

SURVEY ON THE USE OF STARCH HYDROLYSING ENZYMES IN SOUTH AFRICA

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Abstract

A survey was conducted to document the current practices and procedures around the use of α -amylase enzymes for the control of levels of starch in South African sugar factories. Five factories were selected based on the prevalence of starch in each specific cane growing area and the historical routine application of α -amylase by the particular factory.

All of the factories made use of a commercial mixture of heat-stable α -amylases produced by genetically modified strains of *Bacillus licheniformis*. These enzymes can operate at temperatures around 105°C, but preferably at 95°C, and at lower pH and calcium levels than previous generations of enzymes. The optimum operational pH is 5.9, with a required calcium content of 40 mg/kg.

The survey highlights the commonalities between the factories as well as deviations from the optimum or recommended conditions, and possible pitfalls with regards to the handling and use of enzymes.

Keywords: enzymes, amylase, starch, survey, evaporator, hydrolysis, factory process

Summary

The use of α -amylase enzymes in some of the South African sugar cane factories to control seasonally high levels of starch in clarified juice has become routine over the past 20 to 30 years. These are marked by the use of genetically modified strains of *Bacillus licheniformis* which were developed specifically for their heat stable properties (Anon, 2001). This enzyme is more active at lower calcium levels and can operate at higher temperatures and a lower pH than the previous enzymes. The recommended conditions are a temperature of 95°C (although the enzyme can withstand 105°C), a pH of 5.9 and a minimum calcium content of 40 mg/kg.

Starch consists of long-chain glucose polymers. It is the primary product of photosynthesis and therefore enters the factory together with the cane. The amount of starch in the cane depends on many factors including variety, growing conditions and regional climate. Some of the starch is believed to be hydrolysed by natural enzymes, particularly in diffusers; some of the starch may also be physically removed during clarification. High starch levels in a factory contribute to high viscosity in massecuite and molasses, which gives these streams poor handling characteristics, boiling problems in vacuum pans, melassigenesis (an increased loss of sucrose to molasses) and filterability impediment in carbonatation refineries.

α -Amylase does not physically remove the starch from the factory, but rather hydrolyses the starch polymers to smaller, more benign molecules. Since the enzymes are typically dosed after clarification, the hydrolysis products and unreacted starch will find their way, together with the inactive enzyme, to raw sugar or to molasses.

At least five of the 14 factories in South Africa use α -amylase at some time during the season, specifically when rainfall increases from October to December. Only one of these factories operates a mill, while the others have either one or two cane diffusers in parallel.

The recommended point of application is the third or fourth evaporator effect, where conditions were found most favourable (Madsen, 1974). Since the last factory trials in this industry were done more than 30 years ago, actual practices have slowly deviated from the initial recommendations. A survey was done (Schoonees, 2005) of these five factories to document the current practices and to accentuate the responsible use of enzymes.

Each factory has its own in-house criteria to determine whether to dose enzyme or not (and how much) while one of them doses continuously throughout the crushing season. All of the factories change their dosing rates according to predetermined criteria. These criteria generally appear to be based on the South African Sugar Millers' Association Ltd (SASMAL) Sugar Quality Committee's penalty/bonus scheme which currently penalises the delivery of raw sugar with a starch content of more than 140 mg/kg to the South African Sugar Terminal (SAST). This converts roughly to just under 400 mg/kg (on Brix) starch in juice.

However, only two factories analyse for starch in juice, while the others rely on raw sugar starch analyses, either in their own or another laboratory, to determine the starch levels in the factory. A delay in results of between a day and a week is therefore not uncommon, which would in turn result in a considerably delayed response to unexpectedly higher or lower starch levels.

The enzyme supplier indicates that the enzyme should be diluted with distilled water at a 1:20 ratio. The five South African factories that use amylase have various dilution policies that range from a 1:25 ratio down to no dilution. The average annual dosage rate ranges from 0.3 to 4.2 g/ton cane; the recommended dosing rate is between 1.0 and 2.5 g/ton cane. During the 2005/6 season the average raw sugar starch levels for October, November and December for the five factories under evaluation, were between 111 and 125 mg/kg with maximum by month figures of 122 to 158 mg/kg (Anon, 2006).

Enzymes, even 'industrial' enzymes, can be delicate where conditions are not conducive to their endurance. The handling of the enzymes, transport and storage conditions, the length of storage, dilution and transfer to different containers, will all have a marked effect on the activity of the enzymes. The activity should ideally be monitored on arrival from the suppliers and directly before use; this is not currently being practised, so that the factories do not know what could reasonably be expected of the enzymes. Even under perfect conditions the amylase enzymes will gradually lose their activity and are only expected to stay above the declared activity for three months if stored at 25°C (Anon, 2001).

Conclusions and Recommendations

The use of enzymes in the South African factories under evaluation achieves success in lowering the starch content to acceptable levels. It is essential that the practices be monitored on a regular basis to prevent substandard handling of the enzymes. Optimisation in terms of handling and dosing of enzymes will lead to a direct reduction in the enzyme cost per annum and/or improved enzymatic performance.

Current practices at the factories involved in the survey are clearly based on the historical perspective and climate of the factory, the specific experience of the managers and the skill of the operators.

It is recommended that factories analyse for starch in composite juice samples so that immediate steps can be taken in cases of unexpectedly higher or lower starch levels. Dilution ratios of 1:20 with distilled water should be done in containers made from material that is not hazardous to the enzymes, i.e. polypropylene. The enzymes should, where possible, be stored at 25°C and not for longer than three months. The determination of enzyme activity upon receipt of the enzyme and just before its use is strongly recommended.

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