **Soft Serve Maple Ice Cream**

#### **Ingredients**

½ gallon Cornell Dairy soft serve ice cream mix (with vanilla, 10% fat) 2200 mL Dark maple syrup (approximately ½ gallon)

#### **Directions**

1. Combine ice cream base and maple syrup. Mix well until homogenous
2. Add mixture into a soft ice cream machine and allow ice cream to aerate and form.
3. Follow manufacturer’s instructions on the soft ice cream machine to serve. Recipe yields 1.5 gallons of soft serve ice cream.

### **Sensory Evaluation**

The quality of frozen desserts is evaluated by the texture (mouthfeel), consistency (hardness or softness), and body.

A good quality frozen dessert will have a smooth, creamy texture, a consistency that is neither too hard nor too soft, and body that is not too watery and compact nor too viscous and spongy when the product begins to melt. This soft serve ice cream recipe was evaluated by 95 panelists at the Cornell Sensory Evaluation Center. Overall, 74% of panelists liked the ice cream moderately to extremely and 51% of panelists “would purchase” the ice cream. This ice cream was noted for its creamy texture, reduced melting speed, and balanced flavor. Some panelists noted that the maple flavor was weak (27.4%), but that the ice cream was too sweet (44.2%).

## **7.8 Maple Syrup Sticks/ Straws**

Olga Padilla-Zakour, Cheryl Leach, Herb Cooley, Belen Baviera, NYS Food Venture Center,

Cornell University Revised (2022): Catherine Belisle, Ph.D. and Ailis Clyne, Cornell Maple Program

As a coordinated effort of the NYS Food Venture Center and the Cornell Maple Program, several value-added maple products were developed or optimized to offer marketing alternatives to maple producers. This project was funded by the New York Farm Viability Institute.

### **Research Objective**

This product is modeled after honey sticks/straws which are often marketed as a snack or “to-go” sweetener. Maple syrup sticks/straws can be prepared in a similar manner, but without proper

processing, mold can grow. We evaluated pasteurization methods to produce a shelf-stable product.

## Results

The following procedure should be used for shelf-stable maple syrup sticks/straws:

1. Fill food grade plastic sticks/straws with room temperature maple syrup.
2. Heat seal both ends of the plastic.
3. Process sealed sticks/straws in a boiling water bath for five minutes.

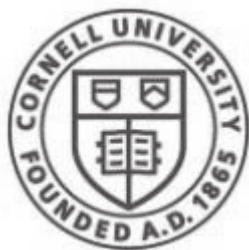
Pasteurized, shelf-stable maple syrup sticks/straws can be stored indefinitely at room temperature.

Recipes provided by:

Cornell Maple Program Sugar Maple Research & Extension, Cornell University

<https://blogs.cornell.edu/cornellmaple/maple-confections/>

<https://bpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/7/5773/files/2022/12/NYS-Confections-Notebook-6th-Edition.pdf>



## Letter from the Editor of the Maple Digest Theresa Baroun

Hello Maple Enthusiasts,

The beginning of maple season has begun for many of us. At our small operation of 1200 taps in De Pere, WI we are about 7/8 tapped. We have boiled down about 500 gallons of sap. We have had a weird weather patterns. The beginning of February with no snow to 12 inches, to no snow and unseasonable warm weather a couple days to a couple days for some of us many inches of snow others in the form of an rainy, icy wintery mix. It looks like in the extended forecast the next couple weeks should be great for the maple season.

As we continue to make changes to the Maple Digest Feel free to reach out with articles, pictures, events and stories about your season and events. This edition of Digest I added some value-added maple recipes from New York State Maple Confections Notebook: 6th Ed. Making Quality Maple Value Added Products: Cornell Maple Program Sugar Maple Research & Extension, Cornell University 6th. Please feel free to send in recipes as well. Thank you to again all the researchers, who continue to send research articles about their current research and all advertisers who help make the Maple Digest possible.

Have a great maple season,  
Theresa Baroun  
Maple Digest Editor

# Support the Maple Research that Supports you!

Every time you set a tap, fire your evaporator, or put syrup into bottles, you are benefitting from research that helped us all learn how to do these things better. Much of that research has been supported by the North American Maple Syrup Council's Research and Education Fund. The Fund has given out more than \$1 million in grants in the last 35 years, catalyzing the research that has helped the maple industry grow and thrive.

The fund gets its resources from industry stakeholders – equipment manufacturers, producer associations, dealers, and individual producers. Alliance Partners commit to making annual contributions that help assure the long-term sustainability of the Fund.

If you're interested in becoming an Alliance Partner, or in making a one-time donation to the fund, contact NAMSC Executive Director Theresa Baroun at [mapledigest@gmail.com](mailto:mapledigest@gmail.com), or Treasurer Joe Polak at [joe.maplehollow@frontier.com](mailto:joe.maplehollow@frontier.com).

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