Respiratory Losses from Sugar Beets Soon After Harvest

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Most of the published data concerning the respiratory loss of sugar from stored sugar beets have been concerned with the post-harvest losses that occur over a relatively long period of time. The magnitude of losses over extended periods of time can be determined by chemical analysis of carefully selected samples before and after the storage period. Small losses sustained by beets over a short period of time require very careful selection, handling, and analysis of a large number of samples for statistically significant results.

Direct measurements of respiration rates are far more accurate than chemical analysis of selected samples before and following experimental storage because fewer factors affect respiration rate than affect chemical composition. One set of data involving eight replications of analytical samples and only four replications of respiration rate samples showed errors only 1/13 as great in the respiration rate measurements as that determined by chemical analysis of the same matched samples before and after storage for 38 days at 72° F. The losses calculated from respiration data required differences of only 0.07 percent sugar for significance while the losses, based on analytical data, required differences of 0.92 percent sugar for significance at the 5 percent point.

Many beets are stored for only a few hours or days before processing. Since these beets undergo losses, it seems pertinent to examine the rate of loss in relation to the length of time they are stored following harvest.

Most tissues exhibit a rapid rise in respiration rate following injury (2) (1)[2]. Some of this rapid increase in CO_2 output is undoubtedly due to the escape of gas that has accumulated in the intercellular spaces of the tissues. This is especially true of massive tissues such as the sugar beet, or potato tubers. The removal of the periderm probably also makes the tissue more permeable to oxygen until suberization reduces the permeability. Frequently, an injury that fails to rupture the periderm fails to produce the usual rise in respiration rate.

Two principal factors have been responsible to a large degree in minimizing early post-harvest data. It usually takes one or two days to get the beets harvested, washed, uniformly topped, and the matched beet samples ready for all of the large drums. They must then be placed and sealed in the drums and the system checked for leaks and time allowed for the beets to reach thermal equilibrium at controlled temperature. The oxygen concentration inside the drums is then checked and adjusted before the start of the first 24-hour measurements. The technique used (4) is also subject to variations due to changes in barometric pressure. Apparently changes in barometric pressure modify the rate of apparent oxygen consumption in a manner not entirely consistent with Boyles' law. It has, therefore,

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[2] Numbers in parentheses refer to literature cited.

been the practice to average the respiration rates of several drums over 10-day periods and report these averages, which are more consistent values. High initial respiration rates are always observed. By averaging the daily values over several separate tests, one can reduce the fluctuations caused by changes in pressure and obtain fairly consistent average daily changes in the respiration rates.

Average daily respiration losses of sugar, calculated in pounds per ton of beets per day, were determined for six separate tests involving 16 drums of beets containing 88 pounds each. Each value, therefore, represents the average daily measurements on a total of 8,448 pounds of beets. The data in Figure 1 show that there were still some variations in the average barometric pressure during the first twenty-five days after the beets were harvested. The average changes from the third to the seventh day were small, however, and the changes in the respiration rate were apparently nearly linear between these points. It is very apparent that the sugar losses during the first few days are much higher than the basic rate of loss usually associated with previously reported studies. By extrapolating the curve to the time of harvest, it seems probable that the average losses during the first day after harvest occur at a rate more than twice as high as those usually considered by the writer as representative of the general storage period. It should be mentioned that in the absence of appreciable growth of fungi in the drums, there is a slightly progressive decrease in oxygen consumption

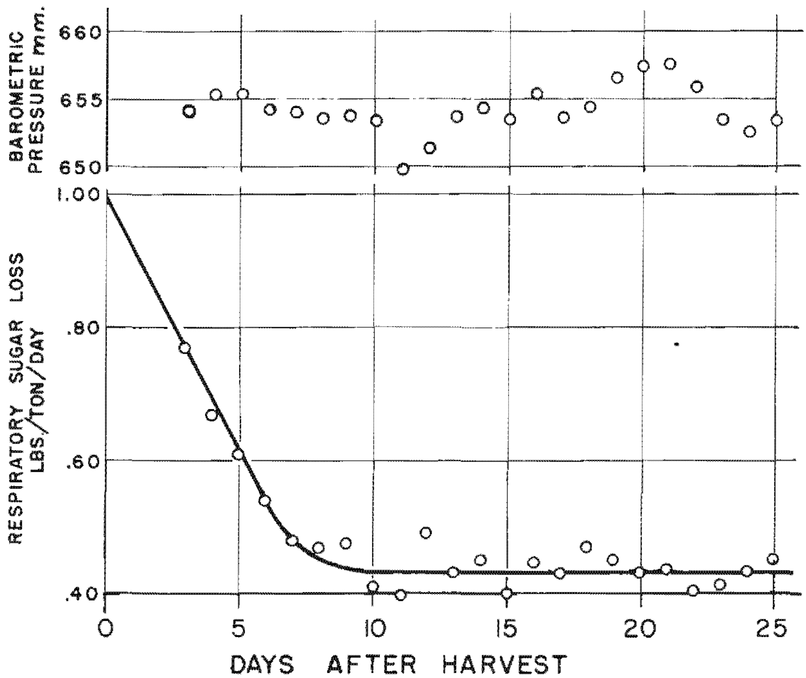

Figure 1.—Rate of respiratory loss of sugar from sugar beets in relation to time after harvest, tests conducted at 70° F.

until the end of the test (usually 40-50 days at 70° F.). An increase in oxygen consumption is commonly used by the writer to indicate the progress of spoilage, and the tests have been discontinued after these observations have indicated definite differential progress of spoilage between different treatments or varieties being studied.

Because of the much higher degree of precision possible in respiration rate measurements and the very small analytical differences involved in some short-period storage experiments it may be profitable to recalculate the losses from time-temperature data by applying respiratory loss observations. Orleans and Cotton (3) reported studies of storage losses at the Carlton plant of the Holly Sugar Corporation near Brawley, California, in 1949 and 1950. Temperature differences between the ventilated and check bins were fairly large after only a few hours. If we assume that the initial respiratory loss of freshly harvested beets at 70° F. is 1.00 pound of sugar per ton per day (see Figure 1) and that this loss is doubled for each 15° F. rise in temperature, then the initial loss of freshly harvested beets at any given temperature (T° F.) can be calculated by first converting the losses in Figure 1 at 70° F. to the losses at 40° F. by dividing by four and calculating the losses at any given temperature above 40° F. by the formula:

Loss (lbs. sugar per 1000 tons per hour

or

Loss (lbs. sugar per 1000 tons per hour $= 10.42\ (10^{.02007\ (T-40)})$

A graph showing the pounds sugar loss per hour per 1,000 tons of beets, calculated from temperature data of ventilated and unventilated beets by use of the above formula, is more convenient in estimating losses for short periods of retention in bins such as those reported by Orleans and Cotton. The savings in sugar, due to the use of forced ventilation on 225,000 tons of beets (3750 tons per day x 60 days) for the temperature differences reported for 1949 and 1950, would be as indicated in the following table:

Table 1.—Calculated Savings by Ventilating Sugar Beets for Short Periods of Storage Based on Temperatures of Ventilated and Check Bins at Carlton, California, in 1949-1950 (3) and Assuming a Total of 225,000 Tons of Beets Processed.

Average Retention Time in Bins	Sugar Saved Based on: 1949 Data	1950 Data
Hours	Pounds	Pounds
4	17,460	6,187
6	31,365	11,880
8	47,205	19,102
12	82,125	36,990
15	110,002	51,830
18	147,000	68,000

In addition to the respiratory sugar losses on which the data in Table 1 are based, Cotton and Orleans reported perceptible differences in purity loss during short periods of storage. The smaller loss of purity of the ventilated beets would also improve the extractability of the sugar present in these beets.

It is also possible to calculate from weather data at a given location the cooling of beets that could be expected by forced ventilation. Previous studies (5) have shown that the ambient air rapidly absorbs heat and increases in humidity in passing through a column of beets. Actual measurements of the cooling effected closely approximated the total calculated values obtained by heat transfer and evaporative cooling. Open piles might be further cooled by winds and increased draft through the sides of the piles induced by blowing air up through the piled beets.

References

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