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UNIVERSITY OF MINNESOTA
AGRICULTURAL EXPERIMENT STATION

RAISING THE DAIRY CALF WHEN WHOLE MILK IS SOLD

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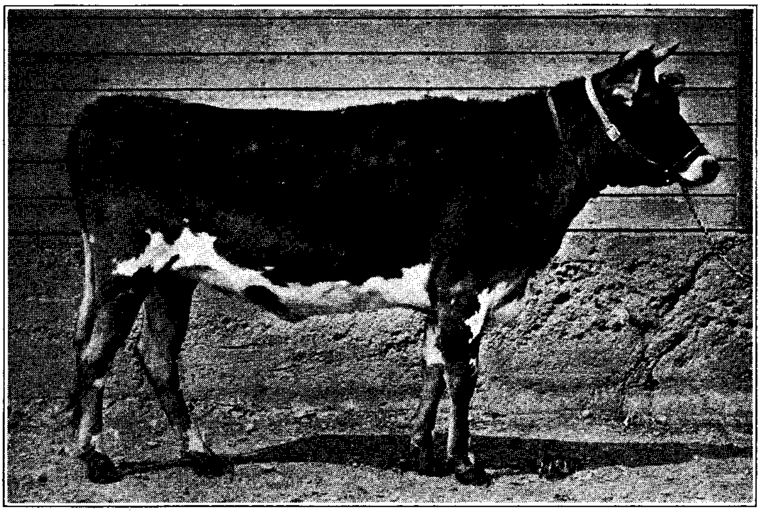
DIVISION OF DAIRY HUSBANDRY



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RAISING THE DAIRY CALF WHEN WHOLE MILK IS SOLD

C. H. Eckles and T. W. Gullickson[1]

The growing demand in recent years for milk and milk products has materially affected the problem of calf raising. As a result a constantly increasing proportion of the milk produced is used as whole milk and a larger number of calves are deprived of their natural food. Statistics show that out of a total of approximately eighteen million dairy calves born each year in the United States, 54 per cent, or more than nine million, are the offspring of cows the milk of which is sold as whole milk from the farm. Since the introduction of the cream separator the problem of raising the calf has been largely solved on farms where cream is sold or butter is made. Under these conditions the heifer calves are generally raised, at least in sufficient numbers to replace the discarded cows.

Unfortunately where whole milk is sold only too often few calves are raised, as to feed a calf on whole milk, worth on the market from $2 to $4 a hundred pounds, means that it will eat its "head off" in a few weeks. Feeding skimmilk is likewise usually impracticable when whole milk is sold because of the inconvenience of separating the milk and marketing both cream and milk. Farmers under these circumstances, instead of raising calves, usually depend upon purchasing cows with which to maintain their herds.

Experience shows that little or no improvement results where this method of keeping up the herd is followed. The cows offered for sale are as a rule not the class that will increase the average production of a herd but are more often culls, inferior in producing ability. Furthermore, it is practically impossible to follow the plan of purchasing cows and keep the herd free from disease. Herd improvement can come only where discarded cows are replaced by well raised heifers of better breeding and type. The only practical plan for the farmer who wishes to build up the quality and productive capacity of his herd is to raise the heifer calves from the best cows in his herd.

[1] The details of the experimental work connected with Groups 1, 2, and 7, and Groups 8 and 9 as found in this bulletin were supervised by S. W. Mead and R. H. Lush, respectively, graduate students in the Department of Dairy Husbandry, University of Minnesota.

MILK SUBSTITUTES

A number of so-called milk substitutes have been placed on the market, designed especially for use on farms where whole milk is sold. Some of these proprietary calf meals sold under various names have been tested experimentally, and the consensus of opinion is that none of them gives satisfactory results as a complete substitute for milk in the calf ration. In all direct comparison with home mixtures no special advantages have been found for the proprietary feeds. As supplements to milk, or when used to replace part of the milk, both home mixed and commercial calf feeds have given fairly satisfactory results. The cost of commercial calf meals is also in many cases almost prohibitive, or at least out of reason considering their ingredients. Some of the materials most commonly used are finely ground corn, middlings, oat flakes, red dog flour, rice flour, ground flaxseed, linseed meal, cocoanut meal, blood meal and powdered skimmilk. Recent discoveries in the field of nutrition have made clear why most of these so-called milk substitutes have not been especially successful. They do not contain all the essential food factors in a form adapted to the needs of the young calf. Milk is the only food stuff that supplies these substances in such a form. There is no substitute for milk, and a calf must receive some milk if the best results are to be obtained.

MINIMUM MILK PLAN

The constant increase in the number of farms selling whole milk for city use, to milk condensaries, cheese factories, and powdered milk plants appeared to justify further study of the whole question as to practical methods of raising calves when the whole milk is sold.

A study was first made of experimental work reported with milk substitutes from the standpoint of the recent discoveries in nutrition. It was clear in most cases why calf meals under consideration did not prove satisfactory. As the result of this study the conclusion was reached that it should be conceded in the beginning that the calf must have some milk for a while if anything like satisfactory results are to be obtained. The work of the Illinois Experiment Station appeared to point the way. Some years ago, after tests made to determine the minimum amount of milk required to raise a calf, they decided that "the important thing in the raising of calves is to give them a good start on whole milk during the first three weeks, and that after this whole milk may be successfully replaced with skimmilk if the skimmilk is fed sweet and warm as it comes from the separator. The calves should be continued on 12 pounds of skimmilk a day until they are about seven weeks old. . . . ."

The problem is not to find a complete substitute for milk but to use the least possible amount and still get the desired results.

It was decided that any plan of feeding to be considered satisfactory must conform to the following:

1. The ration used must include only common well known feeds easily obtained.
2. The ration must be one that can be prepared with little work and fed dry.
3. The ration must make possible the raising of a calf of which the owner will not be ashamed.

PLAN OF EXPERIMENT

The project was divided into two parts: (1) raising calves on the minimum amount of whole or skimmed milk, (2) raising calves on dried milk using powdered skimmilk, powdered or semi-solid buttermilk, or malted milk, the minimum amount of each being used.

In the first part 18 calves were used, divided into five groups. Representatives, mostly grades, were included from the Holstein, Guernsey, and Jersey breeds. Most of the calves used were purchased when from one day to two weeks of age. The care they received previous to their arrival at the station was therefore not always known. But upon their arrival they were always fed whole milk at first in proportion to their size and condition. This was usually one pound of milk for every ten pounds of live weight of calf. Care was taken not to overfeed and when signs of excessive looseness or scouring appeared the quantity of milk fed was promptly reduced. The calves were kept in individual pens, and fed three times a day until at least two weeks old, after which twice a day was considered sufficient. Each calf was provided with a feed box for hay and grain. They were not allowed to run on pasture but were given sufficient exercise in the barn lot.

Three of the five groups were fed whole milk during their entire milk feeding period. The remaining two groups received skimmilk as part of their milk ration. The change from whole milk to skimmilk was made only after the calves were at least two weeks of age and the change was gradual, usually requiring a week or ten days. The calves in a group were all weaned at as near the same age as possible, but the length of the milk feeding period differed for each group and as a result the age at which milk feeding was discontinued ranged from 50 to 72 days. Weaning was accomplished by gradually decreasing the quantity of milk at the rate of a pound a day.

Table 1 gives the age at weaning and the average amount of feed consumed by the different groups up to six months of age. Groups 1, 2, and 3 received whole milk only. Group 4 received whole milk during almost the entire 70 days they received milk, a small amount of skimmilk being substituted beginning about the fortieth day, but the whole milk was never entirely replaced except during four or five days at the end. Group 5 began to receive some skimmilk in the ration when about two weeks of age and at four weeks were receiving skimmilk alone.

TABLE I

AGE AT WEANING AND FEED CONSUMED TO SIX MONTHS OF AGE

CALVES RAISED ON THE MINIMUM AMOUNT OF MILK. AVERAGES FOR EACH GROUP

Group No.	No. of animals in each group	Breed	Age at weaning	Whole milk from 5 days of age	Skimmilk	Grain	Alfalfa hay
			days	lbs.	lbs.	lbs.	lbs.
1	4	Grade Holstein	72	864	...	555	263
2	3	Grade Holstein	50	442	...	528	279
3	2	Purebred Jersey	72	572	...	397	309
4	6	Grade Guernsey	70	449	88	412	295
5	3	Grade Holstein	60	166	378	476	385

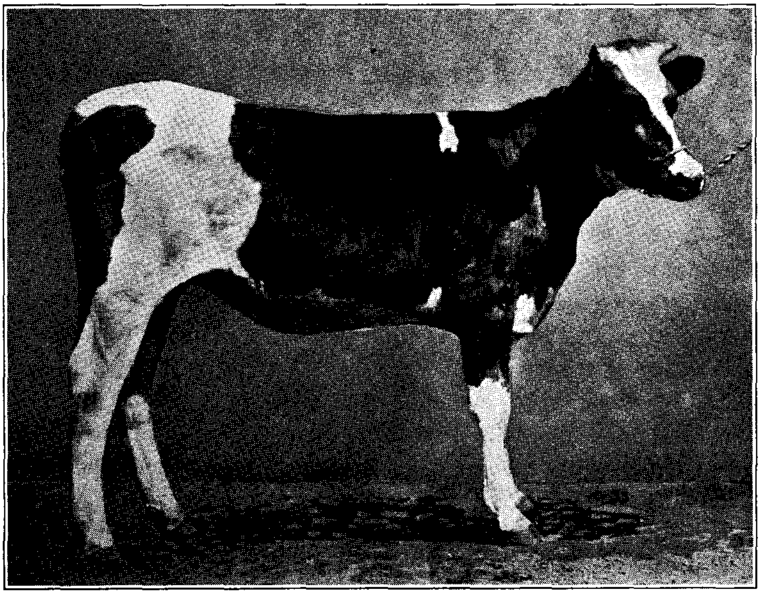


Fig. 1. Grade Holstein Heifer at 12 Months of Age

Raised on whole milk first 50 days. Weight at six months, 362 pounds. Daily gain in weight to six months, 1.46 pounds, which equals the average or normal gain for calves at that age. Weight at 12 months, 575 pounds. Average weight for animals of that age 569 pounds. Feed received up to six months: Whole milk 432 pounds, grain 594 pounds, alfalfa hay 313 pounds.

When whole milk alone was fed the amount required by the Holstein calves varied between 432 and 879 pounds, while the two Jersey heifers received 572 pounds each of whole milk. When both whole milk and skimmilk were fed, from 161 to 178 pounds of whole milk and 378 pounds of skimmilk were required by the three Holsteins, while the Guernseys required from 360 to 506 pounds of whole milk and 72 to 103 pounds of skimmilk. The table also shows that the calf raised on skimmilk will consume more hay in proportion to the amount of grain eaten.

At as early an age as possible the calves were encouraged to eat grain and hay. The method of feeding grain and hay was to allow free access to good quality alfalfa hay and to feed all the grain that a calf would take until about five pounds was reached. It was found that if no limit was placed on the amount of grain fed, too much grain in proportion to the amount of hay would be consumed after an age of about five months was reached. Calves receiving mostly grain do not thrive as well as when a considerable part of the ration is some good roughage. For this reason the plan was adopted of making no further increase in the grain after five pounds per head per day was reached. The calves were allowed unlimited hay.

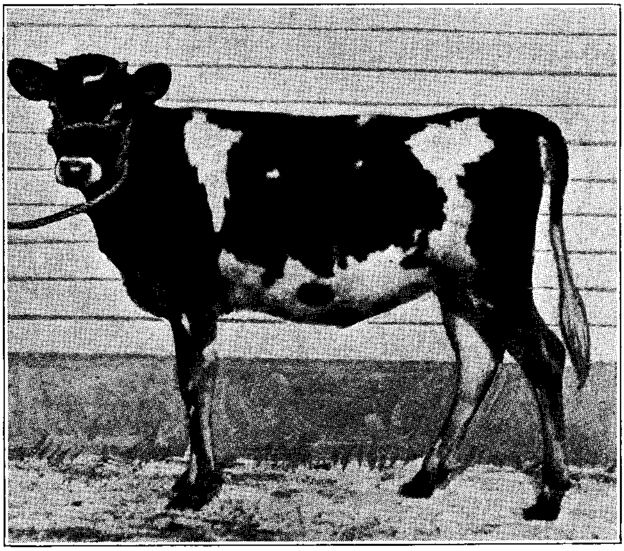


Fig. 2. Purebred Jersey Heifer, Age Six Months

Fed whole milk to 72 days. Weight at six months 222 pounds. Daily gain to six months 0.96 pound, which is less than the gain made by the average calf at that age. Feed received up to six months: Whole milk 573 pounds, grain 387 pounds, alfalfa hay 289 pounds.

On the title page is shown the same Jersey heifer at 21 months of age when the weight was 695 pounds as compared to 649 pounds, the average weight of Jersey heifers at that age.

Tables II to VI inclusive are records of the growth of the animals in the various groups compared with the normal at different ages up to 180 days, or six months of age. The growth in weight and height was determined by weights taken at ten-day intervals and height measurements every 30 days. The growth of the animals was compared with the normal growth curves for females of the dairy breeds as published by one of the authors. These normal growth curves are used in place of check animals in investigations concerning growing dairy animals at this experiment station. Unfortunately no normal growth curves are yet available for the Guernsey breed. For this reason the Jersey normal growth curve was used as a means of comparison in measuring the growth in both Jersey and Guernsey calves.

TABLE II

Group 1

RECORD OF GROWTH FROM 60 TO 180 DAYS
RATION, WHOLE MILK TO 72 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. 2	Calf No. 3	Calf No. 4	Calf No. 5
Weight at 60 days, lbs.	162	156	155	156
Per cent normal weight, 60 days	103	99	99	99
Weight at 72 days, lbs.	181	173	177	168
Per cent normal weight, 72 days	104	99	102	96
Weight at 180 days, lbs.	346	308	364	303
Normal weight 180 days, lbs.	349	349	349	349
Per cent normal weight, 180 days ..	99	88	104	87
Daily gain 60 to 72 days, lbs.	1.58	1.42	1.83	1.00
Normal gain 60 to 72 days, lbs.	1.43	1.43	1.43	1.43
Per cent normal gain, 60 to 72 days	110	99	128	70
Daily gain 72 to 180 days, lbs.	1.53	1.25	1.73	1.25
Normal gain 72 to 180 days, lbs.	1.62	1.62	1.62	1.62
Per cent normal gain, 72 to 180 days	94	77	107	77
Daily gain 60 to 180 days, lbs.	1.53	1.26	1.74	1.22
Normal gain 60 to 180 days, lbs.	1.60	1.60	1.60	1.60
Per cent normal gain, 60 to 180 days	96	79	109	76
Height at withers, 180 days, cm. ...	102	95.8	101	96.6
Per cent of normal height, 180 days	101	95	100	96

TABLE III
Group 2
RECORD OF GROWTH FROM 16 TO 180 DAYS
RATION, WHOLE MILK TO 50 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. 21	Calf No. 25	Calf No. 531
Weight at 16 days, lbs.	117	122	102
Per cent normal weight, 16 days	110	114	96
Weight at 50 days, lbs.	142	153	135
Per cent normal weight, 50 days	98	105	93
Weight at 180 days, lbs.	271	362	322
Normal weight 180 days, lbs.	349	349	349
Per cent normal weight, 180 days	78	104	92
Daily gain 16 to 50 days, lbs.	0.73	0.91	0.97
Normal gain 16 to 50 days, lbs.	1.13	1.13	1.13
Per cent normal gain, 16 to 50 days	65	81	86
Daily gain 50 to 180 days, lbs.	0.99	1.60	1.44
Normal gain 50 to 180 days, lbs.	1.57	1.57	1.57
Per cent normal gain, 50 to 180 days	63	102	92
Daily gain 16 to 180 days, lbs.	0.94	1.46	1.34
Normal gain 16 to 180 days, lbs.	1.48	1.48	1.48
Per cent normal gain, 16 to 180 days	64	99	91
Height at withers, 180 days, cm.	94.7	100.9	97.6
Per cent normal height, 180 days	94	100	97

TABLE IV
Group 3
RECORD OF GROWTH FROM BIRTH TO 180 DAYS
RATION, WHOLE MILK TO 72 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. 136	Calf No. 138
Weight at birth, lbs.	49	48
Per cent normal weight, birth	89	87
Weight at 72 days, lbs.	106	106
Per cent normal weight, 72 days	89	89
Weight at 180 days, lbs.	222	220
Normal weight 180 days, lbs.	260	260
Per cent normal weight, 180 days	85	85
Daily gain birth to 72 days, lbs.	0.79	0.80
Normal gain birth to 72 days, lbs.	0.89	0.89
Per cent normal gain, birth to 72 days	89	90
Daily gain 72 to 180 days, lbs.	1.07	1.05
Normal gain 72 to 180 days, lbs.	1.30	1.30
Per cent normal gain, 72 to 180 days	82	81
Daily gain birth to 180 days, lbs.	0.96	0.96
Normal gain birth to 180 days, lbs.	1.14	1.14
Per cent normal gain, birth to 180 days	84	84
Height at withers 180 days, cm.	88.9	90
Per cent normal height, 180 days	95	96

TABLE V
Group 4
RECORD OF GROWTH FROM 32 TO 180 DAYS
RATION, WHOLE MILK AND SKIMMILK TO 70 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. G-1	Calf No. G-2	Calf No. G-3	Calf No. G-4	Calf No. G-5	Calf No. G-6
Weight at 32 days, lbs.	70	84	82	84	105	83
Per cent normal weight, 32 days	90	108	105	108	135	106
Weight at 70 days, lbs.	108	126	107	116	160	132
Per cent normal weight, 70 days	93	108	92	99	137	113
Weight at 180 days, lbs.	209	240	228	227	298	240
Normal weight 180 days, lbs.	260	260	260	260	260	260
Per cent normal weight, 180 days	80	92	88	87	115	92
Daily gain 32 to 70 days, lbs.	1.00	1.10	0.65	0.84	1.44	1.29
Normal gain 32 to 70 days, lbs.	1.02	1.02	1.02	1.02	1.02	1.02
Per cent normal gain, 32 to 70 days	98	108	64	82	141	126
Daily gain 70 to 180 days, lbs.	0.92	1.03	1.10	1.00	1.25	0.98
Normal gain 70 to 180 days, lbs.	1.30	1.30	1.30	1.30	1.30	1.30
Per cent normal gain, 70 to 180 days	71	79	85	77	96	75
Daily gain 32 to 180 days, lbs.	0.94	1.05	0.98	0.96	1.30	1.06
Normal gain 32 to 180 days, lbs.	1.23	1.23	1.23	1.23	1.23	1.23
Per cent normal gain, 32 to 180 days	76	85	80	78	106	86
Height at withers, 180 days, cm.	89.0	89.3	89.3	89.0	99.3	87.0
Per cent normal height, 180 days	95	95	95	95	106	93

The calves receiving some skimmilk made on the whole as good gains up to time of weaning as did those on whole milk. Figures 3 and 4 show, as would be expected, that all the calves in each group had a tendency to decrease somewhat in the rate of growth, as compared with the normal, for a time after weaning. This tendency is no more evident in the case of the calves weaned at 50 days than in the other groups. The whole milk groups appear to be slightly more affected by weaning than do those receiving skimmilk, the Holsteins in each case seeming best to stand the change of feed.

The loss sustained by the slowing up in growth after weaning is not entirely overcome by the time the calves are 180 days old. Therefore most of the calves weigh less in proportion to the normal at six months of age than at the beginning of the experiment. The rate of growth, however, near the end of the 180-day period is more rapid than directly after time of weaning. This acceleration of the rate of growth continues for some time and by the time the animals reach two years of age, if given good feed and care, they will be above the normal in weight. This is shown to be a fact by Table VII.

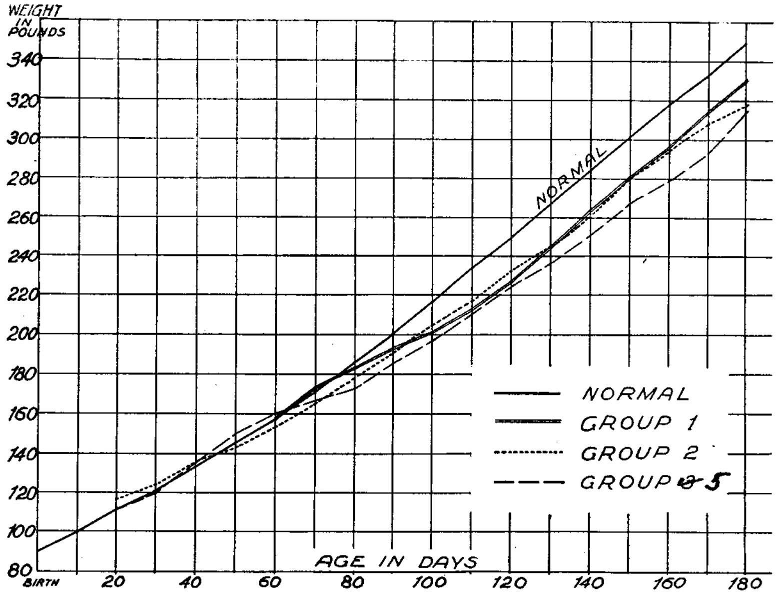


Fig. 3. Growth of Holstein Calves Raised on a Minimum Amount of Milk Compared with Normal Growth of Calves of this Breed

Period includes only the first 180 days. Calves of Group 1 received whole milk to 72 days of age. Those of Group 2 were also fed whole milk but the calves were weaned at 50 days. Group 5 received whole milk during the first two weeks, which was followed by skimmilk to 60 days. After weaning, the ration consisted of alfalfa hay and a grain mixture.

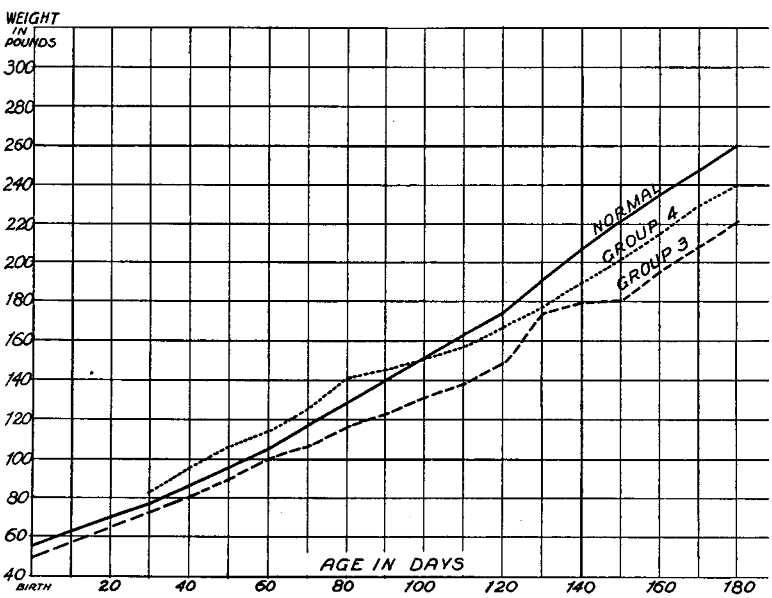


Fig. 4. Growth of Guernsey and Jersey Calves Raised on Minimum Amount of Whole Milk and Skimmilk Compared with Normal Growth of Calves of the Jersey Breed

Period represented by chart includes first 180 days only. Group 3 consisted of two Jersey heifers fed whole milk to 72 days. Group 4 was made up of six Guernseys. They were weaned at 70 days after receiving whole milk and only a small amount of skimmilk.

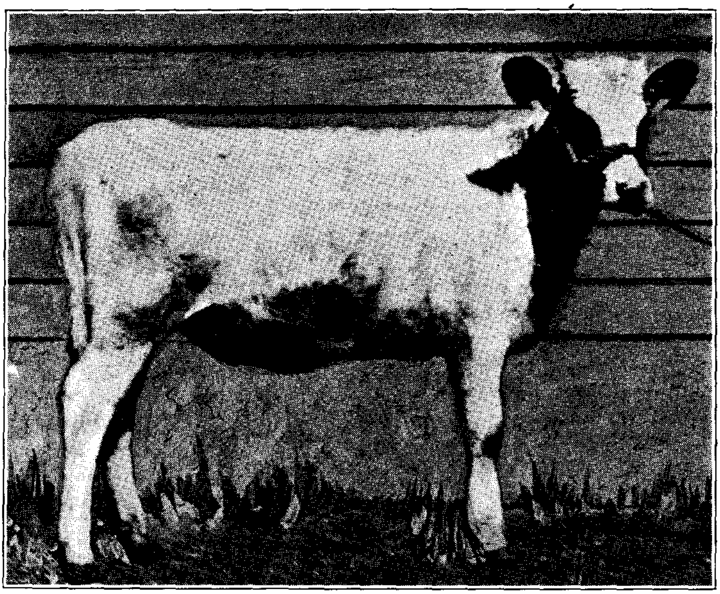


Fig. 5 Grade Guernsey at Six Months

Raised on whole milk and a small amount of skimmilk to 70 days. Weight at six months, 240 pounds. Daily gain up to six months 1.06 pounds. This is slightly less than the average gains made by calves of this breed receiving skimmilk during the same period of time. Feed consumed up to six months: Whole milk, 478 pounds, skimmilk 95 pounds, grain 433 pounds, alfalfa hay 336 pounds.

TABLE VI

Group 5

Record of Growth from 16 to 180 Days

Ration, Whole Milk and Skimmilk to 60 Days

Grain and Alfalfa Hay to 180 Days

	Calf No. H-1	Calf No. H-2	Calf No. H-3
Weight at 16 days, lbs.	108	114	105
Per cent normal weight, 16 days	101	107	99
Weight at 60 days, lbs.	149	169	161
Per cent normal weight, 60 days	95	108	103
Weight at 180 days, lbs.	294	320	331
Normal weight 180 days, lbs.	349	349	349
Per cent normal weight, 180 days	84	92	95
Daily gain 16 to 60 days, lbs.	0.93	1.25	1.27
Normal gain 16 to 60 days, lbs.	1.15	1.15	1.15
Per cent normal gain, 16 to 60 days	81	109	110
Daily gain 60 to 180 days, lbs.	1.21	1.26	1.41
Normal gain 60 to 180 days, lbs.	1.60	1.60	1.60
Per cent normal gain, 60 to 180 days	76	79	88
Daily gain 16 to 180 days, lbs.	1.13	1.25	1.38
Normal gain 16 to 180 days, lbs.	1.48	1.48	1.48
Per cent normal gain, 16 to 180 days	76	85	93
Height at withers 180 days, cm.	96.2	100.2	98.9
Per cent of normal height, 180 days	95	99	98

TABLE VII
WEIGHTS OF HEIFERS RAISED ON MINIMUM AMOUNT OF MILK COMPARED WITH NORMAL
APPROXIMATE AGE, TWO AND ONE-HALF YEARS

No. of animal	Age, days	Weight, lbs.	Jersey normal weight,* lbs.	Normal weight, Per cent
136	981	894	824	108
138	980	902	824	109
G-2	930	912	824	111
G-3	932	967	824	117
G-4	928	855	824	104

* Estimated.

The growth in height is apparently less affected by the ration than is the weight. The heights of all the calves were nearly normal at 180 days, varying only by a few per cent. Little trouble was experienced from sickness in raising any of the calves in these groups, in fact less than with calves raised in the ordinary way. The experiment showed that some calves can get along without milk at a considerably younger age than others. The milk may be dropped from the ration of a large vigorous calf at the age of 50 days. With others less vigorous it is not wise to begin to take away the milk until the age of 60 or 70 days or even a greater age has been reached.

POWDERED SKIMMILK, MALTED MILK, SEMI-SOLID AND POWDERED BUTTERMILK FOR CALF RAISING

The possibility of utilizing some form of dried or condensed milk for calf raising was suggested by the rapid development of the dried milk industry in recent years. From a very small beginning a comparatively few years ago this industry has grown to mammoth proportions in the last dozen years. It is estimated that the present output of powdered skimmilk alone amounts to approximately 50,000,000 pounds annually. Besides this there are more than 30,000,000 pounds of condensed or semi-solid buttermilk, and 10,000,000 or more pounds of dried buttermilk produced yearly. While these are enormous amounts yet they represent but a small fraction of the total quantity of raw products which might properly and undoubtedly will eventually be utilized for these various purposes.

It is estimated that the manufacture of butter in the United States provides annually 18,000,000,000 pounds of skimmilk. This skimmilk, if reduced to the dry form, would yield approximately 1,800,000,000 pounds of skimmilk powder. Also, of the more than 1,600,000,000 pounds of buttermilk produced yearly only about 10 per cent is utilized for the manufacture of both condensed and dried buttermilk. The great possibilities for the use of these products for calf feeding are therefore apparent.

These products do not differ materially in composition from the raw products from which they are derived. None of the ingredients except water originally present is removed or decreased during the process of concentration. Also, according to the best available information, neither the digestibility nor the vitamine content present in the original fluid product is seriously affected by the processes of condensation and drying as now practiced. Powdered skimmilk and dried buttermilk have approximately the same concentration. They contain from 90 to 95 per cent milk solids and from 5 to 10 per cent water. The ratio of concentration of semi-solid buttermilk is more variable. It averages from about 25 to 35 per cent total solids and from 65 to 75 per cent of water.

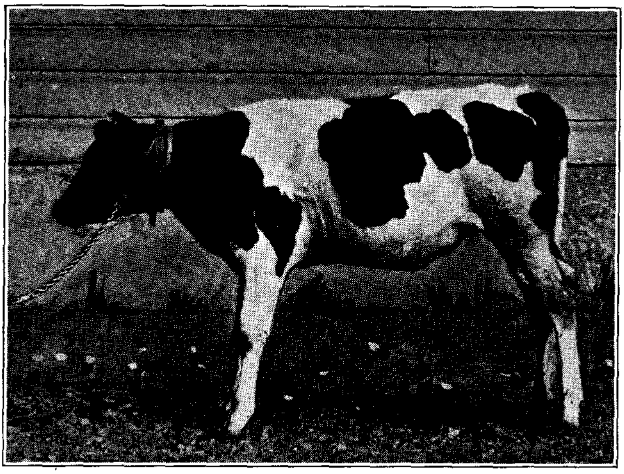
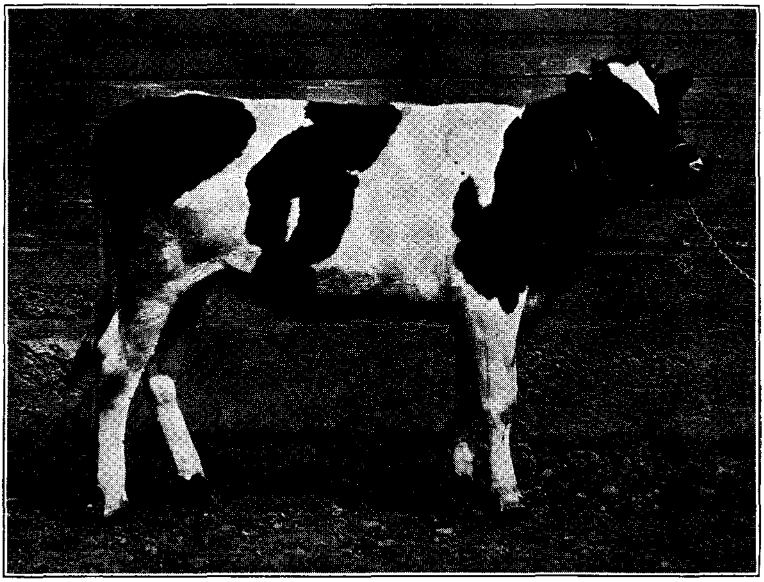


Fig. 6 (See legend on opposite page.)

EXPERIMENTAL WORK

In the first experiment powdered skimmilk was used. The first trial was for the purpose of determining if a calf would thrive on it in place of skimmilk in the ordinary form. It soon appeared that exactly the same results were secured with the powdered as with ordinary fresh skimmilk. The next trial consisted in changing calves from the ordinary to the powdered milk to determine if any special difficulties would be encountered in making such changes. Great caution was exercised at first but no bad results following, later changes were made freely from one to the other. Sometimes ordinary skimmilk was given at one feed and powdered skimmilk at the next, but through it all the calf did not seem to be aware that a change had been made. It was clear from these experiments that powdered skimmilk could be used for calf feeding with the same success as ordinary skimmilk.



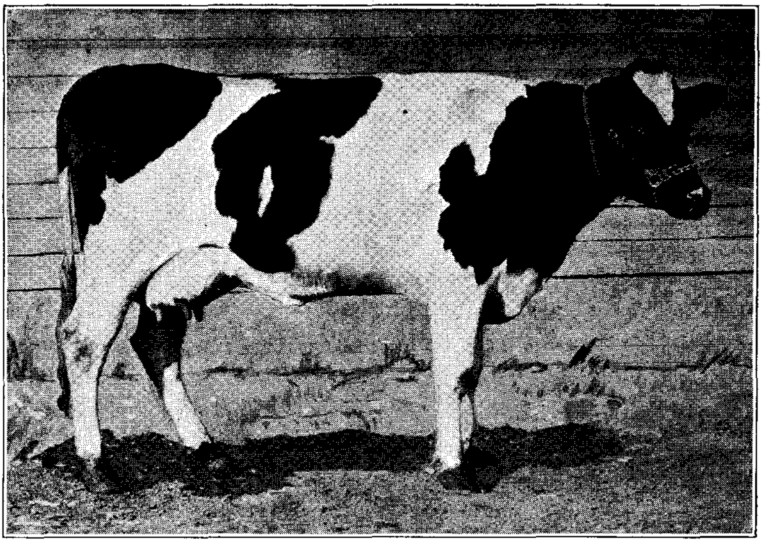


Fig. 6. Grade Holstein Heifer Raised on Powdered Skimmilk to 70 Days of Age

First picture taken at 3½ months, second at 11 months, and third soon after first freshening at 2½ years of age. Weight at six months, 280 pounds. Daily gain in weight to six months, 1.14 pounds. Daily gains by average Holstein calf raised on skimmilk during same period, 1.46 pounds. Weight at two years 972 pounds as compared to 841 pounds, the average weight of Holstein heifers at that age. Feed consumed up to six months: Whole milk 134 pounds, powdered skimmilk 70 pounds, grain 389 pounds, alfalfa hay 417 pounds.

The next experiment was to combine the use of powdered skimmilk with the plan outlined for raising calves on the minimum amount of milk already described. Five calves were used, three thrifty Holsteins, one Jersey, and one Guernsey. The last was not in good physical condition when he arrived at the station and considerable trouble was experienced in getting him started on the whole milk. The calves were fed whole milk until they were from ten days to two weeks of age, after which the whole milk was gradually withdrawn at the rate of a pound a day and replaced by an equal portion of the remade milk prepared by dissolving one part of the skimmilk powder in nine times its weight of warm water. The amount of remade milk fed varied with the size and vigor of the animal. Usually the ratio was one pound of milk to ten pounds of live weight of calf.

At an early age the calves were taught to eat grain and hay. The same grain mixture was used as in the other experiment, namely, a mixture of four parts cornmeal, one part wheat bran, and one part linseed oilmeal, all by weight. The hay was a good grade of alfalfa which was kept before them at all times. The amount of grain consumed was limited to 5 pounds a day.

When these calves reached the age of 63 days, the amount of milk was gradually cut down until at 73 days all but one, the Guernsey, were receiving hay and grain only, as shown by Table VIII. To bring them to that age required the following amounts of feed: the average for the three Holsteins was 149 pounds whole milk, 71 pounds skimmilk powder, 41 pounds grain, and 49 pounds alfalfa hay; the Jersey required 146 pounds whole milk, 51 pounds powdered skimmilk, 40 pounds grain, and 45 pounds alfalfa hay. The Guernsey was not weaned entirely until he was 105 days old. During that time he received a total of 127 pounds whole milk, 79 pounds powdered skimmilk, 40 pounds grain, and 73 pounds alfalfa hay. These calves received less whole milk than those raised on ordinary skimmilk. The amount of skimmilk, however, was considerably greater. About the same amount of grain was consumed but the calves raised on powdered skimmilk ate more hay.

TABLE VIII

AGE AT WEANING AND FEED CONSUMED TO SIX MONTHS OF AGE, CALVES RAISED ON POWDERED SKIMMILK

No. of animal	Breed	Age at weaning, days	Whole milk from 5 days of age, lbs.	Powdered skimmilk, lbs.	Grain, lbs.	Alfalfa hay, lbs.	Silage, lbs.
S-1	Grade Holstein	73	134	70.4	389	417	..
S-2	Grade Holstein	73	178	72.0	448	438	..
S-3	Grade Holstein	73	135	70.6	437	470	..
S-4	Grade Guernsey	105	127	79.3	280	292	6
S-6	Purebred Jersey	73	146	50.7	371	372	34

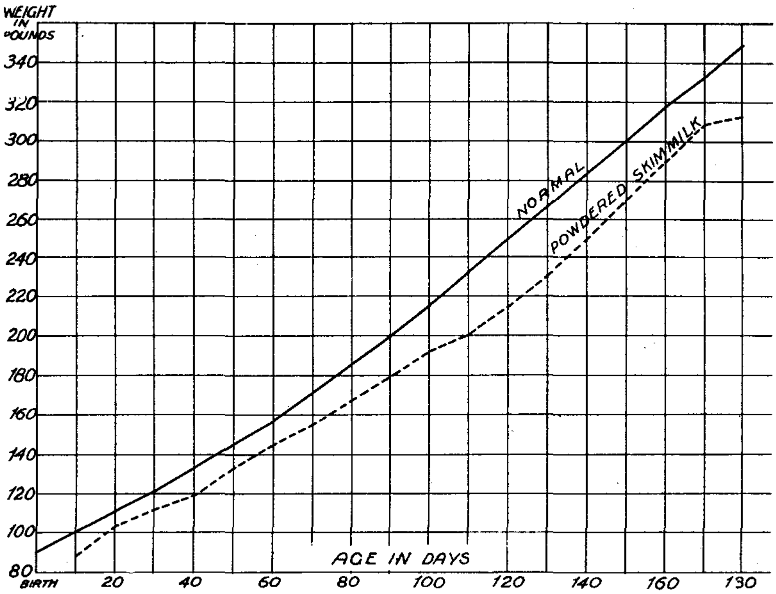


Fig. 7. Growth of Holstein Calves Raised on Powdered Skimmilk to 73 Days of Age Compared with Normal Growth of Calves of this Breed
Period represented includes the first 180 days only.

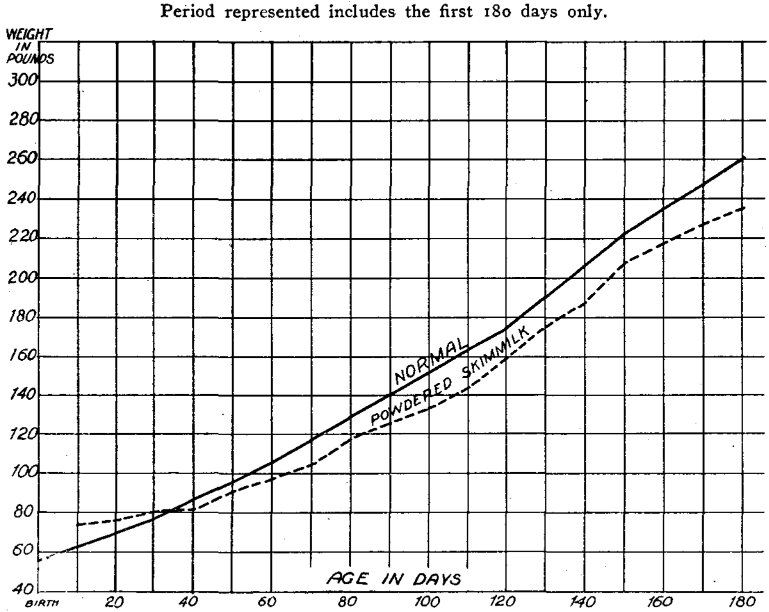


Fig. 8. Growth of a Group of Jersey and Guernsey Calves Raised on Powdered Skimmilk to 73 Days of Age as Compared with Normal Growth of Calves of the Jersey Breed
Period covered includes the first 180 days only.

The calves were kept in roomy individual pens. During pleasant weather they were turned out in the day time for exercise in a dry lot in which they had free access to fresh water and salt. Weights were taken regularly every ten days and height measurements were made once every thirty days.

TABLE IX

Group 6

RECORD OF GROWTH FROM 10 TO 180 DAYS
RATION, WHOLE MILK AND POWDERED SKIMMILK TO 73 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. S-1	Calf No. S-2	Calf No. S-3	Calf No. S-4	Calf No. S-6
Weight at 10 days, lbs.	87	94	84	68	79
Per cent normal weight, 10 days	87	94	84	110	127
Weight at 70 days, lbs.	147	173	145	89	120
Per cent normal weight, 70 days	86	101	85	76	103
Weight at 180 days, lbs.	280	327	333	215	255
Normal weight 180 days, lbs.	349	349	349	260	260
Per cent normal weight, 180 days	80	94	95	83	98
Daily gain 10 to 70 days, lbs.	1.00	1.31	1.01	0.35	0.68
Normal gain 10 to 70 days, lbs.	1.18	1.18	1.18	1.18	1.18
Per cent normal gain, 10 to 70 days	85	111	86	38	75
Daily gain 70 to 180 days, lbs.	1.21	1.40	1.71	1.14	1.23
Normal gain 70 to 180 days, lbs.	1.61	1.61	1.61	1.30	1.30
Per cent normal gain, 70 to 180 days	75	87	106	88	95
Daily gain 10 to 180 days, lbs.	1.14	1.37	1.46	0.86	1.03
Normal gain 10 to 180 days, lbs.	1.46	1.46	1.46	1.16	1.16
Per cent normal gain, 10 to 180 days	78	94	100	74	89
Height at withers 180 days, cm.	97.6	98.8	100	84	90.7
Per cent normal height, 180 days	97	98	99	90	97

Table IX shows the growth of the calves compared with the normal at various ages up to 180 days. Figures 7 and 8 show how closely the growth of these calves followed that of the normal from the beginning to the close of the experiment. On the whole these calves showed tendencies similar to those of the preceding group. During their milk feeding period they made almost normal gains, but after weaning the rate of growth showed a tendency to lag for a time as compared to the normal. Toward the end of the 180-period, however, the rate of gain was accelerated. They were all below normal weight at 180 days. However, several of them were no lower than when they were placed on experiment. That they regained their normal size later is shown by the fact that S-1, the Holstein heifer in the group shown in Figure 6, weighed 972 pounds at 690 days of age, which is 118 per cent normal weight for the age.

These calves were all growthy and very thrifty looking. No difficulty was experienced in getting them to take the skimmilk as prepared. They were unusually free from sickness and calf ailments, not one of them being off feed after getting fully started on the experiment.

MALTED MILK FOR DAIRY CALVES

Malted milk is another form of dried milk product. It is made from a combination of whole milk and an extract of malted barley and wheat flour. The mixture is reduced to a dry form by evaporation in a vacuum. Like powdered skimmilk it is a substance of acknowledged high feed value. As whole milk is used in its manufacture, it contains the milk fat.

Under normal conditions malted milk is used for human food and the price is so high as to make it prohibitive for calf feeding. However, a limited amount of lower quality product can at times be obtained at comparatively low cost by patrons of malted milk factories. This experiment was conducted in order to determine whether such lower grades of malted milk can be satisfactorily utilized for calf feeding.

EXPERIMENTAL WORK

Three grade Holstein heifer calves were used in the experiment. The same general method of caring for the calves was followed as for those raised on powdered skimmilk. As with skimmilk powder, the malted milk was dissolved in nine times its weight of warm water.

The malted milk used was obtained from a well known manufacturer of this product and was representative of the quality found in the lower grades of malted milk which it is not desirable to place on the regular market.

The calves in this group were weaned at 50 days of age as compared to 70 days for those receiving powdered skimmilk. Table X shows the amount of feed consumed to six months of age. As compared with the Holsteins in the powdered skimmilk lot, the amount of whole milk consumed was somewhat greater while the amount of malted milk as compared with the powdered milk was less. More grain and less hay was also consumed by those raised on malted milk.

TABLE X

AGE AT WEANING AND FEED CONSUMED TO SIX MONTHS OF AGE, CALVES RAISED ON MALTED MILK

No. of animal	Breed	Age at weaning, days	Whole milk from 5 days of age, lbs.	Malted milk, lbs.	Grain, lbs.	Alfalfa hay, lbs.
532	Grade Holstein	50	274	21.0	580	346
533	Grade Holstein	50	278	16.4	550	270
534	Grade Holstein	50	280	20.5	531	259

These calves, as is indicated in Table XI and Figure 9, were all normal or above at the beginning of the experiment. Their daily gains during the milk feeding period, however, were much below normal and their weights at weaning time were from 14 to 20 per cent lower than normal than at the beginning. For some reason they did not make normal gains while receiving the malted milk ration. However, they also showed a tendency like other groups to decrease in the rate of growth for a time after weaning. By the time they were 180 days old they had regained some of the loss and were near normal in size again.

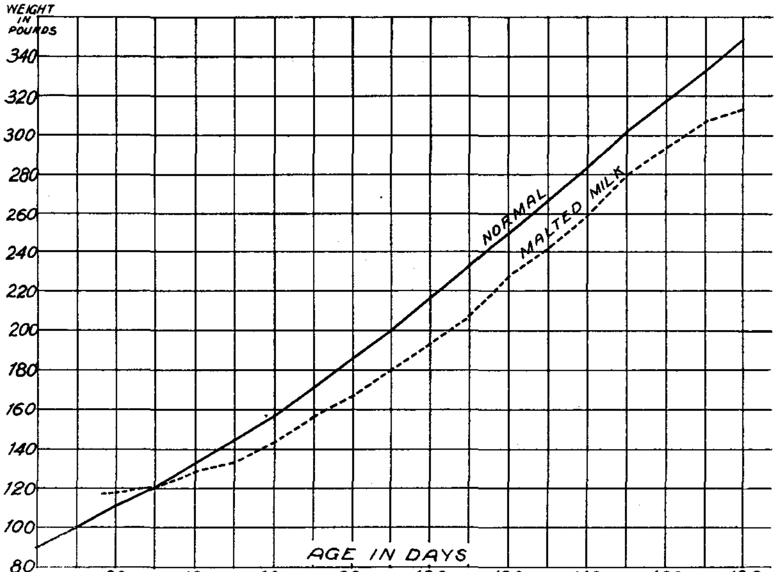


Fig. 9 Growth of Holstein Calves Raised on Malted Milk to 50 Days of Age Compared with Normal Growth of Calves of this Breed
Period represented includes the first 180 days only

TABLE XI

Group 7

RECORD OF GROWTH FROM 16 TO 180 DAYS
RATION, WHOLE MILK AND MALTED MILK TO 50 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. 532	Calf No. 533	Calf No. 534
Weight at 16 days, lbs.	118	106	125
Per cent normal weight, 16 days	111	99	117
Weight at 50 days, lbs.	143	118	141
Per cent normal weight, 50 days	97	81	97
Weight at 180 days, lbs.	346	293	301
Normal weight 180 days, lbs.	349	349	349
Per cent normal weight, 180 days	99	84	86
Daily gain 16 to 50 days, lbs.	0.73	0.35	0.47
Normal gain 16 to 50 days, lbs.	1.13	1.13	1.13
Per cent normal gain, 16 to 50 days	65	31	42
Daily gain 50 to 180 days, lbs.	1.56	1.34	1.23
Normal gain 50 to 180 days, lbs.	1.57	1.57	1.57
Per cent normal gain, 50 to 180 days	99	85	78
Daily gain 16 to 180 days, lbs.	1.39	1.14	1.07
Normal gain 16 to 180 days, lbs.	1.48	1.48	1.48
Per cent normal gain, 16 to 180 days	94	77	72
Height at withers, 180 days, cm.	99.1	93.0	95.0
Per cent normal height, 180 days	98	92	94

POWDERED BUTTERMILK AND SEMI-SOLID BUTTERMILK FOR CALVES

Powdered buttermilk and semi-solid or condensed buttermilk were used in the next experiment. The fact that ordinary raw buttermilk is used as a calf feed in certain dairy sections of the world indicated the possibility of using the condensed forms of this product for the same purpose. Furthermore, the practical consideration that raw buttermilk is almost a waste product in the sections where produced, making its ultimate cost in condensed or powdered form comparatively low, adds to the desirability of utilizing it for calf feeding.

Ordinary raw buttermilk has almost the same percentage composition and feed value as skimmilk. The chief difference is in the higher percentage of acidity which it usually contains. In the process of concentrating it, certain chemical and physical changes take place. These, however, are not of such a nature as seriously, if at all, to decrease the digestibility and food value of the product. It would appear from this that it should prove entirely satisfactory as a calf feed.

EXPERIMENTAL WORK

The object of the experiment reported here was to determine whether calves would make satisfactory growth when fed concentrated buttermilk products in place of skimmilk. The general plan was to rear the calves on condensed or dried buttermilk properly diluted and fed in the same manner as skimmilk supplemented by a good hay and grain ration. Ten calves in all were used.

In the first experiment two groups were used. The animals in the first group, a purebred Jersey male and a grade Guernsey heifer calf, were fed the semi-solid or condensed form of the buttermilk to 105 days of age. A second group consisting of two grade Guernsey heifers and a purebred Jersey bull calf received powdered buttermilk to 150 days of age.

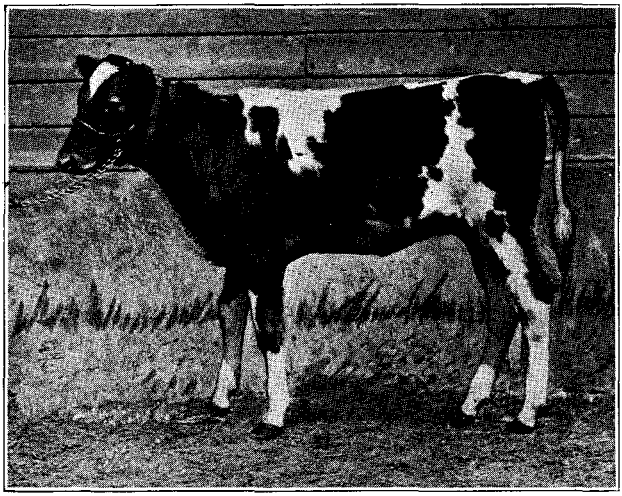


Fig. 10 Grade Guernsey at Five Months

Fed powdered buttermilk to 150 days. Weight at six months, 283 pounds. Daily gain in weight to six months, 1.31 pounds, which is more than the average daily gain made by calves of this breed receiving skimmilk during the same period. Feed consumed to six months: Whole milk 268 pounds, powdered buttermilk 135 pounds, grain 363 pounds, alfalfa hay 237 pounds.

A second experiment was started after the first had been completed. The object was to secure further data and also to compare the results obtained from early weaning with those of late weaning. Five grade Holstein calves receiving powdered buttermilk were used. Three of them were taken off the buttermilk at 70 days of age while the other two continued to receive it to the age of 150 days.

As is shown by Table XII, semi-solid buttermilk product is approximately three times as concentrated as the original product. It was fed in a diluted form, being mixed in the ratio of one part buttermilk to three parts by weight of warm water. This gave a mixture with practically the same composition as ordinary skimmilk.

Two lots of powdered buttermilk were used. That fed to the Guernsey-Jersey group was obtained from an Iowa manufacturer, and that fed to the Holstein calves in the second experiment from a St Paul firm. The composition of the products used, together with the average analyses of buttermilk for comparison is given in Table XII. This table indicates that these products contained about nine times as high a percentage of solids as common buttermilk. Consequently, in order to give them approximately the same composition as skimmilk one part of the powder was dissolved in nine part by weight of warm water.

TABLE XII

COMPOSITION OF SEMI-SOLID AND POWDERED BUTTERMILK USED IN CALF FEEDING EXPERIMENTS, ALSO COMPOSITION OF ORDINARY FRESH BUTTERMILK FOR COMPARISON

Per 100 lbs.	Semi-solid buttermilk, lbs.	Powdered buttermilk, lbs.	Fresh buttermilk,* lbs.
Total solids	30.51	92.11	9.4
Water	69.49	7.09	90.6
Protein	11.14	35.00	3.6
Fat	0.84	2.86	0.1
Nitrogen-free extract	15.80	43.59	5.0
Ash	2.73	11.46	0.7
Calcium	0.45	2.73	...

* Feeds and Feeding, 18th ed. p. 713.

Both the semi-solid and the powdered lots were typical of the product made from buttermilk of the quality common in creameries of the so-called centralizer type, where the cream is transported a considerable distance and is ordinarily neutralized before churning. That a neutralizer was used is indicated by the relatively high calcium content. When computed on the basis of the percentage present in the dry matter, the concentrated products contain approximately twice the amount of calcium found in ordinary skimmilk. This fact, however, is not objectionable from a nutritional standpoint, for it may increase rather than decrease the feed value of these products. Howver, in case a magnesium compound was used as a neutralizer in the cream, the added mineral matter would not be desirable on account of the well known magnesium calcium antagonism within the body. It has been shown experimentally that an excess of magnesium in the food intake results in calcium elimination from the body structure.

As when calves are to be raised on skimmilk, whole milk feeding was continued during the first ten days to two weeks of their lives, or until they appeared sufficiently vigorous to stand a change in their diet. The change from whole milk to buttermilk was always made gradually. The method of feeding both the semi-solid and powdered forms of the buttermilk after the addition of the water was identical to that followed in skimmilk feeding.

In addition to the buttermilk the calves were given all the alfalfa hay they would eat besides receiving a grain ration consisting of 4 parts by weight of cornmeal, one of wheat bran, and one of linseed oilmeal. The amount of grain was usually limited to five pounds per day per calf at any time up to six months of age.

The calves were kept in separate pens at night and turned out for exercise in a dry lot during the day. Their growth in weight and height was determined in the same manner as in the other experiments reported in this bulletin. Figures 11 and 12 show the growth curves for the various groups in their relation to the normal curve. As has previously been stated no normal growth curves are yet available for the Guernsey breed. This is also true for males of any breed. For this reason, as in previous experiments, the growth curves of the various Guernseys are compared with the Jersey normal. As one group consisted of two Guernsey females and a Jersey male, and another group of one Guernsey female and a Jersey male, the results as shown in Figure 11 give the appearance of being somewhat better than they really are.

Table XIII gives the age at weaning and the feed consumed up to six months of age. Tables XIV, XV, XVI, and XVII are records of the growth of the animals in the various groups compared with the normal at different ages up to 180 days. The results indicate that all the calves made excellent growth while on the buttermilk ration. This is especially true of the Jersey-Guernsey group weaned at 150 days of age. That calves weaned at 70 days of age receive a set-back from which they do not entirely recover by the time they are six months old is shown by Figure 12. There is, however, not enough difference in weight at 6 months of age between them and those weaned at 150 days to justify the longer period of buttermilk feeding.

TABLE XIII
FEED CONSUMED TO SIX MONTHS OF AGE
CALVES RAISED ON SEMI-SOLID AND POWDERED BUTTERMILK

No. of animal	Breed	Age at weaning, days	Whole milk from 5 days of age, lbs.	Powdered butter-milk, lbs.	Semi-solid butter-milk, lbs.	Grain, lbs.	Alfalfa hay, lbs.
E- 7	Purebred Jersey	105	250	...	186	376	262
E- 8	Grade Guernsey	105	250	...	186	399	278
E- 9	Grade Guernsey	150	268	135.1	...	363	237
E-10	Grade Guernsey	150	243	138.7	...	391	242
E-11	Purebred Jersey	150	156	147.7	...	430	255
E-12	Grade Holstein	70	201	65.0	...	497	500
E-14	Grade Holstein	150	176	156.2	...	406	450
E-15	Grade Holstein	70	180	51.7	...	452	433
E-16	Grade Holstein	150	140	154.3	...	466	414
E-17	Grade Holstein	70	146	60.8	...	464	475

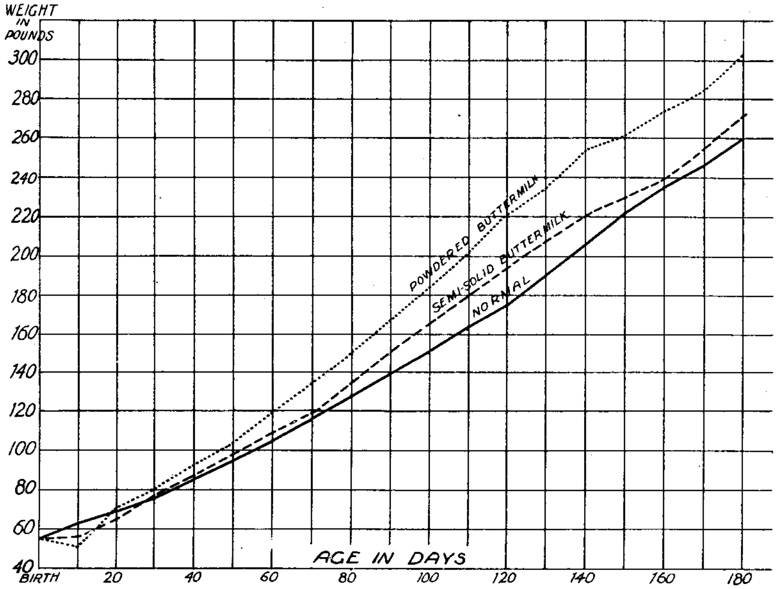


Fig. 11. Growth of Two Groups of Guernsey and Jersey Calves compared with Normal Growth of Calves of the Jersey Breed

The value of the comparison with the Jersey normal is limited, as the group raised on semi-solid buttermilk to 105 days consisted of a vigorous Jersey male and a Guernsey heifer. The other group raised on powdered buttermilk to 105 days was made up of two Guernsey heifers and one Jersey male. Period includes the first 180 days only.

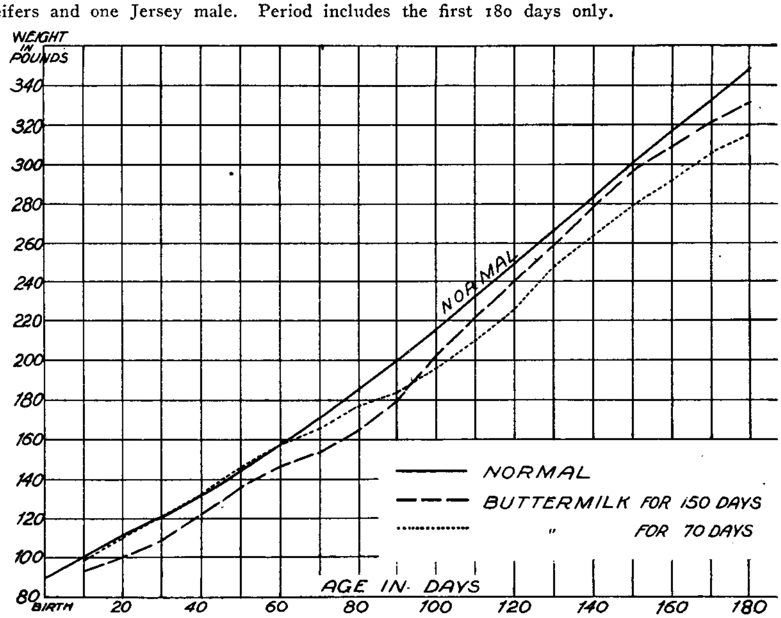


Fig. 12. Growth of Two Groups of Holstein Calves Raised on Powdered Buttermilk and Weaned at 70 and 150 Days of Age Respectively, Compared with Each Other and with Normal Growth of Calves of this Breed

The decrease in the rate of growth of calves beginning soon after weaning at 70 days and continuing for 30 days or more is evidence of the effect of early weaning. The difference in weight between the two groups at 180 days is, however, hardly sufficient to justify the longer period of powdered buttermilk feeding.

TABLE XIV
Group 8
Record of Growth from 15 to 180 Days
Ration, Whole Milk and Semi-Solid Buttermilk to 105 Days,
Grain and Hay to 180 Days

	Calf No. E-7	Calf No. E-8
Weight at 15 days, lbs.	59	63
Per cent normal weight, 15 days	90	96
Weight at 105 days, lbs.	174	171
Per cent normal weight, 105 days	111	109
Weight at 180 days, lbs.	267	275
Normal weight at 180 days, lbs.	260	260
Per cent normal weight, 180 days	103	106
Daily gain 15 to 105 days, lbs.	1.28	1.20
Normal gain 15 to 105 days, lbs.	1.01	1.01
Per cent normal gain, 15 to 105 days	127	119
Daily gain 105 to 180 days, lbs.	1.24	1.38
Normal gain 105 to 180 days, lbs.	1.37	1.37
Per cent normal gain, 105 to 180 days	91	101
Daily gain 15 to 180 days, lbs.	1.26	1.28
Normal gain 15 to 180 days, lbs.	1.18	1.18
Per cent normal gain, 15 to 180 days	107	108
Height at withers, 180 days, cm.	91.4	94.7
Per cent normal height, 180 days	98	101

TABLE XV
Group 9
Record of Growth from 15 to 180 Days
Ration, Whole Milk and Powdered Buttermilk to 150 Days
Grain and Hay to 180 Days

	Calf No. E-9	Calf No. E-10	Calf No. E-11
Weight at 15 days, lbs.	67	76	56
Per cent normal weight, 15 days	102	116	85
Weight at 150 days, lbs.	245	253	288
Per cent normal weight, 150 days	110	114	130
Weight at 180 days, lbs.	283	297	332
Normal weight at 180 days, lbs.	260	260	260
Per cent normal weight, 180 days	109	114	128
Daily gain 15 to 150 days, lbs.	1.32	1.31	1.72
Normal gain 15 to 150 days, lbs.	1.16	1.16	1.16
Per cent normal gain, 15 to 150 days	114	113	148
Daily gain 150 to 180 days, lbs.	1.26	1.46	1.46
Normal gain 150 to 180 days, lbs.	1.26	1.26	1.26
Per cent normal gain, 150 to 180 days	100	116	116
Daily gain 15 to 180 days, lbs.	1.31	1.34	1.67
Normal gain 15 to 180 days, lbs.	1.18	1.18	1.18
Per cent normal gain, 15 to 180 days	111	113	141
Height at withers, 180 days, cm.	96.1	98.1	99.5
Per cent normal height, 180 days	102	105	106

TABLE XVI
Group 10
RECORD OF GROWTH FROM 10 TO 180 DAYS
RATION, WHOLE MILK AND POWDERED BUTTERMILK TO 70 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. E-12	Calf No. E-15	Calf No. E-17
Weight at 10 days, lbs.	110	96	92
Per cent normal weight, 10 days	109	95	91
Weight at 70 days, lbs.	183	155	161
Per cent normal weight, 70 days	107	90	94
Weight at 180 days, lbs.	327	299	320
Normal weight at 180 days, lbs.	349	349	349
Per cent normal weight, 180 days	93	85	91
Daily gain, 10 to 70 days, lbs.	1.21	0.98	1.15
Normal gain 10 to 70 days, lbs.	1.18	1.18	1.18
Per cent normal gain, 10 to 70 days	103	83	97
Daily gain 70 to 180 days, lbs.	1.28	1.22	1.44
Normal gain 70 to 180 days, lbs.	1.61	1.61	1.61
Per cent normal gain, 70 to 180 days	80	76	89
Daily gain 10 to 180 days, lbs.	1.27	1.19	1.34
Normal gain 10 to 180 days, lbs.	1.46	1.46	1.46
Per cent normal gain, 10 to 180 days	87	81	92
Height at withers, 180 days, cm.	100.9	100.9	100.9
Per cent normal height, 180 days	99	97	97

TABLE XVII
Group 11
RECORD OF GROWTH FROM 10 TO 180 DAYS
RATION, WHOLE MILK AND POWDERED BUTTERMILK TO 150 DAYS
GRAIN AND ALFALFA HAY TO 180 DAYS

	Calf No. E-14	Calf No. E-16
Weight at 10 days, lbs.	80	95
Per cent normal weight, 10 days	80	95
Weight at 150 days, lbs.	282	311
Per cent normal weight, 150 days	93	103
Weight at 180 days, lbs.	317	344
Normal weight at 180 days, lbs.	349	349
Per cent normal weight, 180 days	91	98
Daily gain, 10 to 150 days, lbs.	1.44	1.54
Normal gain 10 to 150 days, lbs.	1.44	1.44
Per cent normal gain, 10 to 150 days	100	107
Daily gain 150 to 180 days, lbs.	1.17	1.10
Normal gain 150 to 180 days, lbs.	1.56	1.56
Per cent normal gain, 150 to 180 days	75	70
Daily gain 10 to 180 days, lbs.	1.39	1.46
Normal gain 10 to 180 days, lbs.	1.46	1.46
Per cent normal gain, 10 to 180 days	95	100
Height at withers, 180 days, cm.	97.9	97.8
Per cent normal height, 180 days	97	97

All the calves used in this experiment were unusually free from sickness or digestion troubles. Not one of the calves was ever off feed after getting finally started on the experiment. No trouble was experienced in getting them to take the buttermilk as prepared. Rather they seemed to prefer it to whole milk. Scours or indigestion was never present. A slightly greater degree of looseness of the bowels was apparent among all the calves during the period of buttermilk feeding than is common when skimmilk is fed. This, however, did not affect their vigor or vitality. The calves were as a whole sleek coated and thrifty appearing, equal in size and condition to calves raised on typical farms.

SUMMARY AND CONCLUSIONS

More than fifty per cent of all the calves born each year in the United States are from cows the milk of which is sold as whole milk. Under this condition calves are usually not raised because of the high price that can be obtained for the milk necessary to feed them. This situation has led to numerous attempts to find a practical and economical method of calf raising, as experience has shown that herds seldom are improved unless the owner raises the heifers necessary to maintain the herd.

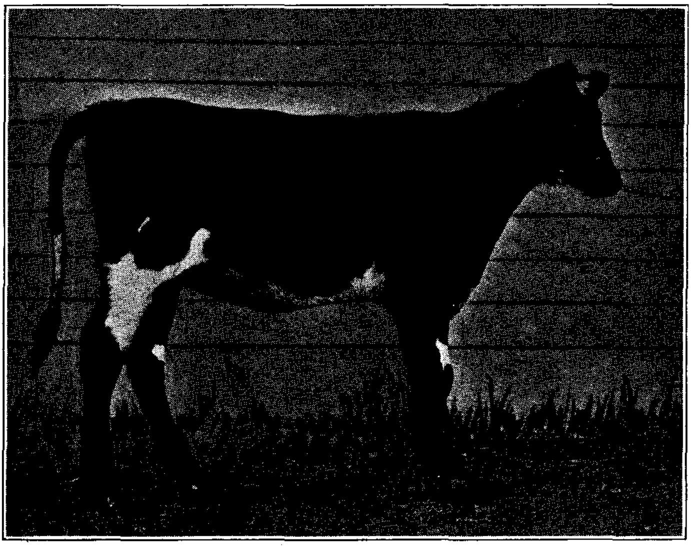


Fig. 13. Grade Holstein Heifer at 5½ Months, Raised on Powdered Buttermilk to 70 Days of Age

Weight at six months, 320 pounds. Daily gain in weight to six months, 1.34 pounds. This is slightly less than the gains made by the average calf fed skimmilk during this period. Feed consumed to six months: Whole milk 146 pounds, powdered buttermilk 61 pounds, grain 464 pounds, alfalfa hay 475 pounds.

The so-called "milk substitutes" and proprietary feeds on the market have not entirely solved the problem. In general these feeds are not satisfactory substitutes for milk and they are rather expensive. A study of the list of feeding stuffs used in the so-called milk substitutes from the standpoint of the newer knowledge of nutrition, suggests that the difficulty experienced in getting a satisfactory milk substitute also involves the question of vitamines, proteins of a suitable quality, and an adequate supply of mineral matter, especially calcium. Milk is the only feed that supplies all the substances needed in a suitable form.

A careful study of the entire question led to the conclusion that the practical solution of the problem of raising the calf when whole milk is sold is not to attempt to find a milk substitute but to use the least possible amount of milk.

The experiments reported in this bulletin, therefore, were not designed to find a substitute for milk but to determine the least possible amount that can be used and still get the desired results. Two plans were followed: (a) Raising calves on the minimum amount of whole or skimmed milk, (b) raising calves on some form of dried or condensed milk, the minimum quantity of each to be used.

Eighteen calves were raised according to the first plan. Nine received whole milk until weaned at 60 days of age. The remainder received whole milk and some skimmilk until weaned when about 70 days old. From time of weaning to six months of age, alfalfa hay and a grain mixture consisting of four parts cornmeal, one part each of bran and linseed oilmeal, constituted their sole diet.

The calves that received some skimmilk made as good gains and were as thrifty as those raised on whole milk throughout the milk feeding period. Weaning decreased the rate of gain for a time. The resulting loss compared with the normal, however, was partially recovered by the time the calves were 180 days old.

Results indicate that good calves can be raised on a very small amount of milk. Some calves can get along without milk at a considerably younger age than others. Milk may with safety be dropped from the ration of large vigorous calves at the early age of fifty days.

Powdered skimmilk, powdered buttermilk, semi-solid or condensed buttermilk, and malted milk were used in the second part of this experiment. These products do not materially differ in composition from the raw products from which they are derived, as none of the ingredients originally present except water is removed or decreased during the process of concentration.

Five calves were fed powdered skimmilk and weaned at about 70 days, three others received malted milk to 50 days of age. Three lots, a total of ten calves, were raised on the semi-solid and powdered buttermilk. Those receiving the semi-solid form were weaned when 105 days old. The remainder received powdered buttermilk, part of them were weaned at 150 days and the others at 70 days in order to compare the results obtained from early weaning with those from late weaning.

Feeding of the powdered or condensed product was begun when the calves were about two weeks old. Whole milk was then gradually withdrawn at the rate of a pound a day and replaced by an equal portion of the remade milk prepared by dissolving one part of the powder in nine times its weight of warm water. The semi-solid buttermilk was diluted with three times its weight of water.

From time of weaning to six months of age these calves received a ration similar to that of the calves raised on the minimum amount of milk.

As in the previous experiment the rate of growth as compared with the normal showed a tendency to lag for a time after weaning. This was apparent regardless of the age of weaning. Toward the end of the 180-day period, however, the rate of gain was again considerably accelerated.

The results indicated that in the case of calves raised on powdered buttermilk there is not sufficient difference in weight and general appearance between those weaned at 70 days and 150 days to justify the longer period of buttermilk feeding.

Powdered skimmilk or powdered buttermilk seems preferable to semi-solid buttermilk for calf feeding because of greater ease of handling and less danger of spoiling.

The experiments using the concentrated milk products for calf feeding showed that these products can be used for this purpose with entire satisfaction.

All the calves used in these experiments were unusually free from sickness or digestion troubles. They were never off feed and no trouble was experienced in getting them to take the products as prepared. The calves were as a whole sleek coated and thrifty, equal in size and condition to calves raised on typical farms.