ON THE RELATION OF THE SPECIFIC GRAVITY OF URINE TO THE SOLIDS PRESENT.

BY J. H. LONG.

ATTEMPTS have been made several times to establish a relation between the specific gravity of normal urine and the weight of solids dissolved in the secretion. Such efforts are naturally based on the assumption that while the solids must vary, the variations remain within rather narrow limits and the two most important constituents must change in the same direction. These two important substances are urea and sodium chloride, and the specific gravity observed depends largely on the weight of these bodies present.

From early experiments of Trapp, Haeser and others, repeated later by Neubauer,[1] the relation appeared in general to be definite enough to warrant the use of the so-called coefficient of Haeser in making an approximate estimation of the urine solids from an exact determination of the specific gravity. The direct estimation of solids by evaporation is apparently easy, but unfortunately is liable to an error due to the partial decomposition of urea into ammonium cyanate and that into ammonia and carbonic acid. In addition to this, there is a loss on account of the slightly stable ammonium salts present, which fact is generally overlooked, although its importance is as great as that of the loss from the urea, in some cases. Unless a correction is made for these losses, the error in the final result is rather large, in fact usually larger than is the difference between the true result and that obtained by applying the coefficient of Haeser.

As this is a point of no little importance, I have recently undertaken a new determination of the urinary solids along with the corresponding specific gravities, both determinations being made as accurately as possible. The solid residue was found by the method originally suggested by Neubauer. About 5 grams of urine are evaporated in a porcelain boat which is placed in a horizontal glass tube passing through a steam-bath. The glass tube is connected with a small flask containing standard sulphuric acid in such a manner that a current of dried air may be aspirated through the whole apparatus and carry evolved products into the

[1] Ztschr. anal. Chem., 1, 166.

standard acid. A subsequent titration with standard alkali and
methyl orange shows how much acid has been neutralized by am-
monia from the evaporated urine. Three to four hours are given
to each evaporation, after which the residue in the boat is allowed
to stand about two hours over sulphuric acid before weighing.
Neubauer suggested to calculate the ammonia absorbed by the
dilute standard acid to urea and add this to the weight of the
residue. This has been done in the urine evaporations given
below, although the method is not strictly correct. as will be
pointed out.

The specific gravities were found by means of a small pycnom-
eter and at a temperature maintained at 25°, with a variation
within 0.1°. For possible practical applications, 25° is a much
more suitable temperature than is 15° or even 20°. The results
are referred to water at 4° as unity and are all given below.

Some preliminary experiments were made to determine the loss
in evaporating solutions containing pure urea and certain salts in
proportions corresponding to those obtaining for urine. In the
first of these I took, with water enough to make about 4 cc. :

	(a).	(b).
NaCl	0.0930	0.0708
K_2SO_4	0.0077	0.0059
CON_2H_4	0.1467	0.1117
	0.2474	0.1884
Residue recovered	0.2430	0.1851
Urea from ammonia	0.0052	0.0037
	0.2482	0.1888

In the first case, the loss of 5.2 mg. of urea calculated from the ammo-
nia is 3.5 per cent. of the urea present or 2.1 per cent. of the solids.
In the second case, 3.7 mg. amounts to 3.3 per cent. of the whole
urea, or 2 per cent. of the total solids. Very similar results were
found in other tests and need not be given in detail. In the fol-
lowing experiments the effect of a phosphate was determined.
With water enough to make about 3.5 cc. in each case, I took:

	(c).	(d).
NaCl	0.1126	0.0881
K_2SO_4	0.0080	0.0101
HNa_2PO_4	0.0120	0.0120
CON_2H_4	0.1526	0.1927
	0.2852	0.3029

The evaporation was continued three and a half hours, and the ammonia was caught as before.

Recovered directly	0.2830	0.2991
Loss	0.0022	0.0038

The ammonia evolved was found in (c) to be equal to 0.5 cc. of N/4 acid and in (d) to 0.6 cc. of N/4 acid. Calculating this as urea would more than account for the loss. In this case, however, a part of the carbonic acid from the urea decomposition is held by the alkali phosphate. In (c) the total loss was 14.4 mg. per gram of urea, or 1.44 per cent. of the total urea. In (d) the loss was 19.2 mg. per gram of urea or 1.92 per cent. of the urea present. These losses are about one-half as great as they were in the absence of the alkali phosphate.

Since the urine is commonly slightly acid and probably from the presence of the dihydrogen phosphate, two further evaporations were made with known amounts of this salt present. It was produced by addition of N/10 sulphuric acid to a solution of the disodium salt. The weights taken, with water enough to make up 4.5 cc., were:

	(e).	(f).
NaCl	0.1046	0.1053
K_2SO_4	0.0099	0.0100
Na_2SO_4	0.0060	0.0060
H_2NaPO_4	0.0100	0.0100
CON_2H_4	0.1893	0.1900
	0.3198	0.3213
Recovered directly	0.3171	0.3174
Loss	0.0028	0.0039
The ammonia evolved calculated as urea gives	0.0023	0.0037

In such cases, therefore, it seems perfectly proper to add urea to correct the evaporation loss, and the presence of the salts does not appear to increase this appreciably. The decomposition with alkaline phosphate present is probably the same, but the ammonia only is fully liberated.

Below are given the results of fifty-two determinations on the urine of six persons. The samples taken for the tests did not represent the excretion of the whole day but were chosen to represent extreme cases, as far as possible, as the main object of the

investigation was to determine the limits of variations. From other investigations, the average amounts of urea and ammonia excreted by the same individuals, under the same general conditions, had been determined. The urea amounted to 28 grams per liter and the ammonia to 650 mg. per liter. All the tests were made on perfectly fresh urine, from individuals in normal health, consuming an average meat, vegetable and bread diet.

No.	Sp. gr. $\frac{25^{\circ}}{4}$	Solids in grams per liter.	Loss as urea, grams per liter.	Multiplication factor.
1	1.0199	51.57	2.36	0.259
2	1.0207	51.19	2.95	0.247
3	1.0206	52.33	2.37	0.254
4	1.0189	44.28	2.28	0.234
5	1.0209	53.70	2.14	0.257
6	1.0215	53.10	1.72	0.247
7	1.0227	61.93	2.89	0.272
8	1.0217	53.51	2.46	0.247
9	1.0224	56.54	2.13	0.252
10	1.0180	53.84	2.51	0.299
11	1.0252	66.05	2.56	0.262
12	1.0251	63.54	2.10	0.253
13	1.0226	57.19	1.71	0.253
14	1.0231	60.00	1.95	0.260
15	1.0236	57.38	1.76	0.243
16	1.0236	62.82	2.35	0.266
17	1.0248	59.90	2.74	0.242
18	1.0279	70.73	1.75	0.254
19	1.0230	59.31	1.70	0.258
20	1.0279	75.21	1.96	0.270
21	1.0223	57.48	2.09	0.258
22	1.0177	43.13	1.60	0.244
23	1.0231	63.06	1.92	0.273
24	1.0228	58.37	2.15	0.256
25	1.0284	75.55	1.67	0.266
26	1.0256	73.26	2.34	0.288
27	1.0246	59.75	1.93	0.243
28	1.0191	44.98	2.00	0.235
29	1.0317	79.29	2.31	0.250
30	1.0118	30.02	0.97	0.254
31	1.0237	63.45	4.53	0.268
32	1.0207	51.06	1.73	0.247
33	1.0291	70.90	4.19	0.244
34	1.0243	62.41	2.81	0.257
35	1.0140	37.81	2.01	0.270
36	1.0217	56.56	2.40	0.261
37	1.0225	59.29	2.75	0.264

No.	Sp. gr. $\frac{25°}{4}$.	Solids in grams per liter.	Loss as urea, grams per liter.	Multiplication factor.
38	1.0165	45.13	2.49	0.274
39	1.0212	60.01	3.64	0.283
40	1.0155	43.08	2.91	0.278
41	1.0247	62.74	1.62	0.254
42	1.0113	33.47	2.26	0.296
43	1.0161	44.72	2.03	0.277
44	1.0201	53.46	1.61	0.266
45	1.0231	60.95	2.38	0.264
46	1.0225	55.47	0.98	0.242
47	1.0221	56.19	1.83	0.254
48	1.0120	31.69	1.56	0.264
49	1.0160	41.84	1.60	0.261
50	1.0215	53.98	1.70	0.251
51	1.0267	68.91	1.17	0.258
52	1.0160	41.26	2.12	0.258
Mean,	1.0215	55.83	2.19	0.260

The evaporation losses calculated as urea, from the ammonia evolved, are seen to be far greater with the urine than with the artificial mixtures. With an average of 28 grams of urea in the urine the mean loss is evidently about 8 per cent. of this content. While as a matter of convenience it is satisfactory to calculate the loss as urea, a little consideration will show that a part of it must come from other sources. In the evaporation, part of the ammonia present, and possibly sometimes all of it, is driven off and this may be considered as combined as some organic salt and possibly partly as carbonate. In one case the loss would be less and in the other greater than that found by calculation as urea. The usual method of calculation probably represents the average loss, and this has been included in the figures representing the total solids in column 3.

The correspondence between high specific gravity and high solids is a fairly good one in most cases, as shown by the factor in the last column, representing the so-called Haeser coefficient for the temperature of 25°. This factor is obtained by dividing the last three figures of the specific gravity into the weight of solids found. In most cases the variations are not great from the mean value of 0.260, but in Nos. 4, 10, 26, 28, and 42 the divergence is much greater than given by Neubauer. For the *mixed* day's urine the results would be much closer and in any such case the factor 0.260 would not be far from the truth. This factor can be

applied only when the specific gravity is taken at 25°, for which temperature many urinometers are now adjusted.   For an instrument graduated to give the specific gravity at 20° referred to water at 4° the factor to be used is 0.234.   This was found by making a number of determinations of the specific gravity at the two temperatures and calculating the average coefficient of expansion. Neubauer's average factor is 0.233, based on urine at 15° referred to water at 0°.   For the same temperature limits the results are practically identical, which indicates that for normal mixed urine the coefficient has a sharp definite value, and that it may be used as a control in certain kinds of analyses.   Results of still greater value in practice may doubtless be secured through the exact determination of a factor for the solids, exclusive of the sodium chloride, that is, for the products of metabolic origin.   A series of determinations in this direction is now in progress.

In any case the *exact* determination of the total solids by evaporation does not appear to be possible because of the uncertainty as to how the ammonia loss should be calculated.

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DERIVATIVES OF ISOSAFROL AND ISOAPIOL.

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IN a previous paper,[1] certain compounds were described which were found to result by the action of hot methyl and ethyl alcohols upon the bromine derivatives of anethol, isosafrol, ethyl isoeugenol and isoapiol; it was stated that these compounds are formed by the replacement of the bromine atom in the side-chain, which stands in the α-position to the benzene ring, by the methoxyl- and ethoxyl-groups.   Thus, for example, a compound having the formula,

[1] Pond, Erb and Ford : This Journal, **24,** 327.