

DECOMPOSITION OF SUCROSE IN THE MILLING PROCESS

By C. VAN DER POL and J. B. ALEXANDER

Origin of Sucrose Loss

The decomposition of sucrose in the milling process can be due to two factors.

Firstly, the inversion of sucrose due to the combined effect of temperature and pH, and secondly, the destruction of sucrose by enzymes. Possible sucrose losses due to the temperature and pH effect are small under normal operating conditions and can be neglected. Sucrose-destroying enzymes are present in cane juices, the main source of these enzymes being micro-organisms which enter the mill on the cane and are also present as slimes in the milling tandem.

Owing to the lack of accurate knowledge on the quantity of sucrose entering the mill in the cane, an accurate sucrose balance cannot be drawn up over the milling process and sucrose lost by destruction can only be assessed by indirect methods. The method adopted in this investigation can be briefly outlined as follows:

The micro-organisms producing the enzymes responsible for the sucrose destruction are considered to be active in three different localities—

- (1) those adhering to the bagasse, as it moves from mill to mill;
- (2) those suspended in the juice as it flows through the tandem;
- (3) those adhering to the milling plant in the form of slimes.

A summation of the sucrose losses in each of these three localities represents the total sucrose loss.

The quantity of sucrose lost in, e.g., the juice stream in a given time T can be expressed as

$$Q = Y \times T \times W$$

where Q is the quantity of sucrose lost, Y is the deterioration rate of the juice, T is the residence time in the mill and W is the weight of juice in the mill.

If, hence, the deterioration rate of the juice due to micro-organisms in the three localities can be measured, Q can be calculated.

Determination of Deterioration Rate

The determination of the deterioration rate of a juice as it exists at the time of sampling is a complicated matter due to the increase in population of micro-organisms (and hence of enzymes) with time, which results in a continuously increasing deterioration rate. The shape of the theoretical deterioration curve is shown as the curve ab in Fig. 1, and the

deterioration rate of the juice at sampling time can be represented by the tangent drawn to the curve at time $t = 0$.

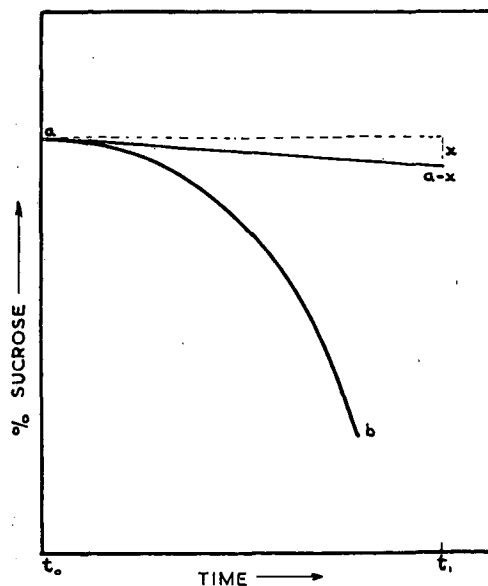


Fig. 1.

The shape of the curve and also the slope of the tangent depends on the concentration of enzymes, the rate of multiplication of organisms and the concentration of sucrose in the juices. Since these factors vary through the milling train, a determination of the absolute sucrose loss involves the analysis of a large number of samples of all the individual mill juices and intermediate bagasses. This would involve an enormous amount of analytical work for which no mill is properly equipped or staffed.

Since the purpose of this work was to find the order of the quantity of sucrose lost rather than the exact value of the sucrose loss, certain assumptions were made which enabled us to determine the *maximum* sucrose loss which could have occurred if conditions in the whole milling train had been as at the worst point.

Owing to the natural increase in the population of organisms with time it is obvious that the deterioration rate of juices at the end of the milling tandem is the highest in the tandem. (This was confirmed by experiment.) Hence if the deterioration rate as existing at that mill is applied to the whole tandem, the highest overall sucrose loss possible would be obtained.

Since the slope of the tangent to the theoretical curve, i.e. the deterioration rate at sampling time, is also a function of the sucrose concentration, the deterioration rate of last mill juice has to be corrected to the average sucrose concentration of the juice in the whole mill.

The rate of decomposition of sucrose by a constant concentration of enzymes, and hence the equation of the tangent to the deterioration curve, has the form:

$$\frac{x}{t_1 - t_0} = k.C \quad \dots \quad (1)$$

where x is the quantity of sucrose destroyed in the small time interval $t_1 - t_0$, C is the average concentration of sucrose between the times t_1 and t_0 and k is the velocity constant of the reaction which depends on the temperature, pH and concentration of enzymes, but is independent of the sucrose concentration. Rewriting the above equation in the

differential form one obtains $\frac{dx}{(a-x)} = k.dt$, which,

on integration, produces the expression

$$k = \frac{2.303}{t} \log \frac{a}{a-x} \quad \dots \quad (2)$$

where t =time interval ($t_0 - t_1$), a =concentration of sucrose at time t_0 and x =the quantity of sucrose destroyed in the time interval t .

k can hence be calculated for the last mill and can be applied to the whole milling tandem for the estimation of maximum losses.

Conditions in the Mills at the time the Tests were Conducted

The milling tandem at Umfolozi consists of a three-roller crusher followed by five mills. Sanitary conditions in the tandem at the time the tests were conducted were not worse than observed at any other factory in Natal and no special efforts were made to clean the mills or cush-cush screens by mechanical means. All the intermediate mill juices are screened prior to pumping and slimes were present on the cush-cush screens and conveyor slats.

The tests were conducted over a period of three consecutive weeks, during the first and last week of which the normal procedure of chlorination was applied. During the second week chlorination was stopped. The normal chlorination procedure at Umfolozi consists in bleeding a stream of saturated chlorine water into fourth mill juice just before the juice pump at the rate of about 2 lb. chlorine per 100 tons cane crushed.

Experimental Procedure and Results Obtained

Bagasse Loss. 400 g of final bagasse were agitated with 1,500 ml of sterilized last expressed juice. Samples of juice were periodically withdrawn and analysed for reducing sugars and sucrose by the Luff Schoorl method. Typical results obtained are as in Table I and Fig. 2.

TABLE I

Time	Red. Sugars mg/l juice	Sucrose mg/l juice	pH	Temp.
10 min.	1810	27920	5.9	27°C
65 min.	2220	28520	5.8	27°C
110 min.	2490	28280	5.7	27°C
155 min.	2800	28020	5.6	27°C

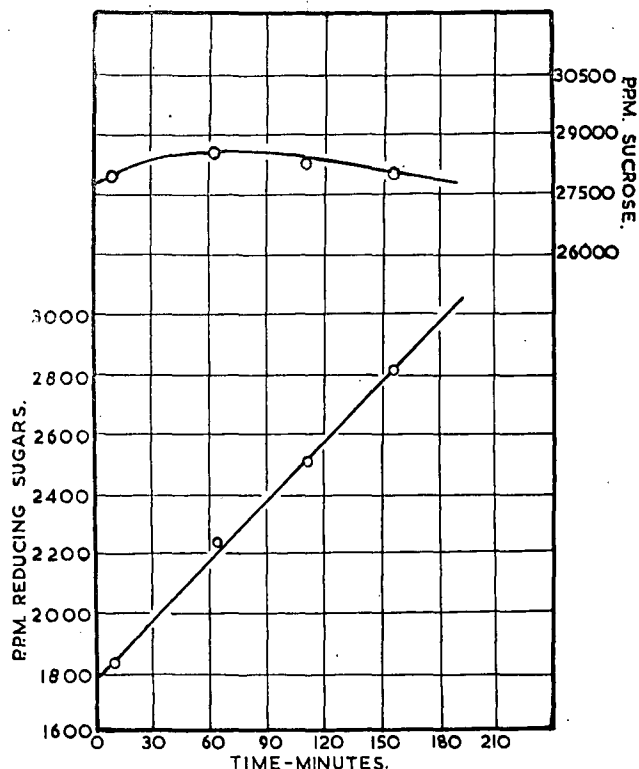


Fig. 2

The shape of the sucrose *vs.* time curve does not conform to the theoretical, due to sucrose being leached from the juice associated with the bagasse. This renders this curve useless for the determination of k . For the same reason the reducing sugars increased more rapidly than can be attributed to enzymatic decomposition of sucrose only. However, acid formation, which takes place to a slight extent (as will be mentioned later) can be assumed to compensate for the higher rate of reducing sugar formation and for the purpose of this investigation it is assumed that the quantity of reducing sugars formed is equivalent to the quantity of sucrose destroyed.

Also, since the change in sucrose concentration is small, it is preferable to use equation (1), whence

$$k = \frac{x}{t \times C}$$

$$\therefore k = \frac{400 \times 0.95}{60 \times 28000} = 2.26 \times 10^{-4}$$

Similarly the arithmetical mean of 10 determinations gave a value of $k=1.25 \times 10^{-4}$ between the limits 0.7×10^{-4} and 2.26×10^{-4} .

Applying this average value to the average mill juice associated with the bagasse, assuming the average sucrose concentration of juice in bagasse to be 50 gram per litre, the deterioration rate of the juice in the bagasse per hour = $1.25 \times 10^{-4} \times 60 \times 50000 = 375$ mg sucrose per litre juice per hour.

Since 400 g bagasse were treated with 1500 ml of sterilized juice, the deterioration rate per unit weight

$$\text{of bagasse} = \frac{375 \times 1.5 \times 1000}{400} = 1406 \text{ mg sucrose}$$

per kilogram bagasse per hour. At 50 per cent. moisture the deterioration rate per kilogram dry fibre = 2.81 gram per hour.

At Umfolozi, it required 4 minutes and 10 seconds for the bagasse to pass from No. 1 mill to the end of the tandem, at an average crushing rate of 160 tons cane per hour at 13 per cent. fibre.

Therefore on its way through the mill the weight of sucrose lost per kg dry fibre = $\frac{2.81 \times 4.1}{60} = 0.192$ g sucrose.

The fibre rate at the above crushing rate amounted to 20.8 tons per hour and hence the total quantity of sucrose lost per hour equals

$$\frac{0.192 \times 20.8}{1000} = 0.004 \text{ tons per hour}$$

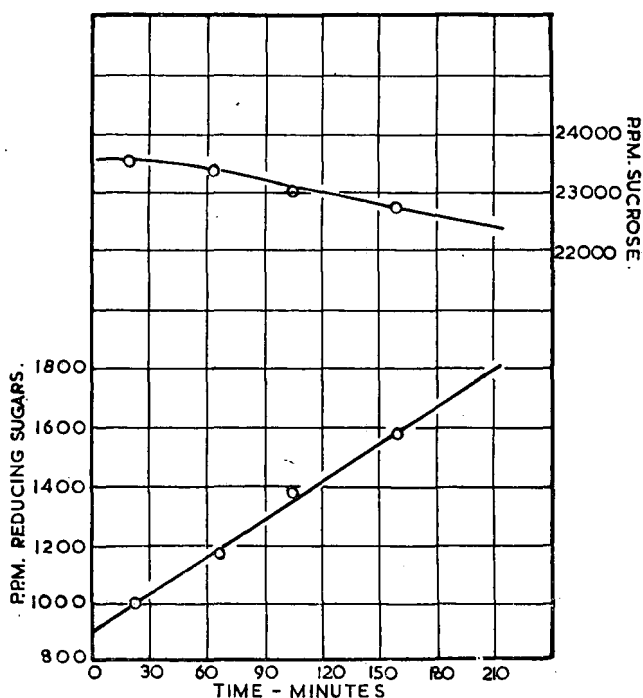


Fig. 3

Juice Loss. Samples of the various mill juices were collected, kept agitated on a magnetic stirrer and analysed for reducing sugars and sucrose at predetermined intervals.

In these tests most of the sucrose curves obtained conformed to the theoretical type mentioned. A typical curve is given in Fig. 3.

From the shape of this curve it is evident that a great deal of imagination would be required to draw a tangent to the curve at time $t = 0$.

It was found in these tests that in the initial stages of decomposition the quantity of reducing sugars formed was very nearly equivalent to the quantity of sucrose destroyed. On the average 100 minutes were required before the reducing sugars formed could account for only 80 per cent. of the sucrose destroyed, which dropped to 64 per cent. after 140 minutes. That acid formation was slow was borne out by a very small drop in pH of the juices over the first 100 minutes of deterioration. Hence for the purpose of this investigation no serious inaccuracy can result from the assumption that at time $t = 0$, the rate of sucrose destruction equals the rate of reducing sugar formation. This assumption enhances accuracy since reducing sugar concentrations can be measured with a greater degree of accuracy than sucrose.

k , as determined for last mill juice, averaged at a value of 1.92×10^{-4} between the limits 1.30×10^{-4} and 2.35×10^{-4} . This average value is higher than the average value for the other mills, i.e. 1.08×10^{-4} .

Again assuming the average sucrose content of the juices in the tandem after the first two units to be 50 g per litre the average deterioration rate of the juices amounts to 0.760 gram sucrose per litre juice per hour.

The average weight of juice in the tandem and its average residence time cannot be determined directly but the assumption that all the juice not extracted in the first two units of the tandem remains in the mill for an average time interval of 10 minutes ($2\frac{1}{2}$ times the fibre hold up time) is no under-estimation of fact. On this assumption the ratio of juice to fibre in the last 4 mills is as 7 is to 1, and the quantity of sucrose lost in the juice streams amounts to 0.0070 tons per hour.

Slime Loss. Quantities of slime were collected around the mill, weighed and mixed with known volumes of sterilized juice, stirred continuously and analysed at intervals as before.

The curves produced again conformed to the theoretical shape as is seen in the typical example in Fig. 4.

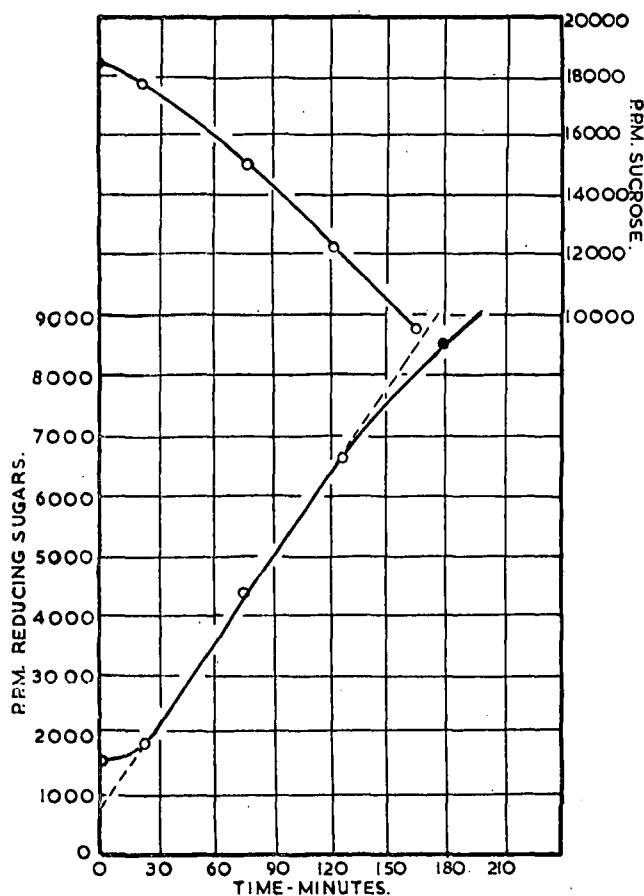


Fig. 4

The straight lines, from which the constant k was calculated, were in every case slopes to a curve at points well beyond time $t = 0$, indicating a much exaggerated rate of decomposition.

Under such circumstances the average value for k per unit weight of slime was found to be 5.08×10^{-3} between the limits 3.78×10^{-3} and 6.91×10^{-3} (using equation (2) since C can no longer be assumed constant). The lower values of k observed, corresponded to samples of slime on the cush-cush slats and the higher values to samples taken from under the cush-cush screens.

The average value of k corresponds to a destruction of 1.5 g sucrose per gram of slime per hour, for an average juice containing 50 g sucrose per litre.

The weight of slime in constant contact with the juice stream in the milling train at Umfolozi is estimated not to exceed 50 lb., whence a loss of sucrose amounting to 0.0375 ton sucrose per hour is calculated.

The total loss can now be summarized as follows:

Loss due to organisms in bagasse	0.004	ton sucrose per hour
Loss due to organisms in juice ...	0.007	ton sucrose per hour
Loss due to organisms in slime ...	0.0375	ton sucrose per hour
	0.0485	ton sucrose per hour

At a crushing rate of 160 tons cane per hour at 13 per cent. sucrose this amounts to a loss of

$$\frac{0.0485 \times 100}{20.8} = 0.23 \text{ per cent. of sucrose in cane.}$$

Discussion

There is little doubt that the actual sucrose losses which occurred at Umfolozi during the period the tests were conducted, were smaller than 0.23 per cent. on sucrose in cane. The slime loss was calculated to be proportional to the weight of slime present in the mill. In actual fact the surface area of slime exposed to the juice stream determines the sucrose losses and not the weight of slime.

The assumption that conditions in the last mill can be applied to the whole tandem also tends to yield an exaggerated estimation of the loss, as does the exaggerated slopes to the curves from which the values of k were calculated.

From the results obtained it is concluded that the main possible source of sucrose destruction is that due to slimes with which the juices come in contact. This conclusion is supported by numerous other investigators who are almost unanimous in reporting that the removal of slimes and stale bagasse from the mill, resulted in a diminishing of phenomena usually associated with deterioration losses.

The results obtained also indicated that the method of chlorination as applied at Umfolozi is not effective. No tendency towards higher sucrose losses was observed during the week chlorination was stopped. This is not really surprising since the method of chlorination cannot be effective in reducing the concentration of slimes in the mill. In a recent report on chlorination as applied in the Beet Sugar Industry¹ and in other literature published by the manufacturers of chlorine-containing disinfectants^{2,3} the necessity of mechanical cleaning in conjunction with chlorination is pointed out very clearly. Chlorination should also be directed at localities where regular mechanical cleaning is not possible, to prevent the formation of slime deposits. Adding chlorine or chlorine-containing disinfectants directly to the juice stream cannot be effective, since organic matter in the juice reacts with the chlorine and renders it inactive before it has a chance to do any effective sterilization of the path along which the juice flows.

Although we can as yet not produce any experimental evidence to support our statement, it is our opinion that the scrubbing brush and a high pressure steam jet applied regularly at the most effective points in the milling tandem will be more economical and as efficient in curbing sucrose losses in the milling process as is the application of chlorine in

any form. Chlorination can never be a substitute for cleanliness.

It is hoped to confirm the results obtained at Umfolozi at some other mill in the near future and also to carry out some work on the effectiveness of mechanical cleaning in preventing sucrose losses during the milling process.

Acknowledgments

The authors wish to express their grateful appreciation to the Manager and Staff of the Umfolozi Factory for provision of laboratory and other facilities.

REFERENCES

¹ Ueber die Vorgänge bei der Chlorung des Rücknahmewassers, Dr. H. David, *Zeitschrift für die Zuckerindustrie*, October 1954, pp. 438-440.

² Wyandotte Chemicals Corporation, Pamphlet on Chlorination in the Cane Sugar Industry (No. 16).

³ Food and Chlorination, E. A. Whitlock, *Food*, 1953, **XXII**, p. 259.

Mr. du Toit (Chairman) said that this would naturally be a rather controversial subject, particularly after Mr. Antonowitz' paper last year which indicated severe losses in the milling train and the results of combating these losses by the use of chlorine. It was very difficult to measure, and indeed is not usually attempted, to measure losses which result during the interval from the time the cane entered the crusher to when the juice was weighed. One method of estimating this loss was to sample cane and compare it with the milling results. A second method was to measure the Java Ratio as Mr. Antonowitz had shown us last year. This paper indicated a third method. The first method mentioned by him was dependent upon the difficulty of obtaining an adequate sample. The second method depended upon the Java Ratio which was affected by other factors. In this third method the endeavour was made to measure the maximum amount of sucrose which might be destroyed. They arrived at a figure of only 0.23 per cent. of the sucrose, which was very low as compared with determinations carried out elsewhere by the first two methods. It was necessary in this method to assume many things which could not be measured and it was necessary to take these micro-organisms out of their environment so that they could be dealt with in glass flasks in the laboratory. These are decided disadvantages. The biggest factor in deterioration was found by the authors to be the slime, but as pointed out by the authors, it was not the amount, but rather the area, of slime exposed to the juice. According to the

authors a certain amount of slime was added to juice, but could the authors be sure that an area of slime was exposed in this case which would compare with the actual milling process?

Mr. Antonowitz mentioned that it was not possible to measure the activity of organisms by measuring the action of the enzymes. In this paper the estimation of the decomposition of sucrose in the milling train was based upon the assumption that the measurement of enzymatic activity was proportional to the metabolic activity of the micro-organisms secreting the enzyme. He referred to his paper on fermentation in the milling train, read to this Congress last year, in which he shewed that conclusions drawn from the deterioration rate of heavily contaminated juices placed in buckets could be most misleading. The activity, density and heterogeneity of a mixed microbial population was conditioned by its environment. When the environment was changed the various characteristics of this population changed also. The only circumstances under which he felt a measure of enzymatic activity would give an estimate of sucrose destruction in juices were those applying to juices entering the subsidiers.

Referring to "Alcoholic Fermentation," by Arthur Harden, 1932, page 30, he noted that the activity of live yeast was forty times greater than that of its principal enzyme, zymase. This applied of course to a specific yeast and a specific enzyme. When it was appreciated that the fibre of the cane carried most of the naturally-occurring enzymes present, it was obvious that the destruction of sucrose by micro-organisms was much more rapid in the presence of bagasse. A relative observation in this connection was that in the brewing of beer great care was taken in the malting of barley to secure the maximum amount of diastase so that subsequent fermentation, after inoculation with yeasts, would proceed at optimum rate. Thus a high concentration of enzymes would stimulate the metabolic activity of the micro-organisms, the function of the enzyme being simply inversion, while that of the micro-organism was principally functional metabolism.

In the experimental procedure outlined in the paper under discussion, the principal factor was the deterioration per unit of time. All contentions made by the authors hinged upon this factor, so that if it were unreliable, all conclusions drawn would be worthless. He had already pointed out that this deterioration factor could apply specifically to the activity of the enzyme in the sample of juice in the container in which it was placed. Measurement of enzymatic activity in an environment wherein the activity of the micro-organisms which secreted it was suppressed, could have no relation to the activity which the enzyme could display when

operating within or in conjunction with the live organism. Microbial populations in all their ramifications maintain a dynamic equilibrium with the environments in which they occurred.

One reason for his writing his own paper was to draw attention to an aspect of microbial activity which was not readily apparent unless one had practical and comprehensive knowledge of continuous fermentation processes. It was not readily appreciated that an enormous consumption of nutrients and multiplication of microbial populations could take place in an environment favourable to a variegated microflora, such as would be the case under certain favourable conditions in a continuous fermentation process—and conditions in a milling train using compound imbibition paralleled to a remarkable degree the environmental characteristics of such a process.

Dr. van der Pol said that Mr. du Toit had correctly pointed out that the nature of the experiment forced them to make certain assumptions. That being so they had endeavoured to make that type of assumption which would throw light on the maximum deterioration which could possibly have occurred at the time of the investigation. That was why the last mill juices and bagasses were studied. The assumption that the total weight of slimes in the milling train amounted to 50 lb. was perhaps open to question. However, the weight of slime was unimportant, since it was the area of slime exposed to the juice stream which was the deciding factor.

The objection raised by Mr. du Toit and Mr. Antonowitz, on the grounds that the environment of the organisms was changed in the studies were, in his opinion, unfounded. The physical and chemical conditions of the juices in contact with the organisms in the laboratory were identical to the mill juices and he did not think that the container could have a major effect. He agreed that sucrose concentration was an important factor, but since it was an established fact that organisms were most active in dilute solutions, the use of last mill juice could only have had a positive effect on the results obtained.

He said that he thought that Mr. Antonowitz spoke as though the experiments had determined the activity of the enzymes in the juices and not the activity of the micro-organisms. He explained that the activity of organisms was solely due to the enzymes which were secreted by the organisms or which were contained within the cells of the organisms. He mentioned that a similar type of experiment had been carried out in Java many years ago, in which the organisms were killed by preservatives, which did not effect the enzymes. He had considered working along the same lines, but after contacting the Council for Scientific and Industrial Research,

some serious objections to this method were brought forward and so he preferred to study the effect of the organisms themselves and not the effect of their enzymes separately, as Mr. Antonowitz seemed to think was the case.

As far as the time factor was considered, he said the the only time interval to be considered was the time the juices and the bagasses spent in the mill.

Mr. Antonowitz observed that inversion of sucrose by enzymes could occur whether antiseptics were present in the juice or not, for enzymes were preserved by antiseptics; and hence when determining the rate of enzymatic activity in juices, the presence or absence of chlorine was irrelevant. He considered it pointless to try to estimate the effectiveness of chlorine by estimating the activity of the enzymes when chlorine was applied to the milling train, and then comparing this activity when it was not applied. It seemed to him that the statement made in the paper to the effect that no tendency towards higher sucrose losses was observed during the week chlorination was stopped would have been more precise if the words "enzymatic activity" were substituted for "sucrose losses."

Dr. van der Pol agreed with Mr. Antonowitz on the unimportant effect of chlorine on enzymes and saw in that an objection to the addition of chlorine to mill juices.

Mr. Antonowitz, to illustrate the chlorination (although applied in an unsatisfactory manner) did have some effect on reducing sucrose loss, submitted the following table:

	1954			1955		
	S.M.R.I. Test Period					
Week ending ...	22/11	28/11	5/12	10/1	17/1	24/1
Pounds Cl ₂ used	450	±150	450	450	Nil	±300
Java Ratio ...	80.96	78.64	79.62	80.61	78.47	79.53
Fibre percent. cane ...	12.96	13.21	13.27	13.31	13.80	13.15
Java Ratio	93.01	90.61	91.81	92.99	91.03	91.57
Abs. Ju. % cane						
Purity crusher juice ...	86.06	86.74	86.55	86.16	86.61	84.79
Purity mixed juice ...	84.44	84.42	84.15	83.48	83.74	82.59
Purity drop ...	1.62	2.32	2.40	2.68	2.87	2.20
Sucrose percent. bag. (calculated on absolute juice lost percent bagasse) ...	2.91	3.13	3.00	3.34	3.36	3.30
Sucrose percent. bag by analysis ...	2.72	2.78	2.73	2.87	2.81	2.83
Difference ...	0.19	0.35	0.27	0.47	0.55	0.47
Percentage under-estimated	6.53	11.18	9.00	14.07	16.37	14.24

He then stated that it would be noted from the table that the Java ratio decreased materially when no chlorine was used, and on calculating the absolute juice sucrose ratio (Java ratio divided by 100 — fibre per cent. cane), to eliminate the influence of fibre on Java ratio, a very marked difference in favour of the use of chlorine was apparent. It was also to be noted that the theoretical sucrose per cent. bagasse, calculated as indicated by the method of S. G. Smart (I.S.J., Dec., 1954), shewed a larger quantity of sucrose was lost in bagasse when no chlorine was used.

Mr. Christianson reminded the authors that it was stated at the last annual congress that to check on the value or otherwise of chlorine, a large number of tests would have to be done and these properly examined by statistical method, before any conclusion could be arrived at. He pointed out also that there was a serious discrepancy between the sucrose loss estimated by the authors and that found by Mr. Antonowitz when comparing the use of chlorine as against no chlorine and also the loss found at Gledhow in 1935. Mr. Antonowitz last year showed a loss of ten times as much as that recorded in the paper, while at Gledhow, where some 700-800 cane samples were tested against four week's crushing by the mill, the loss shown was twenty times as much. This was a very serious discrepancy, indeed, there was something wrong somewhere and he asked Dr. van der Pol, when he tested out the effect of manual cleaning of a milling plant, to attack it from the practical angle and not try to simulate milling conditions.

Dr. van der Pol, in reply to Mr. Antonowitz, said that as far as the drop in Java ratio was concerned, he thought that this was just a coincidence. He then read a letter previously sent to the Umfolozi Sugar Planters Ltd., in which he had pointed out that sudden drops in Java ratio, even with the application of chlorine, were by no means uncommon. Such drops were never associated with an increase in the purity drop between first expressed and last expressed juice, which would surely have been the case if 6 per cent. of the sucrose in bagasse after the first mill had been destroyed during the milling process. He then said that another paper had been mentioned, one published in the I.S.J. This paper contained, as a fundamental argument, the assumption that brix extraction was equal to sucrose extraction. This was a serious error and any conclusions based on such an assumption must be erroneous. If the application of chlorine, as done at Umfolozi, prevented a fall in the Java ratio of two units, then some out-of-the-ordinary rise in Java ratio should result when chlorination was applied correctly. He quoted from the Swedish Journal, *Sucker*, on experience in the beet sugar

industry with the application of chlorine to the diffusion battery, where it was found that the primary aid to all disinfection was mechanical cleaning.

Mr. Christianson said that there were several factors which affected the Java Ratio. As shewn by himself in 1952, the pressure at the crusher was not one of these. One important factor was fibre. A shredder in front of the crusher might be another, but the two most important were fibre percentage of cane and the deterioration of sucrose in the milling train.

Mr. du Toit said that Mr. Antonowitz had attempted to eliminate the effect of fibre by calculating the absolute juice sucrose ratio.

Mr. Antonowitz said that he could not see that after two years' experiment and finding that the Java Ratio was always lower when chlorine was not used, as compared with the comparable period when it was used, that this could be due to coincidence alone.

Mr. du Toit said that this paper was a new method of approach to the problem and it should be considered at its face value. He felt that the loss of 0.23 per cent. of sucrose on cane was very small, and furthermore that the conclusion made that no difference was apparent whether chlorine was used or not was open to question. As the mill was not particularly clean and chlorine had no effect, it would look as though cleaning of the milling plant was unimportant, which was contrary to general experience.

Dr. Douwes Dekker averred that it was not possible to measure the Java Ratio correctly over a period of one day.

Mr. Antonowitz replied that increase in Java Ratio when chlorine was used, was something that happened not only over one day, but it happened time and time again.

Mr. Rault said that the variations between daily Java Ratios were known to exist, but if these variations were continually one-sided under certain experimental conditions, one had to accept the fact that those conditions were the cause of the variation.

Dr. McMartin said that the Experiment Station, many years ago, realised that they should try out various disinfectants to prevent rotting of setts and a number were tried. One of the groups discarded first were those which contained chlorine in any shape at all. He was therefore not surprised that chlorine was of no value in disinfecting cane juices.

Mr. Phipson said he had found that it was possible to prevent the growth of slime by sprinkling chloride of lime on mill bed-plates and the like, or using it in

the form of a 1 per cent. solution of chloride of lime, particularly on the cush-cush chain slats and the plates underneath. He preferred to use mechanical means as far as possible, using hot water rather than steam, and a scrubbing brush and thereafter using chlorine in the form of chloride of lime.

Mr. Bax had tried using hypochlorite of lime in conjunction with hot water every three hours. He had found no improvement from the use of chlorine. On the other hand he noted that in Hawaii and in Cuba, however, there had been different results. The purity drop between crusher and mixed juice had been reduced to 0.3 degrees with the use of chlorine in those countries.

Dr. Douwes Dekker said there were two problems to be kept separate. Firstly, was there any appreciable deterioration and furthermore, what could be done to stop it? He agreed with the general opinion that there was deterioration in the milling train, although there was controversy about the extent of it. Secondly we have to be very careful in the application of chlorine. It is better to keep our mills clean and to rely on that, rather than on the application of chlorine.

Mr. Main said that chlorination of the milling train was tried many years ago in India, and the use of chlorine in large quantities had to be discarded, because of complaints from sweet manufacturers and also from users of molasses. He could not agree with Mr. Phipson that chloride of lime was at all effective in the milling train.

Dr. Douwes Dekker pointed out one disadvantage of chlorine, which was the corrosion factor.

Mr. Phipson replied to Mr. Main and said that by sprinkling chloride of lime, and thus getting a high concentration, the breeding of micro-organisms could be prevented completely.

Mr. Hayes said that it would appear that people did not realise the magnitude of the problem, for all kinds of bacteria are involved. To ensure that one had a sterile, clean surface and to make sure that a clean surface could be kept sterile, it was necessary to change the form of disinfection from time to time. This was a very complicated problem and he thought that to use chlorine by itself in the juice was probably useless and liable to cause trouble in other directions.