Northern New York Agricultural Development Program
2023-2024 Final Project Report

Developing Alternative Tree Sap Beverages

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Background:

Maple syrup production has long been an economically important agricultural crop across northern New York (NNY) for generations. Although maple sugaring can yield different products, there is a limited depth of products for producers to offer consumers. In recent years, maple producers in NNY have ventured outside of tapping solely maple trees and have started taping birch trees and beech trees for syrup production thanks to research, techniques, and promotion developed by the Uihlein Maple Research Forest. The advantage of tapping into these alterative trees species provides the opportunity for landowners in NNY to increase the economic potential from their forests. Tapping from different species also encourages landowners to manage for a diversity of species, which encourages healthier and more resilient forests for NNY.

Despite findings from Northern New York Agricultural Development Program (NNYADP) projects outlining the potential for economic value from tapping birch or beech trees, there is still some hesitancy from producers to tap into this new market due to the low sugar concentration in the sap which creates processing issues and requires more energy when turning sap into syrup. An alternative option would be to turn the sap from these alternative tree species into a bottled beverage. The maple sap beverage market has been growing within the functional beverage industry (Yuan et al. 2013), yet there has been very little exploration of bottling alternative tree saps. By bottling sap, the energy required to concentrate sap to syrup is no longer necessary. The ratio of sap to syrup for birch and beech is often as high as 140:1 (Wild 2022). Bottling the birch or beech sap creates an increased quantity of the product available for sale, which in turn increases profit margins.

A concern when bottling sap is creating a shelf stable product in the sap producer's operation, as the operations total sap yield may be smaller than a commercial bottling company's minimum run size. Current methods for bottling maple sap utilize large commercial equipment that is beyond the scale and budgets of smaller maple and tree sap producers. The Cornell Maple Program has recently developed methods and procedures for maple producers to preserve maple sap as a bottled beverage utilizing low-cost equipment already present in most sugaring operations. These methods can be transferred to alternative tree saps but would need to be evaluated to fit each species of sap. Different tree species produce sap with different compounds that can impact final product quality. These saps need to be analyzed in order to create a procedure for forest owners in NNY to package and sell a shelf stable alternative tree sap beverage.

This project explored the feasibility and potential benefit of alternative tree species as bottled sap beverages through three research objectives:

- We first assessed common issues encountered in sap and juice bottling and storage, including cloudiness (Cerreti et al. 2017), stability (Hsu et al. 1989), and discoloration (Rattanathanalerk et al. 2005).
- The second focus was assessing the chemical profile of each tree sap by evaluating the organic acids, soluble solids, antioxidants, and mineral profiles to assess the functionality or health benefits of the sap beverages.
- Lastly, we evaluated consumer preference and likeliness to purchase the individual bottled tree saps.

Methods:

All sap was collected from trees tapped at Cornell University's Uihlein Maple Research Forest in Lake Placid, NY. Collection took place during the 2024 sugaring season. Sap was collected from 10 beech trees, 10 birch trees, and 10 aspen trees. The trees were tapped using standard methods for maple sap. A 5/16" taphole was drilled in each tree and connected to a vacuum tubing system. Sap from the sample trees flowed into individual vacuum chambers that were then emptied to collect the sample. The sap was frozen within 24 hours of collection and shipped to the Cornell Maple Food Science Lab at the Arnot Forest in Van Etten, NY.

Laboratory work took place at the Arnot Maple Lab, laboratories on the Cornell Agritech Campus in Geneva, NY, and through an independent laboratory. Sensory evaluations were conducted by the Cornell Food Science Sensory Evaluation Center in Ithaca, NY.

Bottling and Storage

A small-scale bottling method for maple sap recently developed by the Cornell Maple Program was adapted for this study. The method is intended as an option that can be replicated with equipment typically already available in sugarhouses with a commercial food-processing license. The small-scale method avoids the pitfalls of working with a copacker including large minimum-run size requirements and considerable up-front costs. The small-scale method uses a combination of acidification and thermal pasteurization to create a shelf-stable product. A challenge for this method was determining the food grade acid with the best flavor profile for maple sap. Lactic acid was determined to be the best option through an in-house sensory test.

We began this study with a feasibility test to determine whether the small-scale method could be adapted for alternative saps. Since alternative tree saps have slightly different flavor profiles, we first tested the two acids with the most favorable sensory perception from our previous maple sap work and conducted new sensory tests with those acids added to the alternative saps. For this test, samples were thawed in a water bath at 37°C (98°F) for 45 to 50 minutes. Samples were then concentrated to 2 °Brix via boiling. Food grade malic acid (0.12%) or lactic acid (0.24%) powders were added to each sap to obtain a pH of 4.2. Samples were then pasteurized by heating sap to 190°F for 12 minutes. An in-house sensory panel of maple researchers familiar with sap flavors evaluated the six samples (birch, aspen, and beech sap acidified with either malic or lactic acid).

Next, tests were conducted to improve clarity. Previous work has found that sap from some species, including beech, forms a cloudy, gelatinous precipitate during thermal processing. A literature review suggested this substance may be pectin, so a pectin isolation test was conducted to determine the presence of this pectin. For the test, 40 g of frozen sap was thawed in a water bath for each sap at 37°C (98°F) for 20 minutes. The enzyme Lallzyme EX containing 10% polygalacturonase enzyme was added to each treatment at concentrations of 0.25% or 0.825% and stirred until dissolved. The samples were heated to 50°C (122°F) for 120 minutes followed by an enzyme inactivation at 85°C (185°F) for 2 minutes. The samples were divided into two subsets, centrifuged or non-centrifuged samples. The centrifuged samples were processed at 3000 rpm for 20 minutes. The presence of a pellet following centrifugation was recorded. The clarified liquid was then collected in a new 15 mL tube. Both centrifuged and non-centrifuge samples were stored at 4°C (39°F) for 30 days then evaluated to determine whether the enzymatic treatment and centrifuging reduced turbidity and improve clarity in saps.

A second turbidity experiment aimed to test the effectiveness of enzyme treatment methods at different enzyme concentrations and holding times to isolate pectin in beech sap. In these tests, beech sap was treated with different concentrations of the enzyme EnartisZym RS(P) which is a proprietary product containing a combination of the enzymes polygalacturonase, pectinesterase, pectin lyase, and cellulase. To conduct the tests, frozen beech sap (0.4 °Brix) was thawed in a water bath at 37°C (98°F) for 45 minutes. Enzyme was added to each treatment at concentrations of either 0, 0.05, 0.125, or 0.25% and mixed until dissolved. Next samples were heated to 50°C (122°F) for 30, 60, or 120 minutes followed by an enzyme inactivation at 85°C (185°F) for 2 minutes. Samples were then centrifuged at 4000 rpm for 10 minutes. The clarified sap from each centrifuged sample was transferred into a new centrifuge tube and stored at 4°C (39°F) for turbidity evaluation over a 30-day storage period.

Sap Composition Analysis

To determine sap composition, samples were evaluated for pH, °Brix, acid (citric, acetic, and malic), minerals (Ca, K, Fe, and Mg), and total phenolics. To conduct these tests, samples were thawed in a water bath at 37°C (98°F) for 45 to 50 minutes. Some samples were immediately divided into 50 mL containers, frozen, and sent for phenolic, acid, and mineral analysis. pH and °Brix were measured in house with samples at 18°C (65°F).

Consumer Tests

To gain insights into consumer preferences for alternative tree saps that have been acidified and thermally processed into shelf stable formulations, a consumer acceptability study was conducted through the Cornell Sensory Evaluation Center. Birch, beech, and aspen sap were all tested at a sugar content of 4°Brix. There were two samples for each species, one acidified with lactic acid and the other with malic acid, for a total of 6 samples. For the study, 100 consumer panelists were recruited to taste and evaluate the samples.

Results:

Bottling and Storage

The results of the feasibility test suggested that the small-scale bottling method also works for alternative saps. This method is described in detail in the Bottled Maple Sap extension bulletin available for free download on the New Products Development page at CornellMaple.com.

The pectin isolation tests showed that pectin was present in beech, with a trace amount also detected in the birch sap samples. No pectin was isolated from aspen sap samples. The beech sap samples treated with 0.25 or 0.825% Lallzyme EX that underwent centrifuged and non-centrifuged samples were evaluated with a visual inspection after 30 days. No precipitate was present in samples that were physically clarified through centrifuge, suggesting enzymatic treatment and clarification reduced pectin content in beech sap. By contrast, samples enzymatically treated that did not undergo centrifugation formed a precipitate during storage, suggesting that a filtration or centrifugation procedure is necessary in beech sap to remove pectin.

Samples treated with the EnartisZym enzyme blend showed mixed results in reducing turbidity (Table 1). Regardless of enzymatic treatment concentration, samples heated for 30-minutes did not develop any precipitate, indicating that 30 minutes is insufficient holding time for enzyme activity to occur. Slight precipitate pellets formed in centrifuged beech samples with 0.05, 0.125, or 0.25% enzyme blend after 60 minutes and 120 minutes of heat treatment. In control samples (0% enzyme blend), a slight pellet formed in samples heat treated for 120 minutes. This result validates the formation of pectin during thermal treatment without enzyme intervention, but less effectively. To isolate and remove pectin from beech saps, producers can treat sap with 0.825% pectinase or a pectin enzyme blend followed by a heat treatment at 50°C (122°F) for 120 minutes, as described above.

Table 1. Pectin precipitate formation in beech sap (0.4 °Brix) following pectin isolation treatments with various concentrations of enzyme blend EnartisZym RS(P) and incubation times.

Enzymatic Treatment (% of total solution)	Heat Treatment (minutes)	Precipitate
0 (Control)	30	No
	60	No
	120	Yes
0.05	30	No
	60	Yes
	120	Yes
0.125	30	No
	60	Yes
	120	Yes
0.25	30	No
	60	Yes
	120	Yes

Sap Composition Analysis

The composition of aspen, birch, and beech sap samples are presented in Table 2. The pH of these alternative saps was either very slightly acidic or neutral. Aspen was the most neutral sap with an average pH of 7.13, followed by beech with an average pH of 6.26, and birch at 5.98. Sugar content measured as °Brix was below 1% for all three species. Interestingly, beech contained a much higher level of citric acid than the other species. However, the levels of all acids, minerals, and phenolics were relatively low and unlikely to have detectable influences on flavor differences between the species. Total phenolic content ranged from 10.9 to 18.8 mg/L among sap samples, with the highest content in birch sap. Phenolic concentrations of the three tree saps are comparable to total phenolic concentrations of bottled (13.0 mg/L), ultra-high temperature processed (UHT; 10.9 mg/L), and fresh red dwarf (18.4 mg/L) coconut waters (Santos et al. 2012). **To the best of our knowledge this is the first report of aspen and beech sap composition, besides mineral composition of beech *syrup* as presented in Wild, 2022 (a precursor to this study).**

Table 2. Composition of aspen, birch, and beech saps harvested in Lake Placid, NY during the 2024 harvest season.

Sample	pH	°Brix	Citric (mg/L)[1]	Acetic (g/L)[1]	Malic (g/L)[1]	Ca (mg/ 100 g)[2]	K (mg/ 100 g)[2]	Fe (mg/ 100 g)[2]	Mg (mg/ 100 g)[2]	Total Phenolics (mg/L)[3]
Aspen	7.01	0.7	<11.1	<0.004	0.28	5.71	5.78	<0.5	<5	10.9
Aspen	7.26	0.6	<11.1	0.01	0.19	<5	5.49	<0.5	<5	_
Aspen	7.11	0.6	<11.1	<0.004	0.19	<5	<5	<0.5	<5	_
Birch	6.03	0.5	<11.1	0.02	0.24	6.63	5.6	<0.5	<5	18.8
Birch	6.01	0.4	<11.1	<0.004	0.28	<5	<5	<0.5	<5	_
Birch	5.90	0.4	<11.1	<0.004	0.32	5.49	<5	<0.5	<5	_
Beech	6.49	0.4	80	<0.004	0.15	<5	<5	<0.5	<5	15.2
Beech	6.30	0.3	63	<0.004	0.1	<5	<5	<0.5	<5	_
Beech	6.01	0.3	53	<0.004	0.08	<5	<5	<0.5	<5	_

[1]Enzymatic, [2]Atomic absorbance, [3]Folin-Ciocalteu method

Flavor differences might be more pronounced in syrups where these compounds are heavily concentrated. However, for sap, the importance of these minerals is primarily nutritional with implications for marketability as a functional beverage. The results show that these saps all contain calcium and potassium, but very little iron or magnesium.

Consumer Tests

To understand consumer insights, a consumer preference test was conducted with 100 panelists. When comparing flavor, sweetness, acidity, and likeliness to purchase, aspen sap was liked the most among samples, followed by birch sap (Fig. 1-4). Acidifying birch and beech saps is not an acceptable preservation method for the majority of consumers. Overall, panelists did not demonstrate a strong liking for any of the saps as formulated (Fig. 1). The beech sap was deemed less acceptable to panelists with around 50% disliking each formulation. A 4% sugar concentration was just about right for birch and aspen for a large portion of panelists, most felt it was insufficient for beech sap (Fig. 2). The acid addition rates were acceptable for aspen but considered too acidic for birch and beech (Fig. 3). Aspen showed some promise in likeliness to purchase evaluations but the results for birch and beech with less than 20% indicating a strong interest in purchasing (Fig. 4).

Flavor Liking

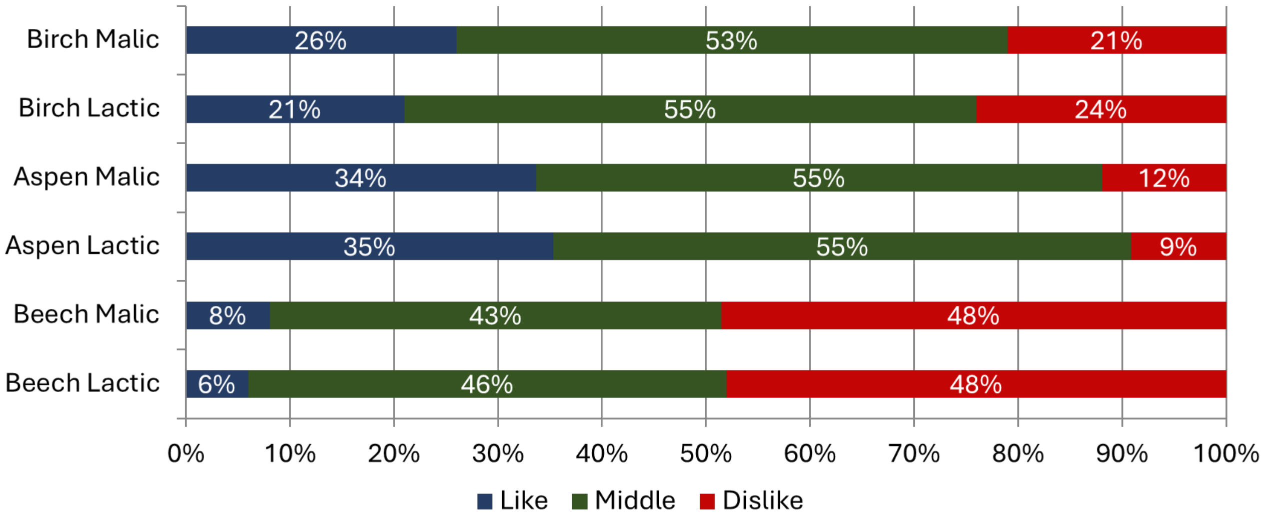

Figure 1. Overall flavor liking of acidified and pasteurized alternative tree saps (birch, aspen, and beech saps) (n=100).

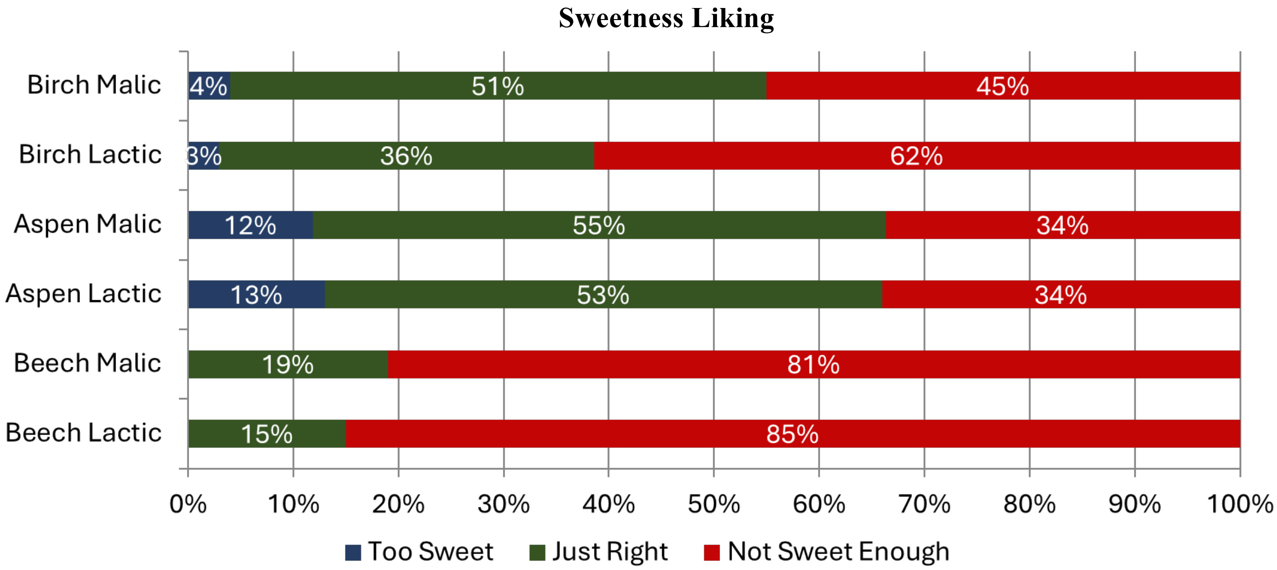

Figure 2. Overall sweetness liking of acidified and pasteurized alternative tree saps (birch, aspen, and beech saps) (n=100).

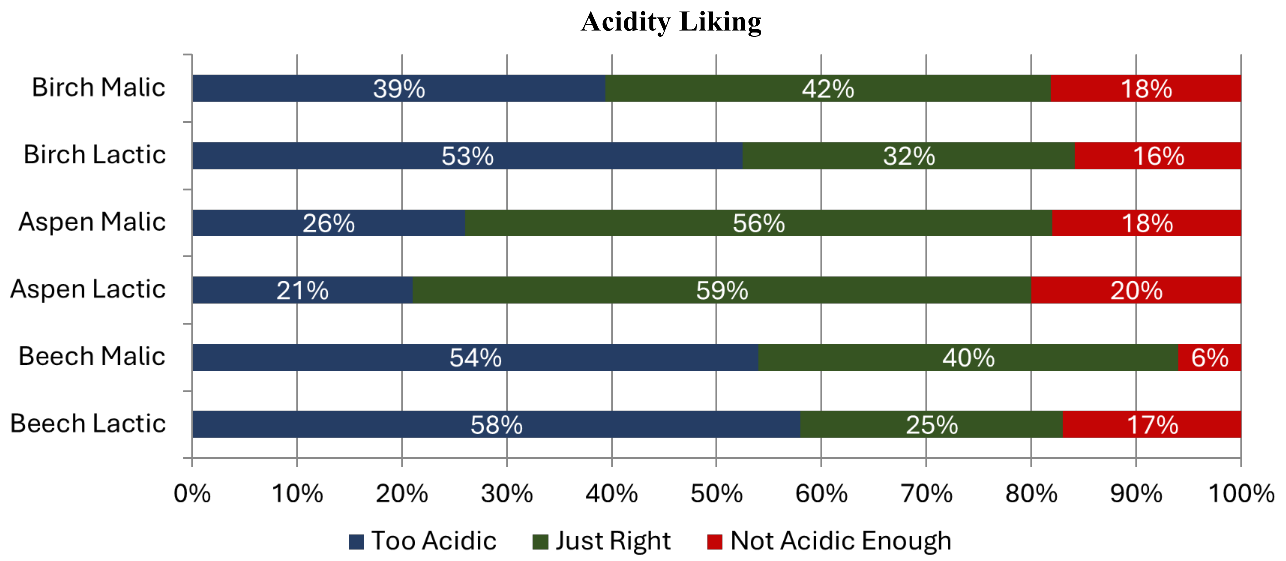

Figure 3. Overall acidity liking of acidified and pasteurized alternative tree saps (birch, aspen, and beech saps) (n=100).

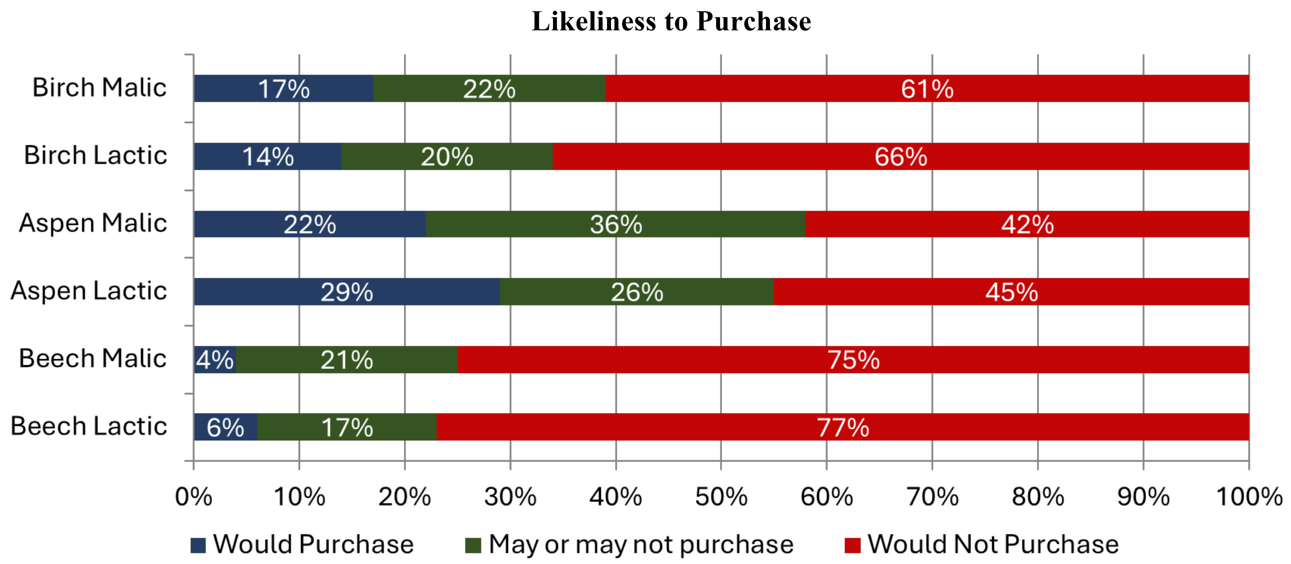

Figure 4. Likeliness to purchase acidified and pasteurized alternative tree saps (birch, aspen, and beech saps) (n=100).

To validate the in-house sensory evaluation test, consumer panelists (n=100) were asked for their preference between lactic or malic acid acidifier in each of the three sap types (Fig. 5). Among the saps, malic acid was the preferred acidifier in birch and beech saps. No preference was given for an acidifier in aspen sap. When asked to describe the preference between lactic acid and malic acid samples, panelists evaluating birch sap noted that malic acid samples contained "richer fruit taste without a sour aftertaste", "more balanced flavor profile", and "sweeter and more complex flavor". Meanwhile, malic acid was preferred in beech sap samples because it was "less bitter" and "less acidic" than lactic acid samples. Aspen sap samples acidified with lactic acid were preferred by 52% of panelists with panelists noting a "really pleasant maple taste", "notes of toasted sugar or coconut", and "more balanced sweetness and acidity". Panelist who preferred aspen sap with malic acid (48%) reported a "sweeter and more distinctive taste", "smoother flavor", and liking the "refreshing feeling in the throat".

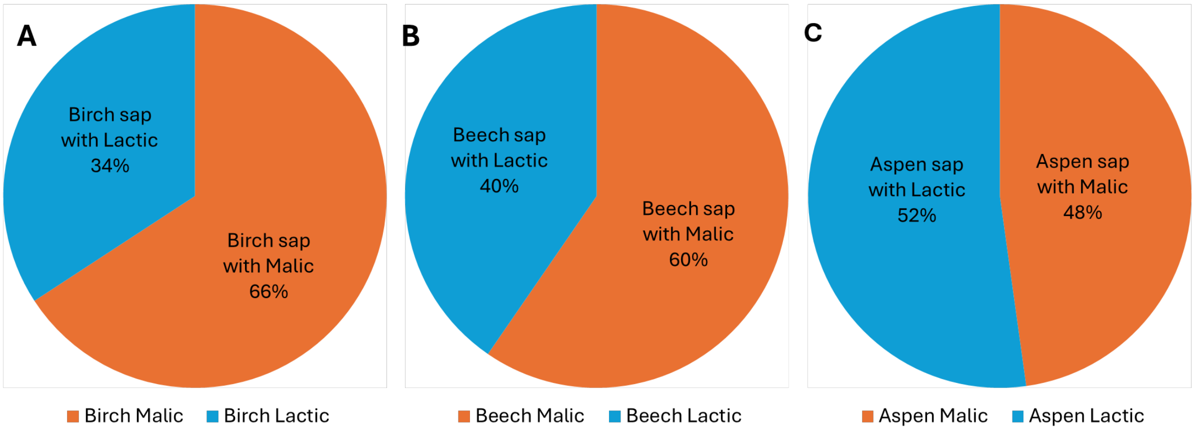

Figure 5. Consumer preference for acidifier (lactic acid or malic acid) used in birch (a), beech (b), and aspen (c) sap acidified and pasteurized procedure (n=100).

Conclusions:

In this study, the feasibility of processing and bottling aspen, beech, and birch saps as a shelf stable beverage was validated. Among saps, aspen and birch sap can be processed without concern for cloudiness or discoloration developing in storage. Beech sap was found to contain pectin, which can be isolated and removed prior to processing. A procedure for pectin isolation and removal was elucidated and can be improved with efficient filtering methods, such as ultrafiltration, among others. **To the best of our knowledge, this is the first validation of pectin in beech sap. This method can be used to isolate pectin in other trees saps where gelatin occurs, such as walnut sap. work that could also benefit the harvest of walnut sap.**

To the best of our knowledge, this is also the first report of aspen and beech sap composition. The composition of aspen, beech, and birch saps can be utilized by producers interested in the functional properties of their saps. Lastly, it was determined that small-scale bottling methodologies can be used to create a shelf-stable beverage from birch, beech, and aspen sap. However, based on consumer's perception of acidified and pasteurized sap, it may be advantageous for processors to consider a pasteurized sap beverage instead of an acidified sap beverage, or refine sugar concentration and acid addition rates for improved consumer liking. Pasteurized sap beverages have a shelf life of up to 5 days at 4.4°C (40°F). The shelf life of pasteurized sap beverages may be extended following a laboratory shelf-life study. Production overviews for a refrigerated sap beverage and a shelf-stable acidified sap beverage are listed below.

Production Overview for Refrigerated Pasteurized Sap:

To produce a refrigerated 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 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 5 days. The estimated Best By date is for 5 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 Shelf-Stable Acidified Sap:

To produce a shelf-stable 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 sap and freeze or store below 40°F until processing. Increase concentration of sugars if desired.

2. Adjust the pH of the sap to below 4.20. This can generally be accomplished by adding 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 (about 68°F - 72°F).
3. Once the pH is adjusted and stable, heat the sap in a pot, vat, kettle, or syrup bottling unit until the sap is at or above 195°F. Hold it at this temperature for a minimum of 6 minutes.
4. Bottle the sap using a hot-fill process. Immediately after heating and holding, pour the hot sap into clean, hot-fill, food-grade containers.
5. Immediately cap and invert the bottle for a minimum of 2 minutes to ensure the container is pasteurized and has an airtight seal. Hold the containers at room temperature.
6. Store bottled sap at room temperature. The estimated Best By date is for 6 to 12 months.
Commercial kitchen license is required if you plan to sell the bottled sap.

Education and Outreach:

Two extension factsheets are in preparation and will be posted on Cornellmaple.com and MapleResearch.org. Summary articles will also be submitted to the Maple News and Maple Digest, two publications that reach producers in NNY. Results from the study will be shared with maple producers at the Lewis County Maple Meeting in February. Results will also be shared on a future episode of the industry podcast, Sweet Talk, All Things Maple. The Northern New York Agriculture Development Program has been and will be identified as the funding source for this project.

For More Information:

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