STORAGE OF SUGAR BEETS
Effect on Sugar Packed Per Ton of Beets Delivered

By: S. T. Dexter [1]

A factory that will process 4,000 tons of sugar beets a day,-- something like the capacity of the Monitor plant at Bay City, is reported to cost $20,000,000 to build. This does not include the land necessary. This sum amounts to $5,000 per ton of daily capacity. To pay the interest, taxes, depreciation and upkeep on this $5,000 might be lumped at about 15% or $750 annually to process one ton of beets a day. If you can imagine running the factory for one day, it would cost something like $750 to process each ton of beets, without figuring anything for salaries, wages, coal or lime. It is evident, therefore, that it is necessary to run the factory a good many days beyond the first one, in order to make any money. Even if the factory is run 100 days, the overhead charge per ton remains very substantial. Factory superintendents will agree that it is perfectly feasible to run the factory for 200 days or even 300 days a year. Some suggest 365 days. Yet most factories in Europe seem to plan on running only until mid-December. In a recent year a nearby factory ran 61 days. But all factories would like to run as long as possible. The problem is how to store the beets in such a way that any money can be made by running longer, -- money for the farmer and for the processor. Obviously, this is not an easy problem to solve. The Europeans have not seen fit to carry on the research to give us the answers. We are able to import their equipment and a great deal of their know-how, but we may be compelled to do something about storage problems ourselves. We have accomplished a lot by ventilating beets and all that, but not enough. This is a problem on which we all will need a good deal of help from each other. Stored beets act in many strange ways, not fully understood by the sugar technologists. During the past year or two, we have been renewing our efforts in studying storage, since industrial research has been described by Boss Kettering, once of General Motors, as something that you do so that you'll know what to do when you can't make any money doing what you're doing now.

We have a large and important group of men engaged in the important problems of how to grow beets properly, and another large group concerned with how to process them properly. My topic concerns the general subject of what happens to the beets between the time they are grown and the time they are processed. This is an important consideration, also, since the way the beets are grown and harvested affects the way the beets will store and the way they will process.

My topic today mainly concerns two things that are brought out in Figure 1: (1) How can we store so that we lose a minimum of <u>sugar</u> before processing, and (2) how can we store so that we prevent the <u>deterioration</u> that leads to more molasses produced per ton of beets stored. Let me emphasize that if we can avoid

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an imcrease in impurities (soluble impurities) during storage, the factory need produce no more molasses per ton of original beets at the end of the campaign than at the beginning.

In preparing this report, I have received the cooperation of several sugar companies and have had access to their records. Thus, this material is old stuff, in many ways, to them, but we may see the problem better in a very condensed form. Figure 2 shows the temperature of piles at two Michigan factories in two years and the minimum loss of sugar per ton of beets.

Table 1 shows how much the beet roots shrink in the course of storage. As an average of six consecutive campaigns, there was a loss in weight of about 4.5% from the time the beets were purchased until they were sliced. Thus, the last beets sliced might have lost more than 10% of their weight. Note that almost as many tons of untared beets were sliced as the tons of tared beets purchased.

For this factory all loads of beets were analyzed on delivery, and when sliced. Table 2 shows that these beets were losing sugar in the pile. This loss amounted to over 25 pounds of sugar per ton of beets purchased. Of course, the additional loss through recovery percentages is in addition to this.

It is of particular importance to note a point or two. This 25 pounds of sugar per ton does not represent the loss on the last tons processed. It represents the average loss for each ton delivered or paid for. A good many of these beets were processed within hours after delivery. Some may have been stored a day or two or a week, and so on. Thus, the loss, per ton of beets delivered, was probably at least 50 pounds of sugar per ton at the end of the campaign, if computed on the basis of the original delivered weight of the beets. Yet factory figures often show more sugar recovered from a ton of beets sliced in the last week of the campaign than a month or two earlier. For example, 248 pounds of sugar was bagged per ton sliced during the first part of a campaign in Michigan, gradually increasing to 256 pounds at the end of 18 weeks. The molasses produced per ton told an entirely different story, however. If the molasses produced per ton of beets sliced during the first four weeks is called 100%, the beets sliced during the last four weeks produced 157%, or over 50% increase. This represents the fact that there were more beets in a ton of the shrunken beets at the end than in the fresh beets at the start. But, in addition, there were more impurities per beet, and thus more impurities to make molasses.

The simple disappearance of sugar shown in Table 2 amounted to 8% of the original sugar delivered. I may remark that the loss of sugar in the molasses usually amounts to something like 15%, -- and this molasses sugar is not a complete loss as is the sugar lost in the pile. Thus, we can account for most of the loss in extraction here.

In Table 3 we see another change. Even though the beets dried out about 4.5%, this desiccation was not sufficient to maintain the percent sugar in the cossettes. Sometimes, drying out is sufficient so that the cossettes at the end of a campaign contain more sugar than at the beginning. In a good storage year, the change in TJP may be rather small, -- in fact, no more than would be considered unavoidable, due to simple sugar loss, and thus a smaller proportion of sugar in the total soluble solids. However, in a poor storage year, the impurities may increase per ton of original beets, while the sugar decreases.

The beets, as delivered, contained an average of 15.642% sucrose, when correction is made for the attached tar tissue. By correction for the 4.57% shrinkage, this figure must be increased to about 16.42% for the entire campaign. You will note that the cossettes averaged to contain 15.256% sugar. This loss of about 1.16% sugar leads to an inevitable lowering in the thin juice purity, as the proportion of sugar decreases. Thus, with no increase in impurities, the drop in TJP is about 0.6 to 0.7 of a point for each loss of 1% sugar, at purities around 90 percent and sugar around 15 or 16 percent. Such a change in sugar percent, with the inevitable loss in purity, leads to a drop in percent recovery of a little over 2% for each 1% change in sugar, (from, say, 81-79%), assuming no deterioration of the beets, so far as increase in impurities is concerned. (This is a minimum of about 22 pounds of sugar (bagged) lost per ton of original beets for each 1% sugar lost).

Tables 3 and 4 show deterioration in two recent years. In the good storage year, the impurities in the original beets did not increase, and molasses produced per ton of original beets remained practically the same. But in the year when trouble occurred in storage, the impurities increased sharply, and, of course, so did the molasses.

Here, although the losses of sugar percent were not exceptionally high, the losses in TJP are informative. In the good storage year, note that the TJP fell only from 90.424 to 89.914, or a little over 0.5 of a point, and that the impurities remained essentially constant at 1.60%. But with the better beets, starting with impurities of 1.51, and both higher sugar and higher purity, the TJP fell from 91.06 to 89.436 or about 1.6 points. Since each point of drop in purity costs the factory a loss of about six additional pounds of sugar in the molasses, one can see that something like 20,000 pounds of extra sugar was going into the molasses each day at this factory due to this deterioration of originally superior beets. Thus, an unusually good campaign from the standpoint of beet quality was turned into a rather poor one, because of storage difficulties.

We have taken samples from some of these hot spots for analysis. Of course, some of the beets in the hot spots are completely rotten. We chose beets that were obviously damaged, and somewhat moldy, but still reasonably solid, in contrast to beets that were hot but not moldy. Table 5 shows that the differences are very marked. Although the non-moldy beets were far lower in TJP than one would expect, (about 92-93 TJP), in view of their high sugar content, -- and, thus, obviously damaged (perhaps 24 pounds of bagged sugar per ton), the moldy beets were so low in sugar and so exceedingly high in impurities that probably no sugar at all could be extracted from them. They would make only pulp and molasses, -- and, of course, considerable of a nuisance in the factory.

Last time we met, I showed you some beets stored under water. Last year we repeated this test, making analyses for sugar and thin juice purity. while storing the beets also in other ways. Table 6 shows the results Storing frozen or in cold air kept the losses to a minimum, while storing under water was about the same as storage in the company pile for the first four weeks. After that there was more deterioration.

We sorted the beets in a pile into large and small beets, beets with no crown removed, crown tissue alone, topped beets and beets with a high, medium and low specific gravity. Table 7 shows the bagged sugar per ton after storage in the company pile and in the grozen condition. Note that the better quality beets stored better. Table 8 shows the comparative loss of percent sugar, corrected back to the original weight of the samples. Again, the losses of sugar were much higher in the poorer quality beets.

This year we have been and still are testing the storage behavior of beets grown with high, medium and low fertilization with nitrogen. These growing conditions were aimed to, -- and did -- give us differences in composition somewhat comparable to low, medium and high specific gravity. These beets were stored at about 35° and about 50° F., and are still in storage, with samples removed for analysis every few weeks. In brief, beets grown with low nitrogen fertilization, -- even though they may have yielded as much in tons, or even more than those with more nitrogen, -- lost less in sugar, in thin juice purity and in bagged sugar per ton than did the beets grown with more nitrogen fertilizer.

Obviously, there was much greater loss of bagged sugar in the storage at 50° than in the storage at 35°. The combination of too warm temperatures and too high nitrogen is quite striking.

We have made numerous other analyses for minerals and amino nitrogen in the juice after storage, in an attempt to understand the deterioration process still better. This data will be presented at a later date.

FIGURE 1

Sugar Losses Related to Storage

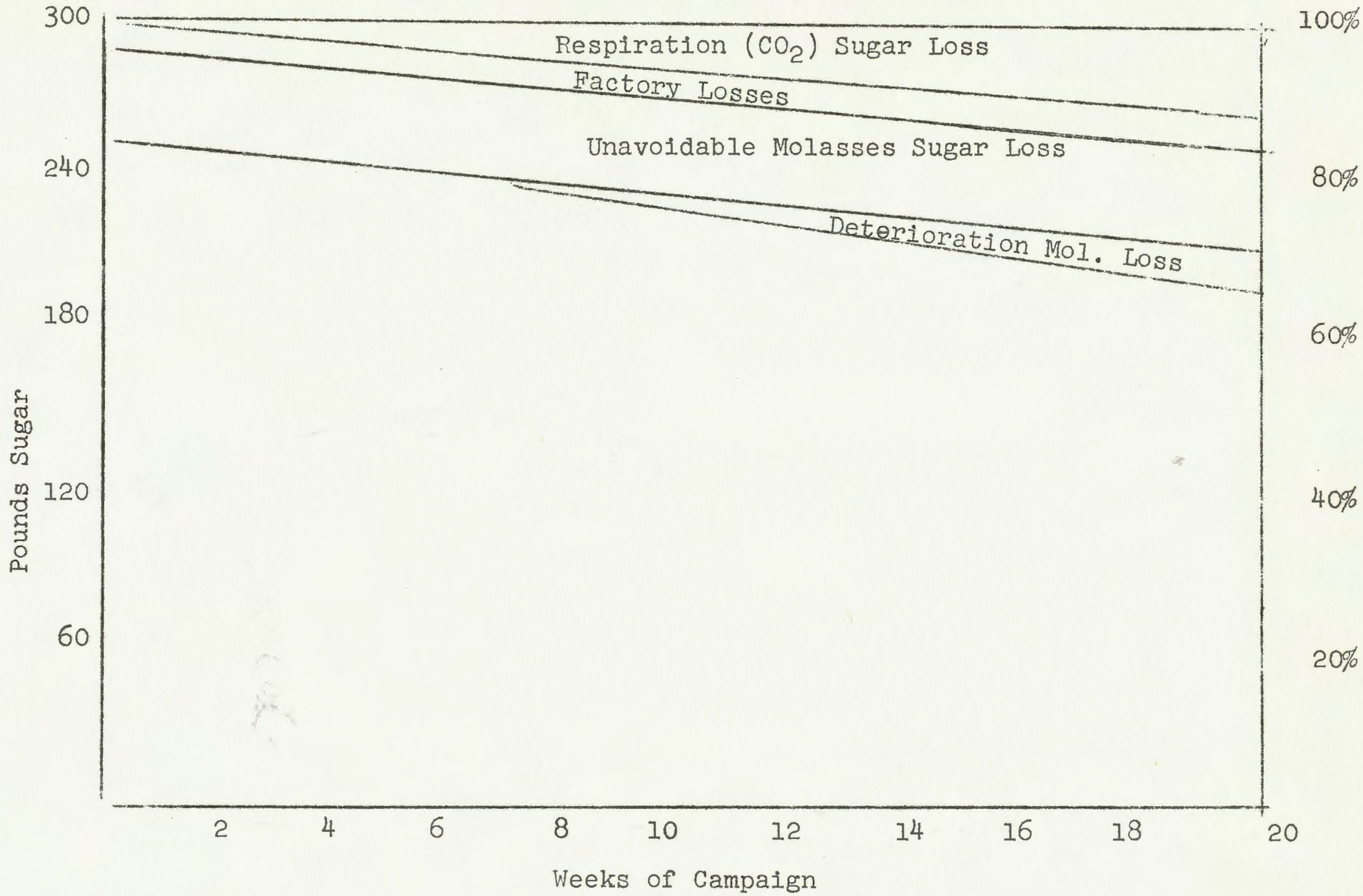

Figure 2

Pile Temperature and Minimum Sugar Losses

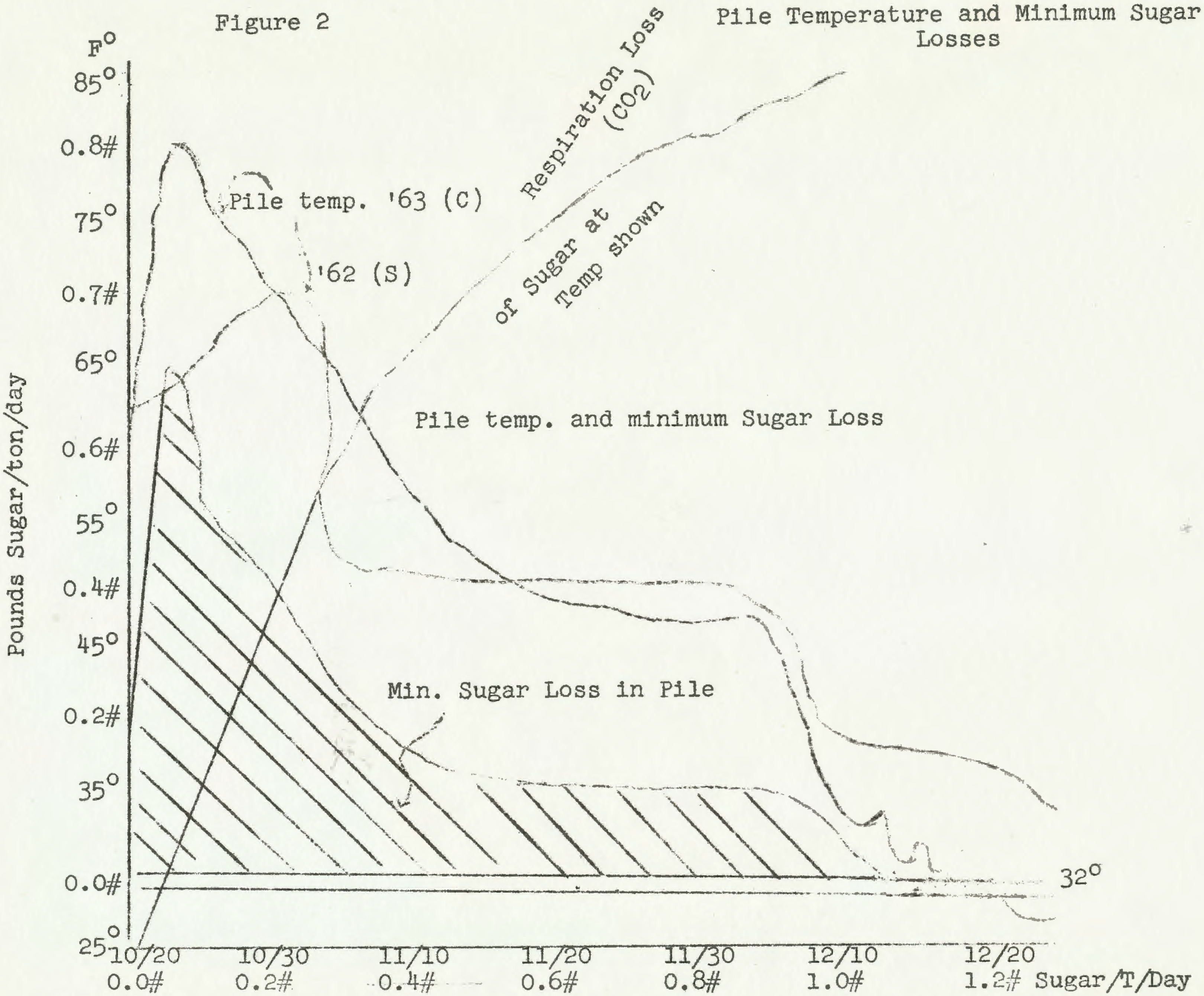

Table 1

Average shrink in weight for six consecutive years for one factory

Beets paid for	258,946 tons
Beet tissue in tare	12,029
Total tons delivered (less dirt tare)	270,975
Total tons sliced	258,447
Weight shrunk to	95.38%

Table 2

Average sugar loss for six consecutive years for one factory

Sugar in beets purchased	40,719.26 tons
Sugar in tare tissue	1,567.0
Total sugar delivered	42,386.26
Sugar in cossettes, tons and percent of total	38,987.4 or 91.98%
Sugar lost per ton beets purchased	26.5 pounds
Tons sugar lost before slicing	3,398.86
Value at 6¢ per pound	$407,863 per year

Table 3

Change in composition -
Average for six consecutive years

Percent sugar in tared beets		15.725%
Percent sugar in untared beets		15.642
Percent sugar in cossettes		15.256
	Start	End of campaign
Thin juice purity good storage year*	90.424%	89.914%
Thin juice purity, poor storage year*	91.063	89.470%

*A different factory

Table 4

Impurities in beets and molasses per ton

Week	Good storage year Impurities*	Good storage year Molasses**	Poor storage year Impurities*	Poor storage year Molasses**
1	1.58%		1.51%	
4	1.59	4.46%	1.54	4.47%
7	1.59	4.80	1.68	5.45
10	1.61	4.93	1.72	5.64
14	1.60	5.26	1.79	6.18
17			1.81	7.025
		Av. 4.725		Av. 5.630

*Impurities calculated as percent of original beets
**Molasses calculated as percent of beets sliced

Table 5

Hot spots (average of five samples)

	Moldy beets	Not moldy, but hot
Percent sugar in beets	7.63%	18.03%
Thin juice purity	57.31%	88.66%
Impurities in thin juice, % original beets	5.35	2.25
Sugar recovery possible	none	275 pounds per ton

Table 6

Bagged sugar per ton of original beets and clear juice purities of beets stored at near freezing temperatures under water, under 2% brine, or in air, frozen and in the company pile.

	Storage Method				
Storage Period	Under water 32°F.	Under 2% brine 32°F.	In air 32°F.	Frozen	Company pile
	Bagged sugar per ton, corrected to original weight				
4 weeks	260	244	277	269	258
7 weeks	231	215	276	272	265
	Clear Juice Purities				
4 weeks	90.5	89.1	91.8	91.6	89.6
7 weeks	87.0	86.7	90.1	30.3	89.8

Table 7

The bagged sugar per ton and clear juice purity are compared for beets stored ten weeks in the company pile or in the frozen condition.

Sample	Bagged Sugar/T. of Original Beets		Clear Juice Purity	
	In Pile Lbs.	Frozen Lbs.	In Pile %	Frozen %
Large beets	258	276	91.1	90.2
Small beets	301	293	92.9	92.4
Over 17 Brix	293	284	92.1	91.1
15-17 Brix	267	281	91.1	91.3
Below 14 Brix	202	237	86.1	88.6
Whole beets	240	285	88.2	90.6
Topped beets	265	307	89.7	92.6
Crowns	122	158	80.2	81.7

Table 8

Effect of ten weeks storage in the pile or in the frozen condition on the loss in percentage sugar in beets, corrected to the original weight of each sample.

The ratio of $\frac{\text{\% sugar in beets stored in pile}}{\text{\% sugar in beets stored in frozen condition}}$ is given in the table.

Sample	Ratio Calculated From Weight Shrinkage	Actual Ratio From Sugar Analyses	Change in Ratio of Sugar %
Large beets	0.981	0.900	-0.081
Small beets	0.951	0.976	0.025
Over 17 Brix	0.956	0.976	0.020
15-17 Brix	0.990	0.940	-0.050
Below 14 Brix	0.961	0.884	-0.077
Whole beets	0.986	0.859	-0.127
Topped beets	0.998	0.914	-0.084
Crowns	1.002	0.819	-0.183