DECOMPOSITION LOSSES OF SUGAR FROM CUT SURFACES OF BEETS

F. R. Bachler
American Crystal Sugar Company

In such beet sugar factories where the beets are bought from the grower on a basis of their sugar content, the records show that there is invariably not only an appreciable loss in net weight of beets bought and sliced, but also a very considerable loss in the weight of sucrose paid for as compared with the weight of sucrose entering the house.

The existing differences are fairly easily traceable and can be accounted for within close limits as being due to the combination of weight losses due to shrinkage in transit and in storage, and the weight gains due to water absorption during fluming and washing. Such a control requires the keeping of daily records of the earth-tare and top-tare ratios, also frequent daily determination of the percent of water absorbed during fluming and washing.

But when sugar balance is struck there will be invariably found costly losses of sucrose, which we cannot assign to analytical errors, but must be assigned as decomposition losses. This being, no doubt, correct it is equally correct to say that a part of these losses are preventable. For instance, the beet, as a living organism, must consume some of its sucrose to satisfy its biological needs, but if the beets are temporarily stored this oxidation can become unduly high, while proper storage conditions may reduce this source of loss to a point close to the irreducible minimum and thereby could be achieved an appreciable reduction in the over-all decomposition losses.

Next to poor storage, perhaps the most potent cause of sugar losses, is that due to destruction of sucrose by inversion, starting at the point where the beet has suffered an injury. Some of these injuries are avoidable but one injury, the most serious one, that due to topping, is unavoidable, even though it could be somewhat lessened.

Topping of the beet produces an open wound of greatly varying area in which the injured and the non-injured sugar bearing cells become exposed to the deleterious effects of the air and infection by micro-organisms which bring about inversion and the destruction of the sucrose thus attacked. This sugar destroying effect grows with increasing temperature, moisture of the air, length of time and size of the wound, soon the infection spreads and, aided by the acid decomposition products which are formed at the same time, penetrates deeper and deeper into the adjoining healthy tissue, carrying in its wake further destruction of sucrose and a further increase in the organic non-sugars.

A series of carefully conducted tests were made which had as their aim the study of the decomposition losses that will occur on a light and heavily topped beet upon different length of storage. The following experimental procedure was employed:

Completely ripe, perfectly healthy and non-injured beets were selected which were grown in the same field, from the same seed, under identical soil, water and cultural conditions and which possessed, as close as it was possible

to select, the same shape and nearly the same weight. It was hoped that in meeting these conditions each individual beet would possess approximately the same invert to sucrose ratio at the time of harvest. We arranged for three groups of tests, each comprising five individual beets.

FIRST GROUP: Five beets were taken, the leaves were cut off as closely as possible at their base and care was taken not to injure the top of the beets. The beets were then weighed individually. The one which came nearest the average weight of the group was immediately completely shredded, the pulp thoroughly mixed and analyzed. The remaining four beets were stored on the concrete floor of the basement and covered lightly with a gunny sack which was kept moist. After the lapse of one week one of the beets was removed, weighed again and analyzed. After the second, third and fourth week the procedure was repeated.

SECOND GROUP: Five beets were taken. Each of the beets was topped close at the base of the green leaves. The area of the cut surface was measured. Each beet was weighed. The one whose weight came nearest to the average weight of the group was immediately shredded and analyzed. The remainder was stored alongside the beets of the first group and treated as described.

THIRD GROUP: Five beets were taken. Each of the beets were topped just below the base of the lowest leaf scar. After measuring the area of each topping surface the procedure was the same as for group one and two.

A record was kept throughout the entire storage time of the daily average temperature and moisture of the air.

METHOD OF ANALYSES: As each beet was shredded, the pulp was thoroughly mixed. Five separate normal weight portions of the pulp were weighed out and digested with distilled water for thirty minutes at 75° C. The Oxnard Sachs Le Docte factor of 179.1 ml was used. The five digestion fluids were united. In a portion was determined the immersion refractometric Brix. The remainder was clarified with Horne dry lead and polarized. For the determination of invert sugar we followed Classens procedure as follows: 110 gr. of the pulp were transferred to a 500 ml flask, 15 cc of neutral leadacetate and 2 gr of $CaCO_3$ added, then filled up to nearly the mark, mixed, placed in the hot water bath for 60 minutes, cooled, made up to 500 mark and mixed. 100 cc of the decanted juice are once more clarified with neutral lead acetate, made up to 110 ml and filtered. 100 ml of the filtrate are deleaded with Na_2CO_3, made up to 200 ml and filtered. 100 ml of the filtrate = 10 grams of original substance, are boiled with 10 ml of Fehlings solution for 2 minutes with one drop of Methylen blue solution. The still remaining blue color is then discharged by the addition of a measured volume of an 0.2% invert sugar solution. In the same manner is treated a mixture of 10 ml of Fehlings solution, 50 ml of water, 1.5 gr. of sucrose, 1 drop of methylene blue and 15 ml of the 0.2% invert sugar solution, and gradually more invert solution is added until the blue color is discharged. From the total ml of invert sugar solution used is subtracted the volume of the invert sugar solution used in the testing of the beet pulp solution. The difference, multiplied with 0.02, gives the invert sugar content in 100 grams of beet pulp.

The results obtained will be found in the accompanying table.

Table Showing the Changes in the Composition of Untared, Lightly and Heavily Topped Beets During Different Storage Times.

Beet	Item No.	Untopped Beets Free of Leaves					Beets Topped at Green Leaf Base					Beets Topped at Base of Lowest Leaf Scar				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Length of Storage in Days	1	-	7	14	21	28	-	7	14	21	28	-	7	14	21	28
Weight of Beet at start of Test, Grams	2	577	572	574	578	580	523	500	526	530	527	470	466	466	472	478
Weight of Beet at end of storage, Grams	3	577	564	562	560	555	523	492	514	512	502	470	458	455	456	455
Percent of weight lost during storage	4	-	1.40	2.09	3.11	4.31	-	1.60	2.28	3.39	4.74	-	1.71	2.36	3.38	4.81
Average storage temp. throughout test period	5	-	21.1°	22.3°	21.4°	21.7°	-	21.1°	22.3°	21.4°	21.7°	-	21.1°	22.3°	21.4°	21.7°
Average % moisture in the air during storage	6	61.2	58.3	58.7	50.3	42.1	61.2	58.3	58.7	50.3	42.1	61.2	58.3	58.7	50.3	42.1
Refractiometric Brix of juice in beet	7	21.1	21.8	21.8	22.0	22.3	21.1	21.9	22.0	21.4	22.3	21.7	22.0	22.2	22.5	22.7
% sugar in beet	8	17.75	18.30	18.10	18.05	18.70	17.90	18.45	18.65	18.20	18.35	18.55	18.75	18.60	18.65	18.25
% Purity of juice in beet	9	84.1	83.9	83.0	82.0	83.8	84.8	84.2	84.7	85.0	82.3	85.4	85.2	83.7	82.8	80.3
Invert sugar in % on Beets	10	.110	.119	.120	.137	.152	.107	.131	.157	.179	.225	.114	.185	.251	.314	.566
Ratio of invert sugar to sucrose	11	1:61.3	1:537	1:508	1:317	1:230	1:672	1:408	1:187	1:016	1:15	1:627	1:013	1:741	1:593	1:32.2
% increase in invert sugar ratio	12	-	4.7	6.5	18.3	23.7	-	15.7	28.9	39.2	51.2	-	37.7	54.5	63.5	80.2
pH of Digestion Juice	13	6.8	6.8	6.8	6.5	6.5	6.8	6.8	6.6	6.5	6.2	6.8	6.6	6.5	6.4	6.1
Area of Surface Injury in Square Centimeter	14	---	---	---	---	---	15.8	15.2	15.8	16.4	16.0	25.2	24.2	24.8	25.3	26.0
Appearance of Beets at end of storage	15	Perfect	Perfect	Perfect	Perfect	Perfect	Perfect	Perfect	Slightly Mouldy	Heavy Mould	Heavy Mould All Over	Perfect	Mouldy at cut	Heavy Mould at cut	Mould all over	Heavy mould all over
Appearance of tissue one inch from top	16	Healthy	Healthy	Healthy	Slightly Healthy dark		Healthy	Healthy	Slightly dark	Darkest	Quite Dark	Healthy		Slight Dark	Quite Dark	Quite Dark
Appearance of tissue two inches from top	17	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy	Healthy	Slightly dark	Healthy	Healthy	Slightly dark		Quite dark