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THE use of substitutes for milk in the raising of calves is always of interest to the progressive dairyman, since there are a number of circumstances in which it is advantageous to reduce the milk feeding period. Producers of market milk often desire to raise their calves on as little milk as possible in order to have more milk available for market. When the demand for milk is good, dairymen who usually market cream only may prefer to sell milk and raise their calves on starters or other milk substitutes. Dairy farmers may wish to use the skim milk generally allowed the calves to replace a part of the protein concentrates used in swine and poultry production when these feeds become scarce or too high in price. In times of labor shortage, dairymen are especially interested in labor-saving methods, and usually methods which substitute dry feeds for liquid milk result in a saving of labor. When there is a scarcity of milk for human food, it may be desirable to raise dairy calves with as little milk as is practicable.

Therefore, while there is normally an interest in methods of raising calves on limited amounts of milk, this interest often becomes acute in time of war scarcities. As a result of renewed interest in milk substitutes for calf feeding, this study was instigated—to determine the value of dried whey as a means of saving milk in the raising of calves, to demonstrate that calves can be raised with a limited amount of labor, and to find an additional use for whey, much of which is wasted annually.

Review of Literature

FEEDING experiments have shown that whey is a valuable feed for pigs and poultry. However, few published reports have demonstrated the value of this product in calf feeding. Otis (3) fed liquid whey to calves on prairie hay, corn meal, and oats, and concluded that it was possible to raise very fair animals with whey as a substitute for milk. The calves were from three to five weeks old when the experiment was begun.

Rupel (4) published the results of studies made with liquid whey at the Wisconsin Experiment Station. In an experiment designed to test the comparative value of white and yellow corn for calf feeding, whey was used in rations containing clover hay, corn, middlings, and linseed oil meal. The calves were approximately 17 days old at the beginning of the experiment. The whey-fed calves made an average daily gain of 1.48 pounds per head while calves on similar rations containing skim milk averaged 1.72 pounds per head per day.

Bünger (1) reported that dried whey could be fed to dairy heifers when the daily allowance was not greater than 0.5 kg. (1.10 lbs.). Hay, cabbage-

Table 1. Nutrients Furnished Each Calf by the 30-day Allowance of Skim Milk, Dried Whey, and Blood Meal.

Lot	Calves in Lot	Feeds Allowed			Nutrients Furnished *						Nutritive Ratio
		Skim Milk	Dried Whey	Blood Meal	Net Energy	Digestible Proteins	Calcium	Phosphorus	Total Digestible Nutrients	Dry Matter	
No.	No.	lbs.	lbs.	lbs.	therms	lbs.	lbs.	lbs.	lbs.	lbs.	
1	9	50	25.9	8.1	34.0	10.5	0.39	0.25	33.0	36.8	1:2.1
2	9	100	20.7	6.5	32.9	10.5	0.40	0.26	31.5	35.2	1:2.0
3	7	150	15.5	4.9	31.8	10.5	0.40	0.29	30.1	33.6	1:1.8
4	8	200	10.4	3.2	30.7	10.5	0.41	0.30	28.6	32.0	1:1.7
5	8	250	5.2	1.6	29.6	10.5	0.41	0.33	27.2	30.4	1:1.5
6	9	300	None	None	28.5	10.5	0.42	0.36	25.8	28.8	1:1.4

* The calculations were based on the average analyses reported by Morrison (2).

turnips, straw, oats, and field beans were fed with the whey. At the beginning of the experiment the heifers were from 228 to 373 days old and ranged in weight from about 333 to 518 pounds. The feeding period was 98 days, during which time the heifers made an average gain of about 1.48 to 1.58 pounds per head daily.

Wise (6) used dried whey as a remedy for certain types of calf scours and other accompanying disturbances in calves which were 42 days old. One-half to one pound per 100 pounds of live weight was given daily, partly dissolved and partly suspended in either separated or whole milk. The duration of the whey feeding varied with the size and reactions of the individual calf.

Experimental Procedure

THE calves used in this experiment were grade Holstein heifers and were purchased in southwestern Wisconsin. They were from 14 to 21 days old and were selected by the junior author from calves which were offered for sale on dairy farms and at the public markets on October 26, 1942. The calves were selected for dairy type, vigor, and freedom from disease. A covered truck was used to transfer them to the Nebraska Experiment Station. These animals were in transit about 20 hours and received neither food nor water during that time.

During the experiment, the calves were housed in a large, well-lighted, tile barn which had a concrete floor and cement walls and ceiling. All calves were in the same room, in which the partitions were made of iron pipe. The stalls were well drained since they had gutters with sewer connections. There were five windows and a door in the north wall and six windows and four doors in the south wall. These doors and windows, in addition to the three doors in the ceiling, furnished ventilation during the first part of the experiment. When the weather grew cold, drafts were carefully avoided by locking all doors and windows and constructing a wooden anteroom around the entrance to the barn. As a result of these precautions, it was necessary to provide ventilation during the last six weeks of the experiment by large exhaust fans. The atmosphere in the barn had become so humid that the walls and ceiling were dripping moisture. However, this excessive moisture had no apparent ill effect upon the calves as they were not turned outdoors and as drafts were avoided.

There was no heat in the barn except that produced by the calves and that produced by the wheat straw and wood shavings which were used as bedding. Droppings were removed daily and a new layer of straw was added. This procedure was continued until the litter had accumulated to a depth of 12 to 18 inches. This method of bedding kept the calves dry and warm due to the heat given off by the litter.

The barn and outside lots, which were concrete, were thoroughly cleaned and disinfected with five per cent cresylol before the calves were placed in them. The experiment extended from October 1942 to March 1943, and as the weather was cold, the calves were turned outdoors only three times.

Before being started on the experiment, the calves were given a rest period of three days during which time they were fed equal parts of whole milk and skim milk. The experimental feeding began on the fourth day, at which time

they were allotted into six groups and fed skim milk, dried whey,[1] blood meal,[2] grain, and hay. The proportions of whey and blood meal allowed each calf in the various groups are shown in Table 1. For example each calf in Lot 1 received 25.9 pounds of whey and 8.1 pounds of blood meal in thirty days. Each calf in Lot 5 received 5.2 pounds of whey and 1.6 pounds of blood meal in thirty days. The amounts of these feeds received by the other lots were as shown. It will be noted that approximately 3.2 pounds of whey were used to each pound of blood meal. Lot 6 received no whey and blood meal but served as a control group.

In order to encourage the early consumption of grain and hay, the feeding schedule (Table 1) was compounded so that the total amount of nutrients furnished by the skim milk, dried whey, and blood meal would be somewhat less than that required by the Morrison Feeding Standards (2) for 100-pound, growing, dairy cattle. The required nutrients not furnished by these feeds were to be derived from the hay and grain. As shown in Table 1 all calves received the same amount of digestible protein from the milk, whey, and blood meal allowance. However, the net energy, total digestible nutrients, and dry matter furnished by these feeds decreased as the amount of skim milk increased from 50 to 300 pounds. On the other hand the amount of calcium and phosphorus supplied increased as the amount of milk increased.

The whey and blood meal allowed each group of calves were weighed, and thoroughly mixed in a mechanical mixer. The total amount of this mixture supplied each calf for the feeding period was then weighed into a lard can and the number of the calf to which it was to be fed was stenciled on the can. Once each day the daily allowance of the whey-blood meal mixture was weighed from the lard can into a small three-quart container which had the same number as the lard can. Approximately half of the daily allowance of the mixture was fed at the 6 a.m. feeding and the remainder at the 5 p.m. feeding. This mixture was fed after it was stirred into the skim milk. As the skim milk allowance decreased, water at 100° F. was added so that the whey and blood meal mixture allowed at each feeding was given in not less than three pounds of liquid.

The amount of skim milk and of the whey-blood meal mixture allowed each calf in the various groups, for the 30-day liquid feeding period, is shown in Table 2. From this table it will be noted that each calf in Lots 1, 2, 3, 4, 5, and 6 received respectively 50, 100, 150, 200, 250, and 300 pounds of skim milk and also 34.0, 27.2, 20.4, 13.6, 6.8, and zero pounds of the whey-blood meal mixture. In other words 6.8 pounds of the whey-blood meal mixture was used to replace 50 pounds of skim milk. The daily allowance of each feed is also given. The maximum skim milk allowance was 13 pounds and the maximum whey-blood meal allowance was 1.8 pounds. The length of the skim milk feeding period increased from nine days in Lot 1 to 30 days in Lots 5 and 6, while the whey-blood meal mixture was given from the second or third to the

[1] The dried whey used in these experiments was contributed by the Kraft Cheese Company and by the Roberts Dairy Company. It was made available through the courtesy of J. J. Zima of the Kraft Cheese Company and W. A. Hatteroth of the Roberts Dairy Company.

[2] The blood meal was purchased from Swift and Company, Omaha, Nebraska.

thirtieth day in all lots excepting 5 and 6. In the case of Lot 5 this mixture was furnished from the third to the twenty-second day. Lot 6 had no blood meal and the only dried whey which it received was in the grain mixture.

Vitamins A and D were supplied by allowing each calf five milliliters (one teaspoonful) of a vitamin concentrate [1] for the first 10 days of the experiment, and then 10 milliliters daily until the end of the experiment. This concentrate was given orally by means of a pipette.

The two grain mixtures which were used were fed in individual grain boxes. These mixtures were composed as follows:

Ingredient	*Ration No. 75*	*Ration No. 77*
Corn, yellow, ground	100 pounds	30 pounds
Oats, ground	100 pounds	20 pounds
Bran, wheat	100 pounds	20 pounds
Soybean meal	100 pounds	7 pounds
Dried whey	100 pounds	—
Bone meal	10 pounds	2 pounds
Salt, iodized	5 pounds	1 pound
Linseed meal	—	20 pounds

The first ration contained 14.6 per cent and the second ration 14.9 per cent digestible protein. These calculations were based on the average analyses reported by Morrison (2). Ration No. 75 was used during the first 14 weeks and Ration No. 77 was used during the last seven weeks of the experiment.

The calves were allowed to eat grain only when tied, although they had access at all times to water in galvanized iron pails which were washed and sterilized weekly. During the first 13 weeks of the experiment they were tied from 6 a.m. until 5 p.m. and during the last seven weeks from 6 a.m. until 10:30 a.m. The grain mixture was, therefore, fed only once daily in order to save labor. Not to exceed five pounds of grain were allowed per head daily for the first 13 weeks and four pounds were furnished per head daily for the last seven weeks. In order to save labor, a wooden grain box was constructed for each calf. Once each week the grain allowance for the coming week was weighed into this supply box. A measuring can was prepared which would hold the daily allowance when level full. The grain was thus measured out for the first six days of the week and whatever grain remained in the supply box was given to the calf for the seventh day.

When the calves were untied, the grain boxes were closed and the calves as a group were given an opportunity to eat loose alfalfa hay from racks. The hay was not limited at any time and most of it was of U. S. No. 1 grade. Feed boxes and hay racks were emptied once each week and the weight of the grain and of the hay consumed during that week was recorded.

The calves were weighed and measured at seven-day intervals. Height was measured from the floor to the withers with a metal caliper. Heart girth

[1] The vitamin concentrate was NOPCO XX, distributed by National Oil Products Co. of Harrison, New Jersey. It was guaranteed to contain 400 USP X1 units of vitamin D and 3000 USP X1 units of vitamin A per gram. Methods for the determination of USP units are given in the Second Supp. to the U. S. Pharmacopoeia—11th Decennial Revision.

Table 2. Amounts of Skim Milk and of the Whey-Blood Meal Mixture Allowed Each Calf Daily.

Day	Skim Milk—lbs.						Whey-Blood Meal Mixture—lbs.					
	Lot No. 1	Lot No. 2	Lot No. 3	Lot No. 4	Lot No. 5	Lot No. 6	Lot No. 1	Lot No. 2	Lot No. 3	Lot No. 4	Lot No. 5	Lot No. 6
1	10	10	10	10	10	10	..	..	..	..	..	None
2	8	10	10	10	10	10	0.3	..	..	..	..	"
3	7	9	10	10	10	11	0.5	0.3	0.1	0.2	0.1	"
4	6	9	10	10	10	11	0.7	0.3	0.1	0.2	0.1	"
5	5	8	10	10	10	12	0.9	0.5	0.3	0.3	0.3	"
6	4	8	10	10	10	12	1.1	0.5	0.3	0.4	0.3	"
7	4	8	9	10	10	12	1.1	0.6	0.4	0.4	0.3	"
8	3	8	9	10	10	12	1.2	0.6	0.4	0.4	0.3	"
9	3	6	9	10	10	12	1.2	0.8	0.4	0.4	0.3	"
10	.	6	9	10	10	13	1.8	1.0	0.5	0.4	0.4	"
11	.	6	8	10	10	13	1.8	1.1	0.7	0.4	0.4	"
12	.	4	8	9	10	13	1.8	1.2	0.7	0.5	0.4	"
13	.	4	8	9	9	13	1.8	1.2	0.7	0.5	0.5	"
14	.	4	6	9	9	13	1.8	1.2	0.9	0.5	0.5	"
15	.	.	6	9	9	13	1.8	1.7	0.9	0.5	0.5	"
16	.	.	6	8	9	12	1.6	1.6	0.9	0.5	0.5	"
17	.	.	4	8	8	12	1.6	1.6	1.1	0.5	0.5	"
18	.	.	4	8	8	12	1.6	1.6	1.1	0.5	0.5	"
19	.	.	4	6	8	10	1.4	1.4	1.1	0.5	0.3	"
20	.	.	.	6	8	10	1.4	1.4	1.4	0.5	0.3	"
21	.	.	.	6	8	10	1.4	1.4	1.4	0.5	0.3	"
22	.	.	.	4	8	8	1.1	1.1	1.1	0.5	..	"
23	.	.	.	4	8	8	1.1	1.1	1.1	0.5	..	"
24	.	.	.	4	8	8	1.1	1.1	1.1	0.6	..	"
25	.	.	.	.	6	6	0.8	0.8	0.8	0.8	..	"
26	.	.	.	.	6	6	0.8	0.8	0.8	0.8	..	"
27	.	.	.	.	6	6	0.8	0.8	0.8	0.8	..	"
28	.	.	.	.	4	4	0.5	0.5	0.5	0.5	..	"
29	.	.	.	.	4	4	0.5	0.5	0.4	0.5	..	"
30	.	.	.	.	4	4	0.5	0.5	0.4	0.5	..	"
Totals	50	100	150	200	250	300	34.0	27.2	20.4	13.6	6.8	None

measurement was taken with cloth tapeline at the sixth rib. The top line was the distance from the second thoracic vertebra to the pin bone as determined with the tape.

Discussion of Results

A PRELIMINARY trial was conducted to determine whether large quantities of dried whey could be fed and whether the whey was sufficiently palatable. This trial demonstrated that calves which were approximately ten days old and which weighed from 75 to 109 pounds could consume as much as 53.2 pounds of the whey-blood meal mixture in 49 days without serious results. In some instances as much as 1.9 pounds of the mixture were fed daily. With two exceptions, all of the 27 calves used in this preliminary experiment consumed the whey-blood meal mixture readily.

The average daily hay and grain consumption of the calves used in the final experiment is shown in Table 3. Very little hay was consumed by Lots 2, 4, and 5 during the first week. During the second week the daily consumption

in the six lots ranged from 0.16 pound (Lot 2) to 0.83 pound (Lot 6). Beginning with the second week, the consumption increased somewhat irregularly to the close of the experiment. Greatest average daily hay consumption per calf during any week was 9.41 pounds (Lot 3). Average daily hay consumption per calf for the entire 21 weeks varied from 3.53 pounds (Lot 5) to 4.56 pounds (Lot 3).

The calves began consuming grain at the rate of 0.18 to 0.33 pound per head daily during the first week, increased this consumption to about three pounds by the fifth week, and reached the maximum allowed (five pounds) from the eleventh to the thirteenth week of the experiment. As explained above, the calves were fed Ration 77 from the fourteenth to the twenty-first week. The average daily grain consumption per calf for the 21 weeks varied from 3.38 pounds (Lot 3) to 3.67 pounds (Lot 6). When the data shown in Table 3 were plotted in the form of graphs, there was no definite indication that the calves which were fed the smaller amounts of milk began to consume the grain and hay any earlier than did those fed the larger amounts of milk.

The calves were apparently healthy and free from disease at the beginning of the experiment. They were observed closely throughout the investigation and their temperatures were taken whenever it appeared necessary. No greater difficulty was experienced with disease than could be expected normally among 56 calves of this age. Two calves died, one in Lot 3 and one in Lot 6. Four calves contracted colds and therefore were removed from the experiment and fed whole milk instead of skim milk, dried whey, and blood meal. These calves were from Lots 3, 4, 5, and 6. There were no losses in Lots 1 and 2.

Table 3. Average Daily Hay and Grain Consumption Per Calf by Weeks.

Week No.	Grain—lbs.						Hay—lbs.					
	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
1	.18	.28	.20	.30	.33	.27	.24	.00	.35	.05	.04	.21
2	.47	.43	.32	.58	.38	.48	.70	.16	.65	.27	.20	.83
3	.88	.90	.32	1.16	.88	.96	1.17	.94	1.16	.77	.41	1.41
4	1.59	1.79	.93	2.03	1.61	2.39	.63	1.10	1.65	.71	.29	1.11
5	2.98	2.81	2.64	3.12	2.51	3.45	.60	.98	1.78	1.52	1.59	2.08
6	3.95	3.53	3.06	3.67	2.93	4.17	1.27	1.94	2.53	1.80	.45	.86
7	4.28	4.24	3.83	4.70	4.01	4.59	2.13	2.10	3.18	1.79	1.59	2.52
8	4.47	4.07	3.98	4.69	4.00	4.62	2.29	3.49	3.08	3.16	2.52	3.06
9	4.55	4.53	4.33	4.91	4.62	4.61	2.52	2.57	4.16	3.00	2.21	3.03
10	4.74	4.56	4.61	4.91	4.25	4.67	2.40	2.29	2.65	3.88	1.98	2.41
11	4.83	4.82	4.90	4.91	4.35	5.00	3.44	3.49	4.08	3.71	2.75	3.05
12	4.98	4.97	4.98	5.00	4.82	5.00	3.81	3.95	4.27	4.05	3.30	3.63
13	4.99	4.99	5.00	5.00	5.00	5.00	4.32	4.10	4.33	4.86	3.57	4.56
14	3.95	4.00	3.85	4.00	3.93	3.95	6.41	5.95	5.55	6.46	5.71	6.56
15	3.96	3.99	3.99	3.99	3.97	4.00	6.54	6.21	6.14	6.71	5.39	6.06
16	3.97	3.92	3.95	4.00	3.93	3.99	6.35	6.71	7.29	7.32	6.55	7.03
17	4.00	4.00	3.99	4.00	4.00	4.00	7.59	7.41	7.92	6.98	6.43	7.14
18	4.00	4.00	4.00	4.00	4.00	4.00	7.35	7.11	7.98	7.80	7.07	7.86
19	4.00	4.00	4.00	4.00	4.00	4.00	8.19	6.71	8.88	8.80	7.43	7.86
20	4.00	4.00	4.00	4.00	4.00	4.00	8.75	8.81	9.41	7.93	7.36	8.19
21	4.00	4.00	4.00	4.00	4.00	4.00	7.21	7.08	8.84	9.95	7.20	8.75
Average	3.56	3.52	3.38	3.67	3.41	3.67	4.00	4.16	4.56	4.31	3.53	4.20

Two of the calves which were removed developed only moderate colds and made a rapid recovery. The gains made by these four calves, furthermore, were 228, 212, 176, and 212 pounds in 21 weeks. It will be noted from Table 4 that these gains were equal to those of a number of the calves which remained normal. It is therefore evident that no serious difficulty was experienced with disease in this experiment.

The original and final weights and measurements of each calf, as well as the gains made, are shown in Table 4. Original weight varied from 100 to 179 pounds and final weight from 276 to 427 pounds. The gains varied from 174 to 275 pounds. Similar variations will be noted in the measurements. From these data it can be seen that small, medium, and large-sized calves were allotted to each group. The smallest calf in each lot was assigned the smallest number while the largest calf was assigned the largest number. The calves

Table 4. Gains in Weights and Measurements of Calves.

Lot No.	Calf No.	Weight			Measurements								
					Heart Girth			Length of Top Line			Height at Withers		
		Original lbs.	Final lbs.	Gain lbs.	Original cm.	Final cm.	Gain cm.	Original cm.	Final cm.	Gain cm.	Original cm.	Final cm.	Gain cm.
	1	104	326	222	81	118	37	66	94	28	78	99	21
	2	115	320	205	86	117	31	65	94	29	73	98	25
	3	120	340	220	85	119	34	65	92	27	75	97	22
	4	125	339	214	85	119	34	66	94	28	80	101	21
1	5	132	360	228	88	123	35	67	99	32	79	103	24
	6	140	320	180	88	117	29	66	91	25	79	100	21
	7	140	381	241	88	126	38	68	98	30	78	99	21
	8	145	396	251	91	125	34	73	101	28	81	104	23
	9	179	424	245	86	132	46	79	103	24	85	107	22
Total		1200	3206	2006	778	1096	318	615	866	251	708	908	200
Average		133.3	356.2	222.9	86.4	121.7	35.3	68.3	96.2	27.9	78.6	100.8	22.2
	10	105	306	201	80	112	32	66	88	22	76	96	20
	11	111	285	174	84	116	32	64	90	26	75	94	19
	12	124	342	218	86	122	36	67	96	29	75	101	26
	13	126	366	240	84	121	37	68	103	35	74	101	27
2	14	137	393	256	88	126	38	70	97	27	79	102	23
	15	140	343	203	91	120	29	72	95	23	80	101	21
	16	142	379	237	90	124	34	76	105	29	80	104	24
	17	145	400	255	88	121	33	68	100	32	80	102	22
	18	170	427	257	95	128	33	74	102	28	82	106	24
Total		1200	3241	2041	786	1090	304	625	876	251	701	907	206
Average		133.3	360.1	226.6	87.3	121.1	33.8	69.4	97.3	27.9	77.8	100.7	22.9
	20	117	333	216	85	117	32	69	93	24	79	102	23
	21	120	343	223	84	120	36	70	99	29	80	100	20
	22	126	364	238	90	121	31	67	99	32	78	102	24
3	23	135	366	231	90	124	34	72	100	28	80	104	24
	24	140	395	255	93	128	35	74	102	28	81	105	24
	25	145	377	232	93	124	31	69	95	26	78	103	25
	27	168	407	239	95	125	30	77	101	24	82	105	23
Total		951	2585	1634	630	859	229	498	689	191	558	721	163
Average		135.8	369.2	233.4	90.0	122.7	32.7	71.1	98.4	27.3	79.7	103.0	23.3

intermediate in age were assigned accordingly excepting in Lot 6. The number of calves which completed the experiment in each group varied, as explained above, from seven to nine. The position in the lots of the calves which were removed from the experiment is shown by the missing calf numbers. Numbers 19, 26, 31, 44, 46, and 54 are missing. The average gain made by each calf for a given week, and also the average daily gains in weight for each calf for that week are shown by lots in Table 5. In general the calves made satisfactory gains throughout the experiment. When the fifth week is omitted, the daily gains varied from 0.10 to 3.35 pounds during the 21 weeks. All lots lost weight or failed to gain during the fifth week. This was the first week that the calves were fed hay and grain only. However, the gains increased during the sixth week and were satisfactory to the end of the experiment. All lots, excepting Lot 5, made an average daily gain of approximately 1.5

(Table 4 Continued)

Lot No.	Calf No.	Weight			Measurements								
					Heart Girth			Length of Top Line			Height at Withers		
		Original lbs.	Final lbs.	Gain lbs.	Original cm.	Final cm.	Gain cm.	Original cm.	Final cm.	Gain cm.	Original cm.	Final cm.	Gain cm.
	28	105	320	215	84	116	32	60	91	31	73	95	22
	29	110	331	221	82	116	34	64	95	31	75	95	20
	30	120	372	252	81	121	40	66	96	30	77	101	24
4	32	132	372	240	90	123	33	68	95	27	81	101	20
	33	140	376	236	86	122	36	68	99	31	79	104	25
	34	145	369	224	90	124	34	73	99	26	79	104	25
	35	155	392	237	92	125	33	70	101	31	81	103	22
	36	167	411	244	93	127	54	69	98	29	83	105	22
Total		1074	2943	1869	698	974	276	538	774	236	628	808	180
Average		134.2	367.8	233.6	87.2	121.7	34.5	67.2	96.7	29.5	78.5	101.0	22.5
	37	100	276	176	79	111	32	64	87	23	76	96	20
	38	120	320	200	86	117	31	65	93	28	78	99	21
	39	120	306	186	73	118	45	66	88	22	79	98	19
5	40	126	311	185	85	112	27	70	94	24	79	98	19
	41	128	316	188	87	115	28	67	96	29	77	99	22
	42	135	393	258	90	125	35	72	97	25	77	101	24
	43	145	351	206	90	122	32	72	93	21	77	96	19
	45	167	375	208	91	123	32	70	97	27	81	101	20
Total		1041	2648	1607	681	943	262	546	745	199	624	988	164
Average		130.1	331.0	200.9	85.1	117.8	32.7	68.2	93.1	24.9	78.0	98.5	20.5
	47	105	332	227	80	119	39	65	93	28	72	98	26
	48	125	350	225	86	120	34	63	96	33	76	99	23
	49	126	332	206	85	118	33	67	92	25	75	98	23
	50	132	407	275	90	125	35	67	94	27	79	101	22
6	51	135	342	207	87	119	32	73	100	27	80	103	23
	52	146	362	216	92	124	32	76	101	25	79	103	24
	53	160	405	245	94	127	33	72	102	30	80	103	23
	55	120	350	230	82	119	37	69	93	24	77	102	25
	56	140	396	256	90	124	34	70	102	32	80	101	21
Total		1189	3276	2087	786	1095	309	622	873	251	698	908	210
Average		132.1	364.0	231.9	87.3	121.6	34.3	69.1	97.0	27.9	77.5	100.8	23.3

pounds throughout the 21 weeks of the experiment. Lot 5 made an average daily gain of about 1.3 pounds during this period. Tables 5 and 6 show that this lot did not gain as rapidly as the other lots from the second week of the experiment. Table 5 shows that the average daily gain per calf in this lot was equalled or exceeded by the gain of all other lots for 11 of the 21 weeks of the experiment.

Gains in weight made by the various lots were plotted at weekly intervals for Chart 1. Calves in Lot 1 made slightly larger gains than calves in the other lots for the first three weeks of the experiment. By the end of the fourth week, however, the gains of this lot were exceeded by those of Lot 4 and at

Table 5. Average Weekly and Daily Gains in Weight Per Calf During Various Weeks.

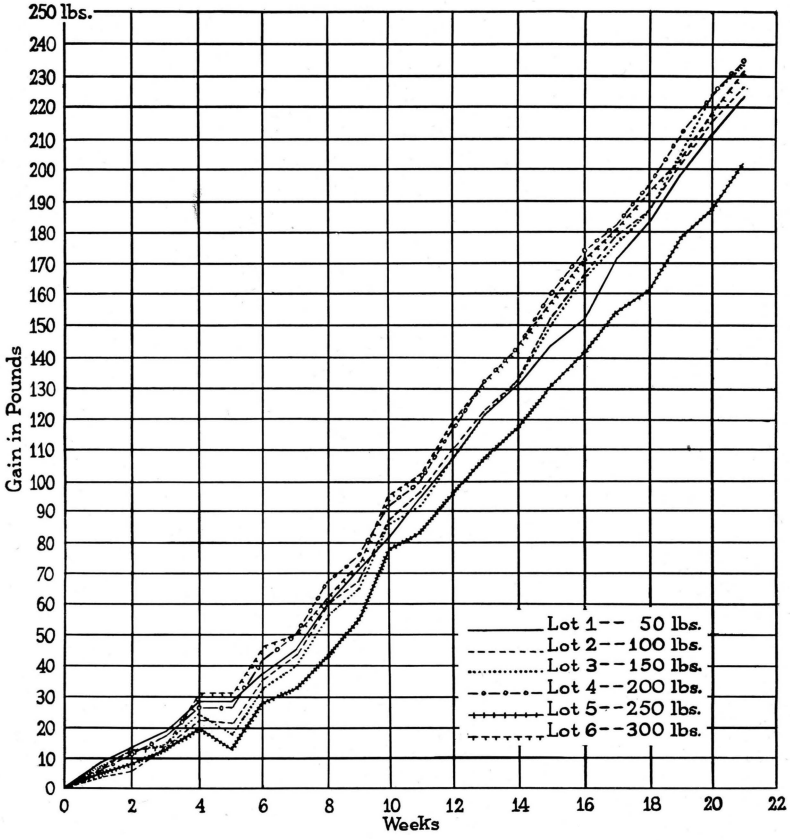
Week No.	Average Weekly Gain Per Calf—lbs.						Average Daily Gain Per Calf—lbs.					
	Lot No. 1	Lot No. 2	Lot No. 3	Lot No. 4	Lot No. 5	Lot No. 6	Lot No. 1	Lot No. 2	Lot No. 3	Lot No. 4	Lot No. 5	No. 6
1	9.0	5.1	7.5	5.5	5.5	6.5	1.28	0.72	1.07	0.78	0.78	0.92
2	4.7	3.3	5.2	6.5	3.3	6.2	0.67	0.47	0.74	0.92	0.47	0.88
3	5.1	6.0	0.8	5.6	4.6	2.5	0.72	0.85	0.11	0.80	0.65	0.35
4	10.4	9.1	10.8	9.0	7.1	16.0	1.48	1.30	1.54	1.28	1.01	2.28
5	– 0.7	– 2.5	– 5.1	0.5	– 7.0	– 0.7	–0.10	–0.35	–0.72	0.07	–1.00	–0.10
6	9.7	14.8	14.5	14.8	16.0	15.1	1.37	2.11	2.07	2.10	2.28	2.15
7	7.2	9.4	5.7	8.3	3.1	4.6	1.02	1.34	0.81	1.18	0.44	0.65
8	15.0	16.0	16.0	17.3	10.2	12.2	2.14	2.28	2.28	2.47	1.45	1.74
9	10.0	5.4	8.8	8.5	12.1	11.6	1.42	0.77	1.25	1.21	1.72	1.65
10	12.7	19.1	19.8	15.1	23.5	20.8	1.80	2.72	2.82	2.15	3.35	2.97
11	12.1	10.3	6.4	8.7	4.2	7.3	1.72	1.47	0.91	1.24	0.60	1.04
12	12.7	13.6	18.0	17.0	13.7	16.1	1.81	1.94	2.57	2.42	1.95	2.30
13	13.5	13.1	12.8	15.0	11.2	13.5	1.92	1.87	1.82	2.14	1.60	1.92
14	8.7	9.1	11.4	11.7	10.6	11.8	1.24	1.30	1.62	1.67	1.51	1.68
15	13.0	20.3	16.8	15.8	13.1	13.6	1.85	2.90	2.40	2.25	1.87	1.94
16	8.7	13.3	14.5	14.1	10.6	14.1	1.24	1.90	2.07	2.01	1.51	2.01
17	18.7	11.7	11.0	8.0	11.1	9.2	2.67	1.67	1.57	1.14	1.58	1.31
18	12.4	8.8	10.4	12.7	9.0	12.6	1.77	1.25	1.48	1.81	1.28	1.80
19	15.1	15.7	20.4	17.1	17.2	13.1	2.15	2.24	2.91	2.44	2.45	1.87
20	12.0	12.4	17.1	11.2	8.0	11.2	1.71	1.77	2.44	1.60	1.14	1.60
21	12.2	12.1	9.8	10.6	13.2	13.8	1.74	1.72	1.40	1.51	1.88	1.97
Average	10.6	10.7	11.0	11.0	9.5	11.0	1.51	1.54	1.58	1.58	1.36	1.57

Lot I—9 Calves Lot III—7 Calves Lot V—8 Calves
Lot II—9 Calves Lot IV—8 Calves Lot VI—9 Calves

Table 6. Summary of Average Gains in Weights and Measurements of the Various Lots of Calves.

Lot No.	Weight			Measurements								
				Heart Girth			Length of Top Line			Height at Withers		
	Orig. lbs.	Final lbs.	Gain lbs.	Orig. cm.	Final cm.	Gain cm.	Orig. cm.	Final cm.	Gain cm.	Orig. cm.	Final cm.	Gain cm.
1	133.3	356.2	222.9	86.4	121.7	35.3	68.3	96.2	27.9	78.6	100.8	22.2
2	133.3	360.1	226.8	87.3	121.1	33.8	69.4	97.3	27.9	77.8	100.7	22.9
3	135.8	369.2	233.4	90.0	122.7	32.7	71.1	98.4	27.3	79.7	103.0	23.3
4	134.2	367.8	233.6	87.2	121.7	34.5	67.2	96.7	29.5	78.5	101.0	22.5
5	130.1	331.0	200.9	85.1	117.8	32.7	68.2	93.1	24.9	78.0	98.5	20.5
6	132.1	364.0	231.9	87.3	121.6	34.3	69.1	97.0	27.9	77.5	100.8	23.3

Chart 1. Gains in weight by various lots plotted at weekly intervals.



the end of the sixth week by those of Lots 6 and 4. From the fourteenth week to the end of the experiment, the gains of all lots excepting Lot 5 were a little greater than that of Lot 1. Lot 5 made the smallest gains of any lot from the third week to the end of the experiment. While the gains made by Lots 4 and 6 slightly exceeded the gains made by the remaining lots, during 17 of the 21 weeks of the experiment, the differences appeared too small to be significant. Furthermore, all lots, excepting Lot 5, gained about 1½ pounds daily during the experiment. There was no marked evidence, therefore, that the calves which received the smaller amounts of milk made slower gains at the beginning of the experiment.

The average original and final weights and measurements of the calves in each lot and also the gains made are summarized in Table 6. Original weights varied from 130.1 to 135.8 pounds. Heart girth measurements varied from 85.1 to 90.0 centimeters. Average original length of top lines ranged from

67.2 to 71.1 centimeters and the heights at withers from 77.5 to 79.7 centimeters. There was, therefore, a variation of 5.7 pounds in original weights, 4.9 centimeters in girth, 3.9 centimeters in length, and 2.2 centimeters in height. As allotted, the average original weight varied 0.4 pound or less while the maximum variations between the original measurements of heart girth, length of top line, and height at withers were respectively 2.5, 2.5, and 1.5 centimeters. It is evident, therefore, that the lots were carefully allotted and that the variations in the original weights and measurements as shown in Table 6 resulted largely from the removal of the six calves mentioned above. The average gain per calf in Lots 1, 2, 3, 4, 5, and 6 were respectively 222.9, 226.8, 233.4, 233.6, 200.9, and 231.9 pounds.

Statistical Examination and Interpretation of Results

SINCE there were variations among the gains made by the various lots and as it did not seem logical that Lot 5 should make the smallest gain, statistical methods were employed to aid in the interpretation of the results. Such analyses aided in determining how much of the variation observed between gains was due merely to chance and how much was due to other factors.

An analysis of variance [1] of gains in weight is shown in Table 7. When Lot 5 was omitted from the calculations, an F value of only 0.40 was obtained and no statistically significant difference was established among Lots 1, 2, 3, 4, and 6. When the average original weight of Lot 5 was increased to 134.4 pounds by omitting calf No. 37, an F value of 1.84 was obtained. It was then evident that the differences in gains among the six lots as thus adjusted were not statistically significant. When original weights were correlated with gains in weight a positive correlation coefficient of 0.442 was obtained and a highly significant relationship was established between original weights and gains. Therefore the calves which were smaller at the beginning of the experiment could be expected to make smaller gains during the experiment.

In view of these results, an analysis of covariance between original weight and gain in weight was made. An F value of 2.76 was obtained when all calves were considered. However, when calf 37 was omitted the F value dropped to 2.27 and the differences became statistically unimportant.

[1] The statistical methods used were published by Snedecor (5).

Table 7. Analysis of Variance of Gains in Weight.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F Values — Lot Nos. Considered		
				1-6 incl.	1, 2, 3, 4, 6	1-6 incl. Calf 37 Omitted
Total	49	27,927.3				
Between lot means	5	6,243.3	1,248.66			
Within lots (errors)	44	21,684.0	492.81			
$F = \frac{\text{Mean Square Between Lot Means}}{\text{Mean Square Within Lots}}$				2.53 *	0.40**	1.84 ***

* The F value at the 5% level was 2.430
** The F value at the 5% level was 2.625
*** The F value at the 5% level was 2.435

Table 8. Analysis of Covariance Between Initial Weight and Gain in Weight.

Source of Variation	Degrees of Freedom	Sums of Squares and Products			Errors of Estimate			F Values	
								Lot Nos. Considered	
		SY^2	SXY	SX^2	Sum of Squares	Degrees of Freedom	Mean Square	1–6 incl.	1–6 incl. Calf 37 Omitted
Total	49	16,848.5	9,596.6	27,927.3	22,461.3	48			
Between Lots	5	144.3	753.8	6,243.3					
Within Lots (errors)	44	16,704.2	8,842.8	21,684.0	17,002.9	43	395.4		
For Test of Significance of Adjusted Means					5,458.4	5	1,091.7		
$F = \frac{1091.7}{395.4} = 2.76$ and $F = \frac{914.01}{402.51} = 2.27$								2.76*	2.27**

* The F Value at the 5% Level was 2.430
** The F Value at the 5% Level was 2.435

Table 9. Standard Errors of Gains in Weight.

Mean Square	Standard Error	Mean Errors of Lot Number			Standard Error of Mean Difference Lots Compared			Difference in Gains Lots Compared—lbs.			T Values Lots Compared		
		1, 2, 6	4, 5	3	5 & 4	1 & 4	5 & 1	5 & 4	1 & 4	5 & 1	5 & 4	1 & 4	5 & 1
492.81	22.19	7.39	7.84	8.38	11.08	10.77	10.77	32.8	10.8	22.0	2.96	1.00	2.04

$$T = \frac{\text{Difference in Gains}}{\text{Standard Error of Mean Difference}}$$

The T Value at the 5% Level was 2.015

The standard errors of gains in weight are shown in Table 9. If Lot 5 was omitted, Lot 1 made the smallest gains. When Lot 1 was compared to Lot 4, the T value dropped to 1.00 and there was no statistically significant difference between gains. In the latter comparison then, it was evident that no difference existed statistically among the gains made by the remaining lots (Lots 1, 2, 3, 4, and 6). This analysis indicates that the statistically significant difference was between Lot 5 and the remaining lots.

From these four analyses it was concluded that no difference existed statistically among the gains made by Lots 1, 2, 3, 4, and 6 and the smaller gain made by Lot 5 was due, in some degree, to the smaller average original weight of the calves in this lot.

Feed Required Per Hundred Pounds of Gain

THE amounts of the various feeds required by each lot per 100 pounds of gain and the feed cost per 100 pounds of gain are shown in Table 10. Average gain made by each lot in 21 weeks is also included. All lots excepting Lot 5 required approximately 1.2 pounds of the vitamin concentrate per 100 pounds of gain. Skim milk required for that gain varied from 22.4 pounds (Lot 1) to 129.4 pounds (Lot 6), while the substitute (whey-blood meal mixture) required ranged from zero pounds (Lot 6) to 15.2 pounds (Lot 1). Grain required to produce 100 pounds of gain ranged from 212.5 pounds (Lot 3) to 249.2 pounds (Lot 5) and the hay required varied from 257.7 pounds (Lot 5) to 285.9 pounds (Lot 3). When the feed consumption record was considered in conjunction with the gains made, it was evident that the gains were not proportional to the amount of milk, whey, or grain consumed. In other words the lots did not rank the same with respect to gains made as they did with respect to the amount of milk, whey, or grain consumed. In general the lots which had the greatest average final weight ate the most hay. This might be expected since the hay was the only feed which was not limited.

The cost of feed per 100 pounds of gain when calculated on the gains actually made are given in Table 10. The following prices were used in the calculations:

Corn	$0.86 per bushel	Bran	$36.00 per ton
Oats	0.61 per bushel	Soybean meal	52.00 per ton
Dried whey	6.40 per cwt.	Bone meal	55.00 per ton
Skim milk	0.45 per cwt.	Linseed meal	52.00 per ton
Blood meal	4.70 per cwt.	Alfalfa	15.25 per ton
Salt	1.50 per cwt.		

Cost of the grain varied from $5.16 (Lot 3) to $6.05 (Lot 5), and the hay cost from $1.96 (Lot 5) to $2.18 (Lot 3). Skim milk cost ranged from $0.10 (Lot 1) to $0.58 (Lot 6). Cost of the vitamin concentrate was $0.58 in all lots excepting Lot 5 where the cost was $0.68. Cost of the substitute (whey-blood meal mixture) varied from zero to $0.91 per 100 pounds of gain. Total cost of feed per 100 pounds of gain in Lots 1, 2, 3, 4, 5, and 6 was respectively $9.34, $9.02, $8.73, $9.06, $9.45, and $8.92.

Since differences in the gains made by Lots 1, 2, 3, 4, and 6 were not statistically significant, the feed costs were calculated using the mean gain of these

Table 10. Feed Required per Hundred Pounds of Gain—Calculated on the Actual Gain Made.

Lot No.	Gain in 21 Weeks lbs.	Feed Consumed per 100 lbs. Gain					Cost of Feed per 100 lbs. Gain					
		Grain lbs.	Hay lbs.	Skim Milk lbs.	Vitamin Concentrate lbs.	Sub-* stitute lbs.	Grain $	Hay $	Skim Milk $	Vitamin Concentrate $	Sub-* stitute $	Total $
1	222.9	234.9	263.1	22.4	1.2	15.2	5.75	2.00	0.10	0.58	0.91	9.34
2	226.8	227.8	258.1	44.1	1.2	11.9	5.56	1.97	0.20	0.58	0.71	9.02
3	233.4	212.5	285.9	64.2	1.2	8.7	5.16	2.18	0.29	0.58	0.52	8.73
4	233.6	230.6	270.9	85.6	1.2	5.8	5.67	2.07	0.39	0.58	0.35	9.06
5	200.9	249.2	257.7	124.5	1.4	3.3	6.05	1.96	0.56	0.68	0.20	9.45
6	231.9	233.0	265.8	129.4	1.2	None	5.73	2.03	0.58	0.58	None	8.92

* Substitute refers to the whey-blood meal mixture.

five lots. In other words, it was assumed that each of these lots made the same gain (229.7 pounds). The results of these calculations are shown in Table 11. On this basis the grain cost varied from $5.24 (Lot 3) to $5.78 (Lot 6) and the hay cost from $1.94 (Lot 2) to $2.22 (Lot 3). The skim milk cost varied from $0.10 to $0.59 per 100 pounds of gain. Cost of the vitamin concentrate was $0.58 in all lots. Cost of the whey-blood meal mixture ranged from zero to $0.89. Total cost of feed per 100 pounds of gain in Lots 1, 2, 3, 4, and 6 was respectively $9.10, $8.92, $8.86, $9.18, and $9.00.

Mention should be made of the reduction in labor which occurred as the calves completed the liquid feeding period and began the dry feeding period. The feeding of the calves required approximately eight man hours of labor daily during the liquid feeding period and only two hours daily during the dry feeding period. Considerable time was required to heat the milk to the desired temperature, to transport it to the barn where the calves were housed, and to wash and sterilize the pails. While it is generally considered a better practice to feed grain twice daily, once-a-day feeding produced very satisfactory gains and saved labor.

Table 11. Feed Required Per Hundred Pounds Gain—Calculated on the Mean Gain * of Lots 1, 2, 3, 4, and 6.

Lot No.	Feed Consumed Per 100 lbs. Gain					Cost of Feed Per 100 lbs. Gain					
	Grain lbs.	Hay lbs.	Skim Milk lbs.	Vitamin Concentrate lbs.	Substitute lbs.	Grain $	Hay $	Skim Milk $	Vitamin Concentrate $	Substitute $	Total $
1	227.8	255.2	21.7	1.2	14.8	5.58	1.95	0.10	0.58	0.89	9.10
2	224.9	254.7	43.5	1.2	11.8	5.49	1.94	0.20	0.58	0.71	8.92
3	215.9	290.5	65.3	1.2	8.8	5.24	2.22	0.29	0.58	0.53	8.86
4	234.5	275.5	87.0	1.2	5.9	5.76	2.10	0.39	0.58	0.35	9.18
6	235.1	268.2	130.6	1.2	None	5.78	2.05	0.59	0.58	None	9.00

* The mean gain of these five lots was 229.7 pounds.

Summary and Conclusions

FIFTY grade Holstein heifer calves were successfully raised from approximately three weeks to six months of age on alfalfa hay, a grain mixture, a vitamin concentrate, and various amounts of skim milk, supplemented with a mixture composed of 3.2 parts of dried whey to one part of blood meal. Six and eight-tenths pounds of this mixture were used to replace 50 pounds of skim milk. The milk was fed at 50, 100, 150, 200, 250, and 300-pound levels.

The calves in five of the lots made an average daily gain of approximately 1½ pounds per head for 21 weeks. There was no statistically significant difference among the average gains in weight made by five of the six lots of calves. The statistically significant difference which did exist between Lot 5 and the other lots disappeared when the original weight of this lot was adjusted so that it was about equal to the mean original weight of the other lots. Three hundred pounds of skim milk alone produced cheaper gains than 50 pounds of skim milk supplemented with 34 pounds of the whey-blood meal mixture.

From the data obtained in this study, it was concluded that, under the conditions of these experiments:

1. Six and eight-tenths pounds of a mixture composed of 3.2 parts of dried whey and one part of blood meal is a satisfactory substitute for 50 pounds of skim milk in the feeding of healthy dairy calves, which are approximately three weeks of age and which weigh not less than 104 pounds.

2. Thirty-four pounds of this whey-blood meal mixture can be fed, without serious effects, in 30 days even though as much as 1.8 pounds are fed daily for a few days.

3. Healthy, vigorous dairy calves can be satisfactorily raised from three weeks to six months of age on as little as 50 pounds of the skim milk if it is properly supplemented with dried whey, blood meal, alfalfa hay, a grain mixture, and a vitamin concentrate.

4. Labor can be saved in the raising of dairy calves by replacing the pail feeding of milk over a long period, with a few weeks of milk feeding followed by a suitable grain mixture, alfalfa hay, and a vitamin concentrate.

5. With the prices of feeds as quoted herein, the feed cost of raising calves on milk only may be less than when the milk is replaced by this whey-blood meal mixture. However, when the labor cost is considered in connection with the feed cost, the additional expense of using the substitute mixture will not be prohibitive.

6. Dried whey and blood meal can be utilized as a means of diverting milk from calf feeding to human food and to other uses.

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Literature Cited

1. *Bünger, H., Fissmer, E., Harre, W., Schmidt, H., Boehm, K., and Reising, F.* 1939. Fütterungsversuche mit Trockenmolke Biedermanns Zentbl. Abt. B., Tierernährung, 11:276–300.

2. *Morrison, F. B.,* 1936. Feeds and Feeding. Pub. by the Morrison Publishing Company, Ithaca, New York.

3. *Otis, D. H.* 1905. Experiments with Hand-Fed Calves. Kans. Agr. Exp. Sta. Bul. No. 126:174.

4. *Rupel, I. W.* 1929. Raising the Dairy Calf. Wis. Agr. Exp. Sta. Bul. 404:16–18.

5. *Snedecor, G. W.* 1904. Statistical Methods. Publ. by the Collegiate Press, Inc.

6. *Wise, G. H.* 1941. Investigations with Dairy Cattle and Dairy Products. 54th Ann. Rpt. S. Car. Agr. Exp. Sta. pp. 84–87.