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Making syrup from black walnut sap

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Experimental tapping of black walnut (*Juglans nigra* L.) trees has shown that there is a substantial amount of sap flow in young black walnut trees and that it can be tapped and processed for the making of sugar syrup. It also shows the importance of a wide sapwood ring in obtaining a good yield of sap. Wind and temperature fluctuations appear to be related to daily sap production. Tree diameter, position in the stand, degree of openness of the crown, and some weather conditions were not reliable in predicting high-yield trees in this study, and sap sugar variation was too narrow to correlate to any other factors. Qualified taste tests indicate that the commercial Log Cabin ® product was preferred over both the walnut and the sugar maple syrups.

Keywords: Black walnut, syrup, collection.

INTRODUCTION

Native Americans enriched their diet of wild game, nuts, and berries with the sugary products from the native maples (*Acer* spp.) in eastern Canada and the United States. They made a crude, dark sugar from the sap of maple trees. They cut a slanting gash in the trunk, put a chip of wood in the bark below the gash, and collected the sap from these wounds in buckets made of birch bark. Hollowed-out basswood logs filled with sap were used to boil off the water using hot stones (Chapeskie 1997). As Europeans settled the land they also tapped the maple trees eventually improving on the methods of collection. They bored holes into the trees and used wooden spiles to collect the sap. Today, the 'maple' syrup enjoyed as topping for our flapjacks is made mostly from the sap of sugar maple; however any other maples can be used.Various reports (Ganns et al 1978, Maher 2004, and Koelling and Heiligmann 1996) have suggested that sap from other hardwoods could also be used including black walnut. No commercial tapping of black walnut trees to collect sap and produce syrup is known. The purpose of this paper is to present preliminary information on the production of walnut sap and describe sensory characteristics of walnut syrup.

MATERIALS AND METHODS / BACKGROUND

These were non-funded preliminary research trials done by volunteers as a beginning point to validate some parameters for more classic research. Twenty black walnut trees were tapped in late winter of 2003 and again in 2004 (Table 1). The sap was collected for five weeks and four weeks, respectively. The trees were selected from those due to be cut as part of a silvicultural thinning in a 25-year old plantation at the Tuttle Creek Research Field of Kansas State University near Manhattan, Kansas. The plantation was at 3.6m x 3.6m spacing. Although the maple syrup industry recommends that trees should be in dominant

Table 1: Individual tree characteristics. Means followed by the same letters are not significantly different at the 1% level.

Tree #	Dbh (cm)	Sap (ml)		Sugar (%)		Sapwood (mm)
		2003	2004	2003	2004	2003
1	32.8	4040cd	2550b	2.17	2.00	34
2	34.3	1935cd	1960b	2.00	2.05	27
3	33.0	3425cd	4350ab	2.04	2.05	34
4	26.9	13210a	7910a	2.46	2.05	31
5	26.4	8580b	4850ab	2.17	2.12	27
6	25.4	2355cd	2730b	2.17	2.05	19
7	33.5	8840b	3385b	2.09	2.05	28
8	28.7	1660de	1510b	1.95	2.11	26
9	31.0	3340cd	1970b	1.92	2.09	23
10	24.9	4605c	1300b	2.12	2.00	29
11	27.9	3630cd	2660b	2.27	2.04	34
12	30.2	2300cd	1410b	2.10	2.11	20
13	29.2	2155f	1230b	1.86	2.02	31
14	23.1	490f	0	2.07	0	12
15	34.3	450f	1380b	2.00	1.92	20
16	33.8	430f	3790ab	2.00	1.94	20
17	31.5	910ef	1290b	2.00	2.05	18
18	28.4	1170ef	870b	1.89	2.16	20
19	24.9	1230c	600	2.10	2.12	17
20	31.2	1790de	1010b	2.05	2.02	26
Mean	28.1	3327	2369	2.08	2.05	24.8

or high co-dominant crown position and have a comparatively fully developed crown, only poorly formed trees slated for removal were tapped in this study. They were generally healthy and their diameters were representative of the stand — ranging from 23.1 to 34.3 centimeters dbh (diameter breast high), with a mean of 28.1 centimeters. Previous experience with walnut has shown it to be a species that will frequently "bleed" sap profusely when live branches are pruned during mid- to late winter. This fact, together with a noticeable sweet taste to the sap at that time of year, led to the idea for the experimental making of walnut syrup reported here.

Weather observations

Generalized information from the maple syrup industry (Chapeskie 1977) suggests that sap runs will start when trees begin to emerge from winter dormancy as daytime temperatures approach 5-10 degrees C and fall below freezing overnight. During the first 10 days of January 2003 the daily maximum temperature at the Tuttle Creek Lake reporting station (2.5 kilometers from the plantation site) ranged from 2 to 24 degrees C, with six of these days over 10 degrees; and the minimum temperatures ranged from -9 to +2 degrees, with nine of these below -2 degrees. In 2004, the daily maximum temperature ranged from +18 to -13 degrees; and the minimum temperatures ranged from -24 to + 4. After the sap collection season was over, daily maximum/ minimum temperature data for the collection period were obtained from the Climatological Archives at Kansas State University as recorded at the nearest (Tuttle Creek) weather observation station. The Manhattan airport weather station, located 13km to the SW, provided wind, relative humidity and air pressure data for analysis.

Trial taps

Two trees were tapped on January 1, 2003 to determine if the sap run had started. The sap flowed freely for two days before the maximum temperatures again dropped below freezing. The 20 test trees were tapped and ready to start sap collection on February 8th, and the first sap production for the study was on February 10th in 2003 and January 24th in 2004.

Tapping procedure

All trees were tapped at 90 cm above the ground and on the east side of the tree. A carpenter's brace with a 9/16 in. (16+mm) bit was used to drill the holes. The holes were slanted slightly upward (about 5 degrees) to enhance natural out-flow of sap, and they were drilled deep enough to fully penetrate the sapwood and until the drill shavings turned dark brown indicating that the hole had entered the heartwood of the tree. The start point of the hole was placed on a bark ridge to maximize the depth of the tap and facilitate holding the spile in place.

Spiles

Polyvinyl double-male hose splicing inserts were used for spiles because they were available at local hardware stores and at a low cost (about 60 cents each). They were 75 mm in overall length with 13 mm inside diameter and 16 mm outside diameter and had friction flanges on the outside that provided a snug fit in the tap holes. The spiles were lightly tapped into the holes with a mallet, only far enough to provide a snug fit. Because the sapwood thickness was less than 20 mm in some cases, it was reasoned that driving the spiles in too far would seal off the exposed sapwood and retard sap flow.

Containers

New plastic milk jugs were used as the primary collectors. A small hole was cut at the top of the handle and the spile was inserted into this hole. The caps were left on the jugs to prevent unnecessary contamination of the sap by foreign material. The sap was clearly visible through the side of the jug and it was possible (with a little practice) to collect the sap by removing the cap and swiveling the jug.

Collection

During the first two weeks of the test in 2003 the trees were checked daily between 3:00 p.m. and 4:00 p.m. As the season progressed, and the effects of temperature fluctuation became familiar, there were some cold days that neither inspection nor collection were made. Sap was collected from each tree separately for transport to the lab, where it was measured with a graduated cylinder to the nearest 5 milliliters for volume. In 2003 a standard brewer's hydrometer (Balling scale) was used and in 2004 a refractometer was used to estimate the sugar content of the fresh sap. Each day's production was recorded separately for each tree. Then the sap was mixed together for refrigerated storage until processing.

Processing

In 2003, when 12 to 15 liters of sap had been accumulated in refrigerated storage it was partially boiled down to about 25% of the original volume to save on storage space. A 1500 watt electric hot plate and a 2 liter cast-iron saucepan were used for this step. In order to pre-heat the refrigerated sap and thereby reduce cooking time, a flat 3 liter aluminum pan was set on top of the space heater in the laboratory; this would take the refrigerated sap from 2 degrees up to about 30 degrees Celsius before it was added to the saucepan for cooking. Cooking was a slow process and would only evaporate away about 3 liters per hour on the highest hot plate setting. The partially finished sap had a light amber color when taken from the heat. At this point it was immediately strained through a cotton cloth to remove impurities. In most cases, the sap was strained at least 3 times in the process before it was finished syrup. At the end of each boiling session the sap was again stored in more concentrated form in the refrigerator.

The brewer's hydrometer did not register sugar content past 30% on the Balling scale, but we needed syrup with sugar content equal to commercial maple syrup. We resolved this by testing the density of pure maple syrup with a hydrometer. The hydrometer was then marked at the floating point at 22 degrees Celsius; later testing of the "done-ness" of the walnut syrup was with the same instrument and at the same temperature, and a close

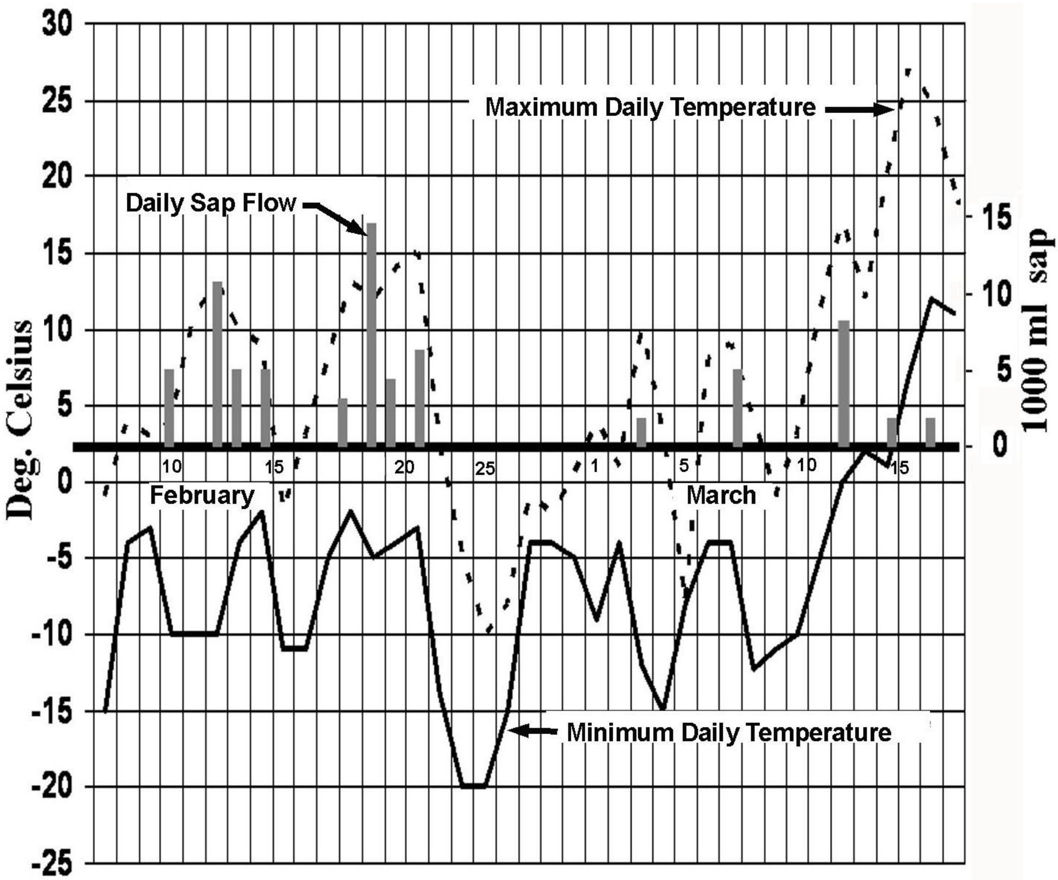

Figure 1. Daily sap flow and maximum-minimum temperatures during the 2003 collection season.

approximation of the density of the proper density for our syrup was determined. This finished walnut syrup was dark coffee-brown in color, was very sweet to the taste, and had no hint of any typical "walnut flavor".

In 2004 the sap was taken directly to the KSU Food Technology Lab where a commercial steam kettle unit was used for processing. For the final processing of the 2004 syrup, a commercial sugar refractometer was used in the laboratory for determining the finishing point of the syrup.

Analyses

Statistical analyses of the tree size, sap yield, % sugar, sapwood thickness, stand position, and weather data were run with Spearman's Rank Order Correlation. Individual tree and collection date sap yield data were analyzed with analysis of variance using SAS General Linear Model procedure (SAS - Version 9.1) on an individual tree basis. Duncan's multiple range tests were applied to the means. Correlation analyses were run with SAS programs for weather data, collection date, individual tree production, and stepwise regression analysis were used to determine the influence of weather variables in combination on sap production for each year individually.

Syrup analyses

Subsequently we submitted the syrup to the KSU Sensory Analyses Center for taste/

sensory evaluation. In 2003, we made three preparations of black walnut syrup for these tests: 50WS (50% walnut syrup [WS] + 50% cane sugar [CS]; 85WS (85%WS+15% CS), and pure walnut syrup (PWS). Only two preparations were made from the 2004 syrup (50WS and PWS). In addition, a commercial brand of maple-colored table syrup was used in consumer testing. For sensory analysis a panel composed of five highly trained panelists participated in the study. Consumer testing was done in 2003 and 2004 with 105 consumers tasted-testing the syrup samples under controlled tests. The syrup was served on pancakes in a 'blind comparison' test with Log Cabin syrup and pure maple syrup. Panelists used a modified flavor profile method adapted from Caul 1957 and Keane 1992. In 2004, the Kansas State University Value-Added Foods Laboratory reduced the water content of the sap with a commercial evaporator and conducted chemistry tests on the syrup, finding no contaminants or adulterants.

Results and Discussion

Sap production

Variance analyses indicates sap yield varied by tree (Table 1) and collection date for both years (1 % level) and as the season progressed sap yield was less. Tree yields for 2003 and 2004 were moderately correlated (0.5807) and significant at the 1 % level. Tree # 4 was the best yielding tree 13,210 ml (2003) and 7,910 ml (2004) of sap, having 2 to 3 times the production of the next highest tree. Maher (2005) in Alaska also found variation in yield by date and year in Alaskan birch. Sap flow begins when temperatures rise above freezing for a few days in order to bring about a physiological change to trigger sap flow which is related to the quantity of carbon dioxide gas produced. About 36 to 48 hours of below freezing temperatures, followed by a warming trend of +5^0 C are needed for good sap flow. If trees are frozen, it normally takes longer, regardless of the temperature (Chapeskie 1997). Figure 1 shows this relationship for the 2003 collection season.

Table 2. Collection date weather parameters

Variable	2003		2004	
	Mean	Range	Mean	Range
Max daily temp (C)	11.9	1 to 28	7.8	-1 to 18
MIn daily temp (C)	-4.6	-10 to 7	-6.6	-19 to 4
Diff daily temp (C)	15.3	0 to 22	14.7	14.7 to 18
Temp AM (C)	1.7	4.1 to 12.9	-0.6	-9.2 to 8.2
Temp PM (C)	8.5	1.4 to 21.7	4.3	-1.1 to 11.6
Rh AM (%)	81.1	57.6 to 100	81.5	66.2 to 90.5
Rh AM (%)	63.9	45.4 to 98.5	65.9	44.7 to 82.9
Wspd AM (km/hr)	6.8	2.1 to 10.0	12.0	5.1 to 18
Wspd PM (km/hr)	9.8	1.9 to 20.4	15.8	11.3 to 27.7
Wdir AM (deg)	222	68 to 322	190	53 to 228
Wdir PM (deg)	170	30 to 359	176	27 to 297
Press AM (hPa)	979	969 to 983	983	966 to 994
Press PM (hpa)	983	966 to 1013	983	949 to 1015

Spearman's rank order "R" analyses suggested sap yield is dependent upon sapwood thickness in 2003 (1 % level @ 0.7214), and in 2004 (5% level @ 0.5252). These tests showed no significance when run for sugar content/sapwood thickness, tree size, nor openness in the stand. Individual tree yields were moderately correlated (0.606) for the 2003 and 2004 collection seasons.

Weather relationships

Shown in Table 2 are the collection period means and ranges for the weather variables monitored for both years. Maximum daily temperatures were a little warmer in 2003 and cooler in 2004. Morning and afternoon temperatures followed a similar pattern. Relative humidities were nearly identical. Wind speeds were less in the morning hours and greater in the afternoon. Wind direction and atmospheric pressure were similar for both years.

Table 3. Stepwise regression values for various weather factors for 2003 and 2004. Note: Four variables in bold type indicate common for both measurement years.

2003			2004		
R-square = 0.8837			R-square = 0.9999		
Variable	Partial R-sqaure	Pr > F	Variable	Partial R-square	Pr > F
Wind speed (PM)	**0.4311**	**0.0148**	**Wind dir. (AM)**	**0.4539**	**0.0327**
Max daily C	**0.1913**	**0.0481**	Min daily C	0.1392	0.1657
Temperature (PM)	0.1379	0.0490	Rel. humidity (AM)	0.0764	0.2835
Pressure (PM)	0.0413	0.2330	**Max daily C**	**0.1415**	**0.1107**
Wind speed (AM)	**0.0433**	**0.2048**	Wind dir. (PM)	0.0567	0.2605
Wind dir. (AM)	**0.0389**	**0.2066**	Rel. humidity (PM)	0.0601	0.2120
Daily diff. temp. C	0.0166	0.4027	**Wind speed (PM)**	**0.0679**	**0.0299**
	---	---	**Wind speed (AM)**	**0.0042**	**0.0730**
Sum of four common partial R-squares = 0.7046			Sum of four common partial R-squares = 0.6675		

Warm day-time temperatures in January 2003 probably reduced one full month of sap flow weather. Only 36 days (February 9 through March 16) were collectible. The test season ended abruptly on March 16, after four consecutive nights of minimum temperatures above freezing and two consecutive days of maximum temperatures above 20 degrees. In 2004 the collection season was shorter and warmer than the previous year with collection dates from January 24 thru February 29. In 2003 total days of measurable sap flow was 13 days (5,118.8 ml/day) in and only 10 days in 2004.

Stepwise regression analysis for sap yield (Table 3) shows the best combination of weather variables had high R^2's (0.8837 and 0.9999) for 2003 and 2004, respectively. Wind and temperature in both years influenced the sap yield. Wind speed in the morning and the afternoon, wind direction in the morning, and maximum daily temperature were significant and common to both seasons (Table 3). Sap yield increased with an increase of maximum daily temperature until the tail end of the collection period. Yields were somewhat higher with northerly winds.

Syrup production

This experiment produced 1,100 ml of sugar syrup in 2003 (65% sugar), for a syrup/sap ratio of [1/100 ml syrup] / [66,545 ml sap] = 1/60.5; sap density measurements which are normally taken to estimate content of dissolved sugars, predicted a higher sugar yield and suggests the presence of other dissolved solids and/or significant processing loss of sugar. In 2004, 700 ml of (67%) sugar syrup was produced from 46,755 ml of sap for a syrup/sap ratio of 1/66.7.

Syrup analyses

Maple syrup should contain no less than 66% by weight soluble solids derived solely from maple sap. In 2003 the black walnut samples were slightly below that requirement. 62.5% to 63.4% TSS. In 2004, all walnut samples had 66% TSS. When the KSU Sensory Analysis Center consumers tasted-tested using the normative scale of "degree of liking" there was no significant difference between the walnut syrups (5 % level). Thus PWS was used in the 2004 tests along with table syrup. Consumers (85%) liked the table syrup best.

Table 4. Walnut and pure maple syrup chemistry comparisons.

Type	pH	a_w	Brix (%)
50% walnut syrup	6.53	0.868@25.9°C	66.5
100% walnut syrup	6.75	0.858@26.6°C	65.1
Pure maple syrup	6.88	0.844@25.8°C	68.2

The Log Cabin ® product was preferred over both the walnut and pure maple syrup because it was sweeter and had a greater aftertaste. The Value-Added Food Center tests gave the following results for 50% walnut syrup, 100% walnut syrup, and pure maple syrup (Table 4). All have similar values. An estimate of mold-free shelf life is given by the a_w value. This value is high for all three concentrations of syrup meaning they have similar shelf lives. A more detailed analysis of these and other parameters are presented in Matta et al 2005.

Summary and Conclusions

This experiment has shown that there is a substantial amount of sap flow in young black walnut trees in the early winter months and that it can be tapped and processed for the making of sugar syrup. It also shows the importance of a wide sapwood ring in obtaining a good yield of sap. Sap production appears to be related to wind and temperature fluctuations. Based upon liking scores, it appears that walnut and maple syrups may not compete with table syrup for about 40% of consumers, but a small niche market of tree-derived syrup could be explored and commercially targeted.

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