

The by-product, containing primarily fibers and proteins, is sold to be used in the manufacture of animal feed. This type of filtration will, without a doubt, replace conventional filtration systems using filter aids in modern corn refining plants.

# THE USE OF NATURALLY OCCURRING TRACERS TO EVALUATE "UNACCOUNTABLE" LOSSES

For the Carbon and Kerosene pilot units use membranes which have exactly the same characteristics, including, in particular, the same length as the final commercial unit. Therefore, the pilot will reproduce exactly the same hydraulic conditions as the commercial unit. Hydraulic conditions through the membrane in a given velocity and transmembrane pressure are the same on pilot and commercial scale, thus eliminating the "scale-up" problem.

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Commercial installations, for example, a multi-stage, continuous, single-pass system used for the production of WPC (whey protein concentrate) in the dairy industry; a unit for standardizing protein concentration in milk before manufacturing cheese; a unit for standardizing starch slurry before manufacturing a starch derivative; and a unit for the continuous manufacture of acetic acid. (This latter unit illustrates a batch system where the tracer concentration is continuously recycled to the fermenter.)

Application and Rhoads-Poulson believe that ultrafiltration and microfiltration by means of the Carbon and Kerosene membranes represent a new generation of products which have the potential for recovering juice and syrup characteristics in the cooking process.

Just raw juice ultrafiltration tests have shown that permeation flux can reach already values of 200 l/m<sup>2</sup>h. This brings ultrafiltration to the point where it should be considered as a very credible alternative to conventional operations.

The sugar industry, together with its technology suppliers, should eagerly undertake the laboratory developmental work which this science deserves.

Carbon is a registered mark of Tech-Sep/Rhoads-Poulson  
Kerosene is a trademark of Tech-Sep/Rhoads-Poulson

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ABSTRACT

Chemical substances which occur naturally in the beet may be used as tracers of sucrose in process. The ratios of sucrose as determined by gas chromatography and the concentration of these substances can be determined and followed through out the diffusion and purification process. The ratios also may be correlated to bacterial concentrations and to losses which occur in the beet end.

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(2) How high of a correlation exists between losses

microbial concentrations?

(3) How much of the "unaccountable" losses can be identified

with natural tracers

natural tracers are chemical constituents which are found in the beet at processing. Those selected for evaluation in this study were betaine, potassium, and chloride. Over 800 samples were

taken in this study.

Results

One of The Amalgamated Sugar Company's facilities, Kansas installed flow meters around the beet end for use in mass balances. The balances seemed to indicate that no sucrose was being lost the diffuser or purification but rather in the evaporators. Means of evaluating the losses chemically were discussed and three "tracers" were chosen for evaluation. Betaine, potassium, and chloride were chosen due to their inertness in the process. The ratio of gas chromatographic (GC) determined percent sucrose

## THE USE OF NATURALLY OCCURRING TRACERS TO EVALUATE "UNACCOUNTABLE" LOSSES

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### Introduction

The importance of understanding and reducing the microbial load in the sugar process has been widely discussed. Optimal use of GMP's, temperatures, and biocides can greatly reduce the amount of sucrose lost to microbial degradation. The experiments described in this paper were carried out in an attempt to answer the following questions:

- (1) Where in the process is sucrose lost?
- (2) How high of a correlation exists between losses and microbial concentrations?
- (3) How much of the "unaccountable" losses can be identified with natural tracers?

Natural tracers are chemical constituents which are found in the beet at processing. Those selected for evaluation in this study were betaine, potassium, and chloride. Over 800 samples were taken in this study.

### Results

One of The Amalgamated Sugar Company's facilities, Nampa, installed flow meters around the beet end for use in mass balances. The balances seemed to indicate that no sucrose was being lost in the diffuser or purification but rather in the evaporators. Means of evaluating the losses chemically were discussed and three chemical "tracers" were chosen for evaluation. Betaine, potassium, and chloride were chosen due to their inertness in the process. The ratio of gas chromatographic (GC) determined percent sucrose

divided by the concentration of the tracers was used to evaluate both the tracer and the location of sugar loss. Since the concentration of the tracer should not change throughout the process any change in the ratio would indicate a change in the sucrose concentration. Samples collected and analyzed included fresh cossettes, mid-tower diffusion juice, diffusion juice (raw juice), pressed pulp water, tailings return, diffuser supply water, thin juice, and thick juice. For this paper only the samples of cossettes, raw juice, thin juice, and thick juice will be discussed. The other samples contained negligible concentrations of sugar and tracers.

Betaine was chosen because of its relatively high concentration and reported inertness through the process. The GC percent sucrose/betaine ratio was plotted against the thermophilic bacteria concentrations and showed an excellent correlation in the cossettes and in the raw juice. Figure 1 is a graph of the ratio-plate count correlation of raw juice in hourly samples taken over a six-hour period. Betaine was rejected as a tracer however because when the ratios between thin and thick juice were compared the thick juice demonstrated a higher ratio. Since sucrose cannot be made in the evaporator this indicated a betaine loss. We theorize that there is some thermal degradation of the betaine in the evaporators.

Potassium was also determined in several sets of samples from two locations. The potassium levels fluctuated throughout the sets of samples. An example of a plot of GC/potassium vs. plate counts is shown in Figure 2. Comparisons of GC/potassium ratios from

## Nampa B-Raw Juice GC/Betaine vs. CFU (hr. comp.)

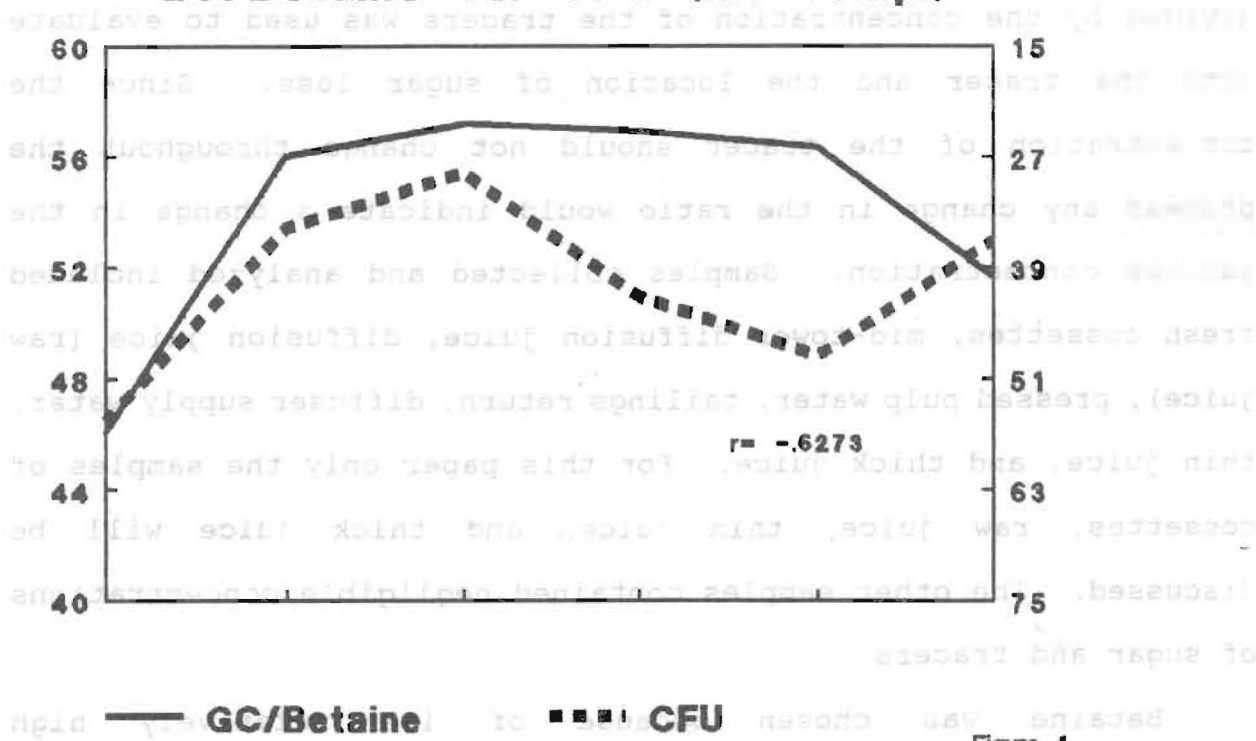


Figure 1

## Twin Falls Raw Juice GC/K vs. CFU (hr. comp.)

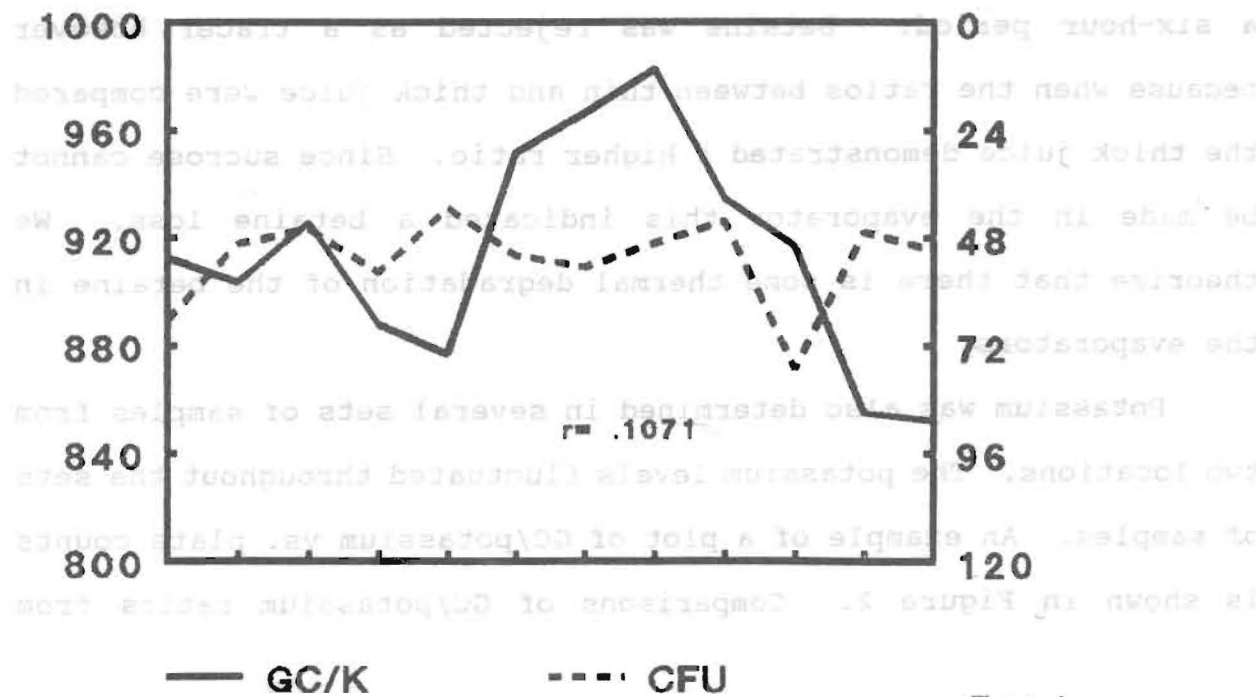


Figure 2

cossettes to thick juice were too erratic to be used for comparisons.

Chlorides are found in lower concentrations in beets than the other tracers but seemed to give the best results. In all cases the ratios decreased from cossettes to raw juice with only small deviations from raw juice to thick juice. Figure 3 illustrates the results of two days of hourly samples of GC/chloride ratios plotted against the microbial titers of the samples.

The correlation of 0.57 is quite good since it is a comparison between a chemical system and a biological system. The question was asked if the sucrose/chloride ratio change in raw juice was due to microbial degradation or changes due to variable incoming beet quality. A plot of the sugar/chloride ratios for cossettes and raw juice is shown on Figure 4.

Good correlations were obtained from sample sets taken in Nampa. Figures 5 and 6 are examples. The high correlations indicate the direct relationship of bacterial concentrations and sucrose lost in the process.

Evaluating the answer to question 1 in the introduction was important in light of the mass balances done at the Nampa factory. A complication at Nampa is that chlorides are added to the system as sodium chloride in the lime kiln. The sodium chloride is used as a flux to reduce clinkers. Since the chloride concentration of the thin juice would be affected calculations were done to correct for the added chloride. Figure 7 summarizes the calculations used. The operators document the amount of salt added per day and so daily averages of percent sucrose/chloride ratios were used in the

## Twin Falls Raw Juice GC/Cl vs. CFU (hr. comp.)

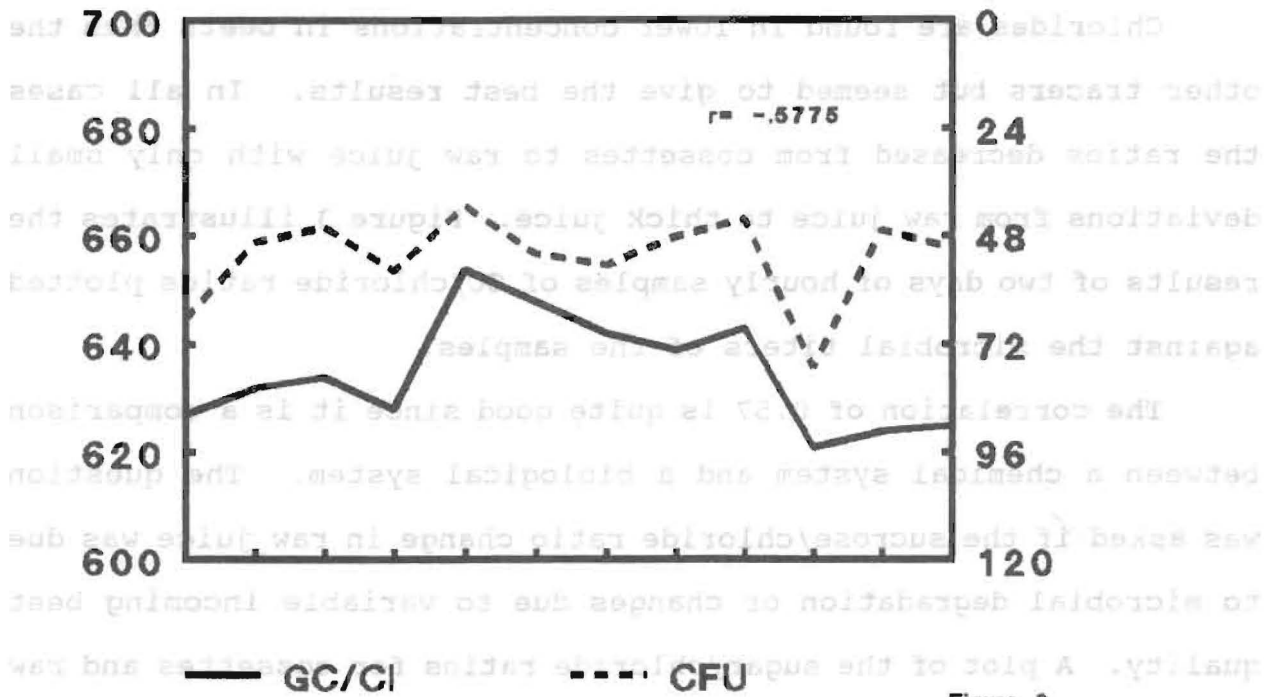


Figure 3

## Nampa B GC/Chloride Cossettes vs. Raw juice (hr. comp.)

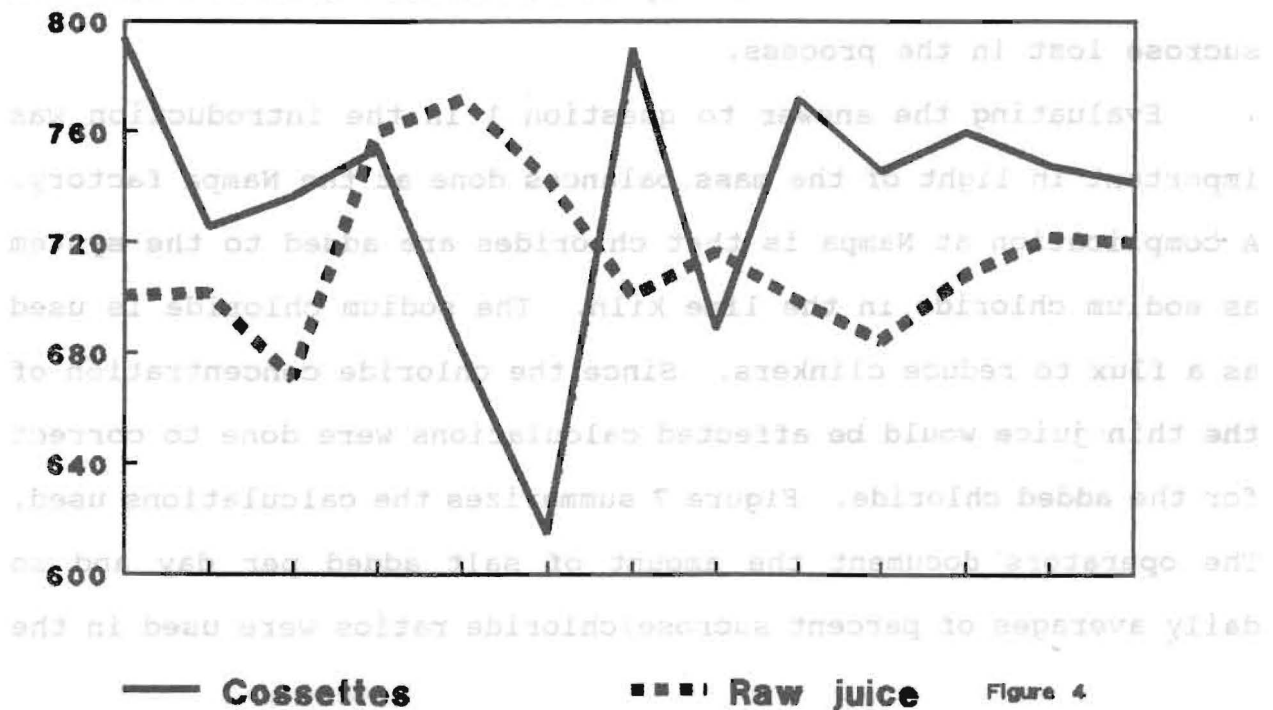


Figure 4

# Calculated GC/CI in Thin Juice

$\text{Slice}(\text{cossette \%sugar-pulp loss}) \times 2000 = \text{lbs sugar}$

$\text{lbs CI in rj} = \text{lbs sugar} / \text{GC/CI of rj}$

$\text{lbs CI} + \text{CI added in lime} = \text{lbs CI in Thin juice}$

$\text{Calc. GC/CI of thin juice} = \text{lbs sugar} / \text{lbs CI in tj}$

Figure 7

## GC/CI Ratios

Cossettes	Raw Juice	Calc.Thin	Thin	Thick
691	662	623	621	614
691	658	620	611	615
673	657	618	619	618
934	895	818	813	856
1170	1104	985	954	956
734	703	653	663	
715	666	625	627	

Figure 8



Calculated GC/CI in Thin Juice

lbs CI in rj = lbs sugar \ GC/CI of rj

lbs CI + CI added in lime = lbs CI in Thin Juice

## % Loss on beets

Calc. GC/CI of thin juice = lbs sugar/lbs CI in rj

Assume: GC/CI = lbs sugar/lb CI

Then: GC/CI of cossettes/ %sugar = lbs beets/ lb CI

GC/CI of coss.- GC/CI of thin juice = lbs sugar lost/ lb CI

lbs sugar lost / lbs beets = calc. loss

calc. loss - pulp loss = % loss / beets

Thick	Thin	Calc. Thin	Raw Juice	Cossettes
614	621	623	662	691
675	611	620	658	673
678	619	618	627	624
888	813	818	888	1170
888	884	885	1104	734
	663	653	703	718
	627	625	666	

Figure 9

Figure 8

## % Loss on Beets

### Twin Falls

	Calc. Loss	Unacc. loss
	.19	.34
	.46	.21
avg.	.33	.28

Figure 10

## % Loss on Beets

### Nampa

	Calc. Loss	Unacc. loss
	.39	
	.48 (.44)	.43
	.06	
	.58 (.32)	.24
	.41	.47
	.29	
	.56 (.43)	.31
	.87	
	.96 (.92)	.96

Figure 11

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2.1	4.6
2.8	3.3

**% Loss on Beta**

Unacc. loss	Calc. Loss
4.3	3.9
2.4	4.8 (4.4)
4.7	2.8 (3.2)
3.1	2.9
3.6	2.6 (4.3)
3.6	2.8
3.6	2.6 (2.2)