Technical Bulletin No. 473 March 1935

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

HEAVY COTTONSEED MEAL FEEDING IN RELATION TO UDDER TROUBLES IN DAIRY COWS

By R. P. HOTIS, *associate market milk specialist, Division of Market Milk Investigations*, and T. E. WOODWARD, *senior dairy husbandman, Division of Dairy Cattle Breeding, Feeding, and Management Investigations, Bureau of Dairy Industry*

CONTENTS

INTRODUCTION

There is a widespread opinion among dairy farmers and others that the heavy feeding of high-protein concentrates to dairy cows will lead to udder troubles and the secretion of abnormal milk, especially the heavy feeding of cottonseed meal, which is one of the richest of all feeds in protein. To obtain definite information on the effect of such feeding, as indicated by physical changes in the udder and abnormalities in the milk, a feeding experiment with cottonseed meal was conducted at the United States Dairy Experiment Station at Beltsville, Md., in which determinations were made on the milk for streptococci, chloride content, and number of cells; also, physical examinations were made of the udders and the milk.

In previous experiments at Beltsville to determine whether cottonseed meal had any injurious effects on nutrition and health (*7, pp. 6–9; 8, pp. 9–10*)[1] a considerable number of cows have been fed large quantities of cottonseed meal (6 to 10 pounds or more per day) without apparent injury. In these experiments the udders and milk were examined, but not in detail. No cases of udder injury from the ration were apparent. In the present experiment the udders were examined more frequently, and the milk was systematically sampled and subjected to a more detailed investigation for evidences of abnormality. In this study the investigators considered milk to be abnormal which showed much sediment in the test tubes after standing, which was bloody, which showed flakes on the strip cup,

[1] Italic numbers in parentheses refer to Literature Cited, p. 16.

which contained over 0.15 g of chlorine per 100 cc, which carried more than 500,000 cells per cubic centimeter, or large numbers of udder bacteria, particularly *Streptococcus mastitidis* (*S. agalactiae*).

DETECTING UDDER TROUBLES

The following discussion of udder troubles is intended for those who are unfamiliar with the subject, or have not had technical training, as an aid in understanding the methods used and the results sought in this experiment. Those interested in a detailed account of udder troubles may consult Farmers' Bulletin 1422, on udder diseases of dairy cows (*3*), and various publications on methods of detection, one by the New York State station (*6*), and a more recent publication on methods, by research workers at the University of Idaho (*4*).

Udder troubles in dairy cows may result from a variety of causes; for example, accidental bruising of the teats or any other part of the udder, undue exposure to cold or wet weather, digestive disturbances, and infectious diseases.

Farmers and dairymen are inclined to call most any udder ailment mastitis. Mastitis, strictly speaking, is inflammation of the udder caused by specific pathogenic organisms, the most prevalent organism being *Streptococcus mastitidis*. In severe cases of mastitis the udder becomes hot, swollen, and tender, and the animal may become extremely ill, and even die. Even when the inflammation has subsided and the animal seems to have recovered, the infection remains. Cows that have had mastitis are likely to suffer a recurrence or aggravation of the abnormal udder condition when subjected to unfavorable conditions, such as severe chilling.

In cases of chronic or subclinical mastitis, the cow usually appears to be in normal health. The udder may have hardened tissues, or be apparently sound, and the milk may appear normal, depending on the mildness or severity of the case. In mild cases, special care is necessary to detect the trouble or abnormal condition. In such cases a physical examination of the udder by a veterinarian is an effective method of detecting abnormalities such as fibrosis or induration of the tissues.

The strip-cup method of examining the milk has been described in various publications. Hucker and his coworkers state (*6, p. 23*) that milk that appears normal in the strip-cup test may on laboratory examination show abnormalities.

Also, an udder may have hardened tissues or other abnormalities and the milk be normal in character, or an apparently normal udder may give abnormal milk. The results obtained in physical examinations, therefore, should be compared with laboratory tests.

Some of the methods that may be used to detect abnormalities in the milk are: Plate counts of milk samples in which special mediums are used for detecting the presence of streptococci; various colorimetric and electrometric tests for determining the pH value of the milk; incubation of milk samples with microscopic examination before and after centrifuging; various methods of making the cell count; and methods for determining the amount of chlorides, lactose, and catalase in the milk.

In the most prevalent type of infection the species of bacteria present is *Streptococcus mastitidis*. It has therefore been regarded that the presence of this organism in the milk gives evidence that condi-

tions within the udder are abnormal. In order to detect this organism, laboratory methods must be used, the usual method being to prepare plates with special mediums. In cases where plate methods fail to show organisms, incubation of the milk sample with microscopic examination is carried out to determine whether the organism is present or not. In this latter method, however, no conjecture can be made as to the number of streptococci that were present in the original sample.

The methods used in this work for determination of streptococci, chloride content, and cells, are discussed later. The lactose method, which depends on the fact that when the udder tissues are affected the amount of lactose in the milk is decreased, has limitations for diagnosing mastitis. The catalase test, while useful for detecting active cases of mastitis, is, according to some investigators, no more accurate than other tests as easily made or more easily made. For these reasons, tests for catalase and lactose were not carried out on the milk in this experiment.

COWS USED IN THE EXPERIMENT

Eight cows, 4 Holsteins and 4 Jerseys, were used in the experiment. Cows were selected which had shown evidence of udder troubles at some time in the past. This was done largely because of the general belief that such cows are more sensitive to, and therefore more likely to be affected by, unfavorable conditions due to feeding than are cows whose udders have always been normal. While this point could be determined only by actual test, it was not practicable to include cows with a normal-udder history in this experiment because of the elaborate set-up required to insure against initial infection.

Precautions were taken to prevent the cows from contracting additional infection through the teat canal as follows: Before milking, the udders and teats were cleaned with a chlorine solution and a clean cloth, the teat cups of the milking machine were rinsed with water and immersed in a chlorine solution; and after milking the teats were dipped in a soapy, antiseptic solution, the idea being that this solution would form a film over the ends of the teats and thus tend to prevent infection from entering the teat canal.

The cows were kept in the barn in stanchion stalls at night, and turned out with other cows to exercise during the day. None of the cows used showed digestive disturbances from the high-protein feeding.

The stage of lactation of the different cows, when the experiment started on October 27, 1932, ranged from less than a month for cow no. 840 to less than 6 months for cow no. 674. The experiment lasted 22 weeks and ended March 27, 1933. Two of the cows, nos. 602 and 617, went dry 2 weeks before the experiment ended, although they had freshened less than 4 months before it began. Their going dry, however, apparently had no relation to the feeding of the high-protein ration. The breeding records which are pertinent to this study are shown in table 1.

METHOD OF FEEDING AND AMOUNTS FED

Table 1 also shows the feeding plan. During the first period 4 of the cows, 2 Jerseys and 2 Holsteins, were fed cottonseed meal, and the other 4 cows were fed a low-protein grain mixture. In addition,

all of the cows received alfalfa hay of good quality at the daily rate of about 2 percent of their body weight, throughout the entire experiment. No other grain or roughage was fed.

TABLE 1.—*Cows used, breeding data, average daily quantities of cottonseed meal and hay, and grain and hay fed from Oct. 27, 1932, to Mar. 27, 1933*

Cow no.	Breed of cow	Date of freshening (1932)	Date pregnant (1932)	Average daily feed record					
				First period			Second period		
				Cottonseed meal	Grain mixture	Alfalfa hay	Cottonseed meal	Grain mixture	Alfalfa hay
				Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
602	Jersey	July 22	Dec. 23	10	--------	16	10	--------	16
688	do	Aug. 18	Oct. 15	10	--------	22	10	--------	22
674	do	Apr. 19[1]	----------	----------	6	20	----------	5	20
838	Holstein	Aug. 19	Oct. 5	----------	6	24	----------	6	24
A-2	Grade Holstein	July 9	----------	10	--------	16	----------	6	18
819	Holstein	Aug. 19	Oct. 5	10	--------	24	----------	9	24
617	Jersey	July 3[1]	Aug. 21	----------	6	20	10	--------	14
840	Holstein	Oct. 14	Nov. 28	----------	10	24	10	--------	22

[1] Aborted.

No change was made in the rations of the different cows during the first period of 12 weeks. At the beginning of the thirteenth week, the rations of two of the cows (nos. A–2 and 819) on the high-protein (cottonseed meal) concentrate and hay were changed to the low-protein (grain) concentrate and hay. The rations of two of the cows (nos. 617 and 840) on low protein were changed to high protein. The rations of the other four cows (nos. 602 and 688 on high protein, and 674 and 838 on low protein) were continued without material change during the second period. The second period was continued for 10 weeks, although two of the cows were dry the last 2 weeks.

The cottonseed meal was fed at the rate of 10 pounds per day per cow throughout the experiment to all cows receiving cottonseed meal. The low-protein grain mixture consisted of one-third ground corn, one-third ground oats, and one-third wheat bran, by weight; it was fed in quantities ranging from 5 to 10 pounds a day, depending upon the size and production of the individual cows receiving grain.

METHODS USED IN DETERMINING CONDITION OF COWS

PHYSICAL EXAMINATION OF THE UDDERS AND MILK[2]

The udders of all the cows were examined by palpation every 2 to 4 weeks, for lumps, swellings, and other abnormalities. At the same time the milk of each cow was sampled by drawing a few streams from each teat into a strip cup, and examined for presence of clots from each quarter. The condition of the udders of the different cows, and the milk as shown by the strip-cup test, at the beginning of the experiment is shown in the first line, headed "November 1", in table 2. This examination was made on the day following the one on which the cows were assembled and placed on the experimental rations.

COLLECTING MILK SAMPLES FOR LABORATORY TESTS

Laboratory tests of the milk afford valuable supporting data, and also may reveal abnormal conditions which are not disclosed by a

[2] This work was done by Fred W. Miller, senior veterinarian and physiologist, Bureau of Dairy Industry.

physical inspection of the udder and milk. Such tests when made at uniform intervals enable deviations from normal characteristics to be recorded systematically, thus giving a picture of the cow's condition, and permit temporary disturbances to be distinguished from those of a more serious or permanent nature.

Samples of one milking from each cow were taken weekly for the determinations of number of cells, content of chlorides, and presence and number of streptococci. The practice in obtaining the milk for these tests was to collect two samples of each cow's milk, one sample being taken from the glass receptacle of the milking machine and the other sample directly from the udder.

The sample taken from the receptacle represented all of the milk given by the cow at that milking. This sample was used in making the cell count and for the determination of chloride content.

The sample taken directly from the udder was obtained by drawing an equal amount of milk from each of the four quarters into a sterile tube, when the milking was nearly completed. In doing this care was taken not to contaminate the milk. This sample was used for examination for *Streptococcus mastitidis*. There were two reasons for using some of the last milk remaining in the udder to determine the number of streptococci. One was that the last milk drawn from the udder is not so likely to be contaminated with organisms from the teat canals as the fore milk; the other, that it was thought that any deep-seated infections would be detected with greater certainty.

As soon as the samples of milk were drawn, the tubes were placed in chipped ice.

DESCRIPTION OF LABORATORY TESTS USED

The methods used in making the determination of streptococci, determination of chloride content, and the cell count were as follows:

DETERMINATION OF STREPTOCOCCI

The determination of streptococci in the milk samples obtained for this purpose was made by means of the colony or plate count for bacteria in milk, only those organisms believed to be *Streptococcus mastitidis* being counted. Plating was done within a period of 5 hours from the time the milk was drawn from the udders. Two different mediums were used in preparing the plates. One plate was prepared using standard beef extract medium, and another plate using a blood-agar medium.

The blood agar was similar to that used by Ayers and Mudge (*2*) and was of the following composition: Infusion broth, 500 cc; peptone (Parke Davis), 10 g; sodium chloride, 5 g; distilled water, 500 cc; and shredded agar, 15 g. The reaction or acid intensity of the medium was adjusted to a value of pH 7.5. After the mixture had melted it was cooled to a temperature of 45° C., and from 0.5 to 1.0 percent of defibrinated horse blood [3] was added.

The plates were incubated 48 hours at a temperature of 37° C.; then a count was made of the number of streptococcus bacteria. In order to determine definitely whether the organisms counted were *S. mastitidis*, representative colonies were picked from the plates into a tube of infusion broth and this culture was incubated 24 hours at 37°. Then a portion of the infusion-broth culture was used to inoculate

[3] The defibrinated horse blood was furnished by the Bureau of Animal Industry.

litmus skim milk and another portion was used to inoculate methylene blue skim milk containing 0.005 percent of dye content and these were incubated for another 24 hours and examined for characteristic reactions of *S. mastitidis*. This organism does not reduce the blue color or coagulate the methylene blue milk when this strength is used. Litmus milk is slightly reduced, acidified, and usually coagulates in about 24 hours.

CHLORIDE TEST

The method used for determination of the chloride content of the samples of the milk of each cow, was the chloride test developed by Hammer and Bailey (*5*) for detecting abnormal milk. This test is based on the fact that when udder tissues are broken down either by physical means or bacterial infection, blood plasma, which is richer in chlorides than normal milk, is allowed to filter through into the milk cistern, and this causes an increase in the chloride content of the milk. A satisfactory comparative index of the amount of chlorides, expressed as chlorine, in the milk can be obtained by direct titration. This was done by placing 10 cc of milk in a beaker, diluting with 30 to 40 cc of distilled water, adding 5 drops of a 10-percent solution of potassium chromate, and titrating with tenth-normal silver nitrate solution until the desired end point was reached. Each cubic centimeter of silver nitrate solution required represents 0.0355 g of chlorides, expressed as chlorine, per 100 cc of milk.

When this test is used for determination of chloride content, normal milk is assumed to have a chloride content equivalent to from 0.09 to 0.14 g of chlorine per 100 cc. On account of the fact that slight variations in results obtained by titration on the same sample are possible, in this work 0.15 g or more of chlorine per 100 cc of milk was assumed to denote an abnormal condition of the milk. Hucker, Trudell, and Jennings (*6*), in a study of milk obtained from over 100 quarters of udders of dairy cows, concluded that the test just described was very accurate in detecting udders which have become "fibrotic or indurated to some degree."

CELL COUNT

The cell counts of the samples of milk from the different cows, taken each week from the receptacles of the milking machines, were made by direct microscopic examination according to the procedure given by the American Public Health Association (*1. p. 30*). In this work both leucocytes and epithelial cells were included in the count, and the average of 20 fields was taken.

RESULTS OF THE EXPERIMENT

The results of the physical examinations of the udders and of the milk are shown in table 2. The results of the examination of the weekly samples of milk for content of chlorides, expressed as chlorine, number of cells, and number of streptococci, are given in table 3. These two tables should be considered together in comparing results of the different tests.

TABLE 2.—*Condition of udders and milk as shown by physical examinations made during first and second periods of experiment in feeding high-protein and low-protein rations, Oct. 27, 1932, to Mar. 27, 1933*[1]

COWS ON SAME RATIONS, FIRST PERIOD

Date of examination	High-protein ration				Low-protein ration			
	Cow 602		Cow 688		Cow 674		Cow 838	
	Udder (examined by palpation)	Milk (strip cup)	Udder (examined by palpation)	Milk (strip cup)	Udder (examined by palpation)	Milk (strip cup)	Udder (examined by palpation)	Milk (strip cup)
Nov. 1	Swelling at base of 2 front teats.	Normal	Normal	Normal	L. F. quarter smaller	Clot from R. F. teat.	Normal	Normal.
Nov. 14	do	do	do	do	Sore on L. F. teat	No clots	do	Do.
Nov. 29	do	do	do	do	L. F. quarter hard	do	do	Do.
Dec. 12	do	do	do	do	Front quarters small	do	do	Do.
Jan. 5	do	do	Small lump in R. F. quarter.	do	L. F. quarter small, hard.	do	do	Do.

COWS ON SAME RATIONS, SECOND PERIOD

Jan. 25	Swelling at base of 2 front teats.	Normal	Small lump in R. F. quarter.	Normal	Front quarters small	No clots	Normal	Normal.
Feb. 3	do	do	do	do	do	do	do	Do.
Mar. 2	do	do	do	do	do	do	do	Do.

COWS ON ALTERNATE RATIONS, FIRST PERIOD

	Cow A-2		Cow 819		Cow 617		Cow 840	
Nov. 1	L. F. quarter firmer; R. F. quarter indurated.	Clots from 2 front teats.	L. F. quarter small, dry.	Normal	Normal	Normal	Normal	Normal.
Nov. 14	R. R. and L. F. quarters harder.	Clots from R. R., L. R., and L. F. teats.	do	do	Front quarters hard	do	R. R. and R. F. quarters larger.	Do.
Nov. 29	Front quarters hard. Enlargement at base L. R. teat.	Clots from all 4 teats.	do	do	Normal	do	do	Do.
Dec. 12	L. F. quarter hard	Clots from L. F., L. R., and R. R. teats.	do	do	do	do	do	Do.
Jan. 5	Front quarters small; whole udder fibrous.	Clots from R. R. and L. F. teats	do	do	do	do	do	Do.

[1] L. F.=left front; R. F.=right front; L. R.=left rear; R. R.=right rear.

TABLE 2.—*Condition of udders and milk as shown by physical examinations made during first and second periods of experiment in feeding high-protein and low-protein rations, Oct. 27, 1932, to Mar. 27, 1933*—Continued

COWS ON ALTERNATE RATIONS, SECOND PERIOD

	High-protein ration				Low-protein ration			
	Cow 617		Cow 840		Cow A-2		Cow 819	
	Udder (examined by palpation)	Milk (strip cup)	Udder (=xamined by palpation)	Milk (strip cup)	Udder (examined by palpation)	Mi[k (strip cup)	Udder (examined by palpation)	Milk (strip cup)
Jan. 25	Normal	Normal	R. R. and R. F. quarters larger.	Normal	Front quarters smaller and harder.	Clots from all 4 teats.	Left half smaller, L. F. teat puffed, dry.	Normal.
Feb. 3	do	do	do	Small clot from R. F. teat.	L. F. and R. F. quarters small, fibrous.	Clots from L. R. teat.	L. F. quarter small, teat puffed, dry.	Do.
Mar. 2	L. F. quarter small	do	do	No clots	Whole udder fibrous	Clots from 2 left teats.	do	Do.

TABLE 3.—*Content of chlorides (expressed as chlorine), number of cells and number of streptococci in milk of 8 cows during feeding experiment with high-protein and low-protein rations*

COWS ON SAME RATION, FIRST PERIOD

Date of examination	High-protein ration						Low-protein ration					
	Cow 602			Cow 688			Cow 674			Cow 838		
	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc
	Grams	*Thousands*	*Number*	*Grams*	*Thousands*	*Number*	*Grams*	*Thousands*	*Number*	*Grams*	*Thousands*	*Number*
Oct. 31	0.1436	935	1,500	0.1178	357	2,500	0.1258	385	(1)	0.1223	687	3,000
Nov. 7	.2424	3,135	3,500	.2121	165	600	.1099	357	10,400	.2121	275	2,200
Nov. 14	.1879	1,485	7,000	.1575	220	1,100	.1099	385	1,100	.1575	797	1,100
Nov. 21	.2060	1,430	[2]700	.1818	220	1,200	.1258	220	27,000	.1636	495	1,500
Nov. 28	.2060	1,155	6,200	.1818	302	2,300	.1773	385	2,800	.1939	1,595	1,400
Dec. 5	.1846	1,375	3,900	.1800	357	600	.1773	605	12,500	.1800	2,667	1,000
Dec. 12	.1737	2,310	2,600	.1560	522	3,200	.1524	247	7,000	.1384	275	1,100
Dec. 19	.1773	2,172	700	.1455	467	4,500	.1384	192	5,400	.1524	385	1,100

Dec. 27	.1666	825	4,000	.1524	275	800	.1420	247	61,000	.1384	247	1,200
Jan. 3	.1950	13,695	13,000	.1420	275	2,000	.1471	1,182	2,100	.1490	495	400
Jan. 9	.1985	2,805	2,000	.1524	357	0	.1420	55	4,000	.1420	330	3,000
Jan. 16	.1846	1,540	14,000	.1702	495	0	.1420	137	8,000	.1631	385	900
Average	.1888	2,738	4,925	.1625	334	1,567	.1408	366	12,845	.1594	719	1,492
Range	.1436–.2424	825–13,695	700–14,000	.1178–.2121	165–522	0–4,500	.1099–.1773	55–1,182	1,100–61,000	.1223–.2121	247–2,667	400–3,000

COWS ON SAME RATION, SECOND PERIOD

Jan. 24	0.2552	3,520	4,000	0.1773	632	400	0.1524	385	2,000	0.1631	852	500
Jan. 30	.2765	7,452	16,000	.1820	412	[3]	.1420	137	10,000	.1490	220	700
Feb. 6	.2056	3,575	3,000	.1666	1,430	2,000	.1524	742	1,800	.1560	522	2,000
Feb. 13	.2056	2,777	14,000	.1631	440	500	.1471	302	4,200	.1631	522	800
Feb. 20	.2127	2,695	8,000	.1524	577	600	.1489	605	6,000	.1631	687	3,000
Feb. 27	.2588	5,060	18,000	.1524	275	850	.1631	550	700	.1631	1,347	1,400
Mar. 6	.2092	1,732	27,000	.1666	357	2,000	.1595	330	2,300	.1560	1,650	700
Mar. 13	.2021	990	1,300	.1524	385	0	.1595	165	900	.1420	495	1,500
Mar. 20		[5]		.1800	247	3,000	1,666	357	141,000	.1773	330	1,500
Mar. 27		[5]		.1914	852	1,500	.1914	962	6,000	.1914	165	1,300
Average	.2282	3,475	11,412	.1684	561	1,206	.1583	453	17,490	.1624	679	1,340
Range	.2021–.2765	990–7,452	1,300–27,000	.1524–.1914	247–1,430	0–3,000	.1420–.1914	137–962	700–141,000	.1420–.1914	165–1,650	500–3,000

COWS ON ALTERNATE RATIONS, FIRST PERIOD

	Cow A-2			Cow 819			Cow 617			Cow 840		
Oct. 31	0.1631	2,695	6,500	0.1178	110	0	0.2056	4,565	0	0.1082	247	0
Nov. 7	.2171	5,967	30,700	.2121	110	900	.1879	3,657	17,000	.2000	137	0
Nov. 14	.2242	8,195	2,300	.1696	110	1,900	.1773	4,757	21,100	.1696	55	0
Nov. 21	.2303	4,785	47,600	.1575	82	2,600	.1846	1,815	37,400	.1515	[4]	300
Nov. 28	.2171	5,252	25,500	.1575	82	0	.2180	1,457	15,000	.1696	55	0
Dec. 5	.2304	3,492	2,800	.1800	385	1,900	.2092	3,025	59,000	.1631	357	0
Dec. 12	.2092	4,977	5,000	.1455	357	0	.1985	3,025	60,000	.1348	110	0
Dec. 19	.2021	4,152	34,000	.1384	1,072	300	.1950	9,047	80,000	.1490	165	0
Dec. 27	.2233	6,462	170,000	.1455	247	0	.2003	4,152	44,000	.1524	110	0
Jan. 3	.2056	6,545	26,000	.1455	247	3,000	.1846	2,942	52,000	.1348	302	0
Jan. 9	.2092	12,100	3,000	.1524	137	4,000	.1702	3,190	13,000	.1490	275	0
Jan. 16	.1737	4,345	2,200	.1524	192	1,000	.1755	2,777	50,000	.1420	302	0
Average	.2088	5,747	29,633	.1562	261	1,300	.1922	3,701	37,375	.1520	192	25
Range	0.1631–.2304	2,695–12,100	2,200–170,000	0.1178–.2121	82–1,072	0–4,000	0.1702–.2180	1,457–9,047	0–80,000	0.1082–.2000	55–357	0–300

[1] Present, but not counted. [2] Estimated. [3] Could not be counted because of surface-spreading organisms. [4] Lost. [5] Cow dry.

TABLE 3.—*Content of chlorides (expressed as chlorine), number of cells and number of streptococci in milk of 8 cows during feeding experiment with high-protein and low-protein rations*—Continued

COWS ON ALTERNATE RATIONS, SECOND PERIOD

Date of examination	High-protein ration						Low-protein ration					
	Cow 617			Cow 840			Cow A–2			Cow 819		
	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc	Chlorine in 100 cc of milk	Cells in 1 cc of milk	Streptococci in 1 cc
Jan. 24	0.1879	14,575	25,000	0.1879	1,045	0	0.2190	3,850	31,000	0.1560	137	0
Jan. 30	.2092	5,995	34,000	.1455	220	0	.2190	4,317	70,000	.1631	605	0
Feb. 6	.1879	4,125	111,000	.1455	357	0	.2162	3,272	3,000	.1560	907	10,000
Feb. 13	.2021	4,070	30,000	.1490	165	200	.2269	5,087	6,000	.1524	1,265	7,000
Feb. 20	.1702	6,902	76,000	.1490	357	1,000	.2056	10,615	0	.1666	137	3,000
Feb. 27	.2021	3,740	87,000	.1524	742	500	.2233	6,875	20,000	.1560	247	5,800
Mar 6	.1950	3,437	600	.1490	385	0	.2269	2,612	6,000	.1914	412	850
Mar. 13	.2021	4,537	39,000	.1524	412	0	.2127	5,417	32,000	.2021	385	850
Mar. 20		(5)		.1490	220	0	.2375	2,502	11,000	.1950	495	1,400
Mar. 27		(5)		.1666	220	300	.2190	4,455	1,600	.2233	1,512	1,400
Average	.1946	5,922	50,325	.1546	412	200	.2206	4,905	18,060	.1762	610	3,030
Range	0.1702–.2092	3,437–14,575	600–111,000	0.1455–.1879	165–1,045	0–1,000	0.2056–.2375	2,502–10,615	0–70,000	0.1524–.2233	137–1,512	0–10,000

[5] Cow dry.

DISCUSSION OF RESULTS

The examinations of the udders by palpation and of the milk for clots failed to show any relation between the quantity of protein in the ration and abnormalities of the udder and milk. Some of the

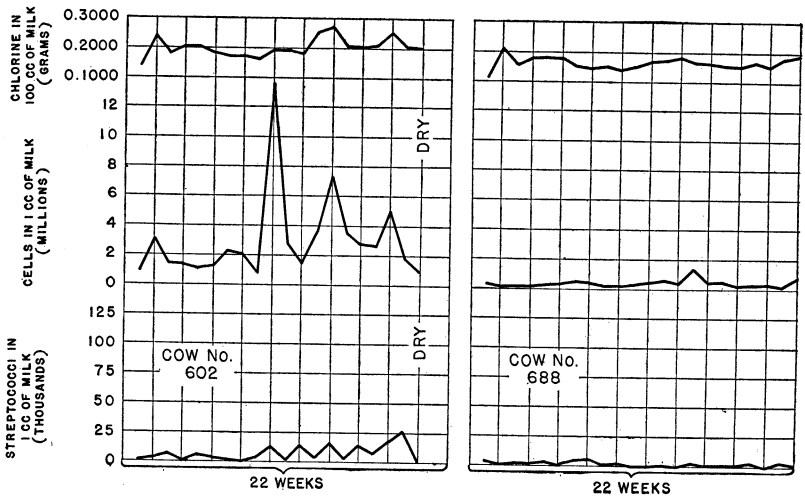

FIGURE 1.—Changes in milk of two cows (nos. 602 and 688) when fed a high-protein ration of cottonseed meal and alfalfa hay.

udders were found to be normal at the start of the experiment and later developed certain minor troubles. The records of the cows' cases indicate that there is apparently no relation between these

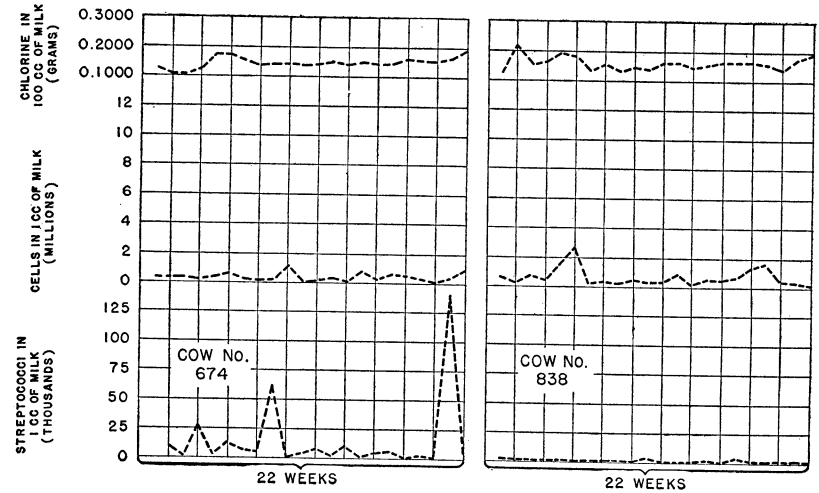

FIGURE 2.—Changes in milk of two cows (nos. 674 and 838) when fed a ration consisting of a low-protein grain mixture and alfalfa hay.

troubles and the plane of protein feeding. The udders that were abnormal at the beginning of the experiment remained so, as a rule, regardless of the ration; their condition did not appear to be either improved or aggravated by changes in the protein content of the ration.

CURVES SHOWING VARIATIONS IN CONDITION OF MILK DURING THE EXPERIMENT

The data showing the results of the laboratory examinations bring out many interesting changes in the milk of the different cows. In order that these changes may be more easily followed, and the general

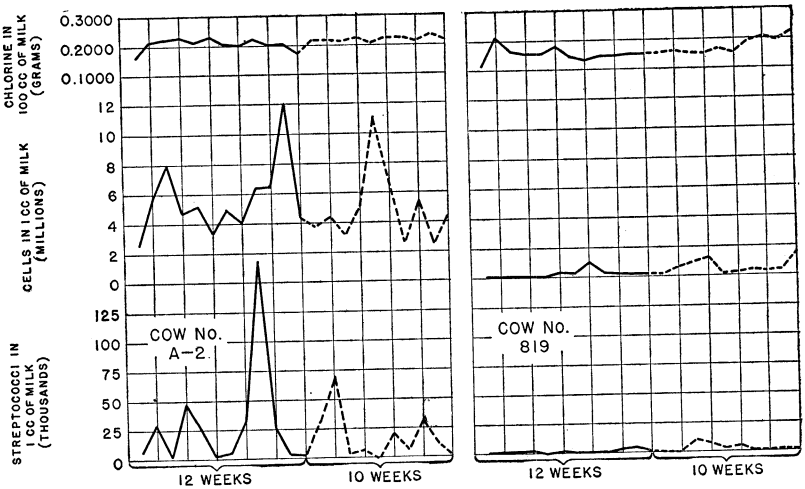

FIGURE 3.—Changes in milk of two cows (nos. A-2 and 819) when fed a high-protein ration and when fed a low-protein ration. The solid line represents milk sampled during high-protein and the broken line milk during low-protein feeding period.

characteristics of the results for each cow may be more clearly understood and compared with the physical observations, the data of table 3 have been plotted graphically in figures 1 to 4.

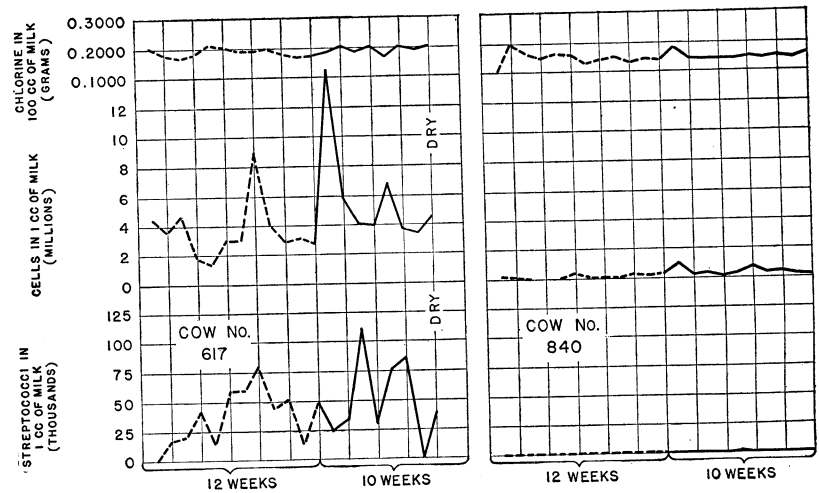

FIGURE 4.—Changes in milk of two cows (nos. 617 and 840) when fed a low-protein ration and when fed a high-protein ration. The solid line represents milk sampled during high-protein and the broken line milk during low-protein feeding period.

In considering the results it must be remembered that the cell count taken alone may be misleading because an excessively high count does not indicate definitely whether a cow has an infectious

disease or whether minor injuries have caused an excessive number of cells to be released into the milk cistern. When the cell count is used in conjunction with the streptococcus count and the determination of chloride content, however, it then serves as a valuable indicator of abnormal conditions within the udder and the severity of such conditions. For example, the milk of cow no. 840 showed very little infection of streptococcus throughout both periods of the experiment, and the cell count as a whole was comparatively low, but on January 24 her milk had a high cell count. If the cell counts alone had been made, it might be assumed from the high count on January 24 that she had contracted an infection. As the streptococcus count remained low and the cell count of her milk for the succeeding week dropped to normal, the sudden increase in cells on January 24 seems to have been due to some other factor.

It is also important to keep in mind in studying the results of the chlorine determinations, cell counts, and streptococcus counts that the trend of the determinations of all the samples for each cow must be taken into consideration rather than the results of any one sample. The reason for this is that the milk of each cow varies from milking to milking, and from day to day, in content of chlorides, number of cells, and number of streptococci. In all probability each of these factors goes through a definite cycle, rather than changing abruptly from one milking to the next. Since samples were taken of only 1 milking each week the extent of the changes on the days intervening between any 2 days of sampling cannot be estimated closely, as the highest peak or the lowest point might not occur on the days that the samples were taken.

For example, the curves for cow no. 617 (fig. 4) show many abrupt changes. If data on the intervening milkings of this cow were available smoother curves might be obtained, although these changes might go higher or lower on certain days. However, the trend of the weekly examinations over the entire experiment shows that her milk was highly abnormal and at no time tended to approach what is termed normal milk. Therefore, even if samples had been taken daily, the general trend of the results for this cow would not have been altered materially, but would be much the same as shown in the present curves.

COMPARISON OF RESULTS WITH DIFFERENT COWS

In addition to the weekly changes, the extreme variation in the milk of each of the cows during the first period and the second period, respectively, is given in the two lines headed "Range" in table 3, together with the average of each period. As stated previously, in comparing wide variations between individual days, the general results must be taken into consideration. The average results of feeding on a high-protein plane as compared with feeding on a low-protein plane are of especial interest in drawing conclusions from this experiment, and in general support the information given by the trends of the curves in figures 1 to 4.

Cow no. 602 was fed a high-protein ration during both the first and second periods of the experiment. Her milk was decidedly abnormal during both periods, but on an average the milk obtained during the second period was more abnormal than that of the first period. On the other hand, cow no. 688 fed similarly gave milk that was nearly as normal in one period as in the other.

Cow no. 674 was fed a low-protein ration throughout both periods, and gave a more abnormal milk on an average during the second period than during the first period. Cow no. 838 fed similarly gave milk that was nearly as normal in one period as in the other.

The average results for these four cows, therefore, indicate that the abnormality of the milk in the case of each cow remained much the same, both for the cows which were fed continuously on a high-protein ration and the cows which were fed continuously on a low-protein ration.

Cow no. A–2 was fed a high-protein ration during the first period and a low-protein ration during the second period. Her milk varied greatly during the experiment, but on an average was more nearly normal in the second period than in the first. Cow no. 819 was fed similarly. Her milk was more nearly uniform in character during the experiment, but slightly more abnormal in the second period than in the first.

Cow no. 617 was fed a low-protein ration during the first period and a high-protein ration during the second; her milk was very irregular in character and during the second period was, on an average, more abnormal than during the first. Cow no. 840 was fed similarly; her milk was more uniform in character, but slightly more abnormal during the second period than in the first.

Inasmuch as the number of cows used was small, it cannot be definitely concluded that changing from a low-protein ration to a high-protein ration, or vice versa, would or would not have any effect on the normality of the milk. However, in the cases studied in this experiment there was no material change.

SUMMARY AND CONCLUSIONS

Eight cows that had shown udder troubles in the past were used in this experiment. All were fed alfalfa hay. Four were fed 10 pounds of cottonseed meal each day, and four were fed from 5 to 10 pounds of a low-protein grain mixture. The experiment lasted 22 weeks.

The milk from each cow was examined weekly for streptococci, chlorine content, and number of cells.

The results of these three tests when studied in conjunction with each other and with strip-cup examination provide information regarding the normality or abnormality of the milk.

The udders were examined by palpation every 2 to 4 weeks and at the same time some of the milk was drawn from each teat into a strip cup.

The conclusion drawn in this work was that the liberal feeding of these cows on a high-protein ration composed of cottonseed meal and alfalfa hay had little, if any, influence on the abnormality of the milk. Neither did such a ration aggravate udder conditions as determined by physical examination of the udders and by the laboratory examination of the milk, nor did the high-protein ration force animals, more or less subject to chronic attacks of mastitis, into clinical cases.

LITERATURE CITED

(1) AMERICAN PUBLIC HEALTH ASSOCIATION.
1934. STANDARD METHODS OF MILK ANALYSIS, BACTERIOLOGICAL AND CHEMICAL. Ed. 6, 105 pp., illus. New York City.
(2) AYERS, S. H., and MUDGE, C. S.
1922. THE STREPTOCOCCI OF THE BOVINE UDDER. IV. STUDIES OF THE STREPTOCOCCI. Jour. Infect. Diseases 31:40–50.
(3) BUNYEA, H.
1924. UDDER DISEASES OF DAIRY COWS. U. S. Dept. Agr. Farmers' Bull. 1422, 18 pp., illus. (Slightly revised, 1932.)
(4) HALVERSEN, W. V., CHERRINGTON, V. A., and HANSEN, H. C.
1934. LABORATORY METHODS FOR THE DETECTION OF MILK FROM COWS INFECTED WITH MASTITIS. Jour. Dairy Sci. 17:281–296.
(5) HAMMER, B. W., and BAILEY, D. E.
1917. A RAPID VOLUMETRIC METHOD FOR APPROXIMATE ESTIMATION OF CHLORINE IN MILK. Iowa Agr. Expt. Sta. Research Bull. 41, pp. [337]–348.
(6) HUCKER, G. J., TRUDELL, F., and JENNINGS, W. S.
1932. MASTITIS. I. THE INCIDENCE AND DETECTION OF SUBCLINICAL STREPTOCOCCUS MASTITIS. N. Y. State Agr. Expt. Sta. Tech. Bull. 199, 52 pp.
(7) WOODWARD, T. E., SHEPHERD, J. B., and GRAVES, R. R.
1932. FEEDING AND MANAGEMENT INVESTIGATIONS AT THE UNITED STATES DAIRY EXPERIMENT STATION, AT BELTSVILLE, MD. 1930 REPORT. U. S. Dept. Agr. Misc. Pub. 130, 24 pp., illus.
(8) ——— SHEPHERD, J. B., and GRAVES, R. R.
1933. FEEDING AND MANAGEMENT INVESTIGATIONS AT THE UNITED STATES DAIRY EXPERIMENT STATION AT BELTSVILLE, MD. 1932 REPORT. U. S. Dept. Agr. Misc. Pub. 179, 51 pp., illus.

ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

Secretary of Agriculture	HENRY A. WALLACE.
Under Secretary	REXFORD G. TUGWELL.
Assistant Secretary	M. L. WILSON.
Director of Extension Work	C. W. WARBURTON.
Director of Personnel	W. W. STOCKBERGER.
Director of Information	M. S. EISENHOWER.
Director of Finance	W. A. JUMP.
Solicitor	SETH THOMAS.
Agricultural Adjustment Administration	CHESTER C. DAVIS, *Administrator.*
Bureau of Agricultural Economics	NILS A. OLSEN, *Chief.*
Bureau of Agricultural Engineering	S. H. MCCRORY, *Chief.*
Bureau of Animal Industry	JOHN R. MOHLER, *Chief.*
Bureau of Biological Survey	J. N. DARLING, *Chief.*
Bureau of Chemistry and Soils	H. G. KNIGHT, *Chief.*
Office of Cooperative Extension Work	C. B. SMITH, *Chief.*
Bureau of Dairy Industry	O. E. REED, *Chief.*
Bureau of Entomology and Plant Quarantine	LEE A. STRONG, *Chief.*
Office of Experiment Stations	JAMES T. JARDINE, *Chief.*
Food and Drug Administration	WALTER G. CAMPBELL, *Chief.*
Forest Service	FERDINAND A. SILCOX, *Chief.*
Grain Futures Administration	J. W. T. DUVEL, *Chief.*
Bureau of Home Economics	LOUISE STANLEY, *Chief.*
Library	CLARIBEL R. BARNETT, *Librarian.*
Bureau of Plant Industry	FREDERICK D. RICHEY, *Chief.*
Bureau of Public Roads	THOMAS H. MACDONALD, *Chief.*
Weather Bureau	WILLIS R. GREGG, *Chief.*

This bulletin is a contribution from

Bureau of Dairy Industry	O. E. REED, *Chief.*
Division of Dairy Cattle Breeding, Feeding, and Management.	R. R. GRAVES, *Principal Specialist in Dairy Cattle Breeding, Chief.*

U. S. GOVERNMENT PRINTING OFFICE: 1938

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - Price 5 cents