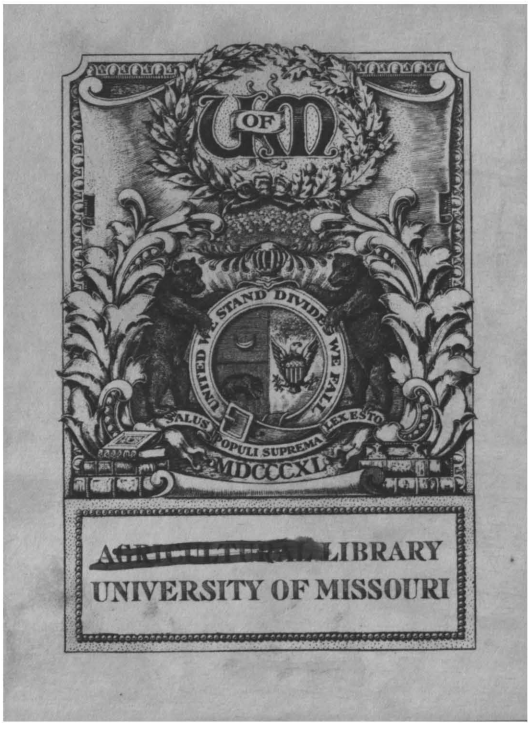

Approved
C. H. Eckles

THE PER CENT OF FAT IN MILK AS INFLUENCED BY THE FATNESS OF THE COW AND THE PLANE OF NUTRITION.

by

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INTRODUCTORY.

The question of the fatness of the cow and plane of nutrition as effecting the per cent of fat in milk has been under invositgation at the Missouri Agricultural Experiment Station for a period of three years. An interest in the question arose from observations made on the fat content of milk at different stages in the period of lactation, and because of the abnormally high tests that were being obtained in seven day records with Holstein cows.

The writer has been connected with this work during the past two years. Considerable data has been obtained and Bulletin 100 of the Missouri Experiment Station has recently been published giving a portion of this data. The scope of the work grows and new problems are confronted as the investigation proceeds.

Many of these phases are only dealt with briefly in this paper. It is expected that the investigation will be continued along this line and the data published in full later by the Experiment Station.

THE PER CENT OF FAT IN MILK AS INFLUENCED BY THE FATNESS OF THE COW AND THE PLANE OF NUTRITION.

It is generally understood that there is an increasing amount of milk solids, particularly fat and casein, with advancing lactation. The breed, the individual, the character of the food to some extent, the age of the cow, and the seasonal conditions are also regarded as factors which can be relied upon to influence the per cent of fat in milk. In addition there is another factor which, as the following data will indicate, has a decided influence upon the per cent of fat in cows milk. This factor is the condition of the animal at the time of parturition as regards the amount of adipose tissue on the body. A few of the possibilities and limitations will also be discussed.

In obtaining data in the investigations carried on by the Missouri Experiment Station in co-operation with the Dairy Division of the U. S. Department of Agriculture concerning the effect of the period of lactation upon the per cent of fat in cows milk, it was found that a hitherto unnoticed factor seemed to have a considerable influence. At first the factor was simply regarded as a detriment in procuring accurate and reliable experimental data. This factor has a very great importance from the standpoint of the investigator where the composition of milk or of fat

is concerned.

Although one phase of the subject has a very important practical application it will be attempted, in the main, to throw light upon the question as one of interest to the scientist. Professor Eckles points out the fallacy of the so called "forced seven day tests" which are very much in vogue at the present time with the Holstein breeder. Table I shows conclusively that there is some factor controlling the per cent of fat in such a way that it is not always lowest during the first part of the lactation period as has been generally taught. It should be understood that "test", as referred to in this paper, is the per cent of butterfat in milk as determined by the Babcock method.

TABLE I.

Official Seven and Thirty Day Tests

of Holstein Cows.

Name of Cow	Av. % Fat 7 days	Av. % Fat 30 days
Pontiac Clothilde DeKol 2d	4.60	4.10
Piertertje Maid Ormsby	5.31	4.54
Grace Fayne 2d's Homestead	5.42	4.59
DeKol Queen La Polka 2d	3.36	3.44
Colantha 4th's Johanna	4.32	3.86
Jessie Folies Bessie Homestead	4.89	3.94
Blanche Lyons Netherland	3.68	3.64
Aaggie Cornucopia Pauline	4.17	4.17
Blanche Lyons DeKol	4.38	3.96
Inka Princess Mutual DeKol	3.74	3.27
Sadie Vale Pietertje	3.80	3.70
Buttercup's Clothilde Pietertje	4.57	4.23
Johanna Colantha 2d	5.02	4.31
Margie Newman	3.02	2.95
Dichter Calamity	4.11	4.00
Nancy Pledge Princess	3.62	3.48

Table I is a list of sixteen among the twenty-five leading Holstein cows in both the seven and thirty day division, as reported by the Holstein-Friesian Association of America.[1] These tests were made when the cows were fresh, the Association permitting the test to begin on the seventh morning following calf birth. It is seen that 14 of the 16 cows have a higher test for seven days than for thirty. The seven day test is included in the thirty day test which causes the thirty day to approach the seven day and also brings the thirty day test well above the average for the year. One cow shows a lower seven day test than thirty and another is the same, while two others are practically the same. It is probable that these four cows were not especially fatted for this test, or that the test did not begin for several days after parturition. In either case the tendency would be for them to approach the normal in accordance with results obtained in this investigation. It is notable that only three of the twenty-five leading cows in the seven and thirty day divisions appear in the leading twenty-five of the yearly records. However, Table II shows clearly that the seven and thirty day tests are above the average for a years period.

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1. Outlines of the Adv. Registry System of the H.-F. Association, Seventh Edition, December 1911.

TABLE II.

Comparison of Tests of Leading Cows in Seven Day, Thirty Day, and Yearly Records.

1.

Records	Above 5 % Fat		Between 4 - 5 %		Between 3 - 4 %		Below 3 %	
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
16 among the 25 leading - 7 day records	3	18.7	7	43.7	6	37.5	None	---
Same cows - 30 day records	None	---	7	43.7	8	50.0	1	6.3
25 leading cows in semi-official yearly records	None	---	3	12.0	20	80.0	2	8.0

1. Seventh Edition of the Advanced Registry System of the Holstein-Friesian Assoc., Dec. 25, 1911.

The data presented in Table II shows that 62.4 % of the cows making these records tested above 4 % fat, and 37.5 % below this figure for the seven days covered by the test. An examination of the records for the thirty day period shows 43.7 % of the cows above, and 56.3 % below 4 %. The records covering an entire year show only 12 % above and 88 % below 4 % fat. These figures indicate clearly that the true average test of cows of this breed is not properly represented by a short period test.

The literature upon this subject is indeed scant. Smith[1] states the milk is as rich the first part of the lactation period as it will be later, except during the last few weeks of milk flow. Collier[2] reports that the fat content of milk exceeds the crude fat of the food during the earlier months but this is not long. The question was first brought before the dairymen in an article by Prof. C. H. Eckles which appeared in Hoard's Dairyman.[3] Since that time there have appeared a few scattering articles in dairy journals both for and against the practice. Those defending the forced tests simply contend that the practice is legitimate and do not attempt to deny that the tests are made under unusual conditions. It will be shown by

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1. Smith (Proc. Soc. Prom. Agri. Sci., 1898 pp 152 - 155)
2. Collier (New York Exp. Sta. Rpt. 1891, pp 124 - 129)
3. Hoard's Dairyman - Vol. XLI, No. 12, p 420.

data taken at this Station, beyond all doubt, that these tests can be influenced in early lactation.

The data which is presented in this paper is taken from members of three dairy breeds viz; Jerseys, Holsteins and Ayrshires. For convenience in the discussion they will be designated by number. It should be borne in mind that the Jerseys are numbered under 100, Holsteins between 200 and 300, and the Ayrshires between 300 and 400.

Only in a few cases have cows been especially prepared for collection of this data. Fortunately there has been an investigation under way at this Station which necessitated having some cows fat and others moderately thin at calving time. These cows furnished a desirable opportunity for securing much data since this experiment did not interfere with the original one.

The evidence easily warrants the conclusion that when cows are fat or moderately fleshy the tests tend to be above the normal for that animal and the breed. In a number of instances these results have been very marked. Ordinarily the tests reach the highest point five or six days after parturition and then commences a gradual decline. The normal is usually reached from twenty to thirty days after calf birth. Very interesting and conclusive data is presented by Prof. C. H. Eckles

of the Missouri Agricultural Experiment Station.[1] He shows that when cows are fat at calf birth an increased percentage of fat will be obtained in the milk for from fifteen to thirty days or even longer under certain conditions. It is shown that this condition becomes more apparent when accompanied by underfeeding and suggests this as being necessary in obtaining high tests. Some of the tables in this paper contain data which was made use of by Prof. Eckles.

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1. Bul. No. 100, College of Agriculture, Agricultural Experiment Station, University of Missouri.

TABLE III

Showing the High Fat Content During The First Twenty Days. Also by Months.

Cow's Fat.

Days after Calving	No. 207	No. 220	No. 221	No. 217	No. 209	No. 225	No. 300	No. 306	No. 223
2	5.8			4.4			4.5		4.1
3	5.7			4.2			4.1		3.3
4	5.4		5.4	4.0			4.0	5.4	3.0
5	4.8	5.5		4.2			4.2	5.9	2.7
6	4.1	5.9	4.6	3.6		3.4	4.5	5.4	3.2
7	4.3	5.8	4.9	3.7		3.8	4.6	5.3	3.2
8	4.2	6.0	4.3	3.8	4.8	4.0	4.4	5.5	3.2
9	3.9	5.5	4.4	3.7	4.2	4.1	4.4	5.2	2.6
10	3.9	7.1	4.2	3.5	4.2	4.0	4.1	5.4	3.9
11	3.6	5.5	4.2	3.7	4.1	3.8	4.2	5.3	3.2
12	3.3	4.8	3.7	3.6	3.8	4.0	3.7	5.0	2.2
13	3.1	4.6	3.6	3.4	4.0	4.0	4.0	4.6	3.2
14	2.9	4.5	3.8	3.2	4.0	3.8	4.1	4.5	3.1
15	3.2	4.8	3.6	3.7		3.6	3.9	4.5	2.6
16	3.0		4.2	3.3	3.6	3.7	3.6	4.3	2.9
17	2.8		3.4	3.2	3.6	3.6	3.6	4.1	3.0
18	2.5		3.4	3.2	3.2	3.7	3.4	4.4	3.1
19	2.9		3.8	3.4	3.4	3.6	3.7	4.1	2.4
20	2.5		3.8		3.2	3.7	3.6		.
Months									
3	2.6	3.0	4.0	3.0	3.1	3.2	3.6	3.6	2.9
4	2.5	3.0	3.4	3.1	2.9	2.7	3.4	3.5	3.5
5	2.8	2.8	3.6	3.6	2.8	3.0	3.9	3.7	3.2
6	2.4	3.0	3.5	3.5	3.2	2.8	4.0	4.1	3.1
7	2.7	2.7	4.3	3.3	2.9	3.6	4.3	4.2	2.9
8	3.1	2.8	4.2	3.4	3.0	3.5	3.8	4.5	2.9
9	3.0	3.2	4.5	3.4	3.6	3.4	3.9	4.9	
10	3.4	3.4	4.8	3.6	3.6	3.5	4.0	4.9	
11	3.3	3.5		4.1	3.4		4.4		
12	3.3	4.0		4.1	3.5				
Av. for Year	2.8	3.3	4.0	3.4	3.1	3.2	3.6	3.8	3.1

The first part of Table III presents the daily butter fat tests of cows that were fat at the time of parturition. In all cases cited in the table the percentage of fat is highest between the third and tenth day. Usually about the seventh or eighth there is commenced a gradual decline. At the end of twenty days the test of some of the individuals has reached the average for the year while others continue high for a somewhat longer period. No. 220 is a Holstein heifer calving in an excessively fat condition as may be seen by the accompanying photograph. The fat percentages are far above the average for the breed as well as for this individual. No. 220 was admitted to the Advanced Registry Official with an average seven day test of 5.2 % made at the time she was fat.

In the lower part of the table is found the tests of these same cows by months in the same lactation period beginning with the third month. This shows the normal fat test for these cows and it should be noted that the yearly averages in every case give conclusive evidence that the early tests were above the normal. No. 207 tested nearly twice as high at first as at any month following. No. 225, whose test did not run as high as the others, was only 20 months old at parturition. Besides she calved prematurely and consequently was not

No-217- Calved in a Fat Condition

No-303- Calved in a Fat Condition

No-221-Calved in a Fat Condition

No-226-Calved Moderately thin

so excessively fat as the others.

In the whole group Cow 223 alone does not give results which are in strict accordance with the others. Upon close study, however, it is found that her test has that tendency to run somewhat higher than the years average. A plausible explanation occurs when the conditions are considered. The cow calved July 24, 1911. This summer was unusually hot and dry and at this particular period, extending for two or more weeks, the heat was intense and the atmosphere depressing. Prof. Eckles[1] has shown that the fat test is higher during the winter months and lower during the summer months regardless of other factors. In this climate the test is always lowest for July and August. This would doubtless account in full for the low tests obtained.

A Study of the Length of Time the Test May be Influenced.

The data presented is constant and uniform and the conclusion must be drawn that at least under certain conditions the fat content of milk is abnormal-

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1. Milchwirtschaftliches Zentralblatt, 11 (1909) p. 488.

ly high during the first part of lactation. It is indeed interesting to know what conditions bring about these results and what factors are conducive to bringing about the results more commonly observed. It is of undeniable concern, both to the practical and scientific worker, to know how long these tests might be expected to remain above normal. Although it seems that they generally reach normal after twenty-five to thirty days, yet it is known that certain conditions will cause a prolongation of the high fat content. When animals that are fat at calving time are fed rather liberally throughout the milking period, the fatness is removed slowly from the body and the test is influenced for from four to six months after parturition. If this be true, and the following data is somewhat leading, then the fat production of a cow might be increased to the maximum for the year by getting high tests the first few months when the milk flow is also highest.

TABLE IV.

Showing the Influence of the Condition of the Cow Upon the Per Cent of Fat.

Fat Percentage by Months.

Month	Cows Fat at Calving				Cows Moderately Thin at Calving.			
	5 Jer's	4 Hol's	2 Ayr's	Av. of All 11	Av. of All 12	6 Jer's	4 Hol's	2 Ayr's
1	5.4	4.0	4.9	4.8	3.5	4.2	2.9	3.3
2	5.1	3.7	3.9	4.4	3.6	4.1	2.9	3.4
3	5.0	3.5	3.9	4.2	4.0	4.5	3.1	3.8
4	5.2	3.3	3.8	4.3	4.2	5.1	3.1	3.8
5	5.3	3.4	3.7	4.3	4.1	5.1	2.9	3.7
6	5.2	3.4	3.8	4.3	4.4	5.5	3.0	3.8
7	5.5	3.5	3.9	4.5	4.5	5.6	3.2	3.7
8	5.5	3.5	4.1	4.5	4.6	5.9	3.1	4.0
9	5.8	3.8	4.5	4.8	4.8	6.1	3.2	4.5
10	6.1	3.9	4.7	5.1	4.7	5.9	3.1	4.7
11	6.1	3.8	5.0	5.2	4.8	5.6	3.7	4.9
12	6.1	4.1	5.2	5.4	5.0	6.1	3.6	5.4
Av. for Year	5.5	3.6	4.3	4.64	4.4	5.3	3.2	4.2

Note:-

Jer's = Jersey
Hol's = Holstein
Ayr's = Ayrshire

Table IV gives data on two groups of cows. One group was fat at parturition and consists of five Jerseys, four Holsteins, and two Ayrshires. It will be noted that with each breed the test is nearly as high the first month as at the last. There is a gradual decline to the fourth month, and practically no further variation until the eighth month when the fat percentages begin increasing.

The other group consists of cows that were moderately thin in flesh. By thin it does not imply that they were ill-nourished by any means but they carried no excess of fatty tissue. In this group there are six Jerseys, four Holsteins, and two Ayrshires. This shows a typical increase in fat percentages with advancing lactation.

By studying the data given in the column showing the average for all the cows in each group it is seen that the moderately thin animals are low at first and gradually increase from month to month. They test .8 % lower for the first month than the average for the year. The other group tests higher in the first month than for the year. Furthermore, they are higher during the first five months than those in the thin group, which is an indication that the per cent

of fat in milk can be effected during the first half of an average lactation period under these conditions. After calving, all of the cows were placed on rations, as soon as the condition of the udder would permit, which were estimated to be sufficient to supply nutrients for milk production above that for maintenance. Under these conditions the cows removed fat but slowly from their body and thus the effect of fatness was extended over a period of from four to six months. The average for the year was .2 % difference in favor of the fat cows and it should be noticed that there is one more Jersey in the thin group than the fat group. The tendency being for the Jersey to test higher than any other breed the thin group is at an advantage in having one more Jersey.

Table V.

Per Cent of Fat by Weeks.

	Cows Fat.								Cows Thin.					
Weeks after calving	No. 303	No. 214	No. 47	No. 2	No. 53	No. 41	No. 54	No. 216	No. 57	No. 215	No. 304	No. 59	No. 55	No. 39
1	4.7			4.6	5.2					3.2	3.5		3.6	
2	4.3	3.9	5.2	4.9	5.3	5.4	5.4			3.0	3.4	4.6	3.9	
3	4.0	3.9	5.5	5.0	5.2	5.0	5.1	3.1		3.2		3.8	4.1	
4	3.9	3.8	5.5	5.0	5.4	5.1	4.8	3.2	3.2	3.2	3.4	4.0	4.5	3.1
5	3.8	3.7	4.5	5.0	5.8	5.3	3.9	3.0	4.0	3.1	3.4		3.8	3.6
6	4.1	3.8	4.9	4.9	5.3	4.5	4.4	3.0	4.4	3.2	3.7	3.8		
7	4.0		4.1		5.3	4.3	4.4	2.7	4.7	3.2	4.1	4.0	3.9	3.3
8	4.3	3.5		5.2		5.1		2.9	4.5	3.0	3.5	4.2		3.5
9	4.2		4.8		5.5	5.0		3.0	4.2	3.2	3.2	4.7		3.7
10	3.9								5.6	3.2	3.9	5.0	4.3	
11	4.0					4.5	4.3		4.5	3.2	3.9	4.5		
12	4.0	3.2		4.5					4.6	3.3	4.0			3.6
Av. for yr.	4.1	3.6	5.2	4.9	5.2	5.1	5.1	3.5	5.3	3.2	4.0	5.1	5.2	5.0

In Table V is given weekly composite tests of cows in both the fat and thin groups for twelve weeks together with the yearly average. It is seen from the data presented that the cows that were fat when calving, test as high (or higher) for each week as they average during the year. It is commonly taught that these are the lowest testing periods and the natural tendency is to gradually increase in fat percentage with advancing lactation. No. 216 alone conforms with the general belief in this respect.

Those in the thin group comply with the natural and normal gradual incline. All except No. 215 are higher for the year than they are for the first twelve weeks of lactation. No. 215 calved in November and consequently the fat percentage is high in accordance with seasonal conditions. It should be understood that these cows that are classed in the thin group are only moderately thin and are not, by any means, in an emaciated state.

After calving, both groups were fed similarly, receiving all the nutrients necessary for maintenance and for yielding milk. It must be concluded therefore, that when a cow calves in a fat condition and is fed a ration nearly sufficient for performing bodily functions, permitting them to gradually remove

No 218 - Calved in a Moderately Thin Condition

No 304 - Calved in a Moderately Thin Condition

excess fatty tissue, the per cent of fat in milk is greater for four to six months than when the cow calves in a thin or moderate condition and that during the first two weeks the test reaches higher than at any subsequent time.

Thin Cows Do Not Yield Abnormally High Tests.

While some data has been presented which shows the test of thin cows to be normally lower than fat cows by weeks and months it is desired to give still more evidence by presenting daily tests following parturition.

№219- Calved in a Moderately Thin Condition

№215- Calved in a Moderately Thin Condition

TABLE VI.

Showing the Low Fat Content During The First Twenty Days. Also by Months.

Cows Thin.

Days after Calving:	No. 39	No. 2	No. 217	No. 220	No. 219	No. 213	No. 226
5			3.2		4.1		
6			3.3	3.4	4.1	3.0	
7			3.6	3.8	4.4	3.3	
8			3.9	3.7	3.6	3.6	
9			3.8	3.6	3.3	3.8	3.4
10				3.6	3.0	3.6	2.8
11				3.7	3.5	3.2	3.0
12	3.5		3.6	3.8	3.6	3.1	3.1
13	3.6		3.2	3.5	3.1	2.8	3.3
14	3.5	4.7	3.5	3.6	3.2	3.1	3.0
15	3.6	4.6	3.4	3.6	3.0	3.3	
16	4.0	4.4	3.6	3.7	3.1	3.3	3.5
17	3.4	4.4	3.8	3.2	3.4	3.4	3.3
18	3.3	4.2	3.7	3.5	2.9	3.2	3.1
19	3.7	4.2	3.4	3.2	3.9	2.9	3.1
20	3.6	4.2	3.8	3.5	3.1	3.2	2.8
21	3.4	4.7	3.6	3.3	3.4	3.3	
22	3.6	4.1	3.2	3.2	4.6	3.7	2.6
23	3.6	4.6	3.7	3.2	4.1	3.5	2.8
24	3.7	5.6	3.6		3.6	3.4	3.0
Months							
3	3.6	5.0	3.4			3.8	
4	4.4	3.9	3.3			2.8	
5	4.3	5.0				2.8	
6	5.4	5.0				3.0	
7	5.6	4.9				3.1	
8	5.5	4.7				3.2	
9	5.8	5.3				3.8	
10	5.6	5.7				3.8	
11	6.0	5.9					
12	7.1	5.8					
Av. for Year	5.0	4.94				3.15	

In table VI is given daily fat tests of seven cows that were only moderately thin when they calved. These cows could not be said to be extremely low in flesh but were in about the condition that a cow would be under good herd management. It could not be said that any of them carried an excessive amount of flesh.

The results are about such as would be found under the general run of conditions. It is seen that the tests are not high the first few days following calf birth, and they are lower than those during the months which follow. It is unfortunate that some of the cows have not completed their milking period at the present time and monthly tests are not available for all.

The daily tests in this table should be compared with those of the fat animals presented in Table III. The fat/yielded by the fat animals gives evidence of a distinct and characteristic decline after the fifth to eighth day while this character is entirely absent among the thin group. In fact, the thin group gives evidence of a slightly increasing percentage which becomes more marked in the monthly test.

TABLE VII.

Record of Two Cows - - Two Lactaction Periods.

No. 207					No. 220			
1908		1910			1912		1910	
Moderate Flesh		Fat Condition			Moderate Flesh		Fat Condition	
Lbs. Milk	% Fat	Lbs. Milk	% Fat	Days after calving	Lbs. Milk	% Fat	Lbs. Milk	% Fat
			5.7	3				
		57.2	5.4	4				
		53.1	4.8	5			24.0	5.5
69.0	2.8	58.7	4.1	6	28.4	3.4	27.0	5.9
59.0	2.4	60.0	4.3	7	28.7	3.8	29.7	5.8
68.5	3.9	65.8	4.2	8	29.1	3.7	31.3	6.0
65.8	3.5	64.2	3.8	9	31.2	3.6	30.5	5.5
70.8	2.8	67.3	3.9	10	29.6	3.6	37.9	7.1
74.1	2.6	74.7	3.6	11	29.5	3.7	34.3	5.5
67.8	3.1	79.4	3.3	12	30.9	3.8	34.4	4.8
69.3	2.7	88.2	3.1	13	31.4	3.5	37.0	4.6
83.5	3.0	84.5	2.9	14	33.1	3.6	37.8	4.5
81.9	2.7	88.0	3.2	15	32.7	3.6	38.3	4.8
80.4	2.7	90.5	3.0	16	32.1	3.7	29.8	4.2
77.4	2.8	93.9	2.8	17	33.7	3.2		
Av. for Year	2.8		2.76					3.3

In Table VII is presented the fat test and milk yield for seventeen days following calf birth of cows 207 and 220. The data consists of two lactation periods for each cow, one when both were excessively fat, the other when they were in only moderate condition. Cow No. 207 is an individual with a natural tendency to test low, as evidenced by the two yearly tests of 2.8 % and 2.76 %. During the first ten days when fat she tested 47.3 % higher than when in a moderate condition of fleshiness. When fat, she was admitted to the Advanced Registry Official of the Holstein-Friesian Registry with a seven day test of 4.1 %. In the lactation period of 1908 she averaged 2.73 % in a seven-day official test.

Cow No. 220 was excessively fat at calving time in 1910. She had been fed a heavy grain ration since birth and had much fatty tissue deposited on her body. The fact that her calf weighed only 33 1/2 pounds when dropped indicated that there was an excessive internal deposition of fat. This is less than half the normal weight of a new born Holstein calf and it died shortly through inability to ingest food. This cow gave the highest percentage of fat of any of the Holstein cows and has an official seven day test of 5.2 %. For the year her average fat

No-220- Calved in a Fat Condition
Seven day test- 5.1 % Fat

No-220-Calved in Moderately thin Condition
Seven day Test- 3.63 % Fat

percentage is 3.3 . Her second lactation period is not complete at present; hence no test for the year is given. The photographs of No. 220 represent the condition of the animal at both periods.

The findings cited above give a striking indication of what might be expected when cows are fat. In both trials the cows removed fat rapidly from their body because their condition would not permit of heavy feeding. The nutrients supplied being insuffficient for performing the body functions, the reserve tissue was broken down rapidly. In Table VIII is given data from fat cows and thin cows during two lactation periods which shows that the cows when fat may test high over a considerable period when fed a ration supplying or nearly supplying the requirements in nutrients.

TABLE VIII.

Comparison of Fat Content of Milk

First and Second Lactation Periods.

Given in Percentage

Month	6 Cows		8 Cows	
	Cows Fat	Cows Normal	Moderately Thin	Cows Normal
1	4.8	4.5	4.0	4.6
2	4.7	4.4	3.9	4.5
3	4.7	4.3	4.3	4.8
4	4.8	4.3	4.8	4.7
5	4.9	4.4	4.7	4.9
6	4.7	5.1	4.9	5.1
7	4.8	4.7	5.1	5.0
8	4.9	5.1	5.3	5.4
9	5.3	5.5	5.5	5.6
10	5.5	5.6	5.4	5.6
11	5.7	5.4	5.2	5.9
12	5.7	5.4	5.7	5.8

As soon as the condition of the cows would permit they were placed on a ration which was intended to maintain their normal body functions and support the milk yield. The results are interesting. In both cases the cows were in their second lactation period. For the first five months the fat cows are much higher in test during the first period than during the second. In the other group it is seen that the thin cows are lower in test the first three months than they were when in normal flesh. Also that during the first three months the fat cows gave a higher average percentage of fat than was produced by the thin cows. The absolute as well as relative butter fat produced by the cows when fat exceeded that yielded by the thin animals during the first three or four months, which would suggest that it might be profitable to fatten milk cows during the last month or two of gestation. The average for the year was about 25 pounds of fat in favor of the fat cows, which is sufficient to yield about 11 % more than that yielded by thin cows. In case this can be done under all conditions it might be recommended for herd practice. The data is insufficient, however, to warrant these conclusions since the fat animals were fed liberally

while young and had the advantage of the other cows in that they had attained a greater development of body and organs at calving time.

The thin and fat groups of cows are subdivided into early and late calving. In order to eliminate the factor of partial development the animals selected for Table IX are all selected from the late calving group. Those in this group are bred to give calf birth at about thirty-three months of age, consequently the thin animals are quite well developed and are not placed at the disadvantage of being immature. When other cows of this group have finished their second milking period much valuable data will be had upon this question.

TABLE IX.

Showing Percentage Increase In The Fat Yield Over First Year.

350 Days in Milk.

Fat Group				Thin Group			
No. Cow	First Lactation	Second Lactation	% Increase or decrease	No. Cow	First Lactation	Second Lactation	% Increase or decrease
41	295	385	30.5	50	350	472	34.9
54	325	318	-2.2	59	259	301	16.2
53	259	217	-14.7	213	201	238	18.3
303	283	267	-6.0				
214	224	255	13.8				

Average Increase over First year - 4.4 %

Average Increase over First year - 24.9 %.

All the cows are in their first and second lactation, so the influence of age should be equally felt in both groups. It is shown in this table that three of the cows in the fat group actually show a decrease in the pounds of fat produced in the second lactation under that of the first. On an average the increase for the five cows was 4.4 %. The thin animals each show an increase in fat production and the average percentage increase is 24.9. In a table prepared from records of the Jersey herd at the University of Missouri[1] an increase in fat yield in the second year over that of the first is 13 %. This would indicate that the thin animals fall considerably below the normal production during the first year while the fat animals go so far above, that the influence of age, in the second year, is over balanced. This data shows that the fat cows produced about 25 % more fat the first year than the normal due simply to their better condition at calving time. It seems that the per cent of fat in milk yielded by the fat cows during the first year was about .2 % lower than in the second milking period. Normally an increase over the first year would be expected.

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1. Prof. Eckles, Dairy Cattle and Milk Production, p. 150, (1911)

It would not be wise to conclude without further evidence that animals in a very fat condition have a decided advantage over thin animals throughout the year, although from the tests presented and the data given in Table IX the indications warrant this supposition.

Experience teaches that the development of the fetus is greatly impeded when the dam is excessively fat. Unpublished data at this Station seems to substantiate this observation, the calves from such cows being small and weak when dropped. They weigh much less than the average, some are born dead, and many others die shortly through weakness. While it cannot be denied that it is desirable to have cows in good condition at calving time yet it could not be recommended that they calve in an excessively fat condition where the calves are of much value.

It is shown that the cows condition may influence the butter fat test to a marked extent during early lactation and that this factor must be reckoned with by both the investigator and practical worker. Butter fat tests from fat cows during early lactation should by no means be taken as an accurate index to the normal richness of a cows milk.

High Tests are Accompanied by Loss of Body Weight.

From the data presented in the preceding pages it is seen that a cow can be made to produce a high per cent of fat in her milk when she calves in a fat condition. Some of the Holsteins in this experiment yielded milk with an almost incredible fat content. Cows in moderate flesh do not show this character to any extent and thin cows may even test lower than normal at this stage. What is the significance of a high test at this period? Is it brought about by an increased activity of the digestive organs in assimilating foods, or is it a stimulated action of the secretory cells of the mammary glandular tissue?

Whatever else takes place in the body of the animal it is assured that certain tissues, stored on the animal body, are being used to furnish the ingredients of milk. Among other ingredients there is a considerable amount of fatty tissue broken down and taken into the blood and lymph streams. It has been found[1] that foods rich in fat increase the fat content of blood and its plasma to the extent of making it milky turbid, the plasma otherwise being clear. I. Munk and Friedenthal[2] state that the normal fat content of blood may be increased six times when a liberal supply of cream is consumed.

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2. Zent. Physiol. 15, 297 (1901) (p. 108 Abderhalden)
1. Abderhalden, Physiologie Chemie, p. 109.

The excess of fat soon disappears, some being utilized in fuctioning the body, the remainder being stored in fat-cells as body fat.

It would seem that the same condition might exist when an animal calves in a fat condition. The stimulation to produce milk, brought about by formation of hormones at parturition, is very great and the fat animal is physically fit to supply much nutrients at a stage when it is unable to ingest large quantities of food. Franz Hofmann[1] conducted a starvation experiment with a dog. The animal first used glycogen, then fat and after the fat supply was exhausted a rapid decomposition of albumen commenced as evidenced by an increased nitrogen elimination. The amount of glycogen stored is not great consequently the fat is soon called upon. But the nutrient requirements of an animal producing milk are much different than those of an animal at rest. In colostrum milk the nitrogen content is very great due to the presence of large amounts of albumin. Even when the albumin has become normal the nitrogen demand is considerable; thirty pounds of average milk containing approximately 1.02 pounds of proteids. The fat broken down cannot furnish all of the necessary milk constituents and much protein tissue is also decomposed leaving a rich supply of the emulsified fat in the blood plasma. These fluids transport the fat to the

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1. F. Hofmann. Z. Biol. 8, 153 (1872) (p 109 Abderhalden.)

udder where the secreting cells transform, or partially transform, it into milk fat.

A. Bode[1] states that colostrum fat lies between body and milk fat in its composition. Unpublished data at this Station taken in Co-operation with the Dairy Division, U. S. Dept. Agriculture confirms this statement. Samples of milk were taken from cows that were fat and fed less than full requirements. Analysis of the butterfat reveals many properties similar to the body fat. This fat possesses a decided lower Reichert-Meissl number, a much higher Iodine number, rather lower Saponification number and slightly higher melting point than that of normal butterfat.

It has been definitely shown by I. Munk[2] and later by many others that food fat may have considerable influence on the nature of fat found in the fat-cells. This is the first fat removed as reserve material. Abderhalden and Brahm[3] show that the fat which is used to build up the body cells is independent of the food fat and is a body made substance. The fat in the milk must come, therefore, from the fatty deposits or the so called "fat depots". Greene[4] has found that a large quantity of finely divided fat makes its appearance in the muscle fibers as soon as the salmon enter the fresh water

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1. Inaug. Diss. Univ. Bern, 1909 p. 45
2. Arch. f. (Anat. V.) Physiol. 1883, 273; Virchow's Arch. 95, 407 (1884).
3. Fert. für Physiolog. Chem. 65, p. 330, 1910
4. Jour. Biological Chem. XI, pp XVIII-XX, Mch. 1912.

of rivers at spawning time. During this migration the fish is fasting and intrafibrous fat is present at all stages of the journey in quite uniform amounts. At the time of death the intramuscular fat has disappeared in the large fibers although it may still be found in the smaller ones. The conditions which exist may not be unlike a body in a state of adipocere. Hill[1] says that putrefactive colliquation of the proteids ensues, fat being set free from the depots and percolates through the tissues. The fats set free in the body of a fasting animal are largely neutral and it seems very plausible that it may be freed in this manner.

Since this transformation of body fat is taking place it might be expected that the animal is undergoing a decline in weight and this is exactly what occurs. The deduction is that the greater the loss in body weight the greater the abnormality of fat content and this seems unquestionably true, at least under unvariable conditions.

1. Physiol. and Bio-Chemistry, p 293.

TABLE X.

High Tests are Accompanied by Loss of Body Weight.

Days After Calving	Cow No. 20		Cow No. 206		Cow No. 305		Cow No. 300	
	% Fat	Weight	% Fat	Weight	% Fat	Weight	% Fat	Weight
2	4.37	830	3.5	1370	5.62	840	4.21	1017
4	5.80	807	3.35	1235	5.36	840	4.04	1037
6	6.89	790	3.87	1280	5.35	835	4.39	1003
8	7.21	787	4.47	1260	5.33	825	4.52	1014
10	6.60	785	3.64	1255	4.79	837	4.25	1005
12	5.86	780	3.40	1225	4.53	835	3.97	997
14	6.82	765	3.86	1187	4.40	831	4.05	968
16	6.00	755	4.03	1170	4.26	835	3.71	975
18	5.07	755	3.76	1145	4.07	839	3.52	987
20	4.94	730	4.39	1130	4.00	812	3.67	985
22	6.37	730	4.07	1130	3.77	817	3.52	995
24	6.82	725	3.86	1132	4.00	817		
26	5.70	720	3.83	1145	3.88	825		
28	6.26	720	3.35	1165	3.78	820		
30	5.60	710	3.24	1152	4.10	797		
32	5.53	690	4.03	1135	3.90	817		
34	4.74	710	3.63	1120	3.95	822		
36	4.28	710	3.43	1122	3.95	802		
38	4.49	720	3.52	1160	3.90	800		
40	4.45	710	3.23	1155	3.55	802		

In Table X is given the tests and live weights of four animals during the first forty days after parturition. All of these cows were exeessively fat when they freshened, having been previously fitted by liberal feeding of grain for two or more months. The data is somewhat incomplete for No. 300 but it can be seen that there is a gradual decline in weight from the time of parturition. In the case of No. 20 it is noticed that the loss of weight is quite rapid during the first thirty days. During this period the per cent of fat in milk was higher and remained higher above the normal than those cows that did not experience such a rapid loss. No. 206 underwent a rapid decline in weight to about the 25th day. At this point her test also became about normal and did not have any tendency to remain high except for one high test on the 32d day.

A close study of this table teaches that the test is appreciably higher when the animals are fat at parturition and are allowed to lose weight. It could be safely assumed that all cows that are fat or moderately fat lose weight, at least for a short time following calf birth, since they are less likely to be in condition to consume such a large amount of feeds as one less fat. In fact it is a common observation that cows become thinner in flesh following parturition. But if they do not carry any surplus flesh they quickly regain their appetite and if feed is available will sustain their body without losses of live weight.

Live Weight by Months.

Group.	1 Mo.	2 Mo.	3 Mo.	4 Mo.	5 Mo.	6 Mo.	7 Mo.	8 Mo.	9 Mo.	10 Mo.	11 Mo.	12 Mo.
Group I Cows Fat ① 1st Lactation	1030	940	952	944	944	961	958	959	974	983	1015	1041
Group II Cows Thin ② 1st Lactation.	762	721	742	760	778	792	796	817	818	849	877	896
Group I Moderate ③ Flesh 2nd Lactation	969	952	945	947	946	943	969	975	975	1011	1034	1057
Group II Moderate ④ Flesh 2nd Lactation.	783	778	795	801	812	824	831	844	870	888	904	931

① 5 Jerseys - 4 Holsteins - 2 Ayrshires.
② 5 Jerseys - 4 Holsteins - 2 Ayrshires.
③ 4 Jerseys - 1 Holstein — 1 Ayrshire.
④ 4 Jerseys - 1 Holstein — 1 Ayrshire.

TABLE XI

In Table XI is given weights by months of cows fat and cows thin at parturition. Group I comprises eleven cows that had been fed very heavily previous to parturition. In fact, since they had become old enough to consume grain they had received all they would eat as they were in another experiment which made this necessary! However, after calving they were fed in compliance with their approximate requirements which was not enough, as the table shows, to prevent them removing some body weight. It is seen, in the first lactation, that there is a large loss of body weight during the first month and by referring to Table III it is noticed that these same cows show very high tests at this time. The weight, as evidenced by the scales, remains quite constant for seven months following the first, but in Table III it is seen that the tests continue high for four or five months. While the scales do not indicate a loss in weight it could be seen that these cows were undergoing a change in type or conformation, losing the smooth beefy appearance and becoming angular over the back , withers and rump as is characteristic of a good dairy animal. While the loss of weight was not indicated by the scales yet the internal fat was doubtless being removed, and replaced by watery fluids; also the alimentary tract was being extended, due to the consumption of large amounts of roughages.

These cows commenced their second lactation period in moderate condition experiencing only a slight decline in weight the first two months and the test in Table VIII is in accord since it is not higher than might be expected. At the seventh month a gradual increase in weight commences and this is typical of properly nuurished cows in advanced lactation, and especially during the last four or five months of the gestation period.

Group II contains the same number of cows that were thin when they calved. They show a slight decline in weight the first month but this is true of all the groups and would hold under any similar condition. The first weights are averages of weights taken on three consecutive days succeeding parturition and any cow might be expected to be somewhat higher in weight at this time due to the presence of large quantities of body fluids necessary to fetus development. After the first month there is a steady increase in weight which is doubtless what normally takes place.

Using Tables VI and VIII in conjunction with these weights it is seen that, as might be expected, the tests are low during the first few months. Later the test becomes higher even though the animal is gaining weight but here advancing lactation over-balances the factor in question. In the second lactation only six animals are used in order to keep them on the same basis as Group I.

During this lactation about the same conditions prevail as were pointed out in the same group, first lactation and Group I, second lactation.

The weights for the second lactation periods in both groups are somowhat lower than the corresponding months of the first period which is due to the use of only 25 % of the Holsteins taken in the first lactation, while 80 % of the Jerseys and 50 % of the Ayrshires are used. The Holsteins being the heavier breed reduced the average weight. The Holstiens were necessarily limited in the second lactation as only one of the fat ones has completed the second milking period at this time.

Influence of the Plane of Nutrition.

Since it is shown in the preceding tables that loss of body weight is usually accompanied by an increased amount of fat in the milk it is suggested that underfeeding an animal may bring about the same results by making it necessary to draw upon the reserve tissue in functioning the body. Lusk[1] found that the per cent of fat was very much increased when a goat was starved. His experiment is given in full below:

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1. Science of Nutrition, p. 237.

Milk in c.c	Fat in gms.	Fat in per cent.	
460	26.50	5.76	
470	25.90	5.52	
338	23.90	6.23)	
198	18.35	9.27)	Starvation
232	18.75	8.08	
298	16.30	5.47	
248	19.40	5.61	
362	22.30	6.16	
490	27.70	5.66	

The effect on the fat percentage in the milk was immediate. The milk yield was also decreased. Such immediate effects could not always be expected from such a large animal as a cow having so much reserve nutrients in the organism. It is well known that the goat yields more milk than the cow in proportion to the body weight. The condition of the goat as to fatness is not stated.

Lusk's[1] theory to explain this high fat content is summarized as follows: When suffieient sugar is not oxidized in the body cells the sugar hungry cells attract fat. Dextrose is converted into milk sugar in the mammary gland and cannot then be burned in the organism, the mammary cell becoming a sugar hungry cell attracts large amounts of fat which is present in the blood.

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1. Science of Nutrition, page 239.

Wing and Foord[1] conducted an experiment which involved the use of a small herd of cows for four years. The first year they were fed under typical farm conditions and the milk and fat yield recorded. The next two years they were removed to the University dairy barn and given a liberal food allowance and an increased yield was noted as well as an increased fat percentage. The fourth year they were returned to the same farm as during the first year and a decreased yield was recorded demonstrating the value of proper and generous feeding. However, most of the cows showed a decreased fat percentage in the fourth as compared with the first year; but cows that had remained at the farm showed an even greater decrease under the first year showing that some factor other than the feed was concerned. Since those cows which were taken to the University gave an average of 0.1 per cent more fat for the year after returning it is suggested to the writer that they were in better condition than those remaining on the farm, and when on a partial starvation diet yielded an increased fat percentage in the milk.

At this Station a number of trials have been made with cows that were previously fattened by having them dry for six weeks to three months before calving and feeding a very liberal grain ration. After calving records were kept of feed consumed, milk and fat yielded and the daily live weights.

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1. Cornell Agr. Exp. Sta. Bul. No. 222

Experimental Ration

All of the cows in question received the same grain ration which consisted of a mixture of four parts of corn chops, two of barn and one of linseed oilmeal (old process). The hay is a good quality of alfalfa and in addition some cows were fed corn silage while others were fed green alfalfa.

In order to get the nutrients consumed and the nutrients required on an easily comparable basis all were reduced to their energy value. The energy value of feeds is that possessed by virtue of the heat or energy available as such to the animal. By this standard one hundred pounds of a mixture of grain consisting of corn four parts, bran two parts and oilmeal one part yields 75.2 therms; one hundred pounds of alfalfa hay yields 34.4 therms; one hundred pounds of corn silage 16.6 therms; and one hundred pounds of green alfalfa 12.4 therms.

The value of one pound of average milk was obtained from a report of the work with two Jersey cows by Prof. Eckles[1]. The milk yielded by the cows had an average of 5.41 % fat, 4.98 % protein and 4.56 % sugar, a combustion value of .417 therm. Subtracting the ration of maintenance it was found that .391 therm was required to produce one pound of this milk. The average composition of milk containing 3 %, 4 % and 5 % fat was obtained from

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1. Mo. Exp. Sta., Research Bul. No. 2, p. 130

a large number of analyses which are as yet unpublished at this Station. Milk having 3 % fat was found to contain 4.5 % sugar and 2.91 % protein, a pound of which yields .283 therm on combustion.

Hence, .417 : .391 :: .283 : x

x = .268 therm to produce one pound of 3 % milk.

A milk containing 4 % butterfat has 5.05 % sugar and 3.51 % protein, a combustion value of .351 therm per pound.

.417 : .391 :: .351 : X

X = .329 therm to produce one pound of 4 % milk.

A milk containing 5 % butterfat has on an average 4.97 % sugar, and 3.66 % protein, a combustion value of .393 therm per pound.

.417 : .391 :: .393 : X

X = .369 therm to produce one pound of 5 % milk.

From these figures the following valuations were calculated:

% Fat in Milk	Therms Required per lb.
5.4	.391
5.2	.380
5.0	.369
4.8	.361
4.6	.353
4.4	.345
4.2	.337
4.0	.329
3.8	.317
3.6	.305
3.4	.293
3.2	.281
3.0	.268

The calculation for maintenance of live weight is made on the basis of .615 therm for 100 pounds daily.

In Table XII is given data from a Jersey cow that had been fed a heavy grain, silage and hay ration for 60 days before calving. She became very fat but calved without difficulty on March 29, 1909 and was immediately placed on a ration which was decidedly below her requirements. She remained on this subnormal ration 30 days which was sufficient only to maintain the animal at rest. At the end of this time the cow was perceptibly in a state of inanition, but continued to produce nearly as much milk as at the beginning. Immediately following parturition the tendency to yield milk is so strong that the body tissue is greatly sacrificed. During this period of low feeding the cow had lost about 115 pounds and when the ration was increased to near normal she ceased to lose weight. The accompanying photographs illustrate her condition at the beginning and at the end of the 30 days.

TABLE XII.

Effect of Underfeeding Upon the Per Cent of Fat in Milk.

Jersey Cow No. 20

Days After Calving	% Fat	Pounds of Milk	Grain Fed Lbs.	Hay Fed Lbs.	Live Weight	Energy Supplied (Therms)	Energy Required (Therms
2	4.4	22.2	3.5	7	830	5.04	14.50
4	5.8	20.9	3.5	7	807	5.04	13.86
6	6.9	22.3	3.5	7	790	5.04	14.32
8	7.2	23.1	3.5	7	787	5.04	14.68
10	6.6	22.6	3.5	7	785	5.04	14.44
12	5.9	21.5	3.5	7	780	5.04	13.94
14	6.8	20.0	3.5	7	765	5.04	13.12
16	6.0	19.1	3.5	7	755	5.04	12.77
18	5.1	21.8	3.5	7	755	5.04	13.92
20	4.9	17.2	3.5	7	730	5.04	11.81
22	6.4	19.0	3.5	7	730	5.04	12.58
24	6.8	19.6	3.5	7	725	5.04	12.79
26	5.7	19.1	3.5	7	720	5.04	12.55
28	6.3	17.8	3.5	7	720	5.04	12.00
30	5.6	19.9	3.5	7	710	5.04	12.83
32	5.5	20.4	3.5	7	690	5.04	12.93
34	4.7	24.4	7.0	11	710	9.04	12.68
36	4.3	25.4	7.0	11	710	9.04	13.02
38	4.5	25.0	7.0	14	720	10.08	12.94
40	4.4	25.0	7.0	14	710	10.08	12.88
42	4.0	27.2	7.0	14	715	10.08	13.76
44	4.8	26.7	7.0	14	740	10.08	13.64
46	4.3	26.1	8.0	16	700	11.52	13.20
48	3.8	25.9	8.0	16	735	11.52	13.37
50	4.2	27.0	8.0	16	747	11.52	13.39
52		25.6	8.0	16	725	11.52	13.17
54	4.0	25.7	8.0	16	715	11.52	13.12
56	4.5	23.7	8.0	16	720	11.52	12.48
58	4.4	24.3	8.0	16	740	11.52	12.80

No-20- Excessively Fat at Begining of Trial

No-20- Condition After Starving 30 Days

When No. 20 was placed on a higher ration the milk yield increased somewhat. The fat content immediately decreased until it became lower than the normal for the year, the weight remaining constant for a few days then increased slightly. The calculations in the table are made upon the basis of 6 % fat for the first 32 days and 4.3 % which is the average for the remaining period. This animal was then continued on a normal ration during the remainder of the lactation period and in the third month from calving tested 4 %. The fourth month 4.1; the fifth 4.5; the sixth 5.2; the seventh 5.2; the eighth 5.6; the ninth 5.5 %. The average for the year was 4.8 %. It is seen that the fat for the first thirty days is abnormal for this animal and underfeeding is apparently very closely connected with this unduly high fat content.

Cow No. 206 was fed a heavy grain ration for 40 days before calving. She was in very good flesh even at the beginning but made rapid gains on grass and 16 to 20 pounds of grain daily. The cow calved on August 8, 1909 and was placed on an approximate maintenance ration at once, maintenance being the nutrients required to maintain the normal body functions without loss of weight provided the animal was not producing milk. A loss in weight and a high per cent of fat in the milk resulted. She did not appear particularly hungry like a staving animal but was dull and listless. The accompanying photograph illustrates the condition of the cow at the beginning and at the end of this period.

No. 206 - Excessively Fat at Beginning of Trial

No. 206 - Condition at the End of 30 Days

TABLE XIII.

Effect of Underfeeding Upon the Per Cent of Fat in Milk.

Holstein Cow No. 206.

Days After Calving:	% Fat	Pounds of Milk	Grain Fed Lbs.	Hay Fed Lbs.	Live Weight:	Energy Supplied (Therms)	Energy Required (Therms)
1	3.5	28.4	4.5	9	1370	6.48	16.94
3	3.4	31.2	4.5	9	1235	6.48	16.98
5	3.9	35.4	4.5	9	1280	6.48	18.49
7	4.5	25.8	4.5	9	1260	6.48	15.48
9	3.6	30.7	4.5	9	1255	6.48	16.92
11	3.4	34.0	4.5	9	1225	6.48	17.73
13	3.9	33.2	4.5	9	1187	6.48	17.25
15	4.0	30.7	4.5	9	1170	6.48	16.45
17	3.8	30.6	4.5	9	1145	6.48	16.22
19	4.4	26.5	4.5	9	1130	6.48	14.90
21	4.1	25.4	4.5	9	1130	6.48	14.57
23	3.9	26.6	6.5	13	1132	9.37	14.94
25	3.8	31.0	9.0	18	1145	12.96	16.34
27	3.3	31.2	9.0	18	1165	12.96	16.52
29	3.2	30.1	9.0	18	1152	12.96	16.21
31	4.0	27.5	9.0	18	1135	12.96	15.13
33	3.6	27.4	10.0	20	1120	14.40	15.10
35	3.4	29.1	10.0	20	1122	14.40	15.62
37	3.5	29.8	10.0	20	1160	14.40	16.07
39	3.2	30.1	10.0	20	1110	14.40	15.85
41	2.9	37.4	10.0	20	1200	14.40	17.60

In Table XIII is given the results of the trial with cow No. 206. She received a low ration for 23 days during which time she lost weight rapidly and her milk contained a high per cent of fat. On this ration No. 206 produced nearly as much milk as when placed on the higher plane, but at a sacrifice of her tissues. When placed on a higher ration the fat percentage quickly approached the normal. The cow was on a normal ration during the remainder of the lactation period and tested 2.9 % in the third month. The fourth month 2.7; the fifth 2.6; the sixth 2.6; the seventh 2.8; the eighth 3.0; the ninth 2.8; the tenth 2.8; and the eleventh 3.2 %. The average for the year was 2.99 % showing that she was far above the average during the period of insufficient nutrients. The average for the entire 41 days reported is 3.5 % which is the figure used in determining the energy required.

Cow No. 300 is an Ayrshire cow that was fed a very heavy grain ration for two months before calving and became very fleshy. On June 10, 1910 the cow calved and was immediately placed on a ration which was sufficient for maintenance and to supply the nutrients for about one-half the milk yielded. The milk yield quickly increased to about 38 pounds per day which was considerably more than could have been produced from the food supplied. The data obtained on this trial is presented in Table XIV.

TABLE XIV.

Effect of Underfeeding Upon the Per Cent of Fat in Milk.

Ayrshire Cow No. 300

Days After Calving	Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
1	3.9	24.4	1005	2.99	14.50
2	4.5	27.9	1030	9.69	15.44
3	4.1	31.9	1055	9.69	15.91
4	4.0	35.5	1020	9.69	17.99
5	4.2	36.0	1010	9.69	18.09
6	4.5	38.3	996	9.69	18.76
7	4.6	35.8	997	10.77	17.94
8	4.4	32.8	1031	10.77	17.16
9	4.4	35.7	1005	11.07	17.96
10	4.1	38.6	1005	11.19	18.91
11	4.2	40.4	1000	10.27	19.48
12	3.7	39.5	995	11.19	19.15
13	4.0	40.5	960	11.19	19.29
14	4.1	41.6	975	11.19	19.72
15	3.8	39.9	960	11.19	19.07
16	3.6	39.0	990	11.19	18.95
17	3.6	40.4	1000	11.19	19.48
18	3.4	39.2	975	11.19	18.93
19	3.7	37.3	990	12.70	18.39
20	3.6	37.2	980	14.20	18.30
21	4.0	40.5	990	14.20	19.45
22	3.1	38.2	1000	13.33	18.75
23		40.9		15.04	
24		41.1		16.66	
25		41.7		15.80	
26		40.5		16.66	
27		41.8		16.66	
28		43.3		17.03	
29	3.23 (Composite sample 29 - 36 days inclusive)				

Note:-

Ration consisted of grain, hay and green alfalfa to the 23d day when the green feed was discontinued and the hay and grain increased.

The calculations for requirements in energy are made on the basis of a 4 % fat content of milk. The green feed consists of alfalfa freshly cut from the field.

The cow was underfed for about 25 days. The fat in the milk is high, testing over 4 % during the first 15 days. A gradual loss of weight is also noted. This data demonstrates that even when a fat animal is only partially starved a high fat content of the milk will result. On the 28th day the energy supplied nearly reaches that required. A butterfat test was not made from the 23d to the 28th day but a composite from the 29th to the 35th is 3.23 %, which corresponds closely to the test obtained on the 22d day.

In the third month following calf birth the test was 2.7; the fourth 2.7; the fifth 3.6; the sixth 3.4; the seventh 3.9; the eighth 4.0; the ninth 4.3; the tenth 3.8; the eleventh 3.9;%. The average for the year is 3.55 %. The accompanying photograph shows the condition of the cow before and at the end of this trial.

Cow Fat and Fed Normally

Cow No. 301 is also an Ayrshire and was fed a heavy grain ration along with No. 300. At the time of calving (June 20, 1910) she carried an excessive amount of body fat, although it is doubtful if she was as fat as

No. 300 - Calved in a Fat Condition

No. 300 - Condition after Being Underfed

No. 300. It was intended to place this cow on a ration which was sufficient to supply all necessary nutritive requirements and thus prevent the loss of body weight. The effect upon the fat content of the milk was to be observed. Owing to the condition of the animal and the season of the year it was impossible to place her on a ration adequate to prevent loss of weight for fear loss of appetite might ensue and the trial rendered valueless. The difficulties of such an experiment are apparent. However, the results in Table XV show that the effect of large amounts of nutrients was very counteracting to the high fat content obtained in the previous trials.

TABLE XV.

Cow Fat and Fed Normally.

Ayrshire Cow No. 301

Days After Calving	Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
2	3.23	28.3	1005	10.65	14.81
3	3.34	30.6	1000	11.94	15.48
4	3.87	35.5	1010	13.66	16.03
5	3.69	35.1	1030	13.12	18.03
6	3.67	34.8	1025	14.30	16.91
7	3.78	34.3	1020	11.74	16.73
8	3.91	36.4	1025	15.80	16.40
9	3.26	36.8	1005	15.80	17.40
10	3.68	36.4	1025	13.22	16.40
11	3.69	37.4	1025	14.99	17.70
12	3.55	35.1	970	12.36	16.66
13	3.61	37.4	995	15.22	17.50
14	3.61	36.0	985	14.53	17.04
15	3.61	37.3	980	15.22	17.39
16	3.61	37.0	970	15.22	17.24
17	3.61	38.5	980	15.22	17.74
18	3.61	36.7	955	15.22	17.06

Note:-
Ration consisted of grain, hay and green/alfalfa to the 12th day when the green feed was discontinued. The hay was increased to supply the deficiency.

The average percentage of fat is taken as 3.6 for the calculations. Green feed consisting of green alfalfa cut fresh from the field was fed.

This cows is of the same breed and age, was prepared similarly and handled in practically the same manner as No. 300, except that she received a larger amount of nutrients. The fat percentage is much lower and is below the average for the year. The milk production of this cow did not reach more than 40 pounds during this lactation thus she was producing close to the maximum amount the latter part of the trial. The loss of weight is slight but on the twelfth day following parturition the green feed was discontinued because no more was available. The loss in weight is largely due to the change in ration, there being an actual reduction in the pounds of food ingested. Although the grain was increased to cover the deficiency in nutrients.

The fat test for the last six days is represented by a composite sample. The results indicate that even though an animal is fat it is essential that the ration be low enough to necessitate the use of the stored tissue in functioning the body and supplying the milk ingredients. In all probability the test would have been even lower had the ration been such as to exactly supply the demand.

No. 301 tested 3.2 % fat in the milk the third month following parturition. The fourth 3.8; the fifth

3.8; the sixth 4.0; the seventh 4.2; the eighth 4.1; the ninth 4.0; the tenth 4.3; the eleventh 4.5; and the twelfth 4.6 %. The average for the year is 3.99 % which shows that the test during the first few days following dalf birth was lower than the year's average.

The next trial is an experiment with the Ayrshire cow No. 306. This cow had been previously fed a heavy grain and hay ration during her entire life and calved on March 7, 1911 at about 30 months of age. The results obtained are presented in Table XVI.

TABLE XVI.

Effect of Underfeeding.

Ayrshire Cow No. 306.

Days After Calving	Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
4	5.6	17.5	840	5.63	11.35
6	5.4	19.3	840	6.37	12.02
8	5.3	20.1	835	5.44	12.26
10	5.3	18.7	825	6.71	11.71
12	4.8	20.2	848	7.17	12.36
14	4.5	20.7	832	8.85	12.46
16	4.2	22.5	837	9.40	13.16
18	4.3	22.5	833	9.40	13.09
20	4.1	23.5	821	9.77	13.24
22	3.8	24.0	817	11.08	12.42
24	3.9	24.2	818	11.25	12.64
26	3.9	24.6	820	11.25	12.80
28	3.8	24.2	823	11.25	13.07
30	3.9	23.2	803	11.25	12.71
32	4.1	23.1	812	9.37	12.33
34	3.9	22.6	820	8.24	12.24
36	4.0	21.8	815	8.24	12.06
38	3.9	21.1	803	8.24	11.72
40	3.9	21.5	802	8.24	11.50
42	3.6	22.6	800	9.75	11.63
44	3.4	23.3	812	11.25	11.93
46	3.7	22.2	810	11.25	12.11
48	3.7	20.6	804	11.25	11.74
50	3.8	21.6	816	11.25	11.73
52	4.0	20.7	801	11.25	11.25
54	3.8	22.0	814	11.25	11.72

Note 1:-

4 - 20 days av. per cent fat, 4.79
22 - 32 days av. per cent fat, 3.89
34 - 42 days av. per cent fat, 3.80
44 - 54 days av. per cent fat, 3.73

Note 2:-

Ration consisted of grain, hay and silage.

During the first twenty days following parturition the cow was fed a ration which was considerably below the requirements and produced an average of about 4.8 % fat. At the same time she declined in weight very preceptibly. From the 22d to the 32d days inclusive she was an a ration which was nearly sufficient to supply the required nutrients. The test as well as the body weight showed no inclination to decline, both remaining quite constant and continued thus to the 42d day. While the test was not higher than the previous days a sharp decline was apparent in both the fat test and weight. This decline is typical as evidenced by the test from fat cows reported in Table III and elsewhere in this paper. When the ration was again increased to near normal the weight became constant as did the per cent of fat.

The third month following parturition No. 306 tested 3.6 %. The fourth 3.6; the fifth 3.4; the sixth 3.7; the seventh 4.1; the eighth 4.2; the ninth 4.5; the tenth 4.9; and the eleventh 4.9 %. The average for the year was 3.8 %, being considerably lower than the test at the beginning of the trial.

No-306-Averaged above 5% for First 12 Days

No-307- Averaged above 3.5% at First of Period

Effect of Underfeeding in Advanced Lactation.

All the trials reported thus far were made in early lactation closely following parturition. Should similar results be expected from a cow in advanced lactation? Three trials were made, two with Jersey cows, the other with a Holstein, that were in a moderately fat condition and the same results obtained. However, one condition was met which did not prevail to a very marked extent, with cows that had recently calved. The reference is to the tendency shown by the cows to decrease in milk yield when the feed was diminished in quantity.

The first trial is with the Jersey cow No. 62 that had been in milk 96 days. Since calving, No. 62 does not possess that inherent quality for yielding a large quanity of milk and consequently no difficulty was experienced in feeding sufficient nutrients to bring about a deposition of fat. The cow yielded only about sixteen pounds of milk daily and received as high as fifteen pounds of grain per day. Table XVII gives the results in tabulated form. The calculations were based on an average of 4.8 % fat taken for the entire period.

TABLE XVII

Effect of Underfeeding - Advanced Lactation.

Jersey Cow No. 62

Date	Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
Mch. 7	4.6	16.9	930	10.00	11.80
8	4.5	16.3	930	10.00	11.58
9	4.9	15.6	915	7.00	11.24
10	4.8	14.6	910	7.00	10.85
11	5.5	14.8	900	7.00	10.86
12	5.7	15.1	890	7.00	10.91
13	5.5	14.6	870	4.66	10.60
14	5.9	14.2	865	4.66	10.43
15	6.1	13.6	865	4.66	10.21
16	5.6	12.9	855	4.66	9.88
17	6.0	13.5	855	4.66	10.11
18	6.5	13.1	845	4.66	9.91
19	5.7	12.9	825	4.66	9.71
20	6.2	12.9	835	4.66	9.77
21	5.6	12.9	840	4.66	9.81
22	5.8	13.3	830	4.66	9.89
23	5.2	12.8	850	4.66	9.83
24	5.4	12.0	830	4.66	9.42
25	5.7	12.8	815	10.00	9.62
26	4.8	13.1	845	10.00	9.91
27	4.8	14.5	855	10.00	10.47
28	4.3	15.2	855	10.00	10.73
29	4.1	15.3	880	10.00	10.92
30	4.5	16.1	880	10.00	11.21
31	4.3	15.2	880	10.00	10.88
Apr. 1	4.4	15.4	880	10.00	10.95
2	5.3	14.4	875	10.00	10.56
3	5.0	15.4	880	10.00	10.95
4	4.9	12.0	870	10.00	9.67
5	4.8	10.2	860	10.00	8.96
6	4.8	12.1	860	10.00	9.64
7	4.5	12.6	860	10.00	9.82

Note:-
Grain, hay and silage fed in proportion of 1 - 1 - 4.

The first two days the cow received approximately sufficient nutrients to supply the required energy. It should be understood that for several days before the trial an excess of nutrients were fed. The ration was then decreased and on the seventh day the nutrients supplied were just adequate for maintenance as determined in an earlier maintenance trial on this animal[1]. The cow continued in this manner for twelve days, at the end of which time the former ration was resumed.

The results are striking. There resulted an almost immediate increase in the fat content and the weight decreased rapidly. The milk yield also decreased as previously mentioned. When the higher ration was resumed the milk yield increased to normal, the fat yield quickly decreased to normal and the weight became quite constant.

The next trial is with the Holstein cow No. 211. The trial commenced 375 days after calving. Having just completed an official year's record the cow was in an excellent state of flesh, having been generously fed in order to sustain a high flow of milk throughout the year. The tabulated data is presented in Table XVIII.

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1. Research Bul. No. 2, Mo. Exp. Sta.

TABLE XVIII.

Effect of Underfeeding - Advanced Lactation.

Holstein Cow No. 211.

Date		Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
Mch	12	3.51	29.0	1085	12.10	15.16
	13	3.41	28.5	1085	12.10	15.02
	14	3.66	26.8	1071	12.10	14.43
	15	3.73	28.3	1080	12.10	14.93
	16	3.73	29.0	1075	12.10	15.10
	17	3.73	26.6	1085	12.10	14.46
	18	3.98	25.5	1085	12.10	14.14
	19	3.93	23.9	1075	12.10	13.61
	20	4.00	23.4	1060	12.10	13.37
	21	3.96	24.6	1075	12.10	13.81
	22	3.72	24.4	1080	19.42	13.49
	23	3.11	29.7	1105	20.93	15.33
	24	3.23	30.9	1110	21.46	15.50
	25	3.16	32.3	1115	23.18	15.93
	26	3.25	31.4	1120	22.49	15.71
	27	3.13	31.3	1120	23.03	15.68
	28	3.22	31.0	1115	21.80	15.56
	29	3.24	30.7	1125	21.80	15.18
	30	3.25	29.0	1095	20.08	14.88
	31	3.38	28.4	1125	19.39	14.89
Apr.	1	3.33	30.9	1105	21.83	15.47
	2	3.27	30.6	1135	20.46	15.57
	3	3.49	26.6	1145	11.78	16.11
	4	3.90	23.1	1100	11.78	14.64
	5	4.31	19.6	1095	11.78	13.41
	6	4.47	19.6	1100	11.78	13.44
	7	4.31	20.0	1120	11.78	13.60
	8	4.30	18.5	1100	11.78	13.77
	9	4.24	17.8	1100	11.78	12.83
	10	4.49	16.4	1105	11.78	12.38
	11	4.34	16.8	1095	11.78	12.50
	12	4.86	14.9	1105	11.78	11.87
	13	4.64	13.9	1100	11.78	11.48
	14	4.44	13.1	1110	11.78	11.49
	15	4.37	13.2	1090	13.26	11.48

Note:-
Ration consisted of grain, hay and silage.

In making the calculations to determine the energy required the data is divided into three periods. From March 12 to March 21 a ration was fed which was slightly less than the requirements. The average per cent of fat during this period is 3.4. The next period from March 22 to April 2 the cow received an excess of nutrients and the fat per cent is 3.2. From April 3 to April 15 the ration is reduced and the average per cent of fat is 4.3.

The ration fed the second period, March 22 to April 2, is greatly in excess of the requirements. After April 2 the cow was again placed on the same ration under which the experiment was started, being that which was required for maintenance, and in addition to supply nutrients for about three-fourths of the milk yielded. The test in the third period following the excessive feeding is much higher than the previous periods. Apparently the cow is not greatly underfed but it seems that a new condition is introduced. Two possible explanations occur to the writer. First, the possibility of introducing large amounts of food nutrients into the blood and organs which is not fully transformed into tissue before the ration is diminished. Secondly, the protein, carbohydrate and fat equilibrium may have been markedly increased by liberal feeding and an actual but temporary starvation may have ensued. This theory seems the more likely since the milk yield and weight each give evidence of a decline.

The third trial is with the Jersey cow No. 2. that had calved 100 days before the experiment was begun. The cow calved in a very thin condition but not being a heavy milk producer was fattened by feeding as high as 12 pounds of grain daily. The ration was then decreased to near normal which is equivalent to underfeeding since the nitrogen equilibrium was necessarily large having been accustomed to a liberal feed allowance. The calculations are based upon the energy requirements of a milk testing 4.9 % and the data is presented in full in Table XIX.

TABLE XIX.

Effect of Underfeeding - Advanced Lactation.

Jersey Cow No. 2.

Date	Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
Apr. 22	4.8	11.9	870	15.76	9.69
23	4.4	11.3	870	15.76	9.47
24	4.5	10.9	870	13.53	9.32
25	5.8	11.1	865	10.58	9.36
26	5.4	10.6	842	9.07	9.05
27	5.5	10.7	840	8.32	9.07
28	5.4	10.8	855	9.47	9.20
29	5.0	10.9	860	11.27	9.26
30	4.7	10.7	852	11.98	9.14
May 1	5.0	12.5	852	15.78	9.79
2	5.2	11.1	850	15.78	9.27
3	4.8	11.6	860	15.78	9.51
4	4.4	10.9	860	11.27	9.25
5	4.8	11.6	860	15.78	9.51
6	4.8	11.8	870	15.78	9.67
7	5.0	11.8	870	15.78	9.67
8	4.8	11.7	865	15.78	9.57
9	4.6	11.8	867	8.64	9.63
10	5.0	11.8	865	9.47	9.61
11	4.5	11.3	855	9.47	9.35
12	5.0	12.4	866	9.47	9.84
13	4.8	11.0	845	9.47	9.20
14	5.8	11.8	850	9.47	9.52
15	4.8	11.8	845	9.47	9.49
16	5.0	11.7	840	9.47	9.42
17	5.2	12.8	850	9.47	9.89
18	4.3	12.0	865	9.47	9.68
19	4.6	13.0	880	9.47	10.14
20		12.3	875	9.47	9.86
21	4.8	12.1	885	9.47	9.83

Note:-

Ration consisted of 20 pounds silage and 10 pounds of hay daily. The grain was decreased from 12 lbs. to 3.6 lbs. Hay was also reduced to 8 lbs. during first underfeeding period.

The grain allowance was reduced April 24 to 30 and during this period of low feeding the test was appreciably higher. It should be noted that the actual nutrients received were still sufficient to support the milk yield as is shown by the energy supplied but in reality the ration was inadequate because of a high nitrogen equilibrium which was established through generous feeding over a considerable period of time. This is in accordance with the results obtained in Table XIX. Following the low plane the cow was again overfed for eight days and the test dropped to normal. When the feed was again reduced to her actual requirements only a very slight increase is obtained and this only for three or four days. It is the opinion of the writer, since many warm days followed in May, that the mere fact that no decline was observed is an indication that the test was somewhat increased by the reduction in nutrients. Since the ration was actually sufficient in nutrients the organism quickly responded to the new conditions and after a few days a high test would be unexpected.

Effect on the Per Cent of Fat - - Cow Thin and Normally Fed.

A thin animal was generously fed immediately following parturition. The object is to determine what influence would be had upon the per cent of fat. In

Table XV an Ayrshire cow that calved in a fatty condition did not produce an abnormal fat content in the milk, except during the first few days, while the cow's condition would not permit of heavy feeding. What would occur if a thin animal be placed under similar conditions? The data is given in full in Table XX.

TABLE XX.

Cow Thin and Fed Normally.

Holstein Cow No. 206.

Days After Calving	Percent of Fat	Pounds of Milk	Live Weight	Energy Supplied (Therms)	Energy Required (Therms)
1	4.5	17.8	1270	14.09	14.93
2	4.4	29.5	1250	15.15	16.61
3	4.6	20.0	1265	15.15	16.56
4	4.6	32.8	1270	14.36	17.73
5	4.4	33.9	1287	9.77*	18.16
6	4.5	33.9	1240	13.22	17.87
7	4.4	28.7	1210	18.10	16.13
8	4.0	33.3	1220	18.10	17.57
9	4.0	37.2	1215	19.13	18.71
10	4.0	39.4	1211	19.13	19.34
11	4.1	40.0	1230	19.13	19.64
12	3.9	43.5	1266	19.88	20.91
13	4.0	42.3	1265	19.88	20.55
14	3.8	43.9	1262	20.57	21.01
15	3.9	43.4	1287	21.60	21.01
16	3.9	42.0	1250	21.60	20.36
17	3.8	43.2	1265	19.38	20.82
18	3.4	40.6	1297	19.98	20.23
19	3.7	43.8	1275	19.82	21.06
20	3.5	41.5	1257	20.07	20.26
21	3.6	42.7	1320	19.57	21.00
22	3.3	41.2	1292	19.57	20.38
23	3.3	44.5	1295	20.00	21.39
24	3.9	44.9	1302	20.00	21.55
25	3.3	42.7	1285	20.00	20.79
26	3.8	44.1	1287	18.33	21.22
27	3.8	41.1	1276	18.33	20.25
28	3.7	41.8	1293	18.33	20.57
29	4.0	38.6	1285	18.33	19.56
30	4.0	38.7	1271	18.33	19.50
31	3.7	37.4	1254	20.00	19.00
32	3.7	36.8	1324	20.00	19.26
33	3.3	40.1	1332	20.00	20.30
34	4.5	44.0	1303	20.00	21.29
35	4.3	42.0	1316	20.00	20.83

* Cow off feed.

Note:-
Began feeding green feed the 17th day.

Cow No. 206 was turned dry about six weeks before she was due to calve and during this time was kept in a dry lot and permitted to have only about 12 to 15 pounds of alfalfa hay daily. As a result she was unusually thin at calving time. In normal flesh the cow would weight 1450 pounds.

In the early part of the period the cow tested more than 4 %. A high milk yield was quickly attained and as a result the cow was somewhat underfed during the first few days. The average test for the entire trial is 3.6 % and the test was as high at the end of the trial as the average. No decline in test or body weight was apparent which shows beyond doubt that unless the animal be underfed this abnormality in test will not be obtained. The test is doubtless high for this animal under the existing conditions but as pointed out in the earlier pages, December is likely to be the month of highest tests. As this was made in November and early December this explanation is very plausible. The monthly test for December is 3.5 %; January 3.5; February 3.8; March 3.5; April 3.6; May 3.6; June 2.7; July 2.6; August 3.2; September 3.3; October 3.6 and November 3.8 %.

The introduction of large quantities of green feeds in the latter half of the trial will account, at least in a large measure, for the apparent tendency to increase in weight.

Underfed and Overfed - Two Lactations.

A very interesting trial was made with Jersey cow, No. 2. The cow was dry during the last part of 1910, and was "roughed" through to calving time on hay alone. She calved January 12, 1911 in a low state of flesh. Soon after calf birth she was placed on a ration sufficient for maintaining the body and milk producing functions. The ration was gradually increased above the requirements of the animal and a high ration fed throughout the entire lactation. As a result the cow calved February 25, 1912 in a fat condition. After calving this time the animal was fed a subnormal ration in contrast to the previous period, giving a reversal of conditions. The data is tabulated in Table XXI.

TABLE XXI

Underfed and Overfed.

Jersey Cow No. 2.

Cow Thin - Overfed			Days	Cow Fat - Underfed		
Energy Required (Therms)	Energy Received (Therms)	Percent of Fat	After Calving	Percent of Fat	Energy Received (Therms)	Energy Required (Therms)
7.82	7.48	4.63	14	4.76	8.50	10.80
7.72	7.48	4.42	16	5.05	8.50	10.87
7.90	8.24	4.21	18	4.87	8.50	10.90
8.24	8.99	4.45	20	4.65	8.50	10.73
8.27	8.99	4.32	22	4.75	8.12	10.82
8.20	8.99	5.34	24	5.12	8.12	10.56
8.28	10.49	4.73	26	5.05	8.12	10.70
8.59	10.49	4.59	28	4.95	7.74	10.47
8.25	10.49	4.46	30	4.80	7.74	10.50
8.42	10.49	4.57	32	4.90	7.74	10.48
8.37	10.49	4.68	34	4.70	7.74	10.57
8.26	10.49	4.39	36	4.66	7.74	10.48
8.00	11.62	4.72	38	4.81	7.67	10.72
7.71	11.62	4.92	40	4.59	7.42	10.74
8.33	11.62	5.05	42	4.55	7.10	10.50
8.38	12.75	4.62	44	4.92	7.10	10.96
8.75	13.13	4.77	46	4.50	6.43	10.74
8.63	13.13	4.45	48	4.67	6.43	10.52
9.05	13.13	5.08	50	4.56	6.43	10.17
8.83	13.13	4.67	52	4.57	6.43	10.73

The results are of striking interest. The tests which are reported in the above table are for corresponding days in two consecutive lactations. Attention is directed to the fat percentages. In the latter lactation, the animal being fat and fed a subnormal ration, the fat percentage yielded is from 0.2 to 0.5 higher than when she was thin in flesh and overfed. It is known that generous feeding of a thin animal will increase the fat content slightly. This was pointed out by Wing and Foord[1] in some work conducted with this point in question. Hence the difference in favor of the period when the cow was fat is less than it would have been had she received only a normal ration when thin.

Effect of Underfeeding - Cows Moderately Thin.

The data obtained and presented in the preceding tables is strikingly uniform. Where animals have been fattened and subsequently underfed an increase in the fat percentage is constantly recorded. Furthermore, it has been shown that a fat cow would not yield an abnormally high per cent of fat in the milk when fed a ration supplying sufficient nutrients. Another trial with a cow moderately thin and normally fed did not result in an abnormally high test immediately after parturition.

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1. Cornell Agr. Exp. Sta., Bul. 222.

Finally, trials were made with cows that were moderately thin and underfed and the results obtained are shown in the following tables.

Trials were made with six cows with the view of answering the following questions. Occasionally in experimental work a cow will sustain a loss of appetite or in changing from one experimental ration to another they are sometimes fed an insufficiency of nutrients. What effect would this have upon the per cent of fat? It is a common practice for dairy cattle associations in this country to conduct two day butterfat tests each month in determining the production of a cow. Would it be possible to underfeed these cows for a day or two before the test is to be made and thus obtain a high test? Data is presented in Table XXII on this question.

TABLE XXII.

Underfeeding - Cows Moderately Thin.

Cow No. 220			Date 1912	Cow No. 219.		
Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)		Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)
37.8	3.65	17.22	Jan. 23	37.4	3.15	15.64
36.0	3.40	17.22	24	35.4	3.00	16.47
36.3	3.27	17.22	25	37.3	3.10	16.47
34.9	3.40	17.22	26	37.7	3.37	16.47
36.5	3.20	17.22	27	37.4	2.85	16.47
35.2	3.25	13.37	28	38.4	3.65	11.96
35.9	3.10	13.37	29	34.8	3.05	11.96
34.6	3.35	17.22	30	36.0		16.47
36.2	2.90	17.22	31	34.4	4.57	16.47
33.5	3.35	17.22	Feb. 1	34.7	4.15	16.47
35.2	3.30	17.22	2	31.4	3.60	16.47
35.0	3.20	18.26	3	38.5	3.25	16.47
33.0	3.50	18.26	4	34.5	3.35	16.47
32.2	3.15	18.26	5	33.0	3.27	16.47
36.2	3.20	18.26	6	37.8	3.10	16.47
36.0	3.05	13.37	7	38.2	2.92	11.96
34.5	2.95	13.37	8	35.9	2.95	11.96
34.8	2.95	18.26	9	35.5	3.15	16.47
35.2	3.00	18.26	10	34.7	2.95	16.47
34.8	3.15	18.26	11	34.0	3.15	16.47
36.0	3.00	18.26	12	35.5	3.20	16.47
35.9	3.05	18.26	13	35.3	3.70	16.47
36.5	2.95	18.26	14	36.7	3.35	16.47
35.0	2.95	18.26	15	35.2	2.70	16.47
35.8	2.85	18.26	16	4.04	3.27	16.47
35.6	2.95	13.37	17	37.3	2.70	11.96
35.7	2.98	13.37	18	35.7	3.00	11.96
32.3	2.83	18.26	19	34.3	2.78	16.47
31.3	2.97	18.26	20	32.7	3.05	16.47
32.0	3.02	18.26	21	33.6	3.00	16.47
32.2	2.97	18.26	22	35.2	3.58	16.47
33.9	2.90	18.26	23	35.1	3.15	16.47
33.6	2.80	18.26	24	35.1	3.10	16.47
31.6	2.95	18.26	25	34.5	2.90	16.47
32.2	2.83	13.37	26	33.0	3.07	11.96
30.2	2.90	13.37	27	31.8	3.17	11.96
30.8	2.95	13.37	28	30.2	2.75	11.96

(Continued)

TABLE XXII

(Continued)

Cow No. 220			Date	Cow No. 219		
Milk Yield: Lbs.	Percent of Fat	Energy Supplied (Therms)	1912	Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)
30.3	3.15	18.26	Feb. 29	35.2	3.03	16.47
28.7	3.47	18.26	Mar. 1	34.7	2.97	16.47
31.5	3.30	16.47	2	35.1	3.25	16.47
30.7	2.73	4.85	3	31.7	3.00	16.47
28.6	2.53	9.90	4	35.4	3.35	16.47
28.5	2.65	15.88	5	34.6	2.82	16.47
30.0	2.45	15.88	6	35.2	2.63	16.47
31.1	2.55	15.88	7	35.9	3.35	11.96
30.9	2.57	15.88	8	34.7	3.10	11.96
29.5	2.60	15.88	9	30.3	2.80	11.96
30.5	2.55	15.88	10	30.0	2.95	16.47
29.3	2.90	15.88	11	31.2	2.30	16.47
29.8	2.70	15.88	12	34.9	3.27	16.47
33.3	2.70	15.88	13	32.6	3.47	16.47
31.3	2.73	15.88	14	35.0	3.10	16.47
30.0	2.87	15.88	15	33.2	2.78	16.47
31.2	3.67	11.96	16	34.4	3.00	11.96
28.8	2.70	8.24	17	31.0	2.85	11.96
27.2	2.62	8.24	18	30.7	3.05	11.96
24.2		8.24	19	28.2	2.67	11.96
24.5	2.75	8.24	20	25.3	3.05	11.96
26.5	2.85	8.24	21	28.4	3.22	11.96
25.8	2.65	8.24	22	29.3	2.20	11.96
28.9	2.85	15.88	23	33.1	3.15	16.47
28.8	2.75	15.88	24	32.7	2.65	16.47
29.7	2.75	15.88	25	32.7	2.75	16.47
29.1	2.68	15.88	26	34.3	3.03	16.47
28.7	2.70	15.88	27.	35.1	2.70	16.47
30.5	2.62	15.88	28	33.9	3.08	16.47
29.5	2.55	15.88	29	34.2	2.80	16.47
29.7	2.57	15.88	30	32.9	2.55	16.47
29.8	2.85	15.88	31	32.5	3.05	16.47

Nos. 220 and 219 are Holstein cows that calved about thirty days before the experiment commenced. They were only moderately thin, i.e. they were not in a starved condition but in a thrifty milking flesh. They were fed normal rations eight days and then reduced to three-fourths normal on the ninth and tenth days. In the latter half of the trial the feed was reduced for three consecutive days instead of two. Unfortunately No. 220 was "off feed" March 3 and 4 and for this reason was not underfed as was No. 219 on the 7th, 8th and 9th of March. In only one case was there a perceptible difference and this with No. 219 following underfeeding on January 28 and 29. Since underfeeding for such a short time seemed to have no effect it was decided to prolong the period of underfeeding for several days. This was done March 16 to 22 inclusive with no preceptible influence upon the per cent of fat.

Since negative results were obtained with cows in the earlier stages of lactation it was decided to conduct the experiment with two cows in more advanced lactation. Nos. 218 and 224 had been milking about ten months since freshening. A detailed report is given in Table XXIII.

TABLE XXIII.

Underfeeding - Cows Moderately Thin.

Cow No. 218			Date	Cow No. 224		
Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)	1912	Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)
11.6	3.90	11.13	Jan. 31	17.2	3.45	10.24
11.8	4.10	11.13	Feb. 1	17.5	3.30	10.24
11.5	3.80	11.13	2	16.5	3.55	10.24
12.1	3.45	11.13	3	18.0	3.20	10.24
10.0	4.00	11.13	4	15.9	2.75	10.24
10.0	3.62	11.13	5	17.0	3.10	10.24
10.2	3.60	11.13	6	18.2	3.45	10.24
10.5	3.50	7.75	7	17.1	3.00	6.96
9.6	3.40	7.75	8	16.6	2.90	6.96
7.2	3.45	11.13	9	15.9	3.00	10.24
8.5	3.40	11.13	10	17.0	3.15	10.24
8.8	3.35	11.13	11	15.2	3.30	10.24
8.0	3.55	11.13	12	15.5	3.40	10.24
8.0	3.55	11.13	13	16.5	3.10	10.24
8.0	2.10	11.13	14	15.5	3.10	10.24
7.1	3.77	11.13	15	17.4	2.95	10.24
7.1	3.65	11.13	16	17.0	2.83	10.24
7.1	3.62	7.75	17	17.5	2.83	6.96
6.5	3.32	7.75	18	17.2	2.87	6.96
5.6	3.55	11.13	19	17.0	2.80	10.24
5.1	3.95	11.13	20	16.0	3.02	10.24
5.7	4.05	11.13	21	15.5	3.10	10.24
4.8	3.81	11.13	22	14.0	3.20	10.24
4.8	3.55	11.13	23	15.0	3.00	10.24

Note:-

No. 218 shows marked decline in milk due to tendency to go dry. The lactation is well advanced.

The cows were fed normally for eight consecutive days, the feed being reduced to one-half on the ninth and tenth days. No perceptible influence upon the fat content of the milk could be observed.

Two Jersey cows that were in a moderately thin condition were underfed for seven consecutive days. The cows were well advanced in lactation, having calved four months before the experimental trial. The trials are reported in Table XXIV.

TABLE XXIV.

Underfeeding - Cows Moderately Thin.

Cow No. 16			Date 1912	Cow No. 124		
Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)		Milk Yield Lbs.	Percent of Fat	Energy Supplied (Therms)
25.4	5.00	14.27	March 13	33.0	4.87	17.01
27.6	5.25	14.27	14	32.4	4.65	17.01
24.9	5.35	14.27	15	31.5	4.85	17.01
26.2	5.13	14.27	16	34.5	4.43	17.01
25.2	5.05	14.27	17	33.5		17.01
28.0	4.15	14.27	18	33.6		17.01
27.2	4.55	14.27	19	34.7	4.35	17.01
26.4	4.85	14.27	20	32.4	4.15	17.01
25.7	4.75	14.27	21	32.9	4.53	17.01
25.6	4.50	14.27	22	33.8	4.25	17.01
24.1	4.70	17.13	23	32.0	4.38	18.50
22.5	4.73	17.13	24	27.7	3.87	18.50
21.3	4.80	17.13	25	25.1	4.45	8.50
20.1	4.95	17.13	26	24.7	4.47	8.50
20.9	4.60	17.13	27	25.0	4.20	8.50
19.4	5.05	17.13	28	24.0	4.60	8.50
19.5	4.72	17.13	29	23.7	4.43	8.50
21.2	4.15	14.27	30	26.2	3.60	17.01
22.9	4.50	14.27	31	28.0	3.95	17.01
23.5	4.25	14.27	Apr. 1	28.9	4.40	17.01
22.7	5.00	14.27	2	29.2	4.92	17.01
24.8	4.75	14.27	3	31.5	4.28	17.01
24.7	4.60	14.27	4	30.9	4.20	17.01
26.2	4.60	14.27	5	32.2	4.45	17.01
25.8	4.55	14.27	6	29.2	4.38	17.01
23.5	4.80	14.27	7	31.0	4.35	17.01
23.6	4.85	14.27	8	30.7	4.40	17.01

Note:-
No samples procured for March 17 and 18.

These cows were fed normally except from March 23d to March 29 inclusive, during which time they were allowed just half the normal ration. As in the other trials negative results were obtained.

The writer does not accept these preliminary trials as conclusive evidence that the test of a moderately thin cow cannot be increased by underfeeding. It must be assumed, however, that fatness is as essential as underfeeding, and it is proven that a combination of the two will produce a high test in the most marked degree.

Theoretically a thin animal would not be expected to yield a high per cent of fat when underfed. An animal in this state will have only a small amount of fat stored in the connective tissue. No excessive amount is liberated when the musculature tissue is broken down to support the milk yield and bodily functions. A thin animal receiving a starvation diet breaks down its tissues very economically and doubtless all of the fat that is freed is used in the body as fuel. E. T. Bell[1] found a gradually decreasing amount of liposomes during inanition with frogs, cats and rats. This would indicate a decreased quantity of fat droplets in the muscle fibers and an abnormal fat content in the milk would be unexpected.

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1. Aus der Internationalen Monatsschrift f. Anatomie U. Physiologie, (1911), p. 326.

A Survey of the Incomplete Work.

The writer is of the opinion that cows, having an inherent faculty for producing large quantities of milk, are more responsive and yield an increased fat percentage when underfed. This opinion is formed from having a personal knowledge of the ability of each cow in the experiment. Cows of this type yield large amounts of milk even under adverse conditions. If they are fat an increased butter fat test results. The milk yield of an inferior cow will decrease when insufficiant nutrients are supplied. Her tissues will not be sacrificed as will those of an animal possessing more pronounced dairy qualities.

Theoretically, a cow in thin flesh at the time of parturition should not yield a high per cent of fat even though she be underfed. But none of the data bears directly on this point and such a trial should be made.

If a thin animal was starved, after having been fed an excessive ration long enough to increase the nitrogen equilibrium, it would seem that the fat percentage would be increased much the same as when a fat animal is starved. Further work will be done to reach a solution of this question.

From the data at hand it is believed that higher tests can be secured in the winter months by under-

feeding cows in a fat condition than can be obtained in the warmer summer season. This phase has not been investigated at the present time.

The cows must be in the hands of a skillful feeder if high seven day fat yields are to be obtained. A combination of a high milk yield and a high test are sought. This combination can best be had shortly after parturition.

Conclusions.

A cow when calving in a high state of body flesh will yield a milk containing an abnormally high per cent of fat. The maximum fat percentage is found from the fifth to the tenth day following parturition, after which time a gradual decline occurs, the normal being reached from the fifteenth to the thirtieth day.

The high per cent of fat is accompanied by a loss of live weight. If a fat cow is permitted to lose weight slowly the high fat content of milk can be prolonged over a period of from two to five months.

Underfeeding a fat animal causes a loss in live weight and an abnormally high fat content is obtained in the milk. A fat animal, permitted to consume sufficient nutrients to fully supply the bodily requirements, yields milk which corresponds to the normal for the animal.

An abnormal per cent of fat will be obtained in the milk by underfeeding a fat animal when well advanced in the period of lactation.

A thin animal, not having an excessive deposition of fat on the body, will not yield an increased per cent of fat in the milk when underfed.

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