THE ANALYSIS OF CONDENSED MILK.

BY J. BRISTOWE P. HARRISON, F.I.C.

STRICTLY speaking, this paper should have been entitled "The Analysis of Sweetened Condensed Milk," for as the examination of unsweetened condensed milks is only a matter of dilution and the employment of the ordinary methods of milk analysis, there is little more to say about the analysis of milks of this class.

The usual determinations in the complete analysis of sweetened condensed milks are: Total solids, ash, fat, proteids, cane and milk sugar.

The contents of a tin having been turned out into a basin or other suitable vessel, the sample is thoroughly mixed by means of a glass rod. About 75 grammes are weighed out into a beaker, enough water added to bring the whole into solution, and then raised to the boiling-point with continual stirring, to prevent burning. The whole is then cooled and made up to 250 c.c. in a graduated flask. The boiling is absolutely essential to destroy birotation of the milk-sugar, which, as I shall describe later, is estimated polarimetrically. We have now sufficient of a 30 per cent. solution to effect a complete analysis, and, as the concentration of condensed milk is usually about three times that of ordinary milk, the solution will roughly approximate in composition to cow's milk containing a certain amount of added sugar. A determination of the specific gravity at 60° F. of this solution should now be made either by means of a Sprengel tube or specific gravity bottle, and the factor found which will be necessary in calculating the percentage of each constituent.

If x = number of grammes of condensed milk diluted to 250 c.c.,

y = the weight of solution used in the determination of any constituent, the percentage of any constituent in the original milk is found by multiplying the weight of that constituent obtained on y grammes of the solution by the factor:

$$\frac{250 \times 100 \text{ specific gravity}}{xy}.$$

Total Solids and Ash.—The most satisfactory method of estimating the total solids is by drying on asbestos, whereby constancy can be obtained in five or six hours. The bowl of an ordinary platinum milk dish is packed fairly closely with pieces of teased-out asbestos not greater than 3 inches in length. The whole is then strongly ignited (preferably in a muffle) for about five minutes, and weighed. Five grammes of the diluted milk are weighed on to the asbestos, dried for two hours on the steam bath, and finally for three or four hours in the water oven. If the drying is done in an ordinary platinum milk dish without asbestos, constancy can only be obtained after twenty to twenty-four hours. By using the flat porcelain dishes now largely employed for the estimation of total solids the drying can be accomplished in eight or nine hours. The ash is obtained by igniting the residue at a dull red heat in the muffle.

Fat.—Five grammes are placed on an extracted coil, and the fat estimated by Adams' method. Pearmain and Moor (ANALYST, xx., 270) have pointed out that this is the most reliable way of estimating the fat in condensed milk, and my experiments go to confirm their statement. Ritthausen's method of extracting the precipi

tated fat and proteids with ether has also been recommended, but the following results obtained in collaboration with Mr. J. A. Goodson show that this method leaves much to be desired, which is the more remarkable seeing that it is completely applicable in the case of fresh milk.

	J. B. and P. H. Precipitate obtained by Acetic Acid.	J. A. G.		J. B. and P. H. Adams' Process.
		Acetic Acid Precipitate.	Copper Sulphate Precipitate.	
Time of extraction ...	1½ hours.	2½ to 5 hours.	5 hours.	3½ hours.
Percentage of fat ...	7.79	9.05 to 9.57	9.75	10.47

The Gerber process can be applied with considerable accuracy in the fat estimation, the results being usually a trifle high. The fat, however, does not separate at once, but requires two or even three "whirlings" before the full amount is obtained. The Gerber bottles are graduated, so that each large division on the stem represents 1 per cent. by weight of fat on 11 c.c. milk of average specific gravity 1.032. Supposing 77.12 grammes condensed milk diluted to 250 c.c. had a specific gravity of 1.069, and that 11 c.c. of this solution yielded 3.5 large divisions of fat, the necessary calculation would be :

$$3.5 \times \frac{1.032}{1.069} \times \frac{250 \times 1.069}{100} \times \frac{100}{77.12} = 11.70 \text{ per cent.}$$

Proteids.—Five grammes of the solution are weighed out into a flask and the nitrogen determined by the Kjeldahl process. Multiplying the percentage of nitrogen by 6.38, we obtain the proteids.

THE ESTIMATION OF CANE AND MILK SUGAR.

Milk-sugar in condensed milk is generally estimated either by Fehling's method or some modification of it. Cane-sugar is often determined by difference; that is, by subtracting the sum of the other ingredients from the total solids. Estimations by difference are always obviously unsatisfactory, because an assumption has to be made that the difference is due only to one constituent, whereas it may be accounted for by two or more substances. Under certain circumstances, however, the cane-sugar has to be determined exactly, and several processes more or less satisfactory have been devised to this end. These may be said to depend on three different principles, viz. :

1. The determination of the difference in reducing power before and after inversion.
2. The determination of the difference in specific rotatory power before and after inversion.
3. The determination of the specific rotatory power given by the two sugars, and subtracting that due to the milk-sugar as calculated from the reducing power without inversion.

Each of these principles has its own peculiar advantages, but the determination of the difference in specific rotatory power before and after inversion seemed to me the best, both in point of time and accuracy. In this respect Kjeldahl's idea of inversion by the action of invertase is highly recommendable. The method is rather

elaborate, however, and involves keeping the solution for several hours at a definite temperature. Something much quicker and simpler seemed to me desirable, and the more rapid inversion of the cane-sugar by means of an acid suggested itself. The acid used, however, must be such as to secure complete inversion of the cane-sugar without affecting the milk-sugar. Stokes and Bodmer had shown that citric acid was a suitable agent for this purpose in the estimation of cane-sugar in presence of milk-sugar by means of the Fehling method, and I determined to find how far such an agent was applicable for use with the polarimeter.

Experiments on the Inversion of Cane-sugar by Citric Acid.

Having proved that a solution containing a normal weight of cane-sugar (16.29 grammes per 100 c.c. for the Laurent instrument) was completely inverted by heating with 3 per cent. citric acid for twenty minutes in a boiling water-bath, I then found that the same result could be accomplished with 2 per cent. As there was no particular object in further reducing the quantity of citric acid used, I decided to make experiments with 2 per cent. in order to ascertain the inversion figure for a normal solution. The exact manner of carrying out the inversion was as follows :

One gramme of finely-powdered citric acid was weighed out into a clean, dry conical flask of about 100 c.c. capacity. Fifty c.c. of the normal sugar solution were then introduced, and the whole weighed on a balance turning to 0.02 gramme. The acid solution was placed in a briskly boiling water-bath, and kept there for exactly twenty minutes. The flask and its contents were then cooled, reweighed, the amount of water lost by evaporation replaced, a correction being also made for the volume occupied by the citric acid. The whole was then thoroughly mixed, filtered, and examined in the polarimeter.

Experiment 1 (twenty minutes' heating).

Solution examined before inversion ... + 99.57 sugar scale degrees.

Average reading on opposite sides of

scale after inversion ... - 30.12 sugar scale degrees.

Temperature of reading 23.5° C.

$$\frac{-30.12 \times 100}{99.57} = -32.25 - 1.75(3.5 \times 0.5) = -32.00 \text{ at } 20^\circ \text{ C.}$$

Experiment 2 (twenty minutes' heating).

Average reading after inversion ... - 31.18 sugar scale degrees.

Temperature of reading 21.5° C.

$$\frac{-31.18 \times 100}{99.57} = -31.31 - 0.75(1.5 \times 0.5) = -32.06 \text{ at } 20^\circ \text{ C.}$$

Experiment 3 (thirty minutes' heating).

Average reading after inversion ... - 30.40 sugar scale degrees.

Temperature of reading 23.0° C.

$$\frac{-30.4 \times 100}{99.57} = -30.53 - 1.5(3 \times 0.5) = -32.03 \text{ at } 20^\circ \text{ C.}$$

These results give a mean value of -32.03 at 20°C. , and further show that there is no object in heating for longer than twenty minutes.

My next concern was to find the best method of removing the proteids and fat. For the sake of uniformity I tried the action of citric acid on fresh milk after the manner of Stokes and Bodmer. For polarimetric purposes this method was not successful, for the proteids were not completely removed, and it was also very difficult to obtain a clear solution. Removal of these substances by acid mercuric nitrate and the subsequent inversion of the cane-sugar by citric acid seemed feasible enough, provided no action took place in the cold between the mercuric nitrate and the sucrose. I therefore decided to put this idea to the test on milk containing a known amount of cane-sugar.

Estimation of Cane-sugar and Milk-sugar in Fresh Milk containing 10 Grammes added Cane-sugar per 100 c.c.

On analysis the milk alone gave the following figures :

Specific gravity, 1.032 . Fat, 4.05 per cent. Milk-sugar, 4.6 per cent.

The volume of the mixture after adding cane-sugar was 106.3 c.c. The proteids and fat were precipitated in 100 c.c. of the mixture by adding 3 c.c. of acid mercuric nitrate, prepared according to Wiley's formula (dissolving mercury in twice its weight of nitric acid of specific gravity 1.42 , and adding, after solution, an equal bulk of water).

The filtered solution was examined polarimetrically immediately sufficient to fill a 200 -millimetre tube had been collected. The reading was $16^{\circ} 50' = 16.83^{\circ}$.

One gramme citric acid was added to 50 c.c. of the solution, and the inversion carried out as before. The inverted solution then read $50'$ at 19°C.

The cane and milk sugar are calculated as follows :

Dividing the difference between the two readings before and after inversion by the inversion value for citric acid at 19°C. , as found above, we have :

$$\frac{16.00}{1.3255} = 12.07 \text{ due to cane sugar.}$$

Deducting this from the reading due to both sugars, then

$$\begin{array}{r} 16.83 \\ 12.07 \\ \hline 4.76 \end{array} = \text{reading due to milk-sugar.}$$

Dividing by 1.33 (the factor for a 200 -millimetre tube) gives the amount of cane-sugar per 100 c.c. ; and increasing this value by one-tenth, we get the amount in the total volume of sugar solution (110 c.c.).

$$\begin{array}{r} 12.07 \\ 1.33 \overline{) 9.91} \\ \hline 9.98 \end{array} \text{ per cent. cane-sugar.}$$

Similarly, dividing the reading due to milk-sugar by 1.106, adding one-tenth, and dividing by the specific gravity of the original milk, we have :

$$\frac{4.76}{1.106} = 4.3 \\ 0.43 \\ 4.73 / 1.032 = 4.60 \text{ per cent. milk-sugar.}$$

This and subsequent experiments prove that cane-sugar is not appreciably affected in the cold by acid mercuric nitrate under the conditions named, a point mentioned by J. C. Shenstone (ANALYST, xiii., 223) in a paper on the same subject. In taking the reading before inversion, I would urge the necessity of examining polarimetrically immediately after the removal of the fat and proteids, and may state that "local excess" of the acid reagent, through improper mixing, gave rise to a considerable error on one occasion.

Several experiments were then carried out on fresh milk containing added cane-sugar, with the idea of shortening the time of inversion. It was found that this could be reduced by at least ten minutes. On repeating the inversion by citric acid on a normal sugar solution, however, I found that the time could not be materially shortened, and could only draw the conclusion that, in the case of milk containing added sugar, the excess of acid mercuric nitrate after removing the proteids and fat was aiding the citric acid in its action. The idea of leaving out the citric acid altogether, if possible, and using mercuric nitrate alone, suggested itself as simplifying matters, and experiment proved that not only was this the case, but that the inversion was complete in seven minutes.

The Inversion of Cane-sugar by Acid Mercuric Nitrate.

The inversion values with 1 c.c. acid mercuric nitrate on 50 c.c. normal sugar solution in seven minutes were obtained, corresponding to those found by the action of 2 per cent. citric acid. The values found in three experiments were: -32.77, -32.55, and -32.53 at 20° C.

The presence of milk-sugar had apparently no appreciable effect on the value, for on substituting a solution containing 13 grammes of cane-sugar (99.7 per cent.) and 5 grammes milk-sugar (100 per cent.) per 100 c.c.—which approximates to the conditions obtaining in a 30 per cent. solution of condensed milk—I obtained values of -32.80, -32.70, -32.84, and -32.60. The mean of all these values is -32.68, which is practically identical with the well-known Herzfeld factor—viz., -32.66—and I therefore decided to use his figure in subsequent experiments. Using this value and calculating the amounts of cane and milk sugar per 100 c.c. from the figures obtained in four experiments, they appear thus :

					Cane-sugar.	Milk-sugar.
Experiment I.	..	...	...	...	12.98	4.99
„ II.	...	...	...	...	12.97	5.00
„ III.	...	...	...	...	12.99	4.98
„ IV.	...	...	...	...	12.96	5.01

Another experiment on the action of 1 c.c. acid mercuric nitrate on 50 c.c. of the solution containing the mixed sugars, in which the heating was prolonged to twenty

minutes instead of seven, showed that the inversion was apparently incomplete, which meant either destruction of the lævulose or inversion of the milk-sugar. This shows that the Herzfeld factor can be only employed when the experimental conditions already detailed are strictly adhered to.

Action of Acid Mercuric Nitrate on a Solution of Milk-sugar.

A 5 per cent. hydrated milk-sugar solution was prepared, which gave an angle of 5.25° . After heating 50 c.c. of this solution with 1 c.c. acid mercuric nitrate for seven minutes the reading was 5.25° . Another experiment after twenty minutes' heating gave 5.23° . Therefore, under the conditions necessary for the complete inversion of cane-sugar acid mercuric nitrate has no action on milk-sugar.

Estimation of Added Cane-sugar in Fresh Milk by Inversion with Acid Mercuric Nitrate.

Two test experiments were made up of milk containing certain quantities of added cane-sugar per 100 c.c., the amounts of which were unknown to me.

Experiment I.—I was told that the volume of sugar solution, after removal of the proteids and fat and addition of 10 c.c. water to hasten filtration, was 114.5 c.c.

The figures obtained on polarimetric examination were :

Before inversion	+ 20.05° .
After ,,	= 0.20° at 21.5° C.

These on calculation gave :

	Cane-sugar.	Milk-sugar.
Actual amount added	13.21 grammes	4.71 per cent.
	13.17 ,,	
Difference	+ 0.04 ,,	

Experiment II.—Volume of sugar solution, 103.6 c.c.

On examination the figures were :

Before inversion	+ 21.57° .
After ,,	= 0.28° at 20.0° C.

On working these out I obtained :

	Cane-sugar.	Milk-sugar.
Actual amount added	12.83 grammes	4.63 per cent.
	12.67 ,,	
Difference	+ 0.16 ,,	

The question arose as to whether there was sufficient excess of acid mercuric nitrate contained in the filtrate, after removal of the proteids and fat by the addition of 3 c.c., to completely invert the cane-sugar by heating to boiling for seven minutes, and experiment proved that this was the case. As the result of the foregoing experiments, I have adopted the following method for the inversion of cane-sugar by acid mercuric nitrate, which is, of course, equally applicable in the case of condensed milk :

Fifty c.c. or more of the filtrate are introduced into a clean dry flask of about 100 c.c. capacity, and the whole weighed on a balance turning to 0.02 gramme. The

acid solution is then placed in a briskly-boiling water-bath, and kept there for *exactly* seven minutes. The flask and its contents are then cooled, reweighed, the amount of water lost by evaporation replaced, and the whole thoroughly mixed, filtered, and examined polarimetrically.

Estimation of Cane- and Milk-Sugar in Condensed Milk.

78.48 grammes of the milk were weighed out and diluted to 250 c.c.; the proteids and fat were then removed from 100 c.c. of this solution by the addition of 3 c.c. acid mercuric nitrate. The percentages of proteids and fat found in the original milk were 9.43 and 11.52 respectively; 100 c.c. of the solution contained 31.39 grammes of milk, and the total volume occupied by the fat and proteids was obtained thus:

$$\begin{array}{rcl} \text{Volume due to fat} & 31.39 \times 0.115 \times 1.08 & = 3.90 \text{ c.c.} \\ \text{,, ,, proteids} & 31.39 \times 0.094 \times 0.86^* & = 2.54 \text{ c.c.} \\ \text{Total} & & = 6.44 \text{ c.c.} \end{array}$$

The volume of sugar solution was therefore $103 - 6.44 = 96.56$ c.c.

The solution examined before and after inversion gave:

$$\begin{array}{rcl} \text{Before inversion} & + 21.33^\circ & \\ \text{After ,,} & - 0.55 \text{ at } 23^\circ \text{ C.} & \end{array}$$

Subtracting the two readings and dividing by the inversion value (Herzfeld) for 23° C. , we have:

$$\frac{21.88}{1.3116} = 16.68 \text{ due to cane-sugar.}$$

Deducting this from the reading due to both sugars, then,

$$\begin{array}{r} 21.33 \\ 16.68 \\ \hline 4.65 = \text{reading due to milk-sugar.} \end{array}$$

Dividing the figure for cane-sugar by 1.33 (the factor for a 200-millimetre tube) gives the amount per 100 c.c., which, expressed as percentage on the original milk, appears—

$$\frac{16.68}{1.33} = 12.54 \times \frac{0.9656}{0.3139} = 38.59 \text{ per cent. cane-sugar.}$$

Similarly, dividing the reading due to milk-sugar by 1.106, and applying the same factor, we have—

$$\frac{4.65}{1.106} = 4.20 \times \frac{0.9656}{0.3139} = 12.92 \text{ per cent. milk-sugar.}$$

Assuming the percentage of proteids in condensed milk to be 10, and applying the Gerber process for the estimation of the fat, the estimation of the cane- and milk-sugar can be accomplished in a comparatively short time. For all practical purposes this can be done within a possible error of ± 0.2 on the percentage of the cane-sugar contained, an error of 0.5 per cent. of fat accounting for less than half this possible error, whilst an error of 1 per cent. on the proteids would make no greater difference than ± 0.1 in the percentage of cane-sugar.

* 0.84 is the more correct factor.

On this assumption the usual calculation can be very much simplified, as in Richmond and Boseley's method for the estimation of milk-sugar (ANALYST, xxii., 99), by adding to every 100 c.c. of the solution :

1. A number of c.c. of water calculated by adding to 10.6 a figure equal to the volume of fat and proteids minus 3.
2. Three c.c. of acid mercuric nitrate.

The reading due to milk-sugar, as calculated in the usual way, will give percentages of milk-sugar direct in the solution, and this, of course, has to be brought to percentages on the condensed milk.

Dividing the cane-sugar reading by 1.2, we get the percentage of cane-sugar in the solution, and this is also calculated as percentages on the condensed milk.

The percentage of fat in a condensed milk was found to be 9.5, and a solution was made up containing 30.95 grammes per 100 c.c.

Calculating the combined volume of the fat and proteids :

$$\begin{array}{rcl} \text{Volume due to fat} & \dots & 30.95 \times 0.095 \times 1.08 = 3.17 \\ \text{Volume due to proteids} & 30.95 \times 0.1 & \times 0.86 = 2.66 \\ & & \hline & & 5.83 + 10.6 = 16.43. \end{array}$$

Therefore 13.45 c.c. of water and 3 c.c. acid mercuric nitrate were added.

The following results were obtained polarimetrically :

$$\begin{array}{rcl} \text{Before inversion} & \dots & +18.70^\circ \\ \text{After inversion} & \dots & -0.33 \text{ at } 25^\circ \text{ C.} \\ & & \hline & & 19.03 \text{ due to both sugars.} \end{array}$$

The percentage of cane-sugar was therefore

$$\frac{19.03}{1.3016} = 14.62 / 1.2 \times 0.3095 = 39.38,$$

the percentage of milk-sugar being

$$\frac{18.70}{14.62} \times 0.3095 = 13.18.$$

The following analyses give the composition of three well-known brands of sweetened condensed milk :

	I.	II.	III. (Machine Skimmed).
Water...	25.48	25.04	25.97
Fat ...	11.52	9.58	0.75
Proteids ...	9.43	10.00	10.99
Cane-sugar ...	38.57 $\left\{ \begin{array}{l} 38.68 \\ 38.59 \\ 38.45 \end{array} \right.$	39.40 $\left\{ \begin{array}{l} 39.43 \\ 39.38 \end{array} \right.$	44.72
Milk-sugar ...	12.89 $\left\{ \begin{array}{l} 12.90 \\ 12.92 \\ 12.86 \end{array} \right.$ (13.09 Fehling)	13.06 $\left\{ \begin{array}{l} 12.94 \\ 13.18 \end{array} \right.$	14.07 (14.45 Fehling)
Ash ...	1.93	2.10	2.39
	<hr/> 99.82	<hr/> 99.18	<hr/> 98.89

I am in agreement with Shenstone in questioning whether invert sugar exists in sweetened condensed milk in more than mere traces. The process of condensing employed in the manufacture of the best-known brands is not conducive to the formation of invert sugar. The method of estimating the cane- and milk-sugar polarimetrically before and after inversion, however, takes no account of the presence of invert sugar. The existence of 1 per cent. of this would not influence the percentage of cane-sugar, but would cause the milk-sugar to be estimated 0.4 per cent. too low, the total sugars showing a deficiency of 1.4 per cent. as determined by this method. The percentage of invert sugar can, of course, be determined by combining the polarimeter readings before and after inversion with a determination of the cupric reducing power of the sample, but the experimental errors made in obtaining these values would render the figure obtained of little value.

The Fehling values of the milk-sugar given in the analyses of the condensed milks Nos. I. and III. were obtained by precipitating the proteids by copper sulphate in neutral solution, and estimating the cupric reducing power of the filtrate, using as a blank a solution containing amounts of cane- and milk-sugar approximating as nearly as possible to those in the solution of condensed milk. The difference between the value of No. III. found in this way and that obtained polarimetrically is possibly due to the presence of invert sugar.

DISCUSSION.

The PRESIDENT (Mr. Fairley) said that Messrs. F. W. Richardson and A. Jaffé, in a paper which they read in January before the Yorkshire section of the Society of Chemical Industry, had described a scheme for the estimation of cane-sugar and lactose in milk, etc., and he had drawn attention at the time to the special advantages of methods which did not need the destruction of any great amount of the substance worked upon. That might be repeated here, though he was afraid that the inversion processes employed by Mr. Harrison might involve some loss of substance.

Mr. RICHMOND said that a large number of careful experiments had been made by Mr. Harrison in order to work out the best conditions for the inversion and estimation of the cane-sugar. The times of heating calculated to give the most reliable results had in particular been ascertained by a large number of trials, and these times must not be departed from. The figures 13.09 and 14.45 for the milk-sugar in samples Nos. 1 and 3, as determined by Fehling's solution according to O'Sullivan's method, in each case were a little higher than that shown by optical methods. The fact that the analyses all added up to less than 100 seemed to indicate some small inversion of the cane-sugar, which would raise the apparent milk-sugar by Fehling's solution, and would be altogether in accordance with the results. The inversion of cane-sugar by citric acid was probably not complete, and the "Herzfeld value" of 132.66 really only indicated the point of equilibrium in the presence of 10 per cent. of hydrochloric acid. Probably also, with both citric acid and acid mercuric nitrate the stage at which the quantity of cane-sugar, dextrose, and lævulose is in equilibrium is not complete inversion. Possibly the equilibrium

would reach the same point with the free nitric acid from the acid mercuric nitrate as with the hydrochloric acid.

Mr. A. R. LING said he presumed the object aimed at was to choose an acid which would invert the cane-sugar to a maximum and the milk-sugar to a minimum, but he very much doubted whether even the citric acid fulfilled both these conditions. Since very few yeasts hydrolysed milk-sugar, it would be interesting if Mr. Harrison would try the physiological method of determining that sugar in presence of a fermentable sugar, employing ordinary *Saccharomyces cerevisiae* to ferment away the latter, as it would, at any rate, afford a means of corroborating his very interesting results.

Mr. MOOR congratulated the author on the successful result of what must have been a very great deal of work. He (the speaker) was glad to find that the Adams method had proved satisfactory, because it seemed to be the only one that could be easily used. The Werner-Schmid method had the disadvantage that a great deal of black matter was formed, while with the Gerber, Leffmann-Beam, and other forms of centrifugal apparatus there was a great quantity of fluff formed which interfered with the reading; so that the Adams process appeared to be the only satisfactory one. He had no doubt that the sugars were much more accurately estimated by the optical method described than by that of Pavy, but surely the Pavy process was very much more simple to use, and if one employed that method it was not necessary, as far as his experience went, to remove the proteids. If one worked with a 10 per cent. solution, 10 c.c. of that diluted to 100 c.c. with about equal parts of ammonia and water could be run into the Pavy solution, and in a short time a fairly accurate estimation of the milk-sugar was obtained. The proportion of cane-sugar could then be obtained with fair accuracy by deducting the other constituents from the total solids. He was interested to note that one of the samples of which the analytical results were given contained only 1.93 per cent. of ash, as he had been taken to task because out of a large number of figures which he had obtained for ash in condensed milk some fell below 2 per cent., and it was thought that there was some mistake. The ash of ordinary milk condensed in the proportion of 3 : 1 would be 3×0.75 , but it would very often be found that the ash of condensed milk, owing to coagulation, was not equally distributed through the bulk, so that the milk in one tin might contain more ash than that in another. He would much like to hear whether anyone present had heard of any new preservative for condensed milk. He had recently met with some samples which would keep almost indefinitely, but he had been quite unable to find any preservatives at all in them, though he had tested for all the ordinary substances used for the purpose.

Mr. CHAPMAN said it seemed to him that what was really needed was not so much a scientifically exact method as a simple and rapid one, that should be sufficiently accurate for the purpose of the examination of samples taken under the Sale of Food and Drugs Acts. He had made a number of experiments at various times for the purpose of ascertaining whether the method of Stokes and Bodmer could be relied on, having added to milks containing estimated quantities of lactose known quantities of cane-sugar, and he had always obtained results which were quite satisfactory. He must confess that as the result of his experience he did not

find himself able to attach that importance which Mr. Moor attached to the method of Pavy. He presumed that in Mr. Harrison's determinations the milk-sugar was calculated as monohydrated milk-sugar. If it were calculated as the anhydrous sugar it would make an appreciable difference on a 5 per cent. solution.

Mr. HEHNER agreed that the Adams method, judiciously employed, was the only really reliable one for the determination of fat in condensed milk. He thought, however, that the *modus operandi* of Mr. Harrison might be usefully modified by extracting a larger quantity on two or three coils, and if there was any suspicion that the extraction was not complete, owing to the presence of the large amount of cane-sugar, steeping the extracted coils in water to dissolve out the sugar, and then, after drying, extracting with ether once more. A small further quantity of fat, as a rule, would be obtained in this way. Centrifugal methods seemed incapable of yielding sufficiently accurate results. Mr. Harrison had mentioned an instance in which 3.5 divisions corresponded to 11.7 per cent. of fat, 1 division, therefore, corresponding to 3.4 per cent. of fat. This would altogether place such a method outside of the range of accurate methods for this purpose. He would also suggest that inversion by means of acid mercuric nitrate in an aqueous solution was on a different footing from inversion by the same agent in the case of milk. The mercury precipitated the casein and other albuminoids, and it seemed probable that the inversion was not the result of the action of the acid mercuric nitrate as such, but was virtually brought about by the action of dilute nitric acid. He thought it was too much to expect that the analyses should sum up to 100. There were other substances in milk beyond those which were usually determined. The ash, for instance, was present, not as ash, but was the residue of something the exact nature of which had not been determined. Many years ago he had investigated Pavy's method, and he found that, although under constant conditions it was capable of yielding comparable results, yet it was so largely affected by any variation in the conditions of working that it could hardly be classed among exact methods.

Mr. CHAPMAN remarked that Mr. Richmond had alluded to the very important influence (frequently overlooked in the treatises on the subject) which the inverting agent exercised on the optical activity of the invert sugar produced. In almost all cases a definite number was taken for this, but, as a matter of fact, it depended upon whether hydrochloric acid was used and was present at the moment of observation, or whether citric acid or any other inverting agent was used. This was not merely an academic matter, the variations being sometimes sufficient to affect the results appreciably.

Mr. HARRISON, in reply, said that he was very much indebted to Mr. Richmond for valuable assistance in this work, and also for his kindness in allowing it to be carried out in the laboratory of the Aylesbury Dairy Company. With regard to Mr. Ling's remarks, he was quite of opinion that, theoretically, the process of fermentation by means of yeast was an admirable one, and remarked that some years ago he had tried the process of inversion by yeast by keeping the sugar solution to which yeast had been added for five hours at 55° F., but had only succeeded in getting about 80 to 90 per cent. of the cane-sugar inverted. Although he had found that the Gerber process gave results somewhat too high, which was, of course, only

an approximate method, his experience did not confirm that of Mr. Moor as to the presence of fluffy matter about the meniscus. One very great objection to Pavy's method was the necessity of conducting the ammonia fumes out of the laboratory. The determination of ash referred to in the paper had been made by heating in a muffle, which, in his experience, was the only way in which this determination could reliably be made. The ash in condensed milk should be in much the same ratio to the proteids and milk sugar as in ordinary milk, and the results now given were not far divergent from this. He was quite aware that the reaction which took place when inversion was carried out by acid mercuric nitrate was rather complex, but the method had certain practical merits, the principal of which was that it enabled the estimations of cane-sugar and milk-sugar to be made in about a couple of hours, whereas processes in which yeast or invertase was used required a much longer time. With relation to Mr. Hehner's excellent suggestion as to a second extraction of the Adams' coils after dissolving out the sugar with water, it was pointed out that the thereby increased results of the Adams process would cause those of the Gerber process to be in closer agreement, as these he had generally found to be about 0.2 per cent. higher. In reply to Mr. Chapman's question, *monohydrated* milk sugar was used in the test experiments.