the (somewhat wide) limits of experimental errors, that *the solubility of lead iodide is diminished both by potassium iodide and by lead nitrate in such a way that the product of the concentration of the lead ions into the square of the concentration of the iodine ions remains constant.*

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,
JANUARY, 1898.

GLUCOSE IN BUTTER.[1]

By C. A. CRAMPTON.

Received January 22, 1898.

I have been unable to find, in the literature of food products or of food adulteration, any reference to the use of glucose or other form of sweetening material in butter. The nearest approach to it is the mention of starch by some of the German authorities as among the possible adulterants. In domestic practice, however, the addition of sugar to butter for purposes of preservation is doubtless almost as old as the art of butter-making itself, sugar and salt being the standard household preservatives for food products from time immemorial. But the use of sugar in this way is comparatively rare, salt being universally preferred as a preservative for this food product as it is for most products of animal origin. Sugar appears in several of the various U. S. Patents for so-called "improving" or renovating processes for butter, being added to it along with salt, saltpeter, and, in some cases, sodium carbonate. The sugar is usually in small quantity in these formulas, perhaps an ounce to eight pounds.

Within the past few years glucose has been used in butter specially prepared for export to tropical countries, as the West Indies or South America. The hot climate of these countries renders its preservation very difficult. It is usually put up in tins and various means are resorted to by the dealers in different nations who export to them for preventing the decomposition of their goods before they reach the consumer. Very large quantities of salt are used by the French exporters. I give below the figures obtained from the analysis of two samples of French butter, as exported, the one to Brazil, the other to the Antilles:

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[1] Read at the Washington meeting, December 30, 1897.

	No. 2436. Butter "a la Morlaix" as exported to Brazil.	No. 2437. Butter "a la Morlaix" exported to the Antilles.
Water	10.29	10.19
Curd	1.24	1.31
Ash	10.29	10.06
Fat	78.18	78.44
	100.00	100.00
Figures for Fat.		
Specific gravity at 40° C	9107	9112
Koettstorfer value	227.2	227.3
Reichert-Meissl figure	28.4	29.4

Chemical antiseptics, borax, salicylic acid, etc., are sometimes used, but the method found most efficacious by exporters in this country, so I am informed, is to use glucose in conjunction with a moderately heavy salting. I give below the figures obtained from two samples prepared in this way and exported to Brazil. One of these, No. 2443, has traveled twice across the equator and remained in my refrigerator since its return last August. While it is not exactly attractive to taste or smell, it is still possible to remain on speaking terms with it, which seems to be pretty good evidence of the effect of the glucose upon its keeping qualities.

I have inserted here also the analysis of a sample of so-called *beurre rouge*, or red butter, as exported to Guadeloupe. This is a very peculiar compound, highly colored, and contains large quantities of salt and glucose.

	No. 2434. Butter exported from the United States to Brazil.	No. 2443. Butter exported to Brazil and returned to the U. S.	No. 2460. *Buerre rouge* exported to Guadeloupe.
Water	16.29	18.93	21.60
Curd (N × 6.25)	1.19	1.06	0.81
Ash	7.00	6.19	16.42
Fat	72.16	69.67	51.15
Glucose (by difference)	3.36	4.15	10.02
	100.00	100.00	100.00
Figures for Fat.			
Specific gravity at 40° C.	9093	9090	9080
Koettstorfer value	225.4	225.5	228.1
Reichert-Meissl figure	27.2	25.4	26.4

Through the kindness of a firm of butter exporters I obtained a sample of butter as purchased by them in western markets, and a sample of the same butter prepared for export by admixture of glucose, salt, and coloring-matter.

Following are the results obtained from these samples:

	No. 2445. Butter purchased in western markets.	No. 2446. Same prepared for export by admixture with glucose and salt.
Water	10.97	17.03
Curd (nitrogen × 6.25)	1.31	0.94
Ash	2.56	8.49
Fat	85.08	70.59
Glucose (by difference)	0.00	2.95
	99.92	100.00
Figures for Fat.		
Specific gravity at 40° C	9114	9110
Koettstorfer value	228.4	227.9
Reichert-Meissl figure	29.6	29.4

I also obtained a sample of the glucose used. It is the heavy, low converted sirup known as confectioners' glucose. It contained 16.5 per cent. of water, and gave $[\alpha]_D = 119.3$; $R = 43.10$.

The detection of glucose in butter presents no difficulty. In making the analysis of a butter containing it by the ordinary method of extracting the fat with ether, weighing the residue, incinerating and determining the curd by the loss on ignition, the presence of the glucose would be manifest by an abnormally high curd, as both would be burned off together. This is shown by the figures obtained in this way for curd in the four samples given above, as compared with the results obtained from the nitrogen determination. In the case of 2445, containing no glucose, the results by the two methods closely agree.

Number.	Percentage of curd obtained by usual method.	Percentage of curd obtained by (N × 6.25).
2434	4.55	1.19
2443	5.21	1.06
2445	1.39	1.31
2446	3.89	0.94
2460	10.83	0.81

In making a direct demonstration of the presence of glucose, I have used the method of washing it out with hot water, in the manner first recommended by Wiley for the direct estimation of salt in butter and now used by the Association of Official Agricultural Chemists as an official method. Ten grams of the butter are weighed out in a beaker, transferred with hot water to a separatory funnel, where it is treated with successive portions (twenty to thirty cc.) of hot water, and the resulting solution made up, when cooled, to 250 cc.

A slight reduction of copper by this solution must not be taken as a qualitative proof of the presence of glucose in the butter, being due to the small amount of milk sugar present or perhaps to a reducing action by some of the albuminoids. Any considerable precipitation of Fehling's solution, however, may safely be ascribed to the presence of glucose or sugar, and the copper oxide reducing strength of the solution can be readily ascertained. The optical rotation may also be determined, the solution being readily clarified by means of alumina cream or by acid mercuric nitrate solution. The determination of salt can, of course, be made in the same solution, if desired.

In the previous analyses I have given the percentages of glucose as calculated by subtracting the sum of the water, ash, and fat from 100. The figures obtained in this way are not very exact, as the ether removes some of the glucose with the fat, making the figure for the latter too high, and for the former too low. I give below the percentage of glucose in each sample on the assumption that the same kind of glucose was used in Nos. 2434, 2443, and 2460, that I know to have been used in No. 2446, and calculating the figures from both the reducing and rotatory power.

Number.	Percentage of glucose calculated on basis of reducing power.	Percentage of glucose calculated on basis of rotatory power.
2434	5.57	5.64
2443	6.50	6.45
2446	5.10	5.24
2460	13.58	13.30

The relative quantities of butter, salt, and glucose used in No. 2446 were given to me by the manufacturer, as follows: 712 pounds of butter, 50 pounds of salt and 55 pounds of glucose. This would make the content of glucose 6.70 per cent. but it is apparent that considerable water was added as well.

Evidently the direct figures obtained above are much nearer the truth than the results obtained by difference. If the composition of the glucose is not known it could probably be worked out by the formula of Brown, Morris, and Millar.[1]

Butter No. 2443 was condemned by the customs authorities in Brazil, not on account of the presence of glucose, which seems to have escaped the notice of the analyst entirely, but on account of the low figures obtained from the fat, upon which was based a decision that it contained oleomargarine. The Reichert figure is low, but not sufficiently so, in my opinion, to justify the assertion that it was not butter fat. It is not to be presumed that the addition of the glucose would have any influence upon the fat, and the figures obtained in the case of Nos. 2445 and 2446 seem to prove conclusively that it does not.

I have had but few opportunities to examine domestic butters for the presence of glucose and have not found it as yet in any of the samples at hand. Its presence would be most likely, of course, in butters which had been subjected to reworking or renovation. In addition to its preservative action, the glucose probably acts mechanically to hold the large water content of the butter, enabling it to retain more than it otherwise would.

I will not attempt to discuss here the question as to whether or not the addition of glucose to butter constitutes an adulteration. It might be said to admit of some argument, however, as there does not seem to be any good reason, except custom, for preferring salt to sugar as a preservative for butter. Such butter could hardly be considered as coming within the scope of the national law known as the " Oleomargarine Law" as it would in no sense answer the definition of oleomargarine in that law.

DISCUSSION : *G. E. Patrick.*—I should like to know how the author accounts for the very great difference between the figures obtained in the glucose by incineration and that obtained by the direct method.

C. A. Crampton.—By the faulty method of fat determination, I have no doubt the ether takes out some glucose.

G. E. Patrick.—Would not petroleum ether be a better solvent ?

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[1] *Chem. News.*, 75, 42.

C. A. Crampton.—The suggestion seems to be a good one. I have no doubt it would dissolve less glucose.

In reply to Mr. Elworthy, who stated that butter was now preserved in India on a large scale by the addition of salt only, in hermetically sealed cans, and kept for six or seven months, and who asked whether the figures given were for dry glucose, Mr. Crampton said that the glucose was calculated on the supposition that the same kind of glucose, "confectioners' sirup," had been used in all cases.

A METHOD FOR DETERMINING THE RESISTANCE OF ELECTROLYTES.

By Parker C. McIlhiney.

Received January 10, 1898.

THE method commonly used for determining the resistance of an electrolyte is that of Kohlrausch, in which the resistance to be measured is made one arm of a Wheatstone bridge, while the current is an alternating one supplied by an induction coil and the balance is determined by a sensitive telephone instead of the galvanometer used in ordinary measurements. It is a zero method capable of a high degree of accuracy, but it is not very rapid and readings can not be taken at short intervals of time.

The method to be described does not lay claim to so high a degree of accuracy, as it is limited by errors in a galvanometer and by changes in the electromotive force of a battery during an experiment, but it is believed to have some advantages in the possibility of making many readings in a short space of time.

It consists briefly in determining by a galvanometer, preferably a d'Arsonval, the potential difference between the ends of a known resistance placed in series with the resistance to be determined. The current is supplied by a gravity battery and before passing through the electrolyte it is transformed into an alternating current by means of a rotary pole changer, but the current passing through the known resistance is direct.

When a current passes through two resistances in series the fall of potential in each of them is proportional to its resistance.

In Fig. 1, let R be a known resistance, R′ be another known resistance, which may be replaced by the unknown resistance X.