TESTING OF CANE FOR DETERMINATION OF FIBRE

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General Considerations

Cane may be considered as consisting of three parts.

1. Dry fibre.
2. Water of composition.
3. Juice.

By water of composition is meant that water which is held by the cells of the cane, but is apart from and unmixed with the juice. This water is not extracted except by extreme pressures.

The juice may be further divided into :—

1. Sucrose.
2. Other soluble solids.
3. Water.

We have therefore five different constituents in the cane. The proportions of these different constituents may be determined for the whole of the crushing over any period, from the direct analysis and measurement of the extracted juice, and the direct analysis of the final bagasse. Our problem, however, is to obtain the proportion of dry fibre in individual consignments, while it is impossible to obtain separate measurements of the juice from these separate consignments. The only analysis at present obtained which relates to separate consignments is that of the crusher juice. This by itself is not sufficient for our purpose, and must be supplemented by an analysis of bagasse either from the last mill or from some other point. The exact point from which this bagasse sample should be taken is one of the first problems requiring investigation. It will also be necessary to decide what other general relations such as Java Ratio, Normal Juice Factor, Extraction Ratio, etc., are suitable for our purpose. Finally, it will be necessary to evolve formulæ by means of which these data may be manipulated to give us our required information.

Choice of Sample.

It is generally conceded that it is not practicable to take small samples of uncrushed cane, owing to the very wide variation between individual sticks. Likewise, there are certain difficulties in the way of taking individual samples of final bagasse. In the first place, a considerable quantity of cush-cush is removed from the mixed juice and returned to one of the intermediate carriers, and fallen cane and chips which fall through the carrier slats are also returned in the same way. Secondly, the use of compound maceration affects the composition of the residual juice, so that it does not accurately represent the cane from which the bagasse results. In addition, there is always difficulty in identifying the final bagasse from different consignments, especially when chokes occur. It would therefore seem necessary to take a sample of bagasse from some intermediate carrier before maceration is applied and before cush-cush is returned. This would usually mean taking the sample from behind the crusher, second crusher or the first mill. As it is advantageous to have the bagasse in as finely divided a condition as possible, it would be preferable to take it from the last point, before it is contaminated with maceration or cush-cush. This also presents the further advantage that with the advance of the crushing the more constant will such ratios as Normal Juice Factor, Java Ratio, Extraction Ratio, etc., tend to become. In our subsequent discussion the sample will be referred to simply as the bagasse, and the mixture of all the juices up to the point where the sample is taken will be referred to as the crusher juice, even though it may contain first mill juice.

Available Factors and Constants.

While extensive use has been made of the Java ratio for the determination of sucrose per cent cane, practice has shown that this factor is liable to many fluctuations, and its use for the determination of fibre has been avoided. It has been found necessary to make use of the quantity of crusher juice extracted either as a percentage of cane or of normal juice. This cannot be measured directly but may be deduced indirectly for any period, and usually remains fairly constant for any given crushing plant and any given rate of crushing. It will also be shown that up to a certain point variations in this ratio do not seriously affect the results obtained. It has been claimed by Mr. Dymond that a definite ratio exists between the extraction and the fibre. Experiments are now being conducted to verify this assertion.

The Normal Juice factor or

$$\frac{\text{Brix of Normal Juice} \times 100}{\text{Brix of Crusher Juice}}$$

is also fairly constant for similar conditions, and has been made use of in our calculations. A constant ratio has also been assumed between fibre and water of com-

position. While several workers have claimed this to be so, the fact is being verified by experiments.

Suggested Methods of Determining Fibre per cent Cane.

Two methods are here suggested, but both must be considered tentative, as further experiments are necessary to establish the values of the constants which have been assumed.

Method Based on Water of Composition—The bagasse consists of—

1. Dry fibre.
2. Water of composition.
3. Residual juice.

If it is possible to determine the solids in the residual bagasse and the brix of the residual juice, it will obviously be possible to determine the juice water in the bagasse. The total water in the bagasse can be determined either by drying, or by distillation. The difference between this total water and the juice water will be water of composition, and if the proportion of the latter to fibre can be established as a constant it will be a simple matter to estimate the fibre. The solids in the residual juice as a percentage of the bagasse can easily be obtained, but the difficulty is to determine the brix of the true residual juice apart from the water of composition. If a satisfactory method of doing this can be devised the above becomes a possible way of determining fibre.

Alternative Method.—In the following calculations normal juice is considered to be cane – fibre and residual juice to be bagasse – fibre, no regard being paid to the fact that part of the water in the bagasse is water of composition, as in this case the distinction is not necessary. The factors assumed are Normal Juice factor, or

$$\frac{\text{Brix of N.J.} \times 100}{\text{Brix of Cr.J.}},$$

and Crusher Juice % Normal Juice. It may be argued that this is a function of the fibre % cane, which is the very thing we are trying to obtain, but our justification for assuming this factor as a constant up to a certain point in our calculations will be shown later. Taking a sample of bagasse as indicated above, we determine the total moisture either by drying or by distillation. We then proceed by means of the following formulæ :—

$$\text{Brix of Residual Juice} = \frac{\text{Brix of Crush. Jce. (N.J. factor} - \text{Crush. Jce. \% N.J.)}}{100 - \text{Crusher Juice \% N.J.}}$$

$$\text{Brix of Bagasse} = \frac{\text{Brix of Residual Juice} \times \text{Moisture \% Bagasse}}{100 - \text{Brix of Residual Juice.}}$$

$$\text{Fibre \% Bagasse} = 100 - \text{Brix of Bagasse} - \text{Moisture \% Bagasse.}$$

$$\text{Fibre \% Cane} = \frac{1}{0.01 + \text{Fibre \% Bagasse}\,\frac{(100 + \text{Fibre \% Bagasse})}{(100 - \text{Cr.J. \% N.J.})}}.$$

Some of these formulæ appear rather formidable, but as none of them contains more than two variables they can all be converted into tables.

The following calculations are given to show the effect of the variation of the figure Crusher Juice % Normal Juice over a wide range :—

Brix of Crusher Juice = 20.
N.J. factor = 95.
Moisture % Bagasse = 60.

Crusher Juice % Normal Juice = 25.

$$\text{Brix Res. Juice} = \frac{20 \times (95 - 25)}{100 - 25.} = 18.67.$$

$$\text{Brix of Bagasse} = \frac{18.67 \times 60}{100 - 18.67} = 13.77.$$

Fibre % Bagasse = 100 – 13.77 – 60 = 26.23.

$$\text{Fibre \% Cane} = \frac{1}{0.01 + \frac{(100 - 26.23)}{26.23 \times (100 - 25)}} = 21.05.$$

Crusher Juice % Normal Juice = 30.

$$\text{Brix Res. Juice} = \frac{20\,(95 - 30)}{100 + 30} = 18.57.$$

$$\text{Brix of Bagasse} = \frac{18.57 \times 60}{100 - 18.57} = 13.68.$$

Fibre % Bagasse = 100 – 13.68 – 60 = 26.32.

$$\text{Fibre \% Cane} = \frac{1}{0.01 + \frac{100 - 26.32}{26.32 \times (100 - 30)}} = 20.00.$$

Crusher Juice % Normal Juice = 35.

$$\text{Brix Res. Juice} = \frac{20 \times (95 - 35)}{100 - 35} = 18.46.$$

$$\text{Brix of Bagasse} = \frac{18.46 \times 60}{100 - 18.46} = 13.58.$$

Fibre % Bagasse = 100 – 13.58 – 60 = 26.42.

$$\text{Fibre \% Cane} = \frac{1}{0.01 + \frac{100 - 26.42}{26.42 \times (100 - 35)}} = 18.93.$$

From the foregoing it will be seen that an error of 17% in the estimation of the figure Crusher Juice % Normal Juice would give an error of a little over 5% in the Fibre % Cane. It has been claimed that the juice expressed by any given pressure is proportional to the Fibre % Cane. If this were the case it would also be a function of the Fibre % Bagasse. Referring again to the above calculations, it will be noticed that the latter figure is only slightly affected by the figure used for Crusher Juice % Normal Juice. It should therefore be possible at this stage of the calculations to introduce a new figure for Crusher Juice % Normal Juice, depending on the Fibre % Bagasse, if subsequent experiments confirm that such a concordance exists. The substitution of such a value in our last formula should allow of a determination of Fibre % Cane to a much greater degree of accuracy.

The next consideration is the effect of variations in the Normal Juice factor. Let us repeat our second example, increasing the latter factor from 95 to 100.

$$\text{Brix Res. Juice} = \frac{20 - (100 - 30)}{100 - 30} = 20.0.$$

$$\text{Brix of Bagasse} = \frac{20 \times 60}{100 - 20} = 15.0.$$

$$\text{Fibre \% Bagasse} = 100 - 15 + 60 = 25.0.$$

$$\text{Fibre \% Cane} = 0.01 + \frac{1}{\frac{100 - 25}{25 \times (100 - 30)}} = 18.92.$$

The error here is a little over 5%. However, it should always be possible to estimate the N.J. factor to a greater degree of accuracy than is indicated here. The N.J. factor would be increased in the case of rain and the consequent decrease of Fibre % Cane would reflect the greater weight of wet cane crushed.

The principal advantage of this method is that it involves the minimum of work in carrying out the fibre test, as nothing would be necessary beyond determining the moisture in the bagasse. All the subsequent calculations could be done with the assistance of tables.

Method of Determining Moisture in Bagasse.

Two methods for making this determination are available, i.e. drying or distillation. With an oven at atmospheric pressure a minimum time of drying of four hours is usually necessary. Where 70 samples are done in 24 hours, it would be necessary to have an oven holding at least 12 trays, which would mean a very large oven. With this method there is always the difficulty that one can never be sure with only one weighing that constant weight has been reached. On the other hand, the distillation method takes only about 20 minutes, so that, allowing for time taken in changing samples, two distillation outfits would be ample for 70 samples in 24 hours. There is the further advantage that the end point of the distillation can be observed when no more water is distilled over. The method is as follows: A weighed quantity of bagasse is placed in a perforated cage and submerged in a closed oil-bath which is connected to an ordinary condenser. The oil-bath is heated to 190° C. and the water distilled over is collected in a graduated cylinder or flask, in which the quantity of water distilled can be read directly. The method is rapid, simple, and reliable.

Further Considerations.

When some reliable method of determining individual fibre has been established, we shall have for each consignment sufficient data for determining the Sucrose % Cane without the use of the Java ratio. This would remove the greatest difficulty at present experienced in the determination of Sucrose % Cane.

Conclusion.

We would like to emphasise again that the above suggestions are not final, as much work still remains to be done to establish the values of the constants which it is proposed to use. They are here presented in the hope that they may provoke useful and constructive criticism, which is needed for the eventual solution of our problem.

Chairman: This is a very valuable paper, but I feel that like so many we have had presented to us during the Conference, it requires time to consider before it can be properly discussed. It occurs to me that the method of determining their moisture in bagasse by distillation is really partially bound up with the decomposition of the cellulose itself. It begins to decompose slightly at about those temperatures, and I was wondering whether the loss in water distilled over is not partly due to decomposition of the cellulose itself.

Mr. Bechard: The method involved is an adaptation of the method of distillation for the determination of moisture in cane adopted by the United States Department of Agriculture Bureau of Plant Industry, and it has been largely used for determination of the moisture in malt barley. At any rate, the temperature is not final and some experiments are being carried out at present.

Chairman: With reference to the figures given of fibre per cent bagasse and fibre per cent cane, I doubt whether the second place of decimals has any significance, in view of the fact that the calculations depend on the Brix of the juice which it is not possible to read with certainty, to more than one place of decimals. It would be preferable perhaps, to express the final result to one place of decimals also.

Mr. Moberly: If you work out that formula you will find that the part after the .01 plus has its first significant figure in the second decimal place, and it becomes .03 something, so that the addition becomes .04 something. Being in the denominator, this second place of decimals is, of course, very important (proceeds to give a detailed explanation of figures).

Mr. Dymond: No mention has been made of how the samples are to be taken, and how much. As you know, it is difficult to get a representative sample of such bagasse, as it depends on the feed.

Mr. Moberly: That is admittedly true, but I don't quite agree that the difficulty is as great as it is in cane. You have your substance in a very much finer subdivision. You have not got it as finely divided as in your final bagasse, but you will not find any single sticks as in the case of cane. Although we have not considered the detailed procedure of taking this bagasse sample, it would be possible to take the bagasse by grabbing samples say, at various points during the running of your sample, and subdivide them afterwards in a way which it would be impossible to do with a cane sample, and it may prove necessary to cut up this bagasse in some way. But it is hoped that by taking the bagasse out as far as possible from the crusher, that would be obviated. The details of doing it will have to be a matter for further consideration by the Committee during the coming year. I think that at the point we take it, the cane will be in a state of subdivision which will considerably help.

Dr. Hedley: One point occurs to me. You suggest it would be preferable in taking your sample, to take it from the last point before it is contaminated by maceration or cush-cush. As Felixton Mill is situated, that would mean taking it at the first crusher. You could not

get a sample after that. It is going to be a very difficult matter to take it even if there were no cush-cush. I have seen the cane going through in sheets and the sticks not broken at all, but later on it is broken up. I think that your taking of the sample is going to be difficult if you are going to legislate for all the mills. You will have to leave some discretion as to the taking of the samples.

Mr. Bechard: This question has been partially considered by the committee, and as I know a little about Felixton, I would remind you of one fact, that although the cush-cush is returned after the second crusher, it would be possible to sample after the second crusher. The distance between the first mill and second crusher is about ten feet, and the cush-cush comes in about half way. On the point that the cane goes through without being crushed, that is quite true at times. But at such times you will notice in the general procedure, that when there is any factor which militates against the taking of a sample, it is not taken at that stage.

Mr. Moberly: In addition, I think some consideration will have to be given by the mills as to when to return that cush-cush. It is a matter of doubt whether you get so very much advantage by returning that too early, because the portions of finely divided cush-cush going through crushers with wide openings would probably give very little advantage. Most of your extraction will be effected when it is passing through the later rollers. That may prove it to be necessary to move your cush cush strainer a bit further back.

Chairman: This report, of course, is not a final one, and I have no doubt it will be modified in the coming season in accordance with the arrangements which are to be found to occur at different factories and probably some arrangement can be arrived at which will be mutually convenient to all of them.