The Science Behind Maple Syrup Production

Posted on March 1, 2020 Leave a Comment

As winter turns to spring, syrup producers turn their eye to the weather forecast. They are in search of the perfect conditions to begin tapping sugar maple trees for sap. Have you ever wondered how sap from a maple tree is turned into a delicious topping for pancakes and waffles?

As winter transitions to spring, the perfect conditions arise for collecting sap from sugar maple trees. (Photo credit: James Pintar/Shutterstock)

Choosing Which Trees to Tap

The sugar maple tree (*Acer saccharum*) is the best choice for producing maple syrup. Compared to other trees, it yields the highest volume and concentration of sweet sap. Sugar maples grow best in fertile soil that is moist and well-drained. The trees are extremely shade tolerant and will grow slowly in the understory for many years. However, when given plenty of sunlight, they grow rapidly in many cases 0.5-inch or more in diameter per year. Though commonly associated with northern climates, in the United States sugar maples also grow in the Midwest and portions of the south, including parts of Kentucky, Tennessee, and northern Georgia.

While sugar maples have the highest sugar content, some syrup producers also tap red maples. Other trees that produce sap suitable for syrup production include walnuts and birches, although the flavor of the syrup is distinctively different from that produced by sugar maple trees.

The Tapping Process

Native Americans tapped maple trees long before the arrival of European settlers. Early methods included slashing the tree, then collecting the sap in a birch-bark container. A fire was built to heat rocks, which then were dropped into hollowed-out logs full of sap. The heat from the rocks slowly transferred to the sap, evaporating the water. Early settlers transformed the process with the use of metal drill bits, buckets, and evaporating pans. These innovations helped to turn syrup into a thriving industry in the late 1800s.

Long before the introduction of low-cost sweeteners such as high fructose corn syrup, maple syrup was widely used in the United States. In 1860, 6,613,000 gallons of it was produced. Given the U.S. population at the time, this averages to about 27 ounces of syrup consumed per person per year. Today, the amount of pure maple syrup each American consumes per year is just under 3 ounces. However, as interest in whole foods and natural ingredients increases, so too is the popularity of maple syrup. In fact, market research indicates that maple syrup production is one of the fastest growing industries in the United States, with 2013 being a banner year as more syrup was produced in the U.S. than any other year since 1945. Along with increased domestic interest, international markets are also showing increased demand. For example, with the help of a direct marketing campaign, between 2000 and 2005, demand for Canadian maple syrup grew by 252 percent in Japan.

Sugar maple trees are tapped in the late winter/early spring when daytime temperatures rise above freezing and nighttime temperature fall below freezing. Sap continues to flow for four to six weeks, or until the daily freeze/thaw cycle ends or buds burst and leaves begin to develop on the trees.

The classic method to collect sap involves drilling a hole into the tree, hammering a metal spout into it, and hanging a bucket directly underneath to collect the sap. Sap flows most rapidly after sunrise, as the temperature increases. In general, approximately 60 percent of the sap flow occurs by noon, decreasing steadily as temperatures typically fall as night approaches. Research also indicates that the amount of sap that flows during the daytime is dependent on the previous nights temperature.

Commercial syrup makers collect sap with the use of tubing and vacuum pump systems. The use of vacuum pumps precludes the need for freeze/thaw cycles as the lower pressure of the tubing system causes the sap to flow automatically from areas of higher pressure in the tree to areas of lower pressure near the spout and tubing.

Turning Sap to Syrup

Approximately 40 gallons of sap are needed to make one gallon of finished syrup. After being collected, the excess water in the sap must be evaporated off to produce a syrup with a 66-67 percent sugar content. As the water evaporates, syrup makers use a hydrometer to measure the syrups specific gravity. Legally, the syrup must contain 66.7 percent sugar content or have a specific gravity of 66.5 on the Brix scale or 36 on the Baum scale. Maple sap has little flavor of its own. The process of heating the sap transforms its active compounds into a variety of new complex and aromatic molecules.

Maple syrup is classified into different grades according to color and flavor. (Photo credit: saturated/iStockphoto.com)

Until recently, the maple syrup produced in the U.S. was classified into five different grades depending on light transmittance (color) of the syrup. Grade A syrups are lighter in color and thinner than Grade B syrups, which are darker and thicker. However, naming conventions were not standardized among syrup-producing states. For example, a syrup classified as Grade B in New Hampshire might be classified as Grade A Extra Dark Amber in Maine. In January 2015, the U.S. Department of Agriculture (USDA) announced a new maple syrup grading system to match guidelines set by the International Maple Syrup Institute (a group representing both U.S. and Canadian maple producers) to help clear up any confusion among consumers. The new classification system gets rid of Grade B altogether and introduces tasting notes into each name. The four new grades are: Grade A Golden and Delicate Taste, Grade A Amber and Rich Taste, Grade A Dark and Robust Taste, and Grade A Very Dark and Strong Taste.

The Future of Maple Syrup

Current research predicts that, as the climate warms, sugar maple trees will migrate northward, and trees better adapted to a warming climate will replace sugar maples in southern habitats. Because sap flow is temperature-dependent, climate change may also alter the timing of sap harvesting and overall sap yields. Research conducted by scientists at the University of Vermont's (UVM) Proctor Maple Research Center indicates that, compared to 50 years ago, the sugaring season now begins about a week earlier and ends 10 days ahead of schedule. One caveat with these data, however, is that the sugaring season used to be calendar-dependent in some areas, meaning that sap was not collected until a certain date, regardless of weather conditions. Scientists at Cornell University predict that, for syrup producers in the northeast, the sugaring season will shift into January by the end of the century.

While some models predict that oak and hickory trees will replace maples in northeastern forests, current evidence does not support this. There is evidence, however, that red maples will expand their range. This is not particularly troubling news as these trees are also a source of sweet sap, though it tends to have a higher water content.

Scientists are also exploring alternative methods of maple syrup production. For example, researchers at UVM recently developed a new high-yield maple syrup production technique. This technique uses plantations of closely-packed sugar maple saplings. The single- or multi-stemmed saplings have a portion, or all, of the crown removed and the cut stem is covered with a sealed plastic bag. With the use of vacuum pressure, sap flows out of the stump into a tube. Traditional sugar maple forest operations tend to yield about 40 gallons of maple syrup per acre. A plantation-style set-up, with approximately 6000 saplings, could potentially yield more than 400 gallons per acre. Not only could this new technique produce more maple syrup, but because it relies on vacuum pressure, it also removes the necessity of specific weather conditions to collect sap, an important aspect in the face of a changing climate.

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