ETHANOL AS AN INDICATOR OF CANE DELAYS UNDER INDUSTRIAL CONDITIONS

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Abstract

The usefulness of the concentration of ethanol in DAC extracts as an indicator of industrial cane delays is investigated. Delay periods, obtained from tags attached to cane bundles, temperatures during the delay periods, ethanol contents of the Direct Analysis of Cane (DAC) extracts and cane variety relating to randomly selected cane consignments were collected at Illovo, over the period July to December 1987. Multilinear regressions are used to give the delay in terms of the above variables. The results show that the delays of industrial consignments can be estimated to within ± 20 hours by this approach. The method is relatively simple and it is recommended that it should be used on a full-time basis.

Introduction

The possibility of using the ethanol concentration in DAC extracts as an indicator of cane delay was investigated[1] on a laboratory scale in 1986 and was found to be promising. The investigation was then extended,[2] to cover most of the South African cane producing areas, by carrying out short term tests at a number of sugar mills. The results obtained confirmed the suitability of the approach and it was decided to implement it at one mill.

Experimental Procedure

A Gow-Mac series 580 gas chromatograph and the required peripheral equipment were installed in the Illovo laboratory and were ready for operation in July 1987. The procedure used was as follows:

- Random DAC extracts, after filtration for the brix determination, were injected into the GC, in duplicate, without further preparation.
- Ethanol standards, in the relevant range of concentration, were injected at regular intervals.
- Ethanol concentrations of samples were calculated by manual measurements of peak heights, and were always expressed as ppm on extract brix.
- If the consignment from which the DAC extract originated was tagged, the burn to crush delay was obtained.
- The mean of the daily maximum and minimum temperatures, averaged over the delay period (or over the 4 days previous to crushing if the consignment was not tagged) was calculated.
- The cane variety, the brix of the extract and the cane purity were also obtained.

The injections were carried out over all 3 shifts (24 h per day), during the period 14 July to 17 December 1987.

Results and Discussion

Basic Data

A total of 695 tagged and 342 untagged consignments were sampled. The ethanol concentrations and other pertinent data have been summarised in Table 1.

Table 1

Range, mean and standard deviation

	Tagged				Untagged			
	Min	Max	Mean	St.dev.	Min	Max	Mean	St. dev.
Cane purity	77,4	92,8	86,2	3,1	75,4	91,8	85,2	3,1
Average temp. during delay (°C)	11,5	25,3	17,7	2,9	12,1	24,4	18,7	2,9
Ethanol (ppm on brix)	315	25 330	5 185	3 793	600	28 520	5 085	3 863

The dummy variables used to represent cane varieties are shown in Table 2.

Table 2

Dummy variables for cane varieties

Variable and value	Variety
$V_1 = 1, V_2 = 1$	NCo376
$V_1 = 1, V_2 = 0$	NCo293
$V_1 = 0, V_2 = 1$	N12
$V_1 = 0, V_2 = 0$	Others

Regression

The results from the tagged sample set were used in multilinear regressions linking delay time to ethanol concentration on brix, temperature and variety.

Inspection of the residuals from the complete data set showed that the outlying points (standardised residuals > 3) fell into two clear categories. Firstly, 19 out of 20 outliers showed much shorter times than those calculated by the regression; on average, measured times were well under 20 hours while calculated values were between 60 and 120 hours. Investigations at Illovo revealed that when the information on a tag cannot be used, the operator enters the previous day's date, which then allows that particular set of data to be processed. Some of the tags giving rise to the outliers were identified, retrieved from files and inspected. Each showed obvious errors, for example missing data, illegible or ambiguous writing, obviously wrong dates or conflicting information. This leads to errors large enough to result in outlying data. Smaller and therefore less easily identifiable errors increase the scatter in the regression and would tend to reduce the precision with which the ethanol content can be used to calculate the delay.

Secondly, regressions involving cane purity showed that 65 other outliers had analysed purities much lower than calculated ones. This is an effect found previously which indicates that the cane has deteriorated through a mechanism not involving ethanol. This phenomenon will be discussed later. All the outliers were removed from the main data set.

The following regression was obtained from the tagged data set (after rejecting the outliers as discussed above):

$$\text{Delay time} = 153 + 0{,}0124 \times \text{EtOH} - 14{,}2 \times V_1 - 6{,}8 \times V_2 - 5{,}26 \times \text{Temp.} \quad (n = 675;\ r = 0{,}74) \ldots\ (1)$$

where time is in hours, EtOH is the ethanol concentration in ppm on brix, V_1 and V_2 are the dummy variables representing varieties (see Table 2) and Temp. is the average temperature, determined as explained previously. It should be noted that all the cane was burnt.

Equation (1) was found to predict the delay time to within ± 22 hours of the time as obtained from the tags. This assumes that the tagged time is always correct which is not necessarily the case, as shown earlier.

Previous equations[1,2] used a logarithmic term for the time. It was found here that there was very little difference if time or logarithmic time was used. Non-logarithmic time has therefore been used for simplicity.

Equation (1) was then used to calculate the delay time for the untagged consignments, after removing the outliers.

The calculated delay times obtained for both sets are shown in Table 3. The results in this Table show that the average delay at Illovo, over the period July to December, was around 110 hours or 4,6 days. A breakdown of the data shows that the delay was around 4 days during winter but rose to around 6 days in the later part of the period, due to rain. It is also encouraging to note that the averaged results for the tagged and untagged data sets are very similar, indicating no bias.

Table 3

Delay times at Illovo

	675 tagged* consignments				328 untagged** consignments			
	Min	Max	Ave	St. dev.	Min	Max	Ave	St. dev.
Delay time (hours)	10	397	111	65	26	416	108	47

* Delays obtained from the tags.
** Delays calculated using Equation 1.

Ease of operation

All the injections were done by the laboratory testers, after each tester had been trained for 2–4 days at the beginning of the project.

The procedures are extremely simple and were easily mastered by the laboratory staff. Data collection was done weekly by the SMRI but this could easily be computerised.

As far as equipment is concerned, supplies of air, nitrogen and hydrogen are necessary. Spare syringes, rolls of chart paper and pens for the recorder are required. Ethanol and the relevant glassware are needed for the preparation of standards. Finally, the GC requires some spare equipment, for example septa, a column and pre-columns. All this equipment is readily available at relatively low costs.

Costs

Capital costs of the installation at Illovo, as at July 1987, were as follows:

Gow-Mac GC	R9 600
Chart recorder	R2 650
Accessories	R1 100
Syringes	R 750
Gas system, regulators etc.	R1 500
Total:	R15 600 excluding GST

The running costs, which include chart paper, gas etc. were minimal.

Labour costs were not incurred during this investigation.

"Abnormal" deterioration

Laboratory tests done[1] in 1986 and industrial work[2] in 1987 have shown that cane can deteriorate through mechanisms not involving the formation of ethanol.

A short programme of work was undertaken with the S.A. Experiment Station and the Darnall field personnel to investigate this phenomenon. Two factors were investigated, namely cane age and the presence of diseases (red-rot, mosaic and ratoon stunting disease, RSD).

Samples of young (12 months) and old (24 months) cane, with and without RSD were allowed to deteriorate under similar conditions and the ethanol concentrations monitored. Although in all cases purity dropped significantly, the results obtained show that age and the presence of RSD affect the formation of ethanol during deterioration. These results are shown in Figure 1 where the ethanol productions

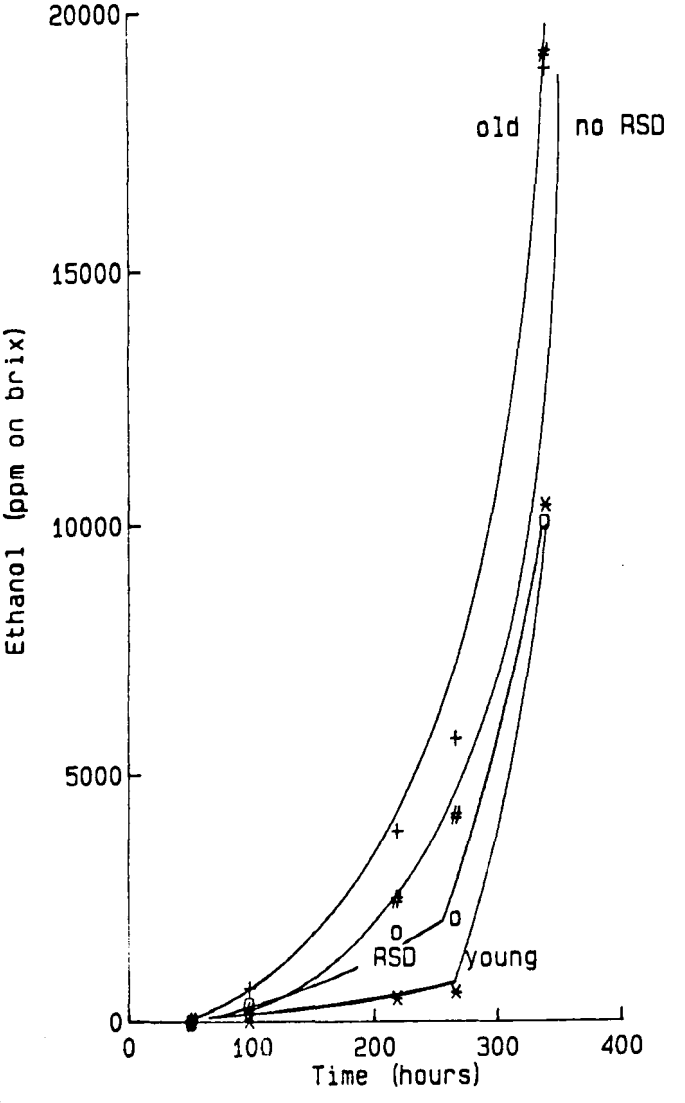

FIGURE 1 The effect of age and of the presence of RSD on the formation of ethanol during deterioration.

of young and old cane, and for cane with RSD and cane without RSD, have been averaged and plotted against deterioration time.

Cane age and/or the presence of RSD could therefore explain some of the abnormal results found previously. It should be noted, however, that this abnormal behaviour occurred in only about 5% of the samples.

These results also indicate that the addition of cane age into the regression linking time delay to the other independent variables could improve the model.

Conclusions

It can be concluded that a chemical method has been developed for measuring the delays of industrial consignments to within ± 20 hours. This level of accuracy is considered satisfactory since average delays have been found to range between 4 and 6 days.

The analytical method is extremely simple, relatively trouble free and was easily implemented in an industrial laboratory. Furthermore it does not require special samples.

In view of the considerable gains that would be made if cane delays were reduced, it would be worthwhile to consider the implementation of this technique on a full-time basis.

Acknowledgement

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REFERENCES

1. Lionnet, GRE (1986). Post-harvest deterioration of wholestalk sugarcane. *Proc S Afr Sug Technol Ass* 60: 51–57.
2. Lionnet, GRE and Pillay, JV (1987). Ethanol as an indicator of burn to crush delay. *Proc S Afr Sug Technol Ass* 61: 5–7.