

amount of nitrogen found by the factor 6.25. Ordinarily, for this purpose, milk can be regarded as "fresh," when it does not show marked development of lactic acid.

II. In Old Milk: When milk has undergone such change as to show marked development of lactic acid, the method above given cannot generally be relied upon to give accurate results in determining casein. So far as our results go, they indicate that we cannot with positive accuracy determine casein in such milk by any method now known, and results obtained with changed milk must be regarded as only approximate. If, however, one part of finely powdered mercuric chloride is added to two thousand parts of milk, when fresh, the changes, which would otherwise take place, are prevented or greatly retarded, so that milk treated in this manner may be used after standing some days for the determination of its casein. In such cases, the method given above for fresh milk may be followed, except that the acetic acid should be added in small portions, a few drops at a time, stirring after each addition, and continuing the addition of acetic acid until the liquid above the precipitate becomes clear or very nearly so.

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SOME POINTS RELATING TO THE COMPOSITION OF COWS' MILK.¹

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IT is my purpose to call attention to some general results secured in our work at the New York State Agricultural Experiment Station at Geneva in the course of an extended examination of the milk of cows in that State. Our results are based upon the analysis of lots of milk aggregating over 200,000 pounds and representing the product of not less than 1,500 individual animals, and 20,000 separate milkings extending over a period of some six months.

The points to which I wish to call especial attention are the following:

1. The relation of casein to albumen in normal milk.

¹ Read before the World's Congress of Chemists, August 24, 1893.

2. The relation of fat to casein and albumen in normal milk.
3. The relation of fat to casein (excluding albumen) in normal milk.
4. The effect of removing fat from normal milk upon the relation of fat to casein.
5. The relation of fat to total solids in milk as defined by law.

(1) *The Relation of Casein to Albumen in Normal Milk.*—In the present state of our lack of detailed knowledge regarding the constitution and relations of the nitrogen compounds of milk, we call casein that portion of the nitrogen compounds of milk that is precipitated by rennet, dilute acids, and certain salts. The remaining portion of the nitrogen compounds of milk we call albumen, though we know that there are at least two different compounds in this portion. The casein was determined by precipitation with dilute acetic acid and the nitrogen in the precipitate estimated by the regular Kjeldahl method, the nitrogen multiplied by 6.25 gave casein. The details of the method are contained in a paper presented elsewhere by me. The amount of casein subtracted from the total amount of nitrogen compounds in the milk gave the albumen by difference.

The point to which I wish to direct attention in this connection is this: Do casein and albumen in the normal milk of cows bear a definite or a variable relation to each other? So far as I have been able to ascertain, the only positive statement on this point has been made by Blyth (*Foods: Composition and Analysis* 2. ed., p. 208,) and he says: "The amount of albumen in milk is really fairly constant, and averages 0.7 per cent. In healthy cows it is a very constant quantity, the chief deviation occurring directly after calving, when the amount may rise as high as three per cent., but this is always accompanied by a corresponding rise in the casein. According to the author's experience, the albumen preserves a very constant relation to the casein, the quantity of the latter being five times that of the albumen; so that if either the amount of casein or albumen is known, the one may be calculated from the other with great accuracy." The foregoing statement has been quite generally accepted as authoritative. It is to be regretted that Blyth does not state the extent of the work upon which he bases his

general conclusion and also the source and character of the milk examined by him.

The results secured in our work with the mixed milk of herds of cows and with individual cows of different breeds do not agree with the statement of Blyth. In outline our results were as follows:

(1) The amount of casein varied from 1.93 to 3 per cent., and averaged 2.48 per cent.

(2) The amount of albumen varied from 0.55 to 0.86 per cent. and averaged 0.66 per cent.

(3) For each pound of albumen in the milk the casein varied from 2.6 to 4.9 pounds, the average being 3.76 pounds of casein for one pound of albumen.

All our work goes to show that the relation of casein to albumen in cows' milk is a variable one, and that very rarely does milk contain five parts of casein for one of albumen and not often does the ratio go above four and one-half to one and seldom goes below three to one, while the average is somewhat under four parts of casein to one of albumen.

(2) *The Relation of Fat to Casein and Albumen in Normal Milk.*—The average composition of milk as given in many of our best authorities generally exaggerates the proportion of casein and albumen. Whether this has come from faulty methods of analysis, or the use of too large a factor in converting nitrogen into casein, or from peculiar kinds of cows, it is difficult to say. In nearly all of the older works we find the amount of casein and albumen given in excess of the fat, and in more recent statements the proportion is large. It may be that our cows in New York State do not give milk like cows in other countries, but the fact has impressed me very strongly that our results show that the relation of casein and albumen to fat in milk is not as great as reported elsewhere.

Giving the general average of our results, we have found the fat to be 3.70 per cent., the casein and albumen, 3.14 per cent., or for each pound of casein and albumen there was on an average nearly 1.20 pounds of fat. The lowest ratio found was 1.07 of fat and the highest 1.33 of fat to 1 of casein and albumen. In working with the mixed normal milk of herds,

we have never found a single instance in which the milk contained more casein and albumen than fat, and, moreover, we have not found a single instance in which the milk contained as much casein and albumen as fat. In working with the milk of individual cows of seven different breeds we have not yet found a single instance where any individual (in normal health) of any breed gave milk for any considerable period of time that contained as much casein and albumen as fat.

(3) *The Relation of Fat to Casein (Excluding Albumen) in Normal Milk of Cows.*—So far as I have been able to ascertain, there are on record outside of the data furnished by the Geneva (New York) Experiment Station no determinations of casein in cows' milk embracing large amounts of milk during an extended period of time; and hence the relation of casein to fat in cows' milk has received little or no attention until recently. In working with the mixed milk of herds of cows for a period of six months we obtained the following results:

(1) In normal milk which contained fat varying from 3 to 4.5 per cent., the casein varied from 1.93 to 3 per cent. The fat averaged 3.70 per cent., and the casein 2.48 per cent.

(2) In no case did normal milk contain less than 1.35 pounds of fat for one pound of casein, or more than 1.74 pounds of fat for one pound of casein, while the average of all was 1.5 pounds of fat for one pound of casein. Over seventy-five per cent. of the individual results were within one-tenth of the average.

(3) In examining the normal milk of individuals of seven different breeds of cows during the past year, we have never found for any extended period that there was less than 1.3 pounds of fat for one pound of casein.

(4) *The Effect of Removing Fat from Normal Milk upon the Relation of Fat to Casein.*—When fat is removed from milk, the milk loses little else in the way of solids. The casein remains essentially undiminished in quantity. Hence, the greater the amount of fat removed the more casein there will be in proportion to the fat left. In numerous experiments made to ascertain the effect of skimming milk upon the relation of fat to casein, it was found that in no case did skim-milk contain more than 1.35 pounds of fat for one pound of casein and this was

in case of a milk which had less than ten per cent. of its fat removed. As a rule, taking average normal milk as found in New York State, we have found that if as much as twenty per cent. of the fat in the milk is removed the resulting skim-milk will contain less than 1.3 pounds of fat for one pound of casein. Now, considering the fact that we have not found any normal milk to contain less than 1.30 pounds of fat for one pound of casein, while the average is 1.50 pounds of fat for one of casein, it would appear that we might make a practical use of this relation of fat to casein for the detection of skimmed milk. Our work makes it appear that if milk contains less than 1.30 pounds of fat for one pound of casein, it has been skimmed. I feel justified in saying that this standard would be found to give true results ten times where the present crude legal standard used in New York State and elsewhere would be found to give correct results once in a case of skim-milk. And this brings me to my next and last topic.

(5) *The Relation of Fat to Total Solids in Normal Milk as Defined by Law.*—The present legal standard of normal milk in New York and several other states requires that normal milk shall contain twelve per cent. of solids, of which three per cent. shall be fat. I am not entirely certain as to where this so-called minimum standard originated, or upon what work done in New York State its adoption there was based; but I have this to say of normal milk as found at present in New York, that in an examination of a large number of samples of mixed milk of herds representing nearly half a million pounds of milk and the product of several thousands of different cows I have not yet found a single instance in which such milk contained at the same time three per cent. of fat and as much as twelve per cent. of solids. Moreover, in examining a large number of samples of milk from individual cows of many different breeds, I have not found twelve per cent. of solids in milk containing three per cent. of fat, unless the animal was in an abnormal physical condition. It is not difficult to see why normal milk containing three per cent. of fat should not contain twelve per cent. of total solids. Normal milk containing three per cent. of fat should contain about 5.50 per cent. of sugar and ash or 8.50

per cent. solids without casein and albumen. If such milk contains twelve per cent. of total solids, then there must be 3.50 per cent. of casein and albumen, that is 3.50 per cent. of casein and albumen for three per cent. of fat, a relation of these compounds, which, as I have previously stated, I have not yet found in normal milk. Only in skimmed milk containing three per cent. of fat should we expect to find as much as twelve per cent. of solids.

General Summary.—We may briefly summarize our statements as follows:

(1) The relation of casein to albumen in normal milk is more or less a variable, and not a definite one.

(2) The amount of fat in normal milk is very rarely less than the amount of casein and albumen. On an average there are 1.20 pounds of fat for one pound of casein and albumen.

(3) Average milk contains about 1.50 pounds of fat for one pound of casein (excluding albumen).

(4) The removal of fat from milk reduces the ratio of fat to casein in the resulting skim-milk. When milk contains less than 1.30 pounds of fat for one pound of casein the milk has in all probability been skimmed.

(5) The legal minimum standard, which requires milk containing three per cent. of fat to contain twelve per cent. of total solids, does not agree with the composition of normal milk as found in New York State, since normal milk that contains three per cent. of fat will contain considerably less than twelve per cent. of total solids. The legal requirement would be met with only in skimmed milk.

IMPROVED UREOMETER.

BY PROFESSOR J. I. D. HINDS.

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IN using the ureometer designed by Prof. Doremus I have found two sources of considerable error. In the first place, it is impossible to run in from the pipette exactly one centimeter of the urine. In the second place, some bubbles of nitrogen almost invariably escape at the bulb of the instrument.

To remove these sources of error, I have devised the appara-