# Maple sugaring and the science of sap flow



# What makes this possible?







The Science of Sap Flow and Maple Syrup Production

#### **Basic physiology of maple sugaring**

Maple syrup production possible - 2 unique properties of maple trees:

Ability to generate positive pressure in **xylem** sap (Allows sap to flow)

The high sugar concentration in spring **xylem** sap



#### Basic physiology of maple sugaring

Must also have the right weather conditions for sap to flow! Freezing nights followed by warm days



#### Phloem

Photosynthate (sugar) from source to sink

Xylem Water from soil to leaves (usually not sugars!)







Sugar maple cross section

#### The sap flow mechanism in maple:



# Freezing and thawing temperatures are required

#### Freezing causes liquid to expand



Why doesn't sap exude during a freeze and shrink during a thaw?

#### Sugar maple wood section







Ice crystal growth (frost) occurs inside the air-filled fibers as the branches freeze. The water is supplied by the sap in the vessels.

← Vessel with sap









Temperature and pressure in the spring in untapped trees

# But why does sap *flow* when we put a hole in the tree?







### Atmospheric pressure lower than inside the tree ~ sap flows out of the wound!

Figure by: Tim Wilmot

#### TreeMet – www.uvm.edu/~pmrc



# Maple syrup production





Photos by: Brian Stowe

# Trees are tapped with cordless drills and plastic spouts are most common





Photos by: PMRC





Photos by: PMRC

Network of 5/16" plastic tubing connects to larger 'mainlines'





# Sap flows from the network of mainlines into the sugarhouse







Many producers add vacuum to their tubing systems

Photo by: PMRC

## Adding vacuum



Figure by: Tim Wilmot

# Filtering

#### Solid material

Microorganisms After sap is removed from lines it is often filtered by UV light



Photo: Tim Wilmot

## Sap storage

# Sap is stored in large tanks for as short a time as possible



Photo by: PMRC

#### **Reverse osmosis**

Raw sap is ~2% sugar

RO concentrates sap (8-10%) without heating

Reduces: Evaporator fuel costs Boiling time



Photo by: PMRC

#### **Reverse Osmosis**



# Boiling

Evaporators Many types

Fuel types Wood Oil



Photo by: George Cook

## **Evaporator basic anatomy**



Back Pan

### **Evaporators**

#### Back pan Where sap comes in

Deep flues facilitate heat transfer

From 2-~8%



Photo by: Tim Wilmot

### **Evaporators**

#### Front pan Where syrup is made Several compartments From 8 to 65%



Photo by: Tim Wilmot

# Boiling



Syrup Draw-off

# Finishing

Get to appropriate density before packing

> If too high: Crystallization

If too low: Fermentation, mold, bacteria...



Photos by: Tim Wilmot

## **Filtering and packing**

#### Syrup must be filtered to remove solids and make a clear product



Photo by: Mark Isselhardt

# Filtering and packing

# Filtered syrup is hot-packed into drums or smaller containers







Photos by: PMRC

# Grading

Syrup is graded on four criteria: Color Flavor Density Clarity



Photo by: Mark Isselhardt

Color is primary determinant, but all syrup must meet the other standards, too

# Grading

Different grading systems VT US Canada



Photo by: Mark Isselhardt

Different names, but similar standards

Only pure VT syrup can be labeled as VT syrup with a VT grade

#### **Vermont Maple Syrup Grades**

#### ~ Vermont Fancy ~

Light amber color and a delicate maple bouquet. A mild maple flavor, excellent on foods such as ice cream which permit its subtle flavor to be appreciated.



#### ~ Grade A Medium Amber ~

Medium amber color and a pronounced maple bouquet. Characteristic maple flavor, that is popular for table and all around use. Great on pancakes and french toast.

#### ~ Vermont Grade B ~

The strongest and darkest grade of maple syrup. Primarily used for cooking and also popular for the table. Makes a great substitute for other sugars in baking.

#### ~ Grade A Dark Amber ~

Dark amber color and a robust maple bouquet. This hearty maple flavor is very popular for table and all around use. Is often used to add flavor when cooking.



# **Frequently asked questions**

#### **Does tapping harm the trees?**

#### Which grade is the best?

Which grade is the sweetest or thickest?

#### **Proctor Maple Research Center**



Photo by: Mike Vayda

#### **Proctor Maple Research Center**

#### Maple research conducted at UVM since 1890s PMRC established in 1946





Photos: PMRC