Future Generations University

Research, Learning, Action for Inclusive & Sustainable Change Worldwide

Tapping Walnut Trees

Making Walnut Syrup for Fun or Profit

Figure 1 - Jordan Mongold at Mongold's Walnut Research Farm, courtesy of Nikki Bowman Mills of WV Living Magazine

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Introduction

Many people know that it is possible to tap maple trees, boil down the sap and make maple syrup. Maple syrup on pancakes is a classic American breakfast. However, few know that the same is true for other select species of trees. People in the sub-artic have, for years tapped, birch trees, both boiling the sap to make a sweet syrup and consuming it raw as a health drink. Walnut trees are on the list of select other species. Members of the Juglans genus, black walnut (*Juglans nigra*), white walnut or butternut (*J. cinere*a) and English walnut (*J. regia*) have all been tapped for syrup production.

Each species produces a sap and syrup with unique characteristics and flavor. Although at first thought one might imagine walnut syrup as having that harsh, slightly bitter flavor of the nut, and possibly the allergic reaction many people experience with nuts in general, it turns out that neither is the case. Walnut syrup has been described as having a smooth slightly earthy flavor, getting bolder as the sap flow season progresses. Concerning allergic reactions, research conducted at the Cincinnati Children's Hospital Medical Center (Lierl et.al., 2019) showed that walnut syrup does not contain the allergenic protein causing a reaction in individuals allergic to walnuts.

Walnut syrup is a specialty product, with a special taste, and it is developing a niche market of its own. With a retail price of $7/oz (Herby) it makes little monetary sense to want to slather it on pancakes. More often, walnut syrup is blended with other syrups, typically maple, or used in the manufacture of other products to add a unique flavor and increase the market price of those products.

Walnut syrup can be made commercially, but this requires a lot of walnut trees. Accordingly, there are a limited but growing number of commercial walnut syrup producers. It can be made for fun, as a backyard hobbyist, with as few as 5 walnut trees. As with maple syrup, many people start out as a hobbyist and grow as they "catch the sugaring bug" and find more trees.

A lot is known about tapping maple trees. The University of Vermont's Procter Maple Research Center has been learning and improving maple tapping practices for over 50 years. Much less is known about making walnut syrup; the earliest published study only dates back to 2006. This section of the primer references what is currently known about tapping walnut trees and making walnut syrup. As more studies are conducted on walnut syrup and more people start tapping walnut trees, more knowledge is gained about increasing sap production and processing efficiency. To connect to fellow walnut syrup makers and to add to the collective knowledge, check out the Black Walnut Syrup Makers Facebook page at https://www.facebook.com/groups/2965351326865418

Why Tap Walnut Trees?

Walnut trees have a larger, and different, range than does the sugar maple. Sugar maple is a northern tree, plentiful in New England, eastern Canada, and down the Appalachian Mountain chain at higher elevations and on cool, moist north slopes. Red maple (which can also be tapped) is widely distributed throughout the east. Walnut is not prevalent in the northeast, instead becoming common south of the maple-beech-birch forests of the north. As shown in **Error! Reference source not found.**, black walnut is common in the mid-Atlantic states and into the Midwest.

Figure 2 - Black walnut (Juglans nigra) native range (Williams).

Walnut is a fast-growing tree, and although commonly referred to as a bottom-land species, it also thrives higher on the slopes especially on abandoned farmland. As with acorns, the nuts are largely distributed and planted by forgetful squirrels who make off with the nuts, cache them, then can't remember where they put them. In West Virginia, it is common to find slope side patches of almost monocultural walnut trees on abandoned pasture lands with a heavy grass or brush groundcover. Walnut trees are also prevalent along fence rows, which makes them nicely lined up for running sap collection tubing.

Foresters often pose a slightly different question. They would ask "why on earth would someone ever drill a hole in a walnut tree?" That is a good question. Walnut is a high-value timber species. Future Generations University would never recommend tapping a high value veneer quality walnut log. However, not all walnut trees are high value veneer quality. If it is sawlog quality, and only the sapwood is drilled, then most—or all—of the tapholes will end up in the slab pile. There are also crooked trees, trees with heavy crowns and short bowls, perfect for tapping but without much timber value, trees along fence lines that might have nails or fence staples in them, or favorite trees one would never think of cutting down but might not mind tapping. One can also tap low on the tree – any cut tree leaves a stump – or tap a low hanging branch. Tapping walnut trees provides an intermediate income while waiting for the tree to mature. It can take 50 or more years to grow a walnut tree with a good sawlog. For those without that much patience, tapping could start at 10 years.

How to Tap Walnut Trees?

Maple tapping has informed practices of walnut and other alternative species of trees, however, walnut trees are a very different species, and researchers and practitioners are just starting to learn how to accommodate that difference when tapping.

Wood anatomists classify maple as a "diffuse porous" hardwood. In maple trees small vessels, commonly called pores, carry water and nutrients up the tree in the summer and carry sweet sap to the tap during the sugaring season. These vessels are diffused, or evenly distributed, throughout the tree's annual growth ring. Walnut trees, however, are classified as a "semi-ring porous" species. They have small, diffused pores like maple, but also large pores – as in true "ring porous" species such as oak and hickory – that are more prominent in the early annual growth or springwood Figure 3.

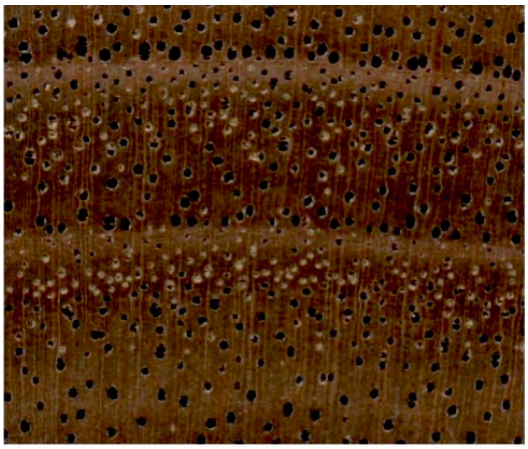

Figure 3 - Walnut heartwood showing vessel structure

Figure 4 - Walnut cookie: heartwood (brown) and sapwood (white)

As is visibly apparent when looking at the end of a cut walnut log, walnut trees have a large very dark heartwood area, see Figure 4. This heartwood is the valuable wood in the tree. The heartwood is surrounded with a small outer band of white sapwood. A walnut tree commonly has 11 – 13 annual rings of sapwood: when a new sapwood ring is formed, the innermost sapwood ring begins its conversion to heartwood. Heartwood is dead, whereas sapwood contains dead and live cells. The width of the sapwood layer is propositional to the growth rate of the tree. A fast-growing tree will have a thick sapwood band because each annual ring is thick. Similarly, a slow growing tree will have a relatively narrow sapwood band. This is important because the thickness of the sapwood has been found to be the best indicator of the amount of sap production (Naughton, 2006). Studies have found that on the average you can expect to get 2 – 3 gallons of sap/year from a walnut tree (Table 1).

Table 1- 2020 Walnut seasons sap production using a gravity bucket system comparing Stainless Steel walnut spouts to standard maple spouts (Rechlin et.al., 2020).

Farmer	**SS walnut spouts gal/tap**	**Maple spouts gal/tap**
#1 Christoph Herby	2.8	1.5
#2 Chip Matheny	3.2	1.5
#3 Elton Bowers	3.0	3.2
Average	3.0 gal/tap	2.1 gal/tap

In contrast, a young healthy maple tree can have mostly sapwood, and when tapped can produce over 10- gallons of sap per year.

Sap sweetness is measured in Brix, which is defined as the percent sugar in the sap. The amount of sap needed to make a gallon of syrup finished to 66 Brix, the legal lower limit for maple syrup, is determined through the application of Jones rule of 86 (86 divided by the brix of the sap = the number of gallons of sap needed to make a gallon of syrup.) In West Virginia, numerous studies have shown that walnut sap has been running from 1.5 to 1.0 Brix. Meaning, it takes anywhere from 57 to 86 gallons of walnut sap to make a gallon of walnut syrup.

Finally, maple and especially sugar maple, also called “hard maple” or “rock maple,” is a very hard wood. Walnut is comparatively soft. These anatomical differences from maple – vascular structure, thickness of the sapwood

layer, and hardness of the wood – impact how walnut trees are tapped, how much sap can be expected, and how to improve sap productivity.

Future Generations University has been working with walnut syrup producers and studying walnut sap flow since 2018. The tapping and syrup making recommendations that follow are based on that work. They also draw on other research and the accumulating knowledge of the walnut tapping community.

When to tap

Maple trees are tapped when there is the highest probability of getting the temperature swings, above freezing periods (days) followed by below freezing periods (nights), that initiate sap flow. That tends to be the waning days of winter and early spring, varying with latitude and elevation. Maple sap flows because of a pressure buildup in the trees during that period. The same holds true for walnut, with stem pressure initiating sap flow when tapped. Maple will build up stem pressures exceeding 20 pounds/sq. in. In a study conducted during the 2021 sap flow season it was found that walnut built up to approximately 5 pounds/sq. in. of pressure (Figure 5).

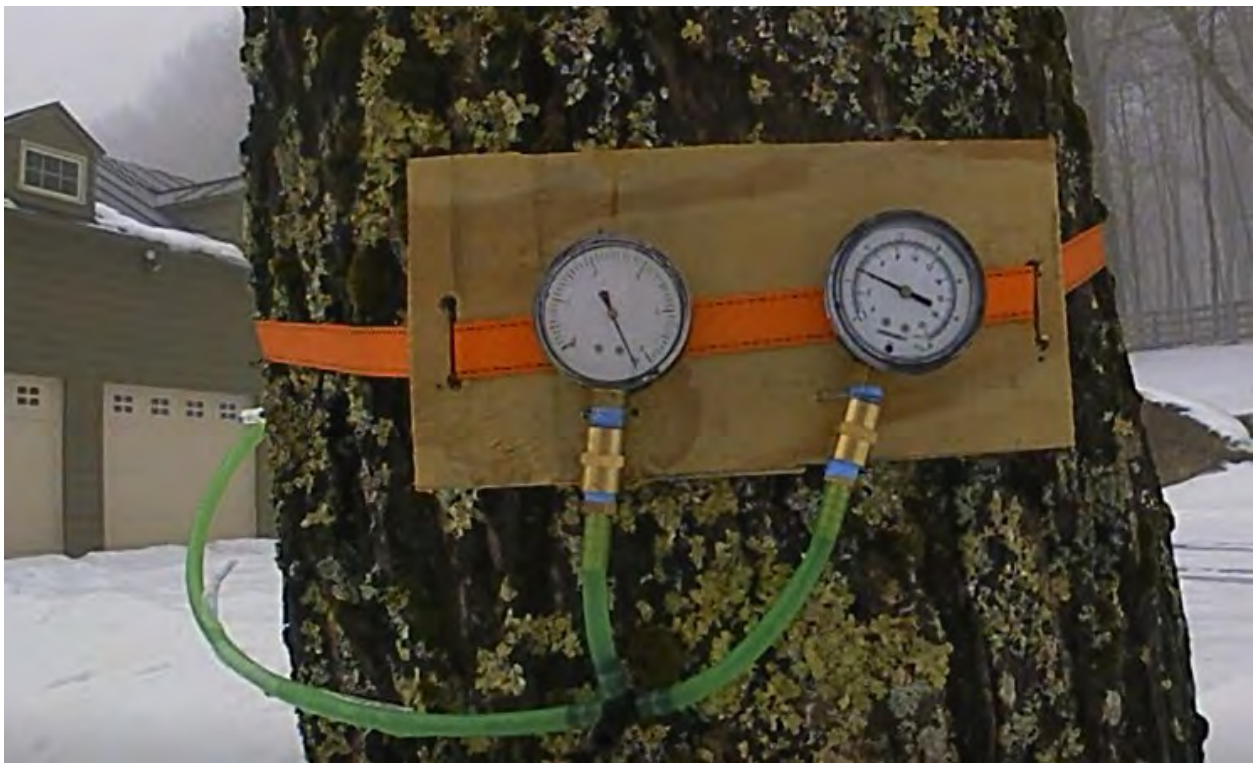

Figure 5 - Pressure gauges on a tapped walnut tree, the left, more sensitive gauge is pegged at 5 pounds and the right gauge reads 4 pounds.

To complicate matters, a research team working on xylem pressures in English walnut (*Juglans rigia*) found that walnut trees not only develop stem pressure, but also root pressure (Ewers, et.al., 2000). Root pressure is the mechanism responsible for sap flow in birch trees, where sap flows later in the spring, after the freeze/thaw period. They found walnut root pressure developing in the fall and in the spring, which leaves open the opportunity for walnut sap flow before and after the traditional maple and walnut tapping period. Future Generations University has documented late spring sap flow events, but they tend to be of short duration and when boiled down, yield a syrup that tastes different from that produced by runs from stem pressure (Herby, 2022). However, more work is needed before counting out an extended productive sap flow season. Individual producers have reported success in fall tapping.

Depth of the Taphole

Gary Naughton (2006) studied various factors that influence the amount of sap a walnut tree exudes when tapped. His study showed that the best predictor of sap flow was thickness of the sapwood. This differs from maple where the best predictor of sap flow is tree basal area (related to diameter) and proportion to crown size. In maple, larger diameter trees are predicted to yield more sap. However larger diameter trees are not necessarily faster growing trees, and sapwood layer thickness is related to tree growth. The trees the University has worked with tend to have 2-3 inches of sapwood. A walnut tree with a sapwood thickness of 3 inches would be growing close to 0.3 inches of radial growth or almost 2/3 inch of diameter growth per year. That is a fast-growing tree. It could be a fast-growing young tree or an older larger open grown tree on a rich site.

Standard maple tapping practice has been to drill a 1.5-inch-deep taphole, recent research is suggesting tapholes of 2-inches. In walnut, it is recommended to drill through the sapwood to the heartwood. There is no need to go any deeper, the heartwood is dead and yields absolutely no sap. To do that one must know the thickness of the sapwood of their trees. As a practical measure drill depth is being set at 2.5 inches for walnut trees. It is important to place the drill in a bark crevice. Otherwise, with the thick bark on a walnut tree, an inch of tap length could be used up before even reaching the wood. Reduce the tapping depth if dark brown heartwood shavings are frequently seen.

Spouts, Spiles or Taps (all names for the same thing)

The ideal spout for tapping walnut trees has yet to be developed. In Figure 6, you see a prototype stainless steel walnut spout. Using this spout and modified tapping guidelines, taps are averaging 3 gallons of sap each.

Figure 6 - prototype stainless steel (SS) walnut spout

Figure 7 - Compartmentalization of decay and healing over of taphole after one year.

Figure 6 shows a 7/16-inch spout with a 3/4-inch longer barrel than the standard maple spouts. In recent years Maple syrup producers have switched from 7/16-inch diameter spouts to smaller 5/16-inch diameter spouts called a health spout or a tree saver spout. The smaller diameter spout causes less internal damage to the tree and heals over more quickly. Sustainable tapping guidelines have been developed with the assumption that the producer is using the smaller spout. Future Generations University has a study in progress to develop sustainable walnut tapping guidelines. Initial results, illustrated by Figure 7, indicate that the compartmentalization of decay in walnut results in much less dead wood than in maple, with the taphole sealing over faster due to the faster growth rate of the tree. This may justify the use of the larger diameter spouts

As shown in Table 1, the prototype 7/16-inch diameter walnut spouts along with revised tapping guidelines led to almost 50% more sap. The problem for commercial producers is that these stainless-steel spouts are expensive and heavy for use in the field.

Vacuum

In maple trees the application of vacuum to a tubing system increases sap yields by 5-7 percent per inch of vacuum applied. Research conducted during the 2020 and 2021 sap flow seasons on 20 trees showed that the application of only 8 inches of vacuum doubled walnut sap flow (Figure 8) in walnut trees. This again appeared to be the case where sap was measured at a commercial walnut syrup producer with 500 plus trees on tap (Table 2). Here sap flow was greatly increased once the vacuum pumps were installed. It should be noted that Table 2 represents field observations, where many conditions could have influences sap flow, whereas Figure 8 represents a controlled study. Either way, it seems as if vacuum works to increase sap flow.

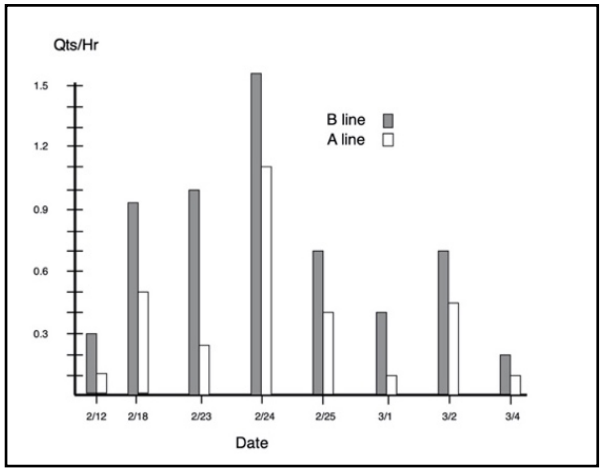

Figure 8 - Controlled study of walnut sap flow Line A – without vacuum, Line B- with vacuum (Rechlin, 2021).

Vacuum can be obtained through a system that uses a vacuum pump and releaser, traditionally using 5/16-inch diameter tubing. Vacuum can also be achieved through a "natural vacuum" system, that relies on elevation change from tree to collection tank, and a tube full of sap to pull the sap out of the tree. The latter is generally achieved in a narrower 3/16-inch tubing system. Some producers combine elements of both, creating a hybrid vacuum system. In a 2021 study, using paired spouts on 20 walnut trees, it was found that when using artificial vacuum 5/16-inch tubing produced 7% more sap than 3/16-inch tubing (FGU, 2021).

Table 2 - 2022 season sap collection data from walnut syrup producer Gary Mongold's farm

Date	Gal sap	Notes
2/3	110	
2/4	30	
2/8	20	
2/9	80	
2/10	75	
2/11	25	
2/16	100	Vacuum pump on
2/16	100	
2/17	100	
2/20	170	
2/21	150	

However, that leaves the question of whether using "natural vacuum" on 3/16-inch tubing for the collection and augmentation of walnut sap flow is useful. During the 2018 and 2019 sap flow seasons, natural vacuum systems

were tried, with plenty of slope, and were not able to develop over 5 inches of vacuum, whereas in maple you would expect to get over 20 inches of vacuum. During that time, it was noticed that walnut sap has a much higher percentage of gas bubbles in the sap lines compared to maple. Many factors influence the amount of gas bubbles in the sap lines, but in maple the line is primarily full of sap whereas in walnut the sap line is primarily full of gas. It has been the working hypothesis that the excessive gases in the sap are due to the presence of the large pores in the semi-ring porous anatomical structure of the wood (Rechlin, et. al, 2019) However, there is another possibility, and that relates to a specific problem with tapping walnut trees.

The Walnut Tapping Problem

Maple, being a hard wood, holds spouts properly tapped into the tree tightly. It is unusual to have air leaks on more than 1% of your spouts. Walnut, however, is different. It is a softer wood with thick bark. Over four years of research, there have been consistent problems with walnut spouts leaking. It's not that they leak sap, but that the spouts do not seal well, causing an air leak in what is a supposedly tight system. Those initially tight spouts that developed vacuum leaks, when tapped in further, seal well for a while. This is a serious problem for walnut syrup producers. It is impossible to hold a tight vacuum system with leaky spouts. To maintain acceptable levels of vacuum, producers need to spend an inordinate amount of time leak checking their system. Some have noted that by the end of the season some of their spouts are driven in all the way to the back of the taphole. The further a spout is driven into the taphole the more of the vessels delivering the sap are sealed off, decreasing sap flow.

After initially surmising that the problem was due to sap freezing and backing the spouts out of the taphole, an occurrence known to maple tappers, researchers now feel that the issue is the wood surrounding the taphole drying out and shrinking as the season progresses.

At this time the only spouts available have been designed for maple. The present recommendation is to use a maple spout with as much taper as possible. A more tapered spout should seal better and be able to be re-sealed without being driven as far into the taphole as a spout with less taper.

How to Make Walnut Syrup

Walnut sap boils more-or-less like maple sap. It starts at 1 to 1.5 Brix, and finished syrup is achieved at 66 Brix. Going from 1% sugar takes a lot of boiling, meaning a lot of time at the evaporator and a lot of energy to sustain the rapid boil needed to get the job done.

Maple syrup producers have reduced the boiling time needed to make syrup by first concentrating the raw sap in a reverse osmosis machine (RO) consisting of a semi-permeable membrane and a pump. Walnut syrup producers have not been able to use an RO because of the presence of what is presumed to be pectin in the sap.

Pectin

Pectin is a long chain, high molecular weight, polysaccharide (Figure 9). The problem is that it gums up the pores on the RO's semipermeable membrane, and when trying to filter the final product, it gums up the filter. If the pectin isn't removed, valuable walnut syrup can turn into walnut jelly, which of yet has no established market.

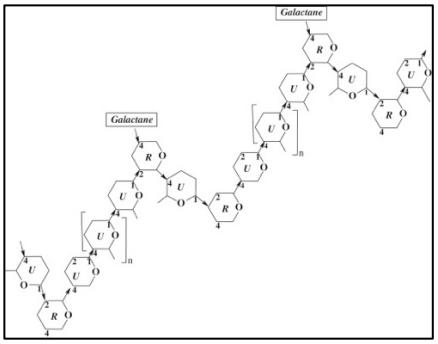

Figure 9 – Pectin molecular structure

In research conducted by Future Generations University in conjunction with Marshall University and West Virginia State University, it was found that this substance could be spun out of walnut sap. A 2 mL sample spun in a lab centrifuge at 14,500xg for 5 minutes and produced a visible pellet of a translucent gel like substance that is presumed to be pectin (Odell, 2021). Further work with a larger centrifuge spinning at 4,700xg for 6 minutes produced a correspondingly larger pellet. Researchers are in the process of analyzing a composite sample to confirm the presence of pectin. Both these centrifuges were batch processors, spinning a set volume of sample for a defined time.

In the meantime, field tests were conducted with a walnut syrup producer using an off-the-shelf continuous feed "Extreme Raw Power" centrifuge designed for clarifying waste oil and used to remove algae cells from pond water. This centrifuge spun at 2,800xg, and was set to process 1 gallon of sap/minute.

The waste port from the centrifuge drained off a milky substance that was presumed to contain some, but not all, of the pectin. The final product still contained a substantial jelling agent that had to be filtered out.

The spun sap was then run through a Next Generation single post RO twice and boiled to 66 Brix. Each trial was boiled immediately after concentrating with the RO (Table 3). Looking at the totals, the 300 gallons of raw sap would have taken 16 hours to evaporate using a 2x4 Next Generation propane fired evaporator with an evaporation rate of 18.6 gallons/hour. Instead, after centrifuging and concentrating to 75 gallons, it only took 4 hours to make the syrup. The fuel cost for the season was $42/gallon of syrup produced. Boiling 300 gallons of 1.3 Brix sap would have yielded 4.5 gallons of syrup (Jones rule of 86). Fuel cost for those 4.5 gallons would be $189. Instead, by concentrating first and only having to boil 75 gallons, the producer used $47.25 worth of propane, or $10.50/gallon of syrup produced.

Table 3 – Walnut sap centrifuged and concentrated with an RO

Date	Centrifuged sap (gal)	Concentrated to (gal)	Final concentration Brix
2/21 +2/22	150	28	4.0
2/23	40	6	3.7
2/27	50	22	4.0
3/1	60	19	5.0
	300 Total	**75**	**4.2 average**

Much of the research cited in this primer, especially work related to tapping walnut, is based on preliminary studies and observations. A sap flow season lasts approximately 6 weeks, and it takes multiple sap flow seasons to substantiate results. Future Generations University and others are committed to continuing this work. There are now three walnut syrup producers with over 500 taps each in West Virginia and Virginia. There is an opportunity to augment the vibrant maple syrup industry in Appalachia with a growing walnut syrup producing industry.

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