SUGAR MILLING
RESEARCH INSTITUTE

THE EFFECT OF EXTRACTION ON MIXED JUICE PURITY AND PROCESSING

by

R. LIONNET

TECHNICAL REPORT NO. 1236
26th May, 1980.

SUGAR MILLING RESEARCH INSTITUTE

S U M M A R Y

1. Report No. : Technical Report No. 1236
2. Title : The effect of extraction on mixed juice purity and processing.
3. Author : R. Lionnet
4. Date : 26th May, 1980
5. Objectives :
   (1) To investigate the effect of extraction on mixed juice purity, for mills and diffusers.
   (2) To investigate the profitability of very high extractions.
6. Summary :

   (1) Statistically significant relationships of the form:

$$\frac{\text{Cane purity}}{\text{M.juice purity}} = a \times \text{extraction} + b$$

   where a and b are positive constants, were obtained for milling trains and diffusers, from regressions of the 1979/80 season's industrial data.

   (2) A similar relationship was obtained experimentally, using a press.

   (3) Comparison of the relations obtained for mills and for diffusers operating in parallel in the same factory did not yield meaningful results, due mostly to the higher scatter of the data from diffusers.

   It is apparent however that large differences (>20%) exist in the values of the constants a and b at different factories.

   (4) Using weekly mill test data, a relation between extraction and the number of mills in a tandem was obtained. This relation has the form:

$$\text{Extraction} = \frac{\text{Number of mills}}{a + b \times \text{Number of mill}}$$

The values of the constants a and b were found not to be highly different for the 3 different factories investigated.

(5) A broad financial analysis was carried out to investigate the cost of processing the additional impurities produced at higher extractions (>98).
The results, which must be interpreted in the context of the analysis, indicate that profitability increases with extraction.

Distribution:

Full Report

Director
Heads of Divisions
Mr. A. Jullienne
Mr. S. Munsamy
Mr. A. Rouillard
Librarian, Huletts R & D

Summary Only

All Mill Managers
Managing Director, Smithtech
Technical Manager, Huletts TMD

R. E. Lionnet
....

1. 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 relation between these two factors, for milling tandems, for diffusers and on a laboratory scale are studied.

An attempt is also made to investigate the financial effects attached to extraction levels with respect to extraction costs, processing costs and recovery of sugar. The objective of this financial study is to investigate whether there is a higher limit of extraction which, if exceeded, would reduce overall profitability.

2. METHOD

2.1. 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.

Weekly mill test analytical data from GH, NB and SZ were also used to calculate cumulative pol extractions as a function of the number of mills.

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

2.2. 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 purity.

2.3. Juice Purity v/s Extraction

The ratio [1] cane purity/mixed juice purity was regressed against pol extraction, the purities used being apparent purities. 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 mixed juice and the weight of pol in cane, the latter using the DAC pol % cane.

For the study of extraction versus number of mills, weekly mill test data were used. An example of the calculations involved is given in Appendix 1.

Finally, the methods used in the financial investigation are given in Appendix 2.

3. RESULTS

3.1. Milling Tandems

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.

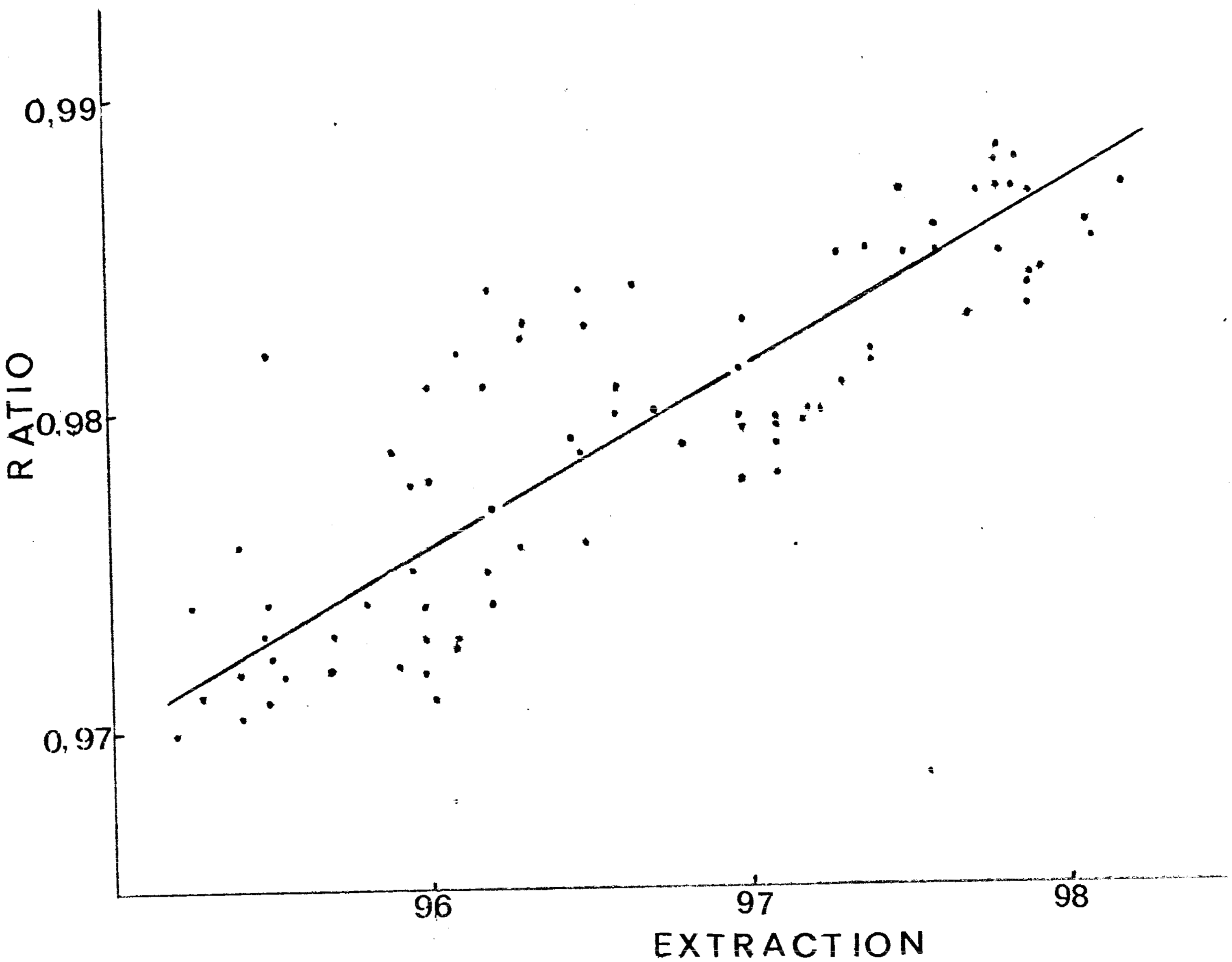

Figure 1 : Ratio of cane purity to mixed juice purity against pol extraction, for milling tandems.

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

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

$$(n = 83; \quad r = 0{,}84; \quad \text{Sig. } > 1\ \%)$$

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

3.2. 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.

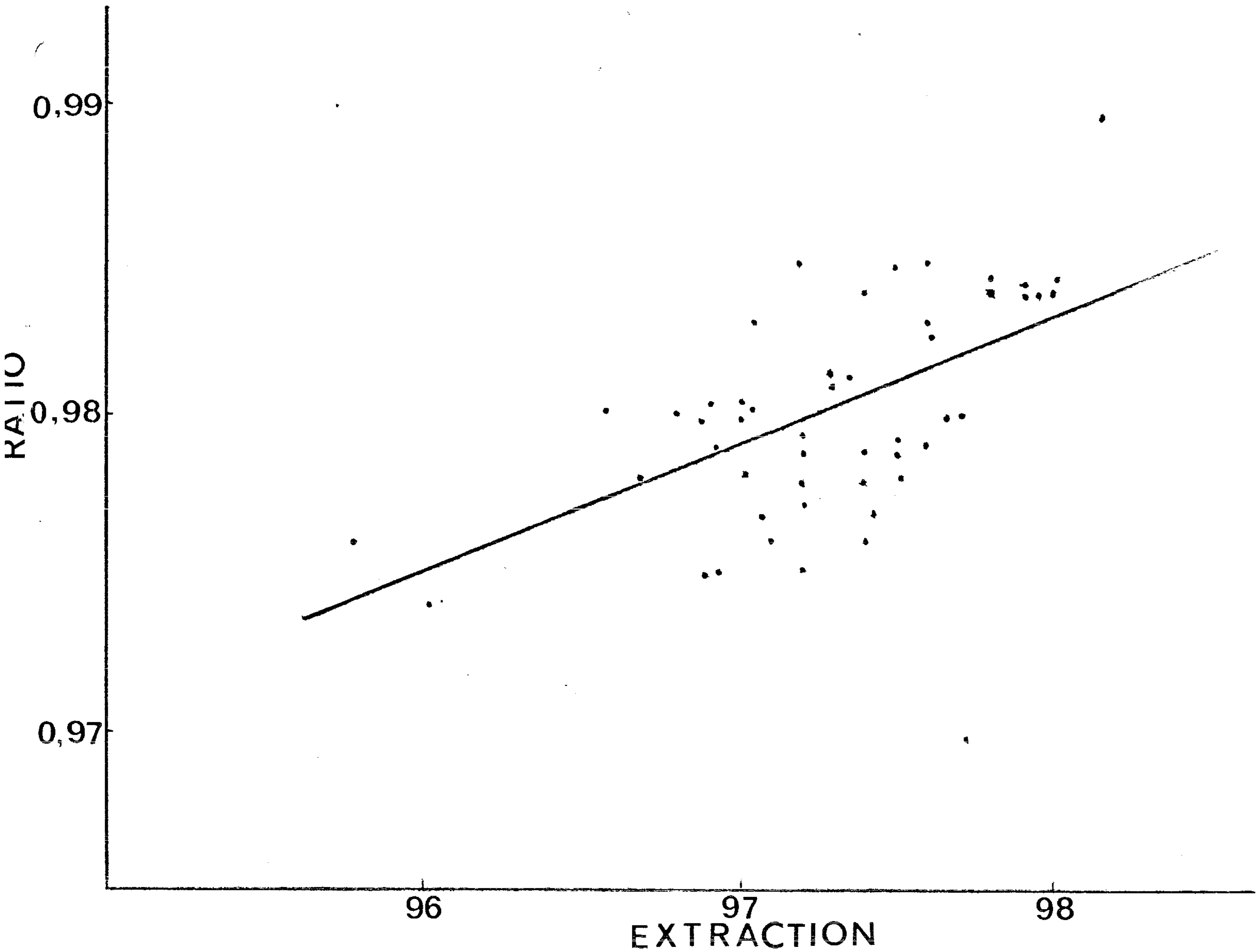

Figure 2: Ratio of cane purity to mixed juice purity against pol extraction, for diffusers.

The linear regression is now

Ratio = 0,00415 Extraction + 0,576 -------- 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	85,6
98,5	84,8	85,1

3.3. Laboratory Tests

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

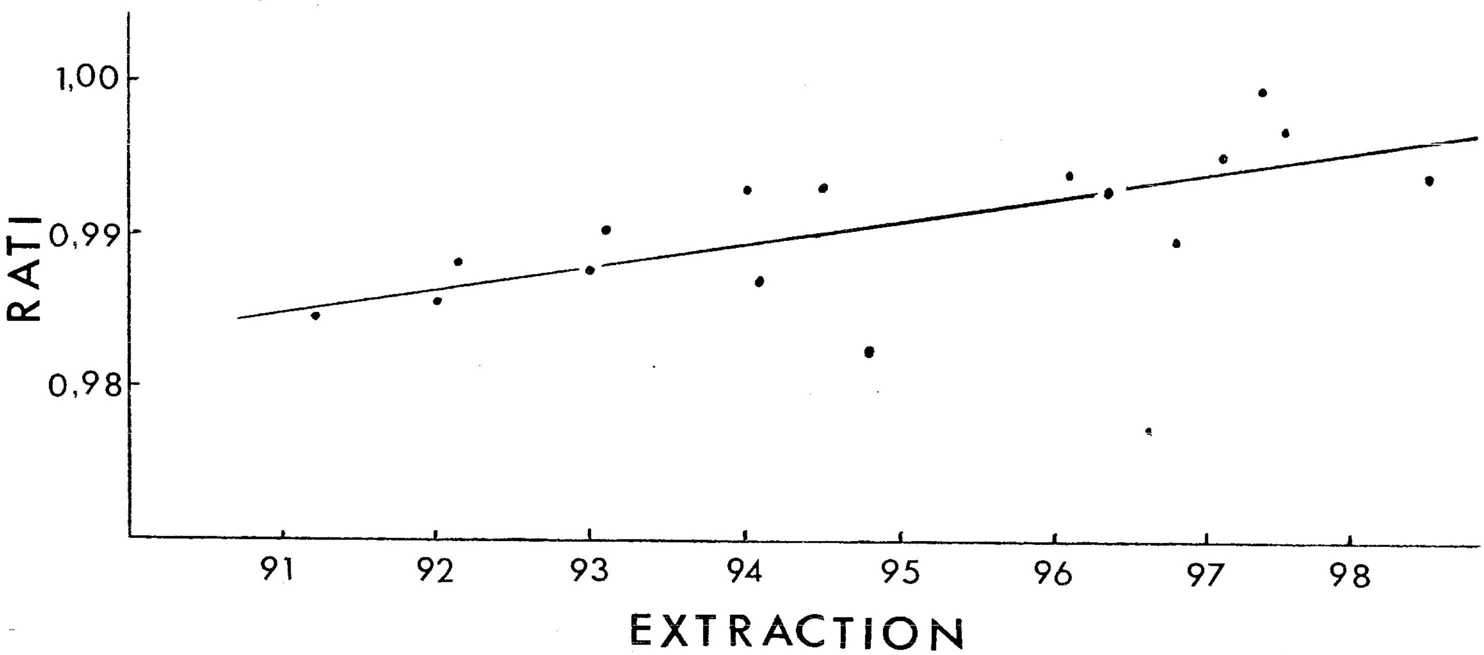

Figure 3 Ratio of cane purity to mixed juice purity against pol extraction, experimental results.

The linear regression for these data is

Ratio = 0,00158 Extraction + 0,841 --------- Eq 3

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

3.4. Comparisons 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, if 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 plots are shown in Figures 4 and 5.

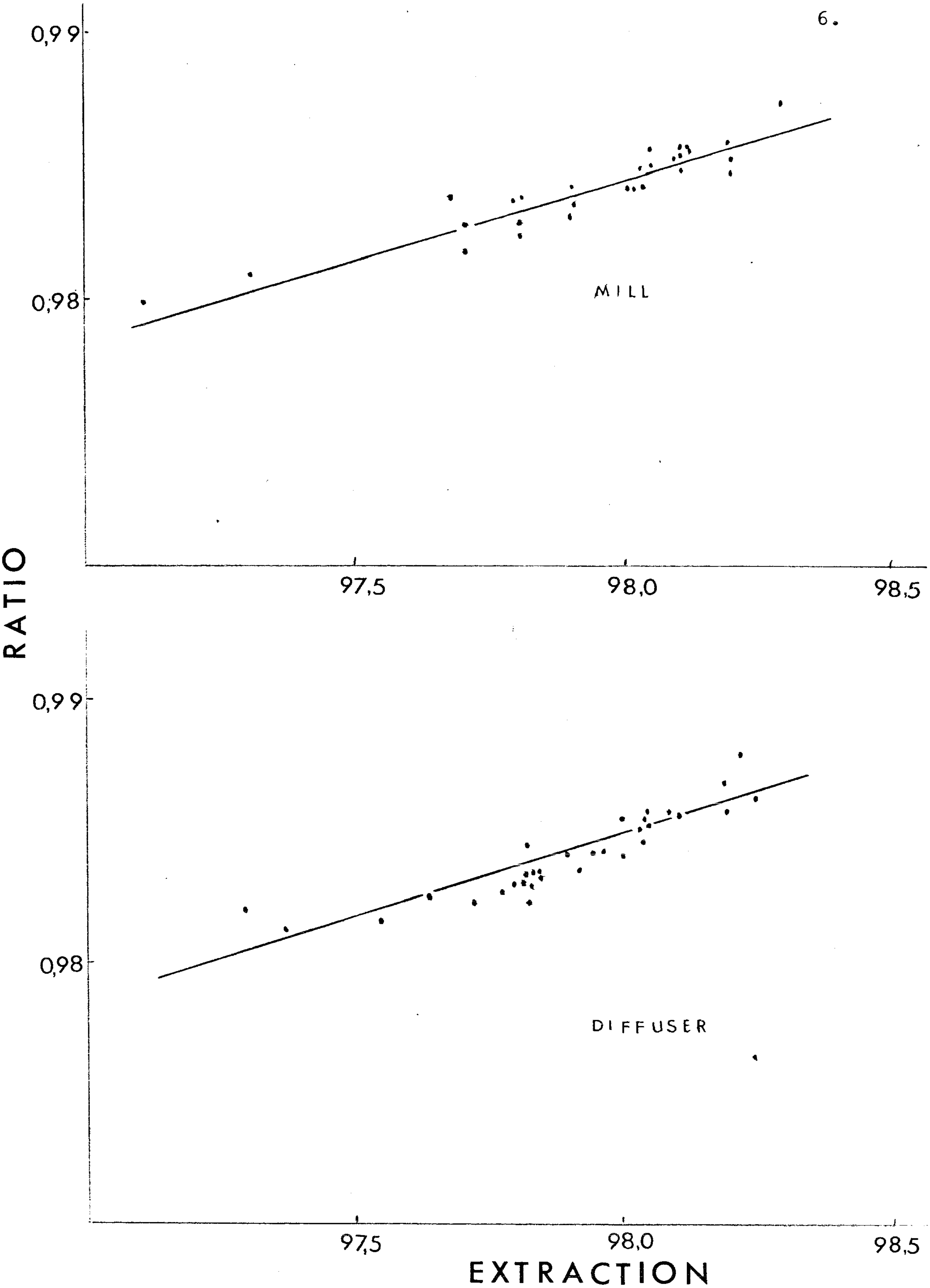

Figure 4: Ratio of cane purity to mixed juice purity against pol extraction, for the mill and diffuser at GH

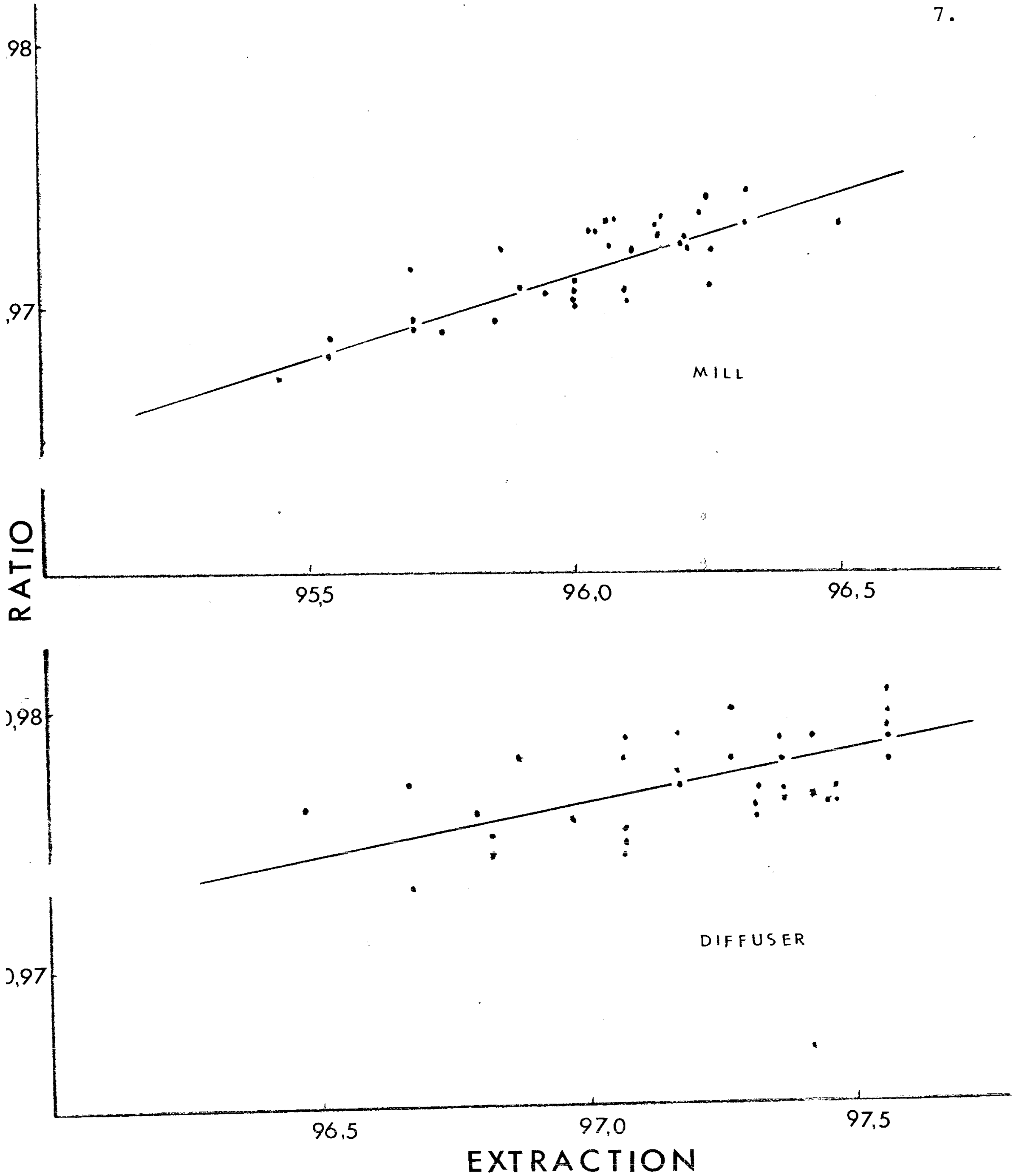

Figure 5: Ratio of cane purity to mixed juice purity against pol extraction, for the mill and diffuser at SZ.

The linear regressions are as follows:-

GH mill:

Ratio = 0,00627 Extraction + 0,370 ------ Eq. 4
(n = 33; r = 0,93; Sig.> 1%)

GH diffuser:

Ratio = 0,00620 Extraction + 0,378 ------ Eq. 5
(n = 33; r = 0,62; Sig.> 1%)

SZ mill:

Ratio = 0,00601 Extraction + 0,395 ------ Eq. 6
(n = 39; r = 0,82; Sig.> 1%)

SZ diffuser:

Ratio = 0,00388 Extraction + 0,600 ------ Eq. 7
(n = 38; r = 0,63; Sig.> 1%)

3.5. Pol Extraction as a Function of the Number of Mills in a Tandem

GH, NB and IL include pol % extract in their mill test analysis. Weekly data were collected from these three factories and were used to calculate weekly cumulative extractions after each mill in the tandem, as shown in Appendix 1.

A curve fitting technique[2] was used to derive equations relating extraction to number of mills, as shown in Appendix 3. The derived equations were then used to yield calculated values of cumulative extractions for a given number of mills. These equations are given in Table 2.

TABLE 2

Relation between cumulative extraction and number of mills.

$$\text{Extraction} = \frac{\text{Number of mills}}{a + b(\text{Number of mills})}$$

	a =	b =
GH	0,00466	0,00948
NB	0,00516	0,00946
IL	0,00454	0,00964

The actual values of cumulative extraction (from all mill test analyses) and the calculated values (from the equations in Table 2) are plotted against the number of mills in Figure 6.

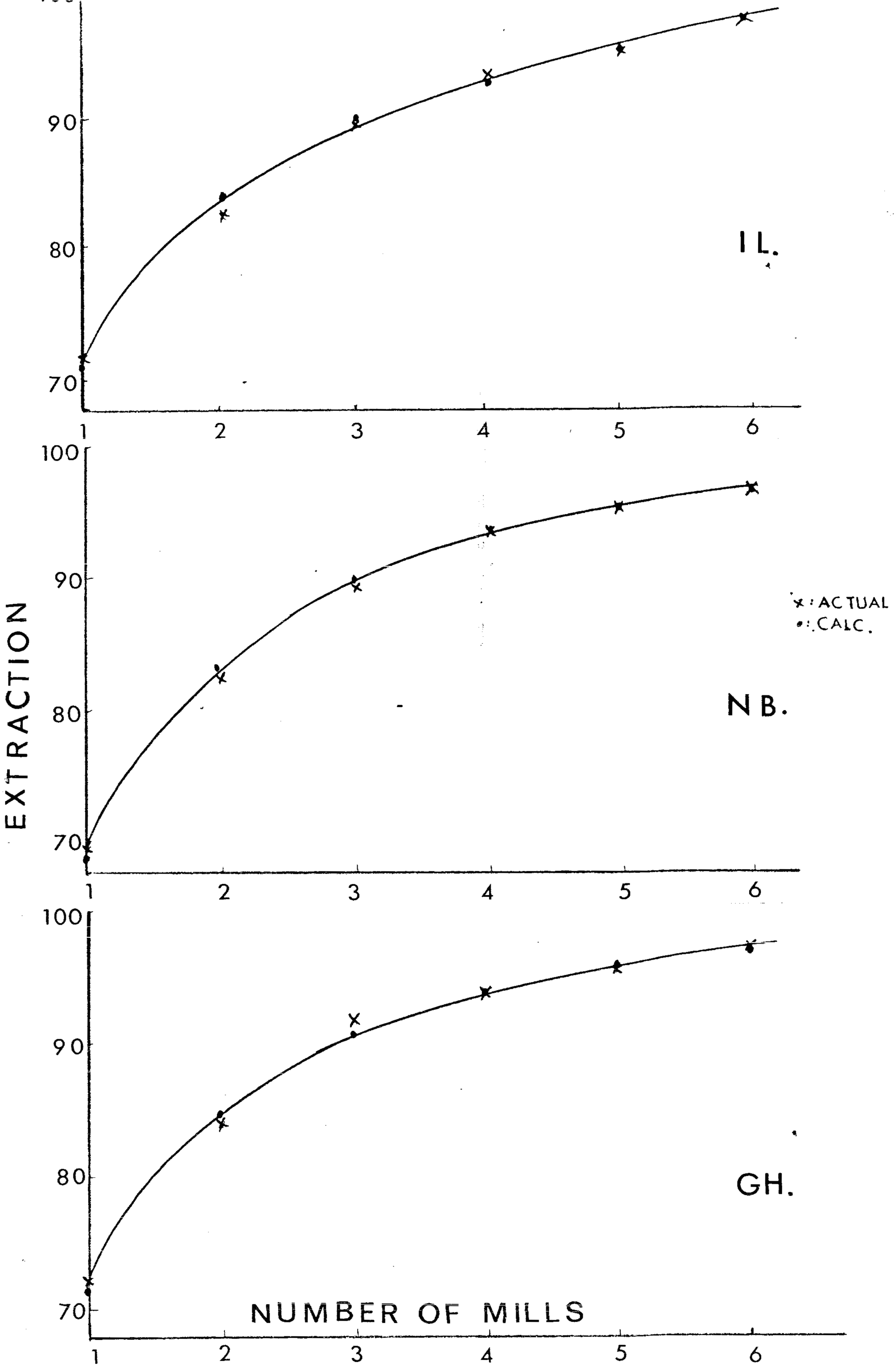

Figure 6: Plots of cumulative pol extraction against number of mills in a tandem

Grouping the data from all 3 factories yielded the overall equation:

$$\text{Extraction} = \frac{\text{Number of mills}}{0{,}00479 + 0{,}00953\ (\text{Number of mills})} \quad \text{----- Eq. 8}$$

Calculated extractions for a given number of mills, using equation 8 are shown in Table 3

TABLE 3

Extraction as a function of number of mills

Number of mills	Extraction(calculated from Eq.8)
1	69,8
2	83,9
3	89,9
4	93,3
5	95,4
6	96,9
7	97,9

4. DISCUSSION

4.1. 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:-

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

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

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

The corresponding equations for diffusers are:

Ratio = 0,00415 Extraction + 0,576 ----- Eq. 2

Ratio = 0,00620 Extraction + 0,378 ----- Eq. 5

Ratio = 0,00388 Extraction + 0,600 ----- 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 are not possible at this stage and that further work would be required.

4.2. Experimental Investigation of the Relation between the Ratio Cane Purity/Mixed Juice Purity.

The linear relation between the ratio of cane purity/mixed juice purity and pol extraction was also established experimentally. The relation obtained was:-

Ratio = 0,00158 Extraction + 0,841 -------- Eq. 3

This confirms the validity of the relation. Thus, the relation as established for the industrial case is not due to the effects of other factors such as time of the year or seasonal trends.

The experimental results differed from the data for the industrial cases mostly in the fact that the ratio, for the same extraction, was generally higher. Thus for mills and diffusers, an extraction of 97 corresponds approximately to a ratio of 0,980 as compared to 0,994 for the experimental data. Since the ratio cannot exceed unity, the slope of the experimental line is smaller than that of the lines derived from industrial data.

These differences could be explained, at least partly, by the fact that DAC purities were used for the experiment.

When DAC purities were used in the industrial case it was noticed that firstly the ratios tended to have higher values, and secondly that the scatter increased. Possible reasons for this were not investigated.

4.3. Extraction as a Function of the Number of Mills in a Tandem

The data collected for the study of purity levels with extraction contained sufficient information to allow the derivation of a relation between extraction and the number of mills in a tandem. This section is thus a by-product of the project, which might however be useful in financial analyses.

A few remarks may be made about the results obtained. Firstly, although the data of Table 2 relate to 3 different factories and thus apply to different cane types, milling equipment etc. the numerical values of the constants are not highly different. Secondly, the fits are good, especially at the higher extractions, that is at the higher number of mills which is the area of interest if extrapolation is to be carried out. This smoothing out effect has also been observed in Australia[3].

Extrapolation from the relation obtained, namely

$$\text{Extraction} = \frac{\text{Number of mills}}{0{,}00479 + 0{,}00953(\text{Number of mills})}$$

to predict the effect of an extra mill must be viewed with caution since changes in cane throughput, imbibition rates and other operational factors would have to be considered.

5. FINANCIAL ANALYSIS

5.1. Limitations

Before considering the details of the financial analysis, its limitations must be clearly set-out. For a number of reasons such as changes in costs, peculiarities of each individual case etc, it is not possible to present a universal model which could be modified to represent any one practical situation.

The approach used here considers only the following aspects of the problem:

a) The change in mixed juice purity with increasing extractions, for a given cane throughput.

b) The resulting changes in revenue from the production of sugar and molasses.

c) The increases in processing costs due only to the increased quantities of massecuite.

d) Costs of additional power, steam, labour etc. have not been considered.

Finally, the analysis will be done only for a factory with a milling train.

5.2. Calculations of Costs and Revenue

The analysis applies to the following basic data:

Tons cane per hour = 200

Brix % cane = 15,08

Pol % cane = 12,64

The detailed calculations together with the assumptions required are given in Appendix 2.

The revenues from the production of sugar and final molasses, assuming a mill door price of R260/ton of sugar and R28/ton of molasses, are given in Table 4.

TABLE 4

Revenue from sugar and molasses, at different extractions, for 200 tons cane per hour.

Extraction	Purity MJ	Tons Sugar at 99,4 Pol	Tons Molasses	B.H.R.	Revenue		
					Sugar	Molasses	Total
94	86,9	22,12	6,25	92,5	5750	175	5925
95	86,4	22,29	6,58	92,3	5800	180	5980
96	85,9	22,42	6,96	91,8	5830	195	6025
97	85,5	22,57	7,31	91,5	5870	205	6075
98	85,0	22,73	7,67	91,2	5910	215	6125
98,5	84,8	22,78	7,87	90,9	5920	220	6140

The costs for massecuite processing are shown in Table 5.

TABLE 5

Capital cost of massecuite processing, at different extractions, for 200 tons of cane per hour (Rands).

Extraction	Pans	Crystallisers	Centrifugals	Total
94	$7,63 \times 10^5$	$5,00 \times 10^5$	$5,54 \times 10^5$	$1,82 \times 10^6$
95	7,76	5,18	5,72	$1,87 \times 10^6$
96	7,88	5,36	5,90	$1,91 \times 10^6$
97	8,00	5,54	6,10	$1,96 \times 10^6$
98	8,13	5,72	6,28	$2,01 \times 10^6$
98,5	8,19	5,82	6,38	$2,04 \times 10^6$

5.3. Comparison of Costs and Revenue, over one Season.

Costs and revenue are now calculated for one season, using 1 million tons of cane and depreciating the costs over 20 years (straight line). Interest on capital is not included. This is shown in Table 6.

TABLE 6

Costs and revenue for 1 million tons of cane. (Rands).

Extraction	Costs/year	Revenue/year
94	$9{,}08 \times 10^4$	$2{,}96 \times 10^7$
95	9,33	2,99
96	9,57	3,01
97	9,81	3,04
98	10,07	3,06
98,5	10,20	3,07

Finally, the additional cost for extractions above 94, the corresponding additional revenue and profits are shown in Table 7.

TABLE 7

Additional costs, revenue and profits, with increased extractions.(Rands)

Extraction	Additional Cost	Additional Revenue	Additional Profit
94			
95	$2{,}5 \times 10^3$	$2{,}6 \times 10^5$	$2{,}6 \times 10^5$
96	$4{,}8 \times 10^3$	$4{,}9 \times 10^5$	$4{,}8 \times 10^5$
97	$7{,}3 \times 10^3$	$7{,}4 \times 10^5$	$7{,}3 \times 10^5$
98	$9{,}8 \times 10^3$	$9{,}9 \times 10^5$	$9{,}8 \times 10^5$
98,5	$11{,}1 \times 10^3$	$10{,}8 \times 10^5$	$10{,}7 \times 10^5$

It is thus evident that, according to the approach used here, increasing extraction up to 98,5 is highly profitable.

6. CONCLUSION

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 very broad financial analysis, investigating the profitability of increasing extraction to 98,5. Bearing in mind the limitations of this analysis and the assumptions made, it was found that high extractions are very profitable.

7. ACKNOWLEDGMENTS

The author is indebted to a number of persons and companies, who have provided both data and advice. He would like to thank mill staff of the C.G. Smith and Huletts Sugar companies for providing mill test and other data; Smithtech and Huletts TMD/RD for costs; Huletts OR for advice; Mr.A. Jullienne of the SMRI for the mass balances and finally the Analytical Department of the same institute for all the analytical work.

8. REFERENCES

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

2. Hoerl, A.E. : Fitting curves to data. Chemical Business Handbook. McGraw-hill New York, 1954.

3. Murray, C.R.: Some theoretical trends in the extraction performance of crushing trains. QSSCT, 32nd Conf., 1965, 223 - 230.

SMRI
RL/JS
26/5/80

APPENDIX 1

Calculation of cumulative extraction with the number of mills in a tandem, from the mill test data.

The steps involved are given below:

(1) Fibre % mill bagasse = 100 - (Moisture % + Brix %)

(2) Pol % fibre and brix % fibre for cane and mill bagasse are calculated from:

$$\text{Pol \% fibre} = \frac{\text{Pol \% x100}}{\text{Fibre \%}}$$

$$\text{Brix \% fibre} = \frac{\text{Brix \% x 100}}{\text{Fibre \%}}$$

(3) Cumulative pol extraction is calculated from:

Cumulative pol extraction

$$= \frac{\text{(Cane pol \% fibre - Mill bag.pol \% fibre)}}{\text{cane pol \% fibre}} \text{ x 100}$$

(4) Cumulative tons pol extracted is calculated from:

$$\text{Cumulative tons pol} = \frac{\text{Cum. pol ext. x tons pol in cane}}{100}$$

(5) Cumulative tons brix extracted is calculated from:

$$\text{Cumulative tons brix} = \frac{\text{Cum. brix ext. x tons brix in cane}}{100}$$

(6) Purity of extracted juice, cumulative is then obtained from:

$$\text{Purity extracted juice} = \frac{\text{Cum. tons pol ext. x 100}}{\text{Cum. tons brix ext.}}$$

(7) Mill number, cumulative pol extraction and cumulative juice purity are then tabulated.

(8) The final calculation gives the arithmetic average of the cumulative pol extraction for the tandem.

An example of these calculations is shown by the attached computer printout.

TESTING

BX % CANE = 16.25
POL % CANE = 14.30
FIB % CANE = 16.80
TONS CANE = 266.670

MILL TEST DATA

* MILL NUMBER *	MOIST % *	BRIX % *	POL % *
1	60.73	11.70	9.56
2	58.68	8.90	7.06
3	57.78	6.74	5.14
4	57.00	5.43	3.95
5	55.95	4.32	2.99
6	55.05	3.33	2.21
7	52.43	2.77	1.83

FIB % MILL BAG = 27.57
FIB % MILL BAG = 32.42
FIB % MILL BAG = 35.48
FIB % MILL BAG = 37.57
FIB % MILL BAG = 39.73
FIB % MILL BAG = 41.62
FIB % MILL BAG = 44.80

POL % FIB CANE= 85.11904761905
BX % FIB-CANE= 96.72619047619

POL % FIB MILL BAG = 34.67
POL % FIB MILL BAG = 21.77
POL % FIB MILL BAG = 14.48
POL % FIB MILL BAG = 10.51
POL % FIB MILL BAG = 7.52
POL % FIB MILL BAG = 5.30
POL % FIB MILL BAG = 4.08

BX % FIB MILL BAG = 42.43
BX % FIB MILL BAG = 27.45
BX % FIB MILL BAG = 18.99
BX % FIB MILL BAG = 14.45
BX % FIB MILL BAG = 10.87
BX % FIB MILL BAG = 8.00
BX % FIB MILL BAG = 6.18

MILL NUMBER	EXTRACTION	PURITY
1	59.26	92.91
2	74.41	91.43
3	82.98	90.86
4	87.64	90.68
5	91.15	90.37
6	93.76	89.95
7	95.20	89.49

APENDIX 2

Calculations for the financial analysis.

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

A2.1. 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, Section 3,2 of the main report is now used to calculate brix and pol loadings. It is assumed that the tonnage of brix in syrup is the same as that in mixed juice.

The following Table may now be drawn up:

TABLE A2. 1. 1

Brix and pol loadings at different extractions.

Extraction	M.J. Purity	Tons in MJ Pol	Brix	Tons brix in syrup
94	86,9	23,76	27,35	27,35
95	86,4	24,06	27,80	27,80
96	85,9	24,27	28,24	28,24
97	85,5	24,52	28,69	28,69
98	85,0	24,77	29,15	29,15
98,5	84,8	24,90	29,37	29,37

A2.2. Tons of sugar and molasses by SJM formulae

Basic data: MJ purity = 85,40

Syrup purity = 85,75

Δp = 0,35

A m/c purity = 86,11

Δp = 0,36

A molasses purity = 69,18

Δp = 16,93

B m/c purity = 69,38

Δp = 0,20

B molasses purity = 47,22

Δp = 22,15

C m/c purity = 52,81

C molasses purity = 35,68

Assuming the above ΔP values, Table A2,2,1 may be drawn up.

TABLE A2. 2. 1

Calculation of purities for the SJM formula

M.J. Purity	Syrup Purity	A m/c Purity	A molasses Purity	B m/c Purity	B molasses Purity
86,9	87,2	87,6	70,7	70,9	48,7
86,4	86,8	87,1	70,2	70,4	48,2
85,9	86,3	86,6	69,7	69,9	47,8
85,5	85,8	86,2	69,2	69,4	47,3
85,0	85,4	85,7	68,8	69,0	46,8
84,8	85,1	85,5	68,6	68,8	46,6

Applying SJM formulae, mass balances and Cobenze diagrams, for 1 000 tons of brix in syrup, yields the following results, assuming no losses:

TABLE A2. 2. 2

Brix balance

M.J. purity	86,9	86,4	85,9	85,5	85,0	84,8
tons Brix in A m/c	1375	1386	1394	1403	1412	1415
Brix in B m/c	511	520	526	533	539	544
Brix in C m/c	301	312	324	335	346	353
Brix in Sugar	808	801	793	786	779	775
Brix in C molasses	192	199	207	214	221	225

Assuming sugar at 99,9 brix and molasses at 84 brix, the corresponding tonnages are given in Table A2. 2.3. for 200 tons of cane per hour.

TABLE A2.2.3

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	22,29	6,58
96	22,42	6,96
97	22,57	7,31
98	22,73	7,67
98,5	22,78	7,87

A2.3. Quantities of massecuites

Basic data:

Brix of A m/c = 92,63
Brix of B m/c = 93,73
Brix of C m/c = 96,06

The above values and the data of table A2.2.2 allow the calculation of massecuite volumes for 200 tons cane per hour. This is shown in Table 2.3.1.

TABLE 2.3.1

Massecuite quantities with different extractions, for 200 tons cane per hour.

Extraction	Tons brix in			Tons			M^3		
	A	B	C	A	B	C	A	B	C
94	37,61	13,98	8,23	40,60	14,92	8,57	27,07	9,88	5,64
95	38,53	14,46	8,67	41,80	15,43	9,02	27,73	10,22	5,94
96	39,37	14,85	9,15	45,50	15,84	9,52	28,33	10,49	6,27
97	40,25	15,29	9,61	43,45	16,31	10,00	28,97	10,80	6,58
98	41,16	15,71	10,08	44,43	16,76	10,49	29,62	11,10	6,90
98,5	41,56	15,98	10,37	44,87	17,05	10,80	29,91	11,29	7,10

A2.4 Processing costs for massecuites

2.4.1. Pans

The following assumptions are used:-

For 100 tons of brix in mixed juice, installed pan volumes are as follows:-

A Pans: 1 M^3 massecuite per ton brix in mixed juice, 4 hours pan time. 400 M^3 required.

B Pans: 0,4 M^3 massecuite per ton brix in mixed juice, 6,5 hours pan time. 260 M^3 required.

C Pans: 0,3 M^3 massecuite per ton brix in mixed juice, 9 hours pan time, 270 M^3 required.

Cost: R3 000/M^3 installed volumetric capacity.

The installed costs, for 200 tons of cane per hour are given in Table A2.4.1.

TABLE A2.4.1

Pan costs for the various extractions (Rands).

Extraction	Tons Brix in Syrup	Pan Capacity m^3			Costs			Total
		A	B	C	A	B	C	
94	27,35	109	71	74	$3,28 \times 10^5$	$2,13 \times 10^5$	$2,22 \times 10^5$	$7,63 \times 10^5$
95	27,80	111	72	75	3,34	2,17	2,25	$7,76 \times 10^5$
96	28,24	113	73	76	3,39	2,20	2,29	$7,88 \times 10^5$
97	28,69	115	75	77	3,44	2,24	2,32	$8,00 \times 10^5$
98	29,15	117	76	79	3,50	2,27	2,36	$8,13 \times 10^5$
98,5	29,37	117,5	74,4	79,3	3,52	2,29	2,38	$8,19 \times 10^5$

2.4.2. Crystallisers

Retention times used are:

A massecuite	6 hours	(water-cooled)
B massecuite	12 hours	(water-cooled)
C massecuite	24 hours	(water-cooled)

The installed costs, for 200 tons of cane per hour are given in Table A2.4.2, assuming a cost of R1 200/m^3.

<u>TABLE A2.4.2</u>

Crystalliser costs for the various extractions

Extraction	m^3 massecuite per hour			Volume required (m^3)			Cost (Rands)			
	A	B	C	A	B	C	A	B	C	Total
94	27,07	9,88	5,64	162	118	136	$1,95 \times 10^5$	$1,42 \times 10^5$	$1,62 \times 10^5$	$5,00 \times 10^5$
95	27,73	10,22	5,94	166	123	142	2,00	1,47	1,71	$5,18 \times 10^5$
96	28,33	10,49	6,27	170	126	150	2,04	1,51	1,80	$5,36 \times 10^5$
97	28,97	10,80	6,58	174	130	158	2,08	1,56	1,90	$5,54 \times 10^5$
98	29,62	11,10	6,90	178	133	166	2,13	1,60	1,99	$5,72 \times 10^5$
98,5	29,91	11,29	7,10	179	135	170	2,15	1,62	2,04	$5,82 \times 10^5$

2.4.3 Centrifugals

Installed capacity, cost data:

A machines : Batch, R10 000/m^3

B machines : Continuous, R15 000/m^3

C machines : Continuous, R24 000/m^3

The installed costs for 200 tons cane per hour are given in Table A2.4.3.

TABLE A2.4.3

Centrifugal costs for the various extractions

Extraction	m^3 massecuite A	B	C	Centrifugal Costs (Rands) A	B	C	Total
94	27,07	9,88	5,64	$2,71 \times 10^5$	$1,48 \times 10^5$	$1,35 \times 10^5$	$5,54 \times 10^5$
95	27,73	10,22	5,94	2,77	1,53	1,42	$5,72 \times 10^5$
96	28,33	10,49	6,27	2,83	1,57	1,50	$5,90 \times 10^5$
97	28,97	10,80	6,28	2,90	1,62	1,58	$6,10 \times 10^5$
98	29,62	11,10	6,90	2,96	1,66	1,66	$6,28 \times 10^5$
98,5	29,91	11,29	7,10	2,99	1,69	1,70	$6,38 \times 10^5$

APPENDIX 3

Curve fitting technique

The shape of the curve obtained from plotting the actual data indicated that the relation is of the form

$$Y = \frac{X}{a + b.X}$$

Where Y is extraction and X the number of mills.

To check the fit and calculate the values of the constants a and b, X is plotted agains X/Y. If the form of the equation is correct, a straight line is obtained. The constant b is equal to the slope of the line while a is equal to its intercept.

The correlation coefficients for the regressions of X against X/Y were high (>0,99) in all cases.

Table A3 below shows the actual values of cumulative pol extractions against the values calculated from the relevant equation of Table 2 in the main text.

TABLE A3

Actual and calculated cumulative pol extractions with number of mills.

Mill No.	Cumulative pol extraction					
	GH		NB		IL	
	Actual	Calculated	Actual	Calculated	Actual	Calculated
1	72,19	70,72	69,48	68,41	72,26	70,49
2	84,04	84,69	82,17	83,08	82,31	83,93
3	90,18	90,65	89,28	89,47	89,53	89,62
4	93,77	93,97	93,07	93,05	93,11	92,77
5	96,08	96,07	95,55	95,34	94,66	94,77
6	97,79	97,53	96,89	96,93	96,24	96,15

As can be seen the fit is good particularly at the higher extractions.