Michigan State College Sugar Beet Storage Experiment

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THE PROBLEM of storing sugar beets at the processing plant without sugar loss has long been recognized in the Eastern area. The acceptance of the harvester has made this problem more acute. The farmer wants to deliver his beets as fast as he can harvest them. Consequently, proper means must be found to receive and store the beets until such a time as the plant can process them. Often this period is marked by "Indian Summer" temperatures which do not go below 65 degrees Fahrenheit. Data collected by Stout and Fort (4)[2] shows that beets stockpiled during warm periods will lose sugar at the rate of ¼ to 1 pound per ton of beets per day depending upon the prevailing temperature. The magnitude of this problem is realized when we consider the Eastern Area crop stored over a period of 30 days. The storage period with damaging temperatures has resulted in a loss of approximately $1,500,000 per year for the past several years.

Engineers, pathologists, botanists and horticulturalists have combined their efforts to find a solution for the problem. Progress has been made.

The purpose of the Michigan State College experiment is to evaluate some phases of published data in terms of the eastern climatic conditions, and set up a project to determine sucrose loss under a series of prescribed treatments which have some possibility of succeeding industrially.

The project consisted of a series of five forced-air treatments and three treatments using various rates of a chemical composed largely of sodium carbonate and a check.

Description of Equipment

It was found that the J. I. Case experimental hay-curing barn could easily be adapted to such a project. This barn has 12- by 20-foot compartments which are protected with an aluminum roof. Three of the compartments were completely enclosed while the remainder had two sides open. The sugar beet storage project was carried on in the open compartments. It was hoped that this protection would eliminate one variable, namely that of beet absorption of solar energy. Building paper was used to seal the side walls against air leaks, and reduce thermo-conductivity from one treatment to another. However, it was found that the treatments in the bins exposed to the south sun were at a disadvantage due to the wall's being exposed to sun which made 1 to 2 degrees Fahrenheit difference in the diurnal temperatures of the beets 1 foot in from the wall.

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[2]The numbers in parentheses refer to literature cited.

The floors were made by heavy wire mesh laid over joists, making it possible to force air through the bins from the bottom.

Seven 6- by 10-foot bins were built into the compartments. Each bin was 8 feet deep and was large enough to carry approximately 10 tons of beets. Six of the bins were used for ventilation tests while the seventh was divided into three equal parts for chemical treatment of beets. A 1,000-c.f.m. fan was used at the end of a main tunnel with laterals feeding air to the respective bins. The air was metered to each bin at the main tunnel by small adjustable openings.

Instruments for Recording Temperatures.—Temperatures were taken by an electronic recording potentiometer and copper-constantan thermocouples. All thermocouples were calibrated to a mercury thermometer in stirred water bath prior to installing and were found to be correct to ± .4 degrees Fahrenheit. Temperatures were taken at eight points which were located as the beets were binned to give representative recordings throughout. At each point two thermocouples were installed; one in a beet and another recorded the air 6 inches away. This method of installation gave an opportunity to study temperature of the beets and of the air passing through the voids. A thermocouple was placed to record the air temperature as it entered the fan. The temperature of the air as it entered the beets was somewhat higher due to the heat generated by friction as it passed through the tunnel.

Experiment Operations

Weight Loss and Sugar Analysis Data.—Freshly harvested beets were run over a Silver Roberts piler and weighed as they were binned. They were weighed again at the conclusion of the experiment. Each load was tared to determine actual usable beet tissue in the bins. All dirt lost in handling was recorded. Ten samples for sugar analysis were taken as beets were binned to secure a representative cross section of the beets for each treatment. Care was taken to select beets from the same areas as the bins were unloaded.

Fan Operation.—The fan was operated during the night hours and in one case it was operated when the temperature of the beets was higher than the air which could be forced through the beets.

Temperature and Humidity Data. Air and beet temperatures and relative humidities were recorded at 6-hour intervals beginning at 6 p.m. of October 15. The quantities of air were calibrated with a velometer after the bins were filled. The water vapor in the air blown into beets has much to do with the keeping qualities. It is for that reason that relative humidity of the air entering the fan and the air leaving the bins was secured. The relative humidity data were secured by means of a sling-psychrometer. These data were obtained from the air as it entered the fan and as it left the beets.

Treatments

A. Check.—The bin used for this purpose was sealed with building paper over the wire-mesh floor. The purpose of this floor covering was to restrict natural thermo-siphoning of the air and tended to stabilize the temperature within the bin. It also gave the best possible check which would be congruent with the exploratory treatments.

B. The beets were wet down 5 days after binning. Ten cubic feet of air per minute per ton of beets were then forced through the beets for each successive night the fan was in operation. The quantity of water was not ascertained but enough was poured over the bin to run freely from the drain at the bottom. Wetting down was repeated on the seventh and ninth days of the experiment.

C. The beets in this treatment were subjected to 10 c.f.m. of air per ton of beets during the periods in which the fan was in operation.

D. No air was forced through the beets in this treatment until 5 days after they were binned. The purpose of this was to determine whether or not a bin of beets could be brought under control after respiratory action had passed through a number of cycles.

E. The beets were sprayed with water as they were binned. No measure was given water but there was no apparent excess after gravational waters had run free. The washing operation removed some dirt, the weight of which was accounted for by a tare figure. Ten cubic feet of air per ton per minute were forced through the beets during the period in which the fan was in operation.

F. This treatment is similar to treatment C except that the c.f.m. of air was increased from 10 to 20.

G_1 A chemical dust was used to coat the beets as they were loaded into the bins. This dust is composed of a compound which has growth inhibiting qualities and has been used with some degree of success in storage of small grains such as shelled corn, wheat, oats, barley and beans. It was felt that it might have some value in storage of sugar beets. The chemical analysis of this compound is:

$CaCO_3$—22.50 percent
Na_2CO_3— 9.03 percent
$NaHCO_3$—60.83 percent
SiO_2— .31 percent
$MgCO_3$— 5.75 percent or MgO—2.75 percent

Beets were treated with 1 pound of dust per ton.

G_2 Two pounds of the above chemical per ton of beets.

G_3 Five pounds of the above chemical per ton of beets.

Discussion

The criteria for evaluating the results of this experiment is the number of pounds of sugar saved per ton of fresh beets. But, before studying these data, it is quite desirable that we first concern ourselves with those data secured, throughout the progress of the experiment—namely, temperatures and relative humidities. The treatments will be discussed in chronological order from the least to the most effective.

Temperature and Humidity Data by Bins. (G_3), (G_2), (G_1).—The average temperature of the beets in bins G_1 and G_3 followed somewhat the same curve as the outside air and tended toward the extremes of the second day (figure 1). The beets in G_2 followed the mean outside temperature of the second day. All three bins remained below the check bins' temperature, after the second day. These treatments were not at all effective inasmuch as they lost more sugar than the check and, therefore, do not warrant any further discussion at this time.

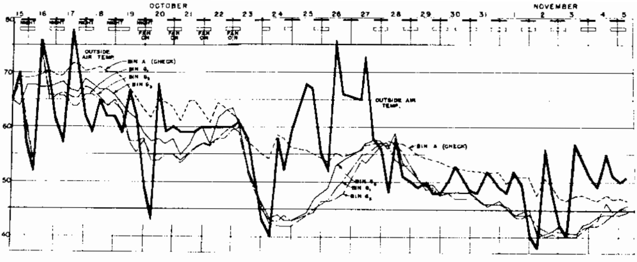

Figure 1. Average bin temperatures for bins G_1, G_2, G_3. Beets were treated chemically as they were loaded into the bins.

D. You'll recall that in this treatment 10 c.f.m. of air were first blown into the beets 5 days after the beets were loaded into the bins.

The average temperature did not follow that of the check bin at the start (figure 2). This is ascribed to the fact that there was a 3-foot space below the beets tending to give a stabilized effect. The radiation of the earth below the bin cooled at least a portion of the beets. October 21 air was blown through the beets for the first time. Beet temperature dropped slightly below the check bin and finished the experiment somewhat higher. This is partly attributed to the fact that one wall was exposed to the south.

The relative humidity of the air entering the fan is plotted in the second graph (figure 2). As was expected, the peaks of this graph occur during the night. The third graph shows the pounds of water vapor which were retained or lost during the fan's operation. This broken curve can be correlated with the air temperature and the subsequent temperature of the beets.

It points out the tendency for the beets to take on water vapor after each time the bin temperatures dropped. In most cases the quantity of the water vapor was not lost or gained in proportion to the increase in volume of air.

B. The beets in this treatment were wet down on October 19 and 10 c.f.m. of air turned into them for the first time. This partly accounts for the rapid decrease in temperature (figure 3). The beet temperature again responded to a wetting down on October 20 when it dropped below the recorded night temperature. The relative humidity of the air above the bin was slightly higher than in the other treatments, after each wetting. No doubt greater cooling by evaporation might have been accomplished if air had been blown through during the daylight hours, when the relative humidity of the incoming air was low.

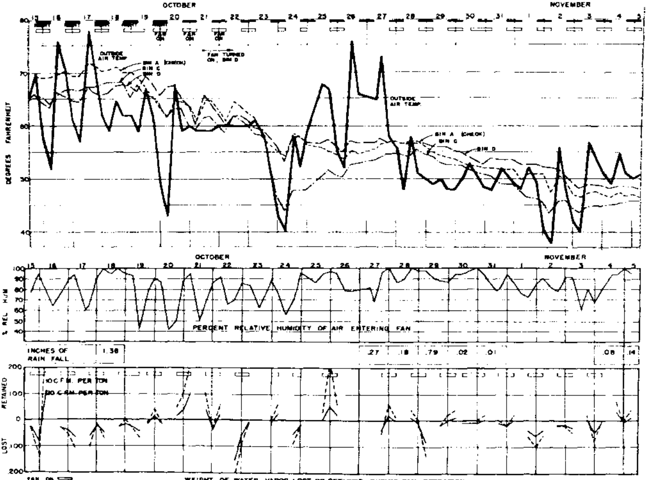

Figure 2.—Data pertaining to treatments A, C and D.

C. The beets in this treatment were given 10 c.f.m. of air per ton. The temperature of the beets was somewhat lower than the check bin at the start and dropped to 45 degrees Fahrenheit (figure 2) the night of October 23 and remained below that of the check to the conclusion of the experiment. Advance stages of decay localized about the thermocouples. The cool air blown into the bin was enough to limit the decay and permitted the "dead" beets to remain cool.

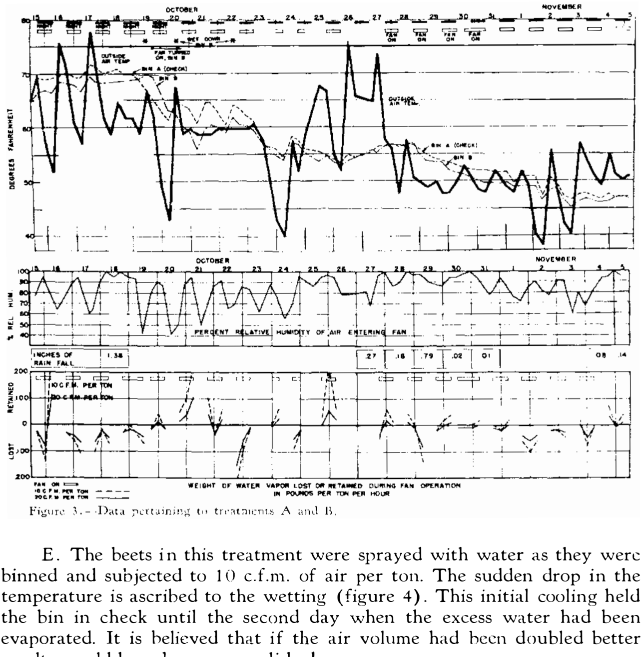

Figure 3.--Data pertaining to treatments A and B.

E. The beets in this treatment were sprayed with water as they were binned and subjected to 10 c.f.m. of air per ton. The sudden drop in the temperature is ascribed to the wetting (figure 4). This initial cooling held the bin in check until the second day when the excess water had been evaporated. It is believed that if the air volume had been doubled better results would have been accomplished.

F. This bin of beets was blown with 20 c.f.m. of air per ton Although they did not markedly respond to the increase air volume at first the bin temperature curve does dip during the night hours (figure 4). The temperature remained below that of the next most successful treatment, namely treatment E.

Analysis of Final Results.—A better understanding of condition of beets and a better evaluation of each method might be afforded by a thorough study of the following creptic summary. As was mentioned previously, the criteria for evaluating a method is the saving of sugar. The total weight loss is not proportional to sugar loss due to the decomposition of beet tissue.

The check treatment shall be considered first and the other treatments shall be again discussed in chronological order from the least to the most effective. (Figure 5.)

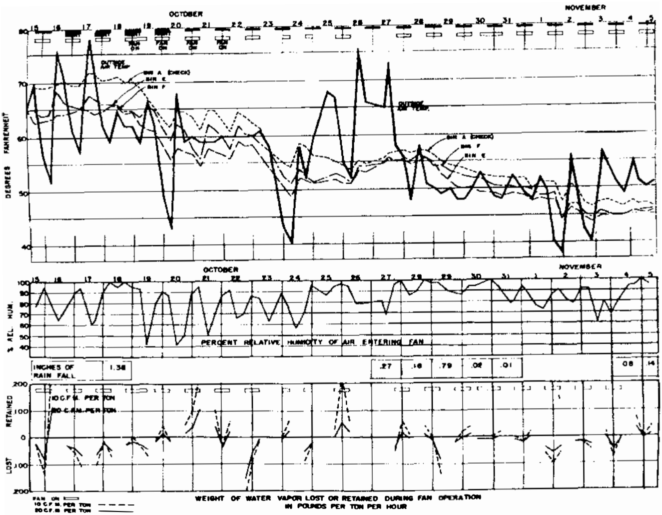

Figure 4.—Data pertaining to treatments A, E and F.

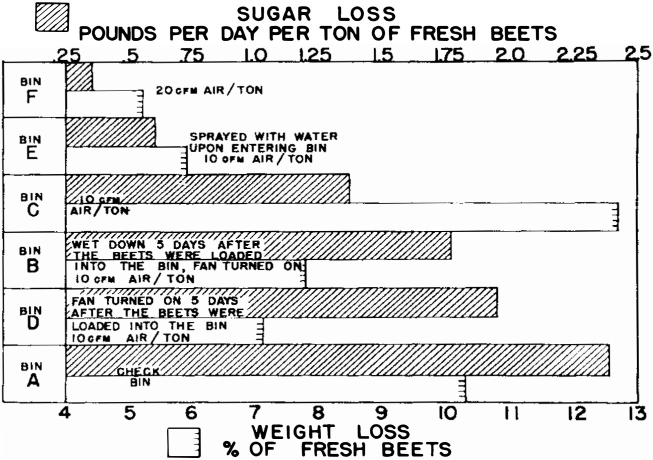

Figure 5.-- Summary of the sugar and weight losses.

A. Check treatment in which beets were put into a bin with sides and bottom sealed.

Sugar lost—2.24 pounds per day per ton of beets.

Loss in weight of beets—10.3 percent.

Tare for bin—.6 percent.

Active leaf growth on crowns—.2 percent, localized on top layer.

Decay—2 percent, only isolated cases.

Mould growth—heavy.

Dehydration—noticeable on top half.

(G_3), (G_2), (G_1).—The beets in these three treatments were covered at the rates of 5 pounds, 2 pounds and 1 pound of chemical per ton, respectively.

Sugar lost—4.66, 4.11 and 2.60 pounds per day per ton of beets.

Loss in weight of beets—13.6, 8.5 and 11.6 percent respectively.

Tare for the bins—.6 percent.

Active leaf growth on crowns—none.

Decay—9, 5 and 1 percent respectively.

Dehydration—G_2 not to the extent of others.

D. The 10 c.f.m. of air per ton was not forced into bin until after heating had started. It was quite evident that the beets were not brought under control soon enough to make treatment effective.

Sugar lost—1.90 pounds per ton per day.

Loss in weight—7.1 percent.

Tare—.7 percent.

Active leaf growth on crowns—none.

Decay—1 percent.

Mould growth—about trash, heavy, extending to light at top and bottom.

Dehydration—1.3 percent.

B. Beets in this treatment were wet down 4 days after binning, as was mentioned previously and 10 c.f.m. of air per ton of beets were turned into them for the first time. This treatment was not too successful due to the fact that the beets had passed through one or two heat cycles. Tissue breakdown had no doubt taken place.

Sugar lost—1.7 pounds per ton per day.

Loss in weight—7.79 percent.

Tare—1 percent.

Active leaf growth on crowns—95 percent.

Decay—1.2 percent.

Mould growth—minimum about trash.

Dehydration—noticeable on top and bottom layers.

C. The beets in this treatment were blown with 10 c.f.m. per ton during night hours.

Sugar lost—1.32 pounds per ton per day.

Loss in weight—12.07 percent.

Tare—.8 percent.

Active leaf growth on crowns—30 percent.

Decay—.3 percent.

Mould—light mould prevailed throughout.

Dehydration—top and bottom layer.

E. The beets in this treatment were sprayed with water as they were being binned and blown with 10 c.f.m. of air per ton during night hours. Treatment quite successful.

Sugar loss—.57 pound per ton per day.

Weight loss—5.89 percent.

Tare—.5 percent.

Active leaf growth on crowns—50 percent.

Mould—very light—freshness nearly equal as to when they were binned.

Dehydration—merely noticeable.

F. The beets in this treatment were blown with 20 c.f.m. of air per ton during night hours. The treatment was most successful.

Sugar loss—.33 pound per ton per day.

Weight loss—5.2 percent.

Tare—.7 percent.

Leaf growth—none.

Decay—none.

Mould—very slight.

Conclusions and Recommendations

1. Means must be found to remove more of the trash before the beets are stockpiled. Decay and mould always starts in the trash where air could not penetrate.

2. Stock piles should have 20 to 30 c.f.m. air forced through them during night hours until the temperature drops—5 to 10 c.f.m. would then be sufficient to hold them. This recommendation has been given by Brooks and Bainer (2).

3. Limited wetting of beets as they are stockpiled indicates that it will be a successful method of controlling temperatures if enough air could be forced into the pile to cause sufficient evaporation. Beets which are too moist will grow readily in warm temperatures.

4. A severely injured and improperly topped beet does not keep well. The harvester must be in best possible adjustment.

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