

Adding Soda Ash to the Main Limer, Not as Odd as you Might Think.

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Soda ash addition just prior to or at the second carbonation station is a common tool used by beet-sugar processors to aid in processing poor-quality juice. It both reduces the juice's calcium and increases its alkalinity. Since 1996, factory personnel at Minn-Dak have been adding soda ash to the main limer instead of just prior to the second carbonation tanks. It has the same benefits of adding to the second carbonation tank, but significantly reduces problems with filtering the juice and increases its stability. The objective of this research was to examine the chemical affects of adding soda ash into the main limer

The benefits of adding soda ash to the main limer seem to include increasing the reactivity of the milk of lime. This could be explained by a common ion effect. When processing beets in good condition, there is plenty of natural alkalinity-an excess of sodium and potassium ions relative to the soluble anions present. However, once the beets have deteriorated, there is an excess of soluble anions relative to the alkali ions. This excess is either created or increased in the main limer where hydroxide reacts with inverts and other neutral species to form organic acids. The creation of these acid anions consumes hydroxide, leaving an excess of calcium ions. As the concentration of the calcium ions builds up, it suppresses the solubility of the calcium hydroxide-the common ion effect. Thus when processing deteriorated beets, the main limer has a lower hydroxide concentration just when a high concentration is most beneficial. Adding soda ash to the main limer instantaneously precipitates calcium as carbonate, thus shifting the equilibrium towards an increased hydroxide concentration. This would explain the apparent increased reactivity with more stable juices and decreased filter problems.



$$K_{\text{sp}} = [\text{Ca}^{+2}][\text{OH}^{-1}]^2 \quad \text{Equation 2}$$

Using the solubility for calcium hydroxide of 0.770 g/L at 100 °C (The Sugar Technologists Manual, Bubnik et al) K_{sp} calculates to 4.5×10^{-6} . The equilibrium concentrations of the calcium and hydroxide are 0.01040 M and 0.02080 M at this temperature. The calculated new equilibrium concentrations after adding 1 gram of CaCl_2 to one liter of this solution (0.5298 g Ca^{+2}) are 0.02097 for calcium and 0.01465 for hydroxide. Thus the calculated hydroxide concentration has decreased by 30%.

Two, 200 mL 15% sucrose solutions were made. To each 3.65 grams of CaO was added. To one of the solution, 2g of CaCl_2 were added as well. After letting stand at room temperature for 15 minutes the solutions were filtered through a 0.45-micron filter. The pH of the solution without the added salt was 12.35 and that with the added salt was 11.99, demonstrating that at least one highly soluble calcium salt has a common ion affect on the hydroxide ion concentration.

Attempts to determine if the common ion effect actually altered reaction rates on glucose and glutamine were inconclusive.

If the common ion effect depresses the solubility of calcium hydroxide, it should also depress the solubility of other partially soluble salts such as calcium sulfate. If this is true, than adding soda ash to the main limer might be detrimental as the main limer is where the sulfate experiences the highest calcium concentration. However, upon investigation it was found that solubility of calcium sulfate was much higher in beet-end sugar solutions ($K_{sp} \cong 1.0 \times 10^{-3}$) than in water ($K_{sp} \cong 1.0 \times 10^{-6}$). The K_{sp} values were determined in raw juice, main-limer juice (with and without excess CaCl_2 added) by measuring the calcium concentration with atomic absorption and sulfate concentration with ion chromatography.

It was found that the main-limer juice contained the same amount of sulfate as the raw juice even though the calcium concentration is much higher in the main limer. Even added calcium chloride did not precipitate the sulfate. However, when the main-limer juice was gassed with CO_2 , the sulfate concentration decreased even though throughout this process the calcium concentration is decreasing. The same type of behavior was found for citrate, another partially soluble calcium salt.

It appears that by adding soda ash to the main limer, the benefits of softening, increased alkalinity, and increased calcium hydroxide solubility are achieved without reducing the amount of partially soluble salts removed in the first carbonation sludge.