

U. S. DEPARTMENT OF COMMERCE

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BUREAU OF STANDARDS

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CIRCULAR OF THE BUREAU OF STANDARDS, No. 375

**WEIGHTS PER UNITED STATES GALLON
AND WEIGHTS PER CUBIC FOOT
OF SUGAR SOLUTIONS**

OCTOBER 2, 1929



UNITED STATES
GOVERNMENT PRINTING OFFICE
WASHINGTON : 1929

WEIGHTS PER UNITED STATES GALLON AND WEIGHTS PER CUBIC FOOT OF SUGAR SOLUTIONS¹

ABSTRACT

A table is presented showing the weights per United States gallon and weights per cubic foot of sugar (sucrose) solutions at 20° C. The table comprises the following: Weights (metric and avoirdupois) per gallon in air and in vacuo; weights (avoirdupois) per cubic foot in air; specific gravities 20°/20° and 20°/4°; and degrees Baumé; all from 0° to 95° Brix at intervals of 1° Brix. The calculations are based on the density values of Plato. The degrees Baumé are taken from the table devised by Bates and Bearce. A supplementary table is included giving the weights per gallon in air at different temperatures.

It is frequently necessary to express the density of a sugar sirup or molasses in terms of weight per gallon or weight per cubic foot. Consequently, numerous requests for a table giving these weights have been received at the Bureau of Standards. Spencer in his "Handbook for Cane Sugar Manufacturers and Their Chemists," sixth edition, page 495, gives a table of weights per cubic foot and per gallon. This table is based on the density values of Stammer, standard at 17.5° C. Obviously, however, it would be more desirable to have such a table standard at 20° C. For that reason in preparing the table which follows (Table 1) the standard temperature of 20° C. was accepted and the density values of Plato² for pure sugar solutions were selected as being the most reliable of those available. The data of Table 1 relate, therefore, to sugar (sucrose) solutions at 20° C. and consist of the following: Weights (metric and avoirdupois) per gallon in air and in vacuo; weights (avoirdupois) per cubic foot in air; specific gravities 20°/20° C. and 20°/4° C.; and degrees Baumé; for each degree Brix from 0° to 95°.

The weight of 1 United States gallon (231 cubic inches) of water at 20° C. in vacuo is 3,778.649 g or 8.33049 pounds avoirdupois.³ The weights per gallon in vacuo were computed⁴ from the specific gravities at 20°/20° C.⁵, which are based on the density values of

¹ Compiled by Carl F. Snyder and Lester D. Hammond.

² Wiss. Abh. der Kaiserlichen Normal-Meßungs-Kommission, 2, p. 153; 1900.

³ B. S. Circular No. 19, p. 48.

⁴ A complete and independent series of computations was made by each author in every case where computations were required.

⁵ Bates and Bearce, B. S. Tech. Paper No. 115. The calculation of this table was made by means of the equation:

$$d = m - \frac{m}{s} \quad (m=145)$$

in which d = degrees Baumé, m = modulus, and s = specific gravity, 20°/20° C.

Plato. The weights in grams per gallon in vacuo were converted to weights in air (barometer reading, 760 mm of mercury; temperature, 20° C.; density of air, 0.0012) for brass weights (density, 8.4). The resulting metric weights were then converted to pounds per gallon in air through dividing them by the equivalent of 1 pound avoirdupois in grams, which is 453.5924 g. Pounds per cubic foot in air were computed from the results of this conversion through multiplying them by the gallons per cubic foot (1,728/231).

There is at present in progress at this bureau a comparative study of the various methods of determining the densities of molasses and sugar sirups, and this table, together with those giving the temperature corrections for Brix⁶ and Baumé⁷ spindles, is of considerable assistance in converting data from the several methods to a common basis for the purpose of comparison. That is, in such an investigation it may be necessary to make experimental determinations by means of any or all of the following: A Brix or Baumé spindle, a picnometer, or a direct reading balance,⁸ etc., and it may be desirable to express all the results in terms of weights per gallon or weights per cubic foot. Table 1 permits such conversions to be made by simple interpolations.

TABLE 1.—Weights per United States gallon and weights per cubic foot of sugar (sucrose) solutions at 20° C.

[This table is based on the density values of Plato^a for solutions of cane sugar. The Baumé values are from the table of Bates and Bearce.^b The weights are for brass weights, density 8.4. One United States gallon, 231 cubic inches. One pound (avoirdupois) 453.5924 g. One United States gallon of water weighs 3,778.649 g (8.33049 pounds avoirdupois) in vacuo]

Per cent sucrose by weight (Brix)	Weight per gallon in air ^c		Weight per gallon in vacuo ^c		Weight per cubic foot in air, ^e in pounds	Specific gravity, 20°/4° C.	Specific gravity, 20°/20° C.	Baumé
	Pounds	Grams	Pounds	Grams				
0.....	8.322	3,774.6	8.330	3,778.6	62.25	0.99823	1.00000	0.00
1.....	8.354	3,789.3	8.363	3,793.3	62.49	1.00212	1.00389	0.56
2.....	8.387	3,804.1	8.395	3,808.1	62.74	1.00602	1.00779	1.12
3.....	8.419	3,818.9	8.428	3,822.9	62.98	1.00993	1.01172	1.68
4.....	8.452	3,833.9	8.461	3,837.9	63.23	1.01388	1.01567	2.24
5.....	8.485	3,848.9	8.494	3,852.9	63.48	1.01785	1.01965	2.79
6.....	8.519	3,864.1	8.528	3,868.1	63.73	1.02186	1.02366	3.35
7.....	8.552	3,879.3	8.561	3,883.3	63.98	1.02588	1.02770	3.91
8.....	8.586	3,894.7	8.595	3,898.7	64.23	1.02994	1.03176	4.46
9.....	8.620	3,910.2	8.629	3,914.2	64.49	1.03403	1.03586	5.02
10.....	8.655	3,925.7	8.664	3,929.7	64.74	1.03814	1.03998	5.57
11.....	8.689	3,941.4	8.698	3,945.4	65.00	1.04229	1.04413	6.13
12.....	8.724	3,957.2	8.733	3,961.2	65.26	1.04646	1.04831	6.68
13.....	8.759	3,973.1	8.768	3,977.1	65.52	1.05066	1.05252	7.24
14.....	8.795	3,989.2	8.803	3,993.2	65.79	1.05490	1.05677	7.79
15.....	8.830	4,005.3	8.839	4,009.3	66.05	1.05916	1.06104	8.34

^a Wiss. Abh. der Kaiserlichen-Normal-Aichungs-Kommission 2, p. 153; 1900.

^b B. S. Tech. Paper No. 115.

^c After the computations were completed, the tabulations were made by rounding off the results to the last figure given.

^d B. S. Circular No. 44, p. 123.

^e B. S. Circular No. 295.

^f B. S. Tech. Paper No. 345.

TABLE 1.—Weights per United States gallon and weights per cubic foot of sugar (sucrose) solutions at 20° C.—Continued

Per cent sucrose by weight (Brix)	Weight per gallon in air		Weight per gallon in vacuo		Weight per cubic foot in air, in pounds	Specific gravity, 20°/4° C.	Specific gravity, 20°/20° C.	Baumé
	Pounds	Grams	Pounds	Grams				
16	8.866	4,021.6	8.875	4,025.5	66.32	1.06346	1.06534	8.89
17	8.902	4,038.0	8.911	4,041.9	66.50	1.06779	1.06968	9.45
18	8.939	4,054.5	8.947	4,058.4	66.87	1.07215	1.07404	10.00
19	8.975	4,071.1	8.984	4,075.0	67.14	1.07654	1.07844	10.55
20	9.012	4,087.8	9.021	4,091.8	67.42	1.08096	1.08287	11.10
21	9.049	4,104.7	9.058	4,108.6	67.69	1.08541	1.08733	11.65
22	9.087	4,121.7	9.095	4,125.6	67.97	1.08990	1.09183	12.20
23	9.125	4,138.8	9.133	4,142.8	68.26	1.09442	1.09636	12.74
24	9.163	4,156.0	9.171	4,160.0	68.54	1.09897	1.10092	13.29
25	9.201	4,173.4	9.209	4,177.3	68.83	1.10356	1.10551	13.84
26	9.239	4,190.9	9.248	4,194.8	69.11	1.10818	1.11014	14.39
27	9.278	4,208.5	9.287	4,212.4	69.41	1.11283	1.11480	14.93
28	9.317	4,226.2	9.326	4,230.2	69.70	1.11751	1.11949	15.48
29	9.357	4,244.1	9.365	4,248.0	69.99	1.12223	1.12422	16.02
30	9.396	4,262.1	9.405	4,266.0	70.29	1.12698	1.12898	16.57
31	9.436	4,280.2	9.445	4,284.2	70.59	1.13177	1.13378	17.11
32	9.477	4,298.5	9.485	4,302.4	70.89	1.13660	1.13861	17.65
33	9.517	4,316.8	9.526	4,320.8	71.19	1.14145	1.14347	18.19
34	9.558	4,335.4	9.566	4,339.3	71.50	1.14634	1.14837	18.73
35	9.599	4,354.0	9.608	4,358.0	71.81	1.15128	1.15331	19.28
36	9.640	4,372.8	9.649	4,376.7	72.12	1.15624	1.15828	19.81
37	9.682	4,391.8	9.691	4,395.7	72.43	1.16124	1.16329	20.35
38	9.724	4,410.8	9.733	4,414.7	72.74	1.16627	1.16833	20.89
39	9.766	4,430.0	9.775	4,433.9	73.06	1.17134	1.17341	21.43
40	9.809	4,449.3	9.818	4,453.3	73.38	1.17645	1.17853	21.97
41	9.852	4,468.8	9.861	4,472.7	73.70	1.18159	1.18368	22.50
42	9.895	4,488.4	9.904	4,492.3	74.02	1.18677	1.18887	23.04
43	9.939	4,508.2	9.947	4,512.1	74.35	1.19199	1.19410	23.57
44	9.983	4,528.1	9.991	4,532.0	74.68	1.19725	1.19936	24.10
45	10.027	4,548.1	10.035	4,552.0	75.01	1.20254	1.20467	24.63
46	10.071	4,568.3	10.080	4,572.2	75.34	1.20787	1.21001	25.17
47	10.116	4,588.6	10.125	4,592.5	75.67	1.21324	1.21538	25.70
48	10.161	4,609.1	10.170	4,613.0	76.01	1.21864	1.22080	26.23
49	10.207	4,629.7	10.215	4,633.6	76.35	1.22409	1.22625	26.75
50	10.252	4,650.4	10.261	4,654.3	76.69	1.22957	1.23174	27.28
51	10.299	4,671.3	10.307	4,675.2	77.04	1.23508	1.23727	27.81
52	10.345	4,692.4	10.353	4,696.3	77.39	1.24064	1.24284	28.33
53	10.392	4,713.5	10.400	4,717.4	77.73	1.24623	1.24844	28.86
54	10.439	4,734.9	10.447	4,738.7	78.09	1.25187	1.25408	29.38
55	10.486	4,756.3	10.494	4,760.2	78.44	1.25754	1.25976	29.90
56	10.534	4,777.9	10.542	4,781.8	78.80	1.26324	1.26548	30.42
57	10.581	4,799.7	10.590	4,803.5	79.15	1.26899	1.27123	30.94
58	10.630	4,821.6	10.638	4,825.4	79.52	1.27477	1.27703	31.46
59	10.678	4,843.6	10.687	4,847.5	79.88	1.28060	1.28286	31.97
60	10.727	4,865.8	10.736	4,869.7	80.25	1.28646	1.28873	32.49
61	10.777	4,888.1	10.785	4,892.0	80.61	1.29235	1.29464	33.00
62	10.826	4,910.6	10.835	4,914.5	80.98	1.29829	1.30059	33.51
63	10.876	4,933.2	10.884	4,937.1	81.36	1.30427	1.30657	34.02
64	10.926	4,956.0	10.935	4,959.9	81.73	1.31028	1.31260	34.53
65	10.977	4,978.9	10.985	4,982.8	82.11	1.31633	1.31866	35.04
66	11.027	5,002.0	11.036	5,005.8	82.49	1.32242	1.32476	35.55
67	11.079	5,025.2	11.087	5,029.0	82.87	1.32855	1.33090	36.05
68	11.130	5,048.5	11.139	5,052.4	83.26	1.33472	1.33708	36.55
69	11.182	5,072.0	11.190	5,075.9	83.65	1.34093	1.34330	37.06
70	11.234	5,095.7	11.242	5,099.5	84.04	1.34717	1.34956	37.56
71	11.286	5,119.5	11.295	5,123.3	84.43	1.35346	1.35585	38.06
72	11.339	5,143.4	11.348	5,147.2	84.82	1.35978	1.36218	38.55
73	11.392	5,167.5	11.401	5,171.3	85.22	1.36614	1.36856	39.05
74	11.446	5,191.7	11.454	5,195.5	85.62	1.37254	1.37496	39.54
75	11.499	5,216.1	11.508	5,219.9	86.02	1.37897	1.38141	40.03
76	11.554	5,240.6	11.562	5,244.4	86.43	1.38545	1.38790	40.53
77	11.608	5,265.2	11.616	5,269.0	86.83	1.39196	1.39442	41.01
78	11.663	5,290.0	11.671	5,293.8	87.24	1.39850	1.40098	41.50
79	11.717	5,315.0	11.726	5,318.8	87.65	1.40509	1.40758	41.99
80	11.773	5,340.0	11.781	5,343.8	88.07	1.41172	1.41421	42.47

TABLE 1.—Weights per United States gallon and weights per cubic foot of sugar (sucrose) solutions at 20° C.—Continued

Per cent sucrose by weight (Brix)	Weight per gallon in air		Weight per gallon in vacuo		Weight per cubic foot in air, in pounds	Specific gravity, 20°/4° C.	Specific gravity, 20°/20° C.	Baumé
	Pounds	Grams	Pounds	Grams				
81.....	11.828	5,365.2	11.837	5,369.0	88.48	1.41837	1.42088	42.95
82.....	11.884	5,390.6	11.893	5,394.4	88.90	1.42507	1.42759	43.43
83.....	11.940	5,416.1	11.949	5,419.9	89.32	1.43181	1.43434	43.91
84.....	11.997	5,441.7	12.005	5,445.5	89.74	1.43858	1.44112	44.38
85.....	12.054	5,467.5	12.062	5,471.3	90.17	1.44539	1.44794	44.86
86.....	12.111	5,493.4	12.119	5,497.2	90.60	1.45223	1.45480	45.33
87.....	12.168	5,519.5	12.177	5,523.3	91.03	1.45911	1.46170	45.80
88.....	12.226	5,545.6	12.234	5,549.4	91.46	1.46603	1.46862	46.27
89.....	12.284	5,572.0	12.292	5,575.7	91.89	1.47299	1.47559	46.73
90.....	12.342	5,598.4	12.351	5,602.2	92.33	1.47998	1.48259	47.20
91.....	12.401	5,625.1	12.409	5,628.8	92.77	1.48700	1.48963	47.66
92.....	12.460	5,651.8	12.468	5,655.5	93.21	1.49406	1.49671	48.12
93.....	12.519	5,678.6	12.527	5,682.4	93.65	1.50116	1.50381	48.58
94.....	12.579	5,705.7	12.587	5,709.4	94.10	1.50829	1.51096	49.03
95.....	12.639	5,732.8	12.647	5,736.5	94.54	1.51546	1.51814	49.49

The densities of solutions of sucrose have been determined by Plato at different temperatures. His results have been reported in three tables; first, densities at 15°/15° C. at concentrations from 0 to 100 per cent sucrose; second, densities at $t^{\circ}/15^{\circ}$ C. at temperatures from 0 to 60° C. in 1° C. intervals at concentrations from 0 to 70 per cent sucrose; and third, densities at 20°/4° C. at concentrations from 0 to 100 per cent sucrose. From these data a supplementary table of the weights per gallon in air was calculated at the several temperatures indicated in Table 2 by the method of computation already described. It seemed desirable to extend the values to include the higher concentrations at temperatures other than those of 15 and 20° C., which are the only ones in which Plato's values extend to 100 per cent sucrose. Accordingly, by means of a series of graphic extrapolations conforming with the trend of Plato's 20° C. values, the values from 75 to 95 per cent sucrose, inclusive, were obtained at the temperatures 10, 15, 25, and 30° C. It is interesting to note that the weights per gallon at 15° C. calculated from Plato's table⁹ at 15°/15° C. agree to less than one in the last figure given with the extrapolated values. In Table 2 the values obtained by extrapolation are given in italics.

⁹ Wiss. Abh. der Kaiserlichen-Normal-Messungs-Kommission 2, p. 140; 1900.

TABLE 2.—Weights per United States gallon of sugar (sucrose) solutions at different temperatures

Per cent sucrose by weight (Brix)	Weights per gallon in air at t° C.									
	$t=10^{\circ}$ C.		$t=15^{\circ}$ C.		$t=20^{\circ}$ C.		$t=25^{\circ}$ C.		$t=30^{\circ}$ C.	
	Pounds	Grams	Pounds	Grams	Pounds	Grams	Pounds	Grams	Pounds	Grams
0.....	8.334	3,780	8.329	3,778	8.322	3,775	8.312	3,770	8.301	3,765
5.....	8.500	3,856	8.494	3,853	8.485	3,849	8.475	3,844	8.463	3,839
10.....	8.672	3,933	8.664	3,930	8.655	3,926	8.644	3,921	8.631	3,915
15.....	8.849	4,014	8.841	4,010	8.830	4,005	8.818	4,000	8.805	3,994
20.....	9.034	4,098	9.023	4,093	9.012	4,088	8.999	4,082	8.985	4,075
25.....	9.225	4,184	9.213	4,179	9.201	4,173	9.187	4,167	9.171	4,160
30.....	9.423	4,274	9.410	4,268	9.396	4,262	9.381	4,255	9.365	4,248
35.....	9.623	4,367	9.614	4,361	9.599	4,354	9.583	4,347	9.566	4,339
40.....	9.840	4,464	9.825	4,457	9.809	4,449	9.792	4,442	9.774	4,433
45.....	10.060	4,563	10.044	4,556	10.027	4,548	10.009	4,540	9.990	4,531
50.....	10.288	4,667	10.271	4,659	10.252	4,650	10.234	4,642	10.214	4,633
55.....	10.523	4,773	10.505	4,765	10.486	4,756	10.466	4,747	10.446	4,738
60.....	10.767	4,884	10.747	4,875	10.727	4,866	10.707	4,856	10.685	4,847
65.....	11.018	4,998	10.997	4,988	10.977	4,979	10.955	4,969	10.933	4,959
70.....	11.277	5,115	11.256	5,105	11.234	5,096	11.212	5,086	11.189	5,075
75.....	11.544	5,236	11.522	5,226	11.499	5,216	11.477	5,206	11.453	5,195
80.....	11.813	5,361	11.796	5,351	11.773	5,340	11.749	5,329	11.725	5,319
85.....	12.101	5,489	12.078	5,478	12.054	5,467	12.030	5,457	12.005	5,445
90.....	12.391	5,620	12.367	5,610	12.342	5,598	12.313	5,587	12.293	5,576
95.....	12.688	5,755	12.664	5,744	12.639	5,733	12.613	5,721	12.587	5,709

In the calculation of Tables 1 and 2 the density of air (at 20° C., and barometer reading 760 mm of mercury) was taken as 0.0012. The effect of differences of barometric pressure on the weights of a gallon of a 70 per cent solution of sucrose in air is shown in Table 3.

TABLE 3.—Weight in air of 1 gallon of a 70 per cent solution of sucrose at 20° C. at different barometric pressures

Pres- sure mm. Hg	Density air	Weight per gallon in air	
		Pounds	Grams
780	0.00124	11.234	5,095.6
760	.00120	11.234	5,095.7
740	.00117	11.234	5,095.8
720	.00114	11.235	5,095.9
700	.00111	11.235	5,096.0
680	.00108	11.235	5,096.1
660	.00105	11.235	5,096.2

To aid in comparing Table 1 with the previously cited table of Spencer some corresponding values from both of them are given in Table 4.

TABLE 4.

Brix	From Table 1 (20° C.)		From Spencer's table (17.5° C.)		Brix	From Table 1 (20° C.)		From Spencer's table (17.5° C.)	
	Weight per gallon in air	Weight per cubic foot in air	Weight per gallon	Weight per cubic foot		Weight per gallon in air	Weight per cubic foot in air	Weight per gallon	Weight per cubic foot
10-----	<i>Pounds</i> 8.655	<i>Pounds</i> 64.74	<i>Pounds</i> 8.67	<i>Pounds</i> 64.84	60-----	<i>Pounds</i> 10.727	<i>Pounds</i> 80.25	<i>Pounds</i> 10.75	<i>Pounds</i> 80.43
20-----	9.012	67.42	9.03	67.55	70-----	11.254	84.04	11.26	84.23
30-----	9.396	70.29	9.41	70.44	80-----	11.773	88.07	11.80	88.28
40-----	9.809	73.38	9.83	73.54	90-----	12.342	92.33	12.37	92.58
50-----	10.252	76.69	10.27	76.87					

CONCLUSION

The tables presented here (Tables 1 and 2) have the following features which commend them for sugar work:

1. They are both based on the density values of Plato.
2. Table 1 is standard at 20° C., the accepted temperature in sugar work.
3. The Baumé values are those of the scale devised by Bates and Bearce.