stant which depends only on the nature of the liquid. It is a fairly straightforward process now to show that

$$L_0 = 8.42 \frac{\rho_0}{m_a^2} M^2$$

where L_0 denotes the internal heat of evaporation[4] at the absolute zero, m_a the absolute molecular weight of a molecule, and ρ_0 the density at the absolute zero, which has been exterpolated for a large number of substances by means of Cailletet and Mathias' linear diameter law. Using this equation, the writer has determined the electrical moments of the molecules of a number of substances and found that they were approximately given by

$$M = 10^{-19} \Sigma N^{2/3},$$

where N denotes the atomic number of an atom. It appears, therefore, that the moment of a molecule is equal to the sum of the moments of its atoms, and that the moment of an atom is proportional to the two thirds power of its atomic number which is equal to the number of elementary electrical charges of one sign the atom contains. This result may be taken as good evidence that the molecules of a substance largely interact as if they consisted of electrical doublets.

If x denotes the distance between the charges of the representative doublet of an atom, we have

$$x N e = M$$

or

$$x = 2.09 \times 10^{-10} N^{-1/3} \, cm.$$

Thus the value of x decreases as the atomic weight increases, which is probably owing to the fact that the larger the number of electrons in an atom, the more symmetrically they may be distributed around the positive nucleus. Moreover, x is also always less than the diameter of the atom, as we might expect. The value 2.09×10^{-10} c.m. of x for the hydrogen atom is much smaller than the value of $.53 \times 10^{-8}$ c.m. of the radius of the circle the moving electron describes around the positive nucleus according to Bohr's theory. Thus in order that the atom may behave as an electrical doublet it is necessary that the nucleus does not occupy the center of the circular path of the electron, but a distance of about 2.09×10^{-10} c.m. from the center at right angles to the plane of motion. Strictly the system will not be in equilibrium by itself under these conditions, but may be when associated with another system. If the electron describes an ellipse with the nucleus at one of the foci, the atom may behave on the whole as a doublet when isolated. The doublet effect of more complicated atoms may be produced along similar lines.

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[4] In ergs per gram.

SIMPLE MILK FORMULAE[1]

CERTAIN formulæ[2] obtain in milk analysis. Among these are:

Fleischmann's:

The mean specific gravity of the milk solids =

$$\frac{T}{T - \dfrac{100G - 100}{G}}$$

where T = per cent. of total solids.
G = specific gravity of the milk.

Babcock's (Hehner & Richmond's):

The per cent. of total solids $= 0.25L + 1.2F$,
where L = lactometer reading $= 10(100G - 100)$
F = per cent. of fat.

Bialon's:

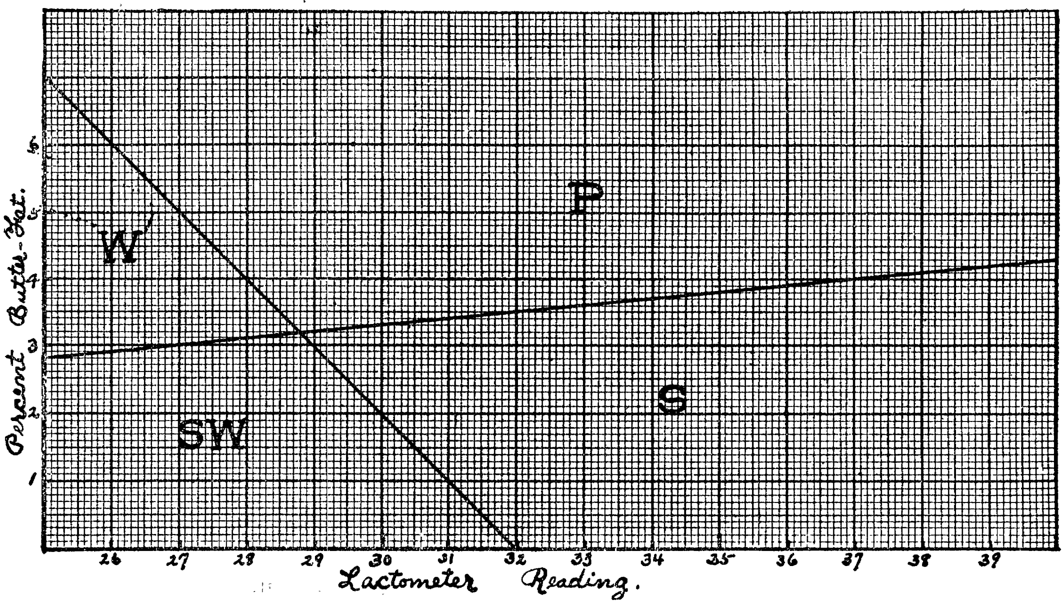
The specific gravity of the fat-free milk =

$$\frac{100G - F}{100 - \dfrac{F}{0.933}}$$

Certain numerical limits in these formulæ are generally recognized: the mean specific gravity of the milk solids does not exceed 1.34 in herd milks above suspicion of skimming,[3] and the

[1] Abstracted from a paper read before the Delaware County Institute of Science, Media, Pennsylvania, May 9, 1921.

[2] More or less adequate discussion of one or more of these milk formulæ are to be found in Bulletin 134, U. S. Dept. Agriculture, Bur. Animal Industry (by Shaw and Eckles) and in books relating to milk control, such as those of Leffmann, Ernst-Mohler-Eichhorn, Barthel, Van Slyke, Race, Jensen-Pearson, Heineman, and particularly in that of Richmond. Books on food analysis, such as those of Leach, Woodman and Allen, also take up milk formulæ more or less completely.



specific gravity of the milk free from fat does not fall below 1.0323 in milks above suspicion of watering.[4] The formulæ given above are not directly connected with the two values that are determined first in a routine milk examination, namely, the specific gravity, G, and the percentage of fat, F. Rules that show F as a function of G are needed, for these two values are the logical bases upon which to sort out milks above suspicion of skimming and watering. This paper calls attention to such rules:

Rule I. Add 3 to the lactometer reading, and then divide by 10. The result is the minimum percentage of fat to be expected in that milk if it is above suspicion of skimming.

Rule II. When lactometer readings from 26 to 30 are arranged in ascending order, the corresponding minimum percentages of fat in herd milks above suspicion of watering are whole numbers arranged in descending order from 6 to 2.

Rule 1 is derived as follows: Put the limiting value (1.34) for unskimmed herd milk into Fleischmann's formula; substitute for percentage of total solids, T, in Fleischmann's formula this same value as it is defined by Babcock's formula; and solve for an equation representing $F = (f)G$. This will be found to be

[3] Woodman: "Food Analysis," New York, 1915, p. 139.

[4] Barthel: "Die Methoden z. Untersuchung v. Milch u. Molkereiprodukten," Leipzig, 1911, p. 135.

$$F = \left(\frac{3.284}{G} - 2.083\right)(100G - 100) \quad . \; . \; . \quad (4)$$

Using in (4) known values of G between the usual limits, namely, 1.025 to 1.040, and solving for F, a table of values is gotten that shows Rule I clearly, and also shows that Rule I gives values for F within about 0.02 per cent. of those calculated by equation (4).

Rule II is derived as follows: Put the limiting value 1.0323 for unwatered herd milks into Bialon's formula, and solve for an expression representing $F = (f)G$. This expression will be found to be

$$F = 969.927 - 939.579G \quad . \; . \; . \; . \quad (5)$$

Using in (5) known values of G between the limits 1.026 and 1.030 and solving for F, a table of values is gotten that shows Rule II clearly, and also shows that Rule II gives values for F within 0.1 per cent. on the average when compared with those calculated by equation (5). As 0.1 per cent. is approximately the average error in the routine determination of butter-fat in milks, this may be neglected.

Plotting Rules I and II gives a diagram that covers the values of F and L met with in routine work, and that shows the region where the two rules overlap.

These simple rules are recommended as guides in sorting out early in the examination of any number of herd milks those that are above suspicion of skimming and watering.

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