POST HARVEST DETERIORATION OF BURNT CANE IN BUNDLES

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Abstract

Recently attention has been focused on cane quality as a means of improving the overall performance of the South African sugar industry. Work by the SMRI pioneered the use of ethanol as an indicator and showed a loss of between 2 and 3% of the mass of sucrose in fresh cane for every 1 000 ppm ethanol on brix. Results obtained during the implementation of this procedure routinely during the 1991 season at Tongaat-Hulett mills were queried on the basis of high ethanol levels coupled with high purities. To answer these queries and gain more information on the losses associated with deterioration two trials were run at Mount Edgecombe mill during August/September and November/December. Mass losses from large bundles were lower than previously measured on smaller bundles at 0,4% to 0,8% per day. The mass of sucrose lost was also much lower at approximately 1,0% for every 1 000 ppm ethanol formed. The effect on overall sucrose recovery was estimated to be a drop of between 0,1 and 0,2 units per 1 000 ppm ethanol.

Introduction

One of the major concerns in the industry has been the deterioration in the quality of the cane delivered to the mill due to excessive delays between cutting and crushing. Lionnet (1986) examined the results of deterioration and together with Pillay, (1987, 1988) developed the procedure of monitoring of ethanol levels in DAC extract as a means of estimating delays. In the most recent paper by de Robillard *et al.*, (1990), the sucrose lost due to deterioration was determined to be between 2 and 3% of the mass of sucrose in fresh cane for every 1 000 ppm of ethanol on brix. The average level of ethanol in cane at Illovo, where the work was done, was found to be approximately 4 000 ppm on brix.

Based on these findings a programme of monitoring ethanol levels in DAC extracts has been instituted at all the Tongaat-Hulett mills, with the mass of pol lost being estimated according to de Robillard's results. While the programme has worked well in providing evidence of delays, doubt has been expressed about the accuracy of the pol loss factor. This has been brought about by high ethanol levels coupled with high purities on some deliveries which would indicate very high fresh cane purities.

To answer these queries and to gain more information on the process and consequences of cane deterioration, two tests were carried out at Mount Edgecombe, one during the middle and one at the end of the season. These tests were planned to increase the data on which the estimates of deterioration loss are based. New aspects which were brought into the tests were the measurement of mass loss on full sized cane bundles and the estimation of the effects of deterioration on overall recovery in the mill.

Method

Both tests followed the same basic pattern. A field on Blackburn Estate was chosen, burnt and harvested as quickly as possible. The first two bundles were sent to the mill for crushing with the minimum delay and the rest of the cut cane was stored in chained bundles in the loading zone. Twenty-eight bundles of eight tons each were stored for the first trial and slightly less for the second. The bundles were then delivered to the mill, two at a time, at predetermined intervals over 21 days. The bundles were crushed consecutively to allow the SICB sample to be taken with confidence.

In the first trial, the mass loss was determined on a triangular stack of ten 50 kg bundles which were weighed daily and restacked in the same positions. For the second trial a four ton bundle was stored on a trailer in the mill yard and weighed on the weighbridge at the same times as the test deliveries.

The normal SICB sampling procedure was used and from this the DAC analysis was obtained plus a sample of DAC extract for ethanol analysis. Expressed juice samples were also obtained by pressing prepared cane samples in a hydraulic press. These were used for the gas chromatographic (GC) sugar and ash analyses needed in the recovery calculations. The pol of the expressed juice was measured to allow pol/sucrose ratios to be calculated and a comparative ethanol analysis was also done.

Results and discussion

The analyses from both tests are detailed in the Appendix (Tables 1 to 4).

Mass loss

The mass loss determination on the first trial showed a significant difference between mass loss of the bundles on the outside of the stack and those on the inside or on the ground. Figure 1 compares the average mass loss rates of the five outside bundles with those of the five inside bundles.

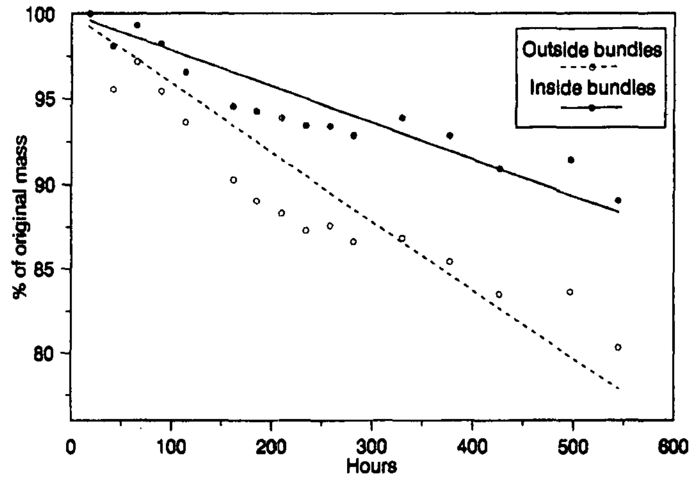

FIGURE 1 Comparison of stack mass losses

The relationships can be expressed as:

% original mass (outside) = 100 - 0,041 x hours R^2 = 0,82 . . . . (1)

% original mass (inside) = 100 - 0,021 x hours R^2 = 0,84 . . . . (2)

The inside bundles showed a mass loss of 0,51% per day, roughly half of that found for the outside bundles at 0,98% per day. This finding indicated that mass loss from a large bundle could be expected to be much lower than that from the small trial bundles which have been used in previous work. To confirm this, the mass loss rate for the second trial was determined on a four ton bundle. The results were affected by rainfall over the first week, but taking all data into account the relationship found was:

% original mass = 100 - 0,018 x hours R^2 = 0,78 ....(3)

This is equivalent to a mass loss of 0,42% per day. If the results prior to 150 hours are ignored, i.e. the period when the mass gains were registered, then the mass loss rate is 0,75% per day. The results are shown in Figure 2.

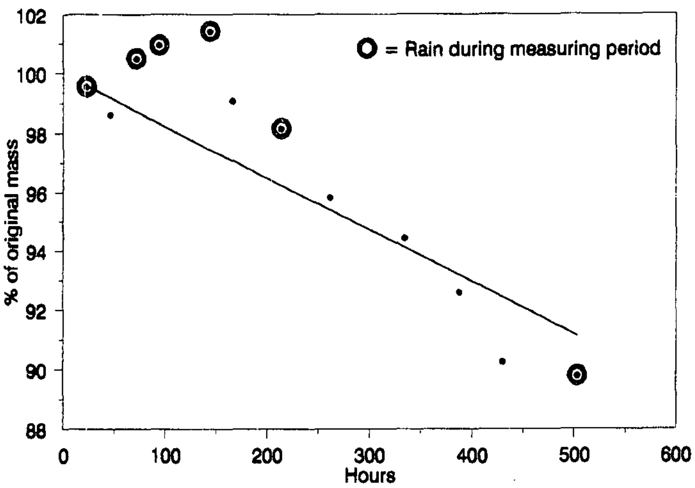

FIGURE 2 Mass loss from a four ton bundle

The mass losses for full scale bundles left in the fields can be expected to be between 0,4 and 0,8% per day which is roughly half that found previously on bundles < 10 kg by:

de Robillard *et al.* (1990)	0,8 - 1,5% per day.
Wood (1973)	0,7 - 1,5% per day.
Wood *et al.* (1972)	0,4 - 1,2% per day.

Drop in pol % cane

The drop in pol % cane was correlated against the ethanol concentration expressed on brix with the following results:

Pol % cane = 14,01 - 8,7 x 10^{-5} x EtOH R^2 = 0,67 ....(4)

Pol % cane = 9,97 - 3,0 x 10^{-5} x EtOH R^2 = 0,14 ....(5)

The two tests produced very different results, the first showing 0,6% relative drop in pol % cane for each 1 000 ppm ethanol and the second 0,3% drop. The comparison is affected by the different fresh cane purities and also by the fact that the rate of ethanol formation related to time was much lower in the second test. The data for the second test were very inconsistent as shown by the poor correlation.

Both test results were however much lower than those reported by de Robillard *et al.* (1990) who found drops in pol % cane ranging from 0,8% to 1,6% relative. The results for the first test are shown in Figure 3.

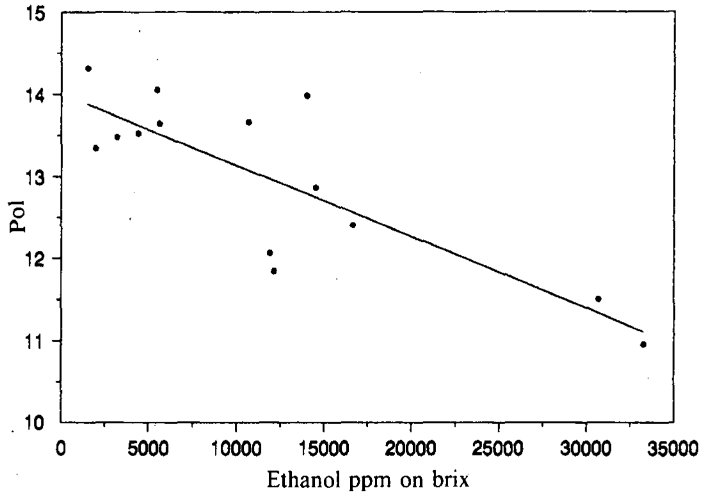

FIGURE 3 Drop in pol % cane

Mass of pol loss

The mass loss was combined with the pol % cane data to calculate the mass of pol lost. The actual mass variations corresponding to each delivery were used rather than the values calculated from the regressions. This gave better correlations, especially for the second test where the rain caused erratic results. The relationships derived are:

% Original mass of pol = 95,7 - 8,3 x 10^{-4} x EtOH R^2 = 0,79 . . . . (6)

% Original mass of pol = 100,3 - 7,4 x 10^{-4} x EtOH R^2 = 0,49 . . . . (7)

These are equivalent to a loss of mass of pol in cane of 0,87 and 0,74% per 1 000 ppm ethanol formed, considerably lower than the 2% reported by de Robillard *et al.* (1990). These relationships are shown in Figure 4.

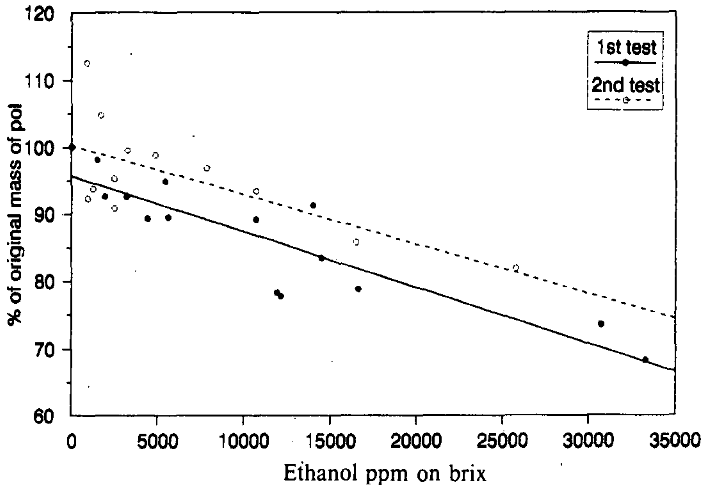

FIGURE 4 Mass of pol loss

The pol/sucrose ratios were calculated for both tests from the expressed juice analyses and were found to vary very little if at all. When the loss of mass of sucrose was calculated it was, within experimental accuracy, the same as the loss of mass of pol in both cases. This is in agreement with the findings in the previous work.

Effect on mill recovery

The expressed juice analyses were used to calculate estimated sucrose recoveries. The method used was to calculate the molasses target purity from the (F+G)/ash ratio and use it in an SJM calculation. To estimate the overall recovery the following assumptions were made:

- 20% loss of monosaccharides in process
- Molasses purity = target purity + 2
- Sugar purity = 99,5
- 4% sucrose loss in (bagasse + filter cake + undetermined)

The relationships derived for sucrose based overall recovery are:

Overall recovery = 92,1 - 9,8 x 10^{-5} x EtOH R^2 = 0,67 . . . . (8)

Overall recovery = 88,8 - 1,7 x 10^{-4} x EtOH R^2 = 0,54 . . . . (9)

This means that for each 1 000 ppm of ethanol formed a drop in overall recovery of between 0,1 and 0,17 units can be expected. The results are shown in Figure 5.

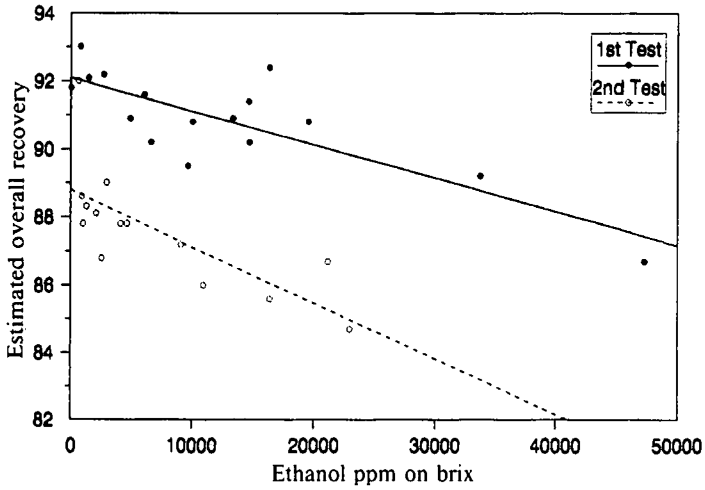

FIGURE 5 Effect on overall recovery

Sucrose inversion

The analysis of the expressed juice samples shows that by far the major cause of sucrose loss is by conversion to reducing sugars and not into further breakdown products. This can be seen in Figure 6, which is the data for the second test. The total sugars hardly change while the sucrose % brix decreases by 10 units.

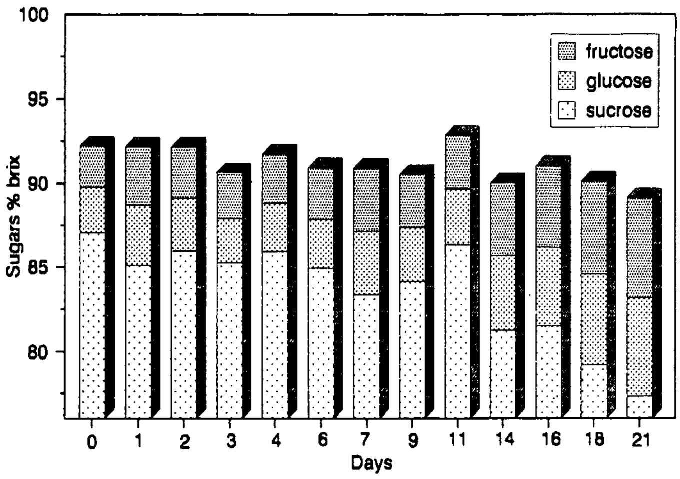

FIGURE 6 Change in sugars with time

Rate of ethanol formation

The rate of ethanol formation in the cane during the two tests was different. What was surprising was that the rate during the second test (average temperature 20°C and raining) was lower than during the first test (average temperature 16°C). Over the 21 days the ethanol ppm on brix reached 35 000 in the first test and only 25 000 in the second test. The data for both tests are shown in Figure 7.

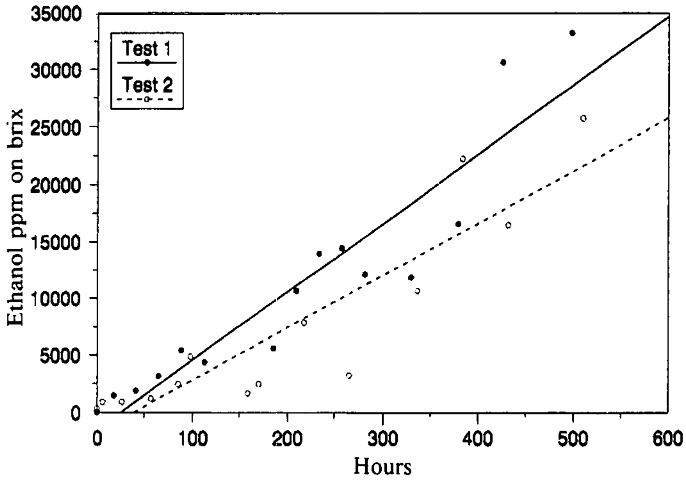

FIGURE 7 Rate of ethanol formation

Comparison with previous results

A comparison between the results found in the two tests at Mount Edgecombe covered in this paper and the work done previously upon which the current estimates of loss are based are summarised in Table 5.

Table 5
Comparison of experimental results

	SMRI/Illovo 1990	STD/ME Aug/Sep	STD/ME Nov/Dec
Average temperature °C	21	16	20
Mass loss % per day	0,8 – 1,5	0,5 – 1,0	0,4 – 0,8
Drop in pol % cane per 1 000 ppm ethanol	1,5	0,6	0,3
% Mass of sucrose loss per 1 000 ppm ethanol	2 - 3	0,9	0,7
Sucrose recovery units per 1 000 ppm ethanol		-0,10	-0,17
Ethanol formation ppm on brix per day	1 230	1 490	1 010

Conclusions

Mass losses from cane stored in large bundles have been shown to be lower than the losses previously measured on small (<10 kg) bundles. This fact taken together with the much lower rates of drop in pol % cane found in the current tests has lead to a calculated loss of mass of sucrose of between 0,7 and 0,9% for every 1 000 ppm ethanol on brix formed. This indicates that the losses in the field due to deterioration may have been overstated and that a more realistic value would be 1% of the original mass of sucrose loss for each 1 000 ppm ethanol on brix.

The effect of the byproducts of deterioration on the overall sucrose recovery in the factory has been calculated to be a reduction of between 0,1 and 0,17 units per 1 000 ppm ethanol on brix. This is a conservative estimate which ignores other negative effects of stale cane such as increased viscosity, higher colours and microbial infection.

Concerns have been raised about the applicability of the conversion factor to calculate pol lost from ethanol formed in cane testing as a routine quality control tool. These concerns are due to the variability in the rate of ethanol formation and more importantly the variation in the loss of sucrose in cane related to ethanol formation. Scope remains for further work to clarify these points.

Acknowledgements

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APPENDIX

Details of the individual test readings and analyses are given in Tables 1 to 4.

Table 1
DAC analysis (Test 1)

Storage hours	Pol % cane	Brix % cane	Purity	Ethanol ppm/brix
17,5	14,3	15,9	89,9	1 500
40,5	13,4	15,3	87,2	1 920
64,5	13,5	15,3	88,2	3 180
88,5	14,1	15,8	88,9	5 440
113,0	13,5	15,5	87,3	4 390
160,5	13,4	15,8	85,0	
185,5	13,7	16,1	84,7	5 590
209,0	13,7	16,0	84,5	10 670
233,0	14,0	16,5	84,6	13 980
257,0	12,9	15,1	85,3	14 480
281,0	11,9	14,7	80,7	12 120
329,5	12,1	15,5	77,9	11 880
379,0	12,4	15,5	80,0	16 600
425,5	11,5	15,1	76,3	30 690
498,0	11,0	14,4	76,0	33 250

Table 2
Expressed juice analysis (Test 1)

Storage hours	Sucrose %	Glucose %	Fructose %	Ash %	Pol	Brix	Ethanol ppm/bx
0	17,64	0,08	0,09	0,41	17,4	18,7	0
17,5	17,92	0,09	0,11	0,29	17,7	18,9	780
40,5	17,61	0,13	0,18	0,31	17,4	18,9	2 690
64,5	17,72	0,09	0,13	0,30	17,6	18,9	1 460
88,5	17,57	0,10	0,13	0,30	17,5	18,9	6 030
113,0	16,59	0,10	0,17	0,35	16,6	18,3	6 600
160,5	16,34	0,20	0,28	0,35	16,1	18,0	10 010
185,5	17,72	0,20	0,22	0,41	17,6	19,4	4 880
209,0	17,51	0,20	0,24	0,36	17,3	19,3	13 320
233,0	18,49	0,19	0,21	0,34	18,3	20,1	14 630
257,0	17,00	0,29	0,41	0,32	16,8	19,2	14 680
281,0	18,23	0,33	0,45	0,46	17,6	19,6	16 300
329,5	18,07	0,34	0,44	0,45	18,0	20,5	9 630
379,0	16,63	0,42	0,53	0,27	16,2	18,8	19 530
425,5	16,37	0,50	0,66	0,31	16,0	19,2	33 700
498,0	13,98	0,75	0,90	0,37	13,4	17,4	47 240

Table 3
DAC analysis (Test 2)

Storage hours	Pol % cane	Brix % cane	Purity	Ethanol ppm/brix
6,0	11,2	13,2	84,8	880
26,0	9,2	11,6	79,8	930
56,5	9,5	11,5	82,3	1 230
85,0	9,0	11,1	81,1	2 490
98,0	9,8	11,8	82,8	4 850
158,5	10,3	12,4	83,1	1 690
170,0	9,6	12,0	79,9	2 490
217,5	9,8	12,3	79,9	7 840
264,5	10,4	12,9	80,0	3 260
336,0	9,9	13,0	75,9	10 680
383,5	10,9	14,0	77,7	22 280
432,0	9,5	12,9	73,5	16 500
510,0	9,1	12,5	72,8	25 730

Table 4
Expressed juice analysis (Test 2)

Storage hours	Sucrose %	Glucose %	Fructose %	Ash %	Pol	Brix	Ethanol ppm/bx
6,0	14,00	0,43	0,40	0,55	13,7	16,1	910
26,0	12,27	0,53	0,50	0,52	12,0	14,4	1 020
56,5	12,51	0,46	0,44	0,48	12,3	14,6	1 300
85,0	12,21	0,38	0,39	0,43	12,0	14,3	4 640
98,0	12,79	0,43	0,43	0,51	12,6	14,9	2 090
158,5	14,04	0,49	0,50	0,48	13,9	16,5	4 100
170,0	12,27	0,56	0,56	0,53	12,1	14,7	2 540
217,5	13,04	0,51	0,49	0,51	12,9	15,5	9 070
264,5	13,55	0,52	0,50	0,43	13,3	15,7	2 950
336,0	13,33	0,73	0,71	0,54	13,1	16,4	10 930
383,5	14,95	0,86	0,89	0,53	14,6	18,3	21 130
432,0	13,39	0,91	0,94	0,49	13,2	16,9	16 370
510,0	12,46	0,94	0,97	0,47	12,2	16,1	22 950

Note: The samples for DAC and expressed juice analysis were taken separately in Test 1, the DAC being the SICB sample and the expressed juice a stalk sample. For Test 2 they were sub samples of the same SICB sample.