Lactic Acid in Sugar Beet Processing Liquors

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Dr. Harry S. Owens and his associates in the Sugar Beet Section of the Western Regional Research Laboratory have recently made the beet sugar industry cognizant of the abnormal occurrence of lactic acid in some processing liquors. Dr. Owens and his group have also prescribed a suitable method for measuring lactic acid (1) (2)[2]. During this past campaign we have been engaged in an investigation of lactic acid at various points in the process in our factories, particularly Twin Falls. This paper is a summary of observations and conclusions.

The method has been found suitable and accurate provided the analyst uses the proper technique for micro-analysis. The precautions listed in the method must be strictly observed.

Extreme care must be exercised in sampling to avoid contamination. Sample lines must be thoroughly flushed out before the sample is collected. Containers must be sterile with provisions for sealing. Samples should be analyzed within a short time after collection or quick-frozen for storage. Tests on unpreserved diffusion juice at room temperatures indicated an increase in lactic acid content of 30 percent in four hours. One would expect this figure to vary widely depending on the diffuser conditions at the time of sampling. To prevent such an occurrence during the period from sampling to analysis or freezing, low-density liquid samples should be protected by a preservative at the time of sampling. The preservative used must be tested for non-interference in the method of analysis. Thymol crystals have been found satisfactory, and there are undoubtedly many others.

The presence of lactic acid in processing liquors represents a loss in recoverable sugar both directly when it is a result of sucrose fermentation and indirectly in the formation of molasses. Lactic acid can conceivably find its way into the process through many sources, but probably the principal known sources are from the beets themselves, the result of fermentation of sugars, and the result of the alkaline decomposition of invert sugar (3) . This, plus the fact that the reactions in which lactic acid participates in the process are not yet fully understood, make it impossible to know exactly the losses suffered as a result of fermentation. Nevertheless, by keeping these points in mind while following the lactic acid throughout the process, the possibilities of such losses can be estimated.

In investigating lactic acid formation in our continuous diffusers, samples of both juice and pulp were taken from various cells in chronological order based on the retention time of the diffuser. The results were reported on the basis of equivalent amounts of juice and pulp in order that the sum of the lactic acid present in these constituents might be followed. One would expect such results, if accurate, to show the total lactic

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[2] Numbers in parentheses refer to literature cited.

acid leaving the diffuser in the diffusion juice and final pulp to be equal to or greater than that in juice or pulp in any cell within the diffuser, assuming that lactic acid, once formed, remained as such.

Our results, however, present a far different picture, as in every test[3] the amount of lactic acid leaving the diffuser was greatly exceeded by amounts measured within various cells of the continuous diffusers. This pattern was also shown in the results of tests on a Robert Battery where juice from a single cell was tested periodically while in service. Tables 1 and 2 show typical lactic acid data for Continuous and Robert Battery type diffusers.

The reason for this negative lactic acid balance is not known, though we have eliminated some possibilities. To determine the presence of an

Table 1.—Twin Falls, Idaho Factory. Silver Chain-type Continuous Diffuser.

	5 Hours After Formaldehyde Treatment					30 Minutes After Formaldehyde Treatment				
Cell Number	Sample	Lactic Acid mg per Equiv. wt.[1]	Sample	Lactic Acid mg per Liter	Juice pH	Sample	Lactic Acid mg per Equiv. wt.[1]	Sample	Lactic Acid mg per Liter	Juice pH
	Coss.	35	Diff. Juice	190	6.40	Coss.	25	Diff. Juice	155	6.35
3	Pulp	155	Juice	290	6.30	Pulp	128	Juice	225	6.30
5	Pulp	220	Juice	445	6.05	Pulp	174	Juice	290	6.50
7	Pulp	185	Juice	445	5.90	Pulp	198	Juice	315	6.30
9	Pulp	255	Juice	420	5.80	Pulp	203	Juice	305	6.25
11	Pulp	200	Juice	400	5.80	Pulp	171	Juice	270	6.50
13	Pulp	175	Juice	335	6.75	Pulp	147	Juice	220	6.45
15	Pulp	145	Juice	280	6.70	Pulp	99	Juice	160	6.50
17	Pulp	120	Juice	250	6.10	Pulp	70	Juice	150	6.65
19	Final Pulp	55	Juice	220	7.10	Final Pulp	33	Juice	65	7.40

[1] Weight approximately equivalent to a liter of juice in same cell.

Table 2.—Rupert, Idaho, Factory, Robert Battery Diffuser, Samples from Single Cell During Cycle.

Time Minutes	Sample	Brix	pH	Lactic Acid mg per liter or Equiv. wt.	Time Minutes	Sample	Brix	pH	Lactic Acid mg per liter or Equiv. wt.
	Cossettes			24		Cossettes			29
0	Juice	17.7	6.45	26	0	Juice	17.3	6.55	61
5	Juice	8.8	6.55	37	5	Juice	7.8	6.60	65
10	Juice	5.7	6.55	66	10	Juice	4.4	6.50	98
15	Juice	3.5	6.60	51	15	Juice	2.6	6.60	102
20	Juice	2.0	6.50	58	20	Juice	1.6	6.50	98
25	Juice	1.0	7.35	11	25	Juice	0.8	7.30	22
	Final Pulp			5	30	Juice Final Pulp	0.06	9.10	7
	Pulp Water	0.06	8.70	1		Pulp Pulp Water	0.00	9.10	2 1

[3] Refers to tests conducted at Twin Falls, Idaho Factory.

interfering substance, samples of pulp and juice were taken from various cells *in* the diffuser and the lactate content measured. Known amounts of lactate were then added to the samples and the amounts of lactate redetermined. The measured values agreed with the calculated values from 93 to 100 percent. It is not believed that an interfering substance is responsible for the balance discrepancy.

To determine the stability of lactic acid at diffusion temperatures two samples of juice were taken from cell No. 9 of the Twin Falls diffuser, this point being one of the highest in lactic acid content. Both samples were preserved and portions removed for immediate analysis. The samples, one in a sealed container and the other in an open container, were then placed in an oven and held at 70° C. Portions of each sample were removed for lactic acid determination every 10 minutes until 30 minutes had elapsed. The result was that the lactic acid was not reduced in either case during this period, but rather appeared to increase about 20 percent in both cases. The question of the disappearance of much of the lactic acid formed in the process of diffusion is as yet unanswered.

PH values in diffusion juices do not always correlate with the lactic acid content because of a constantly changing buffer capacity in the juice. Nevertheless, pH values determined at regular intervals throughout do indicate the general condition of the diffuser, and therefore can be used as a guide in fermentation control during diffusion.

The level of lactic acid was determined at various points of juice travel in the beet end. Results showed an increase in lactic acid content at first carbonation and again as it emerges from the thickener. The invert sugar content of the juice is greatly reduced at these points, indicating that the

Table 3.—Twin Falls, Idaho, Factory, Lactic Acid in Beet End Juices.

Sample	Test 1		Test 2	
	Lactic Acid	Invert Sugar	Lactic Acid	Invert Sugar
	(mg/lOOgm sucrose)		(mg/lOOgm sucrose)	
Diffusion Juice	88	1,038	106	911
1st Carb. Juice	172	324	121	442
Thickener Overflow	259	129	175	166
2nd Carb. Juice	273	108	187	202
Thin Juice	284	108	196	113
Thick Juice	269	205	193	280

increase in lactic acid content here may be due to the alkaline decomposition of invert sugar. From second carbonation to thick juice the lactic acid content of the juice appears to remain quite constant. Table 3 shows typical data from beet end samples.

Following the lactic acid through the sugar end at Twin Falls, we found no serious increases; in fact, our results indicate a downward trend from thick juice to molasses. Spot samples were collected on four consecutive days from various points in the sugar end and lactic acid determined as milligrams per 100 grams of sucrose. These results were averaged, and a factor-—derived from the corresponding weekly sugar flow averages—was anolied to give the results a weighted value. These results are shown in Table 4.

Tabic 4.—Twin Falls, Idaho, Factory, Lactic Acid in the Sugar End.

Lactic Acid (mg. per 100 gin. Sucrose) Sample	Average[1]	Corrected-[2]
Thick Juice	225	225
Low Melter	260	66
Std. Liquor	164	303
White Pan	174	322
High Green	337	322
Intermediate Pan	350	314
Machine Syrup	911	292
Low Raw Pan	793	303
Molasses	1,570	202

[1] Average of 4 tests run on 4 consecutive days.
[2] Corrected to sugar *Row* for corresponding weekly average.

Our investigation has led us to the conclusion that our greatest fermentation losses are occurring in the diffusion process at Twin Falls and that the seriousness of this loss is not shown by the lactic acid content in the final diffusion juice. Only by a study of the entire diffuser can the magnitude of these losses be estimated. Increases in lactic acid in the juices during the carbonation processes must be attributed at least partially to the alkaline decomposition of invert sugar. Our studies failed to show fermentation losses in the sugar end of the process. Certainly care must be exercised in using the quantities of lactic acid present to estimate sugar losses caused through fermentation; nevertheless, we believe that this determination brings us a step nearer in making one of the "unknown" losses "known."

Literature Cited

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