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The Role of Water in a Dairy Cow's Ration

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THE ROLE OF WATER IN A DAIRY COW'S RATION

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THE ROLE OF WATER IN A DAIRY COW'S RATION

THE ROLE OF WATER IN A DAIRY COW'S RATION

C. Larsen, E. H. Hungerford, and D. E. Bailey.

INTRODUCTION

In connection with the investigations by this department on "The Effect of Alkali Water on Dairy Cows and Dairy Products" it became evident that the information on the functions of water in the ration of a dairy cow was meager. Furthermore, during this work some clews were obtained which the investigators desired to carry to a conclusion.

Some practical men have been claiming that the body temperature of the dairy cow could be raised by with-holding water, and that the composition of the milk, especially the percentage of fat, could be thus increased.

It was with a view of obtaining information especially along these lines that the investigations were undertaken.

REFERENCES

The effect of different amount of water in the ration on the composition of the milk has been studied by several investigators. Turner, Shaw, Morton and Wright in experiments comparing, first, a full allowance of water with a limited supply; second, a heavy ration of turnips with a dry roughage one; third, wet beet pulp with dry beet pulp; and fourth, green clover with cured hay, found that while individual cows produced milk having an abnormal fat content, the amount and composition of the milk on the average was not changed by the changes in rations. (191 Jour. Agr. Research, Dept. of Agr. Wash. D. C., Vol. IV, No. 4).

Gilchrist reports little difference if any in the quantity and quality of the milk produced by cows either on pasture or heavy mangel ration, and that produced by

cows on a ration of hay and grain. (Variations in the Composition of Milk and Their Probable Causes in Durham Co., Conn. Edw. Com. Repts. Dairy Invest. Offerton Hall, 1909, pp. 7—27).

Armsby found that cows drink more water when fed a high protein ration than when fed a low protein ration. Armsby also found that cows drink about 40 pounds of water more per day when fed dry roughage than when fed green hay.

OBJECT OF INVESTIGATION.

It was the object of the investigation reported in this bulletin to study the effects of watering the cow at different intervals and in varying amounts upon the amount of food consumed, digestibility of nutrients, amount and composition of feces and urine, amount and composition of milk, composition and quality of butterfat, body temperature and physical condition of cows. Incidentally, the bulletin furnishes some data on the mineral metabolism of the cow.

PLAN OF INVESTIGATION

This experiment was started January 2, 1914, and was continued almost without interruption until September 20th, with the same four cows. The experiment was started again November 16, 1915, using three different cows, and continued until January 26, 1916.

The cows in the first four periods of the experiment were mature grade, or common cows, about eight years old, and advanced about three months in their lactation period when the experiment began. It was hoped the experiment could be completed without change of cows, but the four original cows became so nearly dry that it was thought best to discontinue the experiment until fresh cows could be secured.

Only three were used in period V and VI. These were better dairy cows than those used in the first four periods. They were grade Holsteins from six to eight years of age. Cow No. 5 freshened nearly ten months

previous to the beginning of the experiment. Cow No. 6 freshened about one month, and No. 7 about two months before the experiment began. While there was a wide difference in the stages of lactation of this group, all were giving a normal quantity and quality of milk, and continued to do so throughout the experiment, except as they were affected by the experiment.

There were three separate experiments, each of which included one check period of 30 days, and one experimental period of 30 days. Period I was a check period of experiment A, and began Jan. 2, 1914. During this period the cows were watered once in each eight hours. Period II was the experimental period of experiment A, and began Feb. 2, 1914. The cows were watered once in 24 hours during this period. Period III was the check period of experiment B. It was begun July 11, 1914, and was exactly like check period I. Period IV, the experimental period of experiment B, was begun August 9, 1914. During this period cow No. 1 was watered once in 12 hours. Cows 2, 3 and 4 were watered only once in 60 hours. Period V was the check period of experiment C, and was begun Nov. 6, 1915. During this period three different cows were used and were watered once in 12 hours. Period VI was the experimental period of experiment C, beginning Dec. 27, 1915. Cow No. 6 was used as a check cow during this period. She was given a full allowance of water once in 24 hours. The two experimental cows were given only one-half their usual allowance of water once in 24 hours.

The cows were placed in stalls with feed boxes so arranged that the feed for each cow could be kept seperate. They were fed rations consisting of seven pounds of mixed grain (three pounds of oats, three pounds of bran, and one pound of oil meal), 25 pounds of corn silage, one ounce of salt in two equal portions, and all the hay they would eat. The grain was carefully mixed and sampled and weighed each day.

Enough hay for one day was put into a large sack and weighed. At the end of the day, what was not eaten was weighed back. The hay used was wild hay of uniform quality. It was sampled daily. The water was carefully weighed. Samples of water were taken each day. The corn silage was of good quality, and uniform in composition. A composite sample was obtained by sampling the silage three or four times during the ten day period. The salt used was high grade butter salt. It was weighed out at the beginning of the experiment in small packages and fed with the grain twice daily.

The cows were milked into weighed pails twice daily. Composite samples were taken by volume and kept in glass stoppered bottles in the refrigerator at about 40 degrees F. A little formaldehyde was used to preserve them.

The urine was caught in pails fastened to long handles, and was transferred to tightly covered cans. The urine was weighed morning and night and samples were taken by volume for the composite sample. The composite sample was preserved with formaldehyde. The feces were collected in special shovels and transferred to cylindrical cans with tight fitting covers. Twice a day the feces were weighed, carefully mixed, and samples taken for composite sample. The composite samples were kept in glass jars with ground glass covers, and were preserved with thymol.

To collect the feces and urine, two attendants were stationed behind the cows. These men were relieved at the end of each 12 hours by two others.

In four of the periods, viz: I, II, III and V, records of the intake and outgo were kept during only the last ten days of each 30 day period. In two of the periods, viz: IV and VI, a record of the intake and outgo was taken during the first ten days as well as during the last ten days of each of the 30 day periods.

Analysis of all samples were made as far as possible by the official methods of the A. O. A. C. Chlorine was determined by igniting the sample with sodium carbonate, extracting the ash with water, and nitric acid, and determining the chlorine by the Volhard method; phosphorous was determined by digesting the sample with a mixture of sulfuric and nitric acids, and the sulfur was determined by the sodium peroxide method.

In order to ascertain if any changes in the composition of the butterfat took place, the milk of each cow was collected during two days of each period, the fat separated, and the Reichert—Meissl number, Iodine number (Hubl), Saponification number, Refractometer reading and melting point determined.

TABLE I.

COMPOSITION OF FEED AND WATER.

	Period	Feed	Water %	Nitrogen N %	Protein (nx6.25) %	Ether extract %	Crude fiber %	N-free extract %	Ash %	Chlorine cl. %	Phosphorous P %	Sulfur S %	Calcium Ca. %	Magnesium Mg. %	Sodium Na. %	Potassium K %	Silica SiO_2 %
Experiment A. Effect of watering only once in 24 hours. January 2, 1914	I	Grain	11.96	2.56	16.00	4.99	9.68	52.40	4.97	.....	Ash constituents not determined				.....	.....	.....
		Hay	7.48	0.905	5.65	2.00	29.67	46.88	8.32	.....					.....	.....	.....
	Check	Silage	70.29	0.416	2.60	0.73	6.28	18.31	1.79	.....	.....	.....	.....	.....	.....	.....	.....
		Water	99.929	.....	.....	.....	.....	.....	0.0540	.....	.....	.....	.....	.....	.....	.....	.....
	II	Grain	11.26	2.71	16.92	4.92	9.68	52.40	4.79	.....	.....	.....	.....	.....	.....	.....	.....
		Hay	7.48	0.905	5.65	2.00	29.67	46.88	8.32	....	.....	.....	.....	.....	.....	.....	.....
	Exper-	Silage	69.89	0.44	2.75	0.74	6.28	17.86	1.96	.....	.....	.....	.....	.....	.....	.....	.....
	mental	Water	99.927	.....	.....	.....	.....	.....	0.0522	.....	.....	.....	.....	.....	.....	.....	.....
Experiment B. Effect of watering only once in 60 hours. August 9, 1914	III	Grain	10.05	3.071	19.40	4.33	9.93	56.24	5.05	0.05142 0.04960	0.9440	0.3195	0.1203	0.4164	0.0372	0.9812	0.7905
		Hay	7.95	0.941	5.88	1.86	32.00	44.54	7.77	0.11750	0.0703	0.2404	0.5534	0.1887	0.0443	0.6442	4.9440
	Check	Silage	70.74	0.516	3.22	0.71	6.40	15.12	2.19	0.00142	0.0872	0.0537	0.0657	0.1168	0.0064	0.4374	0.8501
		Water	99.96	.....	.....	.....	.....	.....	0.0218	0.05142	0.00077	0.00778	0.00973	0.00546	0.00265	0.00058	0.00412
	IV	Grain	9.53	2.69	16.80	4.11	10.74	53.77	5.15	0.05320	0.9910	0.3195	0.1163	0.4470	0.0610	0.9917	0.7575
		Hay	7.79	0.953	5.95	2.23	32.50	42.79	8.74	0.08040	0.0652	0.1992	0.6013	0.1636	0.1503	0.6884	5.060
	Experi-	Silage	76.09	0.355	2.22	0.52	6.40	12.15	2.02	0.00142	0.0722	0.0424	0.0657	0.08321	0.0176	0.3381	0.6345
	mental	Water	99.96	.....	.....	.....	.....		0.0218	.....	0.00077	0.0078	0.00973	0.00546	0.00265	0.00058	0.00412
Experiment C. Effect of one-half water November 16, 1915	V	Grain	9.13	2.382	14.90	4.30	10.95	55.58	5.14	0.06028	0.0300	0.2382	0.0720	0.3688	0.03758	0.9814	0.7215
		Hay	6.80	1.303	8.14	2.49	29.00	46.31	7.26	0.08333	0.1200	0.2696	0.4254	0.1686	0.03265	0.8824	4.1804
	Check	Silage	79.43	0.342	2.18	0.40	4.70	10.73	2.56	0.05630	0.0504	0.0343	0.1010	0.0800	0.00671	0.2890	0.5662
		Water	99.941	.....	.....	.....	.....	.....	0.0593	0.00151	.....	0.0044	0.00856	0.0050	0.00222	0.00096	0.0034
	VI	Grain	9.13	2.382	14.90	4.30	10.95	55.58	5.14	0.06028	0.9309	0.2383	0.0720	0.3688	0.03758	0.9814	0.7215
		Hay	6.80	1.303	8.14	2.49	29.00	46.31	7.26	0.08333	0.1200	0.2696	0.4254	0.1686	0.03265	0.8824	4.1804
	Experi-	Silage	79.43	0.342	2.18	0.40	4.70	10.73	2.56	0.05630	0.0504	0.0343	0.1010	0.0800	0.00671	0.2890	0.5662
	mental	Water	99.941	.....	.....	.....	.....	.....	0.0593	0.00151	.....	0.0044	0.00856	0.0050	0.00222	0.00096	0.0034

RESULTS OF INVESTIGATION.

Food Consumed.

All of the intake by the cows was carefully weighed. All food not eaten at the end of each 12 hours was weighed back. The grain and silage rations were kept uniform except for cow No. 6 in experiment C. On account of her large milk production, it was necessary to feed her a grain ration of 11 pounds per day.

In experiment A, to determine the effects of watering only once in 24 hours, there was a slight decrease in the total amount of ingesta during the time the cows were watered once each 24 hours. This was especially noticeable in the amount of hay. The four cows together consumed about seven pounds of hay less, two pounds of silage less, and nine pounds of water less daily when they were watered but once each day than when they were watered once each eight hours, or three times a day.

There was also a slight decrease in milk, amounting to nearly two pounds per day, though the decrease in milk was not in proportion to the decrease in the feed. The composition of the milk is not given in this table, as it shows no points of special interest in this connection.

In this connection, it should be noted that the cows lost an average of 11 pounds per cow during the 30 day experimental period II, while during the preliminary 30 days, when receiving water three times a day there was a gain of 18 pounds a cow.

This tendency toward gain in body weight when the cows were watered at least twice a day and a decrease in body weight when they were receiving water at greater intervals is apparent in all of the trials. This decrease in body weight is most apparent in period VI, experiment C, when the cows received only one-half the normal amount of water. Each cow lost on an average 95 pounds during the 30 days. When receiving water ad libitum, once in 60 hours, each cow lost 17 pounds,

and when receiving water ad libitum once in 24 hours each cow lost 11 pounds during the 30 day period.

In the periods when the cows received a full quota of water at long intervals, there is not the decrease in the milk produced that one would naturally expect. Considering that there is a slight decrease in the total amount of food taken in, and that the cows lost in body weight, one cannot but conclude that the cows are able to utilize water already stored up in the system for milk production and other body functions.

TABLE II.

SHOWING AVERAGE WEIGHT OF COWS, AVERAGE AMOUNT OF FOOD CONSUMED, AND MILK PRODUCED DAILY.

		Period	Cow	Frequency of watering Watered once in hrs	Foods Consumed Per Day					Milk produced daily, lbs.	Wt. of Cows	
					Grain lbs.	Hay lbs.	Silage lbs.	Water lbs.	Salt lbs.		At beginning of period	At end of period
Experiment A	Effect of watering only once in 24 hrs. January 2, 1914	I	1	8	7	14.49	25	73.17	0.0625	20.44	1370	1394
			2	8	7	12.12	25	69.81	0.0625	20.57	1431	1432
		Check	3	8	7	6.18	25	65.69	0.0625	14.60	956	983
			4	8	7	11.37	25	46.87	0.0625	15.52	1052	1070
			Av.	8	7	11.04	25	63.88	0.0625	17.70	1202	1220
		II	1	24	7	11.80	25	67.42	0.0625	17.96	1394	1358
			2	24	7	11.80	24.75	70.07	0.0625	17.96	1432	1434
		Exper-	3	24	7	6.25	23.64	59.98	0.0625	14.49	983	978
		imen-	4	24	7	7.85	25	49.12	0.0625	13.80	1070	1065
		tal	Av.	24	7	9.44	24.6	61.65	0.0625	16.05	1220	1209
Experiment B	Effect of watering only once in 60 hrs. August 9, 1914	III	1*	8	7	11.70	25	77.08	0.0625	12.50	1323	1345
			2	8	7	10.54	25	91.09	0.0625	10.50	1427	1442
		Check	3	8	7	8.41	17.87	67.74	0.0625	8.65	1025	990
			4	8	7	8.21	25.0	68.30	0.0625	12.00	1053	1107
			Av.	8	7	9.05	22.62	75.71	0.0625	10.32	1168	1180
		IV	1*	62	7	12.80	25	67.08	0.0625	9.81	1345	1353
			2	60	7	13.18	25	56.51	0.0625	8.66	1442	1427
		Exper-	3	60	7	9.29	25	50.13	0.0625	8.26	990	975
		imen-	4	60	7	10.00	25	46.96	0.0625	11.35	1107	1088
		tal	Av.	60	7	10.82	25	51.20	0.0625	9.42	1180	1163
Experiment C	Effect of one-half water November 16, 1915	V	5	12	7	18.70	25	81.56	0.0625	10.19	1498	1558
			6*	12	11	17.27	25	58.97	0.0625	33.27	1375	1365
		Check	7	12	7	17.32	25	78.46	0.0625	26.32	1178	1162
			Av.	12	8.33	18.01	25	79.98	0.0625	18.26	1338	1360
		VI	5	24	7	12.27	25	40.00	0.0625	7.46	1580	1530
			6*	24	11	15.45	25	87.97	0.0625	26.83	1395	1360
		Exper-	7	24	7	10.60	25	40.00	0.0625	20.65	1190	1050
		imen-	Av.	24	7	11 44	25	40.00	0.0625	14.06	1385	1290
		tal										

*Check cows not included in averages

In experiment C, where the cows received only one-half of their normal water requirement there was a very noticeable decrease in the amount of hay consumed; in the amount of milk produced, and also in body weight.

Digestion of Rations.

In connection with this discussion, care should be taken to properly differentiate between coefficient of digestibility and the amount of food digested. The former refers to percentage of the various food substances digested and not to the amount of food digested.

TABLE III.

COEFFICIENTS OF DIGESTIBILITY OF RATIONS.

	Period	Cow	Frequency of watering: Watered once in: hrs.	Daily Ration Pounds				Protein Percent	N-free Extract Percent	Ether Extract Percent	Crude Extract Percent
				Grain	Hay	Silage	Water				
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914.	I. Check	1	8	7	14.49	25	73.17	61.72	66.70	71.62	59.30
		2	8	7	12.12	25	69.81	58.62	68.60	74.74	56.20
		3	8	7	6.18	25	65.69	57.36	63.50	70.86	39.57
		4	8	7	11.37	25	46.87	65.37	73.70	79.73	63.30
		Av.	8	7	11.04	25	63.63	60.79	68.12	74.19	54.59
	II. Experimental	1	24	7	11.80	25	67.42	61.74	66.86	75.61	52.85
		2	24	7	11.86	24.75	70.07	58.76	64.08	73.68	58.13
		3	24	7	6.25	23.64	59.98	61.00	63.73	71.85	49.44
		4	24	7	7.85	25.0	49.12	61.67	70.98	78.54	59.37
		Av.	24	7	9.44	24.6	61.65	60.79	66.41	74.87	55.00
Experiment B Effect of watering only once in60 hrs. Aug. 9, 1914	III. Check	1	8	7	11.70	25	77.08	68.39	67.51	75.98	57.80
		2	8	7	10.54	25	91.09	60.26	69.88	77.27	50.86
		3	8	7	8.41	17.87	67.74	65.41	71.38	76.58	56.65
		4	8	7	8.21	25	68.30	64.25	70.16	81.14	57.63
		Av.	8	7	9.71	23.22	76.05	64.58	69.73	77.74	55.71
	IV. Experimental	1*	12	7	12.80	25	67.08	60.56	69.63	68.53	64.83
		2	60	7	13.18	25	56.51	62.39	73.75	69.20	67.64
		3	60	7	9.29	25	50.13	66.63	76.08	71.49	71.45
		4	60	7	10.00	25	46.96	78.51	81.68	77.43	74.11
		Av.	60	7	10.82	25	55.17	69.18	77.17	72.71	71.07
Experiment C Effect of one-half water. Nov. 16, 1915	V. Check	5	12	7	18.70	25	81.56	60.84	70.80	68.58	64.89
		6	12	11	17.27	25	98.97	58.03	75.50	68.45	60.75
		7	12	7	17.32	25	78.40	62.38	65.14	64.99	61.20
		Av.	12	8.33	17.76	25	86.31	60.42	70.48	67.43	62.28
	VI. Experimental	5	24	7	12.27	25	40.00	63.06	71.44	73.41	63.92
		6*	24	11	15.45	25	87.97	56.36	71.05	69.70	58.80
		7	24	7	10.60	25	40.00	66.24	68.32	82.68	65.30
		Av.	24	7	11.44	25	40.00	64.65	69.88	78.05	64.61

*Check Cows not included in averages.

From table III it will be seen that the coefficient of digestibility is increased in each of the experiments where the interval between watering is lengthened, and also in the period when the cows received only one-half of their normal water requirement. This really was contrary to what might have been expected. At first thought, one would think that a full supply of water twice or three times a day would enable a cow to digest the greatest per cent of the food consumed.

This increased coefficient of digestibility is most apparent in respects to crude fiber. When the cows were watered three times a day, 54% of the crude fiber was digested. When they received water once each 24 hours the coefficient of digestibility was 55. In period III, when receiving water three times a day, the percentage of crude fiber digested was 55.7, while in the period just following with the same cows watered once in 60 hours, the coefficient of digestibility is increased to 71.07. When the cows received one-half their normal amount of water, the digestibility of the crude fiber increased but about 2%.

The increase in the digestibility of the nitrogen-free extract and of the protein is not regular, and is not so marked. In the experiments B and C, when the cows received water once each 60 hours and one-half normal amount respectively, the increased digestibility of the protein is quite apparent.

From this one standpoint, these experiments show that infrequency of watering and decrease in the normal water supply tend to increase the coefficient of digestibility. The experiments, of course, cover only 30 days. As has already been shown, lack of normal water supply for the cow causes her to draw upon the body storage water. This drain of water from the tissue could not continue and still keep the cow in good condition to continue to efficiently digest her feed.

TABLE IV.

SHOWING AMOUNT OF WATER DRUNK, AND FOOD NUTRIENTS DIGESTED DAILY.

		Cow	Frequency of watering. Watered once in: hrs.	Water drunk pounds	Protein Consumed, lbs.	Protein Digested pounds	N-free Extract Consumed, lbs.	N-free Extract Digested, lbs.	Ether Extract Consumed. lbs.	Ether Extract Digested, lbs.	Crude Fiber Consumed, lbs.	Crude Fiber Digested, lbs.
Experiment A Effect of watering once in 24 hours Jan. 2, 1914	I. Check	1	8	73.17	2.5894	1.5978	14.9748	10.1378	0.7216	0.4168	6.5468	3.6195
		2	8	69.81	2.4556	1.4393	13.9273	9.5503	0.7742	0.5786	5.8436	2.2823
		3	8	65.69	2.1294	1.2156	11.1427	7.1616	0.6554	0.4634	4.0812	1.6151
		4	8	46.87	2.4131	1.5531	13.5758	9.9968	0.7592	0.6053	5.6211	3.5561
		Av.	8	63.88	2.3969	1.4514	13.4051	9.2116	0.7276	0.5160	5.5232	2.7682
	II. Experimental	1	24	67.42	2.5406	1.5681	13.6648	9.1283	0.7654	0.5787	5.8731	3.0828
		2	24	70.07	2.5369	1.5906	13.6483	9.0992	0.7648	0.5635	5.8909	3.4307
		3	24	59.98	2.1894	1.3357	10.8201	6.8998	0.6443	0.4629	4.2264	2.1201
		4	24	49.12	2.3169	1.4281	11.8131	8.3797	0.6864	0.5389	4.7011	2.7711
		Av.	24	61.65	2.3959	1.4806	12.4806	8.3768	0.7152	0.5360	5.1729	2.8512
Experiment B Effect of watering once in 60 hours Aug. 9, 1914	III. Check	1*	8	77.08	2.8333	1.9772	12.6035	8.5083	0.6985	0.5307	6.4441	3.7261
		2	8	91.09	2.7714	1.6702	12.0784	8.4541	0.6774	0.5234	6.0811	3.0881
		3	8	67.74	2.4147	1.5797	10.0615	7.1718	0.5866	0.4493	4.8191	2.7301
		4	8	68.30	2.6330	1.6917	11.0486	7.7505	0.6336	0.5141	5.3271	2.9701
		Av.	8	75.71	2.6064	1.6472	11.0628	7.7921	0.6325	0.4956	5.4091	2.9244
	IV. Experimental	1*	12	67.08	2.4944	1.5108	12.2918	8.5105	0.7023	0.4813	6.5108	4.2208
		2	60	56.51	2.5169	1.5703	13 4536	9.9222	0.7108	0.4419	6.6343	4.4873
		3	60	50.13	2.2850	1.5225	10.6853	8.1287	0.6241	0.4462	5.4710	3.9080
		4	60	46.96	2.3275	1.8275	11.1403	9.0821	0.6399	0.4922	5.5508	4.1438
		Av.	60	51.20	2.3765	1.6077	11.7597	8.9109	0.6583	0.4779	5.8850	4.1900
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	81.56	3.0991	1.8855	15.2424	10.7916	0.8660	0.5939	7.3635	4.7782
		6*	12	98.97	3.5782	2.0764	16.7750	12.6651	1.0024	0.6870	7.3868	4.4842
		7	12	78.40	2.9868	1.8632	14.6032	9.5125	0.8316	0.5309	6.9633	4.2615
		Av.	12	79.98	3.0429	1.8744	14.9228	10.1520	0.8488	0.5624	7.1634	4.5199
	VI. Experimental	5	24	40.00	2.5756	1.6241	12.2646	8.7618	0.7059	0.5182	5.4988	3.5148
		6*	24	87.95	3.4300	1.9331	14.8040	10.6296	0.9570	0.6670	7.8590	4.6211
		7	24	40.00	2.4396	1.6160	11.4973	7.8550	0.6583	0.5443	5.0145	3.2745
		Av.	24	40.00	2.5076	1.6200	11.8810	8.3084	0.6821	0.5313	5.2567	3.3947

*Check cows not included in averages.

In experiment A, the cows watered once in 24 hours digested 0.09 pound of crude fiber more a day than when watered once in eight hours. In experiment B, the cows digested 1.26 pounds more crude fiber when receiving water once in each 60 hours than when watered three times a day. When receiving one-half normal water supply, the cows digested 1.125 pounds less crude fiber a day than when receiving full amount of water.

From various investigations it is generally understood that the digestion of crude fiber depends to a large extent on the bacteria active in the digestive tract as well as on the action of the digestive juices. It is

probable that an increased amount of water ingested would retard the bacterial action in digesting the crude fiber.

It is also probable that the less water taken into the digestive tract would leave the digestive juices more concentrated, and therefore more effective in their action on the food.

Less water taken by the cow would also effect the consistency of the contents of the digestive tract. The less water, the firmer they would be, and the slower would be the movements. At least this is reasonable to suppose throughout the passages through the stomachs and the first part of the intestines. This slower movement would tend to expose the contents to a longer action of the digestive agencies.

This question has often been raised: Should a cow be watered before or after feeding? From a standpoint of efficient digestion of foods, these experiments indicate that it is best not to give a cow an abundance of water at feeding time, either just before or just after feeding a heavy ration.

Effects of Water on Amount and Composition of Excreta.

The amount of water used by the cow naturally would affect the consistency of the contents of the digestive tract. This at least would be true of the contents of the stomach or part of the digestive tract into which the food first enters. The more water a cow drinks the more the stomach contents would be diluted. If samples of the stomach contents were obtainable and could be analyzed, such would undoubtedly show a high percentage of water, or a percentage of water closely related to the amount of water drunk.

TABLE V.

AVERAGE DAILY AMOUNTS AND COMPOSITION OF FECES.

	Period	Cow	Frequency of watering. Watered once in: hrs.	Feces excreted daily lbs.	Water %	Nitrogen N %	Protein (N x 6.25) %	Ether Extract %	Crude Fiber %	N-free Extract %	Ash %	Chlorine Cl %	Phosphorous P %	Sulfur S %	Calcium Ca %	Magnesium Ma %	Sodium Na %	Potassium K %	Silica Si '2 %
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	66.08	84.07	0.240	1.50	0.31	4.43	7.32	2.37								
		2	8	61.13	84.11	0.266	1.66	0.32	4.19	7.16	2.56								
		3	8	54.56	83.32	0.265	1.65	0.35	4.52	7.48	2.68								
		4	8	49.64	84.29	0.274	1.71	0.31	4.16	7.21	2.32								
		Av.	8	57.85	83.95	0.261	1.62	0.32	4.32	7.30	2.48								
	II. Experimental	1	24	62.63	84.16	0.250	1.56	0.30	4.45	7.29	2.24								
		2	24	62.92	84.63	0.266	1.66	0.32	3.91	7.23	2.24								
		3	24	50.39	83.37	0.271	1.69	0.36	4.18	7.78	2.62								
		4	24	50.79	85.22	0.280	1.75	0.29	3.80	6.76	2.18								
		Av.	24	56.68	84.34	0.267	1.67	0.32	4.09	7.26	2.32								
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	56.51	83.91	0.254	1.59	0.30	4.80	7.26	2.14	0.0368	0.0996	0.0466	0.1079	0.1094	0.0346	0.0966	1.100
		2	8	62.76	85.24	0.262	1.64	0.23	4.45	6.37	2.07	0.0162	0.0964	0.0388	0.1288	0.0803	0.0326	0.1451	1.056
		3	8	41.61	83.55	0.321	2.01	0.33	5.02	6.71	2.38	0.0369	0.1515	0.0470	0.1182	0.1350	0.0204	0.0957	1.202
		4	8	54.55	85.69	0.276	1.75	0.22	4.32	6.01	2.01	0.0225	0.1167	0.0422	0.1184	0.1178	.....	.....	1.345
		Av.	8	52.97	84.76	0.271	1.75	0.26	4.45	6.60	2.15	0.0252	0.1215	0.0427	0.1218	0.1110	0.0260	0.1199	1.201
	IV. Experimental	1*	12	57.86	84.76	0.272	1.70	0.39	3.96	6.52	2.67	0.0166	0.1596	0.0519	0.1547	0.0925	0.0517	0.1056	1.469
		2	60	48.08	82.82	0.315	1.94	0.46	4.47	7.36	2.95	0.0091	0.1667	0.0667	0.1911	0.1062	0.0456	0.1000	1.782
		3	60	36.85	83.00	0.331	2.07	0.48	4.21	6.95	3.26	0.0115	0.1968	0.0625	0.1952	0.1300	0.0439	0.1532	1.553
		4	60	43.34	88.14	0.185	1.16	0.34	3.32	4.62	2.42	0.0115	0.1363	0.0636	0.1482	0.0989	0.0456	0.0928	1.239
		Av.	60	42.76	84.65	0.277	1.72	0.43	4.01	6.31	2.88	0.0107	0.1666	0.0643	0.1782	0.1117	0.0438	0.1153	1.523
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	65.38	84.45	0.297	1.86	0.42	3.96	6.80	2.51	0.0335	0.1248	0.0481	0.1506	0.0917	0.0264	0.1258	1.409
		6*	12	80.73	85.58	0.308	1.92	0.39	3.59	6.39	2.13	0.0345	0.1160	0.0407	0.1270	0.0922	0.0082	0.1568	1.179
		7	12	71.06	84.85	0.253	1.58	0.41	3.80	7.16	2.20	0.0553	0.1069	0.0443	0.1282	0.0843	0.0203	0.1362	1.316
		Av.	12	68.22	84.65	0.275	1.72	0.42	3.88	6.98	2.36	0.0444	0.1159	0.0462	0.1394	0.0880	0.0234	0.1310	1.363
	VI. Experimental	5	24	40.26	81.39	0.364	2.28	0.47	4.65	8.18	3.03	0.0195	0.1973	0.0569	0.1708	0.1162	0.0174	0.1919	.....
		6*	24	70.92	84.82	0.320	2.00	0.40	3.55	6.94	2.29	0.0233	0.1544	0.0495	0.1169	0.0955	0.0132	0.1805	.....
		7	24	39.10	83.11	0.319	1.99	0.40	4.24	7.62	2.64	0.0260	0.1635	0.0587	0.1229	.....	0.0227	0.2053	1.442
		Av.	24	39.68	82.25	0.342	2.14	0.43	4.45	79.0	2.84	0.0228	0.1804	0.0578	0.1469	0.1162	0.0201	0.1986	1.442

*Check cows not included in averages.

The per cent of water in the feces and the percentage of water in the urine do not vary much. When the cows received only one-half of their normal water requirement the resulting feces decreased but little more than 2% in its water content, while in the other experiments where the cows were watered once in 60 and once in 24 hours, the water content of the feces is practically the same as when these same were watered twice and three times a day. It appears that the digestive organs are unable to absorb water, or at least absorb it very slowly, from its contents after it has reached a certain stage of density, providing the cow is normal. The frequency of watering does not appear to have any appreciable effect on the composition of the feces, except as has already been mentioned—that watering less frequently slightly reduces the crude fiber. When the cows received only one-half of their normal water requirement, there was an increase in the percentage of protein and nitrogen-free extract, and also in crude fiber of the feces, a portion of which would be due to the decrease in the percentage of water.

The amount of feces voided bears a close relation to the amount of feed eaten. From this work it appears that the amount of dry rough feed consumed by the cow is closely related to the amount of water drunk. This stands out not only when compared to the amount of dry food in pounds, but also when compared to the amount of dry matter consumed.

In these experiments the cows drank about three pounds of water for each pound of dry matter consumed. When the cows were placed on the one-half water allowance, the ratio was 1.8 pounds of water to each pound of dry matter consumed. During experiment B the cows, when receiving water ad libitum three times a day, used 3.5 pounds of water to each pound of dry matter consumed. In the same experiment, when the cows received water once each 60 hours, they used only 2.38 pounds of water to each pound of dry matter con-

sumed. This increased demand for water per pound of dry matter consumed, was undoubtedly due to the increased evaporation from the body due to the higher summer temperature.

TABLE VI.

RELATION OF AMOUNT OF WATER TO DRY MATTER CONSUMED.

	Period	Cow	Frequency of watering. Watered once in hrs.	Water drunk daily pounds	Dry matter consumed daily: pounds	Ratio of dry matter consumed to water drunk, 1:
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	73.17	27.00	2.71
		2	8	69.81	24.80	2.81
		3	8	65.69	19.31	3.40
		4	8	46.87	24.11	1.94
		Av.	8	63.63	23.80	2.67
	II. Experimental	1	24	67.42	24.65	2.73
		2	24	70.07	24.63	2.84
		3	24	59.98	19.11	3.13
		4	24	49.12	21.00	2.34
		Av.	24	61.10	22.35	2.73
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	77.08	24.41	3.16
		2	8	91.09	23.31	3.91
		3	8	67.74	19.27	3.51
		4	8	68.30	21.19	3.22
		Av.	8	75.71	21.59	3.51
	IV. Experimental	1*	12	67.08	23.26	2.88
		2	60	56.61	23.61	2.40
		3	60	50.13	20.03	2.50
		4	60	46.96	20.68	2.24
		Av.	60	51.27	21.53	2.38
Experiment C Effect of one-half water. Nov. 16, 1915	V. Check	5	12	81.56	28.93	2.79
		6*	12	98.97	31.24	3.17
		7	12	78.40	27.64	2.84
		Av.	12	79.98	28.29	2.82
	VI. Experimental	5	24	40.00	22.94	1.74
		6*	24	87.97	29.54	2.98
		7	24	40.00	21.38	1.87
		Av.	..	40.00	22.16	1.80

*Check cows not included in averages

The frequency of voiding is also but slightly related to the amount of water drunk. A complete record was kept of the time each cow voided feces and urine, and also of the amount excreted each time.

TABLE VII.

AVERAGE DAILY AMOUNTS AND COMPOSITION OF URINE.

	Period	Cow	Frequency of watering. Watered once in: hrs.	Urine excreted daily lbs.	Water %	Nitrogen N %	Ash %	Chlorine Cl %	Phosphorous P %	Sulfur S %	Calcium Ca %	Magnesium Mg %	Sodium Na %	Potassium K %	Silica Si 02 %
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	10.59	90.04	1.26	**3.31**								
		2	8	11.71	90.42	1.19	**3.11**								
		3	8	10.06	90.27	1.31	**3.10**								
		4	8	9.74	90.44	1.34	**3.17**								
		Av.	8	10.52	.....	.....	....								
	II. Experimental	1	24	10.84	90.87	**1.24**	**3.56**								
		2	24	11.94	90.80	**1.10**	**2.80**								
		3	24	11.37	90.97	**1.27**	**3.15**								
		4	24	10.22	90.62	**1.27**	**3.21**								
		Av.	24	11.09	.....	.....	....								
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	13.77	92.67	1.210	2.88	0.2865	0.00239	0.1456	0.0120	0.0981	0.1056	0.8535	.....
		2	8	16.47	92.92	1.186	2.57	0.2823	0.00195	0.1539	0.0016	0.0734	0.0504	1.2939	0.01128
		3	8	16.29	95.50	0.985	2.07	0.2695	0.00446	0.1129	0.0041	0.0336	0.1111	1.3304	0.02866
		4	8	11.68	92.00	1.312	2.68	0.4362	0.00150	0.1528	0.0072	.....	0.0587	1.3692	0.01236
		Av.	8	14.81	93.47	1.161	2.44	0.3292	0.00264	0.1399	0.0043	0.0535	0.0734	1.3312	0.01743
	IV. Experimental	1*	12	16.40	92.59	0.999	2.45	0.2411	0.0024	0.0952	0.0225	0.1117	0.1165	0.9688	0.0075
		2	60	13.98	90.98	1.235	3.04	0.3347	0.0023	0.1083	0.0088	0.1103	0.0969	1.2632	0.0218
		3	60	14.58	93.47	1.001	2.29	0.2737	0.0022	0.0914	0.0044	0.0429	0.1225	0.9092	0.0104
		4	60	11.13	90.53	1.325	3.23	0.3830	0.0026	0.1136	0.0056	0.1349	0.1487	1.3260	0.0095
		Av.	60	13.23	91.66	1.187	2.85	0.3305	0.0024	0.1044	0.0063	0.0960	0.1227	1.1661	0.0139
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	15.13	91.31	1.339	3.19	0.2168	0.0024	0.1655	0.0046	0.0887	0.0831	1.2728	0.0142
		6*	12	11.17	89.47	1.234	3.34	0.0943	0.0030	0.1991	0.0160	0.0826	0.1179	1.2720	0.0222
		7	12	12.93	90.04	1.103	3.37	0.0390	0.0023	0.1800	0.0014	0.0982	0.0771	1.2864	.....
		Av.	12	14.03	90.68	1.221	3.28	0.1279	0.0024	0.1728	0.0030	0.0940	0.0801	1.2796	0.0142
	VI. Experimental	5	24	12.29	90.06	1.712	2.82	0.2135	0.0018	0.1578	0.0069	0.0760	0.0368	1.2880	0.0416
		6*	24	11.89	89.54	1.454	2.80	0.0220	0.0026	0.1890	0.0112	0.1026	0.0267	1.2504	0.0476
		7	24	9.95	90.68	1.387	2.54	0.0567	0.0019	0.1429	0.0087	0.1005	0.0560	1.1000	0.0522
		Av.	24	11.12	90.37	1.033	2.68	0.1351	0.0019	0.1504	0.0078	0.0883	0.0464	1.1940	0.0469

*Check cows not included in averages.

These cows voided feces just before and after feeding. After that they voided about every two hours except from midnight till 5:00 A. M., when the cows were quiet and resting. When the cows were under normal conditions they voided feces from 14 to 18 times each 24 hours, and voided urine from four to seven times during each 24 hours. When in the experimental periods they voided feces from 10 to 17 times, and they voided urine from three to six times. This less frequency of voidance properly should be laid to the less feed consumed, and therefore, less excreta, and only indirectly to the smaller amount of water drunk.

Effects of Amount of Water Drunk on Amount and Composition of Milk.

In these experiments the composition of the milk remained remarkably uniform. There is no variation in the composition of the milk that can be ascribed to the lack of water. In fact, the small variation is only such as would naturally be expected, and such as is within the range of experimental errors. Even when the cows received only one-half the normal water requirements the composition of the milk remained normal. It is believed from these results that the normal cow is able to regulate with great accuracy and uniformity the composition of this natural food. When receiving only one-half of the normal water requirements it was believed that the composition of the milk or of the chief milk components would be changed. The rise of body temperature and the nervous condition of the cows resulting from this lack of water did not materially affect the composition of the milk, as may be noticed from table VIII.

TABLE VIII.

SHOWING AVERAGE DAILY AMOUNTS AND COMPOSITION OF MILK.

	Period	Cow	Frequency of watering. Watered once in: hrs.	Milk produced daily pounds	Water %	Nitrogen N %	Total Protein %	Casein %	Fat %	Ash %	Lactose %	Chlorine Cl %	Phosphorous P %	Sulfur S %	Calcium Ca %	Magnesium Mg %	Sodium Na %	Potassium K %
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	20.44	87.07	0.524	3.35	2.70	4.00	0.74	4.87	Ash constituents not determined.						
		2	8	20.23	87.25	0.510	3.26	2.56	3.99	0.73	4.80							
		3	8	14.60	86.70	0.520	3.32	2.77	4.21	0.74	5.01							
		4	8	15.52	86.57	0.512	3.27	2.74	4.30	0.74	5.13							
		Av.	8	17.70	86.90	0.516	3.30	2.69	4.13	0.74	4.95							
	II. Experimental	1	24	17.96	87.10	0.540	3.44	2.72	3.93	0.74	4.79							
		2	24	17.96	87.64	0.530	3.38	2.64	3.65	0.73	4.60							
		3	24	14.49	86.72	0.529	3.38	2.78	4.23	0.76	4.92							
		4	24	13.80	86.39	0.536	3.42	2.78	4.42	0.74	5.04							
		Av.	24	16.05	86.95	0.534	3.40	2.73	4.06	0.74	4.84							
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	12.50	87.01	0.567	3.62	2.79	3.95	0.75	4.66	0.1035	0.1036	0.0294	0.1197	0.0104	0.0528	0.12744
		2	8	10.30	87.78	0.565	3.61	2.72	3.50	0.74	4.29	0.1369	0.0954	0.0312	0.1163	0.0120	0.0767	0.12894
		3	8	8.65	84.78	0.630	4.12	3.33	5.46	0.75	4.96	0.0812	0.1156	0.0417	0.1449	0.0141	0.0437	0.12692
		4	8	12.00	86.17	0.580	3.72	3.03	4.32	0.77	5.10	0.1083	0.1200	0.0287	0.1187	0.0116	0.0420	0.12442
		Av.	8	10.86	86.24	0.592	3.82	3.03	4.43	0.75	4.78	0.1088	0.1103	0.0372	0.1266	0.0126	0.0406	0.12507
	IV. Experimental	1*	12	9.81	86.51	0.590	3.76	3.00	4.18	0.76	4.70	0.0996	0.1068	0.0394	0.1211	0.0092	0.0516	0.12600
		2	60	8.66	87.80	0.548	4.49	2.70	3.73	0.76	4.60	0.1301	0.0948	0.0348	0.1064	0.0142	0.0739	0.1239
		3	60	8.26	85.08	0.646	4.12	3.40	4.54	0.80	4.90	0.0784	0.1160	0.0416	0.1442	0.0132	0.0320	0.1179
		4	60	11.35	85.83	0.583	3.72	3.06	4.65	0.76	5.10	0.0652	0.1195	0.0343	0.1281	0.0132	0.0309	0.1138
		Av.	60	9.42	86.24	0.592	3.74	3.05	4.31	0.77	4.87	0.0912	0.1101	0.0369	0.1262	0.0135	0.0456	0.1185
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	10.19	88.46	0.473	3.01	2.25	3.34	0.74	4.24	0.1245	0.0858	0.0334	0.0923	0.0135	0.0763	0.13914
		6*	12	33.27	86.40	0.517	3.30	2.63	4.69	0.75	5.00	0.0989	0.0905	0.0363	0.1236	0.0132	0.0518	0.14292
		7	12	26.32	87.59	0.480	3.06	2.24	3.98	0.72	4.70	0.1156	0.1046	0.0341	0.1100	0.0125	0.0652	0.13296
		Av.	12	18.26	88.03	0.477	3.04	2.25	3.66	0.73	4.47	0.1201	0.0952	0.0338	0.1012	0.0130	0.0708	0.13605
	VI. Experimental	5	24	7.46	88.92	0.496	3.16	2.15	3.24	0.73	3.80	0.1653	0.0734	0.0362	0.0768	0.0140	0.1000	0.1279
		6*	24	26.83	86.95	0.473	3.04	2.47	4.29	0.73	5.00	0.0979	0.0993	0.0350	0.1154	0.0131	0.0765	0.1039
		7	24	20.65	87.47	0.492	3.13	2.18	4.11	0.72	4.63	0.1191	0.0889	0.0337	0.1130	0.0127	0.0660	0.1248
		Av.	24	14.06	88.20	0.494	3.15	2.17	3.68	0.73	0.73	0.1422	0.0812	0.0350	0.0949	0.0134	0.0830	0.1264

*Check cows, not included in averages.

The ash of the milk in the two last experiments was analyzed. This was done with the view of obtaining data by which abnormalities of the milk, in case any occurred, might be interpreted. It is well known that the ash and ash constituents affect the prpoerties of milk. These results are entirely normal.

TABLE IX.
ANALYSIS OF BUTTER FAT.

	Period	Cow	Frequency of watering. Watered once in: hrs.	Reichert Meissl No.	Iodine absorbtion number (Huble)	Saponification No. (Koetotorfer)	Refractometer reading at 40oC (Abbe)	Melting Point oC.
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	30.1	34.7	227.4	43.0	30.2
		2	8	26.4	34.8	226.7	43.3	29.4
		3	8	28.3	31.7	227.2	42.9	31.8
		4	8	27.2	30.5	227.0	42.5	33.0
		Av.	8	28.0	32.9	227.1	42.9	31.5
	II. Experimental	1	24	28.2	28.6	227.5	43.1	30.0
		2	24	25.6	28.3	226.8	42.7	28.7
		3	24	26.6	28.1	226.2	42.7	31.7
		4	24	25.1	27.5	226.1	42.7	32.9
		Av.	24	26.4	28.1	226.6	42.8	30.8
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	25.9	33.4	227.6	43.5	32.2
		2	8	21.8	32.1	223.6	44.2	29.9
		3	8	22.8	26.3	223.3	43.0	39.9
		4	8	25.5	29.1	226.4	43.2	31.9
		Av.	8	23.7	29.2	224.4	43.5	33.9
	IV. Experimental	1*	12	26.8	26.2	230.7	43.5	31.5
		2	60	24.9	27.9	227.9	44.0	29.8
		3	60	26.2	29.2	220.6	43.0	39.0
		4	60	26.5	25.8	229.3	42.5	34.6
		Av.	60	25.9	27.6	225.9	43.2	34.5
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	25.6	39.1	228.2	44.0	32.0
		6*	12	29.6	40.6	234.4	32.2	29.1
		7	12	27.1	32.2	233.4	42.2	32.7
		Av.	12	26.4	35.7	230.8	43.1	32.4
	VI. Experimental	5	24	25.9	38.0	237.0	42.9	31.9
		6*	24	29.9	30.6	244.0	41.3	31.3
		7	24	26.3	36.6	244.0	42.3	33.4
		Av.	24	26.1	37.3	240.5	42.6	32.7

*Check cows not included in averages.

A complete analysis of the butterfat was also made. The resulting data is given in table IX. There are no changes in the composition of the butterfat that can be ascribed to a long time between watering nor to giving only one-half amount of normal water requirement.

It is believed from these experiments that the cows would go entirely dry due to lack of water rather than to cause a change in the composition of the milk and milk components. Even this would be brought about very gradually, as the cow is evidently able to draw from her own body and thus supply water for the manufacture of milk.

The amount of milk given is affected some by frequency of watering, but not so much as would naturally be expected. When supplied only one-half amount of water, there was a daily decrease in the amount of milk of 4.2 pounds, or a decrease of about one-fourth. When the cows were first put on one-half water, there was but a slight decrease. Toward the end of the 30 day period the decrease was more noticeable. If the cows had been continued on one-half amount of water they would undoubtedly have gradually decreased in milk flow until entirely dry.

Effect of Water on Body Temperature of Cows.

The body temperature of a healthy and normal dairy cow is remarkably uniform.

In connection with these investigations, data were kept which show the effect of water on the body temperature of the cows. Throughout the experiments daily records were kept of the body temperatures of the different cows, of the atmospheric temperatures in the barn, of the temperature of the water, and of the amount of water drunk.

It was found that when the cows were watered not less than once in 24 hours the body temperature of the cow is lowered only a fraction of one degree Farenheit. In experiment B, period IV, the temperature of the cows after watering was reduced an average of about two degrees F. In this experiment the temperature of the barn was 67.24 degrees F., and that of the water 60.6 degrees F.

In this connection it should also be stated that when the cows were watered not less than once each day

the lowest body temperature was reached within 15 minutes after watering the cow. This would indicate that the contents of the stomach and the immediate heat resulting from chemical and fermentative changes were almost sufficient to raise the temperature of the water taken in, and thus affecting but slightly the body temperature. In experiment B, period IV the cows were watered but once in 60 hours, and each cow drank nearly 130 pounds of water at one time. In this experiment the lowest body temperature was not reached till one and one-half hours after watering. This would indicate that the amount of water was so large as to dilute the stomach contents as well as the active agents, and thus retard the chemical and biochemical changes. Secondly, this large volume of cold water introduced at one time into the cow's body would draw directly from the body heat of the cow and cause the lowering of the body temperature as much as 2 degrees F.

Among some breeders of dairy cattle the idea is current that there is a relation between body heat and per cent of fat in the milk from the cow. The higher the body temperature of the cow, the greater the per-cent of fat in the milk is supposed to be. On this account some breeders have practiced blanketing cows, reducing the water, and keeping the cows in a warm place in order to raise the body temperature. If this lack of water is continued very long, and the cow is fed at the same time a heavy protein ration, the cow assumes a feverish condition, and the body temperature rises several degrees above normal. Such a rise in body temperature is brought about because of an accumulation of waste matter such as urea. This latter is a decomposition product from any cow, and is increased in quantity by a heavy protein ration. A normal water supply is needed to carry off this soluble poison. In thus withholding water from the large producing cows fed a heavy protein ration, there is much danger of impairing the health of the cow.

TABLE X.

SHOWING AVERAGE TEMPERATURE OF BARN AND BODY TEMPERATURE OF COWS.

	Period	Cow	Frequency of watering. Watered once in; hrs.:	Temperature of Barn	Temperature of Water	Water drunk Daily:	Average Temperature of Cows at: 8:00 A. M. Degrees F.	9:30 A. M. Degrees F.	12:00 M. Degrees F.	2:30 P. M. Degrees F.	6:00 P. M. Degrees F.	Average Body Temperature Before watering Degrees F.	Average Body Temperature After watering Degrees F.	Total Average Body Temperature Degrees F.
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	45.2 Degrees F.	45.0 Degrees F.	69.64	101.47	101.00	101.09	101.14	101.53	101.34	101.21	101.23
		2	8			70.60	101.21	101.09	101.05	101.06	101.27	101.18	101.03	101.14
		3	8			61.80	101.60	101.67	101.81	101.46	101.78	101.75	101.53	101.66
		4	8			46.90	101.64	101.44	101.49	101.52	102.01	101.72	101.56	101.61
		Av.	8			62.23	101.46	101.29	101.36	101.30	101.65	101.49	101.33	101.41
	II. Experimental	1	24	31.8 Degrees F.	41.0 Degrees F.	66.60	101.35	101.19	101.47	100.67	101.36	101.47	100.94	101.21
		2	24			68.30	100.89	100.80	101.23	100.56	100.93	101.23	100.75	100.88
		3	24			57.40	101.71	101.97	102.18	101.15	101.57	102.18	101.51	101.71
		4	24			51.20	101.70	101.60	102.29	101.06	101.76	102.29	101.47	101.69
		Av.	24			60.88	101.41	101.41	101.79	100.86	101.41	101.71	101.16	101.38
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	76.9 Degrees F.	59.4 Degrees F.	72.57	101.20	100.94	101.17	101.63	102.13	101.50	101.39	101.50
		2	8			87.54	100.80	101.61	101.01	101.28	101.92	101.24	101.10	101.24
		3	8			64.82	100.78	102.16	102.74	103.19	103.82	103.11	103.01	103.11
		4	8			67.12	101.46	101.26	101.36	101.64	102.18	101.67	101.55	101.67
		Av.	8			73.16	101.01	101.68	101.70	102.04	102.64	102.01	101.89	102.01
	IV. Experimental	1*	12	67.4 Degrees F.	60.6 Degrees F	69.42	100.96	100.78	100.99	101.13	101.64	101.30 †	101.13	101.10
		2	60			64.26	100.95	100.60	100.78	101.02	101.47	101.43 †	99.60	101.04
		3	60			55.06	101.72	101.07	101.52	101.93	102.39	102.11 †	99.00	101.73
		4	60			49.84	101.33	100.90	101.08	101.43	101.84	101.60 †	99.65	101.32
		Av.	60			56.39	101.46	100.86	101.13	101.46	101.90	101.70 †	99.42	101.36
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	48.6 Degrees F.	47.5 Degrees F.	79.91	99.77	100.39	100.70	100.60	101.15	100.58	100.48	100.50
		6*	12			94.91	100.10	100.60	100.70	100.80	101.30	101.00	101.50	100.70
		7	12			79.56	99.90	100.50	100.30	100.40	100.80	100.55	100.25	100.36
		Av.	12			79.74	99.84	100.44	100.50	100.50	100.98	100.57	100.37	100.43
	VI. Experimental	5	24	43.0 Degrees F.	41.5 Degrees F.	40.00	101.15	101.10	101.15	101.25	101.71	101.71	101.38	101.15
		6*	24			84.65	101.20	101.20	101.15	101.29	102.00	102.00	101.40	101.17
		7	24			40.00	101.02	101.05	101.21	101.16	101.63	101.63	101.68	101.20
		Av.	24			40.00	101.09	101.08	101.18	101.21	101.67	101.67	101.53	101.18

*Check cows not included in averages.

† Temperature of cows one and one-half hours after watering.

In experiment B, where the cows received only one-half the normal amount of water, the body temperature averaged about 1 degree F. higher than when they received their full water requirement. The results of this water curtailment, and this rise in body temperature did not show any material increase in the per cent of fat, but on the other hand the amount of milk was materially decreased without the corresponding increase in per cent of fat, so the amounts of fats secreted during the preceding 30 days, when receiving a full allowance of water. In this connection, one should keep in mind that these were common cows in normal condition, and not large producing purebred cows in the very early part of the lactation period.

In order to ascertain more definitely the effect of a high body temperature of healthy cows on the per cent of fat in milk secreted, a series of experiments were conducted.

Four normal grade cows were placed in a room, the temperature of which could be controlled. This room temperature varied from 51 degrees to 104 degrees F. In each trial the cows were given water tempered to the same degree of heat as that of the room. When it was desired to increase the body temperature, the cows were also blanketed. The cows were barren, and were fed the same kind of rations in the different trials.

The high room temperatures, 94 degrees to 104 degrees F. were so trying on the cows that at no time were they exposed to it more than 72 hours.

TABLE XI.

SHOWING EFFECT OF ROOM TEMPERATURE ON TOTAL AMOUNT AND PER CENT OF FAT IN THE MILK.

	COW	Room Temp. oF.	Temp. of Cow oF.	Per cent Fat	Lbs. of Milk	Lbs. of Fat
Atmospheric temperature above 100o F. Drinking water warmed	Grade Jersey No. 1.....	104	104.6	5.3	6.6	.351
	Grade Shorthorn No. 3.....	104	104.6	5.2	7.7	.405
	Grade Shorthorn No. 4.....	104	105.2	4.82	14.8	.728
	Grade Shorthorn No. 6.....	104	104.7	4.86	11.6	.568
	Average	104	104.8	5.04	10.2	.513
Atmospheric temperature between 90o F. and 100o F.	Grade Jersey No. 1.....	94	101.9	4.80	8.8	.422
	Grade Shorthorn No. 3.....	94	102.1	4.80	9.5	.455
	Grade Shorthorn No. 4.....	94	102.7	5.01	16.2	.412
	Grade Shorthorn No. 6.....	94	102.3	4.50	9.7	.439
	Average	94	102.2	4.81	11.05	.532
Atmospheric temperature between 80o F. and 90o F. Drinking water cold	Grade Jersey No. 1.....	85	101.6	4.8	9.0	.433
	Grade Shorthorn No. 3.....	85	102.2	4.01	10.2	.416
	Grade Shorthorn No. 4.....	85	102.3	3.49	14.3	.500
	Grade Shorthorn No. 6.....	85	102.1	4.22	10.5	.447
	Average	85	102.0	4.13	11.0	.448
Atmospheric temperature between 60o and 80o F.	Grade Jersey No. 1.....	69	101.0	4.44	9.3	.412
	Grade Shorthorn No. 3.....	69	101.0	4.25	8.4	.358
	Grade Shorthorn No. 4.....	69	101.4	4.40	15.0	.664
	Grade Shorthorn No. 6.....	69	101.5	4.11	12.2	.402
	Average	69	101.2	4.40	11.2	.459
Atmospheric temperature below 60o F.	Grade Jersey No. 1.....	53	100.5	4.25	8.5	.365
	Grade Shorthorn No. 3.....	53	100.8	3.70	7.5	.281
	Grade Shorthorn No. 4.....	53	101.5	4.00	12.0	.480
	Grade Shorthorn No. 6.....	53	101.1	4.18	11.6	.484
	Average	53	100.9	9.03	9.9	.403

These results do indicate that the average per cent of fat tends to increase with the higher body temperature, though the increase is slight. For instance, at a room temperature of 69 degrees F. and body temperature of 101.2 degrees F., which are both normal, the average per cent of fat is 4.4 When the everage room temperature was 104 degrees F. and the body temperature 104.8 degrees F., the average per cent of fat is 5.04.

The amount of fat, however, is not increased in the same ratio. In the same experiments quoted above the average daily amount of fat produce at the normal body temperature is 0.459 pounds. When the body temperature was increased to 104.8 degrees F. the amount of fat increased to 0.513 pounds. At the same time there was a daily decrease of milk from 11.2 pounds to 10.2 pounds.

Each of the above results in Table XI represents averages of from 10 to 40 different trials, the experiments with high temperatures being the fewest in number.

Physical Condition of Cows.

The abnormal physical characteristics due to lack of water were nervousness, a gaunt appearance, and high body temperature. The latter has already been discussed.

The nervous condition of the cows was due directly to a craving for water. When the cows were watered only once in 60 hours this nervousness was noticeable previous to watering. This condition was most marked in period VI and especially in the latter part of the period when the cows received only one-half of amount of required water. The cows were kept in the stanchions in the barn. Whenever any person came in sight the cows would crowd up in the stalls, head erect and longingly look towards the person in sight, and mooing in a low tone. There was a tense expres-

sion in their eyes and face. When in this condition, they would shift from one foot to the other and continuously crowd ahead onto the stanchion. Their whole behavior indicated a very intense craving for water.

Even in this abnormal condition there was no marked change in the quality of the milk which could be detected by chemical analysis and physical examination.

TABLE XII.

FOOD CONSTITUENTS DIGESTED PER 1,000 LBS. LIVE WEIGHT, DAILY.

	Period	Cow	Frequency of watering. Watered once in; hrs:	Water drunk Daily	Milk Secreted Daily	Am't. of food constituents digested per 1000 pounds live weight: Protein Lbs.	Protein Cal.	Fat Lbs.	Fat Cal.	Crude Fiber Lbs.	Crude Fiber Cal.	N-free Extract Lbs.	N-free Extract Cal.
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	77.08	12.5	1.4553	2706	0.3979	2176	2.7932	5195	6.1844	11502
		2	8	91.09	10.3	1.1637	2165	0.4721	2463	2.1520	4003	5.8627	10905
		3	8	67.74	8.65	1.5669	2914	0.4457	2326	2.7008	5024	7.5317	14009
		4	8	68.30	12.00	1.5896	2957	0.5866	3062	2.7501	5115	7.4963	13943
		Av.	8	75.71	10.32	1.4401	2678	0.5015	2618	2.5343	4714	6.9636	12953
	IV. Experimental	1*	12	67.08	9.81	1.1198	2083	0.3568	1763	3.1288	5820	6.3054	11727
		2	60	56.51	8.66	1.0941	2035	0.3428	2789	2.2908	4261	6.2038	11539
		3	60	50.13	8.26	1.5487	2881	0.4539	2369	3.9766	7397	8.4491	15715
		4	60	46.96	11.35	1.5593	2990	0.4226	2206	3.5358	6577	7.7458	14408
		Av.	60	51.20	9.99	1.4007	2606	0.4064	2121	3.2677	6078	8.1329	15127
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	81.56	10.19	1.2322	2291	0.3797	1602	3.1034	5769	7.0533	13117
		6*	12	98.97	33.27	1.5156	2819	0.5014	2115	3.2731	6087	9.2446	17192
		7	12	78.40	26.32	1.5925	2962	0.4538	1814	3.6423	6774	8.1304	15120
		Av.	12	79.98	18.26	1.4123	2627	0.4168	1708	3.3779	6272	7.5919	14118
	VI. Experimental	5	24	40.00	7.46	1.0494	1952	0.3332	1406	2.2598	4203	5.6346	10479
		6*	24	87.97	26.83	1.4059	2615	0.4851	2046	3.3608	6250	7.7306	14377
		7	24	40.00	20.65	1.4434	2684	0.4860	2050	2.9237	5437	7.0134	13043
		Av.	24	40.00	14.06	1.2364	2318	0.4096	1728	2.5918	4820	6.3240	11761

*Check cows not included in averages.

Calorific value obtained by use of following factors:
Protein .. ..4.1 Calories (Cal.) per gram
Fat .. ..9.3 Calories (Cal.) per gram
N-free Extract ....4.1 Calories (Cal.) per gram
Crude Fiber ....4.1 Calories (Cal.) per gram

TABLE XIII.

DAILY ENERGY REQUIREMENT PER 1,000 LBS. LIVE WEIGHT

	Period	Cow	Frequency of watering. Watered once in; hrs.:	Water drunk Pounds	Milk secreted Pounds	Temperature of Water Degrees F.	Temperature of Barn			Actual total available energy of food Cal.	Energy represented by milk secreted and gain in body wt. Cal.	Energy used for body functions Cal.
							A. M. Deg's. F.	M. Deg's. F.	P. M. Deg's. F.			
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	8	77.08	12.5	59.3	71	78	81	21579	5086	16493
		2	8	91.09	10.3	59.3	71	78	81	19536	3971	15565
		3	8	67.74	8.65	59.3	71	78	81	24273	— 2950	27223
		4	8	68.30	12.00	59.3	71	78	81	25077	12082	12995
		Av.	8	85.71	10.32	59.3	71	78	81	22963	4368	18594
	IV. Experimental	1*	12	67.08	9.81	60.6	62	69	70	21493	3477	18016
		2	60	56.51	8.66	60.6	62	69	70	19624	— 193	19817
		3	60	50.13	8.26	60.6	62	69	70	28362	— 196	28558
		4	60	46.96	11.20	60.6	62	69	70	26181	— 362	26543
		Av.	60	51.53	9.99	60.6	62	69	70	24722	— 250	24973
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	81.56	10.19	47.5	49.1	46.1	50.6	22779	8189	14590
		6*	12	98.97	33.27	47.5	49.1	46.1	50.6	28213	7646	20567
		7	12	78.40	26.32	47.5	49.1	46.1	50.6	26670	4979	21691
		Av.	12	79.98	18.26	47.5	49.1	46.1	50.6	24725	6584	18140
	VI. Experimental	5	24	40.00	7.46	41.5	43.6	41.2	44.1	18040	— 4323	22363
		6*	24	87.97	26.83	41.5	43.6	41.2	44.1	25288	3942	21346
		7	24	40.00	20.65	41.5	43.6	41.2	44.1	23214	—17614	40828
		Av.	24	40.00	14.06	41.5	43.6	41.2	44.1	20627	—10968	31596

* Check cows not included in averages.

The data in table XIII show that a larger amount of energy was required per thousand pound live weight to accomplish the body functions when the water was given once in 60 hours and when only one-half amount of water was supplied the cows.

The method of calculation is open to some criticism, but gives a correct idea of the energy requirement of the cows under the two conditions. The method of calculation is as follows: The total amount of protein, fat, crude fiber, and nitrogen-free extract digested per day was calculated by substracting the amount excreted in the feces from the total intake. The energy value was computed by use of the Hammarsten's factors, which are 4.1 calories per gram of protein, or carbohydrate, and 9.3 calories per gram of fat. The gain in weight for the entire period was divided by the number of days in the period to obtain the gain in weight per day. The gain in protein per day was subtracted from the gain in weight per day, and the remainder considered as fat. The gain in fat and protein was added to the amount of fat and protein secreted in the milk and the combined energy values computed. The energy value of the sugar in the milk was calculated and added to the energy values of the fat and protein. This sum, representing the number of calories of heat that are obtainable from the utilization of the substances secreted in the milk and that retained by the body, was subtracted from the total available energy, the difference representing the energy required for body functions.

This apparent increase of energy requirement of the cows may be due first to a decrease in the efficiency of the cows to carry on life functions, and secondly, to the increased activity of the cows, and thirdly, to the extra required energy to lower the abnormally high body temperature.

SUMMARY OF CHIEF FUNCTIONS OF WATER IN A DAIRY COW'S RATION.

A good dairy cow probably needs more water than any other domestic animal. The chief uses of water by the dairy cow may be grouped as follows:

1. Water dissolves nutrients. No foods can be utilized by the system of the cow until they have been brought into complete solution. In accomplishing this, water plays an important part. The more food consumed, the more water a cow requires.

2. Water is a medium for distributing the food to the different parts of the body. Water may serve both as a direct and an indirect transferring agency. For instance, when food is masticated, saliva is mixed with it. Saliva contains about 90% water. Again, water, when mixed with the food in the digestive tract, serves as a direct medium for transferring food.

3. Water is used as a vehicle for transferring waste and poisonous products from the system. This process of elimination is carried on through the skin, through the kidneys, and through the digestive tract. In all of these instances water plays an important part. In an animal such as the dairy cow, that consumes a relatively large amount of protein, water is of special importance. Urea is one of the soluble poisonous products resulting from a protein ration. With the aid of water and proper circulation, the kidneys are able to rid the system of this particular substance.

TABLE XIV.

SHOWING DISTRIBUTION OF WATER BY COW'S BODY.

	Period	Cow	Frequency of watering. Watered once in; hrs:	Percent of ingested water excreted in:			
				Milk	Urine	Feces	Other Ways
Experiment A Effect of watering only once in 24 hrs. Jan. 2, '14	I. Check	1	8	19.21	10.28	59.99	10.52
		2	8	19.82	11.89	57.72	10.57
		3	8	14.98	10.74	53.79	20.49
		*4	8	15.79	13.33	63.30	7.58
		Av.	8	17.45	11.56	58.70	12.29
	II. Experimental	1	24	18.08	11.39	60.05	10.48
		2	24	17.68	12.17	59.83	10.32
		3	24	16.17	13.31	54.05	16.47
		4	24	17.55	13.63	63.71	5.11
		Av.	24	17.37	12.62	59.41	10.60
Experiment B Effect of watering only once in 60 hrs. Aug. 9, '14	III. Check	1*	8	11.28	13.26	49.21	26.25
		2	8	7.88	13.85	48.51	29.76
		3	8	8.97	19.03	42.43	29.57
		4	8	13.74	12.31	53.53	20.42
		Av.	8	10.20	15.06	48.16	26.58
	IV. Experimental	1*	12	9.67	17.28	55.79	17.26
		2	60	9.96	16.66	52.15	21.23
		3	60	9.60	19.29	43.28	27.83
		4	60	14.47	14.92	56.54	14.07
		Av.	60	11.34	16.96	50.66	21.04
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	8.73	13.38	53.46	24.44
		6*	12	23.78	8.31	57.11	10.80
		7	12	23.05	11.64	60.27	5.04
		Av.	12	15.89	12.51	56.87	14.87
	VI. Experimental	5	24	10.82	18.05	53.43	17.70
		6*	24	21.27	9.70	54.78	14.26
		7	24	29.54	14.74	52.96	2.76
		Av.	24	20.18	16.39	53.20	10.23

*Check cows not included in averages.

The extent to which the wastes are transferred from the system of the cow through the blood may be judged from the data in table XIV. It will be seen that an amount of water equal to about 12% of the total water drunk is eliminated through the skin. This is true during the winter under barn conditions. During the summer or during the month of August about 27% of the water drunk was eliminated through the skin.

Little more than one-half, or an amount equal to 56% of the water drunk was eliminated in the feces.

About 13% of the water taken in was passed through the kidneys in the form of urine. All of the excretory agencies need a constant water supply to perform their work of eliminating waste and poisonous matter from the body.

4. A dairy cow uses water for the manufacture of milk. This latter product contains about 87% water. The cows in these experiments were common cows, and not large milk producers. They used water for milk equal in amount to about 15% of the water drunk. This will vary according to the amount of milk produced. For instance, cow No. 6 produced more milk and used about 24% of water drunk for milk production.

The portion of the water eliminated through the urine, through the skin, and used for milk production evidently must first enter into the circulatory system of the cow, while the water in the feces probably never serves the system of the cow except as a food solvent, transferring medium, and for regulating the consistency of the contents of the digestive tract. This does not refer to the water that may enter the digestive tract in connection with secretory or excretory products.

According to Babcock, *metabolic water results to the extent of 55.5% of the cellulose or starch, 60% of the dextrose, little more than 100% of the fat, and 60 to 65% of the protein digested. These various food elements

are oxidized in the body of the cow, and form chiefly water and carbon dioxide as by-products. In accordance with this these cows were supplied with nearly one gallon of metabolic water in addition to that drunk and that contained in the food eaten. When on normal food they drank about 75 pounds, obtained about 17.5 pounds from the silage eaten, 0.7 pounds from the grain, one pound from the hay consumed, and about eight pounds of metabolic water resulted from oxidation in the body. The total water used daily was then about 102 pounds.

5. Water regulates the body temperature. That there is evaporation from the body surface and from breathing is evident from the above table, and that this loss of water from the body is greater during warm weather or during summer than during the winter. This is shown by the increase from 12% in experiment A to 26% in experiment B. This latter experiment was conducted in August, while the former was carried on in January. The rate of respiration is undoubtedly also greater during the summer, which means an increased loss of body moisture.

*Research Bulletin No. 22, Madison, Wis.

TABLE XV.

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT A, EFFECT OF WATERING ONLY ONCE IN 24 HOURS.

Period	Cow		Material	Total Amts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous, P.	Sulfur S.	Calcium Ca.	Magnesium, Mg.	Sodium Na.	Potassium K.	Silica Si O2
I. CHECK	1	Intake	Grain	7.00	0.837	6.163	0.1792	0.3493	0.6776	3.6680	0.3479	(Ash constituents not determined)							
			Hay	14.49	1.084	13.406	0.1311	0.2898	4.2992	6.7349	1.2056								
			Silage	25.00	17.572	7.428	0.1040	0.1825	1.5700	4.5775	0.4475								
			Water	73.17	73.119	0.051	0.	0.	0.	0.	0.0395								
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625								
			Total	119.722	92.612	27.110	0.4143	0.7216	6.5468	14.9804	2.1030								
		Outgo	Milk, A. M.	11.02	9.615	1.405	0.0579	0.4221	0.	0.5400*	0.0827								
			Milk, P. M.	9.42	8.147	1.273	0.0493	0.3900	0.	0.4559*	0.0687								
			Urine	10.59	9.535	1.055	0.1334	0.	0.	.....	0.3505								
			Feces	66.08	55.553	10.527	0.1586	0.2048	2.9273	4.8371	1.5661								
			Total	97.11	82.850	14.260	0.3992	1.0169	2.9273	5.8330	2.0680								
		Balance		.....	.....	.....	†0.0151	.....	.....	.....	†0.0350								
	2	Intake	Grain	7.00	0.837	6.163	0.1792	0.3493	0.6776	3.6680	0.3479								
			Hay	12.12	0.907	11.213	0.1097	0.2424	3.5950	5.6819	1.0084								
			Silage	25.00	17.572	7.428	0.1040	0.1825	1.5700	4.5775	0.4475								
			Water	69.81	69.761	0.049	0.	0.	0.	0.	0.0377								
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625								
			Total	113.992	89.620	24.372	0.3929	0.7742	5.8436	13.8274	1.9040								
		Outgo	Milk, A. M.	11.32	9.903	1.417	0.0580	0.4188	0.	0.9886	0.0815								
			Milk, P. M.	8.91	7.751	1.159	0.0452	0.3805	0.	0.4255	0.0650								
			Urine	11.71	10.588	1.122	0.1393	0.	0.	0.	0.3642								
			Feces	61.13	51.416	9.714	0.1626	0.1956	2.5613	4.3769	1.5649								
			Total	93.07	79.658	13.412	0.4051	0.9949	2.5613	5.7910	2.0756								
		Balance		.....	.....	.....	—0.0122	.....	.....	.....	—0.1716								

* Lactose

(Continued on next page)

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT A, EFFECT OF WATERING ONLY ONCE IN 24 HOURS.

Period	Cow		Material	Total Am'ts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous, P.	Sulfur S.	Calcium Ca.	Magnesium, Mg.	Sodium Na.	Potassium K.	Silica SiO_2
PERIOD I. CHECK (Continued)	3	Intake	Grain	7.00	0.837	6.163	0.1792	0.3493	0.6776	3.6680	0.3479	(Ash constituents not determined)							
			Hay	6.18	0.462	6.018	0.0559	0.1236	2.4336	2.8725	0.5142								
			Silage	25.00	17.572	7.428	0.1040	0.1825	1.5700	4.5775	0.4475								
			Water	65.69	65.644	0.046	0.	0.	0.	0.	0.0353								
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625								
			Total	103.932	84.115	19.717	0.3391	0.6554	4.6812	11.1180	1.4074								
		Outgo	Milk, A. M.	7.99	6.938	1.052	0.0417	0.3252	0.	0.4011*	0.0599								
			Milk, P. M.	6.61	5.722	0.888	0.0342	0.2882	0.	0.3331*	0.0483								
			Urine	10.06	9.607	0.453	0.1318	0.	0.	0.	0.3119								
			Feces	54.56	45.459	9.101	0.1446	0.1910	2.4661	4.0811	1.4622								
			Total	79.22	67.726	11.494	0.3526	0.8044	2.4661	4.8153	1.8823								
		Balance					—0.0135				—0.4749								
	4	Intake	Grain	7.00	0.837	6.163	0.1792	0.3493	0.6776	3.6680	0.3479								
			Hay	11.37	0.850	10.520	0.1029	0.2274	3.3735	5.2848	0.9460								
			Silage	25.00	17.572	7.428	0.1040	0.1825	1.5700	4.5775	0.4475								
			Water	46.87	46.837	0.033	0.	0.	0.	0.	0.0253								
			Salt	0.062	0.	.062	0.	0.	0.	0.	0.0625								
			Total	90.302	66.096	24.206	0.3861	0.7592	5.6211	13.5303	1.8292								
		Outgo	Milk, A. M.	8.46	7.337	1.123	0.0437	0.3519	0.	0.4281*	0.0635								
			Milk, P. M.	7.06	6.109	0.951	0.0358	0.3128	0.	0.3671*	0.0515								
			Urine	9.74	8.961	0.779	0.1305	0.	0.	0.	0.3088								
			Feces	49.64	41.842	7.798	0.1360	0.1539	2.0650	3.5790	1.1516								
			Total	74.90	64.249	10.651	0.3460	0.8186	2.0650	4.3742	1.5754								
		Balance					†0.0401				†0.2538								

* Lactose

(Continued on next page)

TABLE XV. (Continued).

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT A, EFFECT OF WATERING ONLY ONCE IN 24 HOURS.

Period	Cow		Material	Total Am'ts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous, P.	Sulfur S.	Calcium Ca.	Magnesium, Mg.	Sodium Na.	Potassium K.	Silica Si O2
PERIOD II. EXPERIMENTAL	1	Intake	Grain	7.00	0.788	6.212	0.1897	0.3444	0.6720	3.6680	0.3353								
			Hay	11.80	0.883	10.917	0.1068	0.2360	3.5011	5.5318	0.9818								
			Silage	25.00	17.472	7.528	0.1100	0.1850	1.7000	4.4650	0.4900								
			Water	67.42	67.371	0.049	0.	0.	0.	0.	0.0352								
			Salt	0.062	0.	.062	0.	0.	0.	0.	0.0625								
			Total	111.282	86.514	24.768	0.4065	0.7654	5.8731	13.6648	1.9048								
		Outgo	Milk, A. M.	9.84	8.578	1.262	0.0538	0.3700	0.	0.4743*	0.0738								
			Milk, P. M.	8.12	7.066	1.054	0.0432	0.3329	0.	0.3865*	0.0593								
			Urine	10.84	9.850	0.990	0.1344	0.	0.	0.	0.3859								
			Feces	62.23	52.373	9.857	0.1556	0.1867	2.7692	4.5366	1.3940								
			Total	91.03	77.867	13.163	0.3870	0.8896	2.7692	5.3974	1.9130								
		Balance					†0.0195				—0.0082								
	2	Intake	Grain	7.00	0.788	6.212	0.1897	0.3444	0.6720	3.6680	0.3353								
			Hay	11.86	0.887	10.973	0.1073	0.2372	3.5189	5.5600	0.9868								
			Silage	24.75	17.298	7.452	0.1089	0.1832	1.6830	4.4204	0.4851								
			Water	70.07	70.019	0.051	0.	0.	0.	0.	0.0366								
			Salt	.062	0.	.062	0.	0.	0.	0.	0.0625								
			Total	113.742	88.992	24.750	0.4059	0.7648	5.8739	13.6484	1.9063								
		Outgo	Milk, A. M.	10.52	9.217	1.303	0.0562	0.3892	0.	0.4776*	0.0778								
			Milk, P. M.	7.44	6.523	0.917	0.0391	0.2678	0.	0.3474*	0.0536								
			Urine	11.94	10.841	1.099	0.1313	0.	0.	0.	0.3343								
			Feces	62.92	53.249	9.671	0.1674	0.2013	2.4602	4.5492	1.4094								
			Total	92.82	79.830	12.990	0.3940	0.8583	2.4602	5.3742	1.8751								
		Balance					†0.0119				†0.0312								

(Ash constituents not determined)

* Lactose

(Continued on next page)

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT A, EFFECT OF WATERING ONLY ONCE IN 24 HOURS.

Period	Cow		Material	Total Am'ts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous, P.	Sulfur S.	Calcium Ca.	Magnesium, Mg.	Sodium Na.	Potassium K.	Silica SiO_2
PERIOD II. EXPERIMENTAL (Continued)	Cow 3	Intake	Grain	7.00	0.788	6.212	0.1897	0.3444	0.6720	3.6680	0.3353	(Ash constituents not determined)							
			Hay	6.25	0.468	5.782	0.0566	0.1250	1.8544	2.9300	0.5200								
			Silage	23.64	16.522	7.118	0.1040	0.1749	1.6091	4.2221	0.4633								
			Water	59.98	59.937	.043	0.	0.	0.	0.	0.0313								
			Salt	0.062	0.	.062	0.	0.	0.	0.	0.0625								
			Total	96.932	77.715	19.217	0.3503	0.6443	4.1355	10.8201	1.4124								
		Outgo	Milk, A. M.	7.81	6.777	1.033	0.0419	0.3163	0.	0.3897*	0.0601								
			Milk, P. M.	6.68	5.789	0.891	0.0348	0.2945	0.	0.3250*	0.0501								
			Urine	11.37	10.343	1.027	0.1444	0.	0.	0.	0.3582								
			Feces	50.39	42.010	8.380	0.1366	0.1814	2.1063	3.9203	1.3202								
			Total	76.25	64.919	11.331	0.3577	0.7922	2.1063	4.6350	1.7886								
	Balance						—0.0074				—0.3762								
	Cow 4	Intake	Grain	7.00	0.788	6.212	0.1897	0.3444	0.6720	3.6680	0.3353								
			Hay	7.85	0.587	7.263	0.0710	0.1570	2.3291	3.6801	0.6531								
			Silage	25.00	17.472	7.528	0.1100	0.1850	1.7000	4.4650	0.4900								
			Water	49.12	49.084	0.036	0.	0.	0.	0.	0.0256								
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625								
			Total	89.032	67.931	21.101	0.3707	0.6864	4.7011	11.8131	1.5665								
		Outgo	Milk, A. M.	7.10	6.167	0.933	0.0388	0.2826	0.	0.3493*	0.0533								
			Milk, P. M.	6.70	5.756	0.944	0.0352	0.3250	0.	0.3457*	0.0489								
			Urine	10.22	9.262	0.958	0.1298	0.	0.	0.	0.3281								
			Feces	50.79	43.283	7.507	0.1422	0.1475	1.9900	3.4334	1.1072								
			Total	74.81	64.468	10.342	0.3460	0.7551	1.9900	4.1284	1.5375								
	Balance						†0.0247				†0.0290								

* Lactose

(Continued on next page)

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT B, EFFECT OF WATERING ONLY ONCE IN 60 HOURS.

Period	Cow		Material	Total Amounts	Water	Dry Matter	Nitrogen N	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous P.	Sulphur S.	Calcium Ca.	Magnesium Mg	Sodium Na	Potasium K.	Silica Si O2
III. CHECK	Cow 1. Check	Intake	Grain....	7.00	0.7035	6.2965	0.2150	0.3031	0.6951	3.937	0.3535	0.003599	0.06508	0.02239	0.00842	0.02915	0.00260	0.06868	0.0553
			Hay.....	11.70	0.9302	10.7698	0.1101	0.2176	3.7440	5.211	0.9091	0.008225	0.00823	0.02813	0.06475	0.02208	0.00518	0.07537	0.5780
			Silage....	25.00	17.6850	7.3150	0.1290	0.1778	2.0050	3.780	0.5475	0.029375	0.02180	0.01340	0.01642	0.02920	0.00160	0.10935	0.2125
			Water....	77.08	77.0500	0.0300	0.	0.	0.	0.	0.0168	0.001094	0.00059	0.00600	0.00750	0.00421	0.00204	0.00045	0.0032
			Salt.....	0.062	0.	0.0625	0.	0.	0.	0.	0.0625	0.037920	0.	0.	0.	0.	0.02458	0.	0.
			Total.....	120.842	96.3687	24.4738	0.4541	0.6985	6.4441	12.928	1.8894	0.080213	0.09570	0.06992	0.09709	0.08464	0.03600	0.25385	0.8490
		Outgo	Milk A. M	6.82	5.938	0.882	0.0374	0.2701	0.	0.325 *	0.0516	0.01294	0.01295	0.00368	0.01474	0.00130	0.00660	0.01594	0.
			Milk P. M	5.68	4.939	0.741	0.0332	0.2238	0.	0.258 *	0.0422	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	13.77	12.761	1.009	0.1666	0.	0.	0.	0.3966	0.03945	0.00033	0.02005	0.00166	0.01351	0.01454	0.11753	‡.....
			Feces....	56.51	47.420	9.090	0.1435	0.1678	2.7180	4.103	1.2120	0.02080	0.05628	0.02633	0.06097	0.06184	0.01955	0.05453	0.6216
			Total.....	82.78	71.058	11.722	0.3807	0.6617	2.7180	4.686	1.7024	0.07319	0.06956	0.05006	0.07737	0.07665	0.04069	0.18800	0.6216†
	Balance.....			.....	.....	.....	†0.734	.....	.....	.....	†0.1770	†0.00702	†0.02614	†0.01986	†0.01972	†0.00799	—0.00469	†0.06585	†0.2274
	Cow 2	Intake	Grain.....	7.00	0.7035	6.2965	0.2150	0.3031	0.6951	3.937	0.3535	0.00360	0.06508	0.02239	0.00842	0.02915	0.00260	0.06868	0.0553
			Hay.....	10.54	0.8399	9.7001	0.0994	0.1965	3.3810	4.694	0.8190	0.00524	0.00743	0.02538	0.05846	0.01993	0.00468	0.06806	0.5223
			Silage....	25.00	17.6850	7.3150	0.1290	0.1778	2.0050	3.780	0.5475	0.02938	0.02180	0.01340	0.01642	0.02920	0.00160	0.10935	0.2125
			Water....	91.092	91.0536	0.0364	0.	0.	0.	0.	0.0199	0.00129	0.00070	0.00709	0.00886	0.00497	0.00241	0.00053	0.0037
			Salt.....	0.062	0.	0.0625	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	0.
			Total.....	133.692	110.2820	23.4105	0.4434	0.6774	6.0811	12.411	1.8024	0.07743	0.09501	0.06826	0.09216	0.08325	0.03587	0.24662	0.7938
		Outgo	Milk A. M	5.53	4.858	0.672	0.0311	0.1956	0.	0.239 *	0.0409	0.01355	0.00945	0.00309	0.01151	0.00112	0.00760	0.01276	0.
			Milk P. M	4.77	4.200	0.570	0.0271	0.1617	0.	0.203 *	0.0353	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	16.47	15.304	1.166	0.1953	0.	0.	0.	0.4233	0.04649	0.00032	0.02541	0.00026	0.01209	0.00831	0.21310	0.0019
			Feces....	62.76	53.497	9.263	0.1762	0.1540	2.9930	3.998	1.3910	0.01137	0.06483	0.02609	0.08662	0.05401	0.02196	0.09758	0.7609
			Total.....	89.53	77.859	11.671	0.4297	0.5113	2.9930	4.440	1.8905	0.07141	0.07460	0.05459	0.09839	0.06722	0.03787	0.32344	0.7628
	Balance.....			.....	.....	.....	†0.0137	.....	.....	.....	-0.0881	†0.00602	†0.02041	†0.01367	-0.00623	†0.01603	—0.00200	—0.07682	†0.0310

* Lactose

‡ Not determined

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT B, EFFECT OF WATERING ONLY ONCE IN 60 HOURS.

Period	Cow		Material	Total Amounts	Water	Dry Matter	Nitrogen N	Extract Ether	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous P.	Sulphur S.	Calcium Ca.	Magnesium Mg	Sodium Na	Potasium K.	Silica Si O2
PERIOD III. CHECK	Cow 3	Intake	Grain.....	7.00	0.703	6.297	0.2150	0.3031	0.6951	3.937	0.3535	0.00360	0.06508	0.02239	0.00842	0.02915	0.00260	0.06868	0.0553
			Hay.....	8.41	0.669	7.741	0.0791	0.1564	2.6910	3.746	0.6535	0.00417	0.00591	0.02022	0.04654	0.01587	0.00372	0.05418	0.4158
			Silage....	17.87	12.640	5.230	0.0922	0.1271	1.4330	2.702	0.3913	0.02100	0.01558	0.00960	0.01174	0.02087	0.00122	0.07816	0.1519
			Water....	67.74	67.713	0.027	0.	0.	0.	0.	0.0148	0.00096	0.00052	0.00527	0.00659	0.00370	0.00180	0.00039	0.0028
			Salt.....	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	0.
			Total.....	101.082	81.725	19.357	0.3863	0.5866	4.8191	10.385	1.4756	0.06765	0.08709	0.05748	0.07329	0.06959	0.03392	0.20141	0.6258
		Outgo	Milk A. M	4.71	3.992	0.718	0.0295	0.2605	0.	0.239 *	0.0358	0.00846	0.01000	0.00361	0.01253	0.00122	0.00378	0.01098	0.
			Milk P. M	3.94	3.341	0.599	0.0249	0.2120	0.	0.191 *	0.0302	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	16.29	15.557	0.733	0.1605	0.	0.	0.	0.3372	0.04390	0.00073	0.01839	0.00065	0.00547	0.01809	0.21670	0.0047
			Feces....	41.61	34.680	6.930	0.1336	0.1373	2.0890	2.792	0.9890	0.01535	0.06304	0.01956	0.04918	0.05617	0.00849	0.03982	0.5020
			Total....	66.55	57.570	8.980	0.3485	0.6098	2.0890	3.222	1.3922	0.06771	0.07377	0.04156	0.06236	0.06286	0.03036	0.26750	0.5067
		Balance.....		.....	.....	.....	+0.0378	.....	.....	.....	+0.0834	—0.00006	+0.01332	+0.01592	+0.01093	+0.00673	+0.00356	—0.06609	+0.1191
	Cow 4	Intake	Grain.....	7.00	0.703	6.297	**0.2150**	0.3031	0.6951	3.937	0.3535	0.00360	0.06508	0.02239	0.00842	0.02915	0.00260	0.06868	0.0553
			Hay.....	8.21	0.653	7.557	**0.0773**	0.1527	2.6270	3.657	0.6379	0.00407	0.00577	0.01974	0.04543	0.01550	0.00363	0.05289	0.4059
			Silage....	25.00	17.685	7.315	**0.1290**	0.1778	2.0050	3.780	0.5475	0.02937	0.02180	0.01340	0.01642	0.02920	0.00160	0.10935	0.2125
			Water....	68.30	68.273	0.027	**0.**	0.	0.	0.	0.0149	0.00097	0.00053	0.00531	0.00665	0.00373	0.00181	0.00040	0.0028
			Salt.....	0.062	0.	0.062	**0.**	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	**0.**
			Total.....	108.572	87.314	21.**258**	**0.4213**	0.6336	5.3271	11.374	1.6163	0.07593	0.09318	0.06084	0.07792	0.07758	0.03422	0.23152	0.6765
		Outgo	Milk A. M	6.49	5.598	0.892	0.0371	0.2791	0.	0.337 *	0.0483	0.01300	0.01440	0.00464	0.01421	0.00139	0.00504	0.01493	0.
			Milk P. M	5.51	4.779	0.731	0.0324	0.2386	0.	0.275 *	0.0408	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	11.68	10.746	0.934	0.1532	0.	0.	0.	0.3130	0.05095	0.00019	0.01785	0.00084	0.01500	0.00686	0.15990	0.0014
			Feces....	54.55	46.740	7.810	0.1506	0.1195	2.3570	3.278	1.0950	0.01227	0.06366	0.02302	0.06459	0.06426	0.02000	0.06000	0.7337
			Total.....	78.23	67.863	11.367	0.3733	0.6372	2.3570	3.890	1.4971	0.07622	0.07825	0.04551	0.07964	0.08065	0.03190	0.23483	0.7351
		Balance.....		.....	.....	.....	+0.0480	.....	.....	.....	+0.1192	—0.00029	+0.01493	+0.01533	-0.00172	—0.00307	+0.00232	—0.00331	—0.0586

* Lactose

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT B, EFFECT OF WATERING ONLY ONCE IN 60 HOURS.

Period	Cow		Material	Total Amounts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous, P.	Sulfur S.	Calcium Ca.	Magnesium, Mg.	Sodium Na.	Potassium K.	Silica SiO_2
IV. EXPERIMENTAL	Cow 1. Check	Intake	Grain....	7.00	0.667	6.333	0.1883	0.2877	0.7508	3.7639	0.3535	0.00360	0.06935	0.02265	0.00814	0.03129	0.00427	0.06942	0.05301
			Hay.....	12.80	0.997	11.803	0.1220	0.2854	4.1600	5.4771	1.1187	0.00681	0.08346	0.02550	0.07697	0.02094	0.01924	0.08812	0.64768
			Silage....	25.00	19.173	5.827	0.0888	0.1292	1.6000	3.0375	0.5040	0.02011	0.01805	0.01060	0.01642	0.02080	0.00441	0.08452	0.15860
			Water....	67.08	67.053	0.027	0.	0.	0.	0.	0.0146	0.00095	0.00050	0.00052	0.00653	0.00366	0.00177	0.00039	0.00276
			Salt.....	0.062	.....	.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	0.
			Total....	111.942	87.890	24.052	0.3991	0.7023	6.5108	12.2785	2.0533	0.06939	0.17136	0.05927	0.10806	0.07699	0.05427	0.24245	0.86205
		Outgo	Milk A. M	5.57	4.834	0.736	0.0327	0.2340	0.	0.2562*	0.0424	0.0977	0.01048	0.00386	0.01188	0.00090	0.00506	0.01236	0.
			Milk P. M	4.24	3.665	0.575	0.0251	0.1844	0.	0.2035*	0.0322	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	16.40	15.190	1.210	0.1638	0.	0.	0.	0.3198	0.03954	0.00039	0.01561	0.00368	0.01832	0.01911	0.15890	0.00123
			Feces....	57.86	49.040	8.820	0.1574	0.2210	2.2900	3.7725	1.5440	0.00963	0.09234	0.03005	0.08951	0.05351	0.02993	0.06110	0.85000
			Total....	8.07	72.729	11.341	0.3790	0.6394	2.2900	4.2322	1.9384	0.05894	0.10321	0.04952	0.10507	0.07273	0.05410	0.23236	0.85123
		Balance.....		.....	.....	.....	†0.0201	.....	.....	.....	†0.1149	†0.01045	†0.06815	†0.00975	†0.00299	†0.00396	†0.00017	†0.01009	*0.01082
	Cow 2	Intake	Grain....	7.00	0.667	6.333	0.1883	0.2877	0.7508	3.7639	0.3535	0.00360	0.06335	0.02265	0.00814	0.03129	0.00427	0.06942	0.05301
			Hay.....	13.18	1.027	12.153	0.1256	0.2939	4.2835	5.6397	1.1519	0.00701	0.08593	0.02625	0.07925	0.02156	0.01981	0.08783	0.66691
			Silage....	25.00	19.173	5.827	0.0888	0.1292	1.6000	3.0375	0.5040	0.02011	0.01805	0.01060	0.01642	0.02080	0.00441	0.08452	0.15860
			Water....	56.51	56.486	0.024	0.	0.	0.	0.	0.0123	0.00801	0.00043	0.00440	0.00550	0.00308	0.00150	0.00033	0.00233
			Salt.....	0.062	.....	.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	0.
			Total.....	101.752	77.353	24.399	0.4027	0.7108	6.6343	12.4411	2.0842	0.07665	0.16776	0.06390	0.10931	0.07673	0.05457	0.24210	0.88085
		Outgo	Milk A. M	4.87	4.277	0.593	0.0263	0.1821	0.	0.2435*	0.0369	0.01127	0.00821	0.00301	0.00921	0.00090	0.00640	0.01073	0.
			Milk P. M	3.79	3.327	0.463	0.0210	0.1410	0.	0.1592*	0.0286	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	13.98	12.720	1.260	0.1727	0.	0.	0.	0.4250	0.04679	0.00032	0.01514	0.00123	0.01542	0.01355	0.17660	0.00305
			Feces....	48.08	39.820	8.260	0.1515	0.2189	2.1470	3.5387	1.4160	0.00438	0.08015	0.3207	0.09188	0.05104	0.02190	0.04808	0.85680
			Total.....	70.72	60.144	10.576	0.3715	0.5420	2.1470	3.9414	1.9064	0.06244	0.08868	0.05022	0.10232	0.06736	0.04185	0.23541	0.85985
		Balance.....		.....	.....	.....	†0.0312	.....	.....	.....	†0.1778	†0.01421	†0.07908	†0.01368	†0.00699	†0.00937	†0.01272	†0.00669	*0.02100

* Lactose

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT B, EFFECT OF WATERING ONLY ONCE IN 60 HOURS.

Period	Cow		Material	Total Amounts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous P.	Sulfur S.	Calcium Ca.	Magnesium Mg.	Sodium Na.	Potassium K.	Silica SiO_2
IV. EXPERIMENTAL	Cow 3	Intake	Grain....	7.00	0.667	6.333	0.1883	0.2877	0.7508	3.7639	0.3535	0.00360	0.06335	0.02265	0.00814	0.03129	0.00427	0.06942	0.0530
			Hay.....	9.29	0.724	8.566	0.0885	0.2072	3.1202	3.9752	0.8129	0.00494	0.00606	0.01851	0.05586	0.01520	0.01396	0.06362	0.4701
			Silage....	25.00	19.172	5.828	0.0888	0.1292	1.6000	3.0375	0.5040	0.02011	0.01805	0.01060	0.01642	0.02080	0.00441	0.08452	0.1586
			Water....	50.13	50.110	0.020	0.	0.	0.	0.	0.0109	0.00071	0.00039	0.00390	0.00488	0.00274	0.00136	0.00029	0.0021
			Salt.....	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	0.
			Total.....	91.482	70.673	20.809	0.3656	0.6241	5.471	10.7766	1.7438	0.06728	0.08785	0.05566	0.08530	0.07003	0.04858	0.21785	0.6838
		Outgo	Milk A. M	4.67	3.736	0.934	0.0298	0.2190	0.	0.2288*	0.0368	0.00648	0.00958	0.00344	0.01191	0.00109	0.00264	0.00974	0.
			Milk P. M	3.59	3.051	.539	0.0235	0.1572	0.	0.1759*	0.0293	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	14.58	13.630	.950	0.1459	0.	0.	0.	0.3339	0.03991	0.00032	0.01333	0.00064	0.00626	0.01786	0.13260	0.00152
			Feces....	36.85	30.590	6.260	0.1220	0.1779	1.562	2.4711	1.2010	0.00422	0.07252	0.02302	0.07193	0.04790	0.01618	0.05646	0.57230
			Total.....	59.69	51.007	8.683	0.3212	0.5541	1.562	2.8758	1.6010	0.05061	0.08242	0.03979	0.08448	0.05525	0.03668	0.19880	0.5738
		Balance.....		.....	.....	.....	+0.0444	.....	.....	.....	+0.1428	+0.01667	+0.00543	+0.01587	+0.00082	+0.01478	+0.01190	‡0.01905	+0.1100
	Cow 4	Intake	Grain....	7.00	0.667	6.333	0.1883	0.2877	0.751	3.7639	0.3535	0.00360	0.06335	0.02265	0.00814	0.03129	0.00427	0.06942	0.0530
			Hay.....	10.00	0.779	9.221	0.0953	0.2230	3.200	4.2790	0.8740	0.00532	0.00652	0.01992	0.06013	0.01636	0.01503	0.06884	0.5060
			Silage....	25.00	19.173	5.827	0.0888	0.1290	1.600	3.0375	0.5040	0.02011	0.01805	0.01060	0.01642	0.02080	0.00441	0.08452	0.1586
			Water....	46.96	46.941	0.019	0.	0.	0.	0.	0.0102	0.00067	0.00036	0.00365	0.00458	0.00256	0.00124	0.00027	0.0019
			Salt.....	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02458	0.	0.
			Total.....	89.022	67.560	21.462	0.3724	0.6399	5.551	11.0804	1.8042	0.06762	0.08828	0.05682	0.08927	0.07101	0.04953	0.22305	0.7195
		Outgo	Milk A. M	6.35	5.488	0.862	0.0370	0.2934	0.	0.3239*	0.0472	0.00740	0.01356	0.00389	0.01554	0.00150	0.00351	0.01292	0.00
			Milk P. M	5.00	4.285	.715	0.0292	0.2335	0.	0.2550*	0.0383	.....	.....	.....	.....	.....	.....	.....	.....
			Urine....	11.13	10.080	1.050	0.1475	0.	0.	0.	0.3595	0.04263	0.00029	0.01264	0.00062	0.01497	0.01655	0.14760	0.0011
			Feces....	43.34	38.200	5.140	0.0800	0.1447	1.407	2.0023	1.0470	0.00498	0.05907	0.02757	0.06453	0.04285	0.04022	0.01975	0.5370
			Total.....	65.82	58.053	7.767	0.2937	0.6746	1.407	2.5812	1.4922	0.05501	0.07292	0.04410	0.08069	0.05932	0.06028	0.18027	0.5381
		Balance.....		.....	.....	.....	+0.0787	.....	.....	.....	+0.3120	+0.01261	+0.01536	+0.01272	+0.00858	+0.01169	—0.01075	+0.04278	+0.1814

‡ Not determined.
*Lactose.

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT C; EFFECT OF ONE-HALF WATER REQUIREMENT.

Period	Cow		Material	Total Am'ts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous P.	Sulfur S.	Calcium Ca.	Magnesium Mg.	Sodium Na.	Potassium K.	Silica SiO_2
V. CHECK	1	Intake	Grain	7.00	0.639	6.361	0.1667	0.3010	0.7665	3.8906	0.3598	0.00422	0.06510	0.01668	0.00504	0.02582	0.00263	0.06870	0.0505
			Hay	18.70	1.271	17.429	0.2437	0.4656	5.4230	8.6600	1.3576	0.01558	0.02244	0.05042	0.07955	0.03153	0.00611	0.16501	0.7817
			Silage	25.00	19.860	5.140	0.0855	0.0994	1.1740	2.6825	0.6410	0.01408	0.01260	0.00856	0.02549	0.02000	0.00168	0.07225	0.1416
			Water	81.56	81.512	0.048	0.	0.	0.	0.	0.0484	0.00123	0.	0.00359	0.00698	0.00408	0.00181	0.00078	0.0028
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02459	0.	0.
			Total	132.322	103.282	29.040	0.4959	0.8660	7.3635	15.2331	2.4693	0.7303	0.10014	0.07925	0.11706	0.08133	0.03682	0.30674	0.9766
		Outgo	Milk, A. M.	5.71	5.077	0.633	0.0264	0.1713	0.	0.2398*	0.0416	0.00711	0.00490	0.00191	0.00527	0.00077	0.00436	0.07943	0.
			Milk, P. M.	4.48	3.943	0.537	0.0216	0.1644	0.	0.2003*	0.0335	0.00558	0.00384	0.00150	0.00414	0.00061	0.00342	0.06232	0.
			Urine	15.13	13.815	1.315	0.2026	0.	0.	0.	0.4826	0.03280	0.00037	0.02504	0.00070	0.01342	0.01258	0.19257	0.0022
			Feces	65.38	55.213	10.167	0.1942	0.2722	2.5858	4.4458	1.6443	0.02180	0.08159	0.03142	0.09849	0.05998	0.01723	0.08225	0.9212
			Total	90.70	78.048	12.652	0.4448	0.6079	2.5858	4.8859	2.2020	0.06729	0.09070	0.05987	0.10860	0.07478	0.03759	0.41657	0.9234
		Balance					†0.0511				†0.2673	†0.00574	†0.00944	†0.01938	†0.00846	†0.00655	—0.00077	—0.10983	†0.0532
	2—Check Cow	Intake	Grain	11.00	1.004	9.996	0.2620	0.4730	1.2045	6.1138	0.5654	0.00663	0.10230	0.02621	0.00792	0.04057	0.00434	0.10795	0.07936
			Hay	17.27	1.174	16.096	0.2250	0.4300	5.0083	7.9977	1.2538	0.01439	0.02072	0.04656	0.07347	0.02912	0.00564	0.15239	0.72196
			Silage	25.00	19.860	5.140	0.0855	0.0994	1.1740	2.6825	0.6410	0.01408	0.01260	0.00856	0.02549	0.02000	0.00168	0.07225	0.14156
			Water	98.97	98.940	0.030	0.	0.	0.	0.	0.0587	0.00149	0.	0.00436	0.00847	0.00495	0.00220	0.00095	0.00336
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02459	0.	0.
			Total	152.302	120.978	21.324	0.5725	1.0024	7.3868	16.7940	2.5814	0.07451	0.13562	0.08569	0.11535	0.09464	0.03845	0.33354	0.94624
		Outgo	Milk, A. M.	18.54	16.119	2.421	0.0945	0.7787	0.	0.9275*	0.1391	0.03292	0.03012	0.01207	0.04019	0.00349	0.00864	0.04754	0.
			Milk, P. M.	14.73	12.646	2.084	0.0472	0.7630	0.	0.7365*	0.1105	.....	.....	.....	.....	.....	.....	.....	.....
			Urine	11.17	10.057	1.113	0.1232	0.	0.	0.	0.3764	0.00436	0.00025	0.02224	0.00179	0.00323	0.01317	0.14208	0.00248
			Feces	80.73	69.089	11.641	0.2487	0.3162	2.8998	5.1587	1.7171	0.02782	0.09365	0.03286	0.10252	0.07440	0.00659	0.12580	0.95181
			Total	125.17	107.911	17.259	0.5436	1.8579	2.8998	6.8277	2.3431	0.06510	0.12402	0.06717	0.14449	0.08712	0.02840	0.31542	0.95429
		Balance					†0.0289				†0.2383	†0.00941	†0.01160	†0.01852	—0.02914	†0.00752	†0.01005	†0.01812	—0.00805

* Lactose

TABLE XV. (Continued)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT C; EFFECT OF ONE-HALF WATER REQUIREMENT.

Period	Cow		Material	Total Amounts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous P.	Sulfur S.	Calcium Ca	Magnesium Mg.	Sodium Na.	Potassium K.	Silica SiO_2
V. CHECK (Con	3	Intake	Grain.....	7.00	0.639	6.361	0.1667	0.3010	0.7665	3.8906	0.3598	0.00422	0.06510	0.01668	0.00504	0.02582	0.00263	0.06870	0.0505
			Hay.....	17.32	1.178	16.142	0.2257	0.4313	5.0228	8.0209	1.2574	0.01443	0.02078	0.04669	0.07368	0.02920	0.00565	0.15283	0.7240
			Silage.....	25.00	19.860	5.140	0.0855	0.0994	1.1740	2.6825	0.6410	0.01408	0.01260	0.00857	0.02549	0.00480	0.00168	0.07225	0.1416
			Water.....	78.40	78.354	0.046	0.	0.	0.	0.	0.0465	0.00118	0.	0.00340	0.00671	0.00392	0.00174	0.00075	0.0027
			Salt.....	0.062	0.	.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02459	0.	0.
			Total.....	127.782	100.031	27.751	0.4779	0.8317	6.9633	14.5940	2.3672	0.07183	0.09848	0.07534	0.11092	0.06371	0.03629	0.29453	0.9188
		Outgo	Milk, A. M.	14.84	13.029	1.811	0.0696	0.5654	0.	0.6975*	0.1078	0.03043	0.02754	0.00897	0.02895	0.00329	0.01717	0.03581	0.
			Milk, P. M.	11.48	10.031	1.449	0.0564	0.4753	0.	0.5396*	0.0817	.....	.....	.....	.....	.....	.....	.....	.....
			Urine.....	12.93	11.642	1.288	0.1426	0.	0.	0.	0.4358	0.00504	0.00029	0.02327	0.00019	0.01269	0.00997	0.16663	0.
			Feces.....	71.06	60.291	10.769	0.1798	0.2911	2.7017	5.0879	1.5633	0.03930	0.07599	0.00314	0.09107	0.05989	0.01445	0.09677	0.9354
			Total.....	110.31	94.993	15.317	0.4484	1.3318	2.7017	6.3250	2.1886	0.07477	0.10382	0.03538	0.12021	0.07587	0.04159	0.29921	0.9354
		Balance.....		.....	.....	.....	+0.0295	.....	.....	.....	+0.1786	—0.00294	—0.00534	+0.03996	—0.00929	—0.01213	—0.00530	—0.00468	—0.0166
VI. EXPERIMENTAL	1	Intake	Grain.....	7.00	0.639	6.361	0.1667	0.3010	0.7665	3.5980	0.3598	0.00422	0.06510	0.01668	0.00504	0.02582	0.00263	0.06870	0.0505
			Hay.....	12.27	0.834	11.436	0.1599	0.3055	3.5583	5.3989	0.8908	0.01022	0.01472	0.03308	0.05220	0.02069	0.00397	0.10827	0.5129
			Silage.....	25.00	19.860	5.140	0.0855	0.0994	1.1740	2.6825	0.6410	0.01407	0.01260	0.00856	0.02549	0.02000	0.00168	0.07225	0.1416
			Water.....	40.00	39.976	0.024	0.	0.	0.	0.	0.0237	0.00060	0.	0.00176	0.00342	0.00200	0.00089	0.00038	0.0014
			Salt.....	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02459	0.	0.
			Total.....	84.332	61.310	23.022	0.4121	0.7059	5.4988	11.8794	1.9778	0.06703	0.09242	0.06008	0.08615	0.06851	0.03376	0.24960	0.7064
		Outgo	Milk, A. M.	3.97	3.546	0.424	0.0195	0.1167	0.	0.1866*	0.0286	0.00669	0.00292	0.00149	0.00298	0.00057	0.00402	0.00493	.....
			Milk, P. M.	3.49	3.089	0.401	0.0175	0.1232	0.	0.1683*	0.0257	0.00565	0.00256	0.00122	0.00274	0.00047	0.00345	0.00460	.....
			Urine.....	12.29	11.070	1.220	0.2104	0.	0.	0.	0.3466	0.02624	0.00023	0.01939	0.00084	0.00934	0.00453	0.16210	.....
			Feces.....	40.26	32.760	7.500	0.1467	0.1886	1.8710	3.2933	1.2210	0.00783	0.07943	0.02290	0.06876	0.04678	0.00702	0.07726	.....
			Total.....	60.01	50.465	9.545	0.3941	0.4285	1.8710	3.6482	1.6219	0.04641	0.08514	0.04500	0.07532	0.05716	0.01902	0.24889	.....
		Balance.....		.....	.....	.....	+0.0180	.....	.....	.....	+0.3559	+0.02062	+0.00728	+0.01508	+0.01083	+0.01135	+0.01474	+0.00071	.....

* Lactose

TABLE XV. (CONCLUDED)

AVERAGE DAILY RATIONS, BALANCE OF FOOD NUTRIENTS IN POUNDS. EXPERIMENT C; EFFECT OF ONE-HALF WATER REQUIREMENT.

Period	Cow		Material	Total Amounts	Water	Dry Matter	Nitrogen N.	Ether Extract	Crude Fiber	N-free Extract	Ash	Chlorine Cl.	Phosphorous P.	Sulfur S.	Calcium Ca.	Magnesium Mg.	Sodium Na.	Potassium K.	Silica Si O2
VI. Experimental (Cont.)	2—Check	Intake	Grain	11.00	1.004	9.996	0.2620	0.4730	1.2045	5.6540	0.5654	0.00663	0.10230	0.02621	0.00792	0.04057	0.00434	0.10795	0.0794
			Hay	15.45	1.051	14.399	0.2013	0.3847	4.4805	6.7566	1.1217	0.01287	0.01854	0.04165	0.06572	0.02605	0.00504	0.13633	0.6459
			Silage	25.00	19.860	5.140	0.0855	0.0994	1.1740	2.6825	0.6410	0.01407	0.01260	0.00856	0.02549	0.02000	0.00168	0.07225	0.1415
			Water	87.95	87.898	0.052	0.	0.	0.	0.	0.0522	0.00133	0.	0.00387	0.00753	0.00440	0.00195	0.00084	0.0030
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02459	0.	0.
			Total	139.462	109.813	29.649	0.5488	0.9571	7.8590	15.0931	2.4428	0.07282	0.13344	0.08030	0.10666	0.09102	0.03760	0.31737	0.8698
		Outgo	Milk, A. M.	15.55	13.592	1.958	0.0754	0.6096	0.	0.7408*	0.1106	0.01511	0.01559	0.00532	0.01735	0.00213	0.01167	0.01637	.....
			Milk, P. M.	11.28	9.756	1.524	0.0527	0.5257	0.	0.6365*	0.0843	0.01112	0.01109	0.00403	0.01343	0.00140	0.00877	0.01156	.....
			Urine	11.89	10.650	1.240	0.1729	0.	0.	0.	0.3329	0.00261	0.00030	0.02247	0.00133	0.01220	0.00318	0.14870	0.0057
			Feces	70.92	60.154	10.766	0.2489	0.3099	2.7645	4.9218	1.7800	0.01809	0.12013	0.03937	0.09094	0.07429	0.01028	0.14040	.....
			Total	109.64	94.152	15.488	0.5499	1.4452	2.7645	6.2991	2.3078	0.04693	0.14711	0.07119	0.12305	0.09002	0.03390	0.31703	.....
	Balance			.....	.....	.....	—0.0011	.....	.....	.....	†0.1350	†0.02589	—0.0137	†0.00911	—0.01639	†0.00100	†0.00370	†0.00034	.....
	3	Intake	Grain	7.00	0.639	6.361	0.1667	0.3010	0.7665	3.5980	0.3598	0.00422	0.06510	0.01668	0.00504	0.02582	0.00263	0.06870	0.0505
			Hay	11.46	0.779	10.681	0.1381	0.2853	3.3236	5.3071	0.7696	0.00883	0.01272	0.02858	0.04509	0.01787	0.00346	0.09353	0.4431
			Silage	25.00	19.860	5.140	0.0855	0.0994	1.1740	2.6825	0.6410	0.01407	0.01260	0.00856	0.02549	0.02000	0.00168	0.07225	0.1416
			Water	40.00	39.976	0.024	0.	0.	0.	0.	0.0237	0.00060	0.	0.00176	0.00342	0.00200	0.00089	0.00038	0.0014
			Salt	0.062	0.	0.062	0.	0.	0.	0.	0.0625	0.03792	0.	0.	0.	0.	0.02459	0.	0.
			Total	83.522	61.254	22.268	0.3903	0.6857	5.2641	11.5876	1.8566	0.06564	0.09042	0.05558	0.07904	0.06569	0.03325	0.23486	0.6366
		Outgo	Milk, A. M.	11.94	10.516	1.424	0.0585	0.4227	0.	0.5612*	0.0885	0.01441	0.01091	0.00412	0.01373	0.00163	0.00848	0.01468	0.
			Milk, P. M.	9.39	8.216	1.174	0.0418	0.3962	0.	0.4301*	0.0605	0.01017	0.00748	0.00283	0.00961	0.00102	0.00529	0.01093	0.
			Urine	10.75	9.697	1.053	0.1380	0.	0.	0.	0.2527	0.00564	0.00019	0.01422	0.00087	0.01000	0.00557	0.10945	0.00519
			Feces	43.98	36.178	7.802	0.1248	0.1190	1.8265	1.8647	1.0310	0.01018	0.06246	0.02296	0.04806	‡	0.00887	0.08017	0.56375
			Total	76.06	64.607	11.453	0.3631	0.9379	1.8265	2.8560	1.4327	0.04040	0.08104	0.04413	0.07227	.....	0.02821	0.21523	0.5689
	Balance			.....	.....	.....	†0.0272	.....	.....	.....	†0.4239	†0.02524	†0.00938	†0.01145	†0.00677	.....	†0.00504	†0.01963	†0.0677

* Lactose

‡ Not determined

TABLE XVI.

SHOWING AMOUNT OF WATER DRUNK AND FOOD NUTRIENTS DIGESTED DAILY.

	Period	Cow	Frequency of watering. Watered once in hours	Water Drunk lbs.	Protein Consumed lbs.	Protein Digested lbs.	N-free Extract Consumed lbs.	N-free Extract Digested lbs.	Ether Extract Consumed lbs.	Ether Extract Digested lbs.	Crude Fiber Consumed lbs.	Crude Fiber Digested lbs.
Experiment A Effect of watering only once in 24 hrs. Jan. 2, 1914	I. Check	1	8	73.17	2.5894	1.5978	14.9748	10.1378	0.7216	0.4168	6.5468	3.6195
		2	8	69.81	2.4556	1.4393	13.9273	9.5503	0.7742	0.5786	5.8436	2.2823
		3	8	65.61	2.1294	1.2156	11.1427	7.1616	0.6554	0.4634	4.0812	1.6151
		4	8	46.87	2.4131	1.5531	13.5758	9.9968	0.7592	0.6053	5.6211	3.5561
		Av.	8	63.88	2.3969	1.4514	13.4051	9.2116	0.7276	0.5160	5.5232	2.7682
	II. Experimental	1	24	67.42	2.5406	1.5681	13.6648	9.1283	0.7654	0.5787	0.5731	3.0828
		2	24	70.07	2.5369	1.5906	13.6483	9.0992	0.7648	0.5636	5.8909	3.4307
		3	24	59.98	2.1894	1.3357	10.8201	6.8998	0.6443	0.4629	4.2264	2.1201
		4	24	49.12	2.3169	1.4281	11.8131	8.3797	0.6864	0.5389	4.7011	2.7711
		Av.	24	61.65	2.3959	1.4806	12.4866	8.3768	0.7152	0.5360	5.1729	2.8512
Experiment B Effect of watering only once in 60 hrs. Aug. 9, 1914	III. Check	1*	2	77.08	2.8383	1.9414	12.9280	8.8250	0.6985	0.5307	6.4441	3.7261
		2	8	91.09	2.7712	1.6700	12.4110	8.4130	0.6774	0.5234	6.0811	3.0881
		3	8	67.74	2.4144	1.5794	10.3850	7.5930	0.5866	0.4493	4.8191	2.7301
		4	8	68.30	2.6331	1.7168	11.3740	8.0960	0.6336	0.5141	5.3271	2.9701
		Av.	8	75.71	2.6062	1.6554	11.3900	8.0340	0.6325	0.4956	5.4091	2.9294
	IV. Experimental	1	12	67.08	2.4944	1.5106	12.2785	8.5060	0.7023	0.4813	6.5108	4.2208
		2	60	56.51	2.5169	1.5700	12.4411	8.9024	0.7108	0.4919	6.6343	3.4873
		3	60	50.13	2.2850	1.5225	10.7766	8.3055	0.6241	0.4462	5.4710	3.9090
		4	60	46.96	2.3270	1.8275	11.0804	9.0781	0.6391	0.4952	5.5510	4.1440
		Av.	60	51.20	2.3763	1.6400	11.4327	8.7620	0.6913	0.4778	5.8854	3.8468
Experiment C Effect of one-half water Nov. 16, 1915	V. Check	5	12	81.56	3.0991	1.8855	15.2424	10.7916	0.8660	0.5939	7.3635	4.7782
		6*	12	98.97	3.5782	2.0764	16.7750	12.6651	1.0024	0.6870	7.3868	4.4842
		7	12	78.40	2.9868	1.8632	14.6032	9.5125	0.8316	0.5309	6.9633	4.2615
		Av.	12	79.98	3.0429	1.8744	14.9228	10.1520	0.8488	0.5624	7.1634	4.5199
	VI. Experimental	5	24	40.00	2.5756	1.6241	12.2646	8.7618	0.7059	0.5182	5.4988	3.5148
		6*	24	87.95	3.4300	1.9331	14.8040	10.6296	0.9570	0.6670	7.8590	4.6211
		7	24	40.00	2.4396	1.6160	11.4973	7.8550	0.6583	0.5443	5.0145	3.2745
		Av.	24	40.00	2.5076	1.6200	11.8810	8.3084	0.6821	0.5313	5.2567	3.3947

* Check cows not included in averages.

BULLETINS.

105. Stock Food for Pigs.
106. Sugar Beets in South Dakota.
107. Sheep Scab.
111. A study of South Dakota Butter with suggestions for Improvement.
114. Digestion Coefficients of Grains and Fodders for South Dakota.
129. Growing Pedigreed Sugar Beet Seed in South Dakota.
130. Some New Fruits.
131. Scabies (Mange) in Cattle.
132. Effects of Alkali Water on Dairy Products.
134. More Winter Dairying in South Dakota.
136. Fattening Pigs.
142. Sugar Beets in South Dakota—Results to Date.
143. Roughage for Fattening Lambs.
144. Preliminary Report on the Milking Machine.
145. A Report of Progress in Soil Fertility Investigations.
146. Some Varieties and Strains of Wheat and Their Yields in South Dakota.
147. Effect of Alkali Water on Dairy Cows.
148. Corn Silage and Mill Products for Steers.
149. Some Varieties and Strains of Oats and Their Yields in South Dakota.
151. Trials with Sweet Clover as a Field Crop in South Dakota.
152. Testing and Handling Dairy Products.
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154. The Pit Silo.
155. Selection and Preparation of Seed Potatoes, Size of Seed Pieces, and Bud-Variation.
156. Kaoliang, A New Dry Land Crop.
157. Rape Pasture for Pigs in Corn Field. Kaoliang for Pigs.
158. Proso and Kaoliang for Table Foods.
159. Progress in Plant Breeding.
160. Silage and Grains for Steers.
161. Winter Grain in South Dakota.
162. First Annual Report of Vivian Experiment and Demonstration Farm.
163. Comparative Yields of Hay, from Several Varieties and Strains of Alfalfa, at Brookings, Highmore, Cottonwood and Eureka.
164. Making Butter and Cheese on the Farm.
165. Corn Silage for Lambs.
166. Important Factors Affecting Machine Milking.
167. Transplanting Alfalfa.
168. Breakfast Foods and Their Relative Value.
169. Flax Culture.
170. Quack Grass Eradication.
171. Cream Pasteurization.
172. Grasshopper Control.
173. Sugar Beets in South Dakota.
174. Sorghums for Forage in South Dakota.

Note: We do not add the names of non-residents to the regular mailing list.