

LACTIC ACID FORMATION ACROSS A FILTER STATION

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Abstract

Assessments of microbiological activity in the Maidstone filter station in 1986 indicated significant sucrose losses. The chief end-product of sucrose fermentation by micro-organisms under filter station conditions is lactic acid. In 1986, the level of lactic acid was 700 ppm on brix in clear juice and 5 500 ppm in combined filtrate return. Further tests in 1987 showed that a significant proportion of the sucrose loss appeared to be occurring in the large No. 7 filter. In 1988, an effort was made to maintain high temperatures by steam injection into the mud boot of filter No. 7 and lagging of mud lines to that filter. In addition the filtrate return to the mixed juice was re-routed to the suction of the mixed juice pumps and not to the mixed juice tank, as previously occurred. In 1990, lactic acid in filtrate averaged only 1 900 ppm. This equates to an estimated sucrose loss in filtrate of 1,0% in 1986 and 0,2% in 1990.

Introduction

Various factors such as high microbial levels in incoming cane, a favourable environment for continued growth, and long time delays contribute to microbiological activity in sugar mills. The chief end-product of sucrose fermentation by micro-organisms under filter station conditions is lactic acid. The approximate conversion rate of sucrose to lactic acid is one part of lactic acid formed to every two parts of sucrose destroyed at high temperatures (McMaster and Ravnö, 1975). An assessment of bacteriological activity in the filter station, undertaken in 1986, indicated significant sucrose losses at Maidstone (Cazalet, 1987). This paper reviews data obtained from filter station surveys made during the past five seasons (Bodasing 1988, Mackrory 1988, 1990, Madaree, 1990). Evaluation of this information should provide a better understanding of problems and causes of microbiological activity across a filter station.

Experimental Procedure

Samples from the following streams were sealed in sachets and immediately frozen by immersion in a dry ice/alcohol bath, after retaining a portion for pH measurement.

1. Clear juice (CJ)
2. Clarifier mud (CM)
3. Ex mud mixer (MM)
4. Combined filtrate (CF)
5. High vacuum filtrate (HV)
6. Low vacuum filtrate (LV)
7. High vacuum receiver (HVrec)
8. Low vacuum receiver (LVrec)
9. Mud overflow tank (OF)

In earlier investigations, temperatures were determined, where possible on the material in the vessel or otherwise on the withdrawn sample, using a digital thermometer. In the 1990 survey, temperature probes were installed in sample streams two to eight listed above (Mackrory, 1990). Temperatures were monitored and recorded via a data logger connected to a PC. Information was later retrieved and graphed.

Results and Discussion

Routine monthly lactic acid results

Lactic acid is determined routinely on composites of mixed juice and molasses from all Tongaat-Hulett mills. These data are used to calculate overall lactic acid balances. In recent years these figures have highlighted a problem at Maidstone. All lactic acid results for the past four seasons are depicted in Figure 1.

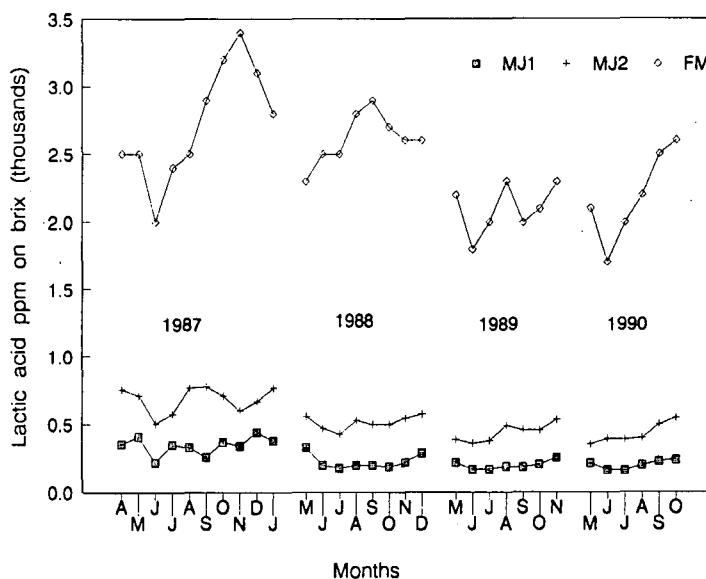


FIGURE 1 Monthly lactic acid levels at Maidstone mill for the past four seasons.

Lactic acid in diffuser mixed juice is consistently lower than in mixed juice from the tandem, due to the very high operating temperatures of the diffuser (Mackrory *et al.*, 1984).

Indications are that levels of lactic acid expressed as ppm on brix declined over the past four seasons. Average lactic acid figures confirm this improvement, which is most apparent in the two mixed juice streams.

Process conditions pH and brix levels

Table 1
Mean pH levels

Year	CJ	CM	MM	CF	HV7	LV7	HV rec	LV rec	OF
1987	6,9	6,8	-	6,5					
1988	7,1	-	7,4	7,0					
1989	6,8	6,8	6,7	6,5	6,7	6,5			
1990	-	6,6	6,7	6,5	6,5	6,6	6,4	6,4	6,0

Gross microbiological activity would result in significant differences in pH between clear juice and filtrate due to the production of organic acids. However the pH levels are fairly constant across the filter station and show a pH drop of around 0,4 units from CJ to CF (see Table 1).

The brix pattern is normal, with the exception of a low value in the mud overflow tank (see Table 2). This is due to liquidating of the individual rotary vacuum filters and dilution from the washing of filter surfaces during continuous operation, as Maidstone does not have a complete shut-down.

Table 2
Mean brix results

Year	CJ	CM	MM	CF	HV7	LV7	HV rec	LV rec	OF
1987	11,9	9,7	-	7,0					
1988	11,1	-	8,8	6,8					
1989	12,2	9,1	7,9	7,6	7,7	7,7			
1990	-	9,5	8,5	7,7	8,0	8,1	7,6	7,8	2,5

Temperature

Table 3
Mean temperature levels (°C)

Year	CJ	CM	MM	CF	MB 1&4	MB 7
1986	-	88	80	62	71	-
1987	-	80	80	61	71	60
1988	97	-	81	64	72	75
1989	-	87	85	-	74	78

From CM to MM, temperatures are fairly constant at 84°C (see Table 3). This is generally high enough to prevent microbiological activity. However, as mud temperatures influence low vacuum filtrate temperature, the value could be higher. Both clarifier mud and mud mixer tanks are partially open and account for some temperature loss.

In addition to the samples listed earlier, temperatures were measured on samples withdrawn from mud boots. In 1986 temperatures were measured only on samples from mud boots one and four (denoted MB 1&4 in Table 3). In 1987 samples were also taken from the big No. 7 filter boot (MB 7). No. 7 temperatures were very much lower at 60°C. At this temperature a significant level of thermophilic activity can be expected. Therefore, in the 1988 off-crop, the feed line to No. 7 filter was lagged and provisions were made for steam injection to the mud boot. As a result, the No. 7 mud boot temperatures rose to 75°C or more, a level at which microbial activity will be minimised.

It is not possible to maintain filtrate temperatures above the saturation temperature corresponding to the filter vacuum. At MS the maximum temperature for low vacuum filtrate is around 90°C, whereas for high vacuum filtrate it is around 77°C (based on gauge vacuums of -28 and -60 kPa at the receivers).

In the 1990 survey, several probes were installed and temperatures continuously recorded by a data-logger. Values are more representative of temperatures in process than measurements on withdrawn samples. Maximum, minimum and average in-line data-logged temperature values were extracted for each 24 hour period. These figures exclude mill stops when the filter station was liquidated and temperatures dropped to ambient. Figures 2 and 3 depict daily values for low and high vacuum filtrates from the No. 7 filter and show that it was very seldom that temperatures reach 72°C. One peculiarity was that on the No. 7 filter, high vacuum filtrate temperatures were higher than for low vacuum filtrates. The high vacuum filtrate is close to its saturation temperature, whereas the low vacuum filtrate could be considerably improved up to 90°C.

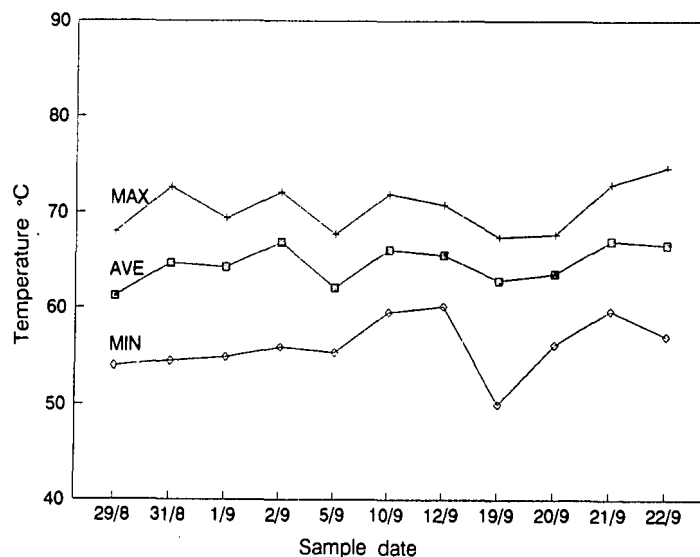


FIGURE 2 Low vacuum No. 7 filtrate (LV7) temperature profile.

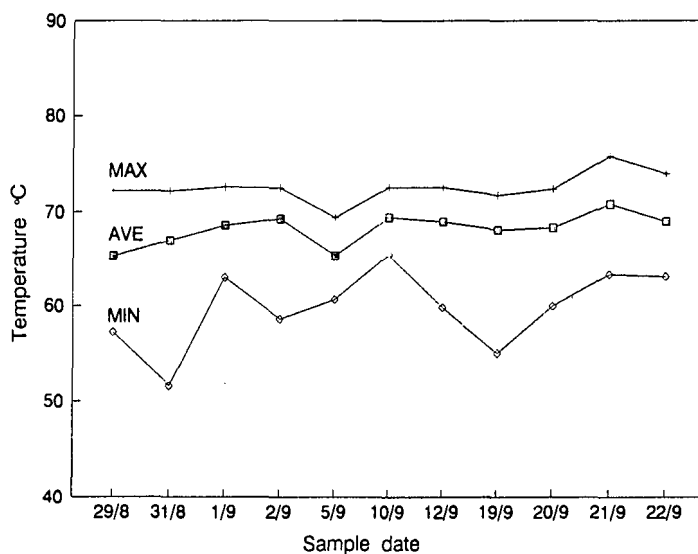


FIGURE 3 High vacuum No. 7 filtrate (HV7) temperature profile.

In general, the Maidstone filter station can run at high temperatures, but not continuously or consistently. There are occasional temperature dips of 5°C in the muds and filtrates which last for one to two hours. No explanation for this occurrence was forthcoming on examination of the mill's daily log.

Lactic acid levels

Lactic acid content is a more sensitive and accurate indicator of sucrose loss by microbial action than is purity drop.

From average results (Figure 4) it can be seen that lactic acid formation has decreased during the past five seasons, particularly in the combined filtrate stream. Lactic acid levels have also declined in the clarifier and mud mixer muds. The pattern for 1989 is peculiar, with high lactic acid values for the mud samples. It is possible that sufficient mud from the highly contaminated overflow tank was returned to the MM tank to raise the acid levels obtained at this time.

Over the past five seasons some unusually high lactic acid levels in combined filtrate have been measured. All project results for CF are presented in Figure 5.

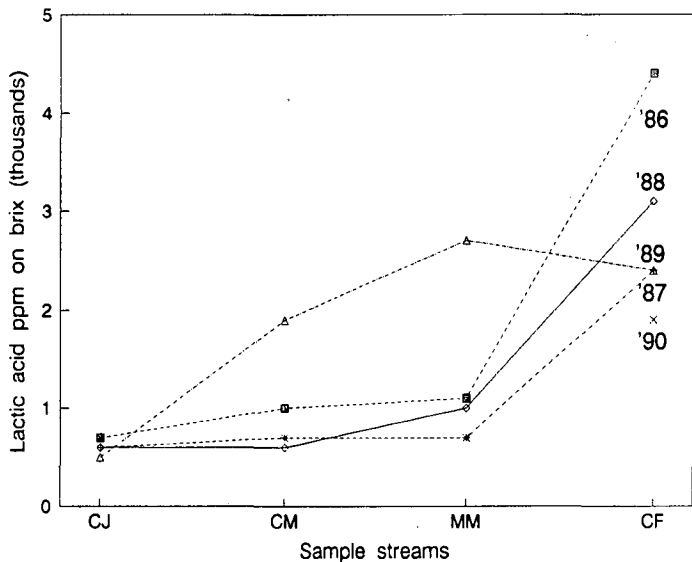


FIGURE 4 Mean lactic acid content across filter station.

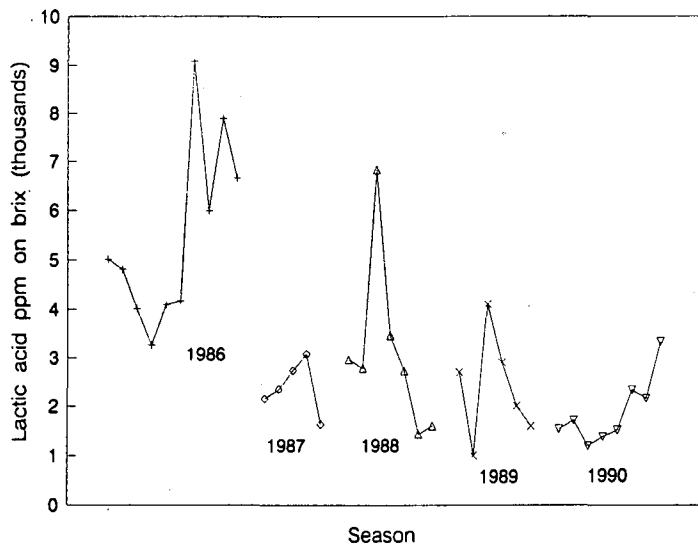


FIGURE 5 Lactic acid in combined filtrate.

It is clear that lactic acid in combined filtrate has varied considerably over the past five years. Results in 1986 were very high, and subsequent results have been lower with only occasional high values. A number of factors could have contributed to these apparent improvements in lactic acid levels – from cane quality, rainfall, and filter station operation to time of season or time of sampling. In general during the latest survey, the CF showed improved quality and had none of the high lactic acid values of previous projects.

Sucrose losses

Estimation of sucrose loss

Previous investigations have quantified the approximate rate of conversion of sucrose to lactic acid as one part of lactic acid formed to every two parts of sucrose destroyed at high temperatures (McMaster and Ravnö, 1975). To illustrate the method of calculation:

assume

$$\text{Ratio sucrose lost to LA formed} = 2:1$$

if

$$\begin{aligned} \text{ppm LA on brix in CM} &= 500 \\ \text{ppm LA on brix in CF} &= 1\ 500 \end{aligned}$$

then

$$\begin{aligned} \text{ppm LA formed in filter station} &(1\ 500 - 500) = 1\ 000 \\ \text{ppm sucrose lost} &1\ 000 * 2 = 2\ 000 \\ \text{i.e. approximately } &0,2\% \text{ sucrose in filtrate.} \end{aligned}$$

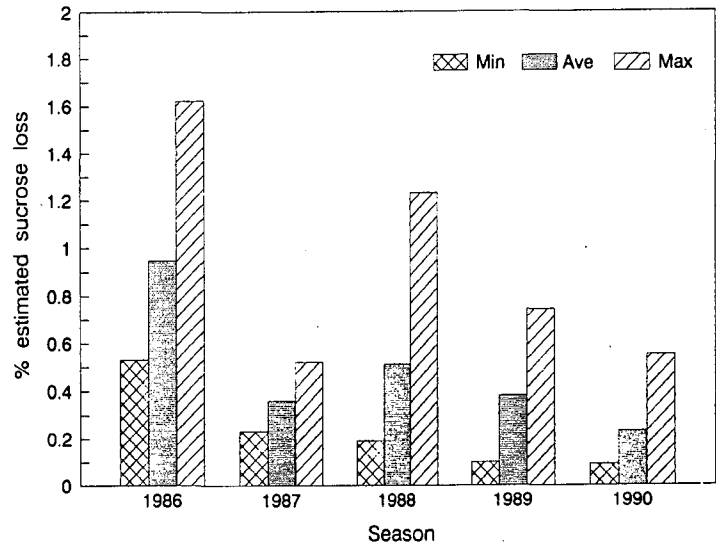


FIGURE 6 Estimated sucrose loss across filter station (as per cent of sucrose in filtrate).

The filter station is now operating better than in previous years, with less sucrose destruction by micro-organisms (see Figure 6). The range of values of estimated sucrose loss for 1990 is typical of values obtained at other Tongaat-Hulett mills.

Conclusions

The sucrose loss across the filter station is the lowest it has been in five seasons, estimated at 0,23% on sucrose in filtrate. Lactic acid formation in process between mixed juice and final molasses has also declined.

Clarifier mud and mud ex mud mixer have average temperatures of 85°C. Filtrate temperatures seldom reach 72°C. The temperature of low vacuum filtrate could be considerably improved. Temperature logs of muds and filtrate streams showed unexplained dips of up to 5°C, which sometimes lasted for one to two hours. Temperature can be used as an effective means of controlling microbiological activity in the filter station.

Temperatures should be kept above 75°C, where practical, to control microbiological activity. Temperatures could be improved and temperature losses minimised by lagging mud feeds to the small filters and the return filtrates to the receivers.

The mud overflow tank should be kept empty as far as possible. This mud is highly contaminated due to its ambient temperature and the fact that it is stagnant. It can constitute a severe source of infection in the filter station and its sucrose value is minimal.

Acknowledgements

Paul Marie and Bobby Rangasamy of the Sugar Technology Laboratory at Tongaat-Hulett Sugar have performed the extensive brix and lactic acid analyses generated during the past five seasons.

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