

# Tips for Top Quality, High Flavor Syrup

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My name is Aaron Wightman. I am a maple specialist with the Cornell Maple Program at Cornell University. Today we will talk about tips for protecting and enhancing the flavor of your maple syrup.

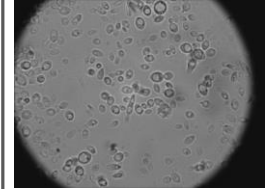
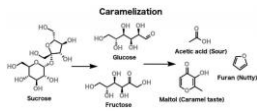
## Overview:

How does  
flavor form

Preventing  
low quality

Options for  
enhancing  
flavor

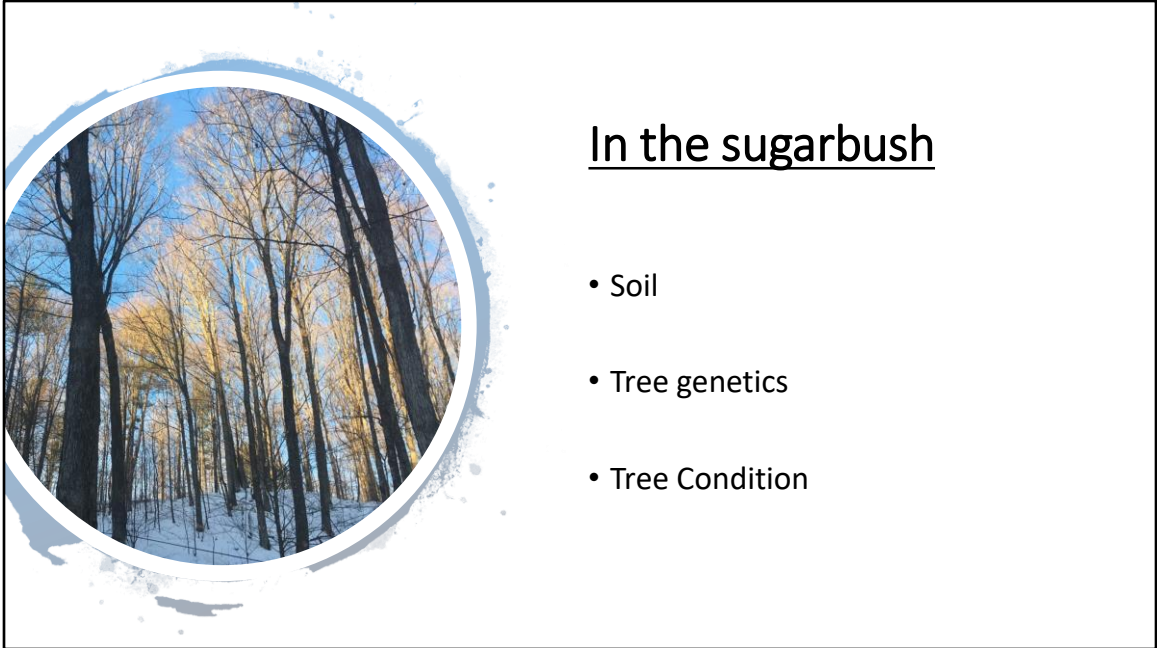
We will begin by discussing how flavor forms, then look at areas where flavor can be degraded. Lastly, we will look at strategies for enhancing flavor.



## What Creates Maple Flavor

???

Let's examine where maple flavor comes from. There are a number of factors that contribute to flavor development, ranging from sap chemistry to chemical reactions. Understanding how flavor develops is critical to enacting quality control measures in maple syrup production.



## In the sugarbush

- Soil
- Tree genetics
- Tree Condition

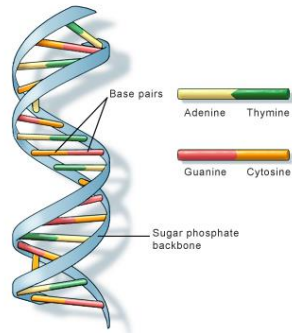
The raw ingredient for syrup is sap, and not all sap is the same. Factors such as soil type, tree genetics and tree health all affect the composition of sap. Differences in composition lead to differences in flavor. That is one of the reasons why syrups produced in different sugarbushes often have their own unique flavors.



## Soil Conditions

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Soil type and soil conditions have a large influence on mineral content, as well as the types of organic and inorganic acids, present in sap. Although these compounds typically represent less than 1% of the sap, they do have a role in flavor formation.



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## Tree Genetics

Tree genetics also influence the composition of maple sap. Trees are unique individuals, just like humans. Their genetic makeup, along with the growing environment, determine sugar content and sap chemistry, among other things.



## Tree Condition

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The health and vigor of a tree is the final factor that can influence sap chemistry in a way that affects syrup flavor. Stressors such as insect damage, disease and drought all initiate responses from the tree that alter sap chemistry.

## In the Sap

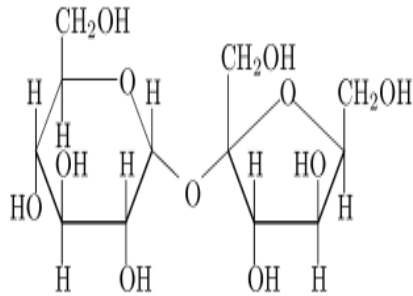
Microbial reactions alter sap chemistry

Once sap is extracted from a tree, it does not remain inert. Sap is a living biological medium populated by microbes such as bacteria and yeast. As these microbes live and multiply in the sap, they slowly change its chemical composition.



## Sugar Composition in Sap

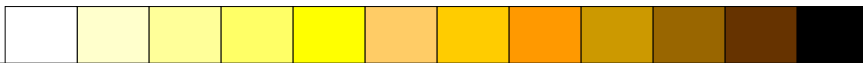
- Sucrose is the only sugar in sap as it comes from the tree.
- Some sucrose is changed into invert sugar by microbial fermentation



When sap first emerges from a maple tree, the only type of sugar present is sucrose which is pictured in the diagram. Sucrose is a disaccharide, which means it is a large sugar molecule made from two smaller sugar molecules that are bonded together. Specifically, sucrose is made from a glucose and fructose molecule held together by a chemical bond. Microbes can break that bond in sucrose molecules and convert it into glucose and fructose. In the maple industry, these smaller sugars are often referred to as invert sugars.

# *Invert Sugars*

*are responsible for much  
of the darkening as well as  
flavor development during  
processing*



Invert sugars behave differently than sucrose when subjected to the heat of cooking. These different chemical behaviors are responsible for much of the darkening and flavor development that takes place as sap is cooked in the evaporator.

## Caramel Color and Flavor

**Caramel reaction with sucrose 365°F**

**Caramel reaction with glucose 295°F**

**Caramel reaction with fructose 219°F**

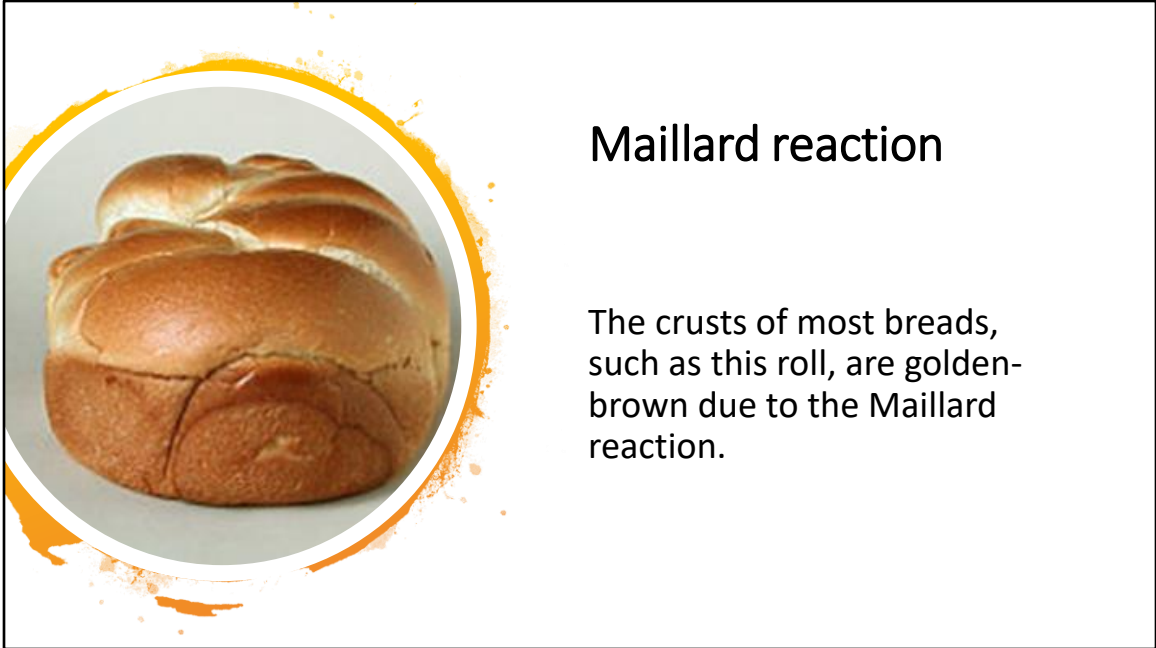
Caramelization describes a class of chemical reactions that take place when sugar is subjected to heat. Caramel is one of the most prominent flavors in maple syrup. As you can see in this slide, invert sugars have a much lower caramelization temperature than sucrose. So higher invert levels in sap will result in darker syrup with more caramel flavor.

## Maillard reaction

is a [chemical reaction](#) between [amino acids](#) and [reducing sugars](#) that gives browned food its distinctive flavor.



The maillard reactions are similar to caramelization because they both require heat and invert sugars. However, maillard reactions also require the presence of amino acids. Because the amino acid profile can vary significantly between individual trees and sugarbushes, the flavors created through this reaction can also vary.



## Maillard reaction

The crusts of most breads, such as this roll, are golden-brown due to the Maillard reaction.

The flavors created by this process are those you find in the browned crust of bread and toasted marshmallows. Without the microbial activity that creates invert sugars, neither maillard browning nor caramelization could occur in maple syrup.

## Unfavorable microbial reactions

Fermentation –  
too long, too  
warm and too  
little oxygen

Spoilage – too  
long, too warm

Microbial activity can also have negative impacts on flavor including fermentation and spoilage. Also, if microbes create too much invert sugar, syrup can be rendered unsuitable for producing crystalized maple confections or can fall out of the desired color grade.

## Key Point

Some microbial activity is important for flavor development. Too much activity under the wrong conditions damages quality

The takeaway is that microbial activity can have both positive and negative impacts on flavor depending on conditions.

## Flavor Control Points:

1. Failure points for damaging flavor
2. Points where flavor can be enhanced

Now that we have reviewed how flavor is formed, let's examine places where flavor can be controlled. There are main two categories of flavor control. The first category is failure points where flavor is damaged. The second, is points where conditions or processes can be changed to improve flavor.



## Failure Points

Sugarbush health

Sap collection and  
handling

Evaporator

Syrup processing and  
packaging

Failure points exist at each of the main stages of maple syrup production. These stages are sugarbush management, sap collection and handling, cooking in the evaporator, and filtering and bottling finished syrup.



## Tree Condition

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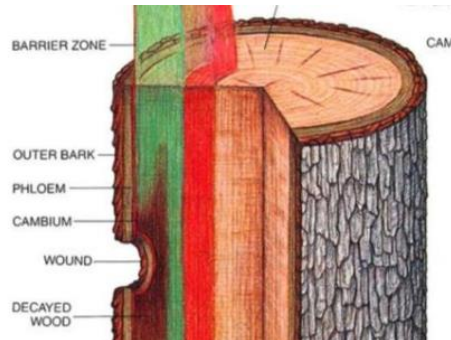
Let's revisit this slide from earlier in the presentation. As previously discussed, tree condition can affect the chemical composition of sap.

## Tree defense mechanisms

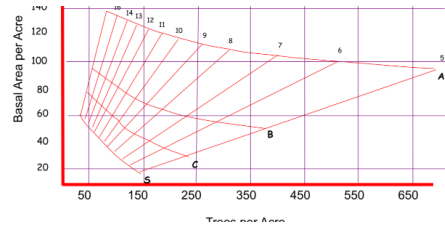
Trees respond to wounds and disease by “compartmentalizing”

- Wall off damaged or infected zone
- Phenolic compounds created to combat disease and decay

*Phenols include a range of compounds that can have an impact on flavor*



Of particular interest is the fact that trees have a complex physiological response to injuries and disease. Areas of infected or damaged wood are sealed off and flooded with a variety of compounds that inhibit damage proliferation. Some of those compounds, including a class of chemicals called phenols, can impact flavor. Although the exact role of these chemicals in maple flavor are not widely understood, they can have an influence on flavor.



## Sugarbush Management

A direct strategy of active sugarbush management is the best approach to maintaining tree health. Factors such as the stocking rate of trees, species diversity and the removal of unhealthy trees can easily be regulated to improve overall stand health and vigor. For more information on this topic, please refer to the sugarbush management webinar that is also available as a part of this webinar series.

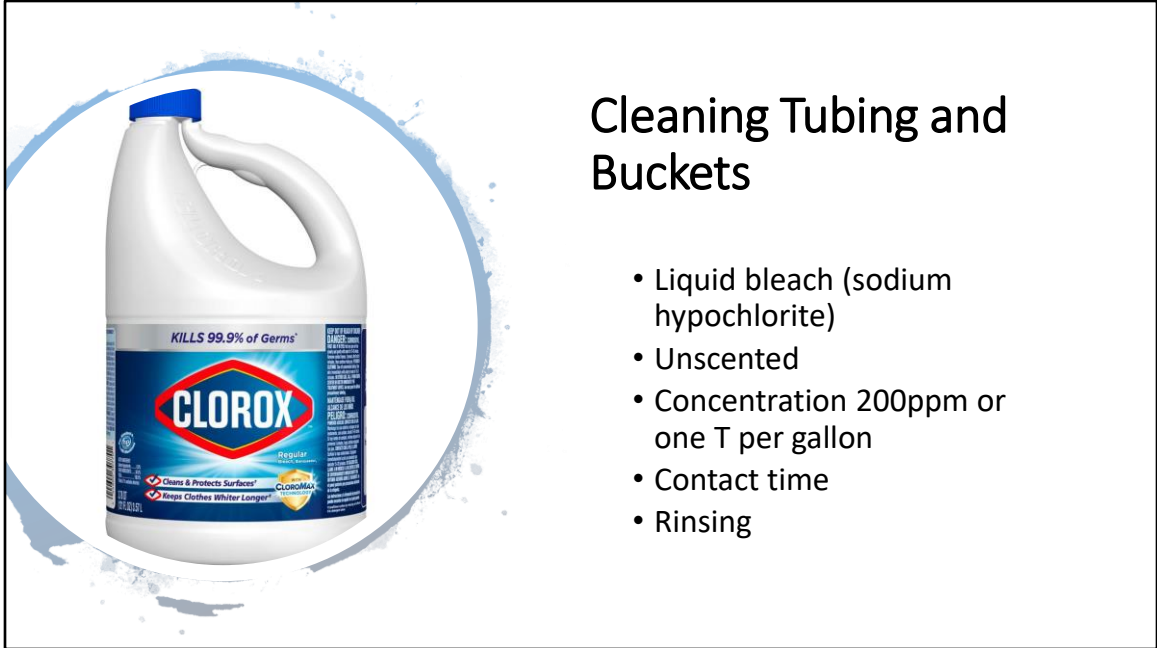


## Sap collection and handling

- Unclean tubing or buckets
- Incorrect slope and sagging lines
- Non-food grade containers and fittings

*Off-flavors in sap are concentrated in syrup!*

Sap sometimes spends a significant amount of time within the collection system. Therefore the conditions within the system can impact flavor quite a lot. Dirty tubing or buckets can quickly impart yeasty and moldy flavors. Sagging mainlines slow sap flow to the sugarhouse and can lead to more spoilage in the lines. Any component that is not food grade may also impart bad flavors to the sap. Off flavors are concentrated and amplified in syrup. Therefore it is important to maintain a pristine collection system.



## Cleaning Tubing and Buckets

- Liquid bleach (sodium hypochlorite)
- Unscented
- Concentration 200ppm or one T per gallon
- Contact time
- Rinsing

One common approach to cleaning buckets and mainlines is the use of a diluted liquid bleach solution. This can be effective when used properly. However, too little contact time or insufficient rinsing after cleaning can lead to negative results. We recommend a 1 tablespoon per gallon of water dilution rate coupled with 20 minutes of contact time. A thorough rinse with clean water is important. As a rule of thumb, the rinse should be about 3 times greater in volume than the sanitizing solution. That equates to a triple rinse for buckets and 3 gallons of rinse for every gallon of sanitizing solution in tubing systems.

## Contaminated Sap Filters

Off-flavors in sap filters are concentrated in syrup

- Musty and moldy
- Chemicals
- Fragrances
- Paper or cardboard

Another common point of failure is contaminated sap filters. Sap will quickly pick up off flavors from filters that are unclean or improperly maintained.

## Filtering Rules

DO

clean filters thoroughly, dry thoroughly, and store in a cloth bag in clean, dry, airy, storage.

DO boil

boil new filters in clean water and air dry before the first use

DO use

use the "SNIFF" test to provide an added check for your filters

At minimum, it is critical to follow these rules for sap filters. Clean them thoroughly in boiling water after use, then air dry them and store them in a container that is not airtight. New filters should be cleaned before their first use. Always smell filters before using. If they have a bad odor, rewash them or throw them away.



## Filtering Rules

DO NOT

store filters in moth balls, cedar closets, airtight containers, or near scented materials.

DO NOT

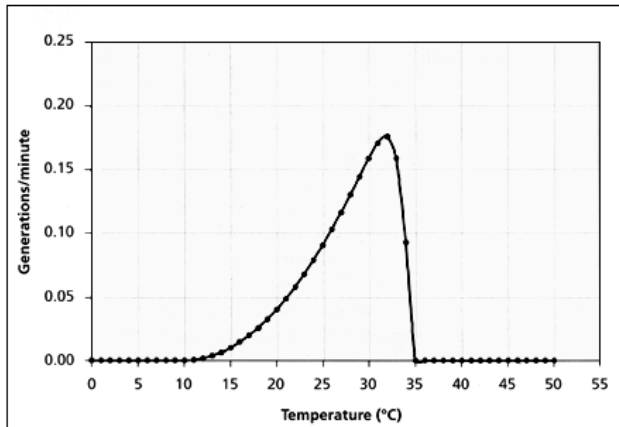
use chlorine bleach to clean filters

DO NOT

use scented cleansers, fabric softeners, and dryer sheets

Filters absorb chemicals and fragrances, then impart those flavors into sap. Therefore the use of mothballs, chlorine bleach or scented cleansers is discouraged.

## Spoilage



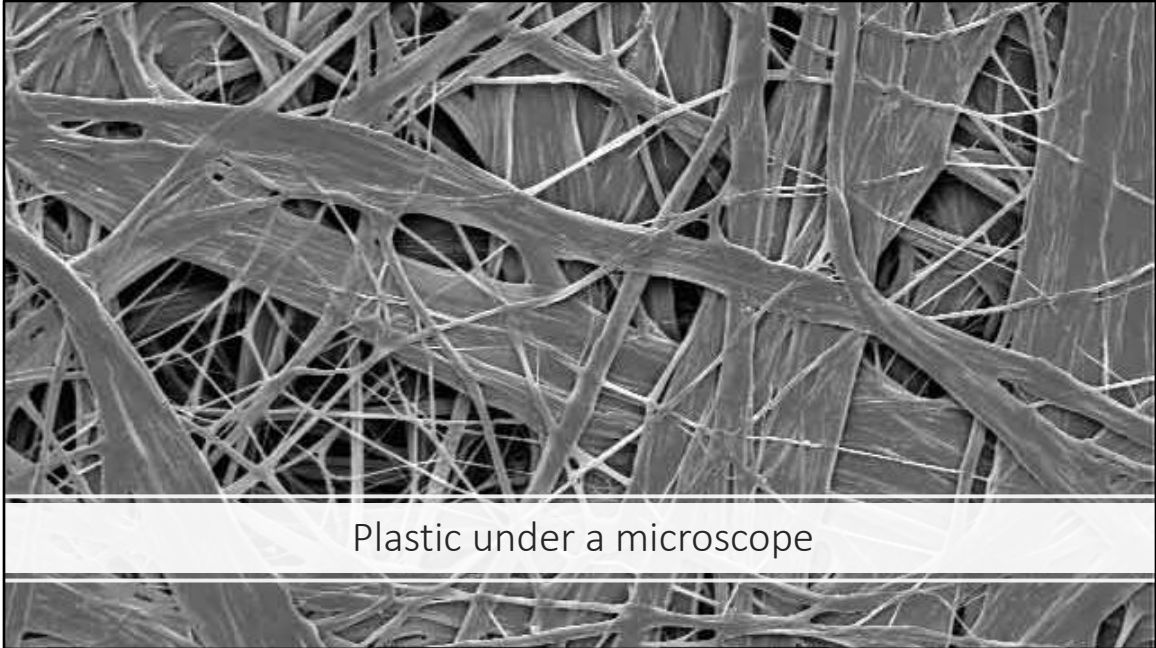
Microbes grow faster in warm sap

➤ Warm temp + time = spoilage

Another point of failure is sap storage. Under the wrong conditions sap will spoil and take on a sour flavor. Syrup made from sour sap is also sour. Spoilage is more common later in the season or on warm days. This chart shows that spoilage microbes quickly become active after the temperature reaches around 40 degrees F. Sap held too long at high temperatures will become cloudy and sour.



Dirty tanks can also impart bad flavor. It is important to maintain tank cleanliness. Open top stainless steel tanks can easily be scrubbed with a long handled brush and rinsed with clean water every time they are empty throughout the season.



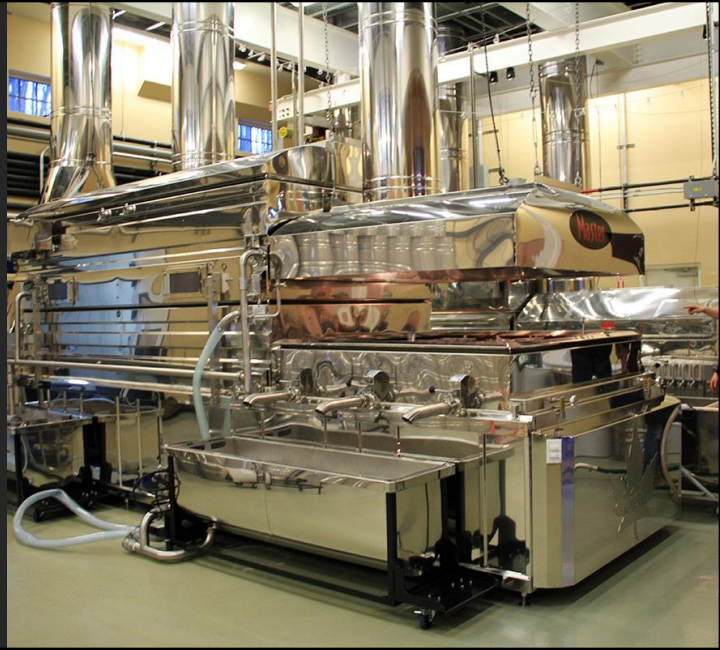
Plastic tanks can be somewhat harder to maintain. They are typically not open topped in shape and therefore it is harder to reach all surfaces with a scrub brush. Also, the microscopic structure of plastic makes it prone to holding off-flavors. Even non-porous plastics have little microscopic nooks and crannies for off flavor compounds to hide in. Once spoiled sap sits in a plastic container for a long period of time, it is hard to make it smell clean again.

Non-Food grade  
paints  
Imparts oily,  
fatty flavor and  
appearance to syrup



Although this is a less common practice now, in the past, the inside of old storage tanks was sometimes painted with food grade paint. However, if non-food grade paint is used, it can leach dangerous petrochemicals into the sap. Painted tanks have no place in a modern sugaring operation.

## In the Evaporator



There are also points of failure in the evaporation process.

## Scorch

- Inattentive boiling
  - Too thin
  - Stuck floats
  - Foam
- Niter buildup
- Poor seal between pans or pan and arch



Scorch is one of the most common defects. This happens when the temperature gets too high in some part of the evaporator and the sugars in the sap burn. Just a little scorching has a big flavor impact and makes the whole batch of syrup smell like smoke. Therefore it is important to carefully maintain your evaporator and be attentive while boiling.

## Defoamer

- Use Sparingly!!!
- Use fresh
- Avoid using foods or vegetable oils



Defoaming is important. Without defoamer, syrup can quickly bubble over and create a dangerous mess. However, when too much defoamer is used it can find its way into finished syrup. It is detectable as an oily flavor that leaves the feeling of waxiness on the teeth. Use defoamer sparingly!





## Exposure

- Smoke
- Clean air supply for bubblers and steam-aways

Maple syrup is a delicate flavor. When exposed to unclean air it quickly absorbs contaminants that show up in the flavor. Smoke is a common exposure agent, especially with homemade hobby rigs. Make sure smoke is properly vented away from your arch to avoid this problem. If possible, invest in a commercially made evaporator specifically designed to manage combustion and smoke exhaust.

# Syrup Handling

The way syrup is handled after boiling can also impact flavor.

## Filters

Syrup may acquire a flavor of defoamer from improperly maintained filters

Detergent flavor from improper washing or storage

Moldy flavor if not dried correctly

New filter flavor – boil before use

Syrup must be filtered in order to be compliant with grading standards. All of the rules that apply to sap filters also apply to syrup filters. Using a filter press rather than cloth filters will avoid some of these issues and filter sap more effectively.



## Canning Containers

- Clean
- New
- Food grade
- Temperature rated

The type of container used for bottling sap is also important. Not all containers are food grade. And some that are food grade, are not meant for the high temperatures of hot syrup. For example, mayonnaise jars melt slightly at 180 degrees F. So save those other containers for Pinterest projects!

Maple syrup must be hot packed at 180 degrees F to avoid spoilage

- Smaller containers may need pre-heating or hot water bath
- Tip on side to ensure sterilized lid



In order to prevent spoilage, syrup must be hot packed. This ensures that both the syrup and the container are sterile. 180 degrees is a temperature that quickly sterilizes maple containers and is an appropriate temperature for canning. Bottles should be tipped on their sides to ensure contact time with the lid.

## Things we can do to improve flavor

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Sometimes avoiding off flavors is not enough to achieve the flavor attributes you desire. Some syrups, especially in the lighter color grades can be bland or perhaps you would like stronger flavor for culinary uses. Fortunately, there are several strategies available to boost flavor.




One factor that can have a substantial impact on flavor development is dissolved oxygen.

Dissolved oxygen (DO) is the amount of oxygen molecules that are dissolved into a solution



Dissolved oxygen is exactly what it sounds like – It is oxygen molecules that dissolve into a solution, the same way sugar does. Just like other solutions, it can become saturated, or reach a point where no more oxygen will dissolve.



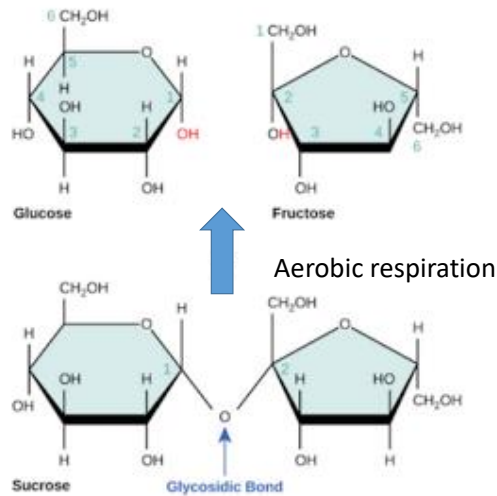


Where does it  
come from?

- Diffused into sap from the surrounding air
- Mixed in through churning and agitation

Oxygen can dissolve into sap through diffusion from the air or it can be mixed in through churning or agitation.

# Sugar interactions with microbes



In sap with sufficient levels of oxygen, microbes can perform aerobic respiration. As a part of this process, these microbes can break the bond in sucrose and create invert sugars.

**More dissolved oxygen**

=

**More aerobic microbial activity**

=

**More fructose**

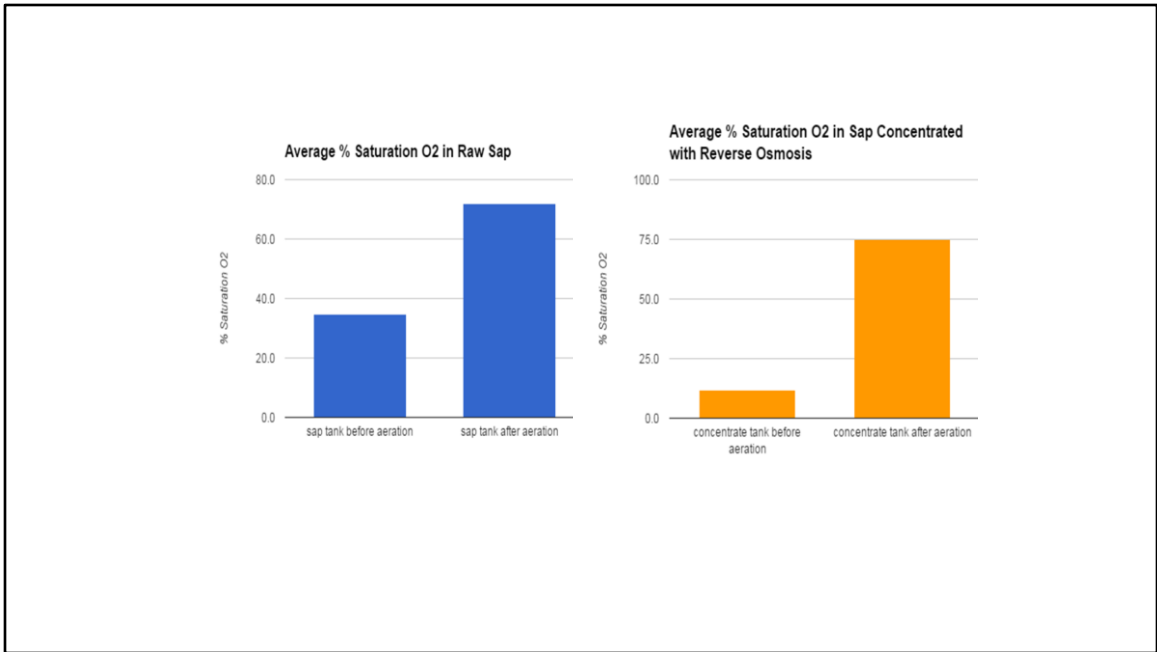
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**More caramelization**

=

**Darker syrup with stronger flavor**

As the amount of dissolved oxygen in the sap increases, so does the rate of invert sugar formation. Hence, more oxygen eventually leads to stronger flavored syrup through increased caramelization.



This is significant because dissolved oxygen levels are often very low in modern sap collection systems. Vacuum collection coupled with large tanks that have a low surface to volume ratio, create especially low oxygen conditions. Reverse osmosis units can also strip oxygen out of sap. In studies at Cornell we found that sap in our system average about 35% dissolved oxygen saturation which is too low for aerobic respiration. After reverse osmosis that level can plunge to 1 or 2 %



## Oxygenation strategies

Bubbling

Fountain or spray bar

Agitator

*See videos in course website*

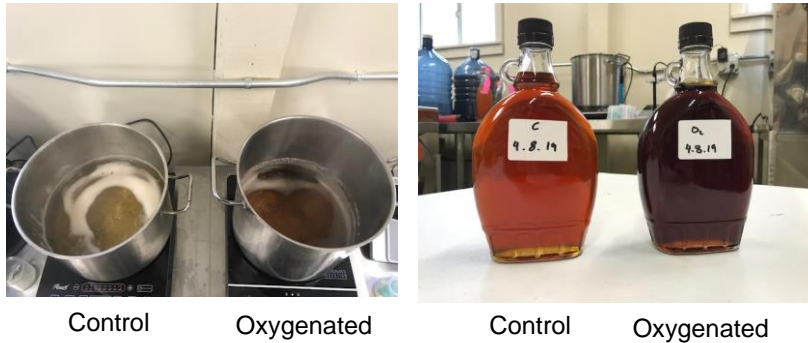
Fortunately, there are several easy ways to boost oxygen levels. These methods all involve increasing the amount of surface area exposed to the air which increases the rate at which it oxygen dissolves into solution. Please view the two videos linked on the webinar website to see these methods in action. In experiments at Cornell we were able to quickly increase oxygen levels to 80+% saturation in about 30 minutes of treatment.

## Sap Oxygenation



In this illustration the sap is being oxygenated by a bubbler powered by a rotary vane air compressor. One side effect of aeration is bubble and foam formation. It is harmless but is messy and can be skimmed off the surface.

## Late Season Sap Study



In an experiment at Cornell we tested increased dissolved oxygen as a potential countermeasure to improve the flavor of late season syrup. In our test sap was divided into two tanks and held overnight at approximately 45 degrees F. One tank had a bubbler that boosted the oxygen content to 100% saturation. The other tank sat undisturbed and by morning the dissolved oxygen level was below 30% saturation. As you can see in the pictures. The sap that was bubbled made much darker syrup. In taste tests the control sample tasted sour, but the oxygenated sample had strong flavor and was suitable as table grade syrup.

## Active Oxygen Management

***Flavor too light***            ***Add oxygen***

***Late season/ off flavors***            ***Add oxygen***

Generally speaking, what we are learning is that increasing dissolved oxygen levels is useful for boosting low flavored syrup and for improving the flavor of late season syrup. Further work is underway to determine ideal oxygen levels and treatment times at different storage temperatures and bacterial loads.





## Heat Induced Caramelization

Another strategy for boosting flavor is to induce more caramelization through higher temperature cooking. This must be done with care to avoid scorching. However, when it is done properly it can result in intense flavor.

## 3 Methods:



Dilute finished syrup and reboil to syrup density



Boil above standard density and adjust back to 66 brix with water



Pressure cook to higher temperature

There are 3 main methods for increasing caramelization. The first is to add water to finished syrup and reboiling it. It can be diluted to any brix, but the more water added, the longer the reboil time. A second method involves cooking the syrup to 250 degrees F then diluting back to 66 brix with water. The higher cook temperature leads to much greater caramelization. The last method utilizes a pressure cooker to achieve the same high temperature caramelization effect but without losing as much water because a pressure cooker is a sealed vessel. More detail on these last two methods is available in the document attached to the webinar website.



## Challenges to this approach:

- Sugar composition and color grade vary widely from batch to batch
  - The results of re-cooking or high temp cooking will also vary
- Potential for over-darkening or developing caramel flavors that are too strong
- What happens to volatile flavor compounds?

These methods all share certain challenges. First and foremost, the exact sugar and chemical composition of every syrup is unique. Therefore it is impossible to develop precise guidance for exact cook times and temperatures to create results that are replicable between batches. Another challenge is the potential for over-darkening and scorching. Lastly, some of the more subtle flavors in maple are created by volatile compounds that are gradually lost during high temperature cooking. Therefore, more intense flavor comes at the expense of a sophisticated flavor profile.

## Conclusions:

Flavor is the result of sap handling practices, syrup processing conditions and chemical reactions

Identify points of control for preventing off flavors

Employ strategies for maximizing flavor

To summarize, flavor is the result of a number of factors. By addressing potential points of failure, quality is protected. Furthermore, strategies exist for boosting flavor to make syrup valuable for a wider range of uses. Thank you for viewing this webinar. I hope you found the information useful. If you have questions, please contact the Cornell Maple Program at [www.cornellmaple.com](http://www.cornellmaple.com)