method, as the former is the commercial method, and the only one used for extracting edible oils. For extracting the oil a cylindrical press was constructed by using an iron cylinder with an inside diameter of $3\frac{1}{4}$ inches and a height of 7 inches into which was fitted a close-fitting piston. The cylinder was set on an iron plate perforated with several $\frac{1}{8}$ inch holes, and holes were drilled in the cylinder near the lower end to facilitate the running out of the oil. When hydraulic pressure was applied to the piston the oil exuded from the holes and collected in a metal pan in which the press had been placed. A pressure of 150 to 300 atmospheres was applied to the piston. A second pressure was applied to the material after breaking up the press cake and heating the press and the press cake to 50–60° C. The following table shows the yield of oil from the various samples, the total per cent of oil present, and the actual per cent of oil extracted:

TABLE II

Kind of sample	Yield in per cent	Total per cent of oil present	Per cent of oil present extracted
<i>C. Ovata</i> —Whole, cracked, cold-pressed.....	15.8	26.5	59.5
Hot-pressed.....	2.0	..	7.5
<i>C. Ovata</i> —Meats alone cold-pressed.....	30.6(a)	70.2	42.7
Hot-pressed.....	17.5	..	23.2
<i>C. Amara</i> —Whole, cracked, cold-pressed.....	22.1	..	..
Hot-pressed.....	3.8	..	..

(a) Only 100 atmospheres pressure.

The oils, as at first obtained, were cloudy, and the hot-pressed were darker than the cold-pressed. After filtration through filter paper the oils became bright and clear, and were of the appearance and consistency of Italian olive oil. They possessed an agreeable hickory nut odor and flavor.

The following table gives the constants as obtained from both these oils and for comparison those obtained at the Maine Experiment Station.¹

TABLE III—CONSTANTS OF HICKORY NUT OILS

	<i>C. amara</i>	<i>C. ovata</i>	Maine Expt. Sta.
Specific gravity at 24° C.....	0.9119	0.9119	0.9164
Refractive index at 20° C.....	1.4699	1.4699	1.4696
Hegner number.....	95.6	95.7	
Reichert-Meißl number.....	0.48	0.47	
Iodine value.....	105.2	106.8	102.8
Saponification value.....	190.0	189.6	

The similarity of the two oils is very evident. Perhaps the most important factor for comparison of the different classes of oils is the iodine value, for this is a measure of the unsaturated glycerides present, and thus determines whether the oil is drying, semi-drying or non-drying. The iodine value here obtained for hickory nut oil seems to classify it with the semi-drying oils. Here belong cottonseed oil, corn oil, rape seed oil, Brazil nut oil, and beech nut oil. In the following table is shown a comparison of constants of hickory nut oil with those of cottonseed oil and those of the non-drying oil, *viz.*, olive oil.

These figures show that hickory nut oil resembles very closely cottonseed oil, and would be difficult to distinguish from it.

The hickory nut oil is very agreeable as a salad oil,

¹ *Loc. cit*

TABLE IV

	Hickory nut oil	Cottonseed oil	Olive oil
Specific gravity.....	0.9119 at 24° C.	0.9203 at 19° C.	0.9100 at 24° C.
Refractive index.....	1.4699 at 20° C.	1.4748 at 15° C.	1.4670 at 20° C.
Iodine value..	106.0	106.0	82.0
Saponification value.....	190.0	192.0	190.0
Reichert-Meißl number.....	0.48		0.6
Hegner number.....	95.7	95.6	95.4

so that if it can be obtained at a sufficiently low cost, it can be used for this purpose. The *C. amara* or the *C. porcine* (pig nut), which are now considered as absolutely of no value, would yield at least a gallon and a half of oil per bushel and the nuts need only be crushed before they are pressed.

SUMMARY

- I. The food value of hickory nuts is high.
- II. The oils from the two species of hickory nuts, *C. ovata* and *C. amara*, are practically identical and are similar to cottonseed oil.
- III. The oil retains the flavor of the hickory nut, and is practically equal to olive oil.
- IV. The possibility of extracting the oil on a commercial basis should be further investigated.

CHEMICAL LABORATORIES
UNIVERSITY OF KANSAS
LAWRENCE

THE ANALYSIS OF MAPLE PRODUCTS I

AN ELECTRICAL CONDUCTIVITY TEST FOR PURITY OF MAPLE SYRUP¹

By J. F. SNELL

The most commonly used adulterant of maple sugar is granulated sugar, which is, of course, chemically identical with the predominating constituent of the pure material. For the detection of such adulteration we are dependent upon measurements of the small quantities of the non-sugar constituents, the percentages of which in the syrup are necessarily decreased by the addition of the practically pure sucrose, together with the proportional quantity of water necessary to convert it into a syrup. The ash, the soluble and insoluble ash, the alkalinities of these, the malic acid value, and the amounts of precipitate produced by lead subacetate and by normal lead acetate are alike lowered by such adulteration, though not necessarily in proportion to the amount of adulteration.²

Sucrose being a non-conductor of electricity, and the salt constituents conductors, it is reasonable to

¹ This test was described at the Washington meeting of the American Chemical Society in December, 1911, but publication was deferred until further experiments could be made, particularly (1) upon the effect of adulteration on the conductivity value and (2) upon the relation between the conductivity of the syrup and that of its ash solution. This later experimental work has been carried out under my direction by Mr. J. M. Scott, to whom my thanks are due for very competent assistance. This assistance was rendered possible by the Dominion Government Grant for the Advancement of Agriculture. Through the courtesy of Prof. Frank T. Shutt, M.A., F.R.S.C., the present paper was read before the Royal Society of Canada at Ottawa, May 28, 1913.

² The effect of such adulteration upon the various analytical values will be discussed in a later paper.

anticipate that maple syrups adulterated with granulated sugar in more than very small quantities will show materially lower conductivities than pure maple syrups. Since with suitable apparatus a measurement of electrical conductivity can be made in a few seconds, a method based upon such a measurement would have a decided advantage in point of rapidity over any of the methods now in vogue.¹

The most rapid methods hitherto proposed have depended upon precipitation with lead subacetate and measurement of the volume of the centrifugally-settled precipitate.² No great delicacy has been claimed for these methods, and even they require more time than a conductivity measurement.

THE CONDUCTIVITIES OF UNDILUTED PURE SYRUP

Measurements of the conductivities of the undiluted syrup have been made upon 43 samples, all of Canadian origin. Eleven pairs of early and late products from the same or adjoining woods were sent me by the makers from various parts of the Province of Quebec in the season of 1911. Thirteen samples from Ontario and six from Quebec, all of the season of 1911, were kindly forwarded by Dr. Anthony McGill, Chief Analyst of the Inland Revenue Department, Ottawa, as fairly representative of the 450 odd samples collected by the Department for the purpose of establishing a standard of purity for maple syrup. Each of these was accompanied by a declaration of genuineness signed by the maker.³

The remaining two samples of the 43 were made from identical sap, one by rapid boiling in a modern evaporator having a corrugated pan, the other in an iron kettle, not entirely free from rust, with very slow boiling.

TABLE I—SUMMARY OF DENSITIES AND CONDUCTIVITIES OF 42 GENUINE CANADIAN MAPLE SYRUPS

	Conductivity	
	Sp. gr. 15° C.	$\kappa \times 10^5$ 25° C.
Mean.....	1.333	18.7
Minimum.....	1.305	9.6
Maximum.....	1.355	33.6
Percentage deviation of minimum from mean....	-2.1	-49
Percentage deviation of maximum from mean....	+1.6	+80

A summary of the variations of the specific gravity and of the electrical conductivity of 42 of these 43 syrups is given in Table I. The syrup omitted from this summary is one of the Inland Revenue Department samples, which was of extremely low density. Its specific gravity was 1.279, its moisture content (according to the analysis made in the Inland Revenue

¹ As long ago as 1889, E. Reichert, *Zeit. anal. Chem.*, **28**, 14 (1899), and more recently, Hugh Main, *International Sugar Journal*, **11**, 334 (1909); *Zeit. Ver. Zuckerind.*, **59**, 783 (1909); *Chem. Abstr.*, **3**, 2249 (1909) and A. E. Lange, *Z. Ver. Zuckerind.*, **60**, 359; *Chem. Abstr.*, **4**, 1554 (1910) have proposed methods of estimating the ash of sugars and syrups from their electrical conductivities. These methods appear to have given good results in the hands of their authors but have been adversely criticized by others—Reichert's, by Fock and Plath, *Zeit. Ver. Zuckerind.*, **39**, 710 (1889); Main's and Lange's, by A. Trenkler, *Oesterr. und Zeit. Zuckerind.*, **39**, 437; *Chem. Abstr.*, **4**, 308 (1910).

² Hortvet, *J. Am. Chem. Soc.*, **26**, 1543 (1904); Bureau of Chem., U. S. Dept. Agr., *Bulletin* **107**, 72; Jones, Vermont Agr. Expt. Sta., *18th Annual Report*, **1906**, 322.

³ See *Bulletin* **228** of the Laboratory of the Inland Revenue Department (1911). The syrups examined were Nos. 184-191, 193-195, 211-214, 263, 278, 281 and 284 of this bulletin.

Laboratory) 38.59 per cent, and its conductivity ($\kappa \times 10^5$) 45.0.

As a general rule, the syrups of high density showed low conductivities and those of low density showed high conductivities. This indicates that in undiluted syrups the concentration of the sugar has more influence upon the conductivity than has the concentration of the electrolyte components.

The syrup made in the iron kettle had a specific gravity of 1.326, and a conductivity of 25.9, while that made from the same sap by rapid, shallow boiling in an evaporator showed a specific gravity of 1.334, and a conductivity of 22.4. This is in harmony with the general rule of lower conductivity accompanying greater density. The minimum conductivity (9.6) was shown by the syrup of maximum density (1.355), while the maximum conductivity (33.6) was found in a syrup of density 1.311.

THE EFFECT OF DILUTION

The results of the above measurements indicate that as the water-content of maple syrup increases, the conductivity increases. In other words, the more dilute the solution the greater the conductivity. This is not in line with the usual behavior of aqueous solutions of electrolytes. In general, the specific conductivity of such solutions decreases with dilution. The thought, therefore, suggested itself that if one continued to dilute maple syrup with water, a point of dilution must eventually be reached at which the conductivity would cease to increase and begin to decrease—a point of maximum conductivity. This proved to be the case, the maximum occurring at a dilution of one volume of syrup to two of water, *i. e.*, in a mixture containing $33\frac{1}{3}$ per cent of syrup by volume, or 39.6 per cent of syrup of normal density (1.320) by weight.

TABLE II—EFFECT OF DILUTION UPON CONDUCTIVITY OF SYRUP

Syrup I		
Per cent maple syrup by volume	Per cent maple syrup by weight	Conductivity value
5	6.6	62
10	13.0	100
20	25.1	147
25	30.9	163
30	36.5	171
$33\frac{1}{3}$	40.1	175
40	47.2	169
50	57.3	153
60	66.8	123
70	75.8	99
80	84.3	63
90	92.3	44
100	100.0	32

Syrup II	
Per cent maple syrup by weight	Conductivity value
20	127
30	141
39.9	148
40	147
60	127
$83\frac{1}{3}$	69
100	26

Table II and Diagrams I and II give results typical of the effect of dilution upon the specific conductivities of maple syrups.

On each side of the point of maximum conductivity there is a considerable range of concentrations, within which the conductivity differs very little from the maximum. This renders it possible to measure the maximum conductivity of diluted maple syrup without observing much precision in making up the mixture of maple syrup and water. This is a point of great practical advantage in relation to the rapidity of the method described below. It is not necessary to weigh the syrup nor to reduce it to a definite density.

An ordinary 25 cc. graduate can be used to measure the syrup, the two portions of water subsequently measured from the same graduate serving to rinse out the syrup which adheres to the sides.

The range of variation of the conductivity of pure maple syrups thus diluted with two volumes of water is much narrower than that of the conductivity of the undiluted syrups. The mean conductivity at 25° C. ($\kappa \times 10^5$) of the diluted solutions of the 42 syrups of Table I was 153, or over 8 times the mean conductivity of the same syrups in the undiluted state. The minimum was 120, the maximum 203, the latter being the conductivity value of the syrup made in the iron kettle. The minimum deviates from the mean by 21 per cent, as against 49 per cent in the undiluted syrup; the maximum by 33 per cent, as against 80 per cent for the undiluted syrup. We have thus a total range of 54 per cent for the diluted as against 129 per cent for the undiluted syrup. The forty-third syrup, omitted from the summary in Table I, on account of its extremely low density and high conductivity, gave a perfectly normal conductivity value (167) when diluted with two volumes of water.

The maximum conductivity, or more strictly speaking, the conductivity of the mixture of one volume of syrup with two volumes of water is, accordingly, made the basis of the method here proposed.

METHOD

Measure out into a small beaker (or directly into the conductivity cell) a suitable quantity (15 cc.) of the syrup, allowing thorough draining. Using the same graduate, add two successive portions of water, each equal in volume to the syrup taken. Mix thoroughly, pour into conductivity cell, bring to 25° C., and make the measurement. Divide the constant of the cell by the observed number of ohms and multiply the result by 100,000.

Genuine syrups have given values of 110 to 200, but further experience may extend these limits a little.¹

Syrups giving conductivity values distinctly outside these limits may be condemned. Those giving normal values are not necessarily pure and should be further examined by well-established tests.

APPARATUS

The essential features of the apparatus are:

1. A low voltage electrical current operating an induction coil.
2. A conductivity cell of a form suitable for liquids of low conductivity, and with electrodes not easily displaced.
3. A Wheatstone bridge with telephone.
4. A device for exact regulation of temperature.

In the present work a Kohlrausch Universal Bridge bearing the name plate of Messrs. Philip Harris & Co., Birmingham, England,² has been used. The induction coil with which this bridge is fitted was operated by two lead accumulators connected in series. A small Deveau telephone was found to give better results than a Bell. With this very convenient bridge and telephone there was no difficulty in obtaining a sharp minimum of sound. The conductivity cell used at first was of the form represented in Fig. 295 (p. 402)

¹ I have collected nearly 130 syrups of the season of 1913, direct from the sugar bushes of Ontario and Quebec and intend determining the limits of conductivity value in these both at 25° and at 20° C.

² No. 7072 in this firm's Physics catalogue, Vol. 1.

of Ostwald and Luther's "Physiko-chemiker Messungen," 2nd edition (1902). Its capacity was about 50 cc. It had electrodes of 2.5 cm. diameter set 1 cm. apart, which maintained their position satisfactorily,

Eimer & Amend, of New York. The platinum electrodes of this special cell are of B. & S. gauge No. 27, and are 3.2 cm. in diameter. They are adjustable as to distance, but are firmly held in position by set-

TABLE III—SYRUPS MADE IN LABORATORY SEASON OF 1912

No.	Date made	Saps	Density 15° C.	Dry matter from density	A Conductivity value	B Conductivity value, ash	C Total ash Dry basis	D Soluble ash Dry basis	E Insoluble ash Dry basis	F Alkalinity Total ash	G Alkalinity Soluble ash	H Alkalinity Insoluble ash
1	Apr. 6	Hard and soft	1.329	66.5	150	..	0.95	0.44	0.51	1.18	0.45	0.73
2	Apr. 7	Hard and soft	1.329	66.5	164	61	0.99	0.66	0.33	1.42	0.50	0.92
3	Apr. 10	Hard and soft	1.326	66.0	144	57	0.88	0.38	0.50	1.46	0.46	1.00
4	Apr. 11	Hard and soft	1.327	66.2	153	56	0.95	0.57	0.38	1.42	0.46	0.86
5	Apr. 12	Hard and soft, evaporated on steam bath	1.333	67.1	145	61	1.00	0.58	0.42	1.30	0.47	0.83
6	Apr. 12	Hard and soft, evaporated over flame	1.320	65.0	135	58	0.88	0.59	0.29	1.19	0.46	0.73
7	Apr. 13	Hard and soft	1.325	65.8	138	50	0.85	0.35	0.50	1.30	0.48	0.82
8	Apr. 15	Hard and soft	1.325	65.8	152	68	0.91	0.52	0.39	1.11	0.45	0.66
9	Apr. 18	Hard and soft	1.327	66.2	135	50	0.88	..	..	1.41	0.43	0.98
10	Apr. 23	Hard and soft	1.320	65.0	119	48	0.95	0.43	0.52	1.18	0.36	0.82
11	Apr. 25	Hard and soft	1.329	66.5	126	54	0.98	0.50	0.48	1.31	0.47	0.84
12	Apr. 29	Hard and soft	1.327	66.2	155	58	1.09	0.46	0.63	1.61	0.49	1.12
Average results for mixed saps.....					143	56	0.94	0.50	0.45	1.32	0.46	0.86
Percentage deviation maximum from mean.....					14.7	21.4	15.9	32.0	40.0	10.6	8.7	30.2
Percentage deviation minimum from mean.....					16.8	14.3	6.4	30.0	35.6	15.9	21.7	23.3
13	Apr. 15	Hard	1.322	65.4	145	48	0.87	0.41	0.46	1.17	0.41	0.76
14	Apr. 16	Hard	1.327	66.2	152	57	1.00	0.49	0.51	1.29	0.46	0.83
15	Apr. 20	Hard, evaporated over flame	1.322	65.4	146	54	1.02	0.47	0.55	1.39	0.50	0.89
16	Apr. 20	Hard, caramelized in boiling	1.319	64.9	148	50	0.97	0.60	0.37	1.28	0.45	0.83
17	Apr. 22	Hard	1.330	66.6	148	..	1.05	0.48	0.57	1.55	0.52	1.03
18	Apr. 24	Hard	1.325	65.8	141	57	0.96	0.45	0.51	1.45	0.47	0.98
19	Apr. 24	Hard	1.325	65.8	137	52	0.94	0.38	0.56	1.23	0.42	0.81
Average results for hard sap syrups.....					145	53	0.97	0.47	0.50	1.34	0.46	0.88
Percentage deviation maximum from mean.....					4.8	7.0	8.2	27.7	14.0	15.7	13.0	17.0
Percentage deviation minimum from mean.....					5.5	9.4	10.3	19.1	26.0	12.7	10.9	13.6
20	Apr. 16	Soft	1.321	65.2	134	54	0.90	0.47	0.43	1.18	0.40	0.78
21	Apr. 20	Soft	1.322	65.4	135	58	0.81	0.42	0.39	1.10	0.44	0.66
22	Apr. 22	Soft	1.330	66.6	148	..	0.92	0.54	0.38	1.27	0.55	0.72
Average results for soft sap syrups.....					139	56	0.88	0.48	0.40	1.18	0.46	0.72
Percentage deviation maximum from mean.....					6.5	3.6	4.4	12.5	7.5	7.5	19.6	8.3
Percentage deviation minimum from mean.....					3.6	3.6	8.0	12.5	5.0	6.8	13.0	8.3
General average.....					143	55	0.94	0.49	0.46	1.31	0.46	0.85
Maximum.....					164	68	1.09	0.66	0.63	1.61	0.55	1.12
Minimum.....					119	48	0.81	0.35	0.29	1.10	0.36	0.66
Percentage deviation maximum from mean.....					14.6	23.6	16.0	30.6	37.0	22.9	19.6	31.8
Percentage deviation minimum from mean.....					16.8	12.7	13.8	28.6	37.0	16.0	21.7	22.4

TABLE IV—FULL ANALYTICAL DATA FOR TWELVE SYRUPS OF TABLE I

Number	Run	A Conductivity value	C Total ash Dry basis	D Soluble ash Dry basis	E Insoluble ash Dry basis	F Alkalinity Total ash	G Alkalinity Soluble ash	H Alkalinity Insoluble ash	Canadian Lead No.	Modified Winton Lead No. (a)
1	Early	133	0.80	0.46	0.34	1.04	0.46	0.58	3.36	1.74
2	Early	149	0.82	0.59	0.23	1.01	0.58	0.43	3.10	2.11
3	Early	152	0.89	0.61	0.28	1.05	0.53	0.52	2.95	2.04
4	Early	139	0.86	0.61	0.25	0.93	0.48	0.45	2.82	1.85
5	Early	147	0.78	0.50	0.28	0.89	0.45	0.44	2.93	1.96
6	Early	145	0.89	0.58	0.31	1.08	0.56	0.52	3.30	2.18
7	Early	139	1.09	0.61	0.48	1.03	0.51	0.52	2.64	1.56
8	Early	162	1.14	0.79	0.35	1.20	0.64	0.56	3.39	2.33
9	Late	187	1.38	0.93	0.45	1.63	0.91	0.72	3.29	2.04
10	Late	149	0.86	0.57	0.29	1.12	0.56	0.56	3.44	2.40
11	Late	138	0.89	0.60	0.29	1.01	0.50	0.51	2.70	2.10
12	Late	158	1.14	0.62	0.52	1.14	0.54	0.60	3.62	1.88
Average.....		150	0.96	0.62	0.34	1.10	0.56	0.53	3.13	2.02
Per cent deviation of maximum from mean.....		24.7	43.8	50.0	52.9	48.2	62.5	35.8	15.6	18.8
Per cent deviation of minimum from mean.....		11.3	18.8	25.8	32.4	19.1	17.9	18.9	15.6	22.8

(a) Determined upon 25 g. dry matter instead of upon 25 g. syrup. Bull. 228, Laboratory of the Canadian Inland Revenue Department.

as was demonstrated by repeated determinations of the cell constant. Later, a special cell of the same type with extra heavy electrodes and with a thermometer set in the cover was made for me by Messrs.

screws. The thermometer range is 20° to 30°, graduated in tenths. This type of cell has proved perfectly satisfactory for the purpose.

In routine work it might be advisable to have a

considerable number of cells fitting the same pair of electrodes. These could be filled with the different samples and set in a thermostat to come to the required temperature, when measurements of all could be made in rapid succession. I have not used a thermostat in this work, but have regulated the temperature by placing the conductivity cell in a beaker of water of a suitable temperature, a fraction of a degree above or below that desired, and stirring the contents of the cell with the electrodes until the thermometer within the cell showed the correct reading.

The cell constant was determined by use of 0.1, 0.02 and 0.01 M potassium chloride solution, made up at 18° C. from the ignited C. P. salt, assuming for these¹ at 25° C. the conductivities 1289, 276.8 and 141.2 $\times 10^{-5}$.

RANGE OF VARIATION OF THE CONDUCTIVITY VALUE IN GENUINE SYRUPS

In addition to the 43 syrups referred to above, the conductivity value has been determined on 22 syrups made in this laboratory in the season of 1912 (see Table III). These syrups were all made from the sap of ten trees in the woods of the Macdonald College farm—six hard and four soft maples. They represent the runs of different days from April 6th to April 29th; some were made from the sap of the soft maples alone, others from the hard maples only, though the majority represent the mixed sap of the ten trees. They were boiled down in basins on gas stoves with the exception of one (No. 5), which was evaporated on the steam bath. These 22 syrups show a range of 119 to 164, average 143. This is a total range of 31.4 per cent. This is about the same range of variation as is shown by the total ash, and a much lower range than those shown by the soluble ash, the insoluble ash and the alkalinities.

Table IV includes analytical data for twelve of the Quebec syrups included in the summary given in Table I. These were examined to determine whether this apparent advantage of the conductivity method held for syrups of various origin, as well as for those from a single bush. It will be seen that among these 12 syrups the range of the conductivity value is much narrower than that of the total ash and narrower also than that of any of the other data except the Canadian lead number.

If this narrowness of range shall be found to be characteristic of the conductivity values of pure maple syrups in general, it will be a point of advantage for this method.

I have also examined three syrups made at the Vermont Agricultural Experiment Station under the supervision of Prof. C. H. Jones, who advised me that they were prepared with great care, "every opportunity being given for the malate of lime to settle out." These syrups were exceptionally light in color. As received, they were of exceptionally high density, as indicated by Prof. Jones' refractometer readings, *viz.*, No. 1 at 24.75° C., 1.4632; No. 2 at 21.5° C., 1.4651; No. 3 at 24.75° C., 1.4623. For my own analyses they were diluted with water, boiled to a boiling point of

219–220° F., and filtered through double S. & S. No. 597 filters.¹ Their densities at 15° C. were then 1.325, 1.321 and 1.332, respectively. Two of these Vermont syrups gave lower conductivity values than any of the Canadian syrups, *viz.*, 110 and 115. The third gave a value of 122. The ash values of these three syrups were also exceptionally low. Complete data for these syrups, as obtained by Professor Jones and myself, are given in Table V.

TABLE V—ANALYSES OF THREE VERMONT SYRUPS BY C. H. JONES AND BY J. F. SNELL

No.	Analyst	Per cent Total ash		Per cent Insoluble ash		Alkalinity Soluble ash		Conductivity value	Malic acid value
		Dry basis		Dry basis					
1	Jones	0.70	0.37	0.35	0.45	...	...	0.44	...
	Snell	0.71	0.59	0.37	0.44	115	...	...	...
2	Jones	0.68	0.33	0.39	0.44	...	...	0.45	...
	Snell	0.83	0.32	0.42	0.50	122	...	...	...
3	Jones	0.64	0.25	0.36	0.35	...	...	0.39	...
	Snell	0.70	0.23	0.37	0.38	110	...	...	...

The minimum value yet found in a genuine syrup is 110. The maximum of 203 obtained with the syrup prepared in the iron kettle has not been reached in any other pure syrup. The highest value yet found in a syrup actually prepared for the market is 197. The limits of variation of genuine syrups may, therefore, be tentatively set at 110 to 200.

The mean conductivity of the 68 syrups may most fairly be estimated by giving the mean of the 22 syrups made from the trees on the Macdonald College farm a weight of 2—the same as one pair of early and late run syrups. We thus obtain for the 48 syrups—46 actual and 2 theoretical—a mean conductivity value of 150. This is approximately equal to the electrical conductivity of an 0.01 M aqueous solution of potassium chloride (141.2).

THE RELATION OF THE CONDUCTIVITY VALUE TO THE ASH DATA

Since the salt components of maple syrup are undoubtedly responsible for the electrical conductivity, relations between the conductivity value and the ash data are worthy of investigation. From the investigations of Hortvet,² Jones³ and Bryan⁴ it is clear that maple syrup ash consists largely (*viz.*, to the extent of about 85 per cent) of the carbonates of calcium and potassium, the two metals being present in about chemically equivalent quantities. The three investigators are in close agreement as regards the lime content which is in the neighborhood of 22 per cent. Bryan finds an average of 38 per cent of potash in 100 syrups, Jones one of nearly 35 per cent in 6 syrups, two of which were composites of a number of samples, while Hortvet finds about 31 per cent in each of two syrup ashes. Hortvet alone has determined carbonic acid. His results show an average of about 30 per cent in the two samples. The proportions of these three constituents of the ash may accordingly be placed at the following figures as a rough estimate:

¹ Jones, Vt. Agr. Expt. Sta., 18th Annual Report, 1906, 328; also Bulletin 167, 470 (1912).

² J. Am. Chem. Soc., 26, 1541 (1904).

³ Vt. Agr. Expt. Sta., 18th Annual Report, 1906, 331.

⁴ Bur. of Chem., U. S. Dept. Agr., Bulletin 134 (1910).

¹ Ostwald-Luther, Physico-chemische Messungen, 2nd edition, p. 407.

Per cent Molecules			
K ₂ O.....	35	0.37	} sum, 0.76
CaO.....	22	0.39	
CO ₂	30	0.68	
Sum.....	87		

These results indicate that organic salts of potassium and calcium are the chief electrolytes of the syrup.¹ Potassium, having a higher ionic conductivity than calcium, may be expected to contribute a little more than an equal share to the conducting power of the

Considered by themselves, the ratios of Table VI would indicate that the closer relationships are those between, on the one hand, conductivity and *weight* of the *total* ash and on the other hand conductivity and *alkalinity* of *soluble* ash. It is to be remembered, however, that these syrups were all from the one bush, and were manufactured on a small scale in the laboratory. As will be pointed out later, they are also peculiar in their ratios of the alkalinities of soluble and insoluble ash. Table VII, which refers to more representative

TABLE VI—RATIOS OF THE ANALYTICAL DATA FOR 22 SYRUPS MADE IN LABORATORY (SEE TABLE III)

		A/B	A/C	A/D	A/F	A/G	A/H	B/D	B/G	E/G	G/H
		Conduc-	Conduc-	Conduc-	Conduc-	Conduc-	Conduc-	Conduc-	Conduc-	Alkal.	Alkal.
		tivity	tivity	tivity	tivity	tivity	tivity	tivity	tivity	total ash +	sol. ash +
		syrup +	syrup +	syrup +	syrup +	syrup +	syrup +	syrup +	syrup +	Alkal.	Alkal.
		Conduc-	Total	Soluble	Alkalinity	Alkalinity	Alkalinity	ash +	ash +	sol. ash	sol. ash
		tivity ash	ash	ash	total ash	sol. ash	insol. ash	ash	Alkalinity		insol. ash
Mixed sap of hard and soft maples	1	...	158	341	127	333	205	...	...	2.62	62
	2	2.52	166	248	115	328	178	92	122	2.84	54
	3	2.53	164	379	99	313	144	150	124	3.17	46
	4	2.73	161	268	108	333	178	98	122	3.09	53
	5	2.38	145	250	112	309	175	105	129	2.77	57
	6	2.33	153	229	113	293	185	98	126	2.59	63
	7	2.76	162	394	106	288	168	143	104	2.71	57
	8	2.24	167	292	137	338	230	131	151	2.47	68
	9	2.70	153	...	96	314	138	...	116	3.28	44
	10	2.48	125	277	101	331	145	112	133	3.28	44
	11	2.33	129	252	96	268	150	108	115	2.79	56
	12	2.67	142	337	96	316	138	126	118	3.29	44
Average mixed sap.....		2.52	152	297	109	314	170	116	124	2.91	0.54
Per cent deviation of maximum from mean.....		9.5	9.9	32.7	25.7	7.6	35.3	29.3	21.8	13.0	9.7
Per cent deviation of minimum from mean.....		11.1	17.8	22.9	11.9	14.6	18.8	20.7	16.1	15.1	29.2
Hard maple sap	13	3.02	167	354	124	354	191	117	117	2.85	54
	14	2.66	152	310	118	330	183	116	124	2.80	55
	15	2.70	143	311	105	292	164	115	108	2.78	56
	16	2.96	152	247	116	329	178	83	111	2.84	54
	17	...	141	308	95	285	144	...	...	2.98	50
	18	2.48	147	313	97	300	144	127	121	3.09	48
	19	2.63	146	361	111	326	169	137	124	2.69	52
Average hard maple.....		2.74	150	315	109	317	168	116	118	2.86	53
Per cent deviation of maximum from mean.....		10.2	11.3	14.6	13.8	11.7	13.7	18.1	5.1	8.0	5.7
Per cent deviation of minimum from mean.....		9.5	6.0	21.6	12.8	10.1	14.3	28.4	5.9	5.9	9.4
Soft maple soap	20	2.48	149	285	114	335	172	115	135	2.95	51
	21	2.33	167	321	123	307	205	138	132	2.50	67
	22	...	161	274	117	269	206	...	...	2.31	76
Average soft maple.....		2.41	159	293	118	304	194	127	134	2.59	65
Per cent deviation of maximum from mean.....		2.9	5.03	9.6	4.2	10.2	6.2	8.7	0.7	13.9	16.9
Per cent deviation of minimum from mean.....		3.3	6.3	6.5	3.4	11.5	11.3	9.4	1.4	10.4	21.5
General average.....		2.58	154	302	110	313	172	117	123	2.85	0.55
Maximum.....		3.02	167	394	137	354	230	150	151	3.29	76
Minimum.....		2.24	125	229	95	268	138	92	104	2.31	44
Per cent deviation of maximum from mean.....		17.1	8.4	30.5	24.5	13.1	33.7	28.2	22.8	15.4	26.7
Per cent deviation of minimum from mean.....		13.2	18.8	24.2	13.6	14.4	19.8	21.4	15.4	18.9	26.7

syrup. But its preponderance is not such as to justify a confident prediction that the conductivity value will be more closely related to the soluble ash (consisting mainly of potassium carbonate) or its alkalinity than to the total ash or its alkalinity.

I have, therefore, made calculations of the ratios of several of the data of Tables III and IV and present these ratios in Tables VI and VII.

¹ Magnesium and sodium salts are present in minor proportions.

samples, shows no material difference in the variability of the ratios of the conductivity value to the different ash data. If anything, the conductivity is more closely related to the total alkalinity than to the separate alkalinities of either the soluble or the insoluble ash. The range of variation of any of these ratios is somewhat wider than that of the ratios of the total alkalinity to the soluble alkalinity.

TABLE VII—RATIOS OF THE ANALYTICAL DATA FOR THE 12 QUEBEC SYRUPS OF TABLE IV

Number	A/C Conductivity ÷ Total ash	A/D Conductivity ÷ Soluble ash	A/E Conductivity ÷ Alkalinity total ash	A/G Conductivity ÷ Alkalinity soluble ash	A/H Conductivity ÷ Alkalinity ash	F/G Alkal. total ash ÷ Alkal. sol. ash	G/H Alkal. sol. ash ÷ Alkal. insol. ash
1	166	289	128	289	229	2.26	79
2	182	253	148	257	347	1.74	135
3	171	249	145	287	292	1.98	102
4	162	228	149	290	309	1.94	107
5	188	294	165	327	334	1.98	102
6	163	250	134	259	279	1.93	108
7	128	228	135	273	267	2.02	98
8	142	205	135	253	289	1.88	114
9	136	201	115	205	260	1.79	126
10	173	262	133	266	266	2.00	100
11	155	230	137	276	271	2.02	98
12	139	255	138	293	263	2.11	90
Average.....	159	245	139	273	284	197	105
Per cent deviation of max. from mean	18.2	18.0	18.7	19.8	22.2	14.7	28.6
Per cent deviation of min. from mean	19.5	18.0	17.2	24.9	19.4	11.7	24.8

CONDUCTIVITY VALUE OF THE ASH

Among the data of Tables III and VI is included for 19 syrups a figure designated "Conductivity Value of the Ash." This was determined according to the following method: 5 grams of syrup are ashed in a platinum dish. The ash is boiled with 30 cc. water for two minutes, filtered through a 7 cm. filter and washed with hot water to a volume of nearly 50 cc. (the residue is ignited and weighed as the insoluble ash). The cooled filtrate is made up to exactly 50 cc. and the conductivity measured at 25° C. The solution is washed out of the conductivity cell and titrated for alkalinity of soluble ash.

This method departs from the conventional one for determination of soluble and insoluble ash in maple products in using only 50 cc. of hot water on the ash of 5 grams of syrup, instead of 100 cc. Possibly it might be preferable to adhere to the conventional method of separating soluble and insoluble ash and to make the determination of conductivity value of ash in a volume¹ of 100 cc. instead of 50 cc.

To determine whether there is any material difference between the results obtained with the two different quantities of wash water, Mr. Scott has repeated the determinations upon syrups Nos. 2, 5 and 11, using 100 cc. of wash water. The results obtained by the two methods are compared below:

		Alkalinities as determined with use of					
		50 cc. wash water			100 cc. wash water		
Syrup No.	Date made	Sol. ash	Insol. ash	Ratio	Sol. ash	Insol. ash	Ratio
2	Apr. 7-9	50	92	0.54	46	82	0.56
5	Apr. 12	47	83	0.57	52	86	0.60
11	Apr. 25	47	84	0.56	52	84	0.62
Average,				0.56	0.59		

I infer from these results that the difference between the two methods of washing is of little consequence.

¹ In the A. O. A. C. provisional method for saccharine products in general, only 60 cc. of water are used. See Bur. of Chem., *Bulletin* 107, 68 (1908). Hortvet followed this method.

As intimated above, the syrups upon which the determination of the conductivity of the ash was made are peculiar in their low ratio of alkalinity of soluble to that of insoluble ash. They average 0.54. On the 94 syrups examined by Jones, the average value of this ratio is 0.94; on the 13 upon which Hortvet made these determinations it is 0.85; Bryan's general average for 481 syrups is 0.77, although for the 100 syrups selected by him for ash analysis, I find the average to be 0.87; and the average for the 12 syrups of Tables IV and VII of the present paper is 1.05. It is clear, therefore, that the syrups made in the laboratory (Tables III and VI) are of exceptional character. Under these conditions I do not feel justified in drawing any conclusions from the results obtained in the determination of the electrical conductivity of the ash solution. This property is, however, worthy of further study.

TABLE VIII—CONDUCTIVITY VALUES OF NON-MAPLE SYRUPS

Number	Description	Specific Conductivity	
		gravity	value
1	Corn syrup	1.40	2.51
2	Golden syrup	1.44	414
3	Molasses	...	656
SYRUPS DILUTED TO DENSITY OF MAPLE SYRUP			
No. 1 diluted	Corn syrup	1.339	253
4	Corn syrup	1.320	359
5	Corn syrup	1.320	209
No. 2 diluted	Golden syrup	1.320	427
6	Golden syrup	1.320	392
7	Golden syrup	1.320	403
8	Molasses	1.320	1121
9	Molasses	1.320	1280
10	Molasses	1.320	604
11	Molasses	1.320	1250
12	Cane sugar syrup from granulated sugar	1.314	0.5
13	Cane sugar syrup from pale brown sugar	1.329	178
14	Cane sugar syrup from pale brown sugar	1.333	185

THE CONDUCTIVITY VALUES OF NON-MAPLE SYRUPS

Table VIII gives the conductivity values of a number of non-maple syrups. It will be seen that syrup made from granulated sugar is practically a non-conductor, that syrups from partially refined cane sugar may give values within the limits found for pure maple syrups, and that all of the others give conductivity values distinctly above the limits for maple. It is clear, therefore, that values either above or below the limits for genuine maple syrup may be produced by adulteration. Syrups yielding values either abnormally high or abnormally low may be condemned without further examination. But it is clear that the possession of a normal conductivity value is not in itself adequate evidence of the purity of a syrup.

USEFULNESS OF THE METHOD

In Table IX are given the results of analysis of 34 syrups as found upon the market in the Provinces of Saskatchewan, Alberta and British Columbia in 1911 and 1912. The modified Winton lead number was determined upon the quantity of syrup containing 25 grams of dry matter.

It will be seen that the conductivity method would condemn 15 of these samples, and that every one of

TABLE IX—SYRUPS PURCHASED IN THE CANADIAN WEST

Number	Sold as	Specific gravity	Per cent Moisture	Per cent Total ash Dry basis	Per cent Insoluble ash Dry basis	Alkalinity soluble ash	Modified Winton		
							Alkalinity insoluble ash	Lead Number (Dry basis)	Conductivity value
1	Pure	1.309	36.8	0.13	0.03	0.11	0.11	0.46	23
2	Pure	1.337	32.2	0.09	0.05	0.06	0.13	0.10	24
3	Pure	1.304	37.6	0.67	0.29	0.34	0.46	1.15	113
4	Pure	1.315	35.8	0.62	0.31	0.34	0.52	1.37	114
5	Pure	1.332	33.0	0.76	0.34	0.47	0.60	1.99	134
6	Pure	1.315	35.8	0.95	0.50	0.42	0.58	2.38	150
7	Pure	1.323	34.4	0.84	0.44	0.46	0.70	1.96	143
8	Pure	1.318	35.3	0.91	0.43	0.42	0.74	2.09	159
9	Pure	1.326	34.0	0.41	0.20	0.23	0.38	0.80	79
10	Pure	1.332	33.0	0.82	0.42	0.50	0.66	1.92	133
11	Pure	1.316	35.6	0.07	0.04	0.08	0.10	0.23	21
12	Pure	1.326	34.0	0.85	0.30	0.38	0.42	1.40	123
13	Pure	1.344	31.1	0.64	0.18	0.28	0.28	0.99	90
14	Pure	1.352	29.8	0.72	0.30	0.35	0.45	1.61	117
15	Pure	1.340	31.7	0.93	0.33	0.48	0.50	1.58	142
16	Pure	1.323	34.5	0.93	0.38	0.49	0.61	2.06	152
17	Pure	1.330	33.4	0.33	0.14	0.20	0.26	0.84	60
18	Pure	1.335	32.5	0.43	0.19	0.23	0.32	0.83	66
19	Pure	1.315	35.8	0.50	0.22	0.29	0.38	1.09	85
20	Pure	1.320	35.0	1.09	0.40	0.50	0.72	2.25	160
21	Pure	1.333	32.9	0.70	0.33	0.38	0.58	1.68	128
22	Pure	1.327	33.8	0.74	0.21	0.31	0.46	1.33	93
23	Pure	1.331	33.2	0.54	0.28	0.32	0.42	1.41	97
24	Pure	1.340	31.7	0.59	0.23	0.30	0.46	1.29	94
25	Pure	1.324	34.3	1.22	0.43	0.49	0.72	2.33	145
26	Pure	1.325	34.2	0.93	0.52	0.47	0.83	2.56	149
27	Pure	1.326	34.0	0.85	0.33	0.50	0.57	2.11	146
28	Pure	1.329	33.5	0.62	0.21	0.32	0.48	1.26	94
29	Pure	1.335	32.5	0.65	0.25	0.40	0.57	1.36	113
30	Pure	1.329	33.5	0.35	0.15	0.16	0.33	0.86	64
31	Compound	1.337	32.2	0.10	0.04	0.09	0.09	0.20	24
32	Compound	1.351	30.0	0.56	0.14	0.31	0.23	0.72	136
33	Maple flavor	1.351	30.0	0.21	0.13	0.15	0.17	0.47	48
34	Maple flavor	1.339	31.9	0.30	0.25	0.36	0.42	1.68	129

Standards of purity:

Canada.....	35.0	0.60	0.12	..	..	1.20	..
Vermont.....	..	0.77	0.23	..	..	..	..

Ordinary limits for genuine syrup:

Minimum.....	..	0.75	0.23	0.30	0.36	..	110
Maximum.....	..	1.35	0.80	0.66	0.94	..	200

these 15 is also condemned by a complete analysis. Syrups 32 and 34, however, which would pass the conductivity test, are condemned by the other determinations, and Nos. 3, 4 and 29, which are near the limit in conductivity value and which, being of the same brand as Nos. 9, 19, 21, 22, 24 and 28, are probably adulterated, are also near the limits of the Canadian standard in respect to the other analytical data and are below the Vermont standard on total ash. When one considers that all the ordinary analytical work on the 15 samples might be omitted, the usefulness of the conductivity method is apparent.

SUMMARY

1. A rapid method of detecting adulteration of maple syrup with commercially pure sucrose is described.
2. The "conductivity value" is defined as 100,000 times the specific conductivity at 25° C. of a mixture of one volume of syrup with two volumes of water.
3. The limits of conductivity value for pure maple syrup are tentatively set at 110 to 200.
4. The relation of conductivity value to ash data is discussed.
5. The usefulness of the test is illustrated.

MACDONALD COLLEGE
QUEBEC

THE COMPOSITION OF DIFFERENT VARIETIES OF RED PEPPERS¹

By L. M. TOLMAN AND L. C. MITCHELL

Received May 26, 1913

CAYENNE OR CHILLI

General Description.—Cayenne or chilli is a small fruited pepper, a variety of *Capsicum frutescens* L., a species of *Capsicum*, which is a genus of the family *Solanaceae*, indigenous to the American tropics, but now grown or cultivated in nearly all tropic and subtropic countries. It is characterized by its extreme pungency and the small size of the pods. The leading commercial varieties (1911) are African and Japanese.

The African cayenne or chillies come chiefly from the ports of Mombasa and Zanzibar, British East Africa, and are usually designated in the trade by the name of the port from which shipped; they are from 10 to 15 mm. in length, dark, dull red in color, and extremely pungent; they are ground for use. A few of the samples contained some unattached stems and calyxes.

The Japanese chillies come from the port of Kobe, Japan; these are from 15 to 40 mm. in length, bright red in color, clean, containing very few stems or calyxes, and are used chiefly in the unground condition for the preparation of the so-called "chilli sauce."

Cayenne or chilli contains a fixed, bland oil, found

¹ Authors' abstract of *Bull.* 163, Bureau of Chem., Dept. of Agr.