Summary of Storage Studies from 1959 to 1970 and Methods Used For Covering Commercial Sugarbeet Piles

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Storage investigations in commercial beet piles were started during the 1959-60 storage season. Early investigations were made to study the magnitude of sugar losses and other changes in the beets during storage in commercial piles and to evaluate the effects of time in storage.

Paired captive samples have been used for all studies being reported. Samples were obtained by digging consecutive beets down the row in commercial fields and dividing them into the number of samples desired. As an example, if two ten-beet samples were needed, then twenty consecutive beets were dug and divided into two samples by visually stratifying according to size so the two samples would be composed of beets of comparable sizes and have approximately the same total weight. The beets were washed and tared with a standard tare machine then weighed. One sample of each pair was immediately run through the laboratory for pre-storage analyses and the other was placed in a nylon mesh bag to which a nylon cord was tied for anchoring the sample in the storage pile (Figure 1). The captive samples were retrieved when the piles were removed for processing, and sent to the laboratory for analyses. Changes in storage were determined by the differences in lab analyses between the paired pre-storage and stored samples.

Following is a summary of results from the first three seasons of testing in uncovered commercial piles:

1. Pile temperatures declined from 50 to 55 F at the time of piling in late October for the first 30 to 45 days of storage to near an average of 40 F after which they remained relatively constant.

2. Sugar losses in the interior of the piles averaged 0.27 lbs per ton of beets per day or approximately 0.31 lbs/ton/day with the surface layer of beets included.

3. Average shrink was 3.3% and the average reduction in % sucrose was 0.35 at 65 to 70 days in storage.

4. There were significant changes in invert content, kestose content, raffinose content and purities of the roots during storage with the changes in raffinose content being erratic from year to year.

5. There were deviations from the general relationships of time in storage to changes in the roots indicating that factors other than length of time in storage affected the changes. It is thought that temperature differences between series of samples representing different lengths of storage time contributed to these deviations because the series of samples for any given time in storage were located in different cross sections of pile.

In 1966-67, a 4,000 ton pile of beets having interior ductwork and circulating fans for ventilation was covered with plastic and sealed. Tectrol generators such as used for apple storage were used to control the oxygen and carbon dioxide content of the storage atmosphere. Although control of the pile atmosphere was achieved with an average oxygen content of 6.55% and 2.75% for carbon dioxide, control of the pile temperature was not adequate.

At the outset it was anticipated that the low oxygen content of the pile atmosphere would slow respiration and thus reduce the heat of respiration in the pile and that this source of heat would dissipate through the plastic cover as well as the heat from the modified atmosphere being introduced. This did not occur and the pile temperatures gradually increased.

Temperatures rose to 55 F and with the accumulation of moisture on the top of the pile a condition conducive to mold and bacterial growth developed. Outside air was introduced into the closed system in an attempt to cool the pile causing the oxygen content to increase to normal. As a consequence, the mold and bacterial growth developed extremely fast on top of the pile. The layer of beets on top began to deteriorate and rot rapidly to a depth of about one foot so the test was terminated. The beets in the balance of the pile were still in as good condition as the check pile.

This trial was followed by another C.A. study in 1967-68 in which the samples were stored in a cold storage room equipped with a Tectrol C.A. unit, refrigeration, and a fog type humidifier. The controls were set to maintain the storage atmosphere at a temperature of 40 F with humidity near saturation and with a composition of 4% oxygen and 5% carbon dioxide. Two series of 100 samples were stored in the controlled atmosphere room and a third series of 100 samples was stored in a plastic covered commercial pile as a check. The average temperatures were 39.7 F in the cold storage room and 42.0 F in the check pile during the storage period.

The results of the test showed a substantial savings in beet quality of the samples stored under controlled conditions in comparison to those stored in the commercial pile (Table 1). There was no way, however, to separate the effects of controlled temperature and humidity from the effects of controlled oxygen and carbon dioxide contents.

In 1968-69 and 1969-70 another approach to C.A. was tested because of the high cost of using Tectrol units. This involved two 40-ton ventilated storage piles both of which were sealed under plastic and equipped with refrigeration (Figure 2). In addition, one pile was equipped with a system whereby part of the circulating air passed through a box containing lime. The composition of the atmosphere in this pile was to be controlled by the respiration of the beets which would lower the oxygen content. The excessive carbon dioxide was removed by the lime. Only partial control of the atmosphere was accomplished because of undetectable leakage during the operation of the circulatory system, and during windy weather the oxygen levels would increase appreciably. In an attempt to maintain the oxygen content at 5%, the circulating fans were turned off overnight periodically which resulted in slight temperature increases. Thus, the

Figure 1. Captive samples in nylon mesh bags being distributed across the face of a pile to be covered by the subsequent swings of the piler boom. Nylon cords tied to the bags extend to the top of the pile where they are anchored.

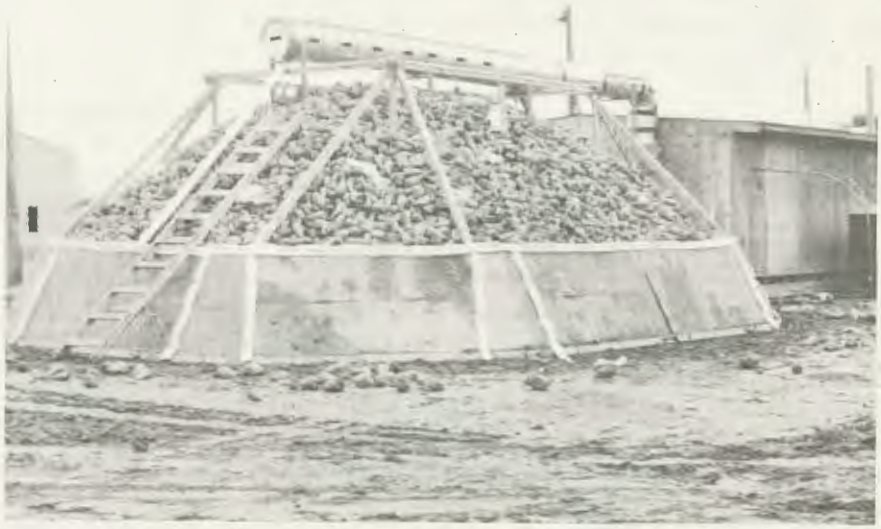

Figure 2. An experimental pile of beets of approximately 40 tons equipped with refrigeration and circulatory ducts. The return duct is under the center of the pile. It is ready to have the plastic covering applied with the bottom edge to be buried in the ground.

average storage temperatures in the piles having C.A. were approximately 3.5 F higher than the piles having only refrigeration with near normal oxygen and carbon dioxide levels.

The sugar losses and changes in the other constituents measured, were less in the piles having refrigeration only than in the C.A. piles which was most likely due to differences in temperature (Table 1). Both treatments gave storage which was superior to the commercial check piles; however, the samples stored in the refrigerated piles had no more sugar loss than those stored in the C.A. room in 1967-68. From these results it was quite evident that the prime factor affecting changes in beets during storage was temperature and that any system to regulate oxygen and carbon dioxide in the storage atmosphere would not be feasible for commercial storage particularly when considering that a major investment would be needed for equipment and to construct sealed pile coverings.

COMMERCIAL PILE COVERING

The use of polyethylene sheets to cover the sides of piles has been a general practice on piles to be processed late in the season. The purpose of the covering is to prevent freezing inward from the sides of the piles. The covers are held in place by wrapping the edges of the plastic around boards and anchoring the boards and plastic to the piles with metal stakes. In addition, nets, old tires, and anchored boards have been used to prevent the plastic from billowing and whipping in the wind. Many small variations in the side coverings have been tried. It has been found best to cover the sides to within 2 to 3 feet below the crown of the pile to allow warm air to escape before reaching the crown rather than covering all the way to the top. Skirts at the base of the piles which can be raised to increase ventilation for cooling during above freezing weather have been used on some piles.

Various types of top coverings including straw, perforated plastic, and canopies have been tried. Perforated plastic appears to be the best for top protection, but nothing tried to date has been entirely satisfactory for dispersing freezing down drafts while allowing the escape of warm air, so no top coverings have been used the past two seasons.

A wood fiber product, Silvacel, has been applied to sections of piles on a trial basis. It provides insulation against rapid freezing and thawing, yet allows better cooling than when covering with plastic.

Schedules are made for side covering on the basis of time to processing and access to the piles. For example, piles to be in storage until after December 15 are covered on the side away from the railroad track. Those to be in storage until after Jan. 1 are to have both sides covered. All covers are to be put on the piles prior to weather which would freeze the beets.

One major problem encountered in the success of pile covering is the fact that storage seasons vary greatly. A practice which is successful one season may not be the best for the next season.

Generally, covering the sides of piles has caused average storage temperatures to be a few degrees higher than when piles were left uncovered.

Table 1.

Average Changes in Constituents of Beets During Storage

Constituent	1967-68		1968-69				1969-70			
		Check[4]			Checks[4]				Checks[4]	
	C.A.[2]	With Cover[5]	C.A.[3]	Refrig.	With Cover[5]	No Cover	C.A.[3]	Refrig.	With Cover[5]	No Cover
Days in Storage	106	119	106	106	108	108	96	96	100	80
Reduction in % Sucrose	1.22	1.83	1.13	0.83	1.41	1.27	0.41	0.19	1.00	0.52
Increase in Invert[1]	1.96	5.25	2.63	1.94	3.27	3.42	1.61	0.93	3.33	2.85
Increase in Kestose[1]	0.78	1.33	1.54	0.89	2.20	1.64	0.89	0.44	3.03	0.83
Reduction in S.T.J.P.	3.28	5.75	4.27	3.52	4.11	5.06	2.31	1.07	4.44	2.31
Sugar Loss, Lbs./T./Day	0.27	0.46	0.30	0.25	0.40	0.45	0.24	0.22	0.39	0.31

1 % on sucrose.

2 Cold room storage, Tectrol unit.

3 In 40 ton piles, using lime to remove CO_2.

4 Commercial piles.

5 Sides covered with plastic.

The warmer temperatures would have caused some increase in sugar loss due to increased respiration throughout the pile although the beets on the surface under cover were in better physical condition than those not covered.

Side covering had been satisfactory in protecting against frost penetration until the 1972-73 storage season when there was an abnormal cold spell from December 5 to December 17 with sub-zero temperatures for nine consecutive nights followed by moderating, near normal temperatures and later, rain. Freezing occurred through the plastic coverings with deep penetration at the edges of the covers. Deep frozen cones developed down from the tops of the piles, many extending to the ground. As thawing proceeded after the weather moderated, the beets began to deteriorate and rot. The greatest problem developed from the frozen cones extending down from the top and down from the upper edges of the sidecovers.