

THE CHEMICAL COMPOSITION OF SUCROSE FREE BAGASSE

By E. P. HEDLEY, Ph.D., M.I.Chem.E., and F. W. HAYES.

In 1907 C. A. Browne and R. E. Blouin published Bulletin 91 of the Louisiana Experiment Station which bore the title "The Chemistry of the Sugar Cane and its Products in Louisiana." In this bulletin there is recorded an analysis of the incrustating matter, which in cane fibre accompanies the cellulose, and reads as follows:—

	Per Cent.
Cellulose (including oxycellulose)	55
Xylan	20
Araban	4
Lignin	15
Acetic acid	6
	—
	100
	—

These results are calculated on 100 parts of cane-fibre, and have been published by H. C. Prinsen Geerlings in "Cane Sugar and its Manufacture," by Noël Deerr in "Cane Sugar" and by G. L. Spencer in his "Cane Sugar Handbook." The analysis referred to was published twenty-eight years ago, and as a search in the literature available recorded only one later analysis it was decided to undertake the work recorded herein. The Fibre Committee and the Boiler Committee of our Association both wanted to know the composition of the varieties of cane with which they will have to deal in the near future.

Hachiro Kumagawa and Kenkici Shirnomura¹ published an average analysis of bagasse comparing it with rice straw as follows:—

	Bagasse (entire)	Bagasse Fibre	Bagasse Marc	Rice Straw
Ash	2.40	1.30	3.02	14.55
Silica	2.00	0.46	2.42	12.10
Fat and Wax	3.45	2.25	3.55	3.65
Lignin	19.95	19.15	22.30	14.84
Pentosans	24.50	26.11	29.20	20.06
Cellulose	46.60	56.60	55.40	45.42

"Bagasse fibre" refers to long bast fibres and the "Bagasse Marc" refers to the short parenchyma cells.

The names of the canes from which the bagasse was derived are unfortunately not given, that in Browne and Blouin's analysis² is Louisiana Purple (Dark Preanger).

The canes used for our work were shredded without being crushed first, and the sucrose in the resulting material was then extracted by cold water until it gave a negative molybdate test. The

resulting material was dried at 95-100° C. and finally powdered in a laboratory grinding mill.

The following series of tests was then made, in the main following the scheme of analysis laid out by Schorger³.

	P.O.J. 2878.	P.O.J. 2725.	Co. 290.	Co. 281.	Uba.
Ether extract	1.34	1.80	0.96	0.64	0.62
Alcohol extract	3.78	4.14	3.11	3.90	3.52
Hot water extract	4.71	4.35	3.09	3.70	2.20
Cellulose (Pentosan free)	45.34	41.74	41.66	43.00	44.61
Total pentosans	24.12	25.36	24.87	26.90	26.60
Lignin (ash free)	22.08	21.99	20.23	21.00	22.05
Protein	1.08	1.75	1.14	0.74	1.20
Acetic acid	3.22	4.49	4.67	3.71	4.25
Total ash	1.64	2.67	1.89	1.87	1.81

ETHER AND ALCOHOL EXTRACTS.

About 4 grams of the powdered bagasse were extracted for six hours with ether, and after driving off the ether the bagasse was submitted to the action of alcohol for a further eight hours in the Soxhlet extractor.

HOT WATER SOLUBLE.

The water extract was made by gently boiling the bagasse for three hours, and it will be noted that the amount extracted under these conditions is quite considerable. This estimation is quite a usual one in the examination of woods, and we draw attention to it for that reason. It will be remembered that the nature of the extract was the subject of a communication to this Association last year⁴. Farnell⁵ submitted bagasse to the action of water at 90° C. for half an hour and 1.66% of the fibre was extracted. But after 12 minutes in an autoclave at 120° C. 2.78% of the fibre was extracted. Of this 2.78% he found that 17.9% consisted of pentosan, and it is from this that the xylose which we reported last year is derived.

PROTEIN.

This is just an ordinary Kjeldahl estimation, the nitrogen being returned as protein.

ACETIC ACID.

The acetyl groups in the lignocellulose are estimated by treatment of the powdered material with 2.5% sulphuric acid for three hours, and subsequently distilled off in vacuum by Schorger's method⁶. It will be noticed that we get considerably less acetic acid than Browne and Blouin.

CELLULOSE.

The cellulose was determined by chlorination using Sieber & Walter's⁷ modification of the Cross & Bevan procedure. After obtaining the crude cellulose the pentosans retained by the cellulose were determined by the usual method, and thus the figure for "pentosan free cellulose" obtained.

In Hawaii, J. N. S. Williams⁸ made an analysis of P.O.J.2878 in which he stated that he had obtained 54.81% crude cellulose per cent bagasse. This cellulose he said contained no pentosan, whereas we found that our P.O.J.2878 contained 10.86 per cent pentosan after chlorination. It is difficult to understand why we differ in our results, our figure (56.2%) for crude cellulose being practically the same as his.

PENTOSANS.

The pentosans were determined by using Krober & Tollen's method.

LIGNIN.

The lignin was not estimated by difference from 100 per cent, but by the following method⁹, which is given in full because of the many recorded variations. The bagasse was extracted for six hours with alcohol-benzene mixture (32 parts of alcohol to 68 parts of benzene), then filtered by suction, washed well with hot water and dried at 100-105° C. The residue, when dry, was placed in a 100 ml. beaker and 30 ml. of 72 per cent sulphuric acid were added, and the fibre allowed to stand with frequent stirring for 18 hours in a desiccator. When freed from cellulose, the reaction mass was transferred to a 1½ litre beaker and diluted to 1,200 ml. and boiled gently for two hours, maintaining the volume by small additions of hot water. After the contents of the beaker had cooled and settled, the clear supernatant liquid was syphoned off and the lignin filtered in an alundum crucible, washed to neutrality, dried and weighed. The lignin was then ashed, and the ash deducted from the gross weight of the lignin. While it is admitted that lignin is the *bête noir* of fibre chemistry, because a perfectly satisfactory quantitative method for the isolation of unchanged lignin does not exist, it is felt that it is preferable to make the determination by this well-known method, rather than throw upon the lignin figure all the errors involved in the other estimations as in subtracting their sum from 100 to obtain "Lignin by difference."

The question of the lignin content had another aspect in our investigation, and in this direction all those who have to deal with the milling of Uba cane in South Africa call it a "hard" cane, especially in contradistinction to the P.O.J. canes; and it is regarded as such because its average fibre lies between 15 and 16 per cent, whereas the latter has an average fibre content of about 11 to 13 per cent. F. Maxwell¹⁰ cites another example when referring

to 247 B. as a hard cane of about 15 per cent fibre and P.O.J.100 as a soft cane of 10 to 12 per cent fibre.

What is the factor which makes for "hardness?" The usual reply is that the higher the fibre the harder the cane. If the fibre content of the cane influences its hardness, it becomes necessary to know what is meant by the term fibre; so that having defined it chemically it should be possible to determine it quantitatively by chemical means.

Noël Deerr¹¹ defines fibre as that portion of the cane which is insoluble in water, and the International Society of Sugar Cane Technologists as the "dry, water-insoluble matter in the cane."

The sugar chemist calculates this fibre in the cane from the dry substance and soluble solids in bagasse, which latter figure involves the sucrose per cent bagasse, which in turn is obtained from the boiling of bagasse with alkaline water. The figures for "water soluble extract" which we publish in this paper, and those given by H. C. Prinsen Geerlings¹² under the heading of "Solubility of Constituents of Cane Fibre in Water," show that Deerr's definition or that of the International Committee on Uniformity in Reporting Factory Data are not sufficiently precise for our purpose.

The question is partly a botanical one so perhaps the botanist can help. It will be found that under the term fibre botanists understand the lignified tissue of the plant. Two quotations will suffice, Haberlandt¹³ says "Fully developed fibrous tissues consist of nothing but a frame work of dead cell walls which are no longer capable of growth."

In discussing these dead cells Strasburger¹⁴ writes "Sclerenchyma cells are the typical mechanical tissue of fully grown parts of the plant which when mature are as a rule dead cells with strongly thickened walls consisting of lamellae of carbohydrate material which is lignified."

It would be expected also that the lignin content should be greater in the hard canes than in the soft canes. The results we publish do not support this view.

Schorger¹⁵ discusses this problem in relation to the hardness of woods. "Fremy & Urbain were of the opinion that a hard wood contained more lignin than a soft wood. . . . It is now known that there is no relation between the hardness or specific gravity and the lignin content." Apart from lignin he says¹⁵ "Griffin concluded that there was no relation between the specific gravity and the cellulose yield."

It is also stated¹⁵, "that a wood having a high lignin content, need not necessarily have high

mechanical properties as is shown by the following table:—

	Lignin %	Sp. Gr.	Modulus of rupture lbs. per sq. in.	Modulus of elasticity lbs. per sq. in.	Hardness Oak=100
Bald Cypress ...	33.9	0.45	7,110	1,378	34
Yellow Poplar ..	23.2	0.37	5,570	1,207	32
Yellow Birch	26.3	0.55	8,810	1,490	70

“In general the best criterion for strength is specific gravity.”

The consideration of all these points leads to the following conclusions:—(1) That the determination of “fibre” by chemical means is impossible because “fibre” is not a definite compound. Any determination of so-called fibre for commercial routine analysis must therefore be of a conventional or arbitrary character, and will not necessarily be a true reflection of the hardness of the cane. Fibre and hardness are concomitant but not causal phenomena. (2) That since hardness cannot be shown to be a function of any chemical constituent or combinations of constituents of the cane, chemical means will be inadequate to define hard canes.

- 1 Zei. f. Ang. Chem. 1923, 36, 414-418.
- 2 La. Exp. Bull. No. 91.
- 3 A. W. Schorger. “The Chemistry of Cellulose and Wood.”
- 4 Proc. S.A.S.T.A., 1934, 4.
- 5 I. S. J., 1923, 634.
- 6 A. W. Schorger, J. Ind. Eng. Chem. 9 (1917), 559.
- 7 R. Sieber & L. E. Water, Papier-Fabr. 11 (1913), 1179.
- 8 Reports of the Assoc. of Hawaiian Sug. Tech., 1934, 162 c.
- 9 Schorger, loc. cit. p. 524.
- 10 F. Maxwell. “Economic Aspects of Cane Sugar Production.” p. 47.
- 11 Noël Deerr. “Cane Sugar,” 1921, p. 15.
- 12 H. C. Prinsen Geerlings. “Cane Sugar and its Manufacture,” pp. 51-52.
- 13 G. Haberlandt. “Physiological Plant Anatomy.”
- 14 E. Strasburger. “Text-Book of Botany.”
- 15 Schorger, loc. cit., pp. 27, 39, 9.

Experiment Station,
South African Sugar Association,
Mount Edgecombe,
Natal.
March, 1935.

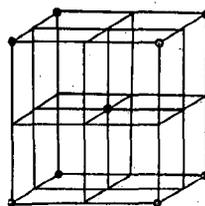
Mr. DYMOND: Could Dr. Hedley give us an indication of the length of time he employed in his cold water extraction and whether the resulting

hot water extract showed any dextro-rotation or not. Further, were the samples of cane representative of various ages of growth and various degrees of maturity, and thirdly will Dr. Hedley give us his definition of hardness of cane.

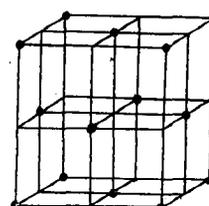
Dr. HEDLEY: The length of time of the extraction varied with the attention given to it. The bagasse was shredded in the shredder at the Experiment Station into a very fine fibrous mass which was then put into a “billy can” and given a rapid wash with water, squeezed in the hands, and then another rapid wash, and for the first hour or two a great deal of sucrose is extracted. It was then left to stand and took 48 hours to be completely freed from sucrose. The hot water extractions were dealt with last year in the paper “Dextro-rotary Substance in Bagasse.” Dextro-rotary substance in the material prepared in that way is extracted and definitely is xylose.

The canes referred to in this paper were all about 20 months of age but we purposely did not state that because we propose, if it is possible, to extend this work to taking canes at different ages and seeing how they vary. That has already been done to a certain extent by Prinsen Geerlings in the book we referred to; he gives tables showing the lignin content increases as the months go on, and we propose to try something on that line with our canes.

To measure hardness or to define the nature of hardness is by no means a simple matter. Three of the properties of matter which are used to determine hardness are (1) resistance to permanent deformation, (2) resistance to abrasion, and (3) resilience. These three properties are possessed by rubber and yet rubber is not a hard substance, so these properties are only an effect of hardness. Again, different conditions produce hardness. A sheet of paper rotating rapidly when struck will ring like a sheet of glass; and a column of water issuing from an orifice under great pressure cannot be cut by a knife. Hardness then is the cohesive strength of a material which the Faraday Society in 1928 discussed and issued a report 127 pages in length. X-rays have been greatly used to study the orientation of atoms in metals, crystals, etc., and since 1928, of organic compounds, and it has been shown that, for instance, in the case of iron, the change from the body-centred cube lattice to the face-centred cube lattice is associated with an increase in hardness. For those unfamiliar with these expressions, the lattices are shown below.



Body Centred.

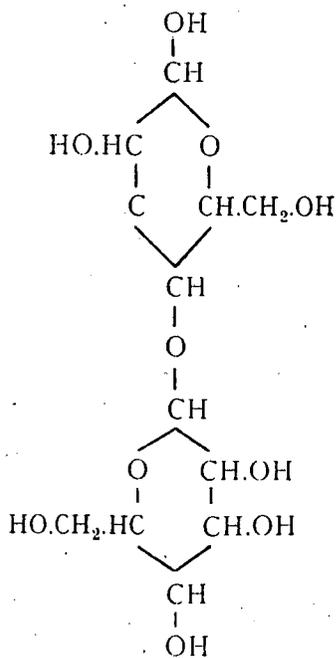


Face Centred.

In the theoretical treatment of hardness much use has been made of the application of Van der Waal's equation to solids. Traube has shown that the internal pressure $\frac{a}{v^2}$ is a measure of hardness. T. W. Richards, of Harvard, also did much work on the mathematics of cohesion which his colleagues extended and showed that by using Richard's equations a definite correlation between hardness and chemical affinity can be established.

Bearing all these statements in mind, consider their application to the case of cane.

It was discovered long ago that cellulose fibres showed a strong double refraction which clearly indicated crystalline anisotropy. Several reasons were advanced to account for this behaviour, and Katz, in 1917, stated that the double refraction of cellulose is most simply explained on the assumption that the fibres are built up of micellae or minute crystals, and there the matter remained until examinations were made of organic compounds by means of X-rays. Only crystalline substances diffract X-rays and it was proved that cellulose molecules, in common with those of many other organic compounds, exist as long carbon chains. Cellulose may be looked on as derived from the dehydration and polymerisation of β -glucose. A ring structure is thus obtained, and two glucose residues, one of which is turned through 180° relatively to the other, form cellobiose. This is



Cellobiose.

regarded as the real unit from which the cellulose chain is built up. Information as to the length of this chain has been obtained in several ways; using chemical or physical methods and the agreement between the various determinations is fair. X-ray methods afford a more accurate means of

measuring the size of the micelle (cellobiose). Its length and width are known in Angstrom units with very considerable accuracy. Such micells linked together into chains form the cellulose molecule, and such main-valence chains are held to one another through associative or cohesive forces. In ramie fibre, for example, the cellulose chains are parallel with the axis of the fibre, but in cotton they have a spiral structure, and in cellophane they occupy no special arrangement other than a definite angle with the film surface. Thus the strength of a fibre is due to the orientation of the micells and cross links giving a tightly felted mass. So that the remarkable tensile properties of natural fibres, e.g., our sugar canes, their elastic and non-elastic behaviour are all accounted for on this conception of their structure.

Mr. F. W. HAYES: There is another aspect to this, and Mr. Dymond really answered the question himself. He asked the question, "What is hard cane." That is a definition. A hard cane is a cane which resists a crushing action. Find a measure of its resistance to the crushing action and you have an indication of hardness. Whether it is a function of the lignin or the formation of the cellulose molecules themselves, is not a definition of hardness, although it may lead us to a thorough understanding as to why a cane is hard. But the definition of a hard cane is simply—"a hard cane."

Mr. LINTNER: I have been most interested in Dr. Hedley's paper which deals intrinsically with a subject of very wide interest and which is of great significance to those interested in the industrial extraction of sugar from different varieties of cane possessing differences in crystallite or micellæ arrangement of the fibre. I have often had the pleasure of discussing the problems of the fibre structure with Dr. Hedley, and the work which he had on hand during the preparation of this paper and at one time I referred to the Encyclopædia Britannica for a definition of a fibre which, with your permission, I should like to quote.

"The common characteristics of the various forms of matter comprised in the widely diversified groups of textile fibres are those of colloids. Colloidal matter is intrinsically devoid of structure, and in the mass may be regarded as homogeneous; whereas crystalline matter in its proximate forms assumes definite and specific shapes which express a complex of internal stresses. The properties of matter which condition its adaptation to structural function, first as a constituent of a living individual, and afterwards as a textile fibre, are homogeneous continuity of substance, with a high degree of interior cohesion, and associated with an irreducible minimum of elasticity or extensibility."

Thus you will see that this quotation confirms what Dr. Hedley has just told us.

Mr. MOBERLY: I was very interested in Dr. Hedley's exposition of hardness. His remarks

about hardness, and the fact that fibre content and lignin content do not go parallel with hardness, might seem at first to throw all our attempts at establishing fibre into the waste paper basket. But I am not entirely sure about that, because although we speak of hard canes and soft canes, it is not entirely hardness that we are really interested in; that is only one factor. What the Chemist or the Engineer and the Sugar Mill Manager generally is interested in is the degree to which certain canes will yield to crushing processes, and we have been in the habit in the past of associating that with fibre content and calling it hardness. Well, we are still interested in the degree to which sugar can be extracted, and the amount that can be extracted, and the ease with which it can be extracted. I do not think the ease with which it can be extracted is entirely a matter of rupturing it. If it is merely a matter of the difficulty of crushing and breaking up the cells then the ultimate analysis would be necessary to find the exact formation in which the cellulose chains are lying, but I think that it also depends on certain other factors. You break up a cell but the juice does not immediately flow away after you have broken it, and there is a great deal of difficulty in getting the juice away from the broken cells. I believe that is due very largely to adsorption at the surface of local cells; and the superficial area of the actual cellulose material will be one factor which will affect the degree of extraction. That is one thing I have in mind and mentioned to Dr. Hedley. Now cotton seed can be crushed fairly easy and broken up, but it is very difficult to extract any of the oil from it because the broken mass retains the oil which has come out of the cells and does not let it get away, and other methods have to be resorted to. So that actual hardness or resistance to oppressive stress is not the only thing you have to consider. If we are interested in the ease of extraction, apparently we have to find out two things about the cane. We have to find out its resistance to oppressive or other stress, and the degree of adsorption in the broken up cells; which is almost an impossible thing to do, so all we can hope for is to find out some other factors which have a more or less parallel value. I think that in the fibre determination by the means we have considered up to now we have something which, whilst admittedly not the whole key to the situation, gives values that are sufficiently parallel to what we are trying to get at, for them to be of some value in assessing the hardness of the cane. Some of the work done by Mr. Dymond shows a correspondence between fibre per cent cane determined by the methods used and millability, and millability is after all the real thing that matters. The important thing to know is how easily one can get the juice out of the cane. Although Dr. Hedley has shown in his paper that on the face of it we may be on the wrong lines in trying to determine fibre per cent cane, I still feel that the determination is one which should be continued, because it is one which I believe is practical

in ordinary working. And whereas the full determination necessary would not be possible in ordinary use, I think one obtains results sufficiently close to the information we are after to make it worth while.

Mr. RAULT: I should like to say a few words to second what Mr. Moberly has said in congratulating Dr. Hedley and Mr. Hayes on this paper, which is the result of very valuable research work. Such papers give standing to the proceedings of our Congress and although they may not be immediately of use, in the near future we will find they have given us valuable information. Now I wish to put a question to Dr. Hedley. In the hot water extract he shows for the P.O.J. and soft new varieties practically double the figure we get from Uba. Does that mean then that the practice of using hot water would be still more dangerous with the soft varieties? I am speaking of using hot water in milling. I might also say that these tests are not representative of what happens in milling, because you do not keep the bagasse in water in the mills for three hours, so the danger is less; but he points out that these canes will yield water soluble substances more easily than Uba. The idea of boiling for at least one hour was impressed on me when working out what the mistake may be in doing extraction figures unless one is sure that all the diffused sugar is extracted. We found that 5% was not extracted if stopped too early. Five per cent on the sucrose in bagasse from a crusher would mean an extraction of 0.3, so you would be showing a better extraction. When you got to the last mill that would be only about 0.3. That is not so bad for the last mill, but it would show that your crusher was doing better work than was actually the case.

Regarding the possibility of dextro-rotary substances being taken away by water, these tests do not seem to confirm what you have found, because these substances are obtained from the fibre. In a last mill bagasse your fibre will be about 45 and for your Krajewski or first mill you may go about 21, or you have doubled the quantity of fibre in the bagasse you are boiling in comparison to your first bagasse, and yet you find that the drop in pol or increase in pol is not as heavy as the last one, so that dextro-rotary substances cannot have been taken from the fibre, or are not proportional to the quantity of fibre, and I take it that it is stuff not dissolved from the fibre.

Mr. HAYES: Replying to Mr. Moberly's remarks; what he said brought forward very forcibly the importance of quality of fibre, as opposed to quantity of fibre. As to the instance of cotton seed, one might instance other plants with the same proportion of "quantitative fibre" that would not behave in a similar way to cotton seed; which demonstrates very clearly that a mere bulk determination is not of great value.

This whole question of "fibre"—its determination, effect upon milling and extraction, and the correct distribution of sucrose in cane—seems to have become extremely involved, and there is some confusion of the issues at stake. As far as the present Natal Industry is concerned, the important point is the effect which that portion of the cane, other than juice, has upon the efficiency of the milling extraction. The Planter is drawn into this by the fact that the Miller will naturally wish to pay for the cane with some consideration of its "mechanical" ease or difficulty of working in the mill, as opposed to its mere sucrose content. In this respect, therefore, the term "fibre" should not be used at all. Neither chemically nor botanically is it correct. In the present "indirect" method for calculation of fibre this is simply found by difference, i.e., dry substance minus soluble solids in bagasse. Now this only considers one aspect of the solid portion of the cane, e.g., its bulk. Naturally the more bagasse in proportion to its original weight a cane will yield, the more sucrose will find its way into the boiler furnaces. But the other avenue of loss in efficiency in milling is the physical nature of the bagasse, its degree of hardness or resistance to the crushing action of the rollers. Neither of the methods of "fibre" determination at present in vogue cope with both these difficulties in differentiating between canes with respect to the solid matter they contain. Water extraction is futile in determining fibre, as is evidenced when one considers the formidable list of the chemical constituents of the structural portion of the cane that are changed or removed by the action of water. Therefore the definition of "fibre" laid down by the International Committee as being the "dry, water-insoluble matter in the cane" means nothing, chemically or botanically; especially when it is continued to state that extraction of all the soluble matter is indicated by the absence of sugar. Nor does this help one in the least in computing the value of a cane from its milling standpoint. It has been quite clearly shown that the proportions of the constituents of the fibre are not fixed, nor is there a sharp line of demarcation between them chemically; lignin, pentosans, pectins—all classified as hemicelluloses, all inter-related and bearing their share in the character of the fibre. And yet these same substances vary greatly with the age and conditions of growth in the same plant.

The so-called "fibre" also influences our payment for cane in respect of its sucrose content. With no method yet to hand for the correct sampling of cane as such, it is necessary to apply an average Java ratio to the sucrose in crusher juice from all consignments. It is maintained, and to some extent correctly, that the proportion of sucrose extracted at the crusher to the sucrose in cane, is affected by the "fibre" of the cane. Rather would it seem, however, that at this early stage of milling the determining factor would be hardness and quality of cane fibre as opposed to mere solid bulk. Therefore there is need to tread warily in the appli-

cation of the term "fibre" to milling problems, and the necessity for a further knowledge of the growing portions of the cane both in respect to chemistry and physics.

Now as to Mr. Rault's remarks; in his paper on milling results from individual units, he calls the difference between half an hour's boiling and $1\frac{1}{4}$ hour's boiling "unextracted pol by underboiling." I do not know whether that word "pol" was put in intentionally, but it very significant, and the difference between that and "sucrose" is also significant. It is admitted that with bagasse in a coarse state extraction would be more difficult, but I think the most efficient way of getting out the sucrose from the larger portions would be through a finer division of the bagasse, taking into account possible error in evaporation. This would be a far simpler and safer method than prolonging the boiling.

Mr. BIJOUX: In Dr. Hedley's paper it says on the last page, "In general the best criterion for strength is specific gravity." Should that not be connected with the determination of fibre, when determining the specific gravity?

Dr. HEDLEY: Mr. Moberly put that question to me once and I think it would be a very difficult thing to do because it depends on how the cane is prepared by the crushers, and I do not think you would get enough out of it. You have to remember the rind has a greater specific gravity than the centre of the cane and to get anything useful out of that I think would be impossible. The statement referred to by Mr. Bijoux refers to what is found in connection with wood which is a much easier thing to handle, because a tree does not vary as much as a stick of cane.

Mr. L. BLACKLOCK: I would like to congratulate Dr. Hedley and Mr. Hayes on the excellence of this paper and the quality of the work done. With regard to this sucrose free bagasse, I would like to ask Dr. Hedley if he was absolutely certain that the bagasse was sucrose free. He told us that there were negative molybdate tests by the cold water extract, but Mr. Hayes has just said that the finer you shred your bagasse the better your diffusion even with cold water. Carrying that down further, when you dry bagasse and powder it to a powder passing through 18 mesh, would you not get more sucrose by cold water diffusion and still more likely by hot water. Are you sure that some of this hot water extract of 4.71 is not sucrose?

Dr. HEDLEY: Absolutely. We took some of the powder and we left it with cold water and could get no result at all. The molybdate test is accurate to one in at least 500,000, and the amount of sucrose that that would miss would be very little, if there was any. I think we can take it that that was absolutely free from sucrose. I do not think you would get any more out with hot

water than long standing in cold water.. Another point is that whilst we say we question Mr. Rault's figure of unextracted pol, we do so because he offers no proof that this "pol" was actually all sucrose. Naturally, Mr. Rault may have done this, as it is comparatively simple to distinguish between sucrose and a pentose sugar by fermentation methods, the naphtho-resorcin, and the phloroglucinol tests. Therefore when Mr. Rault boils for 1¼ hours all that I can say is "be careful." Probably you have something there which is affecting the pol and which is not sucrose, although in all probability the quantity present is very small. I had intended getting some of Mr. Rault's extract from the bagasse and examining it, but I should have wanted a great deal of it. However, the exigencies of the work of the Experiment Station caused me to go away for work on the boilers and I was not able to do it. But I should like to do it some time. He might be able to do it himself. It is certainly worth doing.

Mr. HAYES: An experiment was carried out fifteen or eighteen months ago which helps to answer Mr. Blacklock's question. A hot water soluble substance was obtained after boiling this very finely divided fibre, and was found to give a dextro-rotation of 0.1 to 0.2. This extract was fermented with pure yeast and the rotation still remained, showing it was definitely not sucrose.

Mr. RAULT: There is one point we should mention, and it is found in most text books, that in Java, Hawaii and Mauritius, their time of boiling is longer than ours and they have the soft varieties. I would like to ask the opinion of one of our visiting friends here from Mauritius what is the time of their boiling.

Mr. BERENGER: Between half an hour and one hour; it has been brought down to 25 minutes but that is not the usual practice. It is usually half to one hour.

Mr. ELYSÉE: I would like also to express my congratulations to Dr. Hedley and Mr. Hayes for this excellent paper. It has been an education to me. The excellence of this paper provokes me to make a suggestion to Dr. Hedley more or less for the Chemists' satisfaction, and also I think, for the Engineers. We have here the chemical composition of bagasse, and I wonder whether he could not go further and give us perhaps the chemical composition of the combustible substances in bagasse. During the crushing season we find, at times, that bagasse enters the furnace and will not burn, although it has had the same treatment as that

which burnt well half an hour ago. Why should this be? Therefore I would ask Dr. Hedley and Mr. Hayes if they would go further into the chemical composition of such bagasse.

Dr. HEDLEY: With regard to that point, that is one of the things we had in mind when I stated that the Boiler Committee wanted to know something about the composition of these new canes. It is well known to all who have to burn bagasse that at times the bagasse apparently will not burn, and puts the fire out. I believe that Umfolosi and Doornkop were faced with that position this season and I think some of the refractory bagasse was sent to Mr. Blacklock and he found that the B.T.U.'s in it were the same as in the good burning bagasse. I have been struck in reviewing the literature from this point of view by the consistency in B.T.U. output or content of all the varieties of cane. Quite recently in the International Sugar Journal there was a paper on the B.T.U. of P.O.J.2878 and it was very close to the average figure which Mr. Blacklock found in 1924. I think it was, 8370 B.T.U.'s, and that is very little different to what he found in Uba. The explanation as to why the furnaces will not burn the stuff has not been found. I do not think you will find it in the chemical composition. But I can say this, that using a Cooke's furnace or Mr. Murray's type, even that bagasse which is refractory will burn very much better in it. We found that in all the factories where I have been able to examine this question.

CHAIRMAN: Dr. Hedley and Mr. Hayes are to be congratulated on this paper. It shows the high standard of work which is being carried out at our Experiment Station, and although to many present the material of this paper might take on the character of splitting hairs, nevertheless it is very necessary that we should know definitely the characteristics and ultimate analysis of the material we are dealing with. The question of fibre in the bagasse has a direct bearing not only on the amount of fuel available for running a factory but also upon the millability of the cane, as Mr. Hayes has pointed out, and to the ordinary man engaged in the Sugar manufacturing industry these two features are amongst the most important which he has to deal with. Consequently we sincerely trust that work of this nature shall be studiously continued because, as Dr. Hedley and Mr. Hayes will no doubt admit, this is only a beginning. The type of discussion this morning shows that there are many divergent opinions, and there are many points which have to be definitely settled. I will now ask you to accord the authors a hearty vote of thanks for their paper. (Loud applause).