of one sharp change in the rate of decomposition at 143° there are here shown two such breaks, one at 140° and one at 146°. As the Obermuller apparatus uniformly gives concordant results within ±2 mm. the position of the curve is sensibly free from experimental error.

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[CONTRIBUTION FROM THE AGRICULTURAL CHEMICAL LABORATORY OF THE WISCONSIN EXPERIMENT STATION.]

VARIATIONS IN THE AMOUNT OF CASEIN IN COW'S MILK.

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There is a general belief among dairymen and some dairy chemists that casein and fat are present in milk in very constant relative proportions; that given the percentage of fat in milk, the percentage of casein can be directly calculated by rule. This rule was formulated by Van Slyke[1] and is based on averages of numerous analyses made at the New York Agricultural Experiment Station. The rule is to be applied especially to milks ranging from three to four and one-half per cent. of fat and is stated as follows: to find the per cent. of casein in milk when the per cent. of fat is known, subtract 3 from the per cent. of fat in milk, multiply the result by 0.4 and add the result to 2.1. The limitations placed on the rule as applicable to milks containing but from three to four and one-half per cent. of fat led the writer to inquire how applicable it might be to milks of higher fat content. Hill,[2] as early as 1890, showed that in individual cows the proportion between fat and casein is widely different. He, however, obscured this important fact by conclusions based on averages of many milk analyses. His conclusion was that normal milks, whether rich or poor, have on an average, one-fourth as much casein as total solids, though he further says that single samples may depart widely from this standard.

Shuttleworth,[3] from work on individual cows, showed that a considerable variation in the proportion of casein to fat existed among different animals, and that a ratio established for one period of lactation in any single animal may not be the same as the ratio found at some other period for the same animal.

A priori there seems to be no good reason why we should expect a definite quantitative relation between these two constituents of milk. They are entirely unlike in chemical constitution and their elaboration has been along different lines of synthesis. If we could suppose that they

[1] Modern Methods of Testing Milk," p. 192.
[2] Fourth Annual Rept. Vt. Agr. Exp. Sta.
[3] Rept. of Ontario Exp. Farm, 1895.

have resulted from the splitting of a single chemical entity, then there would be reason for a definite relation between the amounts of these two substances in this secretion. But the facts regarding the production of milk constituents do not appear to support any such hypothesis. The most variable milk constituent we have is the fat, which may rise and fall from day to day in no inconsiderable amount, dependent on feed and the environment to which the animal is subjected. During such fluctuations of the fat[1] content, the casein may remain constant. Instances are on record where the fat content of the milk has dropped from 3.25 per cent. to 2.20 per cent., while the casein content of those milks remained at 2.08 and 2.18 per cent., respectively. This at least would indicate that the precursor of these two important milk constituents was not a single chemical entity, which seems a necessary assumption if the two substances are to remain in constant relative proportion. On the other hand, it indicates rather a differentiated process, with the formation of fat and casein as distinctive and dependent upon inherent cell characteristics.

Again, the relation of fat to casein in the cow's milk established for one period may not be found to be the same at some later period of lactation. In fact, it appears to be the normal tendency for the nitrogen compounds of milk to increase relatively to the fat with the advance of lactation.

Further, while there is no doubt that the rule above formulated is fairly accurate when applied to the mixed milk of herds made up of grade animals, it appears entirely possible that it might not be applicable to mixed milk produced by animals of high fat-producing capacity.

The very fact that the efforts of progressive dairymen is to displace the low fat-producing animals with animals producing higher fat yields, is to introduce a tendency to move away from the application of the rule.

From the standpoint of the breeder of dairy cows and the cheese industry, it would appear extremely important to know whether or not animals producing milks of five to six per cent. fat content, are producing a definitely related percentage of casein, and with animals producing three to five per cent. of fat, whether that same relation holds true. If it does not, then it would appear that here is important work for breeders of dairy cows in the selection and production of animals producing milk more fitted for the butter or the cheese industry, as the case may be.

Studies of the University Herd.—No attempt was made to follow the animal through long periods of lactation. The only attempt made here was to learn whether the variations of fat to casein in different animals was of any significance and what might be expected any time an analysis was made.

[1] Technical Bull. No. 1, N. Y. Agr. Exp. Station.

Casein determinations were made by the Official Agricultural Chemists' method. The only variation was the use of the factor 6.38 instead of 6.25. The samples were from a mixture of night's and morning's milk. Fats were run by the Babcock test from composite samples selected over a period of one week in the usual way. The collection of the samples for casein determination was made in the middle of the week during which the fat sample was being taken. The analyses cover a period from July 26th to August 7th. The data relating to the animals are arranged in the table according to breed. The table contains, besides the percentages of fat and casein, a column showing the amount of casein calculated by Van Slyke's rule from the fat content. Besides these data, two separate columns show the relations of fat to casein and casein to fat.

ANALYSES OF MILK OF UNIVERSITY HERD.

Breed.	No.	Per cent. of casein found.	Per cent. of casein calculated.	Per cent. of fat.	Relation of fat and casein.	Relation of casein and fat.
Jersey	1	2.45	2.60	4.27	1.74:1	0.57:1
	2	3.11	2.83	4.83	1.55:1	0.64:1
	3	3.31	3.28	5.95	1.79:1	0.55:1
	4	3.65	3.24	5.85	1.60:1	0.62:1
	5	3.00	2.81	4.79	1.59:1	0.62:1
	6	2.92	3.30	6.02	2.06:1	0.48:1
Guernsey	7	3.50	3.38	6.21	1.77:1	0.56:1
	8	2.77	3.30	6.01	2.16:1	0.46:1
	9	3.09	3.02	5.31	1.71:1	0.58:1
	10	3.12	3.08	5.46	1.75:1	0.57:1
	11	2.91	2.85	4.89	1.67:1	0.59:1
	12	2.60	2.94	5.11	1.96:1	0.50:1
	13	2.47	3.05	5.37	2.17:1	0.46:1
	14	2.98	3.31	6.04	2.03:1	0.49:1
Holstein	15	2.10	2.17	2.96	1.41:1	0.70:1
	16	2.13	2.17	3.19	1.49:1	0.66:1
	17	2.50	2.27	3.44	1.57:1	0.72:1
	18	2.16	2.32	3.56	1.55:1	0.60:1
	19	1.88	2.17	3.18	1.52:1	0.65:1
	20	2.15	2.11	3.03	1.40:1	0.70:1
Brown Swiss	21	2.66	2.61	4.29	1.61:1	0.61:1
	22	2.70	2.49	3.99	1.51:1	0.66:1
Ayrshire	23	2.56	2.34	3.61	1.41:1	0.70:1
	24	2.14	2.87	4.93	1.57:1	0.63:1
	25	2.47	2.28	3.47	1.40:1	0.71:1
	26	2.61	2.32	3.57	1.36:1	0.73:1

The table shows that in a large number of instances the application of the rule gives data agreeing closely with actual determination. There are, however, as Dr. Van Slyke has already emphasized, high fat milks where the agreement is not very close, and actual determinations would alone disclose their true casein content. No. 13, with a fat content in the milk practically identical with that of No. 10, nevertheless shows a casein content 0.65 per cent. lower than the latter.

The table further shows that there is considerable variation not only among animals of different breeds, but between animals of the same breed. Percentage variation of casein ranges from 1.88 for Holsteins to 3.65 for Jerseys. Among Holsteins themselves the range of percentage is from 1.88 to 2.50, while among Jerseys it is from 2.45 to 3.65. Reduced to a ratio of pounds of fat to pounds of casein, we have among different breeds, for instance, at the time these analyses were made, No. 6, a Jersey, showing 2.06 pounds of fat for every pound of casein, while No. 17, a Holstein, shows 1.37 pounds of fat for one pound of casein. No. 8, a Guernsey, shows 2.16 pounds of fat for every pound of casein, while No. 25, an Ayrshire, shows 1.4 pounds of fat for one pound of casein. These are the extreme cases among the number of animals investigated.

Among breeds themselves, we have No. 6, a Jersey, with a ratio of 2.06 punds of fat to 1 of casein, while No. 3 of the same breed shows a ratio of 1.79 pounds of fat to every pound of casein. Stated in another way, No. 6 shows 0.48 pound of casein for 1 of fat, while No. 3 shows 0.55 pound. The data on the milks of these two cows clearly shows that relative to their fat, No. 3 is the greater casein producer. The yield of cheese from the milk of No. 3 must necessarily be larger, under uniform conditions of manufacture, than from that of the other animal. Again, No. 7 showed a relation of 1.77 pounds of fat to 1 of casein, while No. 8 showed the relation of 2.16 to 1. No. 7 shows the relation of casein to fat as 0.56 to 1, while No. 8's relation is 0.46 to 1. The milks from these animals were at about the same period of lactation.

A further consideration of the table reveals the fact that among breeds the Holsteins, Brown Swiss and Ayrshire uniformly show a higher relative proportion of casein to fat than do the Jerseys and Guernseys. It also shows that certain individuals among the two latter breeds may show as high a relation of casein to fat as certain individuals among the other breeds.

What these animals will do for a whole year is not known, but enough data is at hand to emphasize the fact that individual differences in casein-producing power do occur among animals of different breeds, and surely may occur among animals of the same breed, and that the casein-producing power does not necessarily bear any close relation to the fat-producing power. That a higher fat holding milk means an increased casein holding milk is not here denied, but that the increase is in a fixed proportionate ratio, the data do not support. It emphasizes, it seems, the fact, that the casein-producing function is in part, if not largely, individualistic, and capable of being used in producing dairy types of animals, either for an industry in which fat plays the most important rôle, or for a cheese industry, where both fat and casein are primarily concerned.

Summary.

1. The relation of casein to fat in cow's milk is a variable one.

2. One of the prime factors controlling its relation is individuality.

3. The relation of casein to fat varies among animals of different breeds and among animals of the same breed.

4. Direct determination of both fat and casein seems necessary in determining the value of the milk of any single cow for cheese production.

NOTES.

The Use of the Centrifuge.—Attention has recently been called to the advantage of the laboratory use of centrifugal action for separating crystals from their mother-liquor—a process which has long been of great service in technical operations on a large scale.[1] The object of this note is to point out certain important precautions necessary in the use of this highly serviceable apparatus. The word of caution seems to be especially demanded because new apparatus is being put upon the market by several firms, and the novice may be unfamiliar with the intensity of the centrifugal effect, and the consequent danger inherent in improperly constructed machinery.

It is well known that the forces acting to drain out the liquid in a centrifuge are $\frac{4\pi^2n^2r}{g}$ times as great as they would be in a gravity-vat with a perforated bottom, if n = the number of revolutions per second, r the radius, and $g = 980.6$. Thus if $n = 20$ (*i. e.*, 1200 revolutions per minute) and the radius of the centrifuge is 10 centimeters, the drying is nearly 160 times as great as that effected by gravity—a very great advantage. It must not be forgotten, however, that the strain upon the apparatus increases in the same proportion, being quadrupled for each doubling of the speed. Therefore with high speeds great strength is necessary. Even great steel fly-wheels sometimes burst under their strain. For this reason, centrifugal apparatus constructed of fragile material should never be run rapidly, and even with the simplest and strongest apparatus, the machine should *always be surrounded by a very strong casing or box of wood or metal*, so that no harm would result if anything should break. For the same reason rapidly revolving centrifugal apparatus should *never be constructed of glass, unless the glass is enclosed in metal in such a way that the fragments will not fly if broken.* Glass apparatus is frequently not well annealed, and is liable to break under the heavy strain.

[1] Richards, This Journal, **27**, 104 (1905); Ber., **40**, 2771 (1907). Köthner, Chem. Ztg., **1907** (No. 73).