

THE EFFECT OF THE LEVEL OF EXTRACTION ON MIXED JUICE PURITY

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Abstract

Significant linear relationships between the levels of pol extraction and the apparent purities of the mixed juices obtained have been derived, using industrial data. The relationship has been confirmed experimentally, using a press. The financial aspects of extractions higher than 98 have been briefly investigated.

Introduction

It is usually accepted that for a given cane purity, the purity of mixed juice decreases as the level of extraction increases. In this work the relationships between these two factors are studied: for milling tandems, for diffusers and on a laboratory scale.

An attempt is also made to investigate the financial effects attached to extraction levels with regard to the recovery of sugar. The objective of this financial study is to show only the increases in revenue as extraction rises.

Method

Industry data

Monthly data for the 1979/80 season, as reported in the SMRI monthly summary, were used. Factories with milling tandems and with diffusers were treated separately.

Data used in the financial exercise were obtained from industrial sources.

Laboratory Experiment

Cane was shredded and the pulp used to yield sub-samples. One sub-sample was analysed by the DAC method while the others were pressed in a Pinette Emidecau press, using different combinations of pressing times and imbibition water to achieve a range of pol extractions from 91 to 98,5. Extracted juices were analysed for apparent purity.

Juice Purity versus Extraction

The ratio (Rouillard¹) cane purity/mixed juice purity was regressed against pol extraction, apparent purities being used. The ratio, rather than actual purities, is used to compensate for the effect of variations in cane purity.

In the case of industrial data the cane purity used was always that obtained from mass balance and not the DAC cane purity.

For the laboratory experiment however, the DAC cane purity is used while the pol extraction is calculated from the weight of pol in cane, the latter using the DAC pol % cane.

Finally, the methods used in the financial investigation are given in Appendix 1.

Results

Milling Tandems

Monthly data from the milling tandems of FX, DL, GH, NB, TS, IL, SZ and UK were used.

The ratio cane purity/mixed juice purity is plotted against pol extraction in Figure 1.

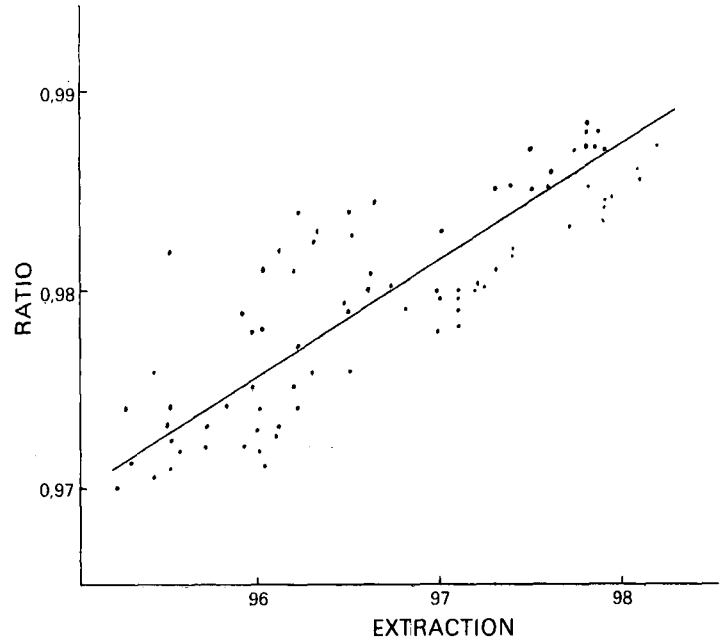


FIGURE 1 Ratio of cane purity to mixed juice purity against pol extraction, for milling tandems.

A linear regression, by the method of least squares yielded the following relation.

$$\text{Ratio} = 0,00533 \text{ Extraction} + 0,464 \dots \dots \text{Eq. 1}$$

(n = 83; r = 0,84; Sig > 1%)

Mixed juice purities against different extractions are shown in Table 1, assuming a cane purity of 83,8.

Diffusers

Data from the diffusers at EM, AK, GH, UC, TS and SZ were used. PG and ML were excluded because of the large scatter present in the values from these two factories. The plot is shown in Figure 2.

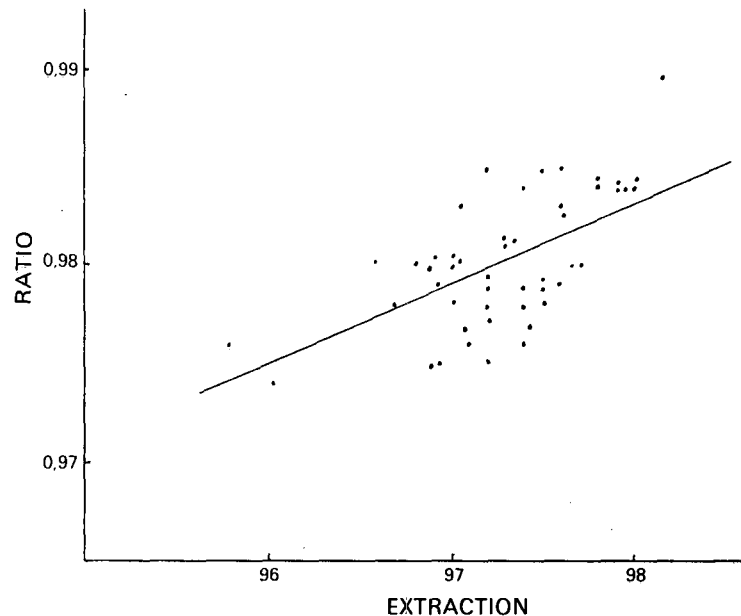


FIGURE 2 Ratio of cane purity to mixed juice purity against pol extraction, for diffusers.

The linear regression is now

$$\text{Ratio} = 0,00415 \text{ Extraction} + 0,576 \dots \text{Eq. 2}$$

(n = 49; r = 0,59; Sig > 1%).

Again assuming a cane purity of 83,8, mixed juice purities at various extractions are shown in Table 1.

TABLE 1

Mixed juice purities for different extractions with a cane purity of 83,8

Extraction	Mixed juice purity calculated from	
	Equation 1 (Mills)	Equation 2 (Diffusers)
94,0	86,9	86,7
95,0	86,4	86,4
96,0	85,9	86,0
97,0	85,5	85,6
98,0	85,0	85,2
98,5	84,8	85,1

Laboratory Tests

Experimentally determined values for the ratio cane purity (DAC)/mixed juice purity are plotted against extraction in Figure 3.

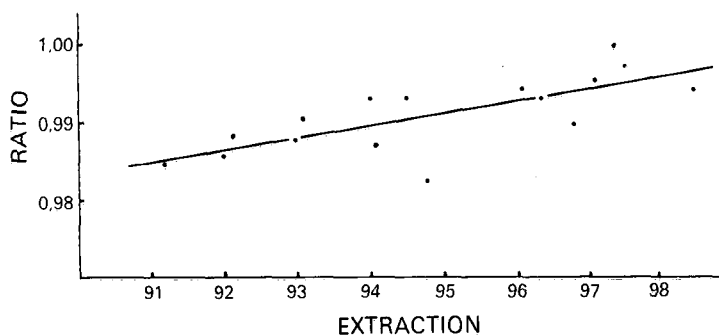


FIGURE 3 Ratio of cane purity to mixed juice purity against pol extraction, experimental results.

The linear regression for these data is

$$\text{Ratio} = 0,00158 \text{ Extraction} + 0,841 \dots \text{Eq. 3}$$

(n = 16; r = 0,72; Sig at 1%).

Comparison of mills and diffusers at the same factory

In an attempt to remove any effects due to cane quality, data from factories operating a milling tandem and a diffuser in parallel were used. The relationships between the ratio and extraction for mills and diffusers would then be more comparable; it is assumed that the cane received at these factories is randomly allocated to the mill and diffuser.

Weekly data from SZ and GH were used.

The linear regressions are as follows:

GH mill:

$$\text{Ratio} = 0,00627 \text{ Extraction} + 0,370 \dots \text{Eq. 4}$$

(n = 33; r = 0,93; Sig > 1%)

GH diffuser:

$$\text{Ratio} = 0,00620 \text{ Extraction} + 0,378 \dots \text{Eq. 5}$$

(n = 33; r = 0,62; Sig > 1%)

SZ mill:

$$\text{Ratio} = 0,00601 \text{ Extraction} + 0,395 \dots \text{Eq. 6}$$

(n = 39; r = 0,82; Sig > 1%)

SZ diffuser:

$$\text{Ratio} = 0,00388 \text{ Extraction} + 0,600 \dots \text{Eq. 7}$$

(n = 38; r = 0,63; Sig > 1%).

Discussion

Effect of Extraction Level on Juice Purity

It is evident from the regressions obtained that there is a significant relation between the levels of extraction and the apparent purities of the mixed juices obtained.

This relation may now be studied firstly for milling tandems (and for diffusers) at different factories, to establish if it is independent of effects due to particular extraction plants, type of cane etc. and secondly for comparing mills and diffusers.

Equation 1 applies to 8 milling tandems, ranging from FX in the north to UK in the south. Equation 4 applies to GH, while equation 6 applies to SZ. These 3 equations are reproduced below:

$$\text{Ratio} = 0,00533 \text{ Extraction} + 0,464 \dots \text{Eq. 1}$$

$$\text{Ratio} = 0,00627 \text{ Extraction} + 0,370 \dots \text{Eq. 4}$$

$$\text{Ratio} = 0,00601 \text{ Extraction} + 0,395 \dots \text{Eq. 6}$$

The corresponding equations for diffusers are:

$$\text{Ratio} = 0,00415 \text{ Extraction} + 0,576 \dots \text{Eq. 2}$$

$$\text{Ratio} = 0,00620 \text{ Extraction} + 0,378 \dots \text{Eq. 5}$$

$$\text{Ratio} = 0,00388 \text{ Extraction} + 0,600 \dots \text{Eq. 7}$$

Although the comparison is limited, it is apparent that there could be large differences (>20%) between the values of the slopes and intercepts for different mills. For diffusers, the differences are inflated because of the lower correlations obtained when compared to those for milling tandems.

Equations 1 and 2 may be used to compare the overall results obtained from milling tandems and diffusers. Again large differences are present between the values of the slopes and intercepts. Using equations 4 and 5, and equations 6 and 7, does not make the comparison more meaningful as, in the first case the agreement is good, while in the second the difference is very large.

The higher scatter present in the data obtained from diffusers contributes markedly to the difficulty in comparing the results.

It must therefore be concluded that meaningful comparisons between the effect of extraction by the two processes on juice purity are not possible at this stage and that further work will be required.

Experimental Investigation of the Relation between the Ratio Cane Purity/Mixed Juice Purity and Extraction

It would be expected that the results obtained from the laboratory press would be free of many of the extraneous influences which could affect the data from an industrial scale milling tandem or diffuser. Hence the highly significant correlation shown in Equation 3 confirms the existence of a linear relation between purity and extraction.

It is, however, disconcerting to note that both the slope and the intercept of Equation 3 differ substantially from those for mills or diffusers.

Possible reasons for this observation could be:

- (a) The fact that DAC cane purities were used for the press.
- and (b) the much shorter juice retention times in the case of the press experiments which greatly reduces the possibility of sucrose destruction.

Thus for the present the press results should only be viewed as a confirmation that a linear relation does exist.

Financial Analysis

The approach used here considers only the changes in the tonnages of sugar and final molasses resulting from the different mixed juice purities. The revenue from the sales of

sugar and molasses is then calculated, using the mill door price of R321 per tone of sugar and R39 per ton of final molasses.

Higher extractions will result in increases in costs due for example to higher processing costs, higher fuel requirements and possibly even an extra mill. Since the increases will be particular to each individual case, no attempt will be made here to estimate them. The financial analysis is thus necessarily very simplistic and is included only to illustrate an approach that could be followed if such an analysis were to be done industrially.

Finally only the results for a factory with a milling train are considered.

Calculations of Cost and Revenue

The analysis applies to the following basic data:

Tons cane per hour	200
Brix % cane	15,08
Pol % cane	12,64

The calculations together with the assumptions required are given in Appendix 1.

TABLE 2

Tons sugar and molasses, at different extractions, for 200 tons cane per hour

Extraction	Purity MJ	Tons sugar at 99,4 pol	Tons Mol	BHR
94	86,9	22,12	6,25	92,5
95	86,4	22,28	6,60	92,2
96	85,9	22,42	6,96	91,8
97	85,5	22,57	7,31	91,5
98	85,0	22,73	7,67	91,2
98,5	84,8	22,78	7,87	90,9

The tonnages of sugar and final molasses equivalent to 1 million tons of cane may now be calculated, and these values used to obtain the millers revenue with mill door prices of R321 and R39 per ton of sugar and molasses respectively. This is shown in Table 3.

TABLE 3

Millers revenue for 1 million tons of cane

Extraction	Revenue (Rands)		Total
	Sugar	Molasses	
94	35,5 × 10 ⁶	1,22 × 10 ⁶	36,7 × 10 ⁶
95	35,8 × 10 ⁶	1,28 × 10 ⁶	37,1 × 10 ⁶
96	36,0 × 10 ⁶	1,36 × 10 ⁶	37,4 × 10 ⁶
97	36,2 × 10 ⁶	1,42 × 10 ⁶	37,6 × 10 ⁶
98	36,5 × 10 ⁶	1,50 × 10 ⁶	37,9 × 10 ⁶
98,5	36,6 × 10 ⁶	1,53 × 10 ⁶	38,1 × 10 ⁶

If the cost of increasing the extraction at a particular factory is known, then the data of Table 3 may be used to investigate the profitability of higher extractions.

Conclusions

A significant relationship between extraction and mixed juice purity has been obtained, both for milling trains and diffusers. This relationship has been confirmed experimentally.

Meaningful comparisons of the relation for mills to that for diffusers was not possible mainly because of insufficient data and because, in all cases, the diffuser data showed more scatter. More work appears to be necessary in that area.

The relations established for milling trains have been used for a simplistic financial analysis, investigating the profitability of increasing extraction to 98,5. Bearing in mind the limitations of this analysis and the assumptions made, increases in revenue have been calculated as extraction is increased. If the cost of higher extractions is known, these values may be used to investigate the effect of extractions on profitability.

Acknowledgements

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REFERENCES

1. Rouillard, A. (1978): Non-sucrose formation — diffuser versus milling. SMRI Communication No. 117. 41-50.

Appendix 1

Calculations for the financial analysis.

The basic data used are the industrial averages for the 1979/80 season.

A1.1. Pol and brix loadings

Basic data:

Tons cane per hour	200
Brix % cane	15,08
Pol % cane	12,64
Tons brix in cane	30,16
Tons pol in cane	25,28

The data of Table 1, in the main text are now used to calculate brix and pol loadings.

The following Table may now be drawn up:

TABLE A.1.1.1

Brix and pol loadings at different extractions

Extraction	MJ Purity	Tons in MJ	
		Pol	Brix
94	86,9	23,76	27,35
95	86,4	24,02	27,80
96	85,9	24,27	28,24
97	85,5	24,52	28,69
98	85,0	24,77	29,15
98,5	84,8	24,90	29,37

A1.2. Tons of sugar and molasses by SJM formulae.

Basis data:

C molasses purity	35,68
Brix % sugar	99,9
Brix % molasses	84

TABLE A1.2.1

Tonnages of sugar and final molasses for 200 tons cane per hour, with different extractions

Extraction	Tons Sugar	Tons Final Molasses
94	22,12	6,25
95	22,28	6,60
96	22,42	6,96
97	22,57	7,31
98	22,73	7,67
98,5	22,78	7,87