Crops From the Maple Trees

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Maple sirup, cream, sugar, and candies all come from the sap of the hard maple tree (*Acer saccharum*), the black maple (*A. nigrum*), and the red maple (*A. rubrum*). Those trees grow from North Carolina and Missouri north to the Great Lakes and along the St. Lawrence River in Canada. The commercial maple area extends westward from the New England States to Minnesota and southward to Kentucky, an area that includes the 10 States that produce most of the crops and the States in which the maple industry is of importance in some localities. It is entirely a North American industry. It is a farm industry. It is unique among all farm enterprises because maple sap, a dilute sugar solution, is the only farm commodity that is unmarketable until it has been processed on the farm.

How long sugar has been made from the sap of maple trees no one knows. The earliest explorers found the Indians making maple sugar for their own use, even producing it in sufficient amounts for trade in some sections, especially along the St. Lawrence. Accounts dating from 1634 show that maple sirup and sugar are among the oldest of American farm products.

Typical is an excerpt from a letter written in 1648: "I have enclosed you some sugar of the first boiling got from the juice of the wounded maple. Mr. Ashton, Secretary to the Royal Society, presented it to me. It was sent from Canada where the natives prepare it from said juice, eight pints yielding commonly a pound of sugar. The Indians have practiced it time out of mind; the French began to refine it and turn it to much advantage."

Perhaps it is this history, wrapped in romance, that makes us associate the production of maple sirup with old-fashioned methods. Most of us, when we think of making maple sirup, think of it as we do of quilting bees—just another old-fashioned, backwoods social highlight of the long hard winters. Seldom do we think of the equipment used as anything at all modern. Instead, our artists have fixed in our minds that maple sirup must be made in a big black iron kettle hung over an open fire, with the whole family participating. In reality, it is a far cry from the old open kettle to the present-day, flue-type evaporators. But even these and the methods of processing sap to sirup are much the same as they have been for the past 50 to 100 years. It would shock some people to be told that maple products can be produced by modern, streamlined methods, upon which research has recently started.

Emphasis has been less on improvement of processing and more on protection of the industry by preventing the sale of adulterated products. The need for this protection has not passed; under present conditions of high prices and insufficient supply, adulteration has again become a problem of the industry.

Maple products, essentially a forest or woodland crop, come mostly from mountain or hill country, where the acreage of tillable soil is limited. The nature of the place of origin is one of the reasons why maple products are an important cash crop. Processing usually is done in March and April, when most other farm activities are at their slowest and income at its lowest. The income, whether a small or a large part of the total, often is the fraction that spells success or failure to the farm.

The actual income from maple sirup and sugar is difficult to estimate, because the season, type of equipment, and cost of labor and wood fuel vary from farm to farm. However, a measure of the profit to the farmer is his hourly income. J. A. Cope, of Cornell University, in a survey of 20 farms in 1947, learned that the farmer got from $0.56 to $3.78 (with an average of $2.08) for each hour of work. The figures were calculated from the total returns, minus all other costs except those for labor. The total return was based on an average price of $4.78 a gallon of sirup. The fixed costs, equipment, trees, and so forth represented only 38 percent of the total cost. According to H. R. Moore and others of Ohio, producers in that State earned as much as $3.51 an hour while making sirup.

From 1945 to 1950, approximately 70 percent of the maple crop was sold in retail trade. Any estimate of the direct sales is difficult to make, because records kept by the farmer-producer are not generally available. In 1944 and earlier, most of the maple crop went into the wholesale trade, so we have an accurate record of the crop. For that year, which was fairly typical, production amounted to 565,000 pounds of sugar and 2,612,000 gallons of sirup, valued at more than 8 million dollars. Were this figure based only on the sugar (sucrose) content, it would have been worth no more than 2 million dollars. The differential of 6 million dollars was due mainly to the premium price which the commodity commands because of its unique flavor and partly to the high cost of farm processing.

Maple sap is essentially a dilute solution of sugar in water. Its sugar content averages 2 to 3 percent. The sap may contain less than 1 percent and as much as 9 percent, as typified by sap from a few trees at the New York, Vermont, and New Hampshire Agricultural Experiment Stations. It takes 86 gallons of a 1-percent-sugar maple sap to produce 1 gallon of sirup. Given the percentage of sugar in any particular maple sap, the number of gallons required to yield a gallon of sirup can be calculated merely by dividing 86 by the percentage of sugar in the sap. That is known as the rule of 86. Thus, a 3-percent-sugar sap requires less than 29 gallons for a gallon of sirup. It is plain, then, that it would be desirable to have for maple sirup production only trees that yield sap with 4 percent or more of sugar and to cull the trees that yield sap of low sugar content.

Research workers at the Vermont Agricultural Experiment Station have begun a study to find the causes for the high concentrations of sugar in the sap from some few sugar maples. Already they have demonstrated that this sweetness is characteristic of the few trees that consistently yield sap high in sugar year after year. They hope to develop trees of increased sirup-producing capacity by vegetative propagation of selected, proved trees or by the development of a better tree through hybridization. Should it become possible to have available stocks of maple trees that are rapid growers and that will produce large volumes of sap rich in sugar, the cost of production would be reduced materially and the quality of the sirup would be improved. At present, it takes more than 20 years for an orchard of wild seedling transplants of uncertain sap yields to come into production.

The processing of maple sap to sirup or sugar involves the evaporation of large volumes of water, perhaps the most costly of all industrial operations. The concentration of sap must be done so that the maple flavor is retained without the development of off-flavors.

For reasons of economics it would be desirable to process sap in centrally located evaporating plants, each serving a large area. That is done in a few places, but the plan is usually impractical because of the inaccessibility of the sugar bush, the cost of transportation of large volumes of sap, and the danger of spoilage. One way to avoid some of the difficulties is to concentrate the sap partly and ship the concentrate to a vacuum evaporating plant for finishing off. According to Orval Polzin, superintendent of the Antigo Milk Products Cooperative, such a plan was inaugurated at Antigo, Wis. The cost of the method may be too high unless the evaporating unit employed is part of an existing industry.

In any case, until an economically feasible method of centralized concentration is developed, the sap will be processed on the producing farm. For this, new equipment that is efficient and simple in design and inexpensive enough to justify its purchase for use only a few weeks a year is urgently needed.

Maple sirup contains about 35 percent water and about 65 percent solids.

Of the solids, the sucrose accounts for about 92 percent; reducing sugars as invert, 5.5 percent; and ash, 1 percent. The undetermined constituents that make up the remaining 1.5 percent are proteinaceous material (proteins, amino acids, and polypeptides), organic acids, and phenolic compounds. The accompanying table gives the analyses of five samples of sirup, which represent the four classified and the one unclassified grades. The samples were produced in the same grove under identical conditions.

They can be compared to the maximum and minimum analytical values typical of sirups produced in the United States and Canada.

The analyses show nothing to justify the luxury prices of maple products, except the 1.5 percent of undetermined constituents. It is in this fraction that we must surely find the flavor, which alone justifies the cost. Until more is known about this substance, little can

Analysis of different grades of maple sirups produced in 1947 from one sugar grove (in percentages)

Grade	*Moisture*	*Invert sugar*	*Sucrose*	*Ash*
Fancy	32.8	0.89	65.07	0.70
No. 1	32.6	1.52	62.90	.68
No. 2	31.5	2.05	64.35	.66
No. 3	32.5	1.72	65.51	.77
Unclassified	32.7	4.86	59.83	.68

Analysis of 481 pure maple samples from the United States and Canada (in percentages)

	Moisture	*Invert sugar*	*Sucrose*	*Ash*
Minimum	24.85	0	47.20	0.46
Maximum	48.14	11.01	70.46	1.06
Average	34.22	1.47	62.57	.66

be done toward improving processing practices and processing equipment, or the development of new uses for maple products. For that reason, the major effort of a current research program is directed toward a better knowledge of the substances that are either directly or indirectly responsible for the maple flavor.

Already we have strong evidence that the flavor does not exist as such in the sap as it comes from the tree, but is developed by what happens to the sap after it leaves the tree, namely heating. The amount of the flavoring material, or the amounts of the substances that make up the material, are extremely small. They account for less than 0.1 percent of the weight of the sirup. We know that the flavoring material is of a complex nature, and so the task of isolating and identifying it at best will not be simple. Fortunately, the past few years have brought the development of the new analytical tools, which will help reveal this unknown quantity.

So far, the work has supported a theory that flavor is due to nonenzymatic browning, a chemical reaction set up by heat between certain of the components of maple sap which include amino acids, organic acids, and reducing sugars. This would indicate

Color development by heat in sirups produced by concentration of maple sap under reduced pressure

Heating period (minutes)	Optical density [1] at 450 millimicrons and—						
	25° C.	60° C.	70° C.	80° C.	90° C.	100° C.	103° C.
0	0.148	0.148	0.148	0.148	0.148	0.148	0.148
15	....	....	....	....	.153	.187	.192
30	....	....	....	.155	.180	.260	.280
45	....	....	....	....	.247	....	.364
60	....	....	.149	.158	.351	.417	....
120	....	.148	.155	.192	.629	.733	.745

[1] Measured by a 1-centimeter cell.

that in the development of maple flavor there is an accompanying development of a yellow-red (brown) color. We have been able to produce maple sirup through low-temperature vacuum evaporation that is essentially free of color and flavor. The use of even lower temperatures and freeze-drying has produced a colorless and tasteless sirup.

In following the development of maple flavor, we have tried to establish the conditions, temperature, and time of heating that contribute to a maximum yield. In doing so, we have followed step by step the development of color, which apparently is associated with flavor. The colorless sirup obtained by low-temperature distillation was used as the starting material. Color was developed in the sirup by heat under controlled conditions of temperature and time. The amount of color developed was measured precisely with a spectrophotometer. The results, given in the table above, show that color begins to be produced at a reasonable rate at about 80° C. (176° F.). The rate of color development becomes pronounced at temperatures above 90° C. (194° F.). The time of heating is of great importance, because the amount of color formed at any one temperature increases directly with time.

The developed color (nonenzymatic browning) is without doubt closely associated with and parallel to the development of flavor. Because there is no known means of measuring accurately differences in flavor levels, the associated color does provide something that can be measured. The color of maple sirup is of great importance because it designated the commercial grade of the sirup, providing it meets the requirements for density and has no off-flavors.

With present-day practices of using open-pan evaporators, the temperature at which the sap is boiled (evaporated) cannot be varied. The only other variable, which also affects the color and which can be controlled, is the time of heating. Therefore, for any given type of evaporating equipment, the producer has little control over the kind of sirups, the grades, that he will produce. His final product, exclusive of fermentation, depends almost entirely on the sugar content of the sap.

As I mentioned before, to make sirup from 1-percent-sugar sap, 86 gallons of water must be evaporated, while only 29 gallons have to be evaporated from a 3-percent-sugar sap. Assuming that evaporation rates are the same in both instances, we see that the 1-percent sap will have to be heated nearly three times as long as the 3-percent sap. We would therefore rightly suspect that sirup made from the 1-percent-sugar sap will be the darker. For example, some producers who normally make only the higher grade (light-color) sirups, in 1948 made sirups of low grade (dark color), using the same equipment and following the same practices. Any im-

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provement in technique that will produce the same grade of sirup throughout the season, regardless of the sugar concentration of the sap, would be an aid to the industry. We hope that such an improvement will result from our studies on the development of flavor and color.

The farmer-producer always has the problem of making his finished sirup of just the right density—that is, of the correct sugar concentration. That means that the sirup must be removed from the evaporator at just the right instant; otherwise it will be too light in weight or too high in sugar content. The desired density of the finished sirup is set by law, which recognizes that below a definite sugar concentration spoilage is likely and that above the concentration sugar will crystallize out of the solution.

THE PRODUCER determines when the boiling sirup has reached the proper density by use of a thermometer, a hydrothermometer, or a hydrometer. All are more satisfactory when sirup is made in single batches than they are for measuring the sirup end product of a continuous process, the procedure most widely used. In the latter case, only the thermometer is satisfactory. The boiling point of the sirup of the proper weight a gallon and of standard density is 7° F. above the boiling point of water or dilute (0- to 3-percent-sugar) sap. This exact elevation of the boiling point makes the thermometer an accurate instrument for following the progress of the evaporation and determining when the sirup is finished and ready for drawing from the evaporator.

The use of the hydrometer for determining the completion of the evaporation process is unsound because it involves measurements that are subject to error. The measurements are the exact level at which the hydrometer floats in the hot sirup and the exact temperature of the hot sirup when the hydrometer is read. The failure of sirup for the wholesale trade to meet the standard density set by Federal and State agencies causes a substantial loss to the producer, because light sirup is marked down in price and heavy sirup yields a smaller volume. The producers need equipment that will tell them exactly when they can draw off the finished sirup at the proper density in a continuous process.

MAPLE SIRUP IS more than something to eat only on pancakes. Many producers extend their incomes by processing their sirup into spreads of fondantlike consistency, which are known as maple cream or maple butter, and into candy or sugar. Those items are the only ones manufactured by the commercial processors and, along with sirup, are insufficient to support the industry in adverse years.

None of the products can be used readily in established food recipes by industry or the housewife—too much of them is needed to get the desired flavor, and the accompanying large amounts of sugar and water upset the ratio of the other ingredients in the recipes. The housewife or food manufacturer therefore must experiment with their old recipes or undertake to use new and unfamiliar ones. New maple products designed for particular needs would help to overcome the objections.

WE HAVE SUCCEEDED in developing a new process which intensifies manyfold the flavor of maple sirup and sugar. The product may fill the need for a full-bodied maple flavor that can be added with little danger of throwing current food recipes out of balance. Its immediate use will be to provide a sirup that because of its high, true flavor is suitable for making blended maple sirup. It is inexpensive. It has opened vast new markets for an old product.

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section of the Eastern Regional Research Laboratory in 1940, he taught chemistry in Westminster College in Utah and conducted research at the New York State Agricultural Experiment Station.

We credit Étienne de Boré with being the first to succeed in producing granulated sugar on his plantation, which stood on the site of the present Audubon Park in New Orleans. His achievement in 1795 marks the establishment of the domestic cane-sugar industry.

The early planters had little chemical science to guide them in their efforts to expand their infant industry. Considering the state of scientific and technical knowledge at that time, their progress was indeed remarkable. They discovered and contributed to science and technology much of the knowledge they required.

Valcour Aime is notable for his invaluable journals, in which he kept detailed records of the many experiments he performed.

Day by day his journals note the effects of weather, fair and foul, on the growth and harvesting of the cane. They record the yields he obtained by novel methods of clarifying and evaporating the juice and granulating the sugar. Despite losses from floods, droughts, freezes, and hurricanes, he persisted courageously for four decades, from 1820 to 1860, in pioneering and making his experience available to other planters. It was during that period that the industry grew to maturity.

Aime eagerly tried every new device that became available for carrying out the various steps of the manufacturing process, often at great personal expense. He traveled and sent agents abroad to learn everything possible that might assist the industry. He introduced scientific methods as they were developed and brought to his attention. In 1850 he imported a polariscope for determining the sugar content of the juices, very soon after the invention of the instrument in France. Aime even considered the possibilities of other crops as sources of sugar. In August 1833, his journal records an experiment in which "one hundred and thirty-seven watermelons gave forty-six gallons of juice which, being evaporated, gave only three gallons of thick syrup."

The Howard vacuum pan, which was invented in 1813 and had been in use in sugar refineries, was adopted by manufacturers of raw sugar in Louisiana as early as 1832.

The vacuum pan was used only for the final crystallization or granulation of the sugar. More important for the evaporation of large volumes of juice were the scientific principles of multiple-effect evaporation and their practical application, which were achievements of the Louisiana industry. Credit for this basic invention goes to Norbert Rillieux, a Louisiana student at the École Centrale in Paris in 1832. The following year he brought his idea home. With the support of Theodore Packwood, a progressive planter, it was successfully developed and widely adopted.—*L. F. Martin, Southern Regional Research Laboratory.*