FACTORY BALANCE SYMPOSIUM

THE FACTORY BALANCE

S.A.S.T.A. Chemical Control Committee

Abstract

The interests of the Committee in aspects of the Factory Balance are outlined and figures given to show the financial implications of undetermined loss and non-sucrose ratio. The work of the Committee on the influence of suspended solids on mixed juice analysis, the determination of refractometer brix, and industry-wide standardisation of sampling, analysis, and reporting, is reviewed.

Introduction

The importance which should be attached to the control of loss in industry cannot be overstressed. The ability to assess when and where losses occur is a necessary forerunner to effective loss control.

When it is remembered that our industry enjoys a world-wide reputation for efficiency it is startling to note the considerable financial implications of sugar factory losses in South Africa.

What has this to do with the Chemical Control Committee?

All calculations of sugar factory losses are based on factory data for weights and analyses. It has long been realised that many of the so-called losses grouped as "undetermined" are by no means genuine. Apparent losses of sucrose are caused by errors in weighing, sampling and analysis of factory products. These fictitious sucrose losses are very much the province of chemical control.

Non-sucrose ratio* has been used as an indicator of the fate of impurities in the factory. Non-sucrose ratios vary considerably from factory to factory. This variation is important in that the ratio is an expression of molasses production. A high non-sucrose ratio reflects an excessive molasses production. Yet, despite the proven parallel between N.S.R. and molasses weighed out of the factory, doubt exists as to the validity of non-sucrose ratio for indicating performance, for the figure depends upon the accuracy of the brix determination in mixed juice and molasses, analyses which do not inspire general confidence! And so non-sucrose ratio, and its larger cousin the factory brix balance, become important aspects for the consideration of the Committee.

Calculations, summarised in the Appendix, indicate that the cost to the industry through factories losing more sucrose in molasses than the industrial average amounted to over R600,000 last season. At the same time the total cost to the industry through undetermined sucrose losses in excess of the industrial mean amounted to over R400,000. The latter figure can be considered a minimum, for the industrial average undetermined loss, 1.54%, is a figure which an industry with a reputation for efficiency should not tolerate without an explanation. If an uncontrollable undetermined loss of 1% is taken as a basis for calculation, this cost soars to over R700,000 for the season.

$$* \text{N.S.R.} = \frac{\text{Non-sucrose in Sugar and Molasses}}{\text{Non-sucrose in Mixed Juice}}$$

Matters Considered by the Committee

1. *Suspended Matter in Mixed Juice*

Suspended matter can affect the official sucrose determination in at least two different ways, namely through sampling in the factory and through the analytical techniques used. When appreciable amounts of suspended matter are present in the juice, although they are weighed in their entirety, the perforated sampling tube canted at an angle can act in a way similar to a DSM screen, selectively passing a sample richer in juice and hence in sucrose. Once having reached the laboratory, a portion of the juice is clarified and filtered, in this way removing all suspended and most colloidal matter before the two portions of juice are measured out for the Jackson and Gillis sucrose determination.

An investigation of the selectivity of the present mixed juice sampling device was undertaken by the Sugar Milling Research Institute at the request of the Committee. The findings, that the device was indeed selective against suspended matter, were accompanied by suggestions for improved sampling of mixed juice.

At the same time the Committee initiated the accumulation of data on the quantity of suspended matter in mixed juice from different factories. A method for the determination of suspended matter was devised, and this was the subject of a paper presented to the 1969 Congress of this Association[2]. The accumulated data were used as the basis for a letter sent to the South African Sugar Association containing the following recommendations:—

(1) Hourly catch samples should be taken from the mixed juice pipe leading to the weigher.
(2) Samples should be composited with mercuric chloride and analysed on a shift basis.
(3) The method of analysis using filtration[2] should be used for the determination of suspended solids in mixed juice.
(4) The sucrose per cent in mixed juice should be determined in the normal manner by J. and G. methods on the usual four-hourly sample, but the weekly sucrose percentage should be corrected for the suspended matter determined as described above.

The recommendations of the Committee were referred by the Sugar Association to the millers and growers. The discussions are still proceeding.

2. *The Use of Refractometers for Factory Control*

Following the success of the decision by Hulett's to adopt the refractometer in place of the spindle for the determination of brix in factory products from

clear juice onwards, the Committee has considered recommending the use of the refractometer throughout the industry.

A problem lies in the details of the method of analysis, particularly sample preparation. Graham and MacGillivray[1] have indicated the extent to which suspended and colloidal matter may influence refractometer readings in juices and extracts, and their work is being extended by the S.M.R.I. to include other factory products.

There is no doubt that refractometer brix gives a truer indication of the soluble solids content of a juice than spindle brix. A logical follow-up of the adoption of the refractometer from clear juice onwards would be an extension to the complete factory through changing the method of determination in mixed juice, at present defined by the Sugar Act. The Committee has suggested that parallel determinations of brix in mixed juice should be carried out by the two methods. This suggestion will be adopted by some factories in the 1970/71 season. The details of the exact method of sample preparation and analysis have recently been finalised by a subcommittee.

3. *Standardisation of Factory Methods and Reporting*

The true significance of differences between factory balances can only be appreciated if the data supplied are based on standard procedures. Standardisation of the method used for determining brix has already been mentioned. There are other measures which have been considered by the Committee.

A recommendation has been put forward that all factories should weigh final molasses. This is an essential prerequisite for industry-wide comparisons of undetected losses and non-sucrose ratios.

The weighing of syrup is a step which may well gain favour when an investigation of losses is intensified. The Committee has undertaken to "encourage" factories to weigh syrup. The current paper on weighing syrup at Empangeni may, or may not, lend weight to the encouragement!

The Committee has recently initiated, through the S.M.R.I., a survey of the methods of sampling and analysis used in all factories. From the results of this survey it will be possible to make suggestions to certain factories with the object of improving standardisation throughout the industry.

Two matters relating to reporting have been dealt with by the Committee. A recommendation has been put forward that all factories should submit data on non-sucrose ratio to the S.M.R.I. for inclusion in the weekly summary of factory returns. This step has been taken because considerable differences have been found between the seasonal average non-sucrose ratios for different factories. Taking clarified juice as starting point, the N.S.R. for factories using spindle brix varied from 0.901 to 0.996, and for factories using refractometer brix from 0.829 to 0.887. Non-sucrose ratio is in itself a statement of factory balance, but, while a ratio of nearly 100% may please the academic, in the case of non-sucrose ratio the lower the better! Calculation shows that the difference in N.S.R. between 0.996 and 0.901 is worth 68 cents per ton of sugar to the "less well balanced" factory. For refractometer factories the difference between 0.887 and 0.829 is worth 42 cents per ton of sugar. While it is not suggested that the mere reporting of these data will solve the overall problem, it will be appreciated that collection of reliable data must form the first step in any methodical scientific approach to the problem.

The second item dealing with reporting may seem less directly connected with the factory balance. This was the decision, taken after long consideration, to abandon the use of Boiling House Performance. One of the grounds on which B.H.P. was attacked was its dependence on mixed juice purity, itself influenced by the accuracy of determination of both brix and sucrose. In fact B.H.P. was intimately tied up with the accuracy of determination of factory balance.

4. *Other Matters Considered by the Committee*

The Committee decided to send a questionnaire to other sugar-producing countries, giving details of the "non-sucrose ratio" and "undetermined loss" problems, and asking for their experience. Any pertinent information from other industries could be most useful.

Projects undertaken within the industry have been fully supported by the Committee. These have included three items to be discussed during this symposium, the chloride balance, solids balance, and isotope dilution method investigations, as well as research into non-sucrose constituents of juices and molasses which influence the sucrose determination.

Discussion

Academic considerations apart, the factory balance has considerable economic significance. The economic aspect can be divided into two problems which may be conveniently labelled undetermined loss and non-sucrose ratio.

It is the intention of the Committee to act as a clearing house for data received and to suggest and initiate new lines of investigation.

Not all the collection of data can be undertaken directly by the Chemical Control Committee. Some investigations may be conducted by individual members, in particular those representing the S.M.R.I. and Hulett's Research and Development, but the basic data collection will consume far more time than can be contributed by the members of the Committee. It has therefore been proposed that a technologist be appointed on a full-time basis to collect and collate statistical data and to undertake specific investigations at the Committee's request.

It may seem that few of the measures mentioned in this report are likely to solve either of the major problems. Improvement to sucrose analysis of mixed juice or, more drastic, the adoption of the isotope dilution method, may reduce fictitious undetected losses, but real undetermined losses will continue to plague the industry, while above-average non-sucrose ratios will continue to reduce the profits of unfortunate factories.

By the application of scientific methods it should be possible, after a fair amount of reliable data

has been accumulated through the present programme, to suggest lines of attack able to yield more positive results.

The purpose of this symposium will be well served if the discussion includes ideas on lines of investigation not covered by the papers.

References

1. MacGillivray, A. W., and Graham, W. S. (1969). "Brix Determination", Proc. S. Afr. Sug. Technol. Assoc. 43, 215-218.
2. Prince, P. A. (1969). "The Determination of Suspended Solids in Mixed Juice", Proc. S. Afr. Sug. Technol. Assoc. 43, 141-142.

APPENDIX A

Calculated Loss of Revenue to the Industry

TABLE I

Calculated loss of revenue for factories not attaining industrial average (8.90%) for loss of sucrose in molasses per cent sucrose in cane, 1969/70 season.

Factory	'Extra' Loss (over 8.90%)	Tons 'extra' Sucrose Lost	Loss in Rand at R60 per ton 98.7 pol sugar
L	0.38	214	13,020
O	0.39	661	40,200
P	0.59	832	50,580
H	0.88	267	16,200
I	1.22	327	19,860
M	1.58	1259	76,500
J	1.79	2393	145,440
N	2.88	4054	246,420
	Total	10007	608,220

TABLE II

Calculated loss of revenue for factories not attaining industrial average (1.54%) for undetermined loss of sucrose per cent sucrose in cane, 1969/70 season.

Factory	'Extra' Loss (Over 1.54%)	Tons 'Extra' Sucrose Lost	Loss in Rand at R60 per ton 98.7 pol sugar
I	0.50	134	8,160
J	0.81	1083	65,840
K	0.98	395	24,020
L	1.00	563	34,250
M	1.22	972	59,060
N	2.50	3519	213,900
	Total	6666	405,230

Note: Factories H, I, J, N, operate diffusers.

TABLE III

Calculated loss of revenue for factories losing more than 1% of sucrose in cane 'undetermined'. 1969/70 season.

Factory	'Extra' loss (over 1.00%)	Tons 'Extra' Sucrose Lost	Loss in Rand at R60 per Ton 98.7 pol sugar
A	0.03	31	1,860
B	0.16	44	2,700
C	0.16	333	20,220
D	0.26	381	23,160
E	0.43	523	31,800
F	0.52	780	47,400
G	0.53	260	15,780
H	0.54	164	9,960
I	1.04	279	16,980
J	1.35	1805	109,740
K	1.52	613	37,260
L	1.54	868	52,740
M	1.76	1402	85,200
N	3.04	4279	260,100
	Total	11762	714,900

APPENDIX B

Economic Effect of Non-sucrose Ratio

The calculations have been based on 1,000,000 tons of cane, and the following assumptions:—

Sucrose % cane	13.5
Extraction %	95
Mixed Juice Purity %	85
Pol of Sugar, °S	98.7
Non-sucrose in sugar %	0.9
Boiling House Recovery %	90
Final Molasses Purity %	38

Tons sucrose in mixed juice
$= 1{,}000{,}000 \times 0.135 \times 0.95$ — 128,250

Tons brix in mixed juice
$= 128{,}250 \times \frac{100}{85}$ — 150,882

(a) Tons non-sucrose in mixed juice
$= 150{,}882 - 128{,}250$ — 22,632

Tons sucrose in sugar
$= 128{,}250 \times 0.90$ — 115,425

Tons sugar
$= 115{,}425 \times \frac{100}{98.7}$ — 116,945

(b) Tons non-sucrose in sugar
$= 116{,}945 \times 0.009$ — 1,053

(c) Non-sucrose ratio

	A	B
	0.901	0.996

(d) Tons non-sucrose recovered
$= (a \times c)$ — 20,391 — 22,541

(e) Tons non-sucrose in molasses
$= (d - b)$ — 19,338 — 21,488

Tons sucrose in molasses
$= \frac{38}{100 - 38} \times e$ — 11,852 — 13,170

The difference in sucrose lost in molasses, 1,318 tons, is equivalent to 1,335 tons of 98.7 pol sugar. At R60 per ton this amounts to R80,100, or in other words:—

R0.08 per ton cane
R0.68 per ton sugar.

By means of a similar calculation it can be shown that a non-sucrose ratio difference between 0.887 and 0.829 is worth:—

R0.05 per ton cane
R0.42 per ton sugar.

For discussion on this Paper, see page 50.