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Standardizing the Use of Sugarcane Hydraulic Press for Estimation of Commercial Recoverable Sugar

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ABSTRACT

For estimation of commercial recoverable sugar in cane samples, hydraulic press was used for juice extraction of fibre prepared in Jeffco Cutter Grinder. The hydraulic press was locally designed and its efficiency in Fibre and juice extraction, Pol extraction, BHR and sugar recovery were compared with USA made Carver Press. Three cane varieties viz; BL-4, BH-162 and CP-43-33 were used to standardize the technique at three pressures viz; 700, 1400 and 2100 bars. For juice extraction locally designed and fabricated sugarcane hydraulic Press showed better efficiency than the Carver Press. The juice extraction was linearly correlated with the increase in pressure. The variety CP-43-33 had the highest Fibre and the lowest extraction. The pressure of 700 bars was more effective for getting higher BHR, overall recovery and sugar recovery. Depending on the cane variety and maturity period, the locally fabricated press gave an efficiency range of 75-80 percent juice extraction, 89-91.5 percent pol extraction, 89-93 percent BHR and 80-84 percent overall recovery. The technique estimated reasonably accurate CRS and was considered an efficient approach for cane quality evaluation of large number of laboratory samples.

INTRODUCTION

Accurate methods for determination of Pol percent cane and assessment of sugar recovery have ever been of great interest, for both millers and growers, to reach the cane price fixation formulae. Several exercises made in this direction were left half the way for want of confidence on Java ratio, SJM and CCS formulae. Each factor has its own limitation for acceptance of parameters being used in respective formulae.

It is however considered view of sugar technologists that juice quality and losses factors during milling and processing in bagasse, press mud and molasses, should be real approach to Pol estimation. Various laboratory methods used for fibre estimation are combursom and very erratic. In Pakistan, SJM is commonly employed on crusher juice which give erratic extraction. Further that the laboratory methods for determination of Pol in bagasse, molasses, press mud etc., employed in the industry are not practicable on a large number of small variety samples in the laboratory.

Fibre/bagasse is an important constituent in determination of milling factor. It varies with varieties and milling efficiency. There are several direct and indirect methods for fibre estimation such as fibre washing, bagasse analysis and the hydraulic press. The former two methods are time consuming and erratic. There is a need for an easy and efficient method for determination of milling factor.

According to Meade and Chen (1988), Jeffco Cutter Grinder gives a homogenous mass of disintegrates with a minimum loss of moisture from the sample. Hydraulic presses are in common use for extracting out juice from the sub-sample in factories of Louisiana. According to Birkett (1988), the hydraulic press was found to be highly reproducible giving negligible coefficient of variation for Brix, Pol% and Fibre% cane. In

further studies Legendre (1992) observed that core/press method gave accurate valuation of cane that encouraged quality with increased profitability to both growers and processors.

Mathur (1993) explained that the weight of bagasse, in factories, is determined from the fundamental equation of milling (cane + imbibition water=juice + bagasse), whereby weight of bagasse is determined by differences. On the other hand procedure of fibre estimation through Jeffco Grinder and hydraulic press is independent of factory operation and simple procedure for direct determination of Pol in cane (Mathur, 1993).

Alam *et al* (1990) described the practical importance of Java Ratio;CCS; Extractable sugar (SE), Recoverable Sugar(SR), Sugar Yield (SY), SJM and Winter crop Formulae in assessing the sugar recoveries for cane price fixation, and emphasised the adoption of SJM for linkage to cane payment formulae under Pakistan conditions.

The direct analysis by pressing fibrated cane is practised in Re-Union, Martinique, Gaudeloupe, South Africa and Mauritius (Meade and Chen, 1987). A sub-sample of prepared cane weighing 0.5 - 1.0 kg is compressed in hydraulic press at 100-400 bars for a period of 2 min; the cake is then released and weighed and juice is analysed for Pol. In Brazil, 500 gram sub-sample of fibre is treated in hydraulic press at 250 kg/cm^2 pressure for juice extraction and equation have been derived for estimation of Fibre percent cane and Pol percent cane (Silva Jr., 1989).

According to Briody (1985) and Anonymous (1989, 1990 and 1992) Sugar factory parameters were reported to be much higher in Mauritius (Mill extraction 96.0, BHR 89.1), India (Mill Extraction 93.0; BHR 90.0) and Australia (Mill Extraction 96.1; BHR 89.0), than in Pakistan (Mill extraction 92.0, BHR 84.6).

In order to estimate Commercial Recoverable Sugar (CRS) of laboratory samples, a sugarcane hydraulic press was designed and used to standardize the technique. The present paper reports a series of experiments to assess the efficiency of hydraulic press and develop a standard technique for determination of CRS.

MATERIALS AND METHODS

The present studies were conducted with a Jeffco Cutter Grinder and Hydraulic Press - at Sugarcane Research Institute, Faisalabad, during 1992-93. The Jeffco Grinder was got manufactured in the workshop of Crescent Sugar Mills, Faisalabad, and was used for preparation of Fibre. The Sugarcane Hydraulic Press (SHP) was designed jointly by Karim Bakhsh Malik (Senior Author) and Shahab-ud-Din Fasihi, and was got manufactured locally by a private firm "Mirza and Sons" at Faisalabad. It was used for extraction of juice from prepared samples of fibre.

Jeffco Grinder works with a 10 HP motor at a speed of 2800 RPM. While the Grinder is run, six full cane samples cut into 4-5 inches pieces are gradually put into Grinder cavity for shreading. It takes more or less two minutes to grind samples into fibre. The fibre is rapidly mixed to attain homogenity and is then placed in air tight plastic container. Five hundred grammes of fibre sample is weighed on electronic balance and put in built in cylinder of SHP. the auxillary pump works to raise filter cylinder briskly. As soon as the needle of pressure guage show slight movement (at about 70 bars), the pressure pump is started and is worked to required pressure and maintained for two minutes. The juice is extracted through juice slots of filter cylinder and collected in juice tray placed under the stand.

After the pressure is achieved, latch lever is set right, pressure is released by moving pressure release value a bit. The cake removing lever is turned anticlock wise that presses the fibre cake to get out of the apparatus. The cake is weighed and placed in the oven. The juice is analysed for brix by hydrometer, and for Pol by polarimetric method (Legendre, 1992).

These studies were conducted to evaluate performance of locally manufactured "Sugarcane Hydraulic Press" (Figure 1), in respect of juice extraction, fibre percent cane, Pol extraction, BHR and CRS. The instrument was tested with three cane varieties at three pressures viz; 700, 1400, 2100 bars. The performance was compared with a USA imported "Carver Press" (Figure 1). In another study the milling and processing parameters of five commercial varieties were also worked out to further confirm the results.

The cane samples of the following juice quality were used in the fore-mentioned three tests:-

Set-I.	USA Vs local Press x Pressure		BF-162	BL-4	CP-43-33
	December	Brix	21.06	21.06	22.68
		Purity	85.53	83.46	83.31
Set-II.	Variety x Pressure x Months.				
	December	Brix	16.88	18.73	19.92
		Purity	80.95	81.19	83.87
	March	Brix	23.13	20.33	22.39
		Purity	87.67	80.69	86.00

Set-III. Varietal effects on quality parameters.

The varieties used in this set comprised Co. 1148, BL-4, CP-70-1547, CP-72-2086 and SPSG-26. The cane quality data is given in the Table 3.

The observations were recorded under simple factorial experiment with four replications. The impirical data on Brix, Pol, and purity percent juice, and whole fibre sample weight, fresh cake weight and oven dry cake weight were fed to computer programme for estimation of various milling and processing parameters (Appendix 1). The working procedure is derived from PSST (1977) and Legendre (1992). The data recorded was analysed statistically using LSD test of significance for comparison of means.

The Commercial Recoverable Sugar was calculated by the formulae suggested by Alam *et al* (1988), which reads as CRS = Pol % cane x Pol Extraction x Retension SJM x Bioling House Efficiency (BHE).

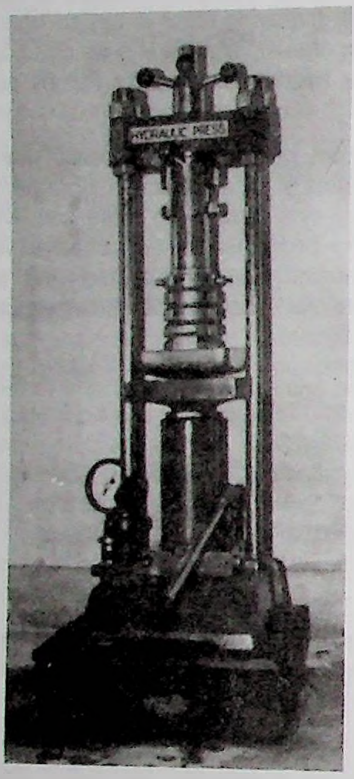

Figure 1a. Locally fabricated Sugarcane Hydraulic Press.

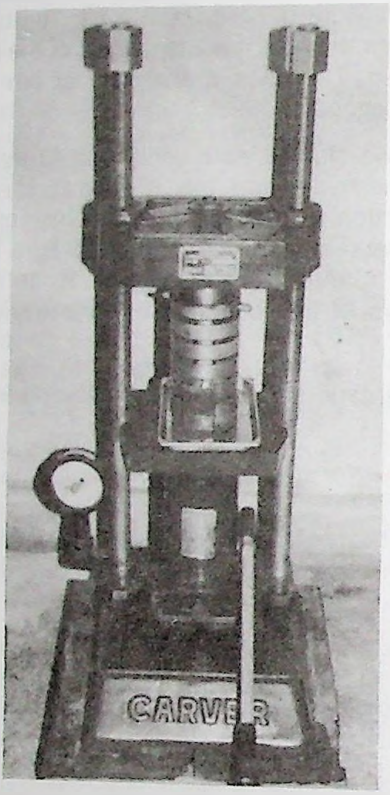

Figure 1b. Carver Press imported from U.S.A.

Figure 2. Cane Fibre Cake being weighed on electronic balance.

RESULTS AND DISCUSSION

The studies on the assessment of CRS through hydraulic press are first of its kind in Pakistan. The results obtained from three sets of experiments are described below:-

1. Local Sugarcane Hydraulic Press Vs Carver Press :

The working efficiency of locally fabricated Sugarcane Hydraulic Press and Carver Press were compared for different cane quality characters and milling parameters and data are presented in the Table 1.

Table 1. Local hydraulic press and carver press compared f or different milling and processing parameters of three cane varieties under three atmospheric pressure.

Hydraulic Press	Varieties			Pressure-Bars			Mean for Instrument
	BF-162	BL-4	CP43-33	700	1400	2100	
1. Fibre % Cane							
U.S.A	10.55 b	10.67 b	12 14 a	11.35	11.01	11.00	11.12
Local	10.67 b	10.67 b	12.40 a	11.32	11.10	11.32	11.25 NS
Mean	10.61 b	10.67 b	12.27 a	11.33	11.06 NS	11.16	
2. Juice Extraction							
U.S.A	80.00 a	76.69 c	76.49a	77.12	77.67	78.39	77.72 b
Local	80.18 a	77.52 b	75.72 d	77.04	77.93	78.44	77.80 a
Mean	80.09 a	77.10 b	76.10 c	77.08 c	77.80 b	78.41 a	
3. Pol Extraction							
U.S.A	91.25 a	90.00 c	90.67 ab	90.67 ab	90.50 ab	90.75 ab	90.64
Local	91.17 a	89.92 c	90.33 bc	90.17 b	90.33 ab	90.92 ab	90.47 NS
Mean	91.21 a	89.96 c	90.50 b	90.42	90.42 NS	90.83	
4. B H R							
U.S.A	90.25 b	89.67 bc	90.00 b	90.42 a	89.92 ab	89.58 b	89.97 NS
Local	91.42 a	89.67 bc	89.00 c	90.67 a	90.08 ab	89.33 b	90.03
Mean	90.83 a	89.67 b	89.00 b	90.54 a	90.00 ab	89.46 b	
5. Overall Recovery							
U.S.A	82.17 b	80.00 e	81.33 c	81.42	81.08	81.00	81.17 b
Local	83.92 a	80.75 d	80.00 e	81.92	81.58	81.17	81.56 a
Mean	90.83 a	80.37 b	80.67 b	81.67 a	81.33 ab	81.08b	
6. Sugar Recovery (CRS)							
U.S.A.	12.77 a	11.85 b	12.73 b	12.68 b	12.26 c	12.41 c	12.45 b
Local	12.38 a	12.00 b	12.45 c	12.58 b	13.01 a	12.25 c	12.61 a
Mean	13.08 a	11.92 c	12.59 b	12.63 a	12.63 a	12.33 b	

Mean having same letter do not differ significantly at the 5% level.

a. Fibre % Cane:

Fibre percent cane was not significantly affected by any of the insturments and pressures. The varieties showed significant differences in their means. The variety CP-43-33 gave the highest fibre contents of 12.27 percent. while BF-162 and BL-4 were at par with each.

b. Juice Extraction:

The data show significant difference for instruments, varieties, pressured and their interaction. The local SHP gave the highest mean Juice extraction of 77.80 percent compared to extraction observed in Carver Press (77.72%). the juice extraction increased with corresponding increase in pressure from 700 to 2100 bars. The juice extraction was significantly higher in variety BF-162 (80.09%) and the lowest in CP-43-33 (76.10%).

c. Pol Extraction:

A Pol extraction of 90.64% and 90.47% was noticed in carver SHP and local SHP, however differences in means were not significant. The variety BF-162 gave significantly higher Pol extraction of 91.21%.

d. Boiling House Recovery:

The BHR is an indicator of efficiency in processing section of sugar factory and is influenced by juice quality (Brix, Pol, Purity) and molasses purity. On an average parameter of sugar purity (99.7%) and molasses purity (35%), variety BF-162 gave the highest BHR value of 90.83%. The BHR was the highest at 700 bars pressure and was at par with 1400 bars. Both the instruments were found statistically similar in performance.

e. Overall Recovery:

The overall recovery is interaction of both milling and processing section in a factory. The local SHP gave significantly higher recovery (81.56%) than carver SHP (81.17 percent). The pressures of 700 and 1400 bars gave higher recovery (81.67%) values than extreme pressure (bars). The BF-162 gave maximum value of 83.04% and was significantly better than rest of varieties.

1. Sugar Recovery:

The effect of juice quality, fibre contents, juice and Pol extraction and BHR is reflected on sugar recovery. Low working efficiency during milling and processing operations would reduce sugar recovery. The local SHP gave significantly the highest CRS of 12.61% compared to carver SHP (12.45%). The pressured of 700 and 1400 bars gave higher recovery (12.63%) than recovery observed under 2100 bars. BF-162 gave higher CRS(13.08%) than the other two varieties.

The overall working efficiency of newly designed SHP indicated that press could safely be used at any of two lower pressures. However, higher juice extraction was directly proportion to higher pressure of the press. Since higher extraction is also associated with large extraction of invert sugars, this treatment could give negative effects on Pol extraction. Thus these data confirm that sugar recovery was not associated with higher juice extraction under higher pressure.

Further, that Fibre appeared to have a negative effects on juice extraction. The varieties having higher fibre contents would yield lesser juice weight; CP-43-33 is a clear example in this experiment.

2. Varieties x Pressure x Months:

Further studies on the effect of three pressures on three commercial varieties were conducted during December and March with local SHP. The data on various cane quality parameters are reproduced in the Table 2.

Table 2. Milling and processing parameters affected by hydraulic pressure on three varieties in two months.

Varieties	Pressure-Bars			Months		
	700	1400	2100	Dec.	Mar.	Mean
Fibre % Cane						
BL 4	11.28 d	10.96 d	11.02 d	11.34 cd	10.84 d	11.09 c
BF 162	12.18 c	12.60 bc	12.95 ab	11.68 c	13.47 a	12.58 b
CP43-33	13.52 a	12.85 ab	12.65 bc	12.74 b	13.27 ab	13.01 a
Mean	12.32 a	12.13 a	12.21 a	11.92 b	12.53 a	
Juice Extraction						
BL 4	76.96 de	78.18 cd	77.75 cde	78.09 b	77.33 b	77.63 b
BF 162	78.56 bc	79.86 ab	80.69 a	80.57 a	78.84 a	79.70 a
CP43-33	74.85 b	77.07 de	75.63 ef	77.06 a	75.31 a	75.85 a
Mean	76.79 c	78.37 a	78.02 ab	78.57 a	77.16 ab	
Pol Extraction						
BL 4	89.75 f	89.88 cf	90.12 cde	90.08 b	89.75 c	89.92 c
BF 162	90.25 cd	91.00 b	91.38 a	90.92 a	90.83 a	90.87 a
CP43-33	90.00 a	90.88 b	90.37 c	90.17 b	90.67 a	90.42 b
Mean	90.00 a	90.58 a	90.62 b	90.39 a	90.42 a	
BHR						
BL 4	89.25 e	87.00 f	86.00 g	87.83 d	87.00 c	87.42 c
BF 162	90.37 b	89.75 de	89.50	87.00 e	92.75 a	89.87 c
CP43-33	91.00 a	90.50 b	90.00 c	89.67	91.33	90.50
Mean	90.21 a	89.08 b	88.50 c	88.17 b	90.36 a	
Overall Recovery						
BL 4	79.87 d	78.25 c	77.50 f	79.17 d	77.92 c	78.54 c
BF 162	81.62 c	81.75 bc	81.75 bc	79.08 d	84.33 a	81.71 b
CP43-33	82.12 ab	82.38 a	81.50 c	80.92 c	83.08 c	82.00 a
Mean	81.21 a	80.79 b	80.25 c	79.72 b	81.78 a	
Sugar Recovery (CRS)						
BL 4	10.52 a	10.54 d	10.45 d	10.24 c	10.76 d	10.50 c
BF 162	11.56 c	11.59 c	11.55 c	9.13 f	14.00 a	11.57 b
CP43-33	11.93 b	12.18 a	11.95 b	11.08 c	12.97 b	12.02 a
Mean	11.34 b	11.44 a	11.31 b	10.15 b	12.58 a	

Means having same letter do not differ significantly at the 5 percent level.

The data reveal that trend of observations is same as observed in prevarious section on comparison of two instruments. However, varietal impact changes a little bit due to change in sample and time of recording observations. The data show significant differences among means of various treatments and treatment interaction. Fibre contents were not affected by pressures used in these studies. The increase in pressure had direct bearing on juice extraction. The BHR, Pol extraction, overall recovery and CRS was higher at 700 bars pressure, the 1400 bars gave the intermediate values. The variety CP-43-33 gave higher juice quality followed by BF-162 and BL-4. The effect of juice quality and milling and processing parameters was noticed on higher sugar recovery of CP-43-33.

The data also showed that quality parameters were identical with quality of cane crushed in earlier season (December) and in the later period when cane was over mature in March.

3. Cane Varieties x Maturity Season:

The milling and processing efficiency parameters of five varieties for different crushing months of crop season are given in the Table 3. The data reveal that varieties and maturity time has direct bearing on Fibre, BHR, overall recovery and the CRS. The later maturing variety Co. 1148, while having low juice purity also gave low BHR and overall recovery. The high purity varieties on the other hand gave higher values of these parameters. It is quite obvious that low purity juice would tend to show more losses through molasses thus affecting the BHR and overall recovery adversely.

Table 3. Juice quality and milling and processing parameters of sugar recovery (CRS) in commercial varieties during crushing season 1992-93.

Variety	Brix%	Purity	Fibre	BHR	Overall Recovery	CRS	Brix%	Purity	Fibre	BHR	Overall Recovery	CRS
	November						December					
Co1148	14.69	72.10	10.94	.80	.72	6.57	16.78	83.19	10.25	.89	.82	9.99
BL 4	17.44	80.15	9.78	.87	.78	9.46	17.96	81.79	9.84	.90	.90	11.27
CP70-1547	17.98	81.35	10.59	.88	.80	10.09	18.88	79.50	11.17	.89	.81	11.19
CP72-2086	18.32	84.41	10.29	.91	.82	10.91	16.30	83.93	11.62	.94	.86	12.01
SPSG26	17.33	85.80	11.42	.91	.83	10.42	18.44	83.84	12.11	.91	.83	11.22
	January						February					
Co1148	16.32	76.47	10.68	.83	.75	8.10	18.62	83.46	11.08	.89	.81	10.72
BL 4	18.22	83.21	11.41	.89	.81	10.28	19.08	85.53	11.07	.91	.83	11.33
CP70-1547	20.82	83.28	11.43	.90	.81	11.87	19.82	87.49	9.74	.92	.84	12.68
CP72-2086	20.32	86.96	10.23	.92	.83	12.27	19.95	89.60	10.25	.94	.86	13.18
SPSG26	19.20	85.87	12.01	.91	.83	11.40	19.48	87.14	12.32	.92	.84	11.86
	March						April					
Co1148	20.56	79.47	10.68	.86	.78	10.97	12.10	81.73	11.12	.88	.80	11.71
BL 4	18.68	84.10	13.57	.90	.81	10.27	19.82	75.33	11.81	.82	.74	9.20
CP70-1547	20.70	83.78	10.62	.90	.82	12.11	20.93	81.15	10.98	.88	.80	11.54
CP72-2086	19.43	85.84	10.37	.92	.83	11.94	18.68	80.19	10.83	.87	.79	10.87
SPSG26	20.93	82.60	11.14	.89	.81	11.91	20.68	81.60	11.98	.88	.80	11.26

The sugar mills in Pakistan are reported to have efficiency of 92 Pol extraction, 85 BHR and 77 overall extraction (Anonymous, 1992). As against the mills efficiencies, the Sugarcane Hydraulic Press showed an efficiency of 93 BHR, 92 Pol extraction and 82 overall extraction. As such the CRS values estimated by Sugarcane Hydraulic Press techniques are considerably higher than sugar recoveries of Pakistani Mills. Considering international standards of 90 BHR, 96 Mill Extraction and 86 Overall recovery, data that emerged through this technique should be reliable the similar findings have been reported by Mathur (1993), Meade and Chen (1988), Birkett (1988) and Legendre (1992).

Considering comparative data of local sugarcane hydraulic press and carver press, it may be concluded that :-

a. The local Sugarcane Hydraulic Press, is more efficient, easy to operate and less labour consuming, than the Carver Press which is very cambursom and requires more manual labour and time.

b. A pressure of 700-1400 bars give satisfactory juice extraction.

c. The Sugarcane Hydraulic Press proved to produce uniform cane quality data with significantly higher values of various quality parameters.

d. The Sugarcane Hydraulic Press gave quality parameters values of 80% juice extraction, 92% BHR, 91.5% Pol Extraction and 82% overall recovery, which are quite reliable for dry milling tests.

e. The instrument can reproduce most correct data, independent of factory operations.

f. The technique is of great practical importance both to Sugarcane Research and Industry Sector. Since large number of samples can be studied at a time, thus the technique is more efficient and reliable for analysis of laboratory samples.

g. There is one limitation that fibre values are on lower side.

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Appendix 1

Working Procedure for Estimation of Commercial Recoverable Sugar (CRS) by Dry Milling Test

1.	Wt. of cane crushed (Grinded)		Juice analysis
2.	Fresh cake wt. (bagasse) *	a)	Brix % =
3.	Wt. of juice (undiluted juice) (1-2)	b)	Pol % =
4.	Dry cake wt. (dried bagasse)	c)	Purity % =
5.	Weight of juice in cake (2-4) =		$\frac{\text{Cane weight - Dry cake weight}}{\text{Cane weight}}$
6.	Brix in cake (bagasse) (a x 5) =		Brix % juice x juice in cake
7	Pol in cake bagasse (b x 5) =		Pol % juice x juice in cake
8.	Brix % bagasse $(\frac{6}{2} \times 100)$ =		$\frac{\text{Brix in cake x 100}}{\text{Fresh cake weight}}$
9.	Bagasse weight (1-3) =		Weight of cane crushed - gross undiluted juice weight
10.	Bagasse % cane $(\frac{2}{1} \times 100)$ =		$\frac{\text{Bagasse weight x 100}}{\text{Weight of cane crushed}}$
11.	Undiluted juice% cane $(\frac{3}{1} \times 100)$ =		$\frac{\text{Net undiluted juice weight x 100}}{\text{Weight of cane crushed}}$
12.	Moisture % bagasse $(\frac{5}{2} \times 100)$		
13.	Fibre in cake (dried bagasse) (4-6) =		Dry cake weight - brix in cake
14.	Fibre % bagasse (100-12-8) =		100 - Moisture % bagasse - birx% bagasse
	=		$100 - \frac{\text{Moisture\% bagasse}}{\text{(1-Brix\% juice) 100}}$
15.	Weight of fibre in bagasse $(\frac{9 \times 14}{100})$ =		$\frac{\text{Bagasse weight x fibre \% bagasse}}{100}$
16.	Fibre % cane (10 x 14) =		Fibre % bagasse x bagasse % cane or
	=		$\frac{\text{Fibre in cake x 100}}{\text{Weight of cane}}$
17.	Pol in bagasse % cane $(\frac{7}{2} \times 100)$ =		$\frac{\text{Weight of Pol in bagasse x 100}}{\text{Weight of bagasse}}$
18.	Weight of Pol in juice $(\frac{3 \times b}{100})$ =		$\frac{\text{Net juice weight x Pol \% mixed juice}}{100}$
19.	Weight of Pol in cane (17 x 18) =		Weight of Pol in juice + Weight of Pol in bagasse
20.	Mill (Pol) Extraction $\frac{18}{19}$ =		$\frac{\text{Weight Pol in juice}}{\text{Weight Pol in cane}}$
21.	Pol % cane $(\frac{19}{1} \times 100)$ =		$\frac{\text{Weight of Pol in cane x 100}}{\text{Weight of cane crushed}}$
22.	Boiling House Recovery (BHR) $\frac{99.7\,(C-35)}{C(64.7)}$ =		$SJM = \frac{S\,(J-M)}{J\,(S-M)}$
			S= Sugar purity (99.7), J = Juice purity (c), M= Molasses purity (35)
23.	Overall Recovery (20 x 22) =		Pol Extraction x BHR
24.	Sugar Recovery (CRS): (20x21x22x0.98) =		Pol % cane x Pol Ext. x BHR x BHE

* Fresh cake weight from hydraulic press is taken as the weight of bagasse.