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MEETING HELD ON TUESDAY, 11TH MARCH, 1902, AT THE ROOMS OF THE INSTITUTE, BREWERS' HALL, ADDLE STREET, E.C.

MR. CHARLES H. BABINGTON (President) in the Chair.

The following paper was read and discussed:—

The Preparation of Invert Sugar in the Brewery.

By Julian L. Baker, F.I.C., F.C.S.

I feel in a measure that an apology is needed for bringing before you this evening a subject which is so well known to all of you, and to which I have little to add from a purely technical point of view. Occasionally, however, certain communications, although they contain no new facts, serve the purpose of awakening interest and discussion on matters which are prone to lie dormant.

At present most of you obtain your invert sugar from the manufacturers, and the product supplied is so satisfactory and so uniform in character, that the question of preparing it yourselves and so saving the manufacturers' profit, may appear on first sight to be hardly worth the trouble and increased turnover of material. I hope to be able to demonstrate that a very considerable saving can be effected, and after having considered this subject very carefully, I venture to lay my conclusions before you this evening for the sake of general criticism.

In these days of keen competition, it is the aim of every brewer to reduce the cost of brewing material so far as is compatible with flavour, stability, and uniformity of the beers he is manufacturing. In many cases it would be false economy for certain materials to be prepared in the brewery, firstly on the score of difficulty, and secondly that the very small saving would not warrant the additional care and responsibility. But with invert sugar the case is very different. The prosperity of manufacturers of brewing sugars is apparent to most of us, and whilst I fully admit the very great assistance they have rendered to the brewing industry since the introduction of the free mash-tun, yet the times advance, and with it our knowledge and experience, and I can see no reason why the brewer should not keep a portion or the whole of the sums that he now pays as profit to the invert-sugar manufacturer.

Before describing the processes for the preparation of invert sugar in detail, a few remarks will be necessary concerning certain deep-rooted misconceptions regarding cane-sugar. Many still believe that the sugar derived from the beet and the cane are different. This has been

proved to be a fallacy over and over again, and to cite an instance, in a particularly trenchant manner by Professor Armstrong in a lecture delivered at the Royal Institution a few years ago. Pure cane-sugar—or, to give it its chemical name, saccharose—is one and the same substance whether derived from the beetroot, sugar-cane, sorghum, maple, cereals, or any other source. As well term water distilled in Jamaica different from that distilled in London. But with raw sugar derived from the cane and the beet other considerations step in. Raw sugar from the cane possesses the luscious flavour resembling molasses so well known to you, whilst raw sugar from the beet has a flavour anything but agreeable, and its use in the brewery without elimination of the objectionable constituents would be attended by most unsatisfactory results. I believe some 20 years ago when raw beet-sugar was first introduced into this country in quantity, some brewers tried using it in the crude state with results anything but satisfactory. The following analyses, which I have recently made, illustrate the difference in the composition of the raw sugar from the two sources:—

	Raw cane-sugar.	Raw beetroot-sugar.
Cane-sugar	95·60	95·42
Ash	1·02	1·23
Invert sugar	0·70	0·10
Moisture	1·30	1·60
Unestimated	1·38	1·65

These are typical analyses of the two kinds of sugars, and although the relative constituents do not show any marked difference, yet, from the specimens before you, it is apparent which of the two would be rejected for brewing purposes.

I have analysed the sulphated ash of the two raw sugars with the following results:—

	Ash from raw cane-sugar.	Ash from raw beet-sugar.
Potash (K_2O)	31·27 per cent.	37·02 per cent.
Soda (Na_2O)	0·45 ,,	10·21 ,,
Lime (CaO)	10·20 ,,	5·40 ,,
Magnesia (MgO)	1·40 ,,	Trace ,,
Iron (Fe_2O_3)	2·30 ,,	0·03 ,,
Alumina (Al_2O_3)	3·40 ,,	0·22 ,,
Silica (SiO_2)	6·50 ,,	0·76 ,,

These figures agree fairly well with those published by Scheibler (Stammer's *Jahresbericht*, **4**, 225), and Wallace (*Chem. News*, **37**, 76). (Compare also *Text-book of Brewing*, Moritz and Morris, p. 174.)

The well-defined difference in the mineral constituents must undoubtedly have some influence on the melassigenic portion of raw beet-sugar, yet the greatest difference between the two raw sugars is to be found in the nitrogenous organic non-sugar.

Now although refined cane-sugar would not repay the brewer for inversion, yet there is an intermediate grade of sugar which I venture to think will become a powerful rival to the raw sugars derived from the cane at present commonly understood to be in use. I refer to the type of sugar known as French, Belgian, German, or Russian crystals. The following analyses of crystals and refined sugar indicate that for all practical purposes the former may be regarded as refined sugar:—

	German crystals.	Refined cube sugar.
Cane-sugar	99·92	99·98
Invert sugar	Nil	Nil
Ash	0·05	0·01
Moisture	0·03	0·02
Unestimated	Nil	Nil

It is difficult to understand how invert sugar prepared from crystals can possibly give rise to irregular fermentation, or to any abnormality in the flavour of the beer. It may be contended that invert sugar prepared by the first of the processes I am about to describe, does not possess the full molasses-like flavour characteristic of the market inverts. Whilst admitting that this is true when the sugar is tasted in bulk, yet in the concentration (about 2 or 2½ per cent.) employed in the brewery the difference is barely distinguishable, and

when it is considered that some of the substances which give rise to the full flavour of market inverts are volatile in steam, any palate difference I think may fairly be inferred is not of a serious nature. The same holds with the invert sugar used for priming; the concentration of the sugar is such that the difference of flavour between market invert and that made in the brewery is not noticeable.

With these few introductory remarks I will proceed to a description of the first process. Briefly, it is the inversion of a pure sugar, such as German or French crystals, by means of quantities of acid so small that the resulting acidity in the inverted sugar is negligible, and so does not require neutralisation or filtration before use.

The first chemist to employ small quantities of acid for the inversion of cane-sugar was Herapath (Eng. Pat., 1862, No. 2,296).* He patented his process, which consisted in dissolving cane- or beet-sugar in water, so that a concentration of 16 to 65 per cent. resulted. To each cwt. of sugar dissolved he added 3 to 4 ozs. of pure hydrochloric acid of sp. gr. 1·16, the temperature of the solution being maintained at 180° to 212° for 1 to 3 hours. (This acidity amounted to 0·05 to 0·07 per cent.) At the end of this time the sugar was inverted. Herapath did not limit himself to the above proportions, periods, or temperatures, for he states in his specification that a smaller quantity of acid will effect the change. The acidity is neutralised by suitable alkalis, and the solution is then in a fit state for undergoing a brewery fermentation.

Nothing further was done with this process until Wohl and Kollrepp, in a paper entitled "Contributions to a Knowledge of the Carbohydrates" (*Ber.*, **23**, 2,084—2,110), studied the matter at some length. These authors were apparently unaware of Herapath's process. Their work and conclusions are shown in Eng. Pat., No. 16,540, 1889, of which I give a brief abstract.

The acid inversion of cane-sugar is generally effected on solutions containing 15 to 25 per cent. of sugar for the reason that solutions of

* Since this paper was written, Dr. L. T. Thorne has drawn my attention to two patents, the first taken out by C. Garton and T. St. T. G. Parsons, Eng. Pat., 1856, No. 2,766, and the second by C. Garton, Eng. Pat., 1859, No. 451. Both these patents have for their object the conversion of cane-sugar with small quantities of acid; in the first instance, 0·85 to 1·70 per cent., and in the second 0·42 per cent. of sulphuric acid on the weight of sugar. Their quantities of acid are, however, considerably greater than those made use of by Herapath.—J. L. B.

higher concentrations are inverted with difficulty, incompletely, and subject to decomposition. The technical defects consist of the necessity for subsequent concentration, and the danger of colouring the products by this operation, but chiefly in the neutralisation of the large quantities of acid used in the inversion. Wohl and Kollrepp found that cane-sugar in more concentrated solutions than 30 per cent. could be inverted easily, and without decomposition. In the inversion of cane-sugar with acids there takes place along with the decomposition of the saccharose, and at a speed increasing with the concentration of the sugar solution, a re-formation or condensation of the products of inversion. This condensation accompanies the decomposition and colouring, and it increases more rapidly with the concentration of the acid than does the invertive power.

Each acid has a very low degree of concentration, at which, when heated for about ½ to 1 hour from 80° to 95° C., it completely inverts a quantity of cane-sugar which may amount to as much as four times the quantity of dilute acid employed. The inversion is not accompanied by decomposition or coloration, so that the above-mentioned condensation is reduced to a minimum. These chemists also determined—and this is the essential point of their work—that the rapidity with which the inversion of cane-sugar takes place is for all temperatures up to 202° F. (95° C.), and for all degrees of concentration up to 80 per cent. by weight, dependent solely on the relation of the quantity of acid employed to the amount of water present. Thus an 80 per cent. solution of cane-sugar contains only $\frac{1}{16}$th of the quantity of water present in a 20 per cent. solution for the same amount of sugar; hence the acid required for the complete inversion of an 80 per cent. solution is $\frac{1}{16}$th of that necessary for a 20 per cent. solution.

For 100 grams of an 80 per cent. solution of pure saccharose the quantities of different acids necessary for inversion are given. The first column indicates the minimum, the second the maximum quantity, with which uncoloured products may be obtained :—

HCl	0·01 to 0·02	gram.
HBr.....	0·02 „ 0·03	„
HNO_3	0·02 „ 0·03	„
H_2SO_4.....	0·03 „ 0·05	„
HF	0·05 „ 0·20	„
H_3PO_4.....	0·15 „ 0·25	„
H_2SO_3	0·20 „ 0·40	„

If colourless products are not required, the quantities of acid may be increased five-fold without affecting the taste of the sugar.

The table (p. 276) is calculated for practical use, and gives the time in hours which is required with the different temperatures of inversion in order to obtain with the given concentration and the given quantity of acid an approximately complete inversion.

These chemists dissolved 1,000 kilos. of pure cane-sugar in 240 litres of water, and when the temperature was 203° F., 0·222 litre of 38 per cent. hydrochloric acid diluted to 10 litres was added, and the temperature maintained for half an hour at 176° to 194° F. The inversion was completed at the end of this time, having been effected by 0·008 per cent. of hydrochloric acid.

For inverting 1 ton of sugar with a small quantity of acid in the brewery I suggest the following arrangement :—

The vessel in which the inversion is to be carried out should preferably have command of the coppers, so that the invert sugar may flow into them by gravitation. It should be made of copper, or iron lined with enamel, and provided with a steam jacket, stirring gear, and means for the introduction of live steam. About 560 gallons of boiling water are introduced into the inverter, and the temperature maintained at 190° to 200° F. by means of the steam jacket. One cwt. of crystals is run in by means of a hopper or other suitable contrivance, the mixer started, and as soon as it is partially dissolved a second cwt. is added, and this procedure repeated until all the sugar is dissolved. 13½ lbs. of a solution of 10 per cent. hydrochloric acid is now run in, and the whole well stirred to thoroughly incorporate the acid, and then occasionally stirred for a period extending to about 1 hour, the temperature being maintained at 190—200° F. At the end of this time the inversion will practically be complete. No neutralisation of the product is necessary, for a certain quantity of the acid has been neutralised by the small amount of ash in the sugar, but assuming that all the acid is present which was added, it would only amount to 0·06 per cent. on the ton of sugar. This quantity has to be still further diluted according to the length of the gyle, so that in the resulting wort the amount is negligible. Should the brewer have reason to object to this small quantity of acid, neutralisation can be effected by stirring in the calculated amount of chalk sludge or other suitable alkali before turning out. This operation should take place about a

Duration of Inversion in Hours

Concentration of sugar solution.	80 per cent.						70 per cent.					60 per cent.			40 per cent.		
Hydrochloric acid calculated for percentage of sugar.	0·0025.	0·005.	0·01.	0·025.	0·05.	0·1.	0·008.	0·017.	0·045.	0·085.	0·17.	0·013.	0·027.	0·14.	0·03.	0·15.	0·3.
Temperature.	Time in hours.																
78°·8 F.	—	—	—	—	—	—	—	—	—	—	—	—	500				
104°—122° F.	—	—	84	34	18	5¼	—	65	20·5	12	5·25	—	—	7·5	—	13·5	7
122°—140° F.	—	—	22·5	9	4·5	2·25	—	19	6·5	3	1·5	—	12	2	3	4·5	0·4
140°—158° F.	—	—	6	2·75	1·5	0·66	—	5	1·25	0·8	—	—	2·75	0·5	5·5	1	0·4
158°—176° F.	—	—	2	1	—	—	3·5	1·75	0·5	—	—	3	1·5	—	2·5	0·5	
176°—194° F.	—	1·5	0·75	—	—	—	1	0·5	—	—	—	0·8	0·4	—	0·8		
194°—212° F.	—	0·5	0·33	—	—	—	0·5	25	—	—	—	0·5	0·2	—	0·5		
212°—230° F.	0·4																

quarter of an hour before the copper is emptied, so that thorough admixture may result. The inverter is washed out with a small quantity of hot liquor or live steam until all the sugar is removed. The invert sugar so prepared is white or of a very faint yellow colour, and is intensely sweet, and has a flavour strongly resembling honey. Although not possessing the luscious flavour of market inverts, yet it is perfectly free of objectionable taste or smell. It contains under 0·5 per cent. of albuminoids, whilst an ordinary invert will generally contain 1·50 per cent. In the cold it is a viscous mass, and on standing for some weeks a magma of crystalline glucose separates. At 150° to 200° F. it is quite limpid, and flows with ease. It gives an extract of 73·00 lbs. per 2 cwt.

If inversion is complete, 1 ton of crystals, 2,240 lbs., will yield 2,357 lbs. of invert sugar in accordance with the equation :—

$$C_{12}H_{22}O_{11} + H_2O = 2C_6H_{12}O_6.$$

French or German crystals cost from £14 to £15 per ton. On the basis of £15 per ton, the invert sugar costs 14*s.* 3*d.* per cwt. In order to compare it with the inverts at present on the market, it will be necessary to reduce it to sugar of the same strength. The 14*s.* 3*d.* represents the price of a cwt. of anhydrous invert sugar, whereas the market inverts contain from 14 to 20 per cent. of water. Taking an average of 16 per cent. of water, the price of the sugar inverted in the brewery becomes 12*s.* 2*d.* per cwt.

I compute that, with a plant making 2 tons of invert daily, 5*d.* per cwt. must be added on for working expenses, and I arrive at this figure in the following way :—

Wages of two men	50*s.*
Acid	5*s.*
Steam.....	37*s.*
Interest on plant, wear and tear, &c. ...	8*s.*

100*s.* per 12 tons of sugar manipulated, or 5*d.* per cwt. This brings the price to 12*s.* 7*d.* per cwt. as compared with 14*s.* 6*d.*, an ordinary market figure for invert sugar. The saving of 1*s.* 11*d.* per cwt. represents £23 per week on an output of 12 tons, or £1,100 per annum. I only give these figures as an example, but I think I have demonstrated that a considerable saving can be effected, and it would be an easy matter

for the brewer to calculate how much per cwt. the invert sugar prepared by himself would cost, and to compare it with the price of the product he at present uses.

This process would be of particular use in large breweries where space is valuable, for the inverters are small, and a battery of two would suffice for four coppers. As the inversion is so rapid, several charges of invert sugar could be prepared each day. For small breweries the alternative method of inversion by yeast would be more profitable.

There are, however, other important considerations in this process to which I would draw your attention. The inversion can be regulated to any desired point by stopping the action of the acid with the calculated quantity of calcium carbonate, or other suitable alkali. Definite mixtures of cane-sugar and invert sugar can be thus prepared, which are of the greatest use for priming purposes. In this direction investigation is urgently needed.

To work the process intelligently and efficiently, a determination of ash should be made on each delivery of sugar. Crystals generally contain 0·05 per cent. of ash; if this amount is exceeded, proportionately more acid is required for the inversion. The following figures illustrate this point:—

1. 100 grams of German crystals containing 0·05 per cent. of ash were dissolved in 25 c.c. of water, and 2·5 c.c. of normal hydrochloric acid added. The temperature was kept at 190° F. for 1 hour. 92 per cent. of the sugar was inverted.

2. 100 grams of inferior Belgian crystals containing 0·09 per cent. of ash was dissolved in water and treated in a similar manner. Only 34 per cent. of the sugar was inverted.

3. 100 grams of raw Barbados sugar under these conditions yielded 3·27 per cent. of invert sugar. This sugar originally contained 1·58 per cent. of invert sugar, so that the amount actually inverted was extremely small. From these figures it will be seen how important the question of ash is.

I have carried out a number of experiments on the retarding influence of ash on the inversion of cane-sugar by this process, and although it would seem that if the alkalinity of the ash is destroyed by the calculated quantity of acid, and then the required amount of acid be added that inversion should be complete. But such is not the

case. From the results of my experiments I would suggest that when the sugar to be used contains over 0·05 per cent. of ash, the following amounts of 10 per cent. hydrochloric acid per ton of sugar should be used :—

Ash per cent.	Lbs. of 10 per cent. hydrochloric acid.
0·050	13·5
0·055	16·0
0·060	20·2
0·065	28·4
0·070	36·5
0·075	46·2

When quantities of acid exceeding 25 lbs. per ton are used, it would be a wise precaution to neutralise with the calculated quantity of alkali.

The analysis of the product may be carried out by determining the rotatory power in a polarimeter or saccharimeter, and the reducing power by Allihn's method. Both these methods have been so frequently described in the literature, that it is necessary only to refer to them here.

Before passing to the second method of inverting cane-sugar, it may be well to give an account of how sugar prepared in this way behaves in practice. In experimental fermentations the results were normal, and no objectionable flavour was observed in the beer. Priming experiments would accentuate any undesirable points in this sugar, and to settle this mild ales were primed at the rate of 1 quart and 2 quarts at a gravity of 1,150 per barrel, and compared with the same beers primed under similar conditions with market invert. It is difficult to form a true judgment, for we have no means of measuring taste, but generally speaking, the beers primed with this sugar had a flavour quite as full as those primed with market invert, and in my opinion they possessed a cleaner palate, and were distinctly sweeter.

The alternative method of inverting cane-sugar is by means of invertase, and this process is so very simple and its results so uniform, that it is a matter of some surprise to me that it is not more generally used. In 1884, F. W. Tompson (Eng. Pat., 8,686) patented this process. He dissolved commercial saccharose in water and heated the solution to a temperature varying from 95° to 160° F.,

1 part of yeast per 100 parts of sugar was added, and the solution allowed to stand for 5 hours. At the end of this time he claimed that the cane-sugar was completely inverted. The publication of this patent was followed by the well-known paper by C. O'Sullivan and F. W. Tompson (*Journ. Chem. Soc.*, 1890, 834—891), on invertase. These authors found that the most favourable concentration for the action of invertase is in a 20 per cent. solution, and 130° F. the optimum temperature. In saturated solutions hydrolysis proceeded with great slowness. Solutions more dilute than 20 per cent. are unfavourable to the reaction, whereas concentrations greater than 20 per cent. are only slightly detrimental until 40 per cent. is reached. The speed of hydrolysis increases rapidly with the temperature until 130° to 140° F. is reached. At 149° F., invertase is slowly destroyed, and at 167° F. it is immediately destroyed. These chemists also showed that the optical activity of a solution undergoing hydrolysis is no guide to the extent to which hydrolysis has taken place, since the dextrose is liberated in a birotatory condition. If a small quantity of caustic alkali be added, the sugars assume their normal rotation, and the rotatory power then becomes an indication of the true extent to which hydrolysis has proceeded.

This very brief abstract of a portion of O'Sullivan and Tompson's interesting paper, placed the manufacture of invert sugar by means of yeast on a well-established basis. It is a process very easy to control, and one which it is difficult to foresee should work irregularly. The process is generally carried out as follows:—The cane-sugar is introduced into suitably shaped inversion tanks and dissolved in hot water. More water is added until the solution contains 30 to 40 per cent. of sugar, the temperature being raised to 133° F. by live steam or other means. Pitching yeast is now added at the rate of $1\frac{1}{2}$ to 3 lbs. per cwt. of sugar; and the temperature kept at 130° to 133° F. for at least 5 hours. If the inversion vessel is deep in proportion to the surface exposed, and is constructed of wood or lined externally with a badly conducting material, very little heat is lost, and the initial temperature will be enough to carry the inversion through. It is well to control the inversion by means of the polariscope. For this purpose, 20 grams of the cold syrup are dissolved in water, a little alumina added, the contents of the flask made up to 100 c.c., the solution filtered, and the gravity determined at 60. The concentration is determined by dividing

the excess gravity over 100 by 3·86. The rotation is then observed in a 200 mm. tube, at a temperature of 68° F.

The specific rotatory power is calculated by the formula $[\alpha]_D = \frac{\alpha}{l.c}$, where α is the reading taken in a Laurent polariscope, l = the length of observation tube, and c = the concentration. Under these conditions, if the reading is taken at 68° F., the specific rotatory power should approximate $[\alpha]_D = -20°$. If the value calculates out to $[\alpha]_D = -10°$ the solution is sufficiently inverted. In a concentration of 25 to 30 per cent. of sugar, the inversion is complete in 4 hours, as shown by Mr. Ling and myself, in a paper read before the Society of Chemical Industry. We brought forward figures to prove that the inversion of cane-sugar by yeast could be used as a measure of cane-sugar in low products and molasses, the values agreeing with those obtained by the well-known Clerget method. (*Journ. Soc. Chem. Ind.*, 1898, 111.)

When inversion is more or less complete, the syrup is run direct into the copper. The last portions contain the yeast; this is also generally added, and I consider the practice a good one, for the comparatively small amount serves as a yeast food and does not in any way interfere with the beer. Where used this process is held in much esteem, the simplicity in working and uniformity of results being much in its favour. The cost is so small as to be almost negligible, one vessel only being required and this of a very simple description. The process is peculiarly adapted for small breweries. I have made calculations as to cost, so that a comparison may be made between the market prices of invert sugar and that prepared in the brewery from crystals or raw cane.

One ton of cane-sugar crystals yields 2,357 lbs. of invert sugar. By this process about 90 per cent. of the sugar is inverted, therefore 1 ton will yield 2,339 lbs. Assuming 1 ton of crystals cost £15, the price per cwt. of invert prepared from it is 14*s.* 4*d.* If this be reduced to the same strength of invert as the manufacturers supply, namely, a product containing 16 per cent. of water, it will cost 12*s.* 3*d.* per cwt. Allowing 10 per cent. for working expenses, a saving of 2*s.* per cwt. is effected.

The inversion of sugar by yeast possesses the great advantage that low-grade raw cane-sugars can be used, this for reasons stated before not being possible with the acid process. On the other hand, the

yeast-inverted sugar is not so well adapted for priming purposes. And perhaps in passing I may be allowed to say a word about the use of raw cane-sugar in brewing. Its use is permissible in beers, the yeast from which is not required for pitching purposes. But yeast which has fermented large quantities of cane-sugar gradually becomes weakened, and in breweries where this practice is adopted, frequent changes of yeast have to be resorted to. It must be borne in mind by the brewer who uses cane-sugar as a brewing-sugar that the yeast has to invert cane-sugar before fermentation takes place, and that the increased work thrown on the yeast is in the end bound to weaken and modify it.

The preparation of invert sugar by either of the processes I have described presents little difficulty, and when the brewer has been initiated, daily control by analysis, although desirable, will probably not be a necessity.

I have entered into some detail with the first-mentioned process, for I believe it to be one that will be serviceable to the brewer. The object of my paper will be well served if I am the means of inducing you to consider the claims of high-grade beetroot-sugar as a brewing sugar. In all probability this question will come more prominently before you in the near future. The outcome of the recent Sugar Convention will be the establishment of a beetroot-sugar industry in this country, and as for various reasons the technology of the beetroot-sugar industry is altogether more advanced than that of the cane-sugar industry, I believe that the beet will gradually oust the cane, even in such comparatively small issues as the manufacture of invert sugar.

Discussion.

The President having invited discussion,

Mr. Arthur R. Ling said, in view of his long association with the sugar industry, he felt bound to make some remark on the paper they had just heard. It had been said over and over again that beetroot-sugar could not be employed for brewing purposes without disastrous results. There was no doubt whatever that the sugar known to chemists as saccharose or sucrose was one and the same thing, whether it was obtained from sugar-cane or beetroot. The question before them was entirely one of purity. In raw sugars the saccharose was asso-

ciated with certain other substances. As Mr. Baker had stated, raw sugars derived from cane contained besides saccharose an appreciable amount of invert sugar, and besides these a number of organic substances having a very pleasant aroma and flavour: raw cane-sugar had a fuller and more luscious flavour than pure saccharose. On the other hand, the impurities in raw beetroot-sugars were of an extremely nauseous character, so much so that these raw sugars could not be used in any way for direct consumption. Mr. Baker's suggestion was not, however, to make use of raw beetroot-sugars of the type he had referred to as first runnings, but of certain products of a semi-refined nature which were on the market, and in regard to these the first question was whether the small amount of impurities present was sufficient to impart an objectionable flavour to invert sugar made from them. In order to invert sugars of this type by the process referred to, the small quantity of acid necessary depended roughly on the percentage of ash in the sample, as Mr. Baker had stated, but he (the speaker) had in his laboratory experience met with some extraordinary differences in the behaviour of sugars containing the same percentages of ash. An amount of acid (other conditions being equal) which would completely invert some samples would only carry the inversion half-way in others. This was undoubtedly due to the fact that the organic acids with which the mineral constituents (estimated as ash) were combined differed in amount and character in different samples, besides which a basic organic compound might also be present. That was a difficulty the brewer would have to face in dealing with these materials, and it would mean that to insure constancy of inversion the most stringent scientific control would have to be observed. With regard to the use of invert sugar derived from beetroot for priming, the question not merely of the absence of objectionable flavour but also of that of the fulness which raw cane-sugars imparted was a highly important one. Every one would agree with Mr. Baker that to fix a standard of flavour was an impossibility. There was no doubt that French and German "crystals" could be purchased at the present time at a price which would show a considerable saving to the brewer who attempted to make his own invert; but the low price of the "crystals" was due to a variety of circumstances which all united to produce it this year. It was due not only to the Continental bounties and cartels, but also to a certain

amount of over-production. He had been much interested in hearing what Mr. Baker had to say on the inversion of sugar by yeast in the brewery, for although in collaboration with the author he had found that inversion by yeast could be made use of in the analysis of the lowest products of the sugar industry, such as jaggery and molasses, he had no experience of the process on a manufacturing scale.

Mr. JOHN HERON congratulated Mr. Baker on the very clever way in which he had warmed up an old chestnut, for this process of Wohl's was, to his knowledge, known in London more than 10 years ago. The patentees went with it, he believed, to every sugar factory in London. The process was published in most of the papers connected with the sugar and brewing industry, and if there had been anything in it brewers and manufacturers would not have waited for Mr. Baker to bring it before them. He must also correct the statement made that Dr. Herapath was the first to discover this process, because the records of the Patent Office would show that there was a process introduced by Mr. Charles Garton in 1859 having practically the same object. He had closely followed the history of invert sugar, and he believed Garton's, Herapath's, and Wohl's were the only three patents taken out for it. He must also say that the analyses shown by the reader of the paper were not at all what they pretended to be. The analyses of raw cane-sugar as made by himself and collected from various sources showed a very much less percentage of cane-sugar, a much higher percentage of ash, and a much larger percentage of invert sugar than the author had given in the analyses before them; sometimes it was as much as 11 or 13 per cent. The ash also varied from 2½ per cent. or 3 per cent. up to 5 per. cent. both in raw beet- and in raw cane-sugar, and the moisture was certainly much higher than was represented. Possibly Mr. Baker had given the analyses of what were known as the first runnings of beet, but he did not call that raw beetroot-sugar at all. The analyses given of raw cane would correspond more nearly to the analyses of partially refined cane-sugar, or that which was known in the brewing world as brewing cane-sugar—that which was supplied by manufacturers to brewers who inverted their own. With regard to beetroot-sugar, he might mention something which occurred in his experience which would throw some light on its supposed harmlessness. Some years ago a process was introduced for the refining of raw cane-sugar which

was very successful. It differed from the ordinary process in that certain chemicals were employed for the purpose of decolorising and so on, and the result was that the crystals produced were practically pure cane-sugar with little or no ash or moisture. The product commanded a ready sale. It was highly spoken of on the market, and in the course of its travels some of it fell into the hands of some large wholesale confectioners, where it was employed for making barley-sugar, lemon drops, and other sweetmeats. In the course of a fortnight, however, affairs took a serious turn, and he was consulted on the matter. All these sticks of barley-sugar and lemon drops had undergone deliquescence and stuck together, and in a month or six weeks they went to a thick syrup. He was asked to analyse the sugar. All of them had contained a very minute quantity of ash, and apparently nothing else, and it was absolutely beyond his power to find out anything in it which would account for these serious results in manufacture. Any one who had once smelt raw beetroot-sugar would have been struck with the odour due to certain substances which were not sugar, and, refine it as much as you might, you could never get rid of that smell, though you might reduce it. He would ask any gentleman present to take some of the very finest refined crystals of beet it was possible to produce, put them into a tight-fitting corked bottle, and place the latter on the mantel-piece in the brewing room, and after 24 hours let them go in the morning as they came in from the fresh air and smell them, and then see if they could not clearly detect this smell peculiar to beet-sugar. The smell might be faint, but a keen nose would always detect it. It was no use to tell him that that substance, whatever it was, if it was so obnoxious and unpleasant in the raw state, though it might be refined so as to make it marketable, was harmless. What English brewer would be mad enough to brew a gyle of beer with raw or even with refined beet-sugar. He certainly would not. With regard to supposed profit, there might be a saving at the present moment, but every one connected with the sugar market knew that this was an exceptionally favourable time for the purchase of beet-sugar, owing to certain circumstances which Mr. Ling had referred to. Beet was at its lowest price, lower than he ever recollected it before, and though everything might appear very favourable now, it was simply temporary. The time would come when beetroot-sugar would be as dear as cane was now, and perhaps dearer, and

when cane-sugar would have a chance of competing not only in the brewing industry, but in other directions. Beetroot-sugar would decline, and there would be a flourishing market for cane-sugar, and a revival of trade in the West Indies and other Colonies which would bode well for the Empire at large.

Mr. LAWRENCE BRIANT said he had been much interested in this paper. It was a subject which some fifteen or twenty years ago caused a certain amount of perturbation, and it was nearly twenty years since he was associated with a process for the home inversion of sugar. It at once struck one that if, according to Mr. Baker's figures, there was an economy amounting to several pounds a ton to be effected by inverting one's own sugar, how foolish brewers must have been to have continued all these twenty years purchasing invert sugar from manufacturers when they could save £3 or £4 a ton by making it themselves. Surely brewers were not so foolish as that. Surely they must have been convinced in some way or another that home inversion did not give them precisely all that they got in a manufactured sugar. He believed that they had done a wise thing on the whole in not adopting wholesale home inversion, although he was to some extent an advocate of the process and had been so for a long time; but he at once joined issue with Mr. Baker on the essential foundation of his process. He used beetroot-sugar, and the experience of brewers was absolutely against it. It was no good to say that the sugar in beetroot was sucrose; for that was not the point. The impurities present in cane-sugar were pleasant, and gave a desirable flavour and luscious roundness to the finished beer, whereas the impurities in beet were most abominable. If beetroot-sugar were purified so as to get rid of these objectionable flavours, you had to purify it until it had no flavour whatever, and was not much good to the brewer, except as an alcohol-producing agent, and that was not what they wanted. If they were merely manufacturers of alcohol, no doubt a pure beet would answer very well. In the process of Wohl, the proportion of acid to be employed varied with the amount of ash present, and every practical man who had to do with sugar inversion on a large scale, knew perfectly well that the proportion of mineral matter had a very serious influence on the inverting capacity of the sugar. It was not merely the total amount of the mineral matter, but its character, and you could not say because a sugar had 0·05 per cent. of ash, it

would take so much hydrochloric acid. In practice it was not so. The amount of ash seemed very low. Very few sugars could be obtained with so small an amount, and he must candidly say he could not recognise the analysis put forward as that of raw beetroot-sugar. He should have said it was partially refined beet.

Mr. BAKER said he really thought it was a representative analysis. For some ten years he had been daily analysing raw beetroot-sugar of various grades, and he would ask Mr. Ling to support his statement.

Mr. LING said the analysis was a typical one of so-called 88 per cent. first runnings beetroot-sugar.

Mr. BRIANT said that, however, was not essential to his argument. His point was that to invert sugar by Wohl's process, it was essential that the amount of mineral matter should be very small, and in practice it was not nearly so small as 0·05. The consequence was, you had to use a larger proportion of acid, and were driven back on the old system of inversion by hydrochloric acid or sulphuric acid. For very many years sulphuric acid was used in breweries for inversion with a fair amount of success for certain classes of sugars, but it was impossible to employ a very high class of sugar because the price was prohibitive. For that reason brewers had to use low-class crystals, which contained impurities which required a considerable amount of acid for inverting, not a constant amount, but varying with almost every sample used, and as a consequence irregularities of inversion were continual, and the resulting sugars were far from being up to the standard of a manufacturer's No. 1 or No. 2 quality. He did not wish it to be thought that home inversion was absolutely a failure, because by the yeast process it did answer within certain limits, but in his opinion it only answered satisfactorily when applied to cane-sugar. Dealing with a very low class of cane-sugar, the amount of yeast to be employed, however, was very large, so much so that in some cases the amount was prejudicial. Provided you used a fair quality of sugar, the yeast inversion was successful for medium-class beers. He held, therefore, that while home inversion was satisfactory for cheap running beers, it was not satisfactory for higher class beers, and that the inversion of beet-sugar was in no case satisfactory. Brewers had found by experience that beet-sugar was objectionable, and he firmly held to the opinion entertained by so many practical men, that it was very objectionable in beer. This

paper was extremely interesting, and revived a matter of great interest to them all, but he trusted that the result would not be to induce brewers to make a retrograde step, and employ beet-sugar instead of cane-sugar.

Mr. ARTHUR C. TANQUERAY said the question seemed to him to be whether they should use beet-sugar in the brewery, and Mr. Baker on the analysis he had put before them said they could, but he could not feel sure of that. If you could interpret a chemical analysis for certain, and know that it always accorded with the ultimate result in the brewery it might be so, but they all knew that in many cases a chemical analysis did not express what a given material would produce. It was one thing for a chemist to make an analysis and to interpret it, and another thing for the brewer to interpret it. The chemist interpreted his analysis from his own point of view, whilst the brewer put it in the light of his own experience and viewed it through very different glasses. There were many things in this matter which required a great deal of consideration. With regard to cost, he had looked carefully into the figures, and could not bring them up to anything like the amount Mr. Baker had put forward. Taking all the labour, wear and tear, he did not think they would gain more than 1*s.* or 1*s.* 3*d.* per 2 cwt., and was it worth while for that small amount to run all the risk and danger of using beet-sugar? It was a dangerous thing for any one, unless he had a long and varied experience in breweries, to advocate the use of beet-sugar, which might create great disaster. He always understood that all beetroot-sugars were very much bleached by chemicals of various kinds before they came on the market, and that might have an appreciable effect on the beer. Another question which occurred to him was, looking at the Act of Parliament with regard to the duties on sugar, whether they would be permitted to invert sugar in a brewery with acid, at any rate without taking out an inverter's licence. The whole process then would be under the supervision of the Excise, which would be very objectionable.

Dr. THORNE said this paper was very interesting, but he could not agree with the author in his conclusions. The inversion of cane-sugar or sucrose from the theoretical standpoint was no doubt very simple, but those who had been engaged in practically carrying it out on a large scale knew that it was by no means as simple in practice as it was

on paper; and it was not so simple on a large scale as it was in the laboratory. There had been a good deal of question as to the correctness of the analyses of raw beetroot and cane-sugar, and he thought the analyses of both the raw beetroot and raw cane were better than what would be ordinarily understood to represent such sugars. He did not say they were not representative analyses of the first runnings, but in the large proportion of what was called 75 per cents. on the market, the analyses would come out much less satisfactorily than the analyses given. In the same way there were very few raw cane-sugars which would be spoken of as such on the market, which would have as little invert sugar and as little ash as appeared on the diagram. Again, coming to the question of refined cane-sugar *v.* French, Belgian, and German crystals, one might often obtain such crystals having analyses similar to that shown; but he certainly should join issue with the statement that one could depend on getting a sugar with that analysis under ordinary circumstances. Those who had experience in the sugar market at all knew that fine French, German, and Belgian crystals were exceedingly variable products, and that if any attempts were made to use them it would want very close watching to decide on the quantity of acid to be used. Those who had carried out the inversion of sugar on a large scale knew how important that question of the quantity of acid and its concentration was. A very small quantity over what was necessary would cause a great deal of retrogressive or reversion products, whereas, with a very slight deficiency of acid with the inversion of cane-sugar, you would get your angle not $-10°$ but it might even be on the plus side sometimes, showing that 20 or 30 per cent. of the cane-sugar was left uninverted. It was a very different thing working this process out on a moderately large scale and carefully watching it, to what it would be in the brewery, where it would be put in the hands of the ordinary workman; unless you were to put on very considerably more wages for manipulation than Mr. Baker had allowed. Mr. Baker had referred to the reversion products which he thought might possibly be useful in the brewery. They might, though even that was open to question; but his experience many years ago, when working on these subjects in Germany, was that it was very easy to get not only these inert bodies formed, but also levulinic acid and humic products, which certainly were not wanted in the brewery. It was very easy, especially on the manufacturing

scale, to get inversion carried too far and get products you did not want instead of those which Mr. Baker spoke about. Again, if you were not very careful in the regulation of the acid, in the heat, and so on, you would not get the beautiful pale-coloured product which had been passed round, but very considerable colour would be set up. In the manufacture of invert sugars, that could be, and was got over by the fact that after inversion they were purified by passing over char and other means; but in a brewery this after-purification would have to be omitted. He emphatically joined issue with the author when he said there was no need to neutralise. You could not depend on getting a supply of French crystals with which you could use such a small quantity of acid that you would venture to put it into the copper without neutralisation. The percentages which Mr. Baker gave were, of course, theoretical, and could be obtained in certain cases, but in practice with the greater part of these crystals which came into the market he felt certain they would be very largely exceeded. The French crystals were certainly not very fine products; they were better than raw, no doubt, but they had those objectionable compounds, organic ammonias, or allied bodies, in a much greater degree than a brewer would venture to use without purification. With regard to inversion by invertase, that was more available than the acid process, but there again a good many brewers would hesitate to put boiled yeast into their beers before fermentation. They certainly would not improve the flavour of the resulting beer, and although to a certain extent they were good yeast foods, the drawbacks overbalanced the advantages. Turning for a moment to the question of price, he thought in dealing with French and German crystals they were on very dangerous ground. Previous speakers had referred to the variation in price, and he had taken out the figures for one or two years. In 1899, the highest price for French crystals was £12 16*s.* a ton, and the lowest £10 7*s.*, buying on the largest scale. In 1900 the highest price was £14 a ton, and the lowest £10 9*s.* In 1901, owing to the scare over the import duty and the large quantities imported into England and the glut in the foreign market, there were very low rates—from £11 12*s.* a ton to £8 8*s.*, but in all cases there was £4 3*s.* 4*d.* to be added for duty to those prices. In addition to that, there was a certain amount to be added for cartage, dock dues, and so on, which would come to another 5*s.* or 10*s.* per ton. Last year, from May to September, it was

absolutely impossible to buy these crystals on the London market, except at absolutely exorbitant prices.

Mr. BAKER said you could make contracts if you went in for this process.

Dr. THORNE said in that case you would not get the advantage of the market. If you decided to use fairly good refined cane-sugar the cost would come very much higher, and any supposed saving would disappear. Mr. Tanqueray had referred to one point he was going to mention, namely, that of the Excise. It was quite certain, he thought, that under the Excise Law a sugar-maker's licence would have to be taken out by the brewer, and all the conditions, regulations, and work that that would entail was an important matter to be considered. Even from Mr. Baker's own paper and the details he went into as to the mode in which the process was to be controlled, he thought the average brewer would say that it was not very desirable. Certainly if they were to undertake it they must make an allowance for superintendence of a much more careful kind than appeared to be the case by the paper. Mr. Heron had referred to the patent of Charles Garton, which was previous to Dr. Herapath's, and he thought it was only due to a pioneer in the industry to say that there were patents, dated 1856 and 1859, taken out by Charles Garton, of Bristol, a partner in a brewery firm there, who died some few years ago. It was only due to him that the step he took should be recognised.

Mr. A. C. CHAPMAN said there could be no doubt that this was a question into which prejudice entered very largely, and there was also no doubt that the dragging in of a considerable number of technicalities tended to obscure what was after all the real issue in connection with the use of beetroot-sugar in the brewery. As a matter of fact what they were primarily concerned with was this: Could beet-sugar be profitably and advantageously used in the brewery? It seemed to him that there were four factors to be considered in connection with this matter. First, the question of convenience; second, the question of cost; thirdly, the effect upon the stability of the beer produced; and fourth, the effect upon the flavour. In the first place, as to the convenience, one could readily understand that in very small breweries where comparatively little sugar was used and the staff was limited, the saving would be so small that it would not be worth while to undertake it. In large breweries it was equally obvious that that objection would not

apply. That introduced the second question of cost. It was quite unnecessary to point out that there was a saving, because the invert-sugar manufacturer made a profit, as he had a right to, and if the brewer could make it, he was fully entitled to it instead of the invert-sugar manufacturer. That was clear, though one might point out that even a large brewer was not in so good a position to purchase the raw material as a large sugar manufacturer. Thirdly, as to the influence on the stability of the beer. Here, he thought, they were on very shaky ground indeed. He might say without risk of challenge, that there was no mass of accumulated evidence to show that the use of such sugars as a brewer would use (there were some which he naturally could not use under any circumstances) had ever produced seriously unpleasant results. But he should like, in regard to the question of flavour, to mention his own experience. Mr. Baker had deplored the absence of any standard for flavour, and it was quite true; but there was no standard code of ethics, and yet they were all fairly agreed upon what was right and what was wrong, and although there was no standard of flavour, they were all pretty well in accord as to what was good and what was bad. One man might not like the beer another man liked, but, generally speaking, a man accustomed to drink beer could say, "This beer is good; that beer is less good, or is bad." Now, fifteen years ago or more he knew of home inverted beetroot-sugars being used in a number of breweries, which were not by any means such good sugars as were represented on the diagrams. They were used for a number of years without being complained of, nor was there any one instance in which any serious defect whatsoever could be distinctly traced to these sugars, so that he found it rather difficult to say that the use of beetroot-sugar in a brewery was altogether inadvisable, or altogether wrong, because there was no case of trouble at all; but still the general trend of the results in connection with the use of beetroot-sugar had been such as to indicate that it was not a desirable brewing material. There were several chemical points on which he should have liked to say something, but they had been already dealt with. Generally speaking, the sugars headed "raw cane" or "raw beet" would not be what the average brewer or technical chemist would have described under those terms; they were distinctly better. With regard to the influence which the amount of ash had on the quantity of acid required for inversion, every body who had expe-

rience of the matter knew there was no direct ratio between the amount of acid required to effect complete conversion and the amount of ash present; there was no particular reason why there should be. A good many years ago he tried to work out a process for determining how much acid would be required for the inversion of any particular sample, based on the determination of the alkalinity of the ash, but had failed, and very likely many others had arrived at the same results. Practically, this paper was a plea primarily for the use of beetroot-sugar, and, secondly, for its inversion by what was known as Wohl's process. He had never yet met with any example of beetroot-sugar which a brewer could have used, and which was not sold at a prohibitive price, which did not bear some traces of its origin, and he could not help saying most strongly that the brewer would be well advised to set his face against the use of beet. If he decided that home inversion in his own case was a good and profitable thing, let him at any rate confine his attention to sugar derived from cane. He said this not as a matter of theory, but as an opinion based on fifteen years' experience of this particular question. In connection with the flavour, he would say that what the brewer wanted was not merely the absence of something bad, but the presence of something good, and that one got in the best purchased invert sugar one made from good Demerara. They gave a lusciousness that could not be obtained from beet crystals.

Mr. BAKER, in reply, said he had a somewhat difficult task before him, and it was evident the supporters of the sugar manufacturers were present in force. Some of the remarks made were practically a *non possumus* in respect of all that he had brought forward. He thanked Mr. Ling for confirming his analysis. One important point raised was the definition of what raw sugar was. There was no doubt there were two types of sugar, refined sugar and raw sugar, which had various grades in either beet or cane. There were first, second, and third runnings, but there was only one refined sugar and all the others were raw. It was almost a quibble to say that this substance he had dealt with was a species of refined sugar. It was nothing of the sort. It was taken by refiners in this country and made into refined sugar. As had been already said, most chemists agreed that there was no difference between refined beet-sugar and refined cane-sugar. He supposed there was in this country at the present moment

and had been for some years past, little or no refined cane-sugar in use as consumable sugar. For years past it had been practically all beet. Cane-sugar had been used principally for the preparation of invert. Mr. Briant had practically re-echoed Mr. Heron's statements and denied that there were raw beet-sugars containing so little ash as 0·05 per cent., and consequently could not be inverted by Wohl's process. The so-called "crystals" with a content of ash varying from 0·05 to 0·07 per cent. was a distinct type of a sugar which was imported in very large quantities into this country. He could not understand what Mr. Briant meant by an average raw beet. Roughly, raw beetroot-sugar could be divided into crystals, 88 per cent., 75 per cent. and molasses, all of them well-known grades in the sugar market. Any amount of beet "crystals" could be obtained on the English market, and contracts could be made for practically any amount six or nine months ahead at the present time at £14 10*s.* per ton. Mr. Tanqueray had made some remarks about analyses and the interpretation of results, and they knew that was a point upon which he felt rather strongly, and rightly so, because, as Mr. Chapman had pointed out, in many things which chemists had to analyse for the brewer it was undoubtedly very difficult to interpret such results from the brewer's point of view; this, however, was due to want of knowledge and inexact methods. But with sugar it was altogether different. Sugar analysis was on a very well-defined basis. Mr. Tanqueray also said that the use of such sugars as he had advocated was too dangerous, but his (the author's) reply was "nothing venture nothing win." It was not an extremely difficult thing to carry out such experiments as he suggested, and they could settle once for all whether it was worth doing.

Mr. TANQUERAY said he did not think two or three or even twenty experiments would be of any use. You must try it for a year before you could tell.

Mr. BAKER, continuing, said he could not agree with that view, which was opposed to the very foundation of all sciences. Dr. Thorne also denied that it was easy to obtain sugar such as he had described in large quantities. All he could say was, that it could be obtained if you went to the right people. With regard to the production of levulinic acid, if the inversion was carried to the ultimate issue all sorts of undesirable products were obtained, but the inversion should

be stopped before such bodies were formed. That was only a side issue. Many of these primings contained quite a large proportion of the unfermentable substances he had referred to. Dr. Thorne also said it would be extremely dangerous to add the quantity of acid, such as he suggested, to a gyle of beer; but his analysis worked out to an acidity of 0·06 per cent. of hydrochloric acid per ton of sugar, assuming the ash of the sugar in no sense neutralised it. This acidity had then to be distributed throughout the length of the gyle, so that the resulting acid was a negligible quantity. With regard to the yeast process, Dr. Thorne said it would be very bad to let the yeast run into the copper. Now, the quantity was not very great. Roughly speaking, it was between 1 and 2 per cent., which, on a ton of sugar, would not amount to a great deal, and could hardly be a serious objection. He knew one brewery well where this process was carried out, and they put their yeast into the copper and thought the results highly satisfactory. Mr. Chapman said in his experience he had come across the use of raw beets, and although there was at no time a crisis, yet the results of the experiments were not satisfactory. He understood that Mr. Chapman admitted that the sugar which was used for the purpose was not of so high a grade as he had indicated in the paper, so that he hardly considered it a fair comparison.

Mr. CHAPMAN said his point was that the brewer would not go to all this trouble unless he could make some very distinct saving, and if he had to buy these very highly refined sugars, where was the inducement? On the other hand, if he bought something cheaper, all these things happened.

Mr. BAKER said these crystals were cheaper, and it was possible to prepare invert sugar from it at a less cost than brewers at the present day paid; in fact, that was the *raison d'être* of the present paper. The criticisms had been very much against the idea, and he had anticipated that, for he knew he was tilting against strong interests. The discussion really centred round one point only, viz., the danger of using beetroot-sugar. The speakers seemed to have gathered their most unsatisfactory experiences from the low-grade beetroot-sugars tried in breweries when beetroot-sugar was a new thing in this country. Sugars were tried then which no one would dream of using now, and he emphatically protested against the argument that because inferior beetroot-sugar had caused trouble,

therefore invert sugar prepared from high-grade "crystals" would behave similarly. Such argument was not logical, and he ventured to think that the considerable saving which could be effected was worth a trial before the process was simply condemned by word of mouth.

Mr. JOHN HERON said there seemed to be some misunderstanding as to what was raw and what was refined sugar. He begged to refer them to a paper which he read before the Society some years ago in which he gave the definition.*

Mr. BAKER said he was sorry he could not accept Mr. Heron's definition.

The PRESIDENT, in proposing a vote of thanks to Mr. Baker, said he might refer to a point which had been raised by a member in a letter, which there was not time to discuss, on the subject of extracts from the brewer's chemist's point of view which was debated at the last meeting, and the suggestion contained in the letter was that steps should be taken to obtain information. Mr. Tanquerary had the question very much at heart, and the answer to the letter was that Mr. Tanquerary was going to move for a committee on this subject which would bring the matter to a head. He was sure they would all agree in thanking Mr. Baker for his interesting paper, and also the gentlemen who had taken part in the discussion.

* Since the paper was read I have referred to Mr. Heron's definition of raw and refined sugar (this Journal, 1896, **2**, 461), which is one I can endorse; it in no way controverts any statement made in this paper.—J. L. B.