Sugar Beet Storage Experiment, 1947

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A substantial saving in sugar was obtained by blowing cold night air through a beet storage pile at Rocky Ford, Colorado, in the fall of 1946. The sugar loss in the ventilated pile was 0.3 pound per day per ton of beets stored, while the loss in the non-ventilated pile was 0.5 pound per day per ton of beets stored. This difference was obtained under ideal beet-storage conditions and for a storage period of only 20 days.

In view of the results obtained in 1946, another test was conducted in the fall of 1947 at Rocky Ford, Colorado.

Experimental Procedure

Two storage piles were made, one of 1,178 tons and one of 1,128 tons. Five wooden ducts placed at right angles to the pile were spaced at 12-foot intervals under the 1,178-ton pile, as it was being made. These ducts were made with 3- by 12-inch sides, spaced 19 inches apart. They were strengthened crosswise at 4-foot intervals with pieces of 2- by 4-inch lumber on top and bottom. Two 3- by 12-inch planks were then nailed on top, leaving a 1-inch space between. This construction left a 1-inch space along the middle of the top of the duct and a 2-inch gap along the sides where the 3- by 12-inch planks rested on the 2- by 4-inch braces. The ducts were made up in 10-foot lengths to facilitate handling. The 10-foot lengths were fitted together as the piling progressed.

In placing the ducts under the pile, one end of each duct projected 2 feet beyond the side of the beet pile. This end of the duct was covered with a filter cloth for a distance of 8 feet into the pile to prevent escape of air before reaching a distance into the pile. The other end of each duct was closed and blanked off, and came to within 8 to 10 feet of the opposite side of the pile.

A fan, with a capacity of 2,400 cubic feet of air per minute, was placed in the projecting ends of each of the five ducts. When all five fans were operating, this made a total capacity of 10 cubic feet of air per ton of beets stored.

During the process of making the two piles, captive samples 20 beets each, enclosed in wide-mesh fiber sacks, were placed at different levels in each of the two piles. There were 45 of these captive samples placed in each pile. These samples were selected as follows: A sufficient quantity of beets was taken from each truck-load to make up two 20-beet samples. The beets for each of the 20-beet samples were selected in pairs as nearly equal in size, shape, type of topping, etc., as possible. One beet from each pair went into one 20-beet sample, and the other beet into the second 20-beet sample.

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One of the 20-beet samples was placed in a water-proofed sampling bag, taken to the laboratory, divided into two 10-beet samples, and analyzed for sucrose, within a period of 24 hours. The beets in the duplicate 20-beet sample were numbered, weighed individually, placed in a wide-mesh fiber sack and placed in the pile as soon as possible.

Temperatures of the beet piles were obtained by hanging stem thermometers inside ½-inch pipe which had been driven into the beet piles at different levels. Six thermometers with rubber tubing over both ends were suspended 6 feet below the surface of each pile and six thermometers were suspended at the 12-foot level below the surface of each pile. Readings were made three times (8:00 a.m., 1:00 p.m., and 5:00 p.m.) a day for the first 2 weeks but only twice (8:00 a.m. and 5:00 p.m.) for the remainder of the storage period.

As soon as the experimental pile was completed, the top, the south end, and the west side were covered with a lime slurry in order to reflect the sun's rays. The fans were turned on the same night. The fans were operated from 9:00 p.m. to 6:00 a.m. when temperatures were suitable.

The two piles, one with ducts referred to as the experimental pile, and one piled in the regular manner referred to as the check pile, were in storage for a period of 40 days.

Results

The initial temperature of the beets going into the experimental pile was approximately 63 degrees Fahrenheit, while the temperature of the beets going into the check pile was 56 degrees Fahrenheit. Due to a drop in air temperature, all of the beets in the check pile, except approximately 80 tons, went in fairly cool.

A hot spot started to develop on the end of the check pile 5 days after the pile had been completed. The temperatures in this spot continued to go up and by the tenth day of storage the thermometers registered up to 88 degrees Fahrenheit. Approximately 240 tons of beets were removed and processed in order to save them. At least 5 to 7 tons of beets removed at this time were badly decayed. One of the samples which happened to be in the center of this spot was analyzed for sucrose and was found to have a reading of 1.15 percent. The duplicate sample which was analyzed at the time of piling tested 16.55 percent sucrose.

Temperatures

The average temperatures for the two piles and the average daily mean are presented graphically in figure 1.

The average temperature for the experimental pile for the last 35 days of storage was 38.4 degrees Fahrenheit, while the corresponding figure for the check pile was 50.2 degrees Fahrenheit. This makes an average temperature differential of 11.8 degrees Fahrenheit between the two piles.

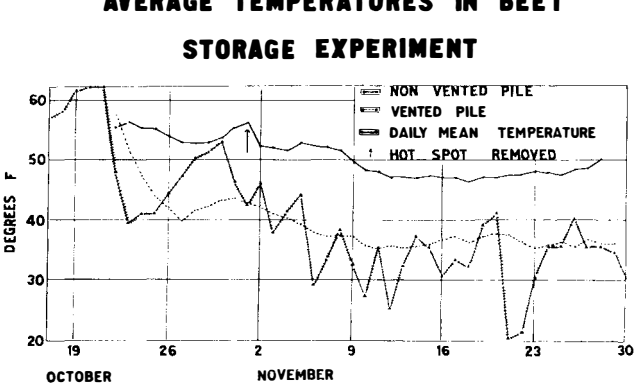

Figure 1.—By use of forced ventilation, the temperature of the experimental pile was reduced from around 58 degrees Fahrenheit to 40 degrees Fahrenheit in the first 6 days of storage, while the average temperature of the check pile was 54 degrees Fahrenheit. Although temperatures were taken at 6- and 12-foot levels below the surface of the two piles, for summarization purposes the readings for the two different levels were averaged for each pile. During the period of storage the relationship between temperatures at 6 and 12 feet below the surface of the experimental pile was fairly constant. The temperature at the 12-foot level was approximately 4 degrees Fahrenheit cooler than at the 6-foot level. This relationship was not nearly as constant in the check pile, due in most cases to small centers of mold which developed at the different depths.

Losses from Shrinkage

A total of 43 of the special samples were recovered from the experimental pile. The total weight of these samples before they were placed in the pile was 1,624.7 pounds. The weight after being in storage 40 days was 1,576.9 pounds. This represents a shrinkage in weight of 2.94 percent.

Forty-three of the original 45 samples in the check pile were also recovered. The original weight on these samples was 1,574.99 pounds, while the weight on recovery from the pile was 1,429.20 pounds, or a shrinkage in weight of 9.26 percent for the 40-day storage period.

Sugar Losses

The average sucrose for the duplicate samples for the experimental pile which were analyzed at the time of piling, was 16.76 percent. The average sucrose of the 43 samples recovered from the experimental pile was 17.13 percent. This represents a gain in sugar percentage of 0.37 percent.

The average sucrose of the 43 duplicate samples for the check pile, which were analyzed at the time of piling, was 16.75 percent. The average

sucrose of the 43 samples recovered from the check pile after 40 days of storage was 15.14 percent. This represents a loss in sugar percentage of 1.61 percent.

Shrinkage and Sugar Losses

The shrinkage loss and the loss in sucrose, as well as the losses of sucrose per ton per day of storage, are presented in table 1.

Table 1.—Comparative results of beets stored in experimental pile and in check pile.

	Experimental Pile			Check Pile		
	Initial	End of storage	Loss or gain	Initial	End of storage	Loss or gain
Total weight of samples (lbs.)	1624.71	1576.92	-2.94%	1574.99	1429.20	-9.26%
Average percent sucrose	16.76	17.13	+0.37	16.75	15.14	-1.61
Pounds sugar per ton of beets	335.2	330.3	4.9	335.0	274.76	-60.24
Loss of sugar per ton per day stored (lbs.)			-0.122			-1.505

By calculating losses on a tonnage basis, it is found that the loss of sugar per ton per day of storage was 0.122 pound in the experimental pile, as compared to a loss of 1.505 pounds sugar per ton per day of storage in the check pile.

Discussion

The loss of 1.505 pounds sugar per ton per day of storage in the check pile appears to be high for the temperature differential that was maintained between the two piles. However, spoilage of beets, due to micro-organisms, influenced sugar losses. Individual beets, in samples taken from the check pile, showed lesions which quite often penetrated to the heart of the beet. Also, there were some samples which showed rot on all 20 of the beets in the sample.

The only places in the experimental pile where mold was present was on the tip ends of the beets. This was due, to a large extent, to partial wilting of the beets due to the high temperatures occurring at the time of piling. There was also some mold in the experimental pile caused by packing of beets in the paths followed by the experimentalist when temperature readings were secured. Laying planks between the temperature stations would probably eliminate some of the damage due to this cause.

Observations on the check pile and on other beet piles indicate that beets going into piles in a wilted condition are one of the chief focal points for the development of micro-organisms and the subsequent development of hot spots. Although many of the beets going into the experimental pile were more or less wilted, the fairly rapid drop in temperature made conditions quite unfavorable for the development of the micro-organisms. However, even where forced ventilation is practiced, it would be much more advantageous to process wilted beets immediately rather than storing

them. There is always the danger that night temperatures may not be low enough to cool the pile to temperatures unfavorable for moderate growth of molds and bacteria.

There is no doubt that if night temperatures are low enough, forced ventilation of beet piles will result in substantial reduction in sugar loss in the average storage season. In seasons unfavorable to beet storage, such as the high temperatures experienced in the 1947 season, the reduction in sugar loss in beets under controlled storage will be sufficient to make a substantial return on the investment required for controlled storage equipment.

Summary

The temperature in a 1,178-ton pile of sugar beets was lowered from 58 degrees Fahrenheit to 40 degrees Fahrenheit in 6 days by the use of forced ventilation with cool night air. The average temperature maintained in this pile was 38.4 degrees Fahrenheit as compared to 50.2 degrees Fahrenheit for a non-ventilated pile.

Losses due to shrinkage in weight were 2.94 percent in the experimental pile, as compared to 9.26 percent in the check pile.

Samples placed in the experimental pile lost 0.122 pound of sugar per ton per day stored, while the samples in the check pile lost 1.505 pounds sugar per ton per day of storage.