Losses of Sugar from American Crystal Sugar Company Commercial Storage Piles

E. L. Swift, Director
Agricultural Research
American Crystal Sugar Company

In all of our factory areas, excepting Clarksburg, California, we must store extremely large quantities of sugarbeets for long periods of time to utilize our sugar processing equipment and personnel more efficiently.

This report deals primarily with sugarbeet storage in the Red River Valley areas of North Dakota and Minnesota, where a large portion of our company beets are stored for extended periods. This also includes a short report on the Clarksburg, California; Rocky Ford, Colorado; and Mason City, Iowa areas where some freezing and thawing occurs on the surface of piles. In the Red River Valley up to one-half of the beets in the piles may be frozen solid, and once the beets are frozen they generally stay frozen. The storage piles are formed as large as possible to minimize surface losses and to reduce shrink (loss of weight). Beets from the storage pile even after long periods of storage, generally appear to be of excellent quality, (white and turgid) with no apparent rotten beets except from a few "hot spots".

Beets in the Clarksburg area of north central California are generally processed within a few hours of harvest. All of the beets for this plant are trucked directly to the factory by the grower. In the later part of the fall harvest season and early part of the spring, a small storage pile is generally formed to provide standby beets for a short rainy period so that the mill operation will not be disrupted by light rains. If it is necessary to hold this storage pile for any length of time, the beets are generally sliced out in good weather and the pile rebuilt.

Even under the most optimum harvesting conditions approximately 27,604 tons of beets (past 4 year average) are stored for approximately 10 days. Temperatures in this storage pile average about 70 F, or at best the lost of sugar from these small piles would amount to more than 276,000 pounds of recoverable sugar. (This 1 pound per ton per day loss of sugar is estimated on work reported by Stout, Wyse, and from our own American Crystal Sugar Company work on beet storage).

In the Rocky Ford area of southeastern Colorado and southwestern Kansas, harvest and storage of the beet crop follows the more normal pattern, with approximately 221,684 tons of beets (past 4 year average) stored annually. These beets are stored in comparatively small outside piles and are reloaded into rail cars for delivery to the processing plant as needed. This tonnage of stored beets provides for at least 70 days of plant operation, or the average ton of stored beets is held for 35 days. The average temperature in the storage pile in this area is 51 F. Under the most ideal simulated storage conditions that we have been able to produce at this temperature, the average ton of beets would lose 24 pounds of recoverable sugar. (This assumes no rot or unusual loss and assuming ideal storage at this temperature) On this basis, 5,320,416 pounds of recoverable

sugar would be lost each year from stored beets in the Rocky Ford factory area if storage conditions are near perfect, and they are far from perfect.

From the Mason City area, beets are harvested and stored in the usual pattern with 184,646 tons of beets stored annually (past 4 year average). These beets are in addition to the beets processed during harvest. Assuming an average factory slice on these stored beets, this tonnage would provide raw material for 88 days of factory operation. The average beet ton would thus be stored 55 days at approximately 51 F temperature in the storage pile. From the work we have done on similar beets stored at a 51° controlled temperature and with other variables near perfect, we would expect a loss of a minimum of 38 pounds of recoverable sugar per ton of beets stored. This loss of recoverable sugar would amount to a minimum total of 7,016,548 pounds of sugar annually. Conditions in outside beet storage we believe are not nearly comparable to storage under our controlled conditions, so that the actual loss would probably be much greater.

To assess the loss of sugar in Red River Valley storage piles (where we operated four processing plants all on an average "belt test") we can estimate the effects of storing sugarbeets by several methods.

In the Red River Valley of Minnesota and North Dakota, beets are harvested from about the middle of September, with limited deliveries to fit the slicing capacity of the four factories. Headlands are taken out and fields opened up, so that when deliveries are unrestricted (about the 7th of October) harvest can be completed in less than 3 weeks. Beet stands in the field headlands are generally poor and sugar content and purity of the beets harvested early are generally quite low. Factory operations reflect these low sugarbeets. During the unrestricted delivery season (from about October 7 to 28) sugar content of the beet is increasing at about a half percent a week or often at a tenth of a percent per day. Beets are delivered 24 hours a day.

During the past 5 years, an average of 2,025,965 tons of beets are stored annually at the four Red River Valley factories, for an average of 130 days. With the average stored beet being held for 65 days and with an average loss of 35 pounds of recoverable sugar per ton (from our company experimental storage data), we project a loss 70,908,775 pounds of recoverable sugar per year.

Prior to the 1973 beet crop, all beets processed in the Red River Valley have been purchased on the "belt test" system, that is all growers are paid on the average sugar content (pol) of all beets sliced. With this system, it is impossible to more than estimate the amount of sugar actually delivered by the beet grower for storage.

Figure 1 shows the weekly average sugar content of all four Red River Valley factories. The average sugar content of the beets sliced during the pre "storing" period was below 14.1%. Since the beets sliced during the "storing" period were direct deliveries, the sugar content increased rapidly. The sugar content of the beets sliced levelled out after the beets were all delivered, then dipped as might be expected. During this period from about November 4 to December 9, the beets that were frosted in the

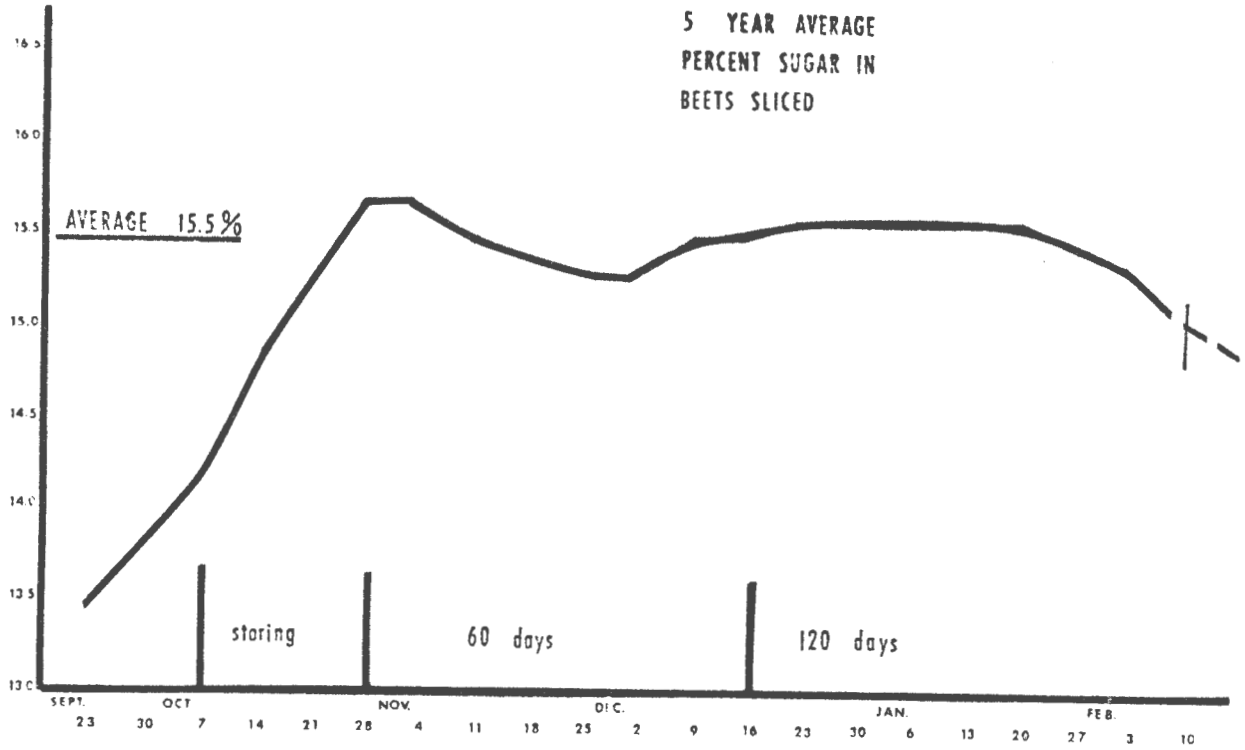

Figure 1.

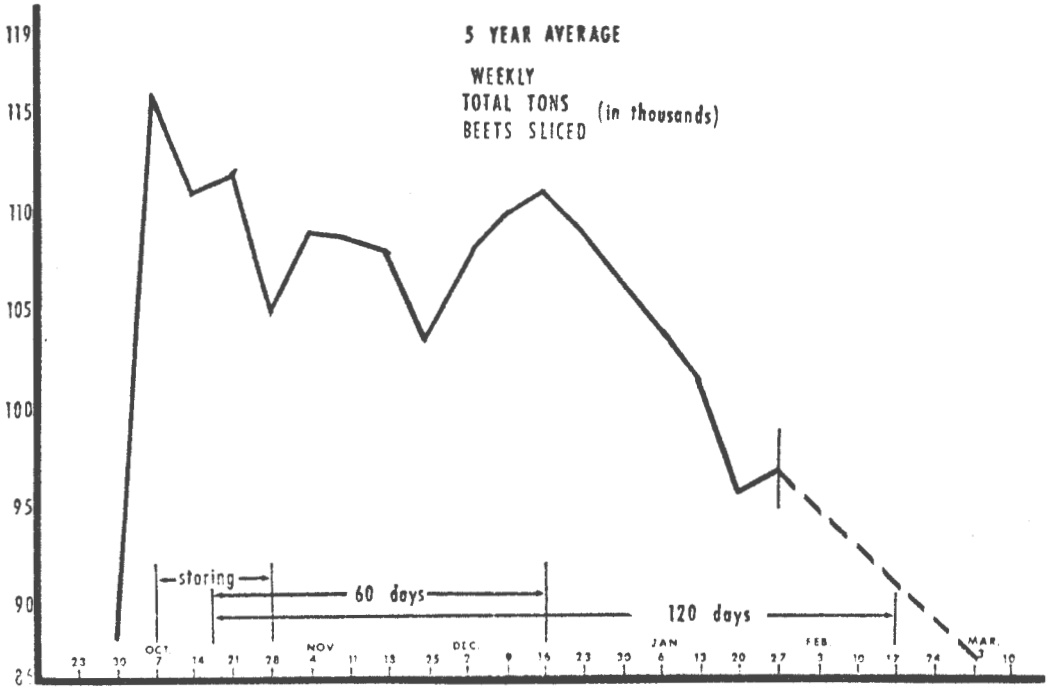

Figure 2.

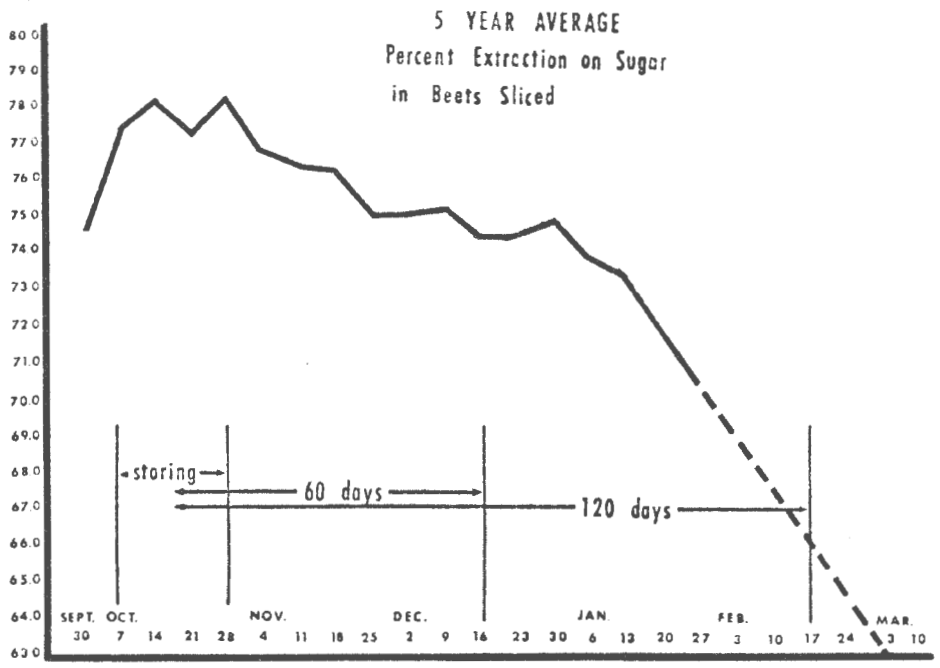

Figure 3.

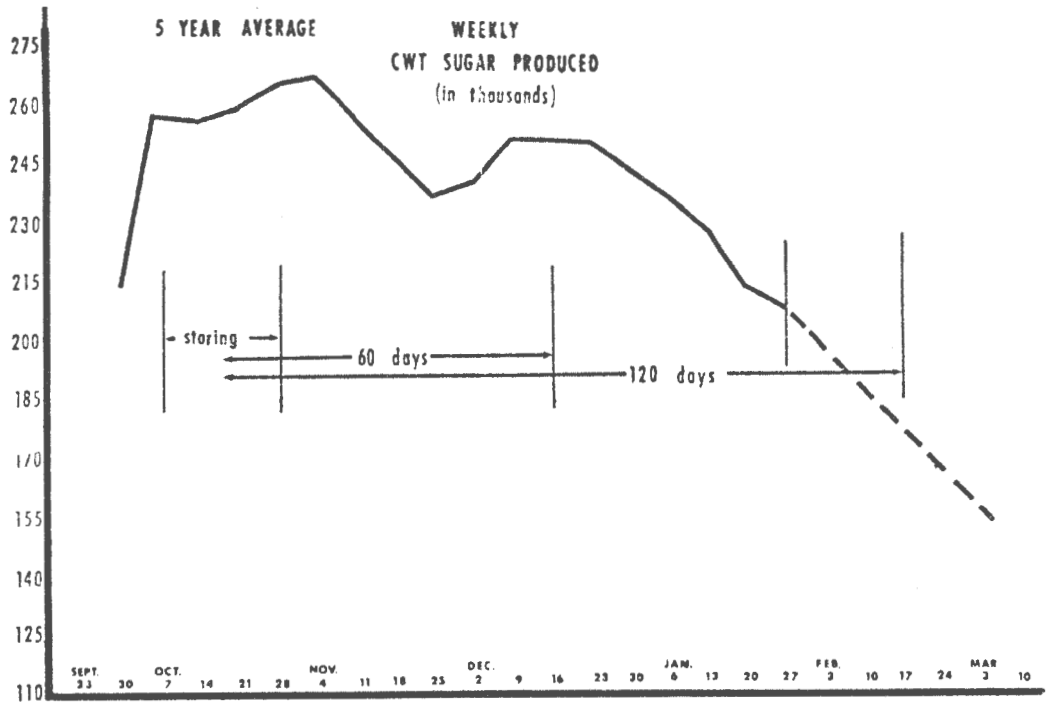

Figure 4.

Figure 7 compares the percent extraction of sugar on beets stored minus shrink with percent recoverable sugar under controlled conditions. This theoretical curve was determined by storing thousands of Red River Valley storage samples at 36 and 41 F temperatures with high humidity, in perforated plastic bags at our company research lab at Rocky Ford, Colorado. Details of this 5 years of work are being reported by Dr. Dick Watkins and John Hobbis at this meeting. This theoretical curve represents the recoverable sucrose that is left in the Red River Valley beets after long periods of storage under what we believe are the best storage conditions we can simulate. These beets under controlled conditions started with a 83.9% recoverable sugar; however, some of this recoverable sugar is gradually lost to respiration, and conversion to raffinose, kestose, glucose and fructose. As these non-sucrose compounds build up at the expense of sucrose, more sucrose will be lost into molasses, as indicated by the rapid decline in recoverable sugar, from 83.9% down to 62.0% at the end of 120 days of storage. At the beginning of the controlled storage period, the 15.5% beet with 83.9% recoverable sugar contained 260 pounds of recoverable sugar. Data from our controlled storage at 36 to 41 F indicates a loss of 4 pounds of recoverable sugar in 2 weeks, 14 pounds in 1 month, 28 pounds in 2 months, 43 pounds in 3 months and a total loss of 68 pounds of 26.1% of the recoverable sugar in 4 months.

Comparing this theoretically recoverable sugar value with actual factory extraction as shown in Figure 7, we must include a 5 year average factory loss of 1.2% (this includes sugar left in pulp, sugar in lime flume, and unknown losses). This is actually 8.0% of the sugar in the beets. This processing loss appears to be quite high primarily because of processing many frozen beets and unusually long campaigns. The frosted beets that are harvested almost every year and the frozen beets in the storage piles cause dextran and levan to form and build up in stored beets. These two complex compounds cause large processing losses and reduce factory capacity and efficiency.

If this processing loss is taken off the theoretical recovery, as shown in Figure 7, it appears that our method of storing beets commercially may be quite good when compared with our simulated storage conditions. However, the commercially stored beets contain many frozen and dehydrated beets, which is reflected in loss of factory slicing capacity. Because of the problems of slicing and processing frozen beets, the factory must slow down. This puts the factory in better balance and allows the factory to process the juice better. An increase in percent extraction on fewer beets results.

We need to process beets faster all season to reduce storage losses. This would mean shorter storage periods. Even with facilities or structures that would prevent freezing and reduce dehydration, our factory extraction would not be better than the theoretical curve since recoverable sugar is lost from beets even under the most ideal conditions.

As shown on Figure 8 the sugar carried into molasses follows an upward trend, increasing as the time in storage progresses. During the storing season, approximately 14% of the sugar in the beet is carried over into molasses, at 60 days of storage almost 18% of the sugar, and at 120 days 22% of the sugar is carried over into molasses. This loss of sugar to molasses follows closely the reduction in extraction of sugar as shown on Figure 3.

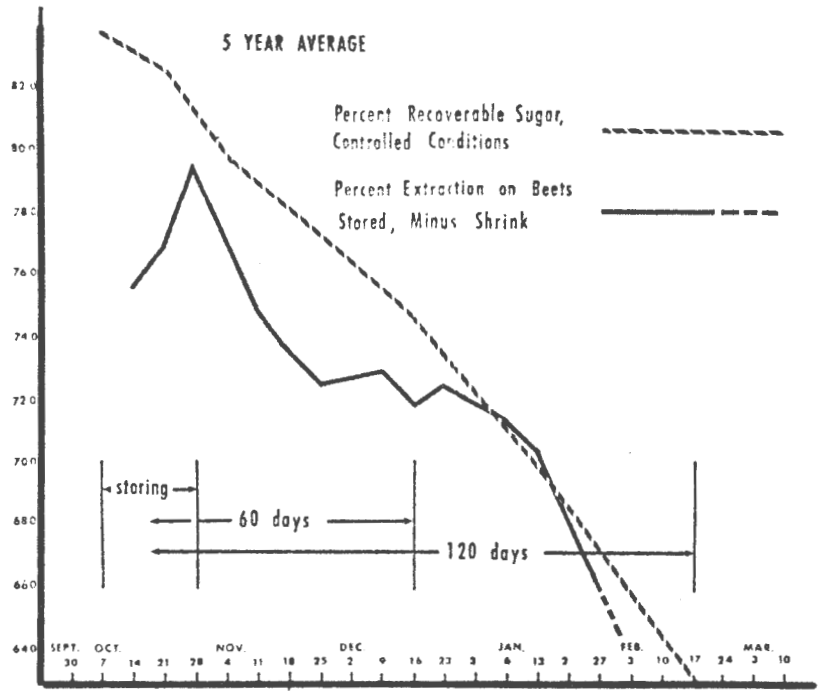

Figure 7.

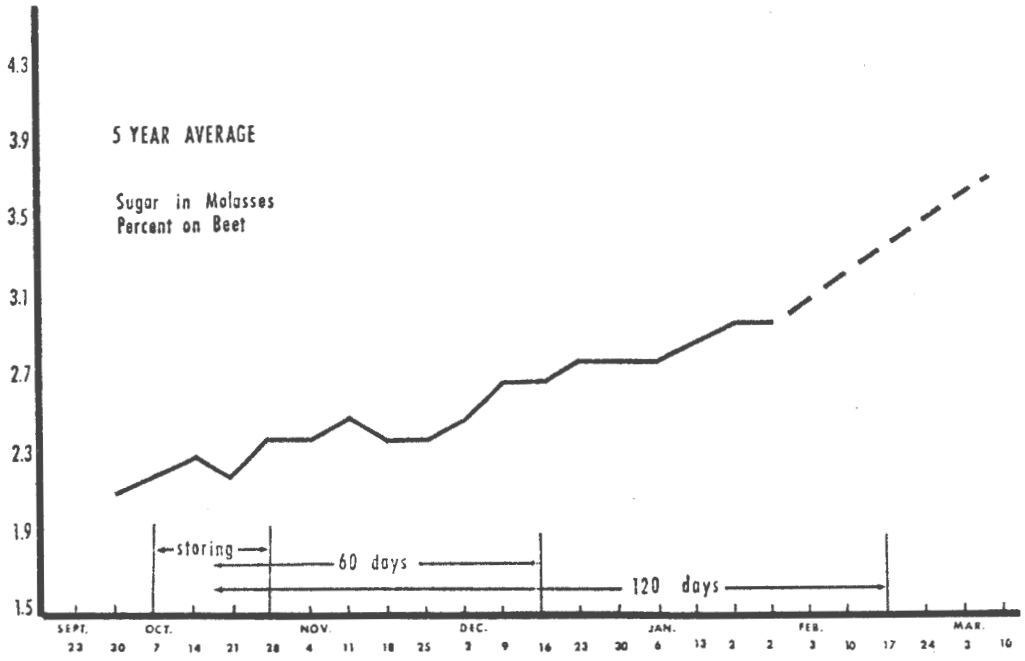

Figure 8.