SUCROSE LOSSES IN JUICE AND DURING CLARIFICATION: EXPERIENCES IN THE UNITED STATES

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Abstract

Two major aims of an ongoing Agricultural Research Service project of the United States Department of Agriculture are: 1) to improve the measurement of industrial sucrose losses; and 2) to reduce sucrose losses. This paper briefly discusses sucrose losses in cane juice at ambient temperatures (~27°C) and, at higher temperatures (55–115°C), during different clarification processes.

Sucrose losses in cane juice at ambient temperatures

Cane deterioration in the field, factory storage pile, or during factory milling processes, has become a topic of major concern in recent years, particularly in the U.S. where mechanical harvesting of billeted sugar cane has increased dramatically. Losses of sucrose in cane deterioration are attributable to chemical (acid) and enzymic inversion reactions as well as those from microbial activity, and can be influenced by cane health and environmental conditions. However, the relative contributions of these reactions to sucrose losses on cane deterioration at factory ambient temperatures (~27°C) has not been fully elucidated.

Laboratory tests were undertaken to compare microbial, enzymic, and chemical deterioration of sucrose in factory cane juice. Heat (boiling temperature) and biocide treated juice, as well as untreated juice, were deteriorated at 27°C in an incubator across 71 h. The biocide treated juice retained its dark brown colour, fresh odour, initial pH and brix levels across 71 h, and no dextran formed. In strong contrast, after 71 h, the untreated juice was light brown, had a strong alcoholic odour and markedly lower pH and brix levels, and dextran formed. The colour of the heated juice only reduced after 23 h. The juice was viscous after 71 h mostly because of the formation of dextran, and had neither a fresh nor alcoholic odour.

Using gas chromatography on these three types of juice samples and knowing the types of degradation reactions that were taking place, it was observed that over the first 14 h of deterioration, 93.0% of sucrose losses were microbial, 5.7% enzymic and 1.3% were chemical (acid inversion). Ion chromatography with integrated pulsed amperometric detection (IC-IPAD) was used to simultaneously analyse for ethanol, mannitol, and oligosaccharides in deteriorated cane juice, which is illustrated in Figure 1. The rate of formation of mannitol, produced from the reduction of fructose by mannitol dehydrogenase in dextran forming Leuconostoc bacteria, was much higher than associated oligosaccharides or ethanol formation. A further investigation of the use of mannitol as a sensitive indicator of future dextran related processing problems at cane factories is warranted.

Sucrose losses during clarification at high temperatures (55–115°C)

In the U.S., cold lime clarification still remains the clarification process of choice. A comparative factory study of hot versus intermediate and cold lime clarification was undertaken to quantitate performance. In cold liming, mixed juice (MJ) was incubated and then limed in a lime tank (4 min), both at ambient temperature (~55°C). For intermediate liming, 50% of the MJ was heated (97–108°C) before incubation, then limed in a lime tank (4 min) at ~81°C. Hot liming was configured very similar to intermediate liming except that lime was added immediately after flash-heating (115°C; 30 sec). Hourly samples across each of the three processes were collected over a six hour sampling period, on three consecutive days respectively, and these were repeated three times across the 2000 grinding season.

For most clarification parameters investigated, both hot and intermediate liming performed much better than cold liming, and hot liming offered some extra advantages over intermediate liming. Gas chromatography was used to measure sucrose and glucose concentrations on a brix basis, and sucrose losses were measured indirectly as glucose % sucrose increases. Markedly less sucrose was lost to inversion reactions across both hot (season av. 0.79%) and intermediate (0.97%) lime processes than across cold liming (1.48%).

The sucrose loss savings alone offered by intermediate and hot liming would currently save sugar-cane factories an estimated US$123,000 and US$283,000 per year, respectively. Increasing the factory target pH of the final evaporator syrup (FES) from ~6.0 to 6.3, in sampling period 3, caused a marked reduction in sucrose inversion losses in both hot and intermediate liming.

KEYWORDS: Sugar Losses, Clarification, Cold Liming, Hot Liming.
Fig. 1—Deterioration products in heat treated cane juice.