SOME NOTES ON GUMS IN A DEFECATION RAW SUGAR FACTORY

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Summary

Attention is drawn to the gum content of Natal raw juice and mention is made of the conditions which increase the quantity of gums in juice. It was previously felt that the high gum content in molasses, which normally varies between 4 to 6 per cent on dry substance, interfered with low grade boilings by increasing viscosities. The investigation was not able to substantiate this and it must be concluded that either the gums do not impede the low grade boilings as much as previously supposed or incomplete exhaustion in the boiling-house was obscuring the effect of gums.

Gum and other filtration impeding impurities were studied in A, B and C sugars as well as the weekly raw sugar samples. There is no doubt that filtrabilities are seriously affected by increasing gum contents.

The factory process streams were analysed and a number of material balances computed for gum. It was found that the defecation process was ineffective in removing gums (35 to 53 per cent removal on results obtained) and further that the "apparent" gum content increased through the process. It is suggested that the latter might be due to further chemical reaction of the gum components throughout the process or due to the shortcomings of the acidified alcohol precipitation technique.

Introduction

A literary survey has revealed that very few investigators in the past have studied the role of gums in the raw sugar process.[1 - 2] Possibly this has been due to very low gum contents in cane juices from countries crushing fresh young cane grown under ideal climatic conditions. In such countries the problem may not have been considered worth while investigating. In Natal where attention is now focussed on sugar quality, it is realised that the major factors which contribute towards high gum contents in juice are (*a*) the age of the cane, (*b*) whether the cane has been grown under droughty conditions and (*c*) the time which has elapsed between cutting and crushing.

Each miller is limited by his clarification technique in the extent to which he can handle these gums and therefore it is necessary to define the process employed at the factory in which this investigation was carried out.

Raw sugar is produced by means of the simple defecation process. The procedure adopted over the last few years has been to mix the oliver filtrate juice with the cold mixed juice from the mills and heat to 160 to 180°F in primary heaters. The juice is then retained for a period of 8 mins. in starch removal tanks[3] and then limed to a pH of 7.0 before secondary heating to 220°F. Secondary lime is added to the boiling juice to give a pH of 8.0 resulting in a clear run off from the subsiders of 7.3 pH.

Several years ago[4] attention was drawn to the fact that molasses purities were considerably higher than the expected purities as determined by the Douwes-Dekker formula. Using this formula as a yardstick it appeared that the boiling-house operation required tightening up. However, with resulting improvements it was thought that the high level of gums entering the boiling-house resulted in high viscosities which made the boiling of low grade massecuites extremely difficult. More recently the quality of raw sugar has assumed great importance and analyses have confirmed the high gum content in all grades of sugar.

It was decided therefore to study gum contents throughout the process.

The term "gums" loosely refers to a heterogeneous group of compounds and in their determination we have used the acidified alcohol precipitation technique. The experimental work of Ruff and Withow[5] has been used as a guide and analytical procedures are given in Appendix I. It will be appreciated that large differences can be obtained by varying the alcohol : water ratio or the HCl acidity. Provided the same technique is adhered to, results will be comparable and it is this that we are principally concerned with in the ensuing discussion.

Gum Contents of Final Molasses

Reference to Graph I shows results collected over three different seasons. Expected purities of final molasses are compared with actual true purities obtained. The similarity in the trends of both curves shows that for a given change in expected purity there is a similar change in actual purity. Unfortunately the magnitude of the change in actual purity cannot be predicted from the fluctuations in expected purity alone. We had hoped that, by superimposing a third curve representing the gum content in molasses, expressed as a percentage of dry substance, we would be able to explain the large variations in actual purity which are obtained over different periods of the season.

A study of the curves shows that although in many instances a high or low gum content coincides with a high or low actual purity, there are also instances where this is reversed. We were forced to conclude that either the gum content did not affect boiling as much as we had presupposed or incomplete exhaustion in the boiling-house was obscuring the influence of the gums.

The curves for the year 1963 are worth mention. During the first half of the year the gum contents

showed some of the highest figures ever recorded at Tongaat. We believe that this might have been due to unsettled conditions at the mill which resulted in successive stockpiling or depletion of cut cane. During the second half of the year the gum contents appeared to be more normal.

Gum Content of Sugars

In examining the quality of sugar we have used the S.M.R.I. filtrability apparatus and standard affination test.[6] The filtrability figure is a comparison of the rate of filtration of a 60° Bx solution of a particular affinated raw sugar sample with a standard refined sugar solution under identically standardised conditions. In analysing our own sugars we have studied the results of work already carried out by the Sugar Milling Research Institute.[7]

In Table I below are tabulated some results comparing A, B and C sugars.

Table I

Some Analyses of Affinated Defecation Raw Sugars vs. Filtrability

Composited Weekly Sample	W/E 12.5.63			W/E 19.5.63			W/E 26.5.63			W/E 2.6.63		
Grade of Sugar	A	B	C	A	B	C	A	B	C	A	B	C
Gums .. .. PPM	1,381	1,272	2,250	1,350	1,540	2,720	1,270	1,500	2,130	—	—	—
P_2O_5 .. .. PPM	22	22	45	25	25	52	21	25	42	19	29	42
Wax .. .. PPM	155	173	—	175	264	241	138	162	169	104	181	196
Silica .. .. PPM	111	110	—	—	—	—	110	130	221	103	206	217
Filtrability %	41	40	12	40	28	13	43	36	18	46	32	16

It will be seen that of the filtrability impeding substances, the increase in gums from A to C sugars is most significant. The corresponding decrease in filtrability leads one to conclude that the "gum" group of compounds must have considerable influence in the filtrability of a sugar.

Table II gives the comprehensive weekly analyses of raw sugars over the 1963 season. It will be noted that the standard affination procedure removed significant quantities of all impurities except waxes as summarised in Table III below. We suggest that waxes may be more evenly distributed throughout the sugar crystal.

Table III

Average Raw Sugar Analysis for 1963 Season

	Before Affination ppm	After Affination ppm	% Removed
Gums	2,597	1,941	25.3
Starch	679	553	22.8
P_2O_5	44	30	31.8
Silica	224	171	23.7
Wax	212	190	10.4

Gum Content of Process Streams

By studying the analyses in Table II it is clear that a considerable quantity of gum is not separated from sucrose during the process of crystallisation. From recent research it is not surprising to confirm that gums exercise a considerable influence in the filtrability of a sugar. If gums are an important factor in the exhaustion of sucrose in low grade massecuites as well as filtrability of sugars, it seems important that their distribution throughout the process should be investigated.

Snatch samples of each stream were collected at regular intervals over a week and stored in a refrigerator. Preliminary tests were carried out to ensure that low temperature storage would not affect the weekly gum determinations. The samples were composited and analysed by the methods outlined in Appendix I. Results of typical tests are given in Table IV and the results of the last four weeks were used in calculating the material balances given in Table V.

It will be noted from the material balances given in Table 5 that the "apparent" gum contents appear to increase through the process. At first it was thought that the sampling and analysis over weekly periods was not sufficiently accurate, but after numerous check analyses we came to the conclusion that there was an apparent gain of gum throughout the process. It is probable that the method of gum determination is unreliable for all conditions although it is also possible that the "gums" themselves undergo changes in composition.

Table IV

Some Typical Gum Contents of various Process Streams — Defecation Process

Composited Weekly Sample	Mixed Juice	Clear Juice	Mud to Filters	Press Cake from Filters	Sugar	Molasses
	% weight	% weight	% weight	% weight	% weight	% weight
17.11.63	0.35	0.12	2.25	—	0.27	4.30
24.11.63	0.35	0.12	2.14	—	0.24	4.89
2.12.63	0.31	0.13	—	4.05	0.27	4.47
12.1.64	0.21	0.12	—	3.70	0.20	4.33
19.1.64	0.26	0.10	—	3.70	0.23	4.37
26.1.64	0.19	0.10	—	3.78	0.21	4.05

Table V

Weekly Material Balances for Gums
Total Gum in Tons

Weekly Period Ending	Sugar	Molasses	Total of Sugar+Molasses	Clear Juice	Press Cake	Total of C.J.+Press Cake	Juice
2.12.63	10.8	38.0	48.8	42.2	75.0	117.2	104.4
12.1.64	6.6	38.2	44.8	34.9	60.7	95.6	81.9
19.1.64	8.4	43.4	51.8	31.9	67.1	99.0	83.9
26.1.64	7.9	38.4	45.3	32.2	70.0	102.2	70.1

Due to the above findings it appeared more reasonable to compare the gum removed by the defecation process on the basis of:

$$\frac{\text{Gum in M.J.} - \text{Gum in Molasses} - \text{Gum in Sugar} \times 100\%}{\text{Gum in Mixed Juice}}$$

The removal for the four weeks computed was as follows:

W/E 2.12.63 .. 53%
W/E 12.1.64 .. 45%
W/E 19.1.64 .. 38%
W/E 26.1.64 .. 35%

It would appear therefore that the defecation process as described above is not at all effective in removing gum. One wonders therefore whether it would not be wise to give more consideration to adaptations of processes which are capable of effectively removing gums and other impurities.

References

1. Steuerwald and Van der Unde (1914).—Det. of gums in cane molasses. I.S.J. XVI.430.
2. Chou (1954).—Removal of gums from Taiwan Cane Juice by defecation. I.S.J. LVI.319.
3. Boyes, P. N. (1960).—Starch in the manufacture of raw sugar Proceedings S.A. Sugar Tech. Assoc. 34.91.
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5. Ruff, H. T. and Withow, J. R. (1922).—Determination of gums in sugar products Journal of Ind. Eng. Chem. Vol. 14 No. 12.
6. Communications from the Sugar Milling Research Institute No. 57 (1962) Appendix I.
7. Douwes-Dekker, K.—Raw Sugar Filterability (1962). 11th Congress International Soc. of Sugar Cane Tech. p. 869.

Appendix I

Analysis of Gums

Gums in Molasses

10 gms. molasses were diluted with 10 mls. distilled water and 2 mls. of 50 per cent HCl added. To this was added 150 mls. 95 per cent Ethyl alcohol slowly with stirring. The precipitate was allowed to settle overnight and then filtered through a Gooch crucible. Ash was deducted from the total weight of the precipitate by subsequent incineration.

Gums in Sugars

20 gms. sugar were dissolved in 30 mls. distilled water and 2 mls. 50 per cent HCl added, followed by precipitation with 150 mls. of 95 per cent Ethyl Alcohol.

Gums in Mixed Juice and Clear Juice

2 mls. 50 per cent HCl were added to 50 mls. juice followed by precipitation with 350 mls. 95 per cent Ethyl Alcohol.

Gums in Mud to Oliver Filters

50 gms. were weighed in a 100 mesh screen. Bagacillo was separated by sieving and washing with distilled water until runnings were clear. The runnings were concentrated to 30 mls. 2 mls. 50 per cent HCl were added and gums precipitated using 350 mls. of 95 per cent Ethyl Alcohol.

Gums in Filter Press Cake

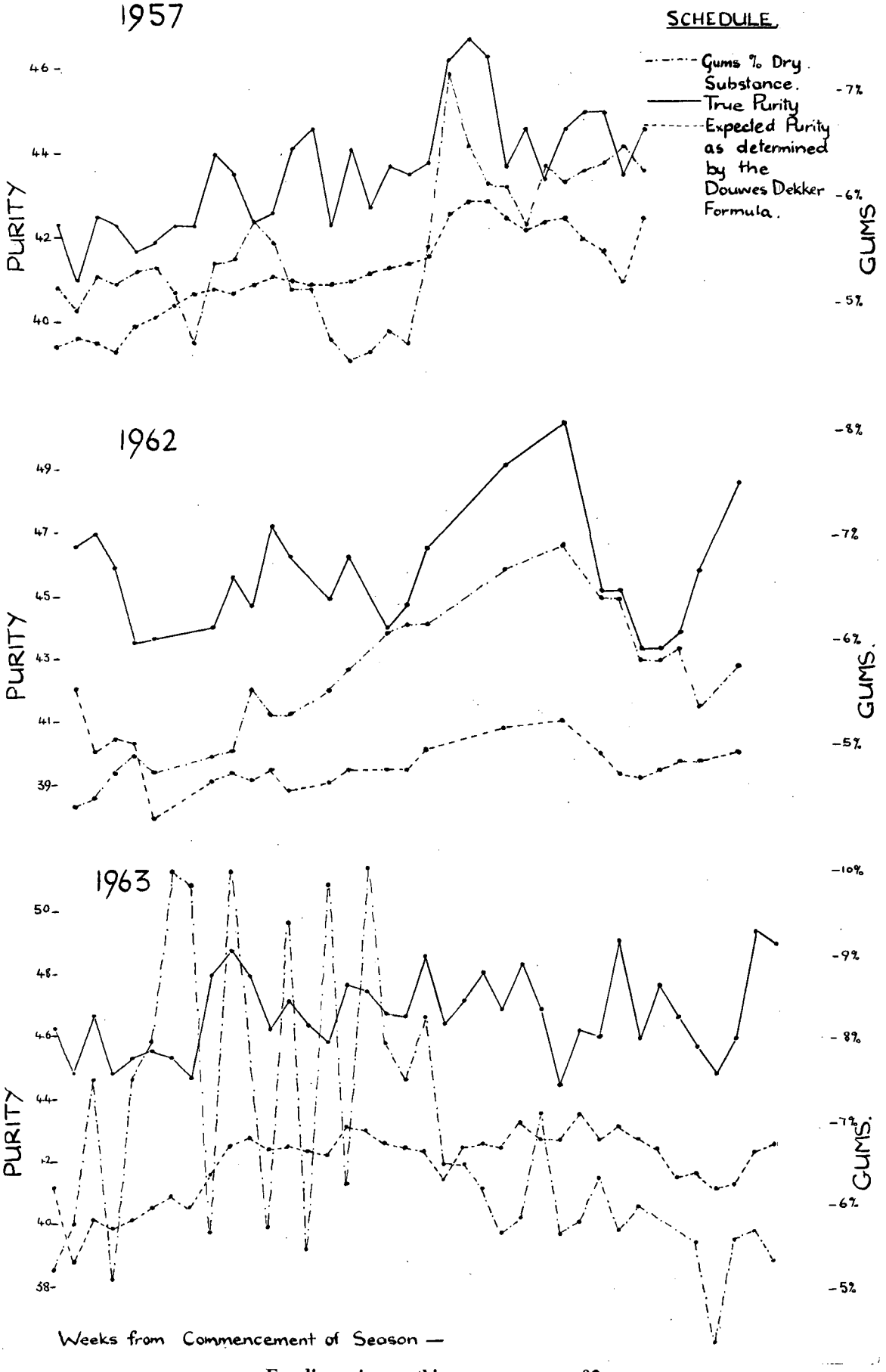
10 gms. of press cake were diluted with distilled water and filtered through a 100 mesh screen to remove bagacillo. The runnings were concentrated to 30 mls. and 2 mls. 50 per cent HCl added. Gums were precipitated using 350 mls. of 95 per cent Ethyl Alcohol.

Table II

1963 Seasonal Analysis of Tongaat Defecation Raw Sugars

Week Ending	Gums PPM		Starch PPM		P_2O_5 PPM		Silica PPM		Wax PPM		filtera-bility %
	Before Affin.	After Affin.	Before Affin.	After Affin.	Before Affin.	After Affin.	Before Affin.	After Affin.	Before Affin.	After Affin.	
12.5.63	1,827	1,320			50	25	228	114	180	184	38
19.5.63	1,950	1,870			—	22		125	187	173	33
26.5.63	—	1,380			32	22		125	123	111	37
2.6.63					31	23		133	131	137	36
9.6.63					27	15	135	121			43
16.6.63					37	29	183	140	186	165	31
23.6.63					29	31	150	162	138	148	30
30.6.63					38	29			189	177	31
7.7.63	2,355	2,375	500	485	48	29			235	179	24
14.7.63	2,485	2,015	580	536	50	43	250	257	233	140	19
21.7.63	1,080	720	445	455	—	—	200	—			27
28.7.63	1,990	1,810	510	400	53	37	223	183	181	179	26
4.8.63	2,600	1,930	538	410	45	35	222	190	190	187	29
11.8.63	2,085	1,700	480	475	52	35	193	169	198	147	26
18.8.63	2,660	2,150	600	513	44	31	265	183	259	170	27
25.8.63	1,830	1,530	400	363	44	32	275	213	214	182	26
1.9.63	3,385	1,650	538	425	65	38	303	227	209	182	25
8.9.63	2,595	1,380	425	—	51	34	210	154	199	153	28
15.9.63	3,100	2,105	490	—	59	34	231	190			31
22.9.63	3,945	2,380	538	510	56	37	293	201	219	180	26
29.9.63	2,420	2,450	640	395	41	28	298	198	186	181	30
6.10.63	2,520	2,030	713	538	31	21	230	198	194	167	33
13.10.63	3,215	2,335	625	538	39	23	253	190	210	230	20
20.10.63	3,315	2,410	760	775	44	33	220	173			17
27.10.63	3,195	2,295	975	685	46	50	330	235	192	210	19
3.11.63	2,715	2,125	830	715	30	19	137	103			23
10.11.63	2,605	2,000	800	715	31	21	238	162			23
17.11.63	2,735	1,755	780	665	35	22	254	172			33
24.11.63	2,350	1,690	760	675	29	25	222	180	274	253	29
1.12.63	2,890	2,300	800	790	47	33	203	110	281	280	24
8.12.63	2,220	1,870	675	625							31
15.12.63	2,350	1,780	725	600	32	21	210	162	250	200	31
22.12.63	2,465	2,285	775	735	27	27	183	183			24
29.12.63	2,505	2,380	870	740	28	25	210	130	223	208	29
5.1.64	3,735	2,480	740	—	37	23	203	133	287	156	28
12.1.64	2,030	1,620	685	560	35	25	200	158	298	285	32
19.1.64	2,335	1,610	535	—	57	45	215	187	290	273	
26.1.64	2,110	1,765	613	400	71	50	210	190	300	281	26
Average	2,597	1,941	679	553	44	30	224	171	212	190	28

Graph I Gum Content of Final Molasses.



For discussion on this paper see page 92.