J. Ethnobiol. 5(1):61-75 Summer 1985

PROCESSING MAPLE SAP WITH PREHISTORIC TECHNIQUES

MARGARET B. HOLMAN
and
KATHRYN C. EGAN
The Museum
Michigan State University
East Lansing, MI 48824

ABSTRACT.–The extent to which prehistoric Indians were able to produce maple sugar has been a question since Europeans first settled in eastern North America. Therefore, experiments were performed to test the efficiency and productivity of prehistoric maple sugaring techniques. Results indicate that it was possible to make maple sugar as efficiently with these techniques as with those employed during the early Historic era. Consideration is also given to the uses of maple sugar and the seasonal context of production. It is argued that it was both efficient and worthwhile for prehistoric Indians to incorporate sugaring activities into their annual subsistence cycle.

INTRODUCTION

The extent to which prehistoric Indians of the Northeastern Woodlands practiced maple sugaring is unclear. The question is not whether the Indians knew how to make sugar, but rather if prehistoric technology could support a regularly scheduled sugaring operation on a scale comparable to that of the Historic Period. Some modern authors, such as Yarnell (1964:78), argue that the absence of metal kettles for boiling the sap was a limiting factor in sugar production. Others, however, maintain that techniques such as stone boiling and/or freezing were adequate to make prehistoric sugaring an "established custom" (Havard 1896:42-43; Fernald and Kinsey 1958:268; Nearing and Nearing 1970:24). Early historic sources are contradictory as well. Charlevoix (1966:192) who traveled through the Northeast from 1720 to 1722, believed that maple sap was always used but that sugar making was taught to the Indians by Europeans. LaHontan (1905: 366), however, who traveled through North America during the late 1600's, claimed that Indians made both syrup and sugar and Latifau (1924) believed the Europeans learned sugaring from the Indians.

Sugar was made throughout the Upper Great Lakes and the Northeast by both Indians and Europeans (Kinietz 1965; Nearing and Nearing 1970). Maple products were used as seasoning (Yanovsky 1936:42), as a preservative for fruit (Kohl 1956:319), as gifts (Densmore 1974), as a summer drink (Havard 1896:42; Densmore 1974:313), and possibly as a famine food (Henry 1969:211). At least occasionally, extra sugar was sold (Finley 1857). In addition, maple sugar can be stored for periods of at least a year (Densmore 1974:313) and is easily transported in bark containers (makuks) (Hoffman 1896), thus extending its subsistence value beyond the season when it is procured. Sugaring also served a social function as the days at the sugar camps were regarded by the Indians (Ritzenthaler and Ritzenthaler 1970) and Europeans (Baird 1898) as a time of celebration and social interaction.

Archaeological evidence for prehistoric maple sugaring is ambiguous and limited, in part because bark and wood utensils used do not preserve and in part because other artifacts, such as pottery and stone tools, are easily associated with other activities. On the basis of the prehistoric record, however, at least two Late Woodland sites in Michigan have been interpreted as maple sugaring sites (Lovis 1978; Kingsley and Garland 1980).

In addition, other Lake Woodland sites in Michigan are thought to be sugaring sites on the basis of environmental characteristics plus archaeological data (Holman 1984). While several lines of evidence suggest that maple sugaring was practiced prehistorically, no studies have adequately considered whether prehistoric technology was a limiting factor in this activity.

THE PROBLEM

In this paper we address the question: Was prehistoric sugaring technology adequate to support a regularly scheduled sugaring operation? To answer this, we conducted limited controlled experiments using utensils and techniques available prehistorically. These experiments allow for a preliminary assessment of the extent to which prehistoric Indians could make maple sugar. Efficiency of various techniques is measured by comparing the results of the experiments with Historic Period production in terms of time expended, fuel used, and quantities produced. Productivity and technological efficiency are evaluated in their own right as well as relative to the economic alternatives and long term benefits of this food. Finally, consideration is given to sugaring in the prehistoric subsistence/settlement systems of the Northeastern Woodlands.

The results of this study are potentially valuable for increasing our understanding of how Eastern Woodland peoples integrated scheduling of seasonally available resources into a cohesive subsistence cycle. Maple syrup and sugar are potentially valuable foods which may have been important during periods of economic deficit, i.e., early spring, when few alternative foods were available. Demonstration of the productivity and efficiency of this activity, given prehistoric technological capabilities, may thus lend support to arguments favoring prehistoric sugaring.

BACKGROUND

Maple sap is basically a solution of sugar (mostly sucrose) plus small amounts of proteins, lime, and potash in water. The sucrose in the sap is manufactured by the tree for its own growth and nutrition (Nearing and Nearing 1970:123). Part of the sucrose is used immediately for growth and part is stored for later conversion into energy. The water in sap is the vehicle which carries the food and nutrients through the tree.

Maple sap does not run when trees are in leaf (Nearing and Nearing 1970:121). The leaves are active in manufacturing the foods that are stored and used. Hence, the water, carrying nutrients from the roots is vaporized by the leaves while the nutrients are used and stored. For this reason, the water content is lowest during the growing season. Rather, sap is present in the late fall, winter and early spring when the trees are leafless. During the fall and winter, the sugar content of the sap is low because much of it has been used during the growing season and the rest is being stored in the wood and bark for later use. In the spring, however, the reserve sucrose is needed for the coming growth period and is carried up the tree through the cambium to the buds. In addition, because no evaporation has taken place since the leaves fell, water is present in maximum quantities.

In the early spring when the sap occurs in greatest quantities and the sugar content is highest, maple syrup and sugar are made (Nearing and Nearing 1970:121). During this time, sap flow is significantly influenced by the weather: it is abundant after severe freezing, but cannot run when the temperature drops below about 32^{o}F (0^{o}C) or rises above 50^{o}F (10^{o}). Thus the alternation of cold nights and warmer days in early spring constitutes sugaring weather.

Maple sugar production requires removal of 94% to 98% of the water in sap, while only 34% to 35% of the water must be removed when making syrup (Crockett 1915). During earlier historic times, this was accomplished by boiling the sap in a graduated series of metal kettles and thus evaporating the water (Densmore 1974). Now special evaporators are used. In all cases, however, the amount of water removed determines whether the product is syrup or sugar.

The collecting and processing of maple sap was a group activity as is reflected in the descriptions of Indian sugaring. Individual nuclear (Rogers 1974) or extended families (Henry 1969) conducted their sugaring in the same sugar bush each year. The sugar bush was a place set aside for this activity alone. Families lived there for the duration of the season and stored equipment there for reuse the following year (Densmore 1974). Evidence suggests that these camps were located from one-half mile (.8 km) to six miles (9.6 km) from villages where planting and fishing took place in the warm season (Holman 1984).

Often two or three families gathered at the same sugar bush (Henry 1969). Thus, the season functioned as a social occasion as well as a working one. It provided a welcome opportunity for socializing after the winter when Indian families dispersed to find game (Henry 1969; Landes 1971). Information relevant to later subsistence and social activities was also exchanged during the sugaring time.

Historic accounts indicate that all family members were involved in sugaring. Women directed the work and performed tasks requiring special skills, such as tapping the trees (Henry 1969:142; Rogers 1974:33-41). Men cut wood for the fires and children helped by tending the boiling sap. Group participation was important because collecting and boiling sap is labor intensive with several tasks to be performed at once. Nonetheless, since sap does not run every day in the season, men and boys were able to spend some time hunting and fishing as well (Henry 1969:142).

METHODS

Ethnohistorical documentation of techniques.—References to sugar making using prehistoric methods and utensils are either sketchy, inferential, or late descriptions under circumstances when metal cauldrons were not available. The statement of a Kickapoo chief is, however, often cited (e.g., Henshaw 1890; Nearing and Nearing 1970) as a direct account favoring prehistoric sugaring. He said:

> Can it be that thou art so simple as to ask me such a question, seeing that the Master of Life imparted to us an instinct which enabled us to substitute stone hatchets and knives for those made of steel by the whites; wherefore should we know as well as they how to manufacture sugar? He has made us all, that we should enjoy life; he has placed before us all the requisites for the support of existence, food, water, fire, trees, etc. Wherefore then should he have withheld from us the art of excavating trees in order to make troughs of them, of placing the sap in these, of heating the stones and throwing them into the sap so as to cause it to boil, and by this means reducing it to sugar? (Keating 1825).

Stone boiling as described by the Kickapoo chief is commonly inferred to have been the method used prehistorically because pottery or wood containers are considered unable to withstand direct heat (e.g., Nearing and Nearing 1970). Other sources, however, do state that direct boiling over the fire was possible so long as pottery was covered by wet clay or birch bark vessels placed only over coals (H. Smith 1933:93; Nearing and Nearing 1970:20).

Freezing is also frequently cited as a method employed by the Indians to reduce the water content of the sap to produce syrup (Havard 1896; H. Smith 1933; Fernald and Kinsey 1958). Freezing of the sap in shallow containers allows the thicker sugar concentrated sap to settle to the bottom while a layer of ice, which can be easily removed, forms on the top.

From these and other references it seems that sap can be processed in vessels made of pottery (H. Smith 1933; Nearing and Nearing 1970; Densmore 1974, 1979), birch bark (Armstrong 1892; Havard 1896) or wood (Keating 1825; Havard 1896) and that evaporation is accomplished by stone boiling (Keating 1825; Havard 1896; Fernald and Kinsey 1958), direct fire (H. Smith 1933) or freezing (J. Smith 1831; Havard 1896; Fernald and Kinsey 1958). Additionally, a combination of vessel types and/or techniques may be used.

Techniques and devices for collecting sap are not at issue in the controversy surrounding prehistoric maple sugaring. The amount of sap collected and the means for doing so remained the same until the recent advent of plastic tubing in some operations (e.g., Nyland 1966). Likewise, bark collecting vessels and wooden troughs were used by some people into the present century (Rogers 1974; Densmore 1979). Rather, as noted, the problem centers on the adequacy of prehistoric technology for evaporating the water from the sap. Thus, this study focuses on the actual processing of sap into syrup and sugar.

THE EXPERIMENT

Since the collection of sap is time consuming and not critical to solving the problem of prehistoric sugaring, sap was purchased on March 22, 1984 from a local sugaring operation. Because our time was limited to one day, the quantity of sap obtained was 40 gallons (151.4 l). This amount, when processed, was projected to yield about one gallon (3.8 l) of syrup or six to eight pounds (2.72 or 3.63 kg, respectively) of sugar (Thompson 1978). While this is nowhere near the amount processed in a normal season, it was considered sufficient to experiment with the various techniques discussed above and to obtain data on the length of time needed to manufacture the final product. This is turn can be compared to other time/efficiency data where historic methods were used.

Freezing, stone boiling and direct fire, the three historically and ethnobotanically referenced techniques, were tested. Each technique was tested independently and in concert with the other techniques. In addition, records were kept of each step of the sugaring process. Quantities boiled, time expended, fuel used and process employed were all noted.

Freezing was a technique used historically for initially removing some of the water from the sap so that less boiling was necessary (J. Smith 1831). Freezing may also have been used prehistorically to produce sugar. Smith (1831) states that the sap was intentionally frozen and the ice cast off several times in an instance when the Indians he was living with made sugar without kettles (see also Havard 1896).

For purposes of our experiment, we took one-half of the original sap, having a sugar content of 3%, and allowed it to freeze overnight. Half of this quantity was set out on an open porch while the other ten gallons (37.9 l) were set on a semi-enclosed porch. Ice formed and was cast off the sap on the open porch three times thus reducing it from 10 gallons to five (18.9 l) and increasing its sugar content from 3% to 6%. Ice formed on the sap set on the enclosed porch only once and consequently only reduced its volumn by 1.5 gallons (5.7 l) while increasing the sugar content to approximately 3.5% (Fig. 1).

The second stage of our experiment involved boiling down the sap. Various types of containers were possibly used in prehistoric sugaring. Ceramic and birch bark vessels are most frequently mentioned in the literature. Consequently, to assess the advantages and disadvantages of each kind of vessel, half of the sap used in stone boiling was placed in birch bark containers and half in ceramic pots (Fig. 2). Only birch bark vessels, however, were used directly over the coals because the ceramic vessels used in the experiment were deemed unsuitable for direct heat.

The ceramic pots used were unglazed, straight sided vessels with flat bases and a capacity of two quarts (1.9 l). Rim diameters were 20 cm and 21.5 cm and vessel heights were 16.5 cm and 17.2 cm. The pots differed from most prehistoric vessels in the Upper Great Lakes in the bases which prehistorically were rounded or semiconoidal (e.g., McPherron 1967). They were similar to prehistoric counterparts in that they were fired at low temperatures and were comparable in size.

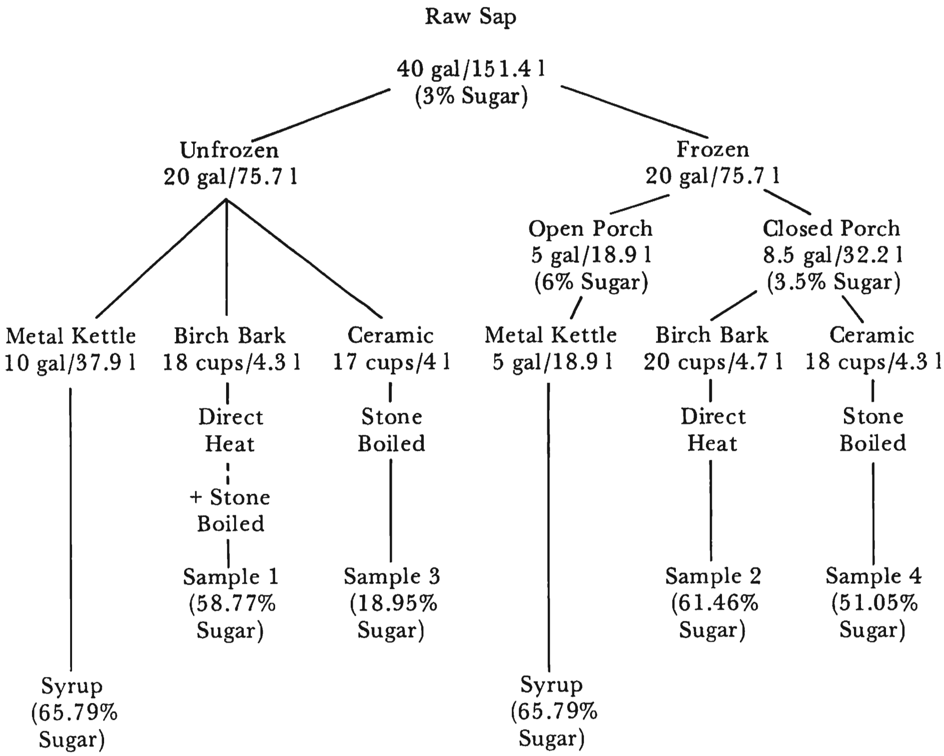

FIG. 1.—Techniques Used in Sap Processing Experiment.

FIG. 2.—Bark and Ceramic Vessels Used in Experiments.

Three of the birch bark vessels, like the pots, had a two quart (1.9 l) capacity. They were tray shaped, however, with a depth of 9 cm, widths from 13 to 25 cm and lengths of 28 to 35 cm. The trays were shallow so that a large area of liquid surface was exposed to heat from the coals underneath the vessels. A fourth bark container was like a kettle, pyramidal in shape, with a flat base and a capacity of about three gallons (11.4 l).

Unfortunately, we were not able to process as much sap as we originally intended. This is primarily because we did not have enough large containers to process the sap. As it turned out, our experiments helped to demonstrate something implied in the ethnographic literature (Densmore 1974); that is, when birch bark comes directly in contact with flames, it will ignite. Consequently, we lost the three gallon (11.4 l) vessel early on in the experiment and thus reduced our processing efficiency.

The small volumes which we were able to process provided illuminating results. Comparable volumes of sap, both frozen and unfrozen, were processed using each of the prehistoric techniques in various combinations. It should be noted that the birch bark vessel samples, with the greater sugar concentration, were in fact processed for lesser periods of time. It is also of interest that the samples we processed for five hours in metal kettles on electric stoves, done for purposes of comparison, were boiled for only 14% less time than the longest time for processing sap using prehistoric techniques. It also reduced by approximately the same volumetric ratio. This suggests that there is not a significant increase in the efficiency of metal kettles over prehistoric type vessels.

Content analysis provides additional insight into our results. Three samples of the sap boiled using prehistoric techniques were analyzed for sugar and ash content by the Laboratory Division of the Michigan Department of Agriculture (Table 1). These included yields from unfrozen sap boiled over the coals in birch bark for 5 hours and 15 minutes (Sample 1), frozen sap boiled directly over the coals in birch bark for 6 hours and 15 minutes with stone boiling being added for the last one hour and 45 minutes of the process (Sample 2), and unfrozen sap boiled in a ceramic vessel for 6 hours and 25

TABLE 1.—Content Analysis of Processed Sap.

	Sample 1 (5 hr., 15 min.)	Sample 2 (6 hr., 15 min.)	Sample 3 (6 hr., 25 min.)	Sample 4* (6 hr., 25 min.)	Michigan Average**
Liquid	39.4	35.91	78.5	33.31	33.8
Total Solids	60.6	64.1	21.5	51.23	66.2
Sugars	58.77	61.46	18.96	49.68	65.79
Sucrose	56.78	59.22	18.49	48.0	62.95
Fructose	0.60	0.77	0.13	0.49	1.12
Glucose	1.39	1.47	0.34	1.18	1.72
Total Ash	0.8	0.87	0.60	0.68	0.59
Other Solids	0.9	1.81	1.94	1.85	0.0

Total solids determined by Abbe' Refractometer. Solids diluted with Acetonitrile and sugars subsequently determined by High Pressure Liquid Chromatography. All results except total solids were calculated on a dry basis.

*Estimated

**Composition meets U.S.D.A. criteria.

minutes (Sample 3). The fourth sample of frozen sap, stone boiled in a ceramic vessel for 6 hours and 25 minutes, was analyzed for sugar content only and the other components were estimated on the basis of the sugar content. In addition to the results of these analyses, as shown in Table 1, the Michigan average for maple sugar is provided as a point of comparison. The Michigan standards are significant because they identify the point at which boiled sap will not ferment and therefore be considered syrup. Achieving a non-fermentable syrup is therefore important for long term storage.

Sugars are not the only component considered. Interestingly, based on Michigan and U.S.D.A. standards, the critical test has been not for sugar content, but rather for ash content (Jones 1928:25). Ash contributes to the flavor of maple syrup. Therefore, unlike syrups made from most other sugars, maple syrup is never subjected to chemical or other forms of clarification because removal of the ash would destroy the flavor.

Although ash must be present in authentic maple syrup, the bulk of the total solids in syrup is, of course, sugar. In recent years, the total solid content of maple syrup is required to be at least 66% (U.S.D.A. 1977), although in the past the standard in both the U.S.A. and Canada was 65%. Syrup having 65% or 66% totals solids will thus have 35% or 34% total liquid. Variation around these percentages is fairly small because syrup that is too thin will ferment and syrup that is too thick will granulate (Snell 1913:36).

In considering the results as displayed in Table 1, it is clear that the sap stone boiled in ceramic pots (Samples 3 and 4) at 21.5% and 51.2% total solids is a long way from being identified as maple syrup. This is despite the fact that stone boiling was continuous for 6 hours and 25 minutes. Sap processed in birch bark trays, however, is very close to syrup at 60.6% (Sample 1) and 64.1% (Sample 2) total solids. It is interesting that Sample 2, which is the closest to syrup, is the sample where a combination of techniques was used. That is, the container was placed directly over coals for the entire processing time of 6.25 hours and was also stone boiled for the last 1.75 hours. There is no doubt that had samples 1 and 2 been processed a little longer, the previous maple syrup standard of 65% total solids, or the recent standard of 66% total solids, would have been achieved.

There is likewise no doubt that U.S.D.A. standards of quality would not have been achieved. As can be seen in Table 1, all samples have a portion of total solids consisting of material that is neither sugar nor ash. Foreign matter is highest in the samples where stone boiling was used because soot from the fire, adhering to the stones, was added to the boiling sap along with the stones. U.S. Grade A table syrup must be "practically free of foreign material such as pieces of bark, soot, dust and dirt" (U.S.D.A. 1977). The problem of additional soot and ash might be remedied by incorporating a water bath into the stone boiling process. Ethnographic references (e.g., Wilson and Towne 1978:389), noted after our experiments were performed, indicate that often times stones from the fire were briefly dipped in water to remove the soot. Use of this procedure would likely have improved the flavor and quality of the syrup we produced.

Efficiency.—It is possible to make maple syrup using prehistoric technology. An important question remaining, however, is whether sugaring is worth the time, labor, and amount of fuel that must be expended.

It is evident that stone boiling sap in a ceramic pot is not at all efficient (Table 1). After 6 hours and 25 minutes, the sap in the ceramic vessels was only 18.5% and 48.0% sugar. This is far from the average of 65% in real maple syrup. By comparison, the sap processed in birch bark trays came very close to the syrup in 5.33 hours, and 6.25 hours.

The process of rotating hot stones from the fire to the vessels is, of course, tedious but it is not difficult in the sense of using a great deal of energy. Given enough workers and a routine, it would be possible to do. However, an expenditure of at least twice as much time and fuel would be required. Since a rolling boil can be maintained with hot stones, it is probably not the activity of stone boiling but rather the shape of the ceramic pots which prevented the sap from reaching a syrup state in the time expended. The birch bark trays, on the other hand, exposed more surface to the heat than did the pots and thus evaporation took place at a faster rate.

In order to compare the rate that syrup can be achieved using prehistoric methods to the rate using metal kettles, some of our sap was boiled on the kitchen stove. Five gallons (18.9 l) of sap were cooked into syrup in a period of five hours. Therefore, in terms of processing time, kettles were only about 1/6 more efficient than birch bark.

The modern evaporator converts sap into syrup in about an hour. This represents an increase in the rate of evaporation of kettles that is similar in scale to the increase seen in birch bark trays over ceramic pots. The reason for both "quantum" leaps in processing time are likewise similar. The evaporating machines used today, like the birch bark trays, are shallow and there is thus greater area for exposure to heat and evaporation.

Fuel.—It can be seen that the time required to process sap in birch bark trays is not much longer than that necessary to boil sap in metal kettles. Likewise, fuel expenditure is not much greater. It is expected that a "backyard" sugaring operation will require about one cord of wood to boil 40 gal. (151.4 l) of sap into one gallon (3.8 l) of syrup (Thompson 1978). This experiment used 1/5 cord of wood to boil 8.3 gallons (31.4 l) of sap, which is reasonably close to 1/4 cord for 10 gallons (37.9 l) of sap required when using metal cauldrons.

It has been noted (Richard Ford, pers. comm. 1984) that "cutting" enough wood for maple sugaring, prior to the introduction of metal axes, might have been the limiting factor in prehistoric sugaring. While some cutting may have been necessary, quality firewood (hardwoods) would also be available on the forest floor as a byproduct of the natural self-pruning that occurs in mature forests (cf. beech-maple forest). Therefore, fuel is not considered a limiting factor significant enough to preclude prehistoric maple sugaring.

CONCLUSIONS

It is clear from the results of our limited experiments that it is possible to make maple syrup with containers made of materials available to Native Americans. Further, syrup making can take place with almost the same amounts of labor and time using "native" technology and pre-nineteenth century techniques. Given more time, there is little doubt that sugar, as well as syrup, could have been made.

It is instructive that the most efficient results were achieved using flat, birch bark trays because this is comparable to improvements made in modern maple syrup equipment, i.e., evaporators. Thus it must be recognized that using a metal kettle is not a necessary condition for maple sugaring. As the Nearings point out metal cauldrons also have shortcomings:

> The method of boiling in cauldron kettles was an endless affair and wasteful of time, labor and fuel, while quality and color necessarily suffered. It was difficult to take the finished syrup out of the unwieldly kettles unless the fire was low and plenty of help was around. So the tendency was to add more and more sap and boil the resulting syrup over and over again all day (1970:54).

The later use of a graduated series of kettles such as those described by Densmore (1974:309) necessarily represented some improvement in efficiency by preventing the problem of reboiling the same syrup over and over. The greatest increase in sugaring efficiency, however, was first the use of flat bottomed pans and then the evaporator which was invented in 1866 (Nearing and Nearing 1970:56). Both the pans and the evaporator are flat and shallow. Thus, more of the surface of the boiling liquid is exposed to heat and evaporation so that both time and fuel are saved.

In summary, increasing the amount of surface exposed to heat seems to be extremely important regardless of the material of the container used. It is likely then that prehistoric sugaring was not done in ceramic pots because of their low efficiency. Rather, the sap was processed in large birch bark pans or perhaps in wooden troughs as suggested by the Kickapoo chief cited above.

The practice of freezing the sap, like the use of flat, shallow containers saves time, energy and fuel in syrup making. This is reflected in the disparate sugar contents of the frozen and unfrozen sap boiled in ceramic pots. Although freezing does increase efficiency, it is a technique that could not always be controlled because it is dependent upon the weather. Thus freezing may have been used when possible but was not reliable on a day to day basis.

Given that prehistoric Indians could make maple syrup and/or sugar with an efficiency comparable to that of the early European settlers, the question becomes whether it was worth doing so. The task under any circumstances is not only labor intensive but requires moving to a specific location and focusing the energies of several people in the process. The question then must relate to the context of the yearly cycle as practiced by particular people in particular places. Hence, the advantages of sugaring need to be weighed against the use and scheduling of other resources.

In northern climes, such as the Upper Great Lakes, New England and eastern Canada, the availability of other foods is low in the early spring. This is true for both hunter-gatherers and farmers. Animals are lean after the long winter, fish have yet to begin spawning, migrating birds have not returned north, and most plants are not yet productive. Further, hunter mobility is greatly reduced in the early spring (LaHontan 1905). The relative absence of other foods and the difficulty of obtaining them creates a situation where the entire labor force of an extended family is available for the sugaring period of four to six weeks. Because productivity during the sugar season is variable, however, supplementary hunting and fishing can and did take place (e.g., Henry 1969). Farmers, like hunter-gatherers, have fewer activities to occupy their time during the early spring. Tilling the soil and planting are yet to begin. Again, the entire family can devote its labor force to sugaring. Thus the timing and duration of the sugaring season *vis a vis* other resources and the availability of labor are relevant factors in choosing to make sugaring a regular part of the seasonal cycle.

The presence of an extended family of men, women and children at the sugar camp, coupled with the fact that other families can process sap nearby, offers an important social opportunity as well. Information so necessary to hunter-gatherers can be exchanged and decisions about the coming warm season can be made. Further, the possibility of simply socializing after the isolation of winter must be considered. Virtually every ethnographic description of sugaring emphasizes the holiday atmosphere of the sugar camp. While the social aspects cannot be quantified, they likewise cannot be neglected as an important benefit in the early spring.

Another consideration is whether the products of boiled maple sap are useful enough to make their manufacture worthwhile. Maple sugar can be stored for long term use, is easily carried, can function as a preservative, provides essential nutrients, was considered a remedy, and is flavorful. Densmore (1974) notes that maple sugar can be stored for at least a year. Thus it is available over the course of the entire seasonal cycle. Additionally, it is easy to carry in small birch bark makuks (Hoffman 1896:288) or small cakes (JCB 1941:94), when traveling.

Maple sugar can also be used as a preservative. Thus, Kohl (1956:319) notes that fruit was preserved with it. This was, potentially, a valuable use since many ethnographic and archaeological sources suggest a considerable percentage of the northern aboriginal diet was composed of fruit, fresh as well as dried/"preserved" (Yarnell 1964; N. Cleland 1977).

The properties of long term storage of sugar and preservation of foods are interesting when coupled with the fact that maple products constitute good sources of carbohydrate and calcium, as well as other nutrients (Black 1980; Leaf 1963). Syrup may contain 40 to 80 mg of calcium, 3 to 6 mg of phosphorous, 10 to 30 mg of potassium, and 4 to 25 mg of magnesium per fluid ounce (30 ml), (Leaf 1963:963). Beverley Smith who is conducting intensive studies of Ojibiwa nutrition, notes that the high meat diet of traditional northern peoples required both carbohydrate and calcium from non-meat foods (1984:9).

Maple syrup and sugar may have been sources of both nutrients, since maple sugar is high in carbohydrates (90 gm), (Watt and Merrill 1975:61) and maple syrup contains comparable amounts of calcium to that found in equal volumes of whole milk (Leaf 1963:964). The storable character of maple products and the desire, among historic Indians, to store maple syrup and sugar for later consumption would thus extend the nutritional benefits of these products beyond the sugaring season (Densmore 1974; Black 1980).

Finally, maple syrup and sugar were used as seasoning (Havard 1896:42; Yanovsky 1936:42; Densmore 1974:313). Indeed, several references note that sugar was preferred over salt (H. Smith 1932:61, 1932:395, 1933:92; Kohl 1956:319; Swigart, pers. comm. 1984). In addition, vinegar was made from maple sap and mixed with sugar to make a sweet and sour meat dish (H. Smith 1932:395). Other uses include sugar being added to water to make a summer drink and to medicines to make them palatable (Densmore 1974:313).

Though syrup produced in our experiements was not U.S. Grade A in flavor, neither was the syrup produced in early historic times. Scorching, caused by sap foaming on the sides of the metal kettles, was a common occurence that imparted a bitter taste (Nearing and Nearing 1970:55). Also, because boiling was often done in the open and other foods cooked in the sap, foreign materials were often incorporated into the sap (Turner 1891). Though the matter of flavor represents a cultural preference, in view of the multiple uses of maple products and the fact that metal kettles did not necessarily produce a more flavorful product, it is possible that taste as much as any other factor was an impetus for regular prehistoric sugar making (cf. Jochim 1981).

These experiments have shown that the introduction of metal kettles was not a necessary condition for the prehistoric production of maple syrup or sugar. The labor and time required is greater using prehistoric containers, but not to an extent which would preclude prehistoric sugaring. Likewise, there was no differentce in the seasonal context of sugaring nor the varied benefits conferred by the product. It is likely then that sugaring was as regularly practiced in many places prehistorically as it was historically.

It is noteworthy that these experiments, which were based on descriptions in documentary sources, are supportive of the reliability of ethnohistoric accounts of sugaring. The apparent ambiguity of the written record reflects the range of available kinds of containers that can be used to process sap. It is possible too that contradictory opinions as to the ability of prehistoric Indians to make syrup or sugar are based on accurate observations. Some early writers may not have seen a complete or normal seasonal cycle. For example, an individual may not have been present for an entire year or social disruption, such as that experienced by the Huron in the 1600s, may have precluded sugaring. It may be too that early travellers accompanied male hunters and/or warriors rather than whole families or villages. Thus, they might not have seen sap processed. Economic context and group composition are both important factors in sugaring. Both are valuable and both need to be taken into account when evaluating ethnohistoric sources on this topic.

Finally, the problem of identifying prehistoric sugaring sites remains. It is our contention that their presence must in part be determined on the basis of the subsistence/settlement system of a given population. In addition, there are ecologic and topographic attributes distinctive of maple sugaring camps (Holman 1984). Though previous research (Holman 1984) suggested that large numbers of ceramic vessels might also be characteristic of sugaring sites this is now being reconsidered in light of our experiments. Instead, we must look for anomalous patterns in site assemblages which cannot be accounted for by more traditional explanations.

ACKNOWLEDGEMENTS

Facilities of The Museum, Michigan State University, were made available for this project by C. Kurt Dewhurst, Director. Val Berryman and Terry Shaffer of The Museum plus Rick Zurel supplied birch bark for the kettles and trays used in the experiments. Linda Kalanitch made the clay vessels used and in addition donated others. Richard J. Seltin, former chair of the Department of Natural Science, Michigan State University, gave us basalt samples for stone boiling. Mr. Fontz of the Michigan Department of Agriculture and Ms. Renate Dezacks of Plant Biology Research at Michigan State University analyzed processed sap. Al Hafner of the Michigan Bureau of Standards supplied us with copies of the U.S.D.A. standards for maple syrup. Maple sap was purchased from George Fogel of Sugar Bush Supply in Mason, Michigan. Computer time was provided by Fran King of the Illinois State Museum and the Whittiers of East Lansing.

Practical advice and encouragement were generously offered by Jerry Wilson, Beth Andrus, Rick Zurel, Michael Hambacher, James Robertson, Philip Franz, Beverley Smith, Shela McFarlin, Donald Weir, Charles Cleland and William Lovis. In addition, discussions with Susan R. Martin and Richard I. Ford were most helpful. Finally, the finished manuscript was read and commented on by James McClurkin. Clearly maple sugaring remains a cooperative enterprise and to each of these people we extend our thanks.

LITERATURE CITED

ARMSTRONG, BENJAMIN G. 1892. Early life among the Indian, reminiscences from the life of Benjamin G. Armstrong. Dictated to and written by Thos. P. Wentworth. Press of A.W. Browion, Ashland, Wisconsin.

BAIRD, ELIZABETH THERESE. 1898. Reminiscences of early days on Mackinac Island. Coll. of the State Hist. Soc. of Wisconsin 14:29-34.

BLACK, MEREDITH JEAN. 1980. Algonquin ethnobotany: an interpretation of aboriginal adaptation in southwestern Quebec. Nat. Mus. of Man, Mercury Series, Canadian Ethnol. Service Paper No. 65.

CHARLEVOIX, PIERRE DE. 1966. Journal of a voyage to North America. Univ. Microfilms Inc., Ann Arbor. Originally published 1761, printed for R. and J. Dodsley, London.

CLELAND, NANCY N. 1977. Identification of plant remains from prehistoric sites in northern lower Michigan. Unpubl. ms. on file, The Museum, Michigan State Univ., East Lansing.

CROCKETT, WALTER H. 1915. How Vermont maple sugar is made. Dept. of Agric., State of Vermont.

DENSMORE, FRANCES. 1974. How Indians use wild plants for food, medicine and crafts. Dover Publ., New York.

__________. 1979. Chippewa Customs. Repr. Ed. Minnesota Hist. Soc. Press, St. Paul. Originally publ. 1929, Smithsonian Inst. Bull. 86, B.A.E.

FERNALD, MERRITT LYNDON and ALFRED CHARLES KINSEY. 1958. Edible wild plants of eastern North America. Harper and Row Publ., New York.

FINLEY, REV. JAMES B. 1857. Life among the Indians; or personal reminiscences and historical incidents, edited by Rev. D.W. Clark, D.D. Hitchcock and Walden, Cincinnati.

HAVARD, V. 1896. Drink plants of the North American Indians. Bull. Torrey Bot. Club 23:33-96.

HENRY, ALEXANDER. 1969. Alexander Henry, travels and adventures in Canada and Indian territories between the years 1760 and 1776, edited by James Bain. M.G. Hurtig, Edmonton, Ontario. Originally publ. 1809.

HENSHAW, H.W. 1890. The Indian origin of maple sugar. Am. Anth. October III:341-351.

HOFFMAN, W.J. 1896. The Menomini Indians. 14th Ann. Rpt. of the B.A.E.

HOLMAN, MARGARET B. 1984. The identification of Late Woodland maple sugaring sites in the Upper Great Lakes. Midcont. J. of Arch. 9(1):63-89.

J.C.B. 1941. Travels in New France, edited by Sylvester K. Stevens, Donald H. Kent, and Emma Woods. Pennsylvania Hist. Comm. Harrisburg. Originally publ. 1887.

LITERATURE CITED (continued)

JOCHIM, MICHAEL. 1981. Strategies for survival. Acad. Press, New York.

JONES, C.H. 1908. The national pure food law and the Vermont maple sugaring industry, pp. 20-27.

KEATING, WILLIAM H. 1825. An Expedition to the source of St. Peter's River. Whittaker, London.

KINGSLEY, ROBERT G. and ELIZABETH B. GARLAND. 1980. The DeBoer site: a late Allegan phase site in Allegan County, Michigan. The Michigan Arch. 26(1):3-44.

KINIETZ, VERNON W. 1965. The Indians of the western Great Lakes 1615-1760 Univ. Michigan Press, Ann Arbor.

KOHL, J.G. 1956. Katchi-Gami wanderings around Lake Superior. Ross & Haines, Inc., Minneapolis. Originally publ. 1860, Chapman and Hall, London.

LaHONTAN, BARON DE. 1905. New voyages of North America, edited by R.G. Thwaites. Repr. from Englis ed., 1703. A.C. McClurg & Co., Chicago.

LANDES, RUTH. 1971. Ojibwa woman. Norton Lib., New York.

LATIFAU, JOSEPH FRANCES. 1724. Publ. of the Champlain Soc. XLIX, Toronto.

LEAF, ALBERT L. 1964. Pure maple syrup: nutritive value. Sci. 143:963-964.

LEAF, ALBERT L. and KENNETH G. WATTERSTON. 1964. Chemical analysis of sugar maple sap and foliage as related to sap and sugar yields. Food Sci. 288-292.

LOVIS, WILLIAM A. 1978. A numerical taxonomic analysis of changing Woodland site location on an interior lakechain. Michigan Acad. XI(1):39-48.

McPHERRON, ALAN. 1967. The Juntunen site and the Late Woodland prehistory of the Upper Great Lakes area. Mus. of Anth., Univ. of Michigan, Anth. Papers No. 30., Ann Arbor.

NEARING, HELEN and SCOTT NEARING. 1970. The maple sugar book. Schocken Books, New York.

NYLAND, ROGER DANIEL. 1966. Sugar maple and its use for sap production in Michigan's lower peninsula. Unpubl. Ph.D. dissert. Michigan State Univ., East Lansing.

RITZENTHALER, ROBERT E. and PATRICIA R. RITZENTHALER. 1970. The Woodland Indians of the western Great Lakes. Nat. Hist. Press, Garden City.

ROGERS, JOHN (Chief Snow Cloud). 1974. Red world and white. Univ. Oklahoma Press, Norman. Originally publ. as A Chippewa speaks.

SMITH, BEVERLEY A. 1984. Sources of vitamins and minerals in the high-protein diet of the traditional Ojibwa. Ms. in possession of author.

SMITH, HURON H. 1923. Ethnobotany of the Menomini Indians. Bull. of the Public Mus. of Milwaukee 4(1):1-174.

____________. 1932. Ethnobotany of the Ojibwe Indians. Bull. of the Public Mus. of Milwaukee (4(3):327-525.

____________. 1933. Ethnobotany of the forest Potawatomi Indians. Bull. of the Public Mus. of Milwaukee 7(1):1-230.

SMITH, JAMES. 1831. An account of remarkable occurences during captivity with the Indians 1755-59. Grigg, Philadelphia.

SNELL, J. F. 1913. Maple sap, its products and their limitations. Report of the proceedings of the Pure Maple Sugar and Syrup Co-operative Ag. Ass. 1:34-431. Canada.

THOMPSON, BRUCE. 1978. Syrup trees. Walnut Press, Fountain Hills, Arizona.

TURNER, JESSE. 1891. Reminiscences of Kalamazoo. Michigan Pioneer and Hist. Coll. Vol. 18, Lansing: Robert Smith and Co. State Printers and Binders.

U.S.D.A.—Food Safety and Quality Service. 1977. U.S. standards for grades of table maple syrup.

WATT, BERNICE K. and ANNABEL L. MERRILL. 1975. Handbook of the nutritional contents of foods. Dover Publ., Inc., New York.

LITERATURE CITED (continued)

WILSON, NORMAL L. and ARLEAN H. TOWNE. 1978. Nisenans. Handb. of N. Am. Ind., Vol. 8, California, edited by Robert F. Heizer, pp. 387-397. Smithsonian Inst., Washington.

YANOVSKY, ELIAS. 1936. Food plants of the North American Indians. U.S.D.A. Misc. Publ. No. 237, Washington.

YARNELL, RICHARD ASA. 1964. Aboriginal relationships between culture and plant life in the Upper Great Lakes region. Mus. of Anth., Univ. Michigan, Anth. Papers No. 23.