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PLASTIC TUBING AND MAPLE SYRUP QUALITY

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Abstract

Maple syrup made from sap collected using improperly or carelessly installed plastic pipelines varied more in color from day to day, and was more often darker in color, than sap collected from either the properly installed pipeline or clean, frequently emptied galvanized buckets. Use of both properly installed tubing and buckets, following recommended procedures, produced light colored syrup of equal quality throughout the entire maple syrup season.

IN RECENT YEARS, the use of plastic pipeline systems for collecting maple sap has increased.

Following the 1974 sap season, there were large inventories of the commercial grade (dark amber) of pure maple syrup. The lack of markets for it and the unstable, low prices had a tremendous effect on the maple syrup industry in both the United States and Canada.

It may be only coincidence, but the question must be asked: Was the surplus of dark syrup in any way a result of the greater use of plastic tubing?

To compare the quality of syrup made from sap collected by several different techniques, we recorded the greatest day-to-day variations in syrup color, and more often observed that dark colored syrup resulted when improperly or carelessly installed tubing was used. The other methods investigated were properly installed tubing, galvanized buckets with covers, and a special aseptic technique.

BACKGROUND

Characteristically, the maple syrups produced early in the season are light amber in color and delicately flavored. Usually darker syrups with stronger flavors are produced as the season progresses. The color of maple syrup is strongly associated with its quality, and this has become the most important criterion for grading it. Typically, the lighter syrups are for table use and are the highest grades.

After the 1974 season, the major users of the commercial grades of syrups did not buy the quantities they had formerly. Because of the magnitude of this problem, the Province of Quebec launched major promotional and financial programs to assist the Quebec industry. This marketing problem was also a major reason for the formation of the International Maple Syrup Institute to promote pure maple syrup products (Sipple 1975).

In recent years, syrup producers have found it more difficult to find labor for sap collecting, and have turned to plastic piping as an alternative. Not only does the pipeline system require less total labor, but it also allows for more efficient use of labor by spreading the workload over a longer period of time before and during the sap season (Huyler 1975). Huyler noted another reason for the increased use of plastic tubing: buckets cost more. As a result, many new operators start out with plastic tubing.

WHAT WE DID

During the 1975 and 1976 sap-flow seasons, we made daily collections of sap samples from 3 trees with sterilized taps and with standard bucket taps, and from 10 trees with plastic pipelines both correctly and poorly installed. The pipeline that was carelessly installed had sharp switchbacks that inhibited a steady sap flow and sags where sap would remain after a flow period ended (Fig 1).

In the 1975 season, the trees were tapped on 14 March. The sap collection began on 17 March and ended on 17 April 1975. Samples were collected on the 11 days that enough sap was produced for a 1- to 2-gallon sample.

The trees were tapped on 24 February for the 1976 season. Sap was collected from 5 March through 30 March 1976. Samples were taken on 9 days.

After each daily collection, the buckets and tanks were emptied, and sterilized jugs were attached to the sterile taps. If there were small "weeping" flows between major runs, this sap was discarded before the next flow. This ensured that each daily sample did not include any sap left over from the preceding day—a procedure recommended to syrup producers if high-quality syrup is to be produced consistently (Willits 1965).

Sap collection by an aseptic method was used to establish a standard for comparison with the other procedures. Before the taphole was drilled, the tree bark was scraped with a sterile chisel, saturated with alcohol, and ignited. As the alcohol burned, the hole was drilled with a sterilized bit, and a sterilized spout quickly inserted. The sap was collected in sterilized gallon jugs (Fig. 2). Each jug was fitted with a two-hole stopper. A glass U-tube, plugged with cotton at one end, was inserted in one hole to equalize the air pressure. A straight piece of glass tubing connected to a plastic tube and spout was inserted in the other. The entire apparatus was sterilized by alcohol dip before it was attached to the tree.

Two plastic pipelines were installed parallel to each other, each connecting one of two tapholes in each of 10 trees. Both lines collected sap from the

Figure 1.—Sap was collected by two parallel plastic pipelines. One was hung properly, while the other has sags and sharp switchbacks.

Figure 2.—Glass jug and apparatus for collecting maple sap under sterile conditions.

same trees. These lines extended for approximately 300 feet from the lowest taphole to the sap collection tank. One line was correctly installed without sags, sharp turns, or switchbacks, and good slope was maintained. The other line was carelessly connected in a deliberate attempt to simulate poor installation.

The sap collections were picked up and taken to the laboratory each afternoon and stored at approximately 2°C. The following morning each sample was subsampled and plated to determine bacteria and yeast counts. Plate counts were made in a manner similar to the standard methods used for dairy products (Am. Public Health Assoc. 1960). The remainder of each sample was then concentrated by boiling in an open stainless steel pan (Fig. 3) to standard density syrup which is 66.0 °Brix (at 20°C).

We graded the samples by comparing them with glass color standards for maple syrup that were developed by the U. S. Department of Agriculture (Brice and Turner 1956). The color intensity of each sample was also measured in the colorimeter at the recommended 560 nm. Light transmitted through undiluted syrup in a round, 1/2-inch cuvette was recorded as a percentage of the amount of light that would pass through distilled water (Brice and Turner 1956).

When maple trees come out of dormancy in the spring, physiological changes in the tree result in sap which lends syrup an unpleasant flavor. This is called "buddy" syrup because it is most noticeable in sap from trees whose buds have swelled or burst. We tested each syrup sample for buddy flavor by using the ninhydrin-reagent method (Underwood 1963). All of the syrup made from sap

Figure 3.—Each sap sample was concentrated by boiling in a separate open stainless steel pan.

collected after 18 April 1975 and 31 March 1976 developed a violet color in the test, which indicates buddy flavor. The samples collected after those dates were discarded because their off flavor make them unacceptable as table syrup. Data on these samples are omitted.

RESULTS AND DISCUSSION

We found that light colored syrup was produced from all sap collections during the entire 1975 season when the sap was collected by buckets or properly installed tubing (Fig. 4). Only at the end of the season, just before the development of buddy flavor, did the color grade change from light amber to medium amber, the accepted minimum for table use. Every sap collection from the sterile tap produced light amber syrup. On the other hand, the syrup made from sap collected by the poorly installed tubing varied greatly from dark to light during the season. Twice, the poor tubing resulted in syrup so dark that it graded below medium amber. One of these dark samples was collected from the first sap run of the season, and graded substandard.

Figure 5 shows that sap collections from poor tubing produced darker syrup on 3 days in 1975, when the other collection systems produced light amber syrup. One day was the first sap flow of the season, 17 March, and the other two days, 2 and 12 April, were preceded by a period without a sap flow. A possible explanation for the dark color is that sap accumulated in the sagging portions of the pipeline and fermented; when a sap flow be-

Figure 4.—Maple syrup samples from the 1975 seasons showing color comparisons among daily sap samples from four different sap-collecting methods. The collection date is shown at the bottom.

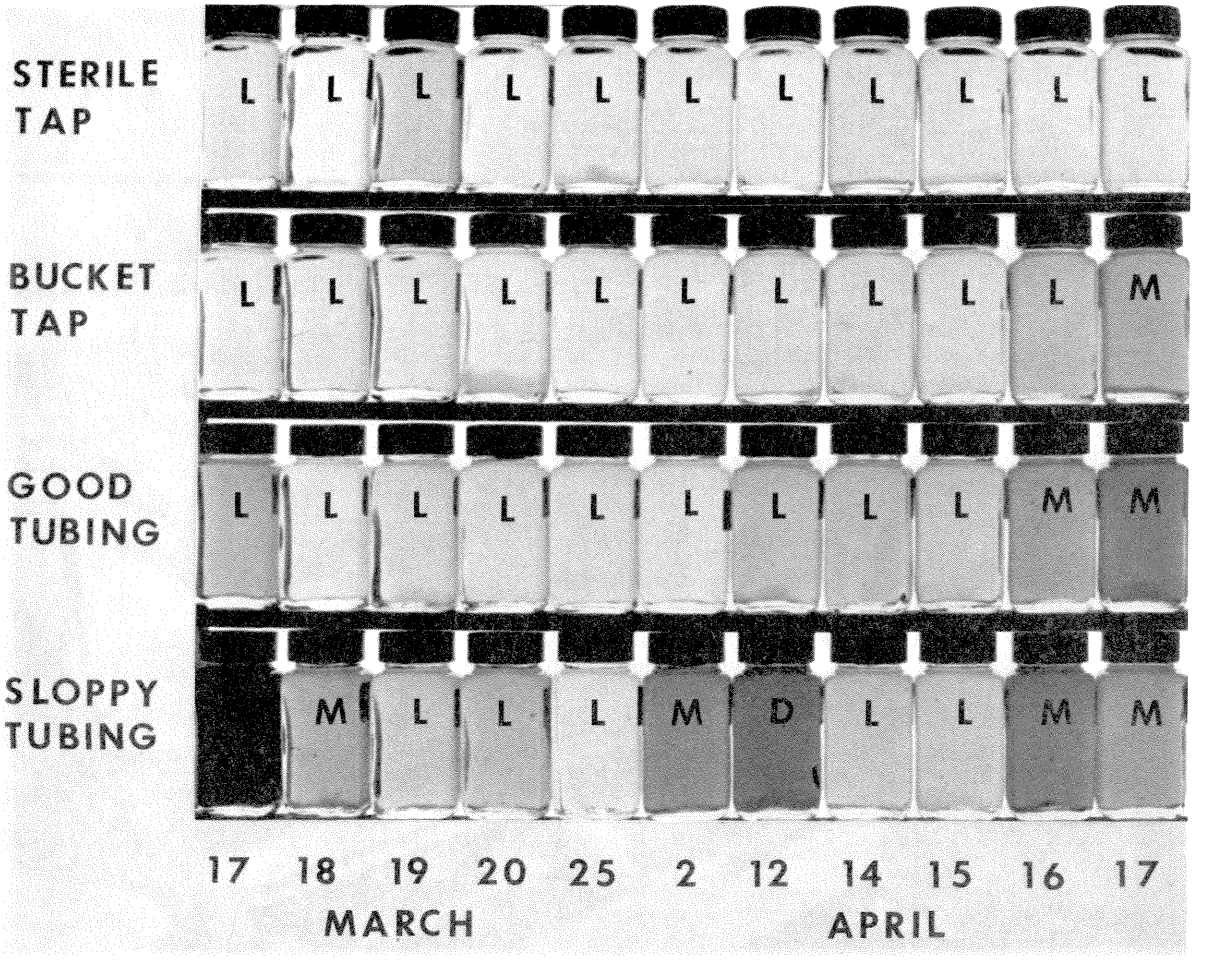
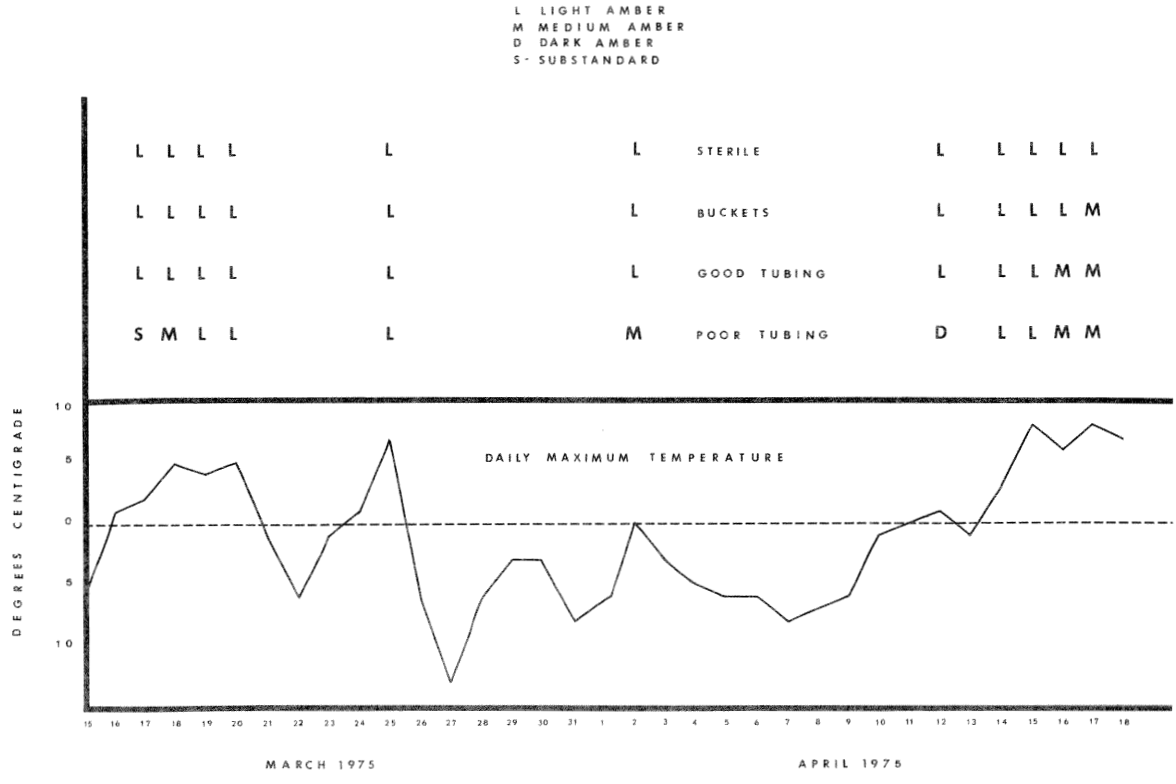


Figure 5.—Maple syrup colors on the day of sap collection, and daily maximum temperatures for the 1975 season.



gan, the fermented sap contaminated the new collection. Fermentation can result in dark colored syrup (Naghski et al. 1957).

A general trend toward a darker syrup color was indicated by lower light transmittance readings as the sap season progressed (Fig. 6). The light transmittance of samples from the buckets and good tubing collections followed a similar pattern: high readings until just before the development of buddy flavor, when both dropped. Readings for the poor tubing varied from high to low throughout the season, while the sterile tap readings remained high (light amber grade) even throughout the buddy sap period.

As the sap season progressed, there was also a trend toward increased quantities of bacteria and yeast in the sap. This trend seems to be associated with the trend toward darker syrup color, and we might assume that increases in microbe population affect syrup color. But we were dealing with total bacteria counts, and made no attempt to isolate or identify specific organisms. Some bacteria affect syrup flavor, others syrup color, and still others apparently do not affect either (Edson et al. 1912). Standard plate counts may be misleading as to the effect of bacteria on syrup quality. We did not find a good correlation between large populations of bacteria in the sap and syrup color. Sometimes bacteria colonies were found in the aseptically collected sap, although considerably less numbers than in the sap collected by other methods. On the other hand, some of the sap collected by the bucket or tube contained high bacteria counts, yet produced very light syrup.

Data from our microbe count suggest that the presence of yeast in sap is more directly related to syrup color than the bacteria populations, and is perhaps even more important. Syrup color darkened or lightened as yeast numbers increased or decreased (Table 1). No yeast populations were found in sap samples from the sterile taphole, and these samples were very light colored during the entire season.

Our observations of the relationship between sap contaminated by yeast and syrup color and flavor is consistent with the literature. Dark color

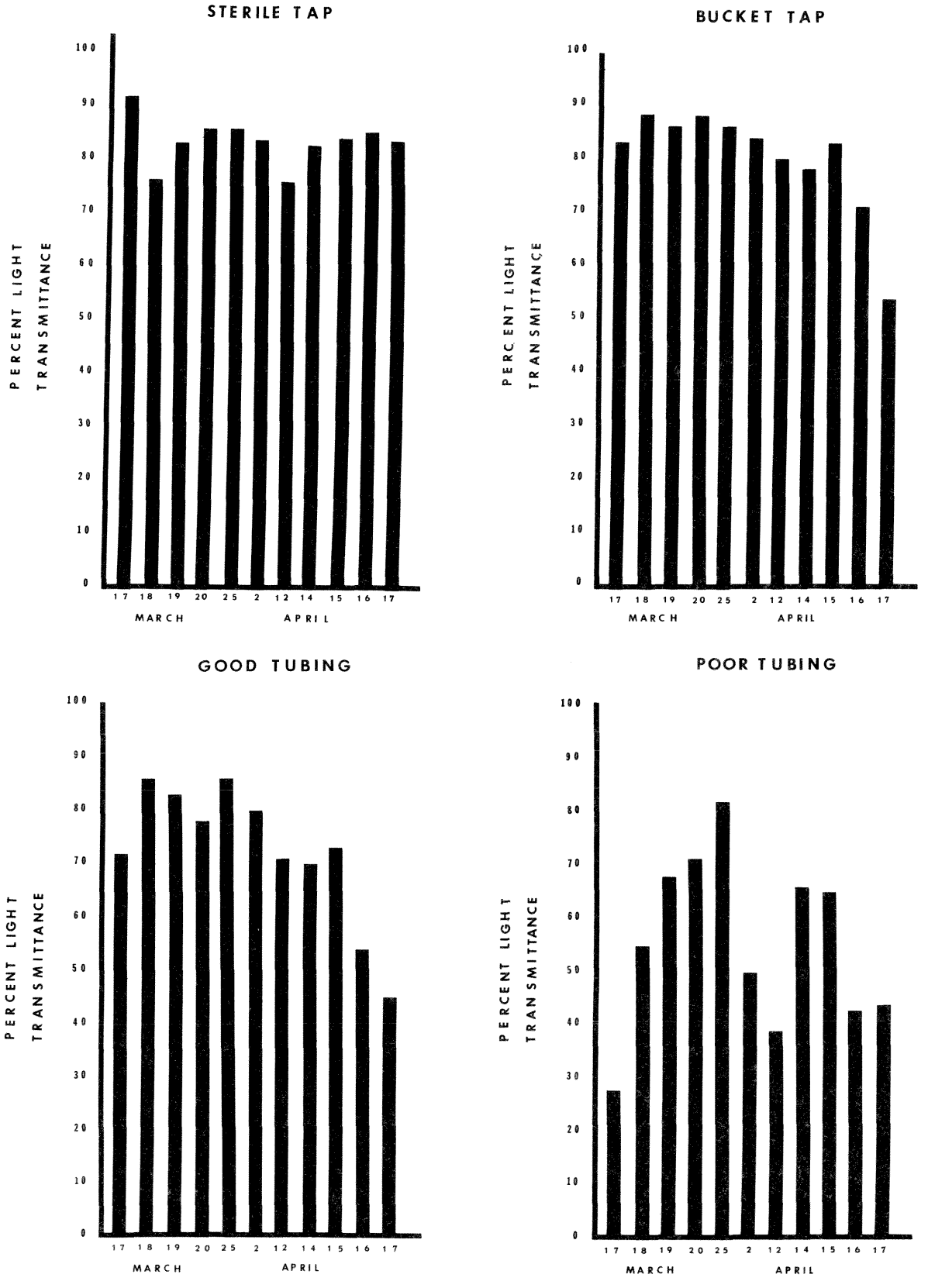


Figure 6.—Percent light transmittance at wavelength 560 nm through daily syrup samples from four different sap collection methods.

Table 1.—Standard plate counts of bacteria and yeast from sap collected by four methods (1975)

Date	Good tubing		Poor tubing		Buckets		Sterile	
	Bacteria	Yeast	Bacteria	Yeast	Bacteria	Yeast	Bacteria	Yeast
March 17	5,000	0	34,000	1,000	9,000	0	12,000	0
March 18	1,000	0	10,000	0	22,000	0	13,000	0
March 19	2,000	0	1,985,000	1,600	2,000	0	3,000	0
March 20	19,000	0	1,365,000	500	10,000	0	1,000	0
March 25	50,000	0	59,000	0	2,000	0	2,000	0
April 2	1,270,000	7,200	3,360,000	1,100	3,000	4,900	0	0
April 12[a]	—	—	—	—	—	—	—	—
April 14[a]	—	—	—	—	—	—	—	—
April 15	277,000	400	258,000	1,300	14,000	300	1,000	0
April 16	465,000	1,400	11,200,000	3,500	2,320,000	2,900	2,000	0
April 17	3,450,000	10,800	—[b]	18,400	1,026,000	42,000	1,000	0

[a] Data lost.
[b] Too numerous to count.

Table 2.—Standard plate counts of bacteria and yeast from sap collected by four methods (1976)

Date	Good tubing		Poor tubing		Buckets		Sterile	
	Bacteria	Yeast	Bacteria	Yeast	Bacteria	Yeast	Bacteria	Yeast
March 5	58,000	0	26,000	1,500	48,000	700	53,000	0
March 6	60,000	0	17,000	2,000	40,000	500	3,000	0
March 15	0	0	74,000	31,100	20,000	14,200	0	0
March 20	10,000	0	13,000	14,900	90,000	8,800	20,000	0
March 21	10,000	0	410,000	13,500	490,000	1,100	3,000	0
March 24	2,000	0	209,000	16,200	80,000	4,800	18,000	0
March 26	2,000	0	300,000	14,400	1,460,000	4,300	2,000	0
March 29	69,000	0	2,180,000	4,200	3,070,000	4,800	0	0
March 30	50,000	0	780,000	300	309,000	9,800	167,000	0

and caramel flavor are strongly influenced by the presence of invert sugars (Naghski et al. 1957). Invert sugars—glucose and fructose—are formed from sucrose (the only sugar in fresh sap) by hydrolytic action of invertase. Fermentation caused by the growth of yeast in the sap is a main source of invertase (Morrisson and Boyd 1966). In our opinion, the length and temperature of sap storage before processing influence fermentation. Invert sugars may not develop in sap containing many yeast spores if the sap is processed promptly. As storage time increases, the amount of fermentation increases.

The results shown by the data collected during the 1976 season (Table 2 and Fig. 7) generally agree with and follow the same trends observed in the 1975 data. The 1976 trends are not as well defined. This is most probably due to the peculiarities of the season.

The 1976 season started unusually early, and was terminated by the very early development of buddy sap. Sap was first collected on 5 March, as compared to 17 March 1975. The sap became buddy after 18 April in 1975, but buddiness was evident by 31 March in 1976—nearly 3 weeks earlier. On 5 March (the date of the first 1976 sap run), the maximum temperature was 14°C. The temperature did not go that high during the entire 1975 season. In addition, the last 2 weeks of March 1976 were characterized by very warm tem-

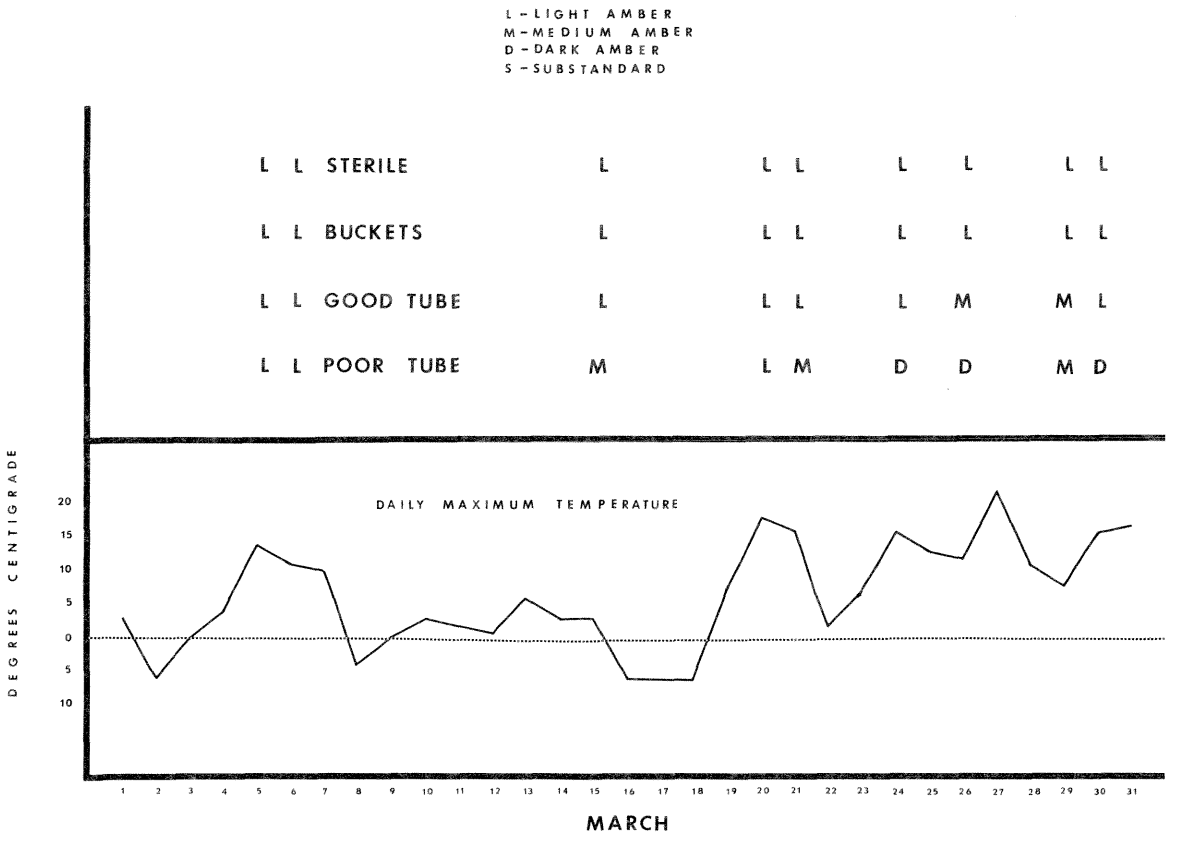


Figure 7.—Maple syrup colors on the day of sap collection and daily maximum temperatures for the 1976 season.

peratures, which reached as high as 20°C. (Fig. 7). High temperatures during these 2 weeks no doubt contributed greatly to the early development of buddy sap.

SUMMARY AND RECOMMENDATIONS

We found that maple syrup color differed very little whether it was made from sap collected by a properly installed pipeline or by frequently emptied, clean, galvanized buckets with covers. However, sap collected by a poorly installed plastic pipeline produced syrup that varied widely in color from day to day during the season. Our collections from sterilized tapholes and apparatus demonstrated that it is possible to produce light colored syrup during the entire season, even from buddy sap.

We have shown that a satisfactory grade of maple syrup can be produced using the plastic pipeline for sap collection. But, it is extremely important that the line is installed without sags and low points, and that it has adequate slope for complete drainage. Our results further indicate the need to sanitize the sap-collection equipment at the beginning of the season, and to keep the equipment clean throughout the season.

Finally, we concluded that the variation in the color of syrup from sap run to sap run was most likely caused by sap that fermented because it was trapped in a poorly installed pipeline or left in buckets. Buckets should be emptied after runs that are too short to warrant collection (even though this is time-consuming and expensive). Failure to install lines properly, keep buckets clean, and process sap promptly could cause the syrup to be dark, perhaps off-flavor, and of a lower grade.

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