Issued January 18, 1913.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY.—BULLETIN 156.

A. D. MELVIN, CHIEF OF BUREAU.

THE INFLUENCE OF BREED AND INDIVIDUALITY ON THE COMPOSITION AND PROPERTIES OF MILK.

BY

C. H. ECKLES,

Professor of Dairy Husbandry, University of Missouri,

AND

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., July 11, 1912.

SIR: I have the honor to transmit, and to recommend for publication in the bulletin series of this bureau, the accompanying manuscript entitled "The Influence of Breed and Individuality on the Composition and Properties of Milk," by Messrs. C. H. Eckles, professor of dairy husbandry, University of Missouri, and Roscoe H. Shaw, chemist in the Dairy Division of this bureau.

The experimental work reported herein forms part of a series of cooperative investigations inaugurated in 1906 between the Dairy Division and the Missouri Agricultural Experiment Station, with the object of studying in detail the factors influencing the composition and properties of milk as produced under normal dairy conditions. The first results of the work have been forwarded for publication as Bulletin 155, entitled "The Influence of the Stage of Lactation upon the Composition and Properties of Milk."

Respectfully,

A. D. MELVIN,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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INTRODUCTION.

In 1906 the Dairy Division of the Bureau of Animal Industry, in cooperation with the Missouri Agricultural Experiment Station, began a series of investigations, the main object of which was to study in detail the factors influencing the composition and properties of normal milk. It is a well-known fact that although the same constituents are always present in milk, the relative amount of each is subject to constant variations. Among the causes of these variations are known to be the breed of the animal, the stage of lactation, the individuality, and to some extent the feed, the interval between the milkings, and the temperature and weather conditions. It is also known that the first and the last milk drawn differ in composition.

A large amount of data has been published regarding these variations, the greater part of which deals with the fat content alone. In planning this series of investigations it was arranged to give attention first of all to the variations occurring during the period of lactation. The data concerning this part of the subject have been prepared for publication as Bulletin 155 of the Bureau of Animal Industry, entitled "The Influence of the Stage of Lactation on the Composition and Properties of Milk." In carrying on this investigation the plans were so arranged that the influence of breed and individuality of the animals could be studied concurrently with that of the period of lactation, and a presentation of these results is the object of the present paper.

There is no lack of data concerning the influence of the breed and the individuality of the animal upon the composition of milk as far as the per cent of the fat is concerned, although in practically all investigations reported there was no uniformity in the rations fed the animals and no data taken concerning the composition of the fat produced. When the influence of the stage of lactation is not taken into account, and when the ration is changed from time to time or varies with different animals, it is clearly impossible to state

to what extent any variation found may be due to the ration fed and to what extent to the stage of lactation, breed, or individuality of the animal. It is especially important to keep the ration uniform, since it has been demonstrated that the nature of the food has an important influence, more particularly in regard to the composition of the fat.

PLAN OF THE INVESTIGATION.

Eleven animals were selected for the investigation, consisting of 3 representatives each of the Jersey, Holstein, and Shorthorn breeds, and 2 of the Ayrshire breed. These cows were typical specimens of the breed—that is to say, neither superior nor inferior producers of milk, but about the average. They were all purebred and registered. They were kept under much the same conditions as would be found in a commercial dairy except in regard to the control of the feed of the animals. The ration fed was of uniform composition throughout the entire lactation period and was made up as follows:

Choice alfalfa hay	3 parts.
Grain mixture:	
Corn, 8 parts	2 parts.
Bran, 1 part	
Oats, 1 part	

This ration supplied the nutrients necessary for milk production in about the right proportion. The ratio between the hay and the grain was such that the animals would eat the entire ration at all times. The amount fed was governed by the needs of the animal. The animals all went through the entire lactation period with no ill effects resulting from the lack of variety, and in no case was there any serious sickness of any kind. The hay, which was the most variable part of the ration, was bought in large quantities from the same source in order that there might be few changes in its composition. The animals were housed at night in the barn for feeding and milking and in the daytime were turned outside in a dry lot. The date for beginning the taking of samples was 5 days after the birth of the calf. The sampling was continued until the production of milk declined to the point where in a commercial dairy the cow would not be milked longer. A more detailed account of the plan of the investigation is found in Bulletin 155, previously mentioned.

METHOD OF SAMPLING AND PREPARATION OF SAMPLES FOR ANALYSIS.

The milk was weighed immediately after milking and mixed by pouring from one pail to another. A sample consisting of about 1 liter placed in a glass jar bearing the number of the cow and marked

with the amount of milk produced was delivered at the laboratory. A certain number of cubic centimeters per pound of milk produced was then measured out and placed in a closed receptacle. In this manner a composite sample was prepared representing the production of that particular cow for 1 week. The milk was preserved by the addition of formalin. At the end of the week the composite sample was thoroughly mixed and a subsample consisting of about 300 c. c. taken for analysis. The remainder of the composite sample was heated to the proper temperature and the cream separated with a hand-power separator. The cream so obtained was churned by shaking in a glass jar, and the butter resulting was melted on a steam bath. The methods of sampling and analysis have been described in detail in Bulletin 155; it is sufficient to say that the methods of analysis followed were those of the Association of Official Agricultural Chemists wherever possible.

THE TRUE AVERAGE PER CENT.

In many cases in reporting analyses of milk a simple average instead of a true average is given. An average made in this manner is often misleading. In the case of the constituents of the milk it generally gives a result somewhat high, since milk becomes richer as it decreases in amount toward the end of the lactation period. Unless otherwise stated the averages given in this publication represent true averages. The average per cent of fat for the lactation period, for example, is found by dividing the total milk into the total fat produced.

RESULTS OF THE EXPERIMENTS.

Table 1 gives the data concerning the cows used in this investigation. Under the heading "Period samples were taken" is shown the periods covered by the samples taken for analysis.

TABLE 1.—*Data concerning the cows used.*

Breed.	No. of cow	Age.	Date of calving.	Date of breeding.	Period samples were taken.	Total yield of milk.	Average fat content.	Total yield of fat.
		Ys. mos.				*Lbs.*	*P. ct.*	*Lbs.*
Jersey.....	4	6 10	Nov. 13, 1906	Dec. 30, 1906	Nov. 24, 1907, to Sept. 7, 1908...	5,429	4.87	264.45
Do.....	99	8 1	Jan. 1, 1907	Mar. 23, 1907	Jan. 5, 1907, to Nov. 30, 1907....	6,115	4.64	284.04
Do.....	118	11 4	Sept. 27, 1906	Not bred....	Oct. 6, 1906, to Oct. 26, 1907.....	5,733	5.36	307.45
Ayrshire..	300	3 8	Dec. 28, 1907	Feb. 23, 1908	Dec. 29, 1907, to Oct. 3, 1908....	6,275	3.51	220.34
Do.....	301	4 8	Sept. 27, 1907	Mar. 16, 1908	Sept. 29, 1907, to Sept. 18, 1908..	6,382	3.85	245.64
Holstein..	205	5 3	July 17, 1907	Dec. 1, 1907	July 20, 1907, to Aug. 8, 1908....	8,684	3.24	280.76
Do.....	206	5 0	May 31, 1907	Sept. 28, 1907	June 1, 1907, to Apr. 4, 1908.....	8,994	2.93	263.66
Do.....	209	3 8	July 20, 1907	Nov. 18, 1907	July 20, 1907, to July 4, 1908....	8,814	3.02	273.34
Shorthorn	400	4 4	Sept. 30, 1907	Jan. 25, 1908	Oct. 5, 1907, to Aug. 1, 1908.....	5,172	3.89	201.37
Do.....	402	4 11	Oct. 13, 1907	Dec. 21, 1907	Oct. 19, 1907, to July 18, 1908...	4,449	4.13	183.57
Do.....	403	6 0	Feb. 11, 1908	July 7, 1908	Feb. 15, 1908, to Dec. 19, 1908...	6,539	3.35	220.52

TOTAL SOLIDS.

The determinations for total solids were made by using the Babcock asbestos method. The figures given are in each case an average of the determinations for 4 weekly composite samples. These are simple averages. The averages given for the lactation period of the animal and for the breeds are true averages.

Table 2 gives the percentage of total solids for each of the 11 animals used in the investigation by 4-week periods, the average for each animal for the period of lactation, and the average by breeds. The results correspond closely with those usually given for the breeds included. In Table 3 is given a compilation of analyses reported by several experiment stations in this country. The figures used include only those that represent purebred animals of the respective breeds, and where an entire period of lactation is involved. The data included in the column headed "Other American experiment stations" include all in print coming under the above conditions. A portion of this data was taken presumably by calculation from the specific gravity and the fat. Since these animals, owned by various experiment stations, represent a variety of conditions, it is believed that the average figure given, which includes all the data of such kind available up to the present, is reasonably accurate.

Table 4 gives the composition of the total solids in percentage of fat, protein, and sugar. The ash is not included, since it was lacking in some of the data, and furthermore, the amount of ash is so uniform with the different breeds and different individuals that no marked variations were found. The animals supplying the data from the New Jersey and New York experiment stations are the same as in Table 3.

TABLE 2.—*Average percentage of total solids for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	14.13	.....	.....	14.13	13.07	13.20	13.13
2	.....	13.09	14.08	13.58	12.27	12.50	12.39
3	.....	13.30	14.55	13.92	12.14	12.57	12.36
4	14.14	13.15	.....	13.64	11.81	12.64	12.23
5	14.28	12.92	.....	13.60	11.66	13.09	12.38
6	14.15	12.76	15.30	14.07	11.35	12.86	12.11
7	13.87	13.04	15.16	14.02	11.38	12.63	12.01
8	13.77	12.81	15.61	14.06	12.15	12.64	12.39
9	13.63	13.35	14.79	13.76	12.56	12.49	12.52
10	14.57	14.27	14.45	14.43	13.85	11.78	12.81
11	.....	15.15	14.42	14.88	.....	13.55	13.55
12	.....	16.08	15.08	15.58	.....	13.04	13.04
13	.....	.....	16.10	16.10	.....	13.27	13.27
14	.....	.....	17.16	17.16	.....	.....	.....
True average of total solids.	14.09	13.34	15.02	14.09	12.08	12.71	12.41

TABLE 2.—*Average percentage of total solids for each cow, and breed average, by 4-week periods*—Continued.

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
	Per ct.	*Per ct.*	*Per ct.*	*Per cent.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per cent.*
1	11.74	10.95	11.24	11.31	13.71	13.74	12.85	13.43
2	11.58	10.10	10.23	10.64	13.29	13.29	12.16	12.91
3	11.70	10.18	10.63	10.84	13.05	13.07	11.75	12.62
4	11.95	10.27	11.07	11.10	12.48	13.07	11.56	12.37
5	12.11	10.54	11.15	11.27	13.06	13.16	11.56	12.59
6	11.77	10.73	10.96	11.15	13.05	12.97	11.65	13.56
7	11.98	10.75	11.20	11.31	12.96	13.02	12.77	12.92
8	12.16	10.80	11.23	11.39	13.08	12.93	12.52	12.84
9	11.95	11.01	11.58	11.51	13.03	13.81	12.38	13.07
10	12.12	11.90	12.58	12.20	12.43	13.94	12.90	13.09
11	12.20	13.30	12.99	12.83	12.84	.....	13.19	13.02
12	12.50	.....	13.51	13.01	.....	.....	.....	.....
13	13.04	.....	14.52	13.78	.....	.....	.....	.....
14	13.42	.....	.....	13.42	.....	.....	.....	.....
True average of total solids.	12.12	10.73	11.35	11.38	13.08	13.01	12.17	12.69

TABLE 3.—*Comparison of total solids in this investigation with results reported by American experiment stations.*

Breed.	This investigation.		New Jersey Experiment Station.[1]		New York Experiment Station.[2]		Other American experiment stations.		General average.	
	Number of animals.	Average total solids.	Number of animals.	Average total solids.	Number of animals.	Average total solids.	Number of animals.	Average total solids.	Number of animals.	Average total solids.
		Per cent.		*Per cent.*		*Per cent.*		*Per cent.*		*Per cent.*
Jerseys	3	14.09	3	14.34	3	15.5	29	14.90	38	14.70
Guernseys	.....	.....	3	14.48	2	14.8	6	14.20	11	14.49
Ayrshire	2	12.41	3	12.70	4	12.8	17	12.98	26	12.72
Holstein	3	11.38	3	12.12	2	12.2	9	12.29	17	12.00
Shorthorns	3	12.69	3	12.45	.....	.....	.....	.....	6	12.57

[1] Neilson, James. Experiments with different breeds of dairy cows. New Jersey Agricultural Experiment Station, Bulletin 77. New Brunswick, Dec., 1890.

[2] New York Agricultural Experiment Station, Tenth, Eleventh, and Twelfth Annual Reports. Geneva, 1891, 1892, 1893.

TABLE 4.—*Average composition of the total solids in milk of dairy cattle, as reported by American experiment stations.*

Breed.	Fat.				Protein.				Sugar.			
	New Jersey.	New York.	Missouri.	Average.	New Jersey.	New York.	Missouri.	Average.	New Jersey.	New York.	Missouri.	Average.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
Jersey	33.3	36.4	35.1	34.9	27.6	25.4	25.8	26.3	33.8	33.4	34.5	33.9
Guernsey	34.7	35.1	.....	34.9	27.1	24.7	.....	25.9	33.3	35.0	.....	34.2
Ayrshire	29.1	27.3	29.6	28.7	27.4	26.3	26.1	26.6	38.1	40.8	39.6	39.5
Holstein	29.1	28.0	27.1	28.1	27.1	27.4	28.1	27.5	38.7	39.1	37.3	38.4
Shorthorn	29.3	.....	29.4	29.3	26.3	.....	26.6	26.4	38.6	.....	39.3	38.9

The fat represents from 28 to 35 per cent of the total solids, varying especially with the breed and to some extent with the individual. The total solids produced by the Jersey and Guernsey breeds contain,

on an average, 34.9 per cent of fat, which is relatively high as compared with the Holstein, Ayrshire, or Shorthorn breeds. Among the breeds included in these data the Holstein, with an average of 28.1 per cent, has the lowest proportion of fat, while the Shorthorn ranks next. The rule is that those animals having a higher per cent of fat in the milk also have a relatively larger proportion of fat in the solids.

The individual animals show some variations, but on the whole they follow the characteristics of their breed quite closely. The per cent of fat in the total solids produced by the 3 Jerseys used in this investigation varied from 34.6 to 35.7, the 3 Holsteins from 26.7 to 27.3, while the 3 Shorthorns varied from 27.7 to 31.7. The individual variation has to be taken into account in connection with the total solids, but is of less importance than is the variation due to breed.

FAT.

Table 5 gives the percentage of fat in the milk of the 11 animals represented in the investigation, expressed in the same manner as the total solids. The well-known facts regarding the relative composition of the milk for the 4 breeds used is brought out in these data.

Table 6 gives the average percentage of fat in the milk of animals used in investigations at the New Jersey and New York experiment stations; also a compilation showing the average per cent of fat for all registered animals of the respective breeds, the records of which have been published by American experiment stations. This table includes only data relating to purebred animals and where it is possible to obtain a true average per cent of fat for the entire period of lactation. It is believed that the summary, representing as it does a large number of animals in different States under somewhat comparable conditions, gives a reliable average as to the fat content of the milk of the breeds represented.

TABLE 5.—*Average percentage of fat for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	5.17	5.22	.....	5.20	4.01	3.87	3.97
2	4.63	4.79	5.31	4.91	3.61	3.74	3.68
3	5.07	4.43	5.55	5.02	3.38	3.81	3.60
4	4.85	4.40	5.11	4.79	3.36	3.81	3.59
5	4.81	4.33	5.51	4.88	3.32	4.08	3.70
6	5.00	4.22	5.71	4.98	3.26	3.78	3.52
7	4.73	4.36	5.09	4.93	3.30	3.95	3.63
8	4.51	4.18	5.80	4.83	3.53	3.94	3.74
9	4.73	4.63	5.17	4.84	3.74	3.67	3.71
10	5.18	4.98	4.47	4.88	4.52	3.58	4.05
11	.....	5.62	4.83	5.23	.....	4.92	4.92
12	.....	6.07	5.28	5.68	.....	3.96	3.96
13	.....	.....	5.48	5.48	.....	4.18	4.18
14	.....	.....	6.47	6.47	.....	.....	.....
True average of total fat	4.87	4.64	5.36	4.95	3.51	3.85	3.68

TABLE 5.—*Average percentage of fat for each cow, and breed average, by 4-week periods*—Continued.

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
	P. ct.	*P. ct.*	*P. ct.*	*Per cent.*	*P. ct.*	*P. ct.*	*P. ct.*	*Per cent.*
1	3.24	3.07	3.12	3.14	4.12	4.55	3.58	4.08
2	3.14	2.88	2.60	2.87	4.09	4.17	3.38	3.88
3	3.02	2.58	2.74	2.78	3.99	3.97	3.18	3.71
4	3.25	2.84	3.24	3.11	3.65	3.80	3.16	3.54
5	3.29	2.89	3.14	3.11	3.70	3.84	3.14	3.56
6	3.06	3.06	2.81	2.96	3.69	3.92	3.13	3.58
7	3.26	2.88	2.94	3.03	3.85	3.98	3.23	3.69
8	3.25	3.00	3.01	3.09	3.73	3.90	3.55	3.73
9	3.15	3.00	3.01	3.05	4.05	4.67	3.85	4.19
10	3.31	3.09	3.52	3.31	4.16	4.42	4.00	4.19
11	3.31	3.40	3.46	3.39	4.17	.....	4.05	4.11
12	3.49	.....	3.90	3.69	.....	.....	.....	.....
13	3.68	.....	5.28	4.48	.....	.....	.....	.....
14	3.68	.....	.....	3.68	.....	.....	.....	.....
True average of total fat	3.23	2.93	3.10	3.09	3.89	4.13	3.37	3.73

TABLE 6.—*Average percentage of fat in milk of dairy cattle, as reported by American experiment stations.*

Breed.	New Jersey.		New York.		Missouri.		All American experiment stations.	
	Number of animals.	Average fat.	Number of animals.	Average fat.	Number of animals.	Average fat.	Number of animals.	Average fat.
		Per cent.		*Per cent.*		*Per cent.*		*Per cent.*
Jersey	3	4.78	3	5.60	3	4.95	153	5.14
Guernsey	3	5.02	2	5.15	.....	.....	21	4.98
Ayrshire	3	3.68	4	3.57	2	3.68	24	3.85
Holstein	3	3.51	2	3.28	3	3.09	83	3.45
Shorthorn	3	3.65	.....	.....	3	3.73	40	3.63
Red Poll	.....	.....	.....	.....	.....	.....	9	4.03

It is a well-known fact that individuals within a breed vary considerably in the percentage of fat. The data here given are too limited to contribute much of value on this point. While by far the greater number of individuals within the breed will come close to the average for that breed, a comparatively few vary widely. It is characteristic of the breeds having the higher percentage of fat to show the greater individual variations. The percentage of fat secured during a lactation period may also be influenced to some extent by the time of the year in which the milking period began.[1] On the average the milk produced during the fall and early winter has a higher percentage of fat than that produced by the same animal in the early spring and summer. For this reason the cow that is fresh in the fall and produces the largest quantity of milk during the cool weather will have a higher average test for the year than will be the case if she freshens in the spring and produces the maximum yield during the period of warm weather.

[1] Eckles, C. H. Jahreszeitliche Schwankungen des prozentischen Fettgehaltes in Kuhmilk. Milchwirtschaftliches Zentralblatt, vol. 5, no. 11, p. 488–502. Leipzig, Nov. 1909.

TOTAL PROTEIN.

Table 7 gives the percentage of total nitrogen as protein for each individual and the average for each breed. The totals are also calculated as protein by using the factor 6.38. The results show a decided influence due to the breed of the animals, the Jersey having a uniformly higher percentage of protein than the others. The Holsteins are the lowest, while the Shorthorns and Ayrshires range between the Holsteins and Jerseys. The marked influence exerted by the stage of lactation upon the proportion of this constitutent present can be seen from the data given and has been shown in a previous publication.[1]

Table 8 is a compilation from the same sources as used in previous tables showing the average percentage of protein in the milk of 5 breeds. It will be noted that the figures obtained at the Missouri Experiment Station for Holsteins, Jerseys, and Ayrshires are somewhat lower than those obtained at the New Jersey and New York stations, while the figure for the Shorthorns is slightly above. There is some variation with the individuals regarding the amount of this constituent secreted, as is the case with other constituents of the milk. The individuals and breeds having the higher percentage of fat have at the same time the higher percentage of protein. The same animals also have a higher ratio of fat to protein. With the 11 cows used in our investigation, for each pound of protein there was found in the milk of the Jerseys 1.36 pounds of fat, in the Ayrshires 1.13, in the Shorthorns 1.10, and in the Holsteins 1.05. While an individual or a breed that produces milk with a high percentage of fat is certain to have a high percentage of protein as well, the protein and the fat do not increase in the same proportion.

TABLE 7.—*Average total nitrogen for each cow, and breed average, by 4-week periods, and average total nitrogen and protein for the whole lactation period.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	0.52	0.51	.....	0.52	0.53	0.56	0.54
2	.53	.51	0.51	.52	.47	.50	.48
3	.57	.51	.56	.55	.48	.48	.48
4	.61	.49	.54	.55	.47	.51	.49
5	.60	.49	.65	.58	.46	.51	.49
6	.59	.49	.65	.58	.47	.53	.50
7	.59	.48	.67	.58	.46	.51	.49
8	.57	.50	.64	.57	.49	.50	.50
9	.62	.52	.64	.59	.57	.53	.55
10	.66	.56	.64	.62	.67	.53	.60
11	.....	.62	.65	.63	.....	.53	.53
12	.....	.66	.70	.68	.....	.57	.57
13	.....	.....	.75	.75	.....	.65	.65
14	.....	.....	.77	.77	.....	.....	.....
True average of total nitrogen	.58	.51	.62	.57	.49	.52	.51
True average of total protein	3.70	3.27	3.97	3.64	3.11	3.33	3.25

[1] Bulletin 155, Bureau of Animal Industry, U. S. Department of Agriculture. Washington, 1912.

TABLE 7.—*Average total nitrogen for each cow, and breed average, by 4-week periods, and average total nitrogen and protein for the whole lactation period*—Continued.

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Averaget for Shotrhorns.
	P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1	0.49	0.44	0.50	0.48	0.54	0.53	0.52	0.53
2	.43	.38	.45	.42	.51	.52	.49	.51
3	.44	.37	.45	.42	.46	.51	.47	.48
4	.44	.39	.47	.43	.48	.54	.47	.50
5	.45	.42	.45	.44	.53	.55	.49	.52
6	.45	.42	.46	.44	.54	.55	.51	.53
7	.45	.41	.50	.45	.56	.55	.53	.55
8	.44	.43	.49	.45	.56	.57	.57	.57
9	.48	.44	.52	.48	.58	.63	.58	.59
10	.48	.51	.60	.53	.60	.70	.60	.63
11	.51	.71	.65	.62	.59	.....	.64	.61
12	.55	.....	.73	.64	.....	.....	.....	.....
13	.59	.....	.71	.65	.....	.....	.....	.....
14	.65	.....	.....	.65	.....	.....	.....	.....
True average of total nitrogen	.47	.42	.50	.46	.53	.55	.51	.53
True average of total protein	3.00	2.70	3.21	2.93	3.40	3.49	3.28	3.38

TABLE 8.—*Average percentage of total protein in milk of dairy cattle, as reported by American experiment stations.*

Breed.	New Jersey.		New York.		Missouri.		Average.	
	Number of animals.	Average protein.	Number of animals.	Average protein.	Number of animals.	Average protein.	Number of animals.	Average protein.
		Per cent.		*Per cent.*		*Per cent.*		*Per cent.*
Jersey	3	3.96	3	3.81	3	3.64	9	3.80
Guernsey	3	3.92	2	3.75	.....	.....	5	3.84
Ayrshire	3	3.48	4	3.29	2	3.25	9	3.34
Holstein	3	3.28	2	3.23	3	2.93	8	3.15
Shorthorn	3	3.27	.....	.....	3	3.38	6	3.32

CASEIN.

Table 9 gives the average percentage of protein in the form of casein for each individual and for each breed. Much the same range of variation is found here as is the case with the total protein. The percentage of the total protein present as casein was for the Holstein milk 80.4, the Jersey 80.7, the Ayrshire 83, and the Shorthorn 83.5. No special breed characteristics can be observed in regard to the relation of casein to the total protein. The individual variation is of some importance, but not so very much.

TABLE 9.—*Average casein nitrogen for each cow, and breed average, by 4-week periods, and average casein nitrogen and casein for the whole lactation period.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	0.44	0.42	.....	0.43	0.44	0.56	0.50
2	.38	.41	.32	.37	.40	.50	.45
3	.48	.40	.48	.45	.40	.48	.44
4	.49	.40	.42	.44	.38	.51	.45
5	.48	.40	.54	.47	.39	.51	.45
6	.48	.40	.52	.47	.39	.53	.46
7	.47	.39	.54	.47	.39	.51	.45
8	.46	.40	.54	.47	.44	.50	.47
9	.50	.42	.51	.48	.52	.53	.53
10	.52	.46	.50	.49	.59	.53	.56
11	.....	.51	.51	.51	.....	.53	.53
12	.....	.53	.55	.54	.....	.57	.57
13	.....	.....	.61	.61	.....	.65	.65
14	.....	.....	.58	.58	.....	.....	.....
True average of casein nitrogen	.46	.42	.49	.46	.41	.44	.42
True average of casein	2.93	2.65	3.13	2.93	2.62	2.81	2.70

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	0.40	0.34	0.39	0.38	0.45	0.44	0.42	0.44
2	.35	.30	.34	.33	.41	.43	.38	.41
3	.34	.29	.34	.32	.38	.42	.36	.39
4	.36	.30	.36	.34	.38	.44	.37	.39
5	.37	.32	.35	.35	.44	.45	.37	.42
6	.38	.33	.36	.36	.44	.44	.43	.44
7	.37	.31	.39	.36	.45	.45	.46	.45
8	.37	.33	.40	.37	.46	.45	.47	.46
9	.38	.36	.41	.38	.45	.53	.46	.48
10	.39	.42	.49	.43	.48	.56	.45	.49
11	.43	.58	.53	.51	.53	.....	.48	.51
12	.45	.....	.59	.52	.....	.....	.....	.....
13	.51	.....	.58	.54	.....	.....	.....	.....
14	.57	.....	.....	.57	.....	.....	.....	.....
True average of casein nitrogen	.39	.33	.39	.37	.43	.45	.41	.43
True average of casein	2.49	2.11	2.49	2.36	2.74	2.87	2.62	2.74

RELATION OF THE CASEIN TO THE FAT.

The relation between the fat and the casein is of considerable interest on account of the possibility it affords of calculating the casein content from the fat analyses and its relation to methods of paying for milk of varying quality to be used for cheese making. Van Slyke [1] formulated a rule for estimating the casein, limited in its application to milk with fat contents between 3 and 4.5 per cent. Shuttleworth [2] showed that considerable variations occur with individual cows regarding the relation of fat to casein.

[1] Van Slyke, Lucius L. Modern methods of testing milk and milk products. New York, 1907. See p. 192.

[2] Ontario Agricultural College and Experimental Farm, Twenty-first Annual Report (1895), pp. 19–27. Toronto, 1896.

Hart [1] studied the relation between the fat and the casein in the milk of 26 cows representing 5 breeds and covering 12 days' time. He finds that "the relation of casein to fat varies among animals of different breeds and among animals of the same breed." His data averaged by breeds are as follows:

Breed.	Relation of fat and casein.
Jersey	1.72 : 1
Guernsey	1.90 : 1
Holstein	1.49 : 1
Ayrshire	1.44 : 1

The following gives the relation of the fat to the casein in the milk of each of the 11 cows used in our investigation:

Breed.	No.	Ratio of fat to casein.
Jersey	4	1.66 : 1
Do	99	1.75 : 1
Do	118	1.71 : 1
Average for Jerseys		1.69 : 1
Ayrshire	300	1.20 : 1
Do	301	1.47 : 1
Average for Ayrshires		1.36 : 1
Holstein	205	1.30 : 1
Do	206	1.38 : 1
Do	209	1.25 : 1
Average for Holsteins		1.31 : 1
Shorthorn	400	1.35 : 1
Do	402	1.44 : 1
Do	403	1.29 : 1
Average for Shorthorns		1.36 : 1

The above statement, representing as it does in each case the entire lactation period of the animal fed a uniform ration, gives a fair basis from which to study this question. The figures show that there is a variation in the ratio between the fat and the casein that is dependent upon breed. There is little difference between the Holstein, Ayrshire, and Shorthorn breeds, but the Jersey shows a much wider ratio than the others. A study of the figures for the individual animals shows a reasonably close agreement within the breed. The conclusion from our data would be that while there is some variation with the individual the variation due to breed is of greater importance, and that the breeds that have the highest percentage of fat have the widest ratio between the fat and the casein.

[1] Hart, E. B. Variations in the amount of casein in cow's milk. Journal of the American Chemical Society, vol. 30, No. 2, pp. 281–285. Easton, Pa., Feb., 1908.

SUGAR.

The sugar content was determined by the optical method.[1] The results are found in Table 10. This table shows that the percentage of sugar in the milk of the Jersey, Ayrshire, and Shorthorn breeds was practically the same, while that in the Holstein was somewhat lower.

Table 11 gives the average percentage of sugar from the same sources as previously used. The average figures show that the Holstein breed has a somewhat lower percentage of sugar than the other breeds, although the variation is small as compared with that of other constituents. It is a well-established fact that, with the exception of the ash, sugar is the least subject to variations of the milk constituents. Some variation, however, is found with the individuals. This is especially noticeable with the Holsteins, where one has an average of 5.05 per cent and another 4.25 per cent. The sugar composes from 34 to 39 per cent of the total solids, varying in this respect with the breed.

TABLE 10.—*Average percentage of sugar for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	4.89	4.94	.....	4.92	5.14	5.17	5.16
2	4.99	5.15	4.47	4.87	4.81	4.72	4.77
3	4.87	5.17	4.70	4.91	4.64	5.62	5.13
4	5.28	5.06	4.56	4.97	4.87	5.16	5.02
5	5.12	5.04	4.83	4.99	4.96	4.77	4.87
6	5.00	4.50	5.21	4.90	4.57	4.43	4.50
7	4.39	4.52	5.20	4.70	4.82	5.38	5.10
8	4.45	5.14	5.40	4.99	5.08	5.13	5.11
9	4.67	4.62	4.57	4.62	5.13	4.85	4.99
10	4.60	5.03	4.73	4.79	4.39	4.88	4.64
11	.....	5.02	4.90	4.96	.....	4.89	4.89
12	.....	5.61	4.72	5.17	.....	5.04	5.04
13	.....	.....	4.46	4.46	.....	5.13	5.13
14	.....	.....	5.22	5.22	.....	.....	.....
True total average	4.85	4.95	4.80	4.87	4.85	4.96	4.90

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	4.69	4.07	4.40	4.39	5.40	4.77	5.21	5.13
2	4.98	4.49	4.00	4.49	5.06	5.32	5.22	5.20
3	4.84	4.44	4.17	4.48	5.44	5.09	5.39	5.31
4	5.18	4.12	3.95	4.42	5.13	4.72	5.00	4.95
5	5.42	4.26	4.42	4.70	4.87	4.55	4.58	4.67
6	5.37	4.04	4.36	4.59	4.95	5.09	5.16	5.07
7	5.20	4.74	4.16	4.70	5.05	5.29	4.98	5.11
8	4.76	4.25	3.94	4.32	5.19	4.73	5.11	5.01
9	5.10	4.09	4.43	4.54	4.65	4.61	4.08	4.45
10	5.12	3.94	4.62	4.56	4.22	4.31	4.17	4.23
11	5.13	4.50	4.79	4.81	4.25	.....	.....	4.25
12	5.02	.....	4.15	4.64	.....	.....	.....	.....
13	4.89	.....	4.30	4.60	.....	.....	.....	.....
14	4.81	.....	.....	4.81	.....	.....	.....	.....
True total average	5.05	4.26	4.25	4.51	5.04	4.91	4.98	4.99

[1] Official and provisional methods of analysis. U. S. Department of Agriculture, Bureau of Chemistry, Bulletin 107 (revised). Washington, 1908. See p. 118.

TABLE 11.—*Average percentage of sugar in milk of dairy cattle, as reported by American experiment stations.*

Breed.	New Jersey.		New York.		Missouri.		Average.	
	Number of animals.	Average sugar.	Number of animals.	Average sugar.	Number of animals.	Average sugar.	Number of animals.	Average sugar.
		Per cent.		*Per cent.*		*Per cent.*		*Per cent.*
Jersey	3	4.85	3	5.41	3	4.87	9	5.04
Guernsey	3	4.80	2	5.16	.....	.....	5	4.98
Ayrshire	3	4.84	4	5.33	2	4.90	9	5.02
Holstein	3	4.69	2	5.02	3	4.25	6	4.65
Shorthorn	3	4.80	.....	.....	3	4.99	6	4.89

THE CHEMICAL AND PHYSICAL CONSTANTS OF THE FAT.

While the previously published data regarding the constituents of milk are extensive, little is in print concerning the chemical and physical constants of the fat as influenced by the breed and individuality of the animal, with the exception of the relative size of the fat globules. Veith[1] studied the milk of 3 breeds of cows and concluded that the breed does not have any appreciable influence upon the nature of the fat. Kirchner[2] states that the composition of the fat is dependent mostly upon the stage of lactation and the food of the animal, but also varies to some extent with the individual animal.

The object of the investigations herein reported, as far as the variations due to breed and individuality are concerned, was especially to gather data concerning the fat. Since the rations fed the animals was uniform in all cases, the variations found can reasonably be attributed to the influence of the breed or of the individual.

RELATIVE SIZE OF THE FAT GLOBULES.

The determination of the relative size of fat globules was introduced by Babcock.[3] A description of this method of measurement is also found in Bulletin 111, Bureau of Animal Industry, United States Department of Agriculture. The method is essentially one of comparing the average volumes. It has been observed by several investigators that the breed of the animal has a decided influence upon the size of the fat globules. Jones[4] found that the milk of the Holstein had a much larger proportion of small fat globules, while the Jersey and the Guernsey had the largest, the Ayrshire standing between. Woll[5] gives the following data concerning the size of the fat globules

[1] Vieth, P. Butterfett-Untersuchungen nach Reichert-Wollny's Methode. Milch Zeitung, vol. 18, no. 28, p. 541–545. Bremen, July 10, 1889.

[2] Kirchner, W. Handbuch der Milchwirtschaft. Berlin, 1898. See p. 16.

[3] New York Agricultural Experiment Station, Fourth Annual Report (1885), p. 293–302. Albany, 1886.

[4] Jones, L. R. Study of milk globules. Vermont Agricultural Experiment Station, Fourth Annual Report (1890), p. 65–69. Burlington, 1891.

[5] Woll, F. W. The fat globules in cows' milk. Wisconsin Agricultural Experiment Station, Eleventh Annual Report (1894), p. 223–239. Madison, 1895.

in the milk of the 3 breeds which were entered in competition at the Columbian Exposition at Chicago in 1893:

Breed.	Number of cows.	Relative size of globules.	Average diameter.
			Microns.
Jersey	25	290	3.95
Guernsey	25	217	3.58
Shorthorn	24	177	3.35

Gutzeit[1] gives the average diameter of the fat globules in his investigation as follows:

	Microns.
Jersey	3.50
Shorthorn	2.76
Holstein	2.58

Table 12 gives the relative size of the fat globules as determined for each of the 11 animals used in our investigation and the averages for the breeds. This table shows the same results as noted by others, the Jersey having by far the largest fat globules, while the Holstein have the smallest, the Shorthorn standing between the Holstein and the Jersey. The comparative size of the fat globules in the milk of these 4 breeds is illustrated graphically in figure 1. The chief difference

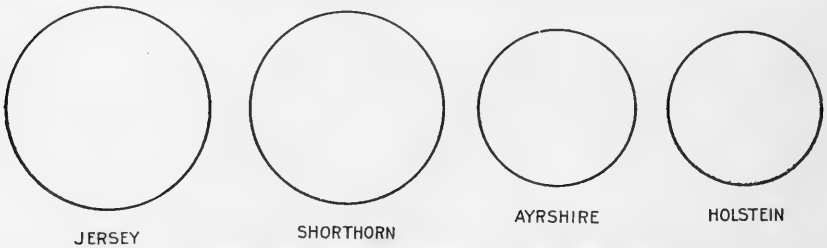

FIG. 1.—Relative size of the fat globules in the milk of dairy cattle.

between the size of the fat globules with the different breeds is that with the Jersey there is a greater proportion of the larger globules and that the milk of the other breeds contains a limited number as large as the largest in the Jersey milk. The milk of the Holstein breed is especially noticeable in containing a large number of small fat globules, together with a wide variation in size.

The table shows that the individuality of the animal has some influence upon the size of the fat globules, but it is of less importance than the breed characteristic. The milk of an Ayrshire or a Holstein can be distinguished from that of a Jersey with considerable certainty by the characteristic of the fat globules alone. The Shorthorn, on the

[1] Gutzeit, Ernst. Die Schwankungen der mittleren Grösse der Fettkügelchen in der Kuhmilch nach Laktation, Fütterung und Rasse, sowie über den physikalischen und chemischen Unterschied der grössten und kleinsten Fettkügelchen. Landwirthschaftliche Jahrbücher, vol. 24, p. 539-667. Berlin, 1895. See p. 648.

other hand, has fat globules that in many cases are as large as those contained in the milk of the Jersey, although less uniform in size.

TABLE 12.—*Relative size of fat globules in milk of each cow, and breed average, by 4-week periods.*

Four week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
1	363	556	.....	459	235	232	234
2	423	339	.....	381	163	189	176
3	370	325	417	371	148	142	145
4	229	274	879	461	135	155	145
5	267	264	358	296	115	165	140
6	267	349	373	326	133	178	156
7	235	370	301	302	93	163	128
8	299	367	334	333	80	151	116
9	318	270	335	308	75	146	111
10	228	209	259	232	129	114	122
11	167	263	342	257	.....	146	146
12	.....	315	229	272	.....	93	93
13	.....	.....	438	438	.....	110	110
14	.....	.....	461	461	.....	.....	.....
True average of relative size of globules	309	336	338	328	141	160	150

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
1	242	253	321	272	442	566	357	455
2	147	269	139	185	593	561	303	486
3	148	124	136	136	317	394	213	308
4	147	157	138	147	245	274	183	234
5	127	134	104	122	250	280	134	221
6	82	155	89	109	277	232	141	217
7	107	132	98	112	231	271	146	216
8	96	110	99	102	197	214	147	186
9	98	96	105	99	214	213	203	210
10	90	74	79	81	179	193	175	182
11	81	79	63	74	194	.....	128	161
12	117	.....	76	97	.....	.....	.....	.....
13	102	.....	118	110	.....	.....	.....	.....
14	179	.....	.....	179	.....	.....	.....	.....
True average of relative size of globules	127	164	134	142	311	353	211	282

THE REICHERT-MEISSL NUMBER.[1]

The results for the Reichert-Meissl number are given in Table 13. The Holsteins show the lowest figure for the number, although the

[1] This and the two succeeding constants of the fat were determined by official methods, the details of which may be found in Bulletin 107 (revised), Bureau of Chemistry, U. S. Department of Agriculture. For the benefit of those who may be unfamiliar with the terms the following explanation may be helpful: The Reichert-Meissl number is an arbitrary measure of the volatile acids of which butyric is the principal one in butterfat. The figures do not show the percentages of the acid, but serve as a means of comparing different fats with reference to their volatile constituents. The iodin absorption number indicates relatively the amount of iodin a fat will absorb. Since the only fatty acid found to exist in butterfat which has the property of absorbing iodin is oleic acid, the iodin absorption number shows relatively the amount of this fatty acid present, but in common with the Reichert-Meissl number the figures do not represent percentages. The saponification number is the number of milligrams of potassium hydroxid required to saponify 1 gram of fat. Since the amount of potassium hydroxid required depends upon the molecular weight of the fat the saponification number serves as an indicator of the relative percentages of the fatty acids of high and low molecular weights present.

Ayrshires on the average are only 0.5 higher, while the Shorthorns and the Jerseys show a somewhat higher figure. The individual variations are very marked in the case of Jersey No. 118 with an average of 23.28, which is the lowest of the entire number. If the data of this individual was not included the average for the Jersey would be considerably higher than any of the other breeds. With the exception of this individual there is no marked variation that is to be attributed to the individuality of the animal. The marked variation in the Reichert-Meissl number due to the advance in the period of lactation is evident from the table.

TABLE 13.—*Average Reichert-Meissl number for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
1	29.22	30.16	29.54	29.64	27.66	30.59	29.13
2	28.72	28.88	23.28	26.96	28.96	27.09	28.03
3	28.52	32.09	24.14	28.25	27.76	26.58	27.17
4	28.50	30.95	23.69	27.71	25.76	25.13	25.45
5	28.96	27.67	23.90	26.84	26.83	24.88	25.86
6	29.20	31.21	24.64	28.35	25.76	26.79	26.28
7	26.87	27.03	26.66	26.83	24.57	25.59	25.08
8	28.63	27.54	23.12	29.76	23.87	26.40	25.29
9	25.24	27.03	25.04	25 77	23.09	24.42	23.76
10	25.95	25.83	22.85	24.88	17.96	24.36	21.16
11	.....	24.73	22.79	23.76	.....	18.09	18.09
12	.....	18.43	20.22	19 33	.....	21.72	21.72
13	.....	.....	14.23	14.23	.....	20.67	20.67
14	.....	.....	14.21	14.21	.....	.....	.....
True average of Reichert-Meissl number	28.17	28.69	23.28	26.73	26.34	25.52	25.93

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
1	26.66	30.15	25.65	27.49	30.77	30.72	29.36	30.28
2	26.01	29.48	26.84	27.44	29.31	27.14	26.67	27.71
3	26.33	28.15	25.10	26.53	25.95	26.69	26.31	26.32
4	27.38	24.58	27.05	26.34	25.99	25.60	26.30	25.96
5	27.82	27.19	24.82	26.61	28.58	26.07	25.69	26.78
6	26.92	24.51	24.68	25.37	26.54	24.12	26.02	25.56
7	28.05	24.28	22.79	25.04	24.70	23.75	26.38	24.94
8	27.53	23.39	23.47	24.80	25.99	22.93	24.53	24.48
9	27.86	23.53	24.23	25.21	24.46	18.39	23.27	22.04
10	26.06	20.76	20.17	22.33	22.57	16.61	24.25	21.14
11	25.63	17.62	21.32	21.52	22.25	.....	25.51	23.88
12	20.39	.....	20.70	20.55	.....	.....	.....	.....
13	12.77	.....	21.14	16.96	.....	.....	.....	.....
14	10.27	.....	.....	10.27	.....	.....	.....	.....
True average of Reichert-Meissl number	25.81	26.13	24.44	25.46	26.89	25.55	26.29	26.28

THE IODIN ABSORPTION NUMBER.

Table 14 gives the data in regard to the iodin number for each individual and for the 4 breeds. It will be observed that with this constant there is an evident variation due to breed. The Shorthorn and the Holstein show a noticeably higher iodin number than the Jersey, while the Ayrshire comes between. The Jersey cow No. 118 shows an individual variation in this respect, as is the case with the Reichert-Meissl number. If the figures on this animal be left out of the total the variation with the breeds would be even more marked. The variation with the breeds, since it shows practically the same for each individual, seems sufficient to warrant the conclusion that there is a variation in this constant to be attributed to breed and that the Holstein and the Shorthorn may be expected to show the highest figures, while the Jersey is at the other extreme.

TABLE 14.—*Average iodin number for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
1	31.08	32.68	39 31	34.36	32.58	28.58	30.53
2	28.04	29.46	36.33	31.28	28.70	29.91	29.31
3	29.61	28.96	32.54	30.37	27.69	30.56	29.13
4	29.94	26.75	28.69	28.46	31.91	29.85	30.88
5	28.84	29.99	31.55	30.13	27.50	30.93	29.22
6	28.03	27.29	30.43	28.58	29.61	30.31	29.96
7	31.46	27.93	28.67	29.35	35.30	31.04	33.17
8	29.75	27.37	32.49	29.87	37.32	30.54	33.93
9	32.27	28.71	33.67	31.55	35.23	32.64	33.94
10	32.15	28.80	31.43	30.79	37.74	35.11	36.43
11	.....	27.61	31.14	29.38	.....	44.11	44.11
12	.....	29.55	32.37	30.96	.....	39.62	39.62
13	.....	.....	38.48	38.48	.....	36.80	36.80
14	.....	.....	35.82	35.82	.....	.....	.....
True total average	29.99	28.87	32.79	30.52	31.14	32.06	31.61

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
1	37.12	31.00	39.46	35.86	30.13	30.76	33.33	31.42
2	34.54	30.57	33.32	32.81	32.12	39.21	35.18	35.50
3	33.23	35.53	32.89	33.88	39.05	31.15	33.19	34.46
4	31.85	31.70	33.10	32.22	31.36	30.42	33.75	31.84
5	31.77	31.79	33.53	32.36	31.66	32.08	35.28	33.01
6	32.64	31.67	34.91	33.07	33.31	35.16	35.57	34.68
7	32.62	33.14	35.62	34.13	35.71	35.13	34.96	35.26
8	33.45	34.25	35.59	34.43	33.25	35.47	36.34	35.02
9	34.07	33.91	37.01	35.00	34.28	41.01	37.32	37.54
10	35.55	35.27	39.08	36.63	36.91	42.19	35.24	38.11
11	35.40	36.53	35.35	35.76	38.49	.....	35.04	36.77
12	37.53	.....	36.69	37.11	.....	.....	.....	.....
13	42.57	.....	39.03	40.80	.....	.....	.....	.....
14	42.24	.....	.....	42.24	.....	.....	.....	.....
True total average	34.46	32.68	35.48	34.20	34.08	34.09	34.72	34.36

THE SAPONIFICATION OR KOETTSTORFER NUMBER.

The data regarding this constant are found in Table 15. The variations that may be attributed to breed are comparatively small. The Holsteins show a number 1.5 higher than the Shorthorns. This difference, while comparatively small, seems to indicate at least some tendency for a variation between these two breeds. With this exception no special variation can be observed that may be attributed safely to the influence of the breed. No marked individual variations are observed, with the exception of Jersey cow No. 118, which shows individual variations in this as well as in the other constants. A high iodin number is usually associated with a low Reichert-Meissl number and a low saponification number. The data of cow No. 118 follow this rule. The variations, however, are not sufficient to justify any special emphasis being placed upon either breed or individuality as a factor in causing variations in the saponification number.

TABLE 15.—*Average saponification number for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
1	231.1	230.6	228.5	230.1	232.6	236.9	234.7
2	233.1	232.1	224.7	229.9	230.7	234.1	232.4
3	232.9	229.5	229.6	230.7	232.3	232.0	232.1
4	229.1	232.3	229.0	230.1	224.8	230.4	227.6
5	230.7	227.7	230.2	229.5	229.2	227.5	228.4
6	229.0	231.7	226.6	229.1	230.1	229.7	229.9
7	227.8	227.3	229.4	228.2	224.5	219.6	222.0
8	229.4	239.8	224.8	231.3	222.0	228.3	225.1
9	234.4	234.3	225.1	231.3	223.9	228.4	226.1
10	235.9	231.4	227.6	231.6	217.2	224.3	220.8
11	.....	229.4	237.0	233.2	.....	216.2	216.2
12	.....	219.6	223.9	221.8	.....	218.7	218.7
13	.....	.....	219.5	219.5	.....	221.3	221.3
14	.....	.....	219.1	219.1	.....	.....	.....
True total average	231.3	228.6	227.2	228.9	228.4	227.9	228.2

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
1	242.2	230.7	237.2	233.4	232.3	234.3	234.3	233.6
2	229.3	228.3	230.6	229.4	231.7	233.9	225.4	230.3
3	229.0	242.4	231.6	234.3	224.2	229.8	228.1	227.4
4	232.9	233.7	230.8	232.8	230.0	223.0	229.9	227.6
5	230.8	232.4	228.3	230.5	229.4	228.3	226.4	228.0
6	228.7	231.2	229.0	229.6	227.2	224.3	230.1	227.2
7	228.1	229.7	224.0	227.3	223.9	223.7	224.6	224.1
8	227.0	225.6	222.4	225.0	226.5	222.7	225.1	224.8
9	225.0	224.4	222.0	223.8	224.9	215.8	223.8	221.5
10	223.9	219.9	219.2	221.0	220.5	211.5	226.4	219.5
11	226.3	216.4	222.0	221.6	216.8	.....	226.6	221.7
12	220.8	.....	230.3	225.5	.....	.....	.....	.....
13	210.1	.....	215.3	212.7	.....	.....	.....	.....
14	205.9	.....	.....	205.9	.....	.....	.....	.....
True total average	228.2	230.1	229.1	229.1	227.6	226.9	227.9	227.6

THE MELTING POINT OF THE FAT.

The melting point was determined according to Wiley's method. An examination of the data given in Table 16 shows a close agreement in the melting point for all of the animals. Apparently there is no variation in the melting point that could reasonably be attributed either to the breed or to the individuality of the animal supplying the samples. A marked variation is noticeable due to the advance in lactation period, but this is regardless of the individual or breed.

Table 17 gives a summary for comparison of the constants of the fat for the four breeds.

TABLE 16.—*Average melting point of the fat for each cow, and breed average, by 4-week periods.*

Four-week period No.	Jerseys.				Ayrshires.		
	No. 4.	No. 99.	No. 118.	Average for Jerseys.	No. 300.	No. 301.	Average for Ayrshires.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1	32.36	24.94	26.62	27.97	34.80	32.07	34.44
2	32.63	33.24	32.66	32.84	33.39	33.21	33.30
3	33.39	33.36	33.31	33.35	33.45	32.61	33.03
4	32.25	34.53	33.31	33.36	33.54	32.80	33.17
5	33.30	33.78	33.80	33.63	33.74	33.85	33.79
6	33.44	34.08	33.40	33.64	33.87	32.98	33.43
7	32.94	34.07	33.92	33.64	33.83	33.98	33.90
8	33.24	34.33	33.66	33.74	33.30	33.55	33.43
9	33.03	34.64	33.39	33.69	33.30	33.33	33.32
10	32.97	33.81	33.59	33.46	34.04	33.10	33.57
11	.....	34.88	33.81	34.35	.....	34.35	34.35
12	.....	34.35	33.68	34.02	.....	33.23	33.23
13	.....	.....	33.46	33.46	.....	33.28	33.28
14	.....	.....	33.50	33.50	.....	.....	.....
True total average	32.91	32.95	32.99	32.95	33.75	33.20	33.47

Four-week period No.	Holsteins.				Shorthorns.			
	No. 205.	No. 206.	No. 209.	Average for Holsteins.	No. 400.	No. 402.	No. 403.	Average for Shorthorns.
	°C.	°C.	°C.	°C.	°C.	°C.	°C.	°C.
1	33.41	32.95	32.58	32.98	33.91	32.69	32.70	33.10
2	32.67	33.52	32.16	32.78	32.99	32.79	33.32	33.03
3	33.39	31.94	32.06	32.46	31.61	33.20	32.70	32.50
4	33.76	32.06	31.84	32.55	33.15	33.09	32.60	32.95
5	33.02	32.47	33.04	32.84	33.01	32.95	33.15	33.04
6	32.93	32.47	31.69	32.36	33.88	33.99	32.98	32.62
7	32.88	32.64	32.30	32.61	33.63	33.76	32.54	33.31
8	32.98	33.13	32.78	32.96	34.13	33.79	32.65	33.52
9	33.26	32.81	32.85	32.97	34.21	34.65	33.14	34.00
10	33.09	32.92	33.82	33.28	35.40	36.31	33.28	34.99
11	33.01	38.80	33.15	34.99	36.49	.....	32.83	34.66
12	32.54	.....	35.45	33.99	.....	.....	.....	.....
13	41.80	.....	37.39	39.59	.....	.....	.....	.....
14	48.34	.....	.....	48.38	.....	.....	.....	.....
True total average	33.76	32.87	32.02	32.88	33.56	33.37	32.89	33.23

TABLE 17.—*Average chemical and physical constants of the fat by breeds.*

Breed.	Relative size of fat globules.	Iodin number.	Saponification number.	Reichert-Meissl number.	Melting point.
					°C.
Jersey	328	30.52	228.9	26.73	32.95
Ayrshire	150	31.61	228.2	25.93	33.47
Holstein	142	34.20	229.1	25.46	32.88
Shorthorn	282	34.36	227.6	26.28	33.23

SUMMARY AND CONCLUSIONS.

1. The data presented show the influence of the breed and the individual upon the composition of the milk and upon the constants of the fat as evidenced by 11 cows, including 3 each of the Jersey, Holstein, and Shorthorn breeds, and 2 of the Ayrshire breed. These cows were kept upon a uniform ration and the samples represent an entire lactation period for each. A compilation is also given which includes all complete analyses of the milk of purebred animals for entire lactation periods published up to the present by American experiment stations.

2. The average percentage of total solids is highest with the Jersey and lowest with the Holstein. The fat represents 34.9 per cent of the total solids with the Jersey breed and 28 per cent for the Holsteins. The relation of the fat to the total solids is influenced by breed especially and to some extent by the individual in the breed.

3. The data corroborate the well-known facts regarding the variations in fat content due to breed.

4. The breed exerts a decided influence upon the protein content. A low average percentage of fat goes with a low protein content, although the ration is not constant. Breeds such as the Jersey, having a high fat content in the milk, also have a high protein content; they also have a higher ratio of fat to protein.

5. The proportion of the total protein present as casein does not seem to bear any special relation to the breed, although some individual variations are observed.

6. The ratio of casein to the fat varies uniformly with the breed. The variation between the Ayrshire, Shorthorn, and Holstein is slight, but the Jersey has more fat in proportion to the casein.

7. The sugar content of milk does not show much variation either with the breed or with the individual. Our data showed a somewhat lower figure for the Holsteins than for the Ayrshires, Shorthorns, or Jerseys.

8. The data presented show the well-known breed characteristics regarding the size of the fat globules, those in the Jersey being the largest, followed in order by the Shorthorn, Ayrshire, and Holstein.

9. The breed apparently is a factor having some influence on the Reichert-Meissl number. The highest was found with the Jersey, while the Holsteins had somewhat lower figures.

10. The influence of the breed is shown on the iodin number. The Holsteins and Shorthorns have a noticeably higher number than the Jersey, with the Ayrshire coming between.

11. Little influence due to breed or individuality can be observed with the saponification number.

12. The melting point of the fat shows no variation that may be attributed to breed and but little with the individual animals.

13. With the exception of the size of the fat globules, the fat constants are far less influenced by the breed and the individuality of the animals than by the stage of the lactation period. The feed of the animal is probably a greater factor than breed or individuality in influencing the nature of the fat.

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