A Study of Siloed Beet Pulp

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The objectives of the study were threefold: first, to determine what percentage of solids entering the pulp silo at Swink is lost; second, to determine what compounds of economic significance are present in silage drainage liquor, or effluent, from pit; and, finally, to assess some of the stream pollution factors in open pit silo storage of pulp. The work was done on pulp from the 1949 campaign at Swink.

Material Losses in the Pulp

Briefly, an accounting was made of pulp introduced to the silo versus pulp removed, each expressed on a dry basis. Thus one could estimate the solid material lost in storage. Pulp introduced was calculated from the total beet slice and the average marc content (4.5 percent) for the Rocky Mountain area. A record was kept of pulp removal at regular intervals and solids content was determined at the same time. Data are presented in Table 1. The results are in agreement with those of Coke and Jones (1)[2].

Table 1.—Solids Lost in Pulp Silo.

Original amount (in tons) Pulp Solids Introduced (=71578 x 0.045)		3,220
Total Accounted for (removal plus residue)		1,715.7
Tons Pulp Solids Removed	1,683.60	
Tons Pulp Solid in Pit (6/26/50)	32.1	
	1,715.7	
Tons Pulp Solids Lost		1,504.3
Percentage Loss in Pulp Solids (= $\frac{1504.3 \times 100}{3220}$)		46.7%

A loss of 46.7 percent of the solids was experienced in the 1949-50 season at Swink. Since by-product utilization may well be a matter of life and death to this industry such a loss is of paramount importance.

Table 2 shows marketable pulp obtained from the silo on a wet basis. It agrees well with the conventional figure of 27.5 percent of beets sliced.

Table 2.—Marketable Pulp from Swink Silo, 1949 Campaign (Wet Basis).

Tons of Pulp Out of Pits:	
10/14/49—1/31/50	7,769
February	3,069
March	3,190
April	2,941
5/1/50—6/26/50	2,500
Estimated residue	300
	19,769

$$\frac{19,769}{71,578} \times 100 = 27.55\% \text{ pulp recovered on beets}$$

Figure 1 shows moisture content of siloed pulp throughout the season. Note the progressive increase in solid content; thus in May a ton of pulp has 100 percent more solids than does a ton in October. This curve is very helpful to us in cattle feeding studies when we want to calculate total digestible nutrients, etc.

Analysis of Silage Drainage Liquor, or Effluent

Periodic anayses of the water draining from the pulp were made from October 22, 1949, to June 28, 1950, Table 3.

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[2] Numbers in parentheses refer to literature cited.

Table 3.—Effluent Analyses.

Sample No.	Date Rec'd.	Volume of Wet Pulp (% Sample)	Estimated Solids by Brix 20° C.	Specific Gravity d 20°/4°	pH	Free Acid (c) (Equiv./liter)	Galacturonic Acid %	Total Uronides %
1	10/22/49	4	0.65°	(1.0003)[1]	4.51	0.00571	0.037	0.056
2	11/2/49	4	0.50°	1.0001	4.30	0.01582	0.024	0.0716
3	11/9/49	3	0.38°	0.9998	4.30	0.00723	0.0104	0.0276
4	11/18/49	6	0.52°	(0.9999)[1]	4.28	0.00840	—	—
5	11/24/49	8.5	1.53°	1.0036	4.09	0.1037	0.1011	0.3120
6	11/30/49	8	1.94°	1.0054	4.02	0.1168	0.1388	—
7	12/7/49	6	1.83°	1.0048	4.00	0.1177	0.1458	0.4204
8	12/13/49	< 0.5	1.50°	1.0037	4.12	0.1024	0.0687	—
9	12/20/49	1	1.43°	1.0034	4.10	0.1164	0.0551	0.2145
10	12/28/49	6	1.93°	1.0055	4.00	0.1623	—	—
11	1/4/50	< 0.5	1.54°	1.0037	4.09	0.1339	0.0492	0.2666
12	1/10/50	1.5	1.75°	1.0046	4.10	0.1562	—	—
13	1/17/50	1.5	2.00°	1.0057	4.02	0.1768	0.1382	0.4075
14	1/24/50	0.5	1.65°	1.0042	4.18	0.1330	—	—
15	1/31/50	6.5	2.00°	(1.0056)[1]	4.08	0.1688	0.0979	0.3977
16	2/8/50	35	2.13°	(1.0061)[1]	4.10	0.1516	—	—
17	2/14/50	< 0.3	0.95°	(1.0015)[1]	4.51	0.0538	0.0194	0.0839
18	3/1/50	< 0.1	0.76°	(1.0008)[1]	4.73	0.02452	—	—
19	3/15/50	1	0.75°	(1.0007)[1]	4.62	0.02885	0.0265	0.0222
20	3/29/50	< 0.3	0.72°	(1.0006)[1]	4.86	0.01669	—	—
21	4/12/50	< 0.1	0.66°	(1.0004)[1]	4.82	0.02229	0.00921	0.0159
22	4/28/50	< 0.5	0.81°	(1.0010)[1]	4.62	0.03581	—	—
23	5/12/50	10.5 (19)[2]	1.75°	(1.0046)[1]	4.00	0.1851	0.0777	0.2499
24	6/1/50	0.5	1.50°	(1.0037)[1]	4.13	0.1459	—	—
25	6/14/50	0.5	1.42°	(1.0034)[1]	4.18	0.1380	0.0810	0.2004
26	6/28/50	6.5	1.70°	(1.0044)[1]	4.06	0.1752	—	—

[1] Indicates value secured by subtracting 0.0004 from density corresponding to Brix reading; this relationship existed for a set of twelve determinations and it was not considered worthwhile to repeat separate specific gravity determinations thereafter.

[2] Value secured by measured heights of solid and liquid in original **bottle.**

[3] Measurements **of volatile** acid (discontinued after first three determinations) were about 85% of free acid.

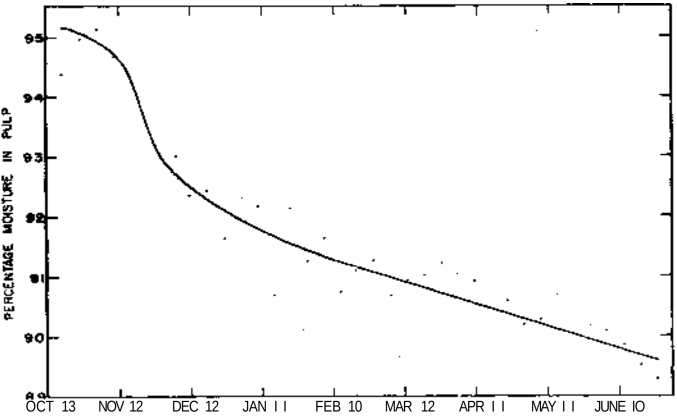

Figure 1.—Moisture Content of Pulp, Swink Silo, 1949 Campaign.

Column 3 in Table 3 shows the volume of loose pulp particles found in the drainage liquor. The average for the campaign was 4.5 percent, a significant loss in revenue. Unfortunately the absolute volume of the effluent and, therefore, of the solids lost in effluent is not known. A device installed to measure this was crushed by pressure of the pulp against it. A screen to recover this pulp might be worth further study.

The Brix values in column 4 are a rough picture of the soluble materials lost in drainage. They are primarily organic matter (Bureau of Standards (2) shows ash value of only 0.19 percent on comparable material) much of which is organic acid (see columns 6, 7 and 8). Pulp contains pectin which is broken down to galacturonic acid. The last column includes galacturonic acid and pectin in various states of decomposition. Galacturonic acid is not a normal article of commerce today, but if it could be recovered cheaply it would be a good starting point in Vitamin C synthesis. Other uses no doubt could be developed. There are other acids present in the effluent, as shown in Table 4.

Table 4.—Volatile Acids in Composite Effluent Samples 5 to 11 (Nov. 24 to Jan. 4)

Formic Acid	0.2114 gms./liter	0.02%
Acetic Acid	4.66 gms./liter	0.47%
Butyric Acid	3.28 gms./liter	0.33%
Lactic Acid	0.0903 gms./liter	0.009%

The sales prices of the four acids are, respectively, 16, 9, 35, and 27 cents per pound. Can they be recovered economically? We have studied their recovery by ion-exchange and distillation. So far we have failed to develop an economic process, in part because of the extreme dilution. However, if a market develops for galacturonic acid a combined recovery of the five acids may some day be feasible.

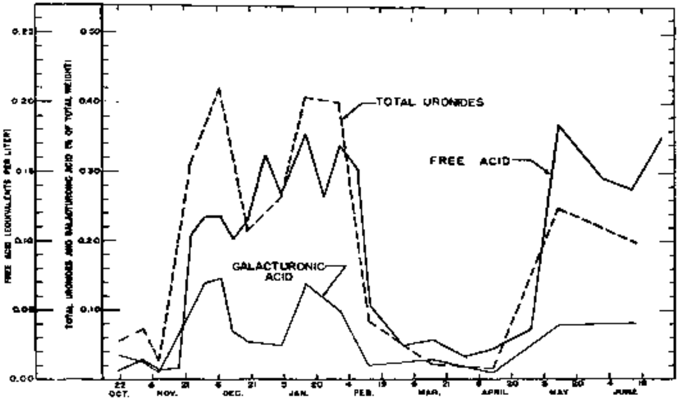

Figure 2.—Free Acid, Galacturonic Acid, and Total Uronides in Pulp Effluent, October, 1949, and June, 1950.

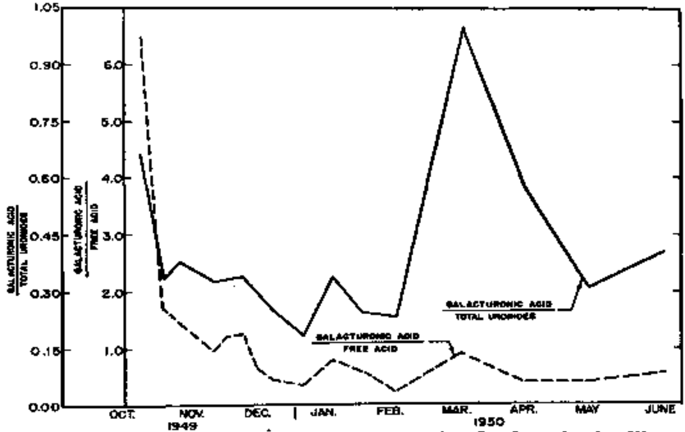

Figure 3.—Ratios Between Various Degradation Products in the Silo as a Function of Time.

The Sugar Research Foundation (3) (4) has made considerable progress in obtaining both pectin and galacturonic acid from pulp. Perhaps some day this will lead to new sources of revenue to our industry. Therefore, we feel that it may be of interest to show changes in these components with the season (figures 2 and 3). The changes in free acids, galacturonic acid and total uronides were remarkably parallel. Uronides are converted to galacturonic acid by an enzyme produced by bacteria feeding on the pulp (such as Penicillium ehrlichii).

Probably several enzymes are involved (5) and, furthermore, once the pulp mass becomes acid the degradation reactions are accelerated by the catalytic activity of the acid itself. Data in figures 2 and 3 give valuable clues to further research since during certain periods conditions were vastly more favorable for galacturonic acid production that at other times.

Figure 3 shows that at about March first all uronic substances (pectin materials) in the drainage liquor were present as galacturonic acid—a very favorable situation if one were to commercially produce galacturonic acid provided a good effluent flow could be obtained as in January and June. When and if a good market develops for galacturonic acid at an attractive price this work will be a basis for further intensive research.

Appreciable quantities of arabans have been found in the effluent but no ready use for these has been developed.

Silo Effluent in Stream Pollution

Since cattle thrive on wet pulp our drainage water is not toxic. Since it carries organic matter which will undergo further oxidation in the stream it can be said to pollute streams. This is because such oxidation will deprive fish of oxygen they need for life. Certainly streams can and do take organic matter and oxidize it without loss of fish life. It is the weight of the load in unit time that is the deciding factor. As towns grow and industries develop the discharge of organic matter into streams becomes progressively more serious. Recent legislation is making this into a more and more acute problem. A sewage disposal system capable of handling this effluent would be prohibitively expensive. Therefore, pulp driers are an attractive alternative to the pit silo since they remove this phase of the problem almost entirely.

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