

The Effects of Processing Conditions on Carbonation Elimination

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Introduction

This paper considers key points from Holly Sugar Corporation Research Report 53 (3)², defining the relationship of operating conditions to impurity elimination in carbonation. Discussion in the following summary will include total carbonation elimination and then organic acid elimination. Studies were made at the Tracy Plant in California using a bench scale Benning carbonator.

Summary

The tests centered around three operating controls: alkalinity of filtered first carbonation juice, CaO addition, and temperature. In three sets of experiments, two controls were held constant while the third was varied within a range. The constant control values were:

Temperature - 84-87 °C

CaO on beets - 2.2%

Alkalinity - 0.095 - 0.105%CaO

Thin juice was prepared for analysis from filtered first carbonation juice by adjusting the pH to 9.2 with phosphoric acid, heating to 80°C., and filtering.

1. Results of the alkalinity tests as diagrammed in Figure 1 indicate that maximum elimination occurs at an alkalinity of 0.123% CaO. This means that as the carbonation alkalinity increases to 0.123% CaO, colloids and other precipitable non-sugars increase in rate of precipitation. Above the alkalinity 0.123% elimination decreases due to colloid peptization. If the alkalinity is lowered by 0.010% from the optimum value, carbonation elimination is decreased 1.2%, corresponding to about 0.90 pounds less sugar extracted per ton of beets.
2. CaO addition has a definite effect on carbonation elimination as shown when % CaO on beets is plotted versus % carbonation

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²Numbers in parenthesis refer to literature cited.

ALKALINITY VS. CARBONATION ELIMINATION

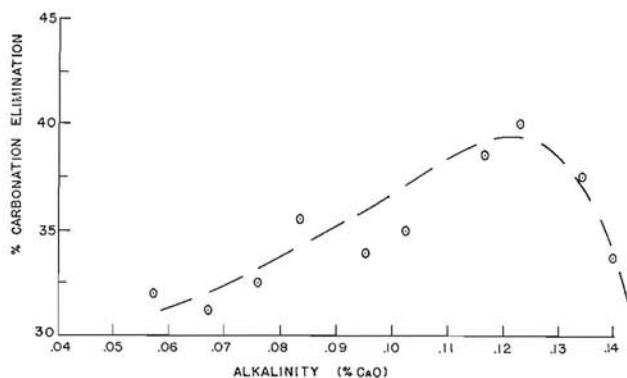


Figure 1.—Alkalinity vs. carbonation elimination.

CaO ADDITION VS. CARBONATION ELIMINATION

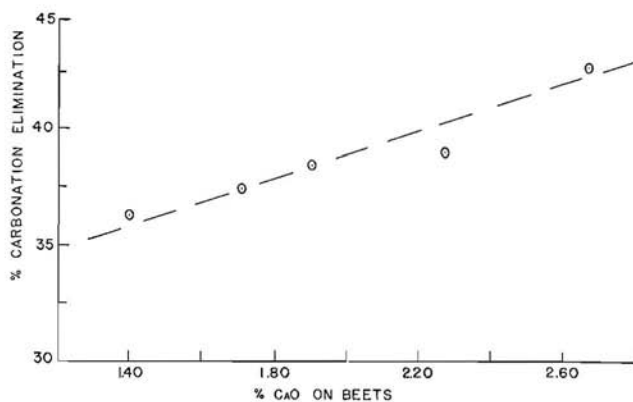


Figure 2.—CaO addition vs. carbonation elimination.

% CaO ON NONSUGARS VS. CARBONATION ELIMINATION

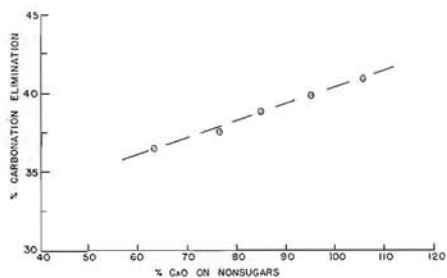


Figure 3.—%CaO on nonsugars vs. carbonation elimination

elimination, Figure 2, and % CaO on non-sugars versus carbonation elimination, Figure 3. By increasing the % CaO on beets from 1.40 to 2.68, elimination is increased 5.62%. This means that for every 25.6 pounds of available quick lime, there is a gain of about 4.5 pounds of sugar per ton of beets. Generally, money spent for additional lime is recovered by increased sugar extraction.

The results from Figures 2 and 3 are supported by the 1961 published findings of Dedek (1) on CaO adsorption. He states, "that under the **most** favorable circumstances, 93% of the amino acids, 40% of the dextran and 80% of color are removed." Previous to this time, the magnitude of the absorption effect was discarded.

In addition to adsorption, Holly Sugar studies (2) have found that other benefits, including better thick juice color, lower lime salt levels, and improved physical properties of filtration rate (F_K) and settling rate (S_K) of first carbonation juices, are realized from using additional CaO.

3. In figure 4, temperature has no marked effect on carbonation elimination. From a practical standpoint, carbonation temperature must be maintained at a higher level for efficient gas absorption. While all of the effects of temperature on carbonation are not too clear, colloid coagulation increases with temperature and some calcium salts become less soluble.

Two studies were made to determine the effects carbonation control had on organic acid elimination. The initial study revealed that organic acids which form highly insoluble calcium salts (*i.e.*, succinic and oxalic) were relatively insensitive to operating controls and easily eliminated in excess of 90%. At the same time, citric and malic acid which form relatively soluble calcium salts were sensitive to operating controls. Consequently, additional studies were made of citric and malic acid.

1. From Figure 5, the effect alkalinity has on citric and malic acid elimination is not very clear. However, in Figure 6, where malic acid is increased in the raw juice feed by approximately 100%, an increase in alkalinity linearly decreases the residual acid in thin juice.

These results are contrary to some opinions (5) that solubility increases with alkalinity, but are supported by the very recent findings of the Brunswick Sugar Institute (4). The results are clear when considering the physical-chemical reaction as shown in the equation below:

$$\text{Ca} \cdot (\text{OH}) + \text{K} \cdot \text{R}_s \quad \text{Ca} \cdot \text{R}_s \downarrow + \text{K} \cdot (\text{OH})$$

where K is a cation and R_s is a relatively soluble salt of an organic acid.

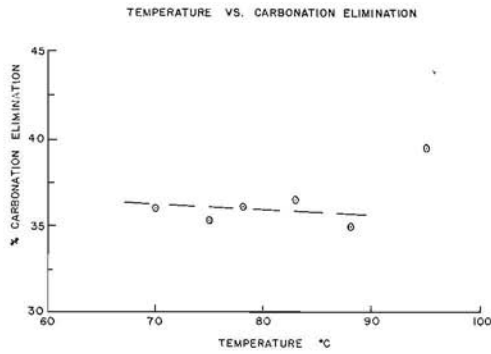


Figure 4.—Temperature vs. carbonation elimination.

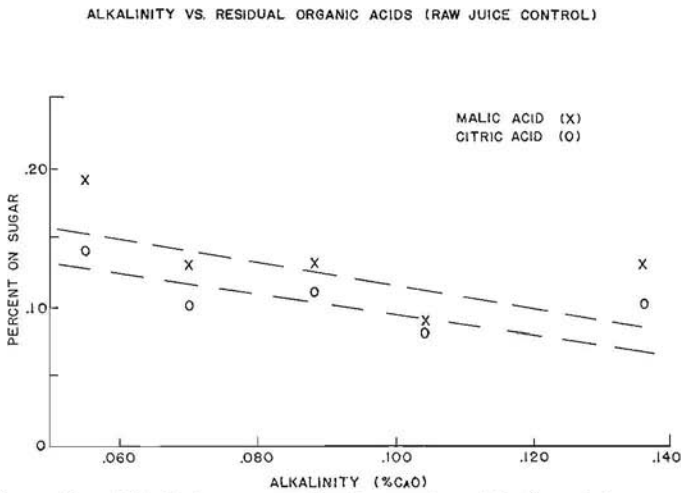


Figure 5.—Alkalinity vs. residual organic acids (raw juice control).

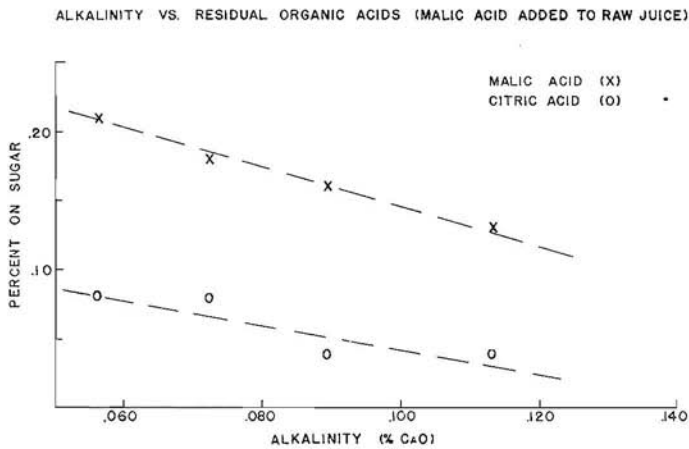


Figure 6.—Alkalinity vs. residual organic acids (malic acid added to raw juice).

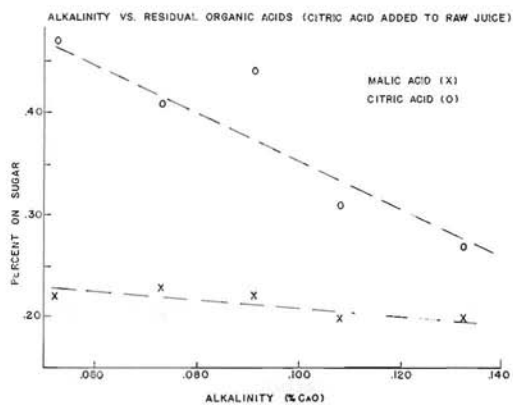


Figure 7.—Alkalinity vs. residual organic acids (citric acid added to raw juice).

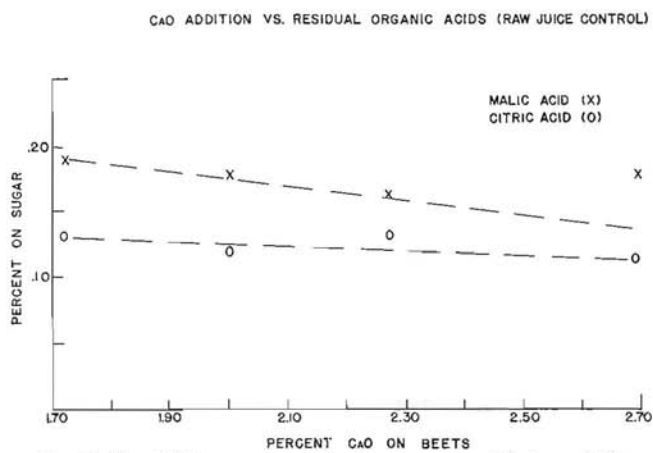


Figure 8.—CaO addition vs. residual organic acids (raw juice control).

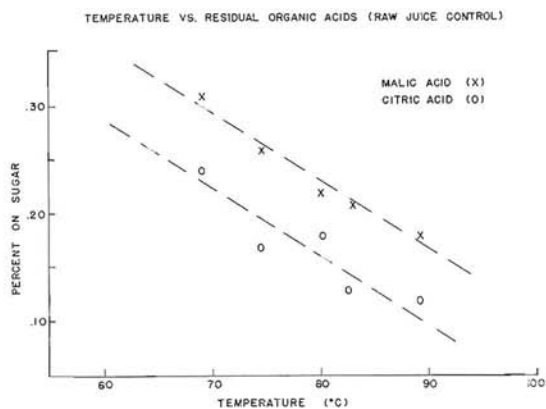


Figure 9.—Temperature vs. residual organic acids (raw juice control).

As the alkalinity increases, the reaction goes to the right and more calcium salts of organic acids are precipitated.

2. Increased CaO addition in carbonation slightly increases the citric and malic acid elimination as seen by the decrease in residual acid in thin juice. Figure 8.
3. Increased temperature definitely increases citric and malic acid elimination as seen in Figure 9. This is probably caused by the fact that the solubility of calcium salts of these acids decreases with temperature.

Conclusions

- 1) The maintenance of first carbonation optimum alkalinity end-point increases carbonation elimination if carbonation is performed in a simplified system such as the Benning.
- 2) There is no evidence to support total carbonation elimination dependence on carbonation temperature.
- 3) The cost of higher additions of CaO is offset by the increased sugar extractions. Monetary bonuses in the form of low color and lime salts and in better settling and filtration rates are realized.
- 4) The elimination of citric and malic acid increases when the controls of alkalinity, CaO additions, and temperature are increased.

Literature Cited

- (1) DEDEK, DR. J., 1961. Absorption of Certain Non-sugars on Calcium Carbonate, *Fourteenth Annual Technical Conference - British Sugar Corporation L.T.D.*
- (2) JESIC, V. M., L. T. ZANTO, and S. E. BICHSEL. 1970. Results of Carbonation Studies at Carlton, Tracy, and Shoup, *Holly Sugar Corporation Report 44.*
- (3) JESIC, V. M., LINDA L. WHEELOCK, and L. T. ZANTO. 1972. The Influence of carbonation operating conditions of total non-sugar elimination and on organic acid elimination. *Holly Sugar Corporation Report 53.*
- (4) SCHNEIDER, VON F., E. REINEFELD, and K. M. BLIESENER. 1971. Untersuchungen zum Fallungsverhalten von Rohsaftinhaltsstoffen. *Zucker*, No. 16.
- (5) SILIN, P. M. 1967. *Technology of Beet Sugar Production*, 218, Moscow.