Starter rations for dairy calves
by Arthur O Jacobs

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Masters of Science in Dairy Production
Montana State University

Abstract:
Twenty-four calves were assigned at birth to four groups for the purpose of determining their response to different starter rations. Each group contained six calves and was composed of two Jersey heifers, two Holstein heifers and two Holstein steers.

All calves were left with their dams for three days and then placed on whole milk until seven weeks of age. Starter rations were offered the calves as soon as they would eat them. At the end of seven weeks, the calves in Groups I, II and III were taken off of milk and fed only their respective starter ration and alfalfa hay ad libitum. The calves in Group IV were continued on whole milk, the control grain ration and alfalfa hay for the entire 16 week period.

Each grain ration contained approximately 16% crude protein. The rations differed primarily in the source of the protein. The starter ration for the calves in Group I contained blood meal as a supplemental protein source, while the starter ration for the calves in Group II contained meat meal and the starter ration for the calves in Group III and IV contained linseed meal. Each calf received forty-five milligrams of Aureomycin (Aurofac 2A) per day and the calves in Group I, II and II were supplemented with 400 international units of vitamin D per day after milk feeding was discontinued.

The rations were evaluated on the response they produced in body weight and skeletal growth. At the end of the 16 week experimental period, calves were compared to Ragsdale's standards on body weight, height of withers and chest measurement by averaging the final measurements of the two Jersey heifers in each, ration group, the two Holstein heifers in each ration group and the two Holstein steers in each ration group.

Nine pair of calves exceeded the Ragsdale standards in body weight, however the two Jersey heifers and two Holstein steers on the blood meal ration and the two Holstein heifers on the meat meal ration were three pounds (2.02, 1.17 and 1.28 per cent respectively) below the weight standards.

All of the groups of calves exceeded the Ragsdale standards on height of withers except the two Holstein heifers on the meat meal ration which were 0.74 per cent below the Ragsdale standards.

When comparing the chest measurements of calves on the experiment with the Ragsdale standards, the two Jersey and two Holstein heifers on the control ration met the Ragsdale growth standards. All other calves in the trial were below the standards in chest measurement from 0.82 to 8.1 per cent at the end of the experiment.

0 As a group, calves on Ration I (blood meal) gained the least, Ration II (meat meal) was second, Ration III (linseed meal) was third and Ration IV (regular ration and milk) gained the most in this trial.

In using actual price of feeds at the time of the study and considering whole milk to be worth $3.50 per 100 pounds, the average feed costs of raising each calf to 16 weeks of age were: Group I (blood meal

ration) $17.04; Group II (meat meal ration) $17.44; Group III (linseed meal ration) $17.74 and Group IV (whole milk plus the control ration) $36.27.

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ABSTRACT

Twenty-four calves were assigned at birth to four groups for the purpose of determining their response to different starter rations. Each group contained six calves and was composed of two Jersey heifers, two Holstein heifers and two Holstein steers.

All calves were left with their dams for three days and then placed on whole milk until seven weeks of age. Starter rations were offered the calves as soon as they would eat them. At the end of seven weeks, the calves in Groups I, II and III were taken off of milk and fed only their respective starter ration and alfalfa hay ad libitum. The calves in Group IV were continued on whole milk, the control grain ration and alfalfa hay for the entire 16 week period.

Each grain ration contained approximately 16% crude protein. The rations differed primarily in the source of the protein. The starter ration for the calves in Group I contained blood meal as a supplemental protein source, while the starter ration for the calves in Group II contained meat meal and the starter ration for the calves in Group III and IV contained linseed meal. Each calf received forty-five milligrams of Aureomycin (Aurofac 2A) per day and the calves in Group I, II and II were supplemented with 400 international units of vitamin D per day after milk feeding was discontinued.

The rations were evaluated on the response they produced in body weight and skeletal growth. At the end of the 16 week experimental period, calves were compared to Ragsdale's standards on body weight, height of withers and chest measurement by averaging the final measurements of the two Jersey heifers in each ration group, the two Holstein heifers in each ration group and the two Holstein steers in each ration group.

Nine pair of calves exceeded the Ragsdale standards in body weight, however the two Jersey heifers and two Holstein steers on the blood meal ration and the two Holstein heifers on the meat meal ration were three pounds (2.02, 1.17 and 1.28 per cent respectively) below the weight standards.

All of the groups of calves exceeded the Ragsdale standards on height of withers except the two Holstein heifers on the meat meal ration which were 0.74 per cent below the Ragsdale standards.

When comparing the chest measurements of calves on the experiment with the Ragsdale standards, the two Jersey and two Holstein heifers on the control ration met the Ragsdale growth standards. All other calves in the trial were below the standards in chest measurement from 0.82 to 8.1 per cent at the end of the experiment.

As a group, calves on Ration I (blood meal) gained the least, Ration II (meat meal) was second, Ration III (linseed meal) was third and Ration IV (regular ration and milk) gained the most in this trial.

In using actual price of feeds at the time of the study and considering whole milk to be worth $3.50 per 100 pounds, the average feed costs of raising each calf to 16 weeks of age were: Group I (blood meal ration)

$17.04; Group II (meat meal ration) $17.44; Group III (linseed meal ration) $17.74 and Group IV (whole milk plus the control ration) $36.27.

INTRODUCTION

Milk is usually considered as the best feed for raising calves. However, when dairymen are selling milk for the bottled milk trade, its use as a calf feed may have a direct influence on reducing income. For example, milk for bottling purposes usually is relatively high priced and the amount fed to calves results in a high direct feed cost. In addition where dairymen are selling on a "base" plan the milk fed to calves may be needed to establish a base. Milk which is not available for market during the base building period will result in a reduced base and a reduced income for the remainder of the year. Thus, research workers and dairymen have been interested in developing methods whereby calves could be raised at the lowest possible cost consistent with adequate growth and well being.

Milk replacers and calf starter rations have been developed, some of which have been used with success. Calf starter rations are usually offered as soon as the calf will eat them but milk is also fed at about 10% of body weight up to six weeks of age. After this period, milk is discontinued and starter ration and hay make up the ration for the next 10 weeks or until the animal is 16 weeks old. At this time, the calves may be changed to a cheaper grain ration. Ideally, the starter ration should maintain the animal in good physical health and permit continued development so that the animal will mature into a cow capable of producing milk at or near her genetic ability.

Calf starter rations which have been used with success are palatable; contain adequate amounts of high quality protein, as well as adequate amounts of minerals and vitamins. Vitamins A and D appear to be especially important. Antibiotics have been shown to be helpful in preventing scours and other infections and in promoting some additional growth.

Most starter rations have contained 20% or more of crude protein. There is some evidence that a lower level of crude protein may be adequate (30). The best source of protein <u>ie</u> animal or vegetable has not been adequately determined (29).

This project was undertaken to determine the effectiveness of a 16% crude protein calf starter ration and to test several sources of supplemental protein <u>ie</u> animal and vegetable.

REVIEW OF LITERATURE

I. Early Work With Starter Ration for the Feeding of Dairy Calves

One of the many problems which has been of great interest to dairy investigators for many years is that of reducing the cost of raising calves. Where milk feeding is considered to be expensive, the only alternative to milk feeding would be to determine the earliest age at which calves may utilize solid food as a sole source of nourishment (15).

A. Simple Starter Rations

In 1924, Meade and co-workers (15) used three groups of calves in comparing simple starter rations for the growing of calves. All calves were weaned from milk between 30 and 40 days of age and continued on their respective starter ration and alfalfa meal ad libitum to the end of the experiment.

Ration I contained yellow corn meal, linseed meal, wheat bran and salt while Ration II was supplemented with two per cent rock phosphate and Ration III was supplemented with ten per cent molasses. The amount of starter ration was limited to five pounds daily to each calf.

Calves were found to be normal in skeletal growth at the end of the experiment but did not reach normal weight until about 12 months of age.

B. Dried Skimmilk and Blood Meal Added to Calf Starter Rations

In 1929 Bender and Bartlett (5) tried to determine the best possible ration to feed dry which would produce a hundred per cent normality in calves at 180 days of age and determine the palatability and amino acid content essential for growth. Five different starter rations were used to determine if there was a difference in growth of calves when the quality of hay varied from poor to good in quality. Starter rations contained different sources and amounts of supplemental protein with Ration I containing 20 pounds dried skimmilk, Ration II linseed meal plus 2 c.c. of .2 per cent hydrochloric acid, Ration III linseed meal, Ration IV blood flour and linseed meal and Ration V dried skimmilk, linseed meal and blood flour.

Practically all of the calves on the various starter rations slowed up in weight growth the first 10 days and, in some cases, this lag in weight growth lasted for 30 days after being removed from milk at 30 days of age.

Growth information indicates that calves on the poorer quality of hay made the least growth in body weight and height of withers in this experiment.

Newman and Savage (21), in 1929, studied the use of yeast in calf meals and pellets.

Calves were on this experiment until they were 16 weeks of age and each calf received 350 pounds of milk. Four pounds of grain was the maximum amount of starter fed each calf per day.

Skimmilk powder and yeast were the only variables in these six starter rations which contained 19.2 to 22.4 per cent crude protein. The yeast did not effect the palatability of any of these rations. Thirty per cent dried skimmilk reduced the palatability thus lowering the amount of growth in this group of calves while ten per cent dried skimmilk, plus soybean meal, seemed to be the most beneficial ration. Pelleting reduced consumption which, in turn, reduced growth in these animals, however all growths were above the Ragsdale standards.

II. Level of Crude Fiber in Starter Rations

It is commonly recommended that a calf starter ration should contain no more than five per cent crude fiber (18). Whitaker and others (28), in 1957, studied the influence of level and source of crude fiber in calf starters on weight and feed consumption. Calves were limited to four pounds of starter per day. Forty-three thousand international units of vitamin A and 5,400 international units of vitamin D were fed daily. The first Group was on a basal ration, Group II on a basal ration plus cobs and shucks, Group III was on a basal ration plus alfalfa, Group IV was on a basal ration plus cobs and shucks and the last Group on a basal ration plus alfalfa. There was from 5 to 13% crude fiber in these rations. A 16% crude protein ration was used in this experiment and milk was fed to calves until they were 63 days of age. When analyzed according to the analysis of variance, no significant difference in accumulative weight gained;

in starter ration or hay consumption was revealed either during the first eight weeks or the entire 16 week period.

III. Response of Young Dairy Calves Fed a Simple vs. a Complex Starter Ration

In 1958, Morley and co-workers (20) studied the response of young dairy calves fed a simple vs. a complex starter with various kinds of hay. Forty-seven Jersey calves were randomly assigned at four days of age to receive either a simple or complex starter limited to 3 pounds daily per calf. Whole milk was fed in limited amounts to 35 days of age. Either coastal Bermuda or oat hay was fed from 8 through 112 days in Trial I. Alfalfa hay or crabgrass hay was fed from 15 to 112 days in Trial II. No significant differences were observed in milk, hay or calculated T.D.N. consumption between starter groups. Calves fed the Coastal Bermuda hay gained at a faster rate than those fed oat hay irrespective of type of starter fed, and were more efficient in their use of T.D.N. In Group II, alfalfa hay fed calves consumed significantly more hay and calculated T.D.N. than the crabgrass hay fed group. There was no advantage in feeding the complex starter ration over the simple starter ration. Thus, it appears that the calves were able to utilize these hays supplemented with a simple calf starter for normal growth gains at an early age even though whole milk feeding was limited to 120 pounds per calf.

IV. Effect of Anise Oil on Palatability of Calf Starter Rations

Miller and others (16) used different kinds of anise oil in determining the influence on palatability of calf starter rations. They used imitation and U.S.P. anise oil in a cafeteria experiment which involved a wide range of basal starters. Five-tenths of one pound to two pounds of anise oil per ton of feed was used. The calves were fed for 51 days on milk and milk replacer. Chopped alfalfa hay was fed ad libitum.

In each of the four experiments, anise oil depressed palatability. Two pounds of anise oil per ton of starter lowered palatability more than one-half pound per ton. Differences in palatability were found between the imitation and U.S.P. anise oil. All differences were highly significant.

V. Effect of Crude Protein Level in Calf Starters

In 1958, Brown et al. (7) fed calves on starter rations containing crude protein at four different levels. Calves were fed whole milk for six weeks and were than fed the starter rations until 86 days of age. The hay was of medium quality alfalfa and was fed ad libitum. Starter rations contained 24.3, 20.2, 16.6, 12.2 per cent crude protein in trial one. The most efficient gains were made on the 12.2 and 16.6 per cent crude protein levels.

The starter ration in trial two contained 23.7, 20.0, 13.0 and 8.5 per cent crude protein. In the second trial, no significant differences were found among groups receiving either 23.7, 20.0 or

13.0 per cent crude protein.

Rations of 12.2 and 16.6 per cent protein were necessary to maintain normal growth when a limited amount of whole milk and medium to good quality hay was fed. A starter containing only 8.5% crude protein supported growth at a significantly lower rate than any other starter.

ANTIBIOTIC FEEDING TO DAIRY CALVES

A. Effect of Feeding Aureomycin to Dairy Calves

Bartley and others (1) found that the addition of aureomycin as aurofac 2A increased the growth rate in calves fed a starter ration. The aureomycin lessened disease in calves during the feeding period.

In 1951, Rusoff and Davis (24) studied the growth promoting effect of aureomycin on young calves weaned from milk at an early age. Calves receiving aureomycin had a better appearance, the Jersey calves gained 25% and the Holstein calves gained 18% over the controls. There was a 2% level of aureomycin in an all vegetable starter ration fed to 16 weeks of age.

Gaunya and Co-workers (10) studied the effects of adding small quantities of aureomycin as aurofac 2A to the starter rations of calves. Group I was fed the control ration; Group II received 2.5 pounds per ton of aurofac 2A added to the ration; Group III, 5 pounds aurofac 2A per ton. There was an average of 4.5 to 9 mg. of aureomycin per pound of starter. The calves were 14 days of age when they went on this experiment and were 91 days old at the end of the experiment.

Calves that had a temperature of 103 degrees at any time were treated for sickness. From seven through 49 days a higher gain was found on calves fed the 5 pound level of aureomycin, but this higher gain disappeared after the 49th day and did not carry on through the full time of the experiment. There were no particular differences in the amount of starter consumed during the experiment. The aureomycin fed calves consumed less hay than the control calves during the experiment.

Bartley and Co-workers (4) found that aureomycin helped only slightly on digestion of nutrients. The beneficial effect of aureomycin was found to be in the control of colds and scours during the feeding period and not in the improvement of digestibility of feed.

Murley and others (19) studied the affect of aureomycin in supplementation and feed utilization in young dairy calves. They fed a starter ration to calves from three days to sixteen weeks. Hay was fed ad libitum and grain was fed to a maximum of four pounds daily. Four groups were used in the experiment. Group I received whole milk, Group II whole milk plus aureomycin and Group III reconstituted milk and Group IV reconstituted milk plus aureomycin. The basal grain ration was made up of 40 pounds ground corn, 30 pounds crushed oats, 28 pounds soybean meal, one pound bone meal and one pound salt. Eighty mg. of aureomycin was fed daily. There was no sparing effect on the amount of feed necessary to make a pound of gain but aureomycin did help to control disease and scours in these calves.

Hogue and Co-workers (11) studied the comparison of antibiotics for dairy calves on two levels of milk feeding. One group received 350 pounds of milk and the other group 175 pounds of milk. In feeding antibiotics only seven weeks, it was found to be just as effective as where it was fed for sixteen weeks. They found 10 mg. of aureomycin as effective as a level of 20 or 40 mg. of aureomycin. There was no particular difference in feed utilization, however, calves fed aureomycin had less scours than those fed the control ration. There was a definite affect on the growth of calves where a greater amount of milk was fed during the early days of the experiment. It is suggested that the affect of the antibiotic on the incidence of diarrhea and average daily gain are, at least, in part independent and that the antibiotics may have a better milk sparing affect in allowing the lower milk feeding.

B. Effect of Aureomycin on the Amount and Type of Protein Fed or Needed

Everett and Co-workers (9) used a limited milk-hay starter ration system to determine if aureomycin had any sparing effect on protein and the minimum starter protein level satisfactory for normal growth of aureomycin fed calves reared on a limited hay starter system. Starter rations varied from 6.3 to 14.2% protein fed with and without aureomycin. The antibiotics did not spare dietary protein in this experiment, but it did give satisfactory gain on the starters containing at least two per cent less protein than the starter required to give similar gains without aureomycin. Normal weight gains were made by calves on the 12.2 and 14.2 protein starters when aureomycin was fed.

Significant increases in average daily gain, height at withers, heart girth and starter consumption were obtained when aureomycin was fed. The antibiotics had no significant effect on apparent digestibility of any of the nutrients.

Rusoff and Co-workers (23) studied the effect of type of protein on the response of young dairy calves to aureomycin with data on the intestinal microflora. A bacteriological study of the effect of aureomycin on the rumen flora of calves failed to reveal any change of the usual microscopic appearance when protozoa and the morphological groups, described by Pouden and Hibbs, were used as the indicator organism. These calves received 50 mg. of aureomycin in their milk. They were weaned from milk at 30 days of age and placed on an all vegetable starter ration. Soybean meal gave a little better growth than cottonseed meal in the starter ration. Four pounds of grain to Jerseys and five pounds to Holsteins was the maximum amount of starter fed per day. Hardly any scours were noted where antibiotics were fed in the starter ration.

C. Comparison of Different Antibiotics in Calf Starter Rations

Bartley and Co-workers (1,3) reported results which indicate that a level of 45 mg. of aureomycin (aurofac 2A) daily will give maximum protection for colds and scours in dairy calf starter rations. Bartley and Co-workers (1,4) indicate that aurofac 2A has given better results in calf feeding than crystolline aureomycin.

Hogue and others (11) found no particular difference in feed utilization when comparing aureomycin, streptomycin, bacitracin and penicillin in starter rations. Calves fed antibiotics had less scours than the calves fed the control ration.

Lassiter and Co-workers (14) compared the affect of crystalline antibiotics and crude antibiotic supplements on the growth and metabolism of young dairy calves. They compared crystalline aureomycin, aureomycin as aurofac D, crystalline terramycin and terramycin as TM-5 at a level of 50 mg. daily to calves fed a starter ration after seven weeks of age. Statistically there was no difference in growth between the groups on antibiotics, but greater growth than in the controls. All antibiotics but crystalline aureomycin lowered the incidence of scours.

Milk was fed until seven weeks of age and then an antibiotic was added to the starter ration. There were five groups of calves on an all plant starter ration diet. Group I was the control group, Group II received the starter ration plus 50 mg. of crystalline aureomycin, Group III the control ration plus 50 mg. of aureomycin as (aurofac D), Group IV the control ration plus 50 mg. of crystalline terramycin and Group V the control ration plus 50 mg. of terramycin TM-5. All antibiotics excepting crystalline aureomycin lowered the incidence of scours in this experiment. The daily gain on this experiment was as follows: Group I, 1.09 pounds daily; Group II, 1.17 pounds daily; Group III, 1.24 pounds daily; Group IV, 1.17 pounds daily and Group V, 1.19 pounds daily.

Bartley and others (3) used four different treatments of antibiotics in feeding starter rations to dairy calves. Ration I contained no antibiotics, Ration II contained 30 mg. of crystalline aureomycin, Ration III, 30 mg. of streptomycin sulphate and Ration IV, 90 mg. of streptomycin sulphate. These antibiotics were fed by capsule daily. Aureomycin gave better control of scours and gave a higher growth rate than streptomycin in these experiments. There was no significant difference in the two levels of streptomycin in starter rations fed calves to 16 weeks of age. Both aureomycin and streptomycin reduced scours in calves and gave better feed utilization.

D. <u>The Effect of Aureomycin on Young Dairy Calves Housed Under a Different Environment</u>

Landagora and Co-workers (13) studied the effect of aureomycin on young dairy calves raised in a new environment. These calves were kept on the experiment until 12 weeks of age. One group was housed in an old barn where calves had been housed previously. The other group was housed in a barn that had not housed calves before. Three rations were used with each group of calves. Ration I was the control ration. Ration II was a control ration plus 50 mg. daily of aureomycin (aurofac 2A). Group III received the control ration plus 400 mg. of aureomycin in oil weekly. Regardless of environment, aureomycin increased growth. Growth response was early in the calves fed aureomycin orally and in the calves housed in the new barn. These findings indicate that cleanliness and sanitary conditions of the environment favor a greater and more effective growth stimulation response of aureomycin feeding.

Bartley and Co-workers (2) used 15 mg. and 45 mg. of aureomycin as aurofac 2A in starter rations when calves were kept in a barn where calves had not been housed previously. In the new surroundings there was less colds and penumonia in the control animals than in the control animals housed under old calf barn conditions. Holstein calves fed 15 mg. of aureomycin did just as well as those fed 45 mg. of aureomycin per day. This was not true in the case of Jersey calves, as the 45 mg. of aureomycin per day gave better results than the 15 mg. There was no significant difference in the feed intake in the three groups of calves regardless of the amount of aureomycin fed per day. It was noted, however, that the rate of growth was higher in the animals treated with aureomycin than those fed the control rations.

EXPERIMENTAL PROCEDURE

Calves used in this experiment were provided by the Montana State College Dairy Industry Department from the regular dairy herd. Twenty-four calves, born between November 27, 1957 and March 28, 1958, were divided into four groups. Each group contained two Jersey heifer calves, two Holstein heifer calves and two Holstein steer calves.

Calves were assigned to one of the four groups by the following method: The first Jersey heifer, Holstein heifer and Holstein steer born were assigned to Group IV which received the regular grain ration commonly fed to calves in the dairy herd. The next Jersey heifer, Holstein heifer and Holstein steer born were assigned to Group II and received the meat meal starter ration. The third Jersey heifer, Holstein heifer and Holstein steer born were assigned to Group I which received the starter ration containing blood meal and the four Jersey heifer, Holstein heifer and Holstein steer born in the dairy herd were assigned to Group III which received the starter ration which contained linseed meal. This method was followed until all calves were assigned to their respective group or ration.

Calves were identified at birth by a plastic tag inserted in the left ear. At three days of age, the calves were removed from their dams and were assigned to their experimental stall. The stalls were equipped with individual covered feed boxes and were bedded with straw.

Milk from the calf's mother was fed until the calves were approximately five days of age. After this time, milk from Holstein cows was used and was fed at approximately 10 per cent of the body weight for the remainder of the milk feeding period. Whole milk was fed to calves in Groups I, II and III through six weeks of age. At the beginning of the seventh week, the milk was reduced one-half and discontinued at the end of forty-nine days of age. In Group IV, Jersey calves were limited to eight pounds of milk and the Holstein calves to ten pounds of milk per day. These calves were fed milk, plus the regular grain ration for the entire sixteen weeks period but were limited to two pounds of grain per head per day.

Grain was made available to calves for one hour each morning and evening. When the calves were turned loose, the grain boxes were closed until the next feeding period.

Grain rations were mixed in the feed room at the dairy barn and placed in burlap bags. These bags were identified with the number of the ration plainly marked on the tag attached to each grain bag.

Forty-five milligram of aureomycin was fed daily to all calves during the experimental period. Following the milk feeding period, aureomycin was mixed with the starter ration at the evening feeding for each calf in Groups I, II and III. Synthetic vitamin D was provided each calf at the rate of 400 international units per day in the aureomycin when milk feeding was discontinued.

Alfalfa hay was fed ad libitum during the experimental period and salt and water were provided at all times except when calves were not tied up for milk and grain feeding. Dehydrated alfalfa meal, at a seven per cent level was added to the starter Ration I, II and III to provide sufficient carotene (vitamin A). Dried skimmilk at the eight per cent level was used in starter Ration I, II and III and at the 4.5 per cent level in Ration IV.

Blood meal was used in starter Ration I, meat meal in starter Ration II and linseed meal in starter Rations III and IV. Phosphorus, steamed bone meal and salt, at a one per cent level, were added to starter Ration I, II and III.

Tables I and II show the composition and chemical analysis of each grain ration used in the experiment.

Daily records were kept of the amount of milk and grain fed each calf. Weight and skeletal growth ie chest measurements and height of withers were recorded weekly. Measurements were taken each Thursday afternoon at 3 P. M. Calves not removed from their dams by noon on Thursday had their measurements taken at the next regular measurement period. During the first four months of this experiment, practically all growth measurements were taken by the same individual. During the remainder of the experiment, circumstances made it necessary for one of three different members of the Dairy Industry staff to be involved in taking growth measurements.

A veterinarian from the College Veterinary Science Department treated animals for bloat or digestive upsets during the experiment.

Table I. Components of Starter Mixtures Used in Comparative Feeding Tests of Dairy Calves to 16 Weeks of Age

	Group I Blood Meal	Group II Meat Meal	Group III Linseed Meal	Group IV Regular
	Pounds	Pounds	Pounds	Pounds
Powdered skimmilk	8.0	8.0	8.0	4.5
Dehydrated alfalfa meal	7.0	7.0	7.0	-
Rolled barley	39.0	38.0	34.0	42.5
Rolled oats	35.0	35.0	35.0	42.5
Sugar pulp	5.0	5.0	5.0	-
Linseed meal	-	-	8.0	9.0
Blood meal	3.25	-	-	-
Meat meal	-	4.5	-	-
Mono-sodium phosphate	1.0	1.0	1.0	-
Steamed bone meal	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0
Aurofac 2A*				
Vitamin D**				
Total	100.25	100.5	100.0	100.5

* 45 mg. Aurofac (2A) was fed each day during the feeding period

** 400 I.U. of vitamin D was provided each calf per day

Table II. Average Chemical Composition of Grain Rations Fed Dairy Calves to 16 Weeks of Age

	Group I Blood Meal Ration	Group II Meat Meal Ration	Group III Linseed Meal Ration	Group IV Regu- lar Ration
	%	%	%	%
Crude protein	16.0	15.2	15.8	15.4
Ether extract	3.2	3.1	3.3	3.6
Crude fiber	8.0	7.6	9.2	6.5
Phosphorus	.94	.85	.73	.46
Calcium	.75	1.08	.83	.75

RESULTS

There was an increase in rate of gain from low to high from Group I through Group IV as shown in Table III. The average daily gain of the calves on the experiment was as follows: Group I, (blood meal ration) 1.23 pounds; Group II, (meat meal ration) 1.30 pounds; Group III, (linseed meal ration) 1.42 pounds and Group IV, (milk plus regular grain ration) 1.62 pounds.

The amount of gain for calf No. 668, which died, was figured from a formula in "Statistical Methods" by Snedecor (28).

In referring to Table III, the cost of a pound of gain is found by dividing the total feed cost for each ration group of calves by the number of pounds of gain to get the average cost per pound of gain in each ration group. The cost of a pound of gain for Groups I, II and III were similar ie 12.3¢, 11.9¢ and 11.1¢ respectively but much higher (20.1¢) in Group IV.

Table III. The Total Amount of Grain and Milk Consumed, Total Feed Cost, Total Pounds of Gain, Cost Per Pound of Gain and Average Daily Gain for all Calves in Each Group Which Include two Each of Jersey Heifers, Holstein Heifers and Holstein Steers

	Group I Blood Meal		Group II Meat Meal		Group III Linseed Meal		Group IV Regular	
	Grain	Milk	Grain	Milk	Grain	Milk	Grain	Milk
	Pounds		Pounds		Pounds		Pounds	
Feed Consumed								
Jersey	239.3	501.5	338.0	473.5	361.6	509.5	221.5	1493.
Holstein Heifer	367.0	661.0	295.2	695.5	416.0	673.5	276.8	2048.
Holstein Steer	406.2	673.5	395.3	734.5	292.0	721.5	303.9	1978.
Total Feed Cost	$102.23		$104.67		$106.45		$ 217.63	
Total Pounds Gain	829		880		959		1082	
Cost Per Pound Gain		12.3¢		11.9¢		11.1¢		20.1¢
Ave. Daily Gain-Pounds	1.23		1.30		1.42		1.62	

The average body weight of the two Jersey heifer calves was 145 pounds for the blood meal ration; 168 pounds for the meat meal ration; 182 pounds for the linseed meal ration and 199 pounds for the regular ration and milk at the end of the 16 week period. The two Jersey heifer calves on the blood meal ration, the meat meal ration and the linseed meal ration were 72.8 per cent; 84.4 per cent and 91.4 per cent respectively, of the weight of the two Jersey heifer calves fed the control ration plus milk at the end of the 16 week period. The control ration plus milk was considered to be 100 per cent.

The average body weight of the two Holstein heifer calves at 16 weeks of age was 239 pounds for the blood meal ration; 230 pounds for the meat meal ration; 258 pounds for the linseed meal ration and 281 pounds for the control ration plus milk. The two Holstein heifer calves on the blood meal ration, the meat meal ration and the linseed meal ration were 85.0 per cent; 82.0 per cent and 92.0 per cent respectively, of the weight of the two Holstein heifer calves fed the control ration plus milk at the end of the 16 week period, when the control ration was considered to be 100 per cent.

The average body weight of the two Holstein steers at 16 weeks of age was 252 pounds for the blood meal ration; 267 pounds for the meat meal ration; 284 pounds for the linseed meal ration and 279 pounds for the control ration plus milk. The two Holstein steers on the blood meal ration, the meat meal ration and the linseed meal ration were 90.0 per cent; 96.0 per cent and 101.0 per cent respectively, when compared to the growth weight of the two Holstein steers fed the control ration plus milk at the end of the 16 week period, when the control ration is considered to be 100 per cent.

Table IV shows the effect of ration on body weight according to the analysis of variance. When the weights data were analyzed statistically, it was found that the differences between periods and the sex-breed differences were highly significant but that the differences between the four different rations were not significant.

Table IV. Effect of Ration on Body Weight When Analyzed According to Analysis of Variance

Variation Due To	Degrees of Freedom	Sums of Square	Means Square	F Value
		Body Weight		
Period	4	377239	94309.7	122.24**
Ration	3	3265	1088	1.41
Sex-breed	2	79398	39699	51.4**
PX Sex-breed	8	8939	1117.3	1.45
PXR	12	2075	172.9	.224
Sex-breed X R	6	1034	172.3	.223
PX Sex-breed X R	24	7945	331	.429
Error	60	46292	771.5	-
Total	119	526187	-	-

* - Significant difference

** - Highly significant difference

The average height of withers of the two Jersey heifer calves was 32.06 inches for the blood meal ration; 32.81 inches for the meat meal ration; 33.56 inches for the linseed meal ration and 35.44 inches for the regular ration and milk at the end of the 16 week period. The two Jersey heifer calves on the blood meal ration, the meat meal ration and the linseed meal ration were 90.40 per cent; 92.50 per cent and 94.60 per cent respectively, of the height of withers of the two Jersey heifer calves fed the control ration plus milk at the end of the 16 week period. The control ration plus milk was considered to be 100 per cent.

The average height of withers of the two Holstein heifer calves at 16 weeks of age was 36.09 inches for the blood meal ration; 35.44 inches for the meat meal ration; 35.81 inches for the linseed meal ration and 38.94 inches for the control ration plus milk. The two Holstein heifer calves on the blood meal ration, the meat meal ration and the linseed meal ration were 92.68 per cent; 91.00 per cent and 91.95 per cent respectively, of the height of withers of the two Holstein heifer calves fed the control ration plus milk at the end of the 16 week period. The control ration was considered to be 100 per cent.

The average height of withers of the two Holstein steers at 16 weeks of age was 36.19 inches for the blood meal ration; 37.28 inches for the meat meal ration; 36.88 inches for the linseed meal ration and 37.50 inches for the control ration plus milk. The two Holstein steers on the blood meal ration; the meat meal ration and the linseed meal ration were 96.50 per cent; 99.41 per cent and 98.34 per cent respectively, when compared to the height of withers of the two Holstein steers fed the control ration plus milk at the end of the 16 week period, when the control ration is considered to be 100 per cent.

Table V shows the effect of rations on height of withers according to the analysis of variance. When the height of withers were analyzed statistically, it was found that the differences between periods, rations, sex-breed and sex-breed-ration were highly significant but all other factors were not significant.

Table V. Effect of Ration on Height of Withers When Analyzed According to Analysis of Variance

Variation Due To	Degrees of Freedom	Sums Of Squares	Means Square	F Value
		Height of Withers		
Period	4	835	208.7	158.1**
Ration	3	18.6	6.2	4.62**
Sex-breed	2	247	123.5	93.56**
PX Sex-Breed	8	19.4	2.42	1.83
PXR	12	2.0	.17	.128
Sex-breed X R	6	31.9	5.3	4.0**
PX Sex-breed X R	24	4.5	.19	.143
Error	60	79.5	1.32	-
Total	119	1237.9	-	-

* - Significant difference

** - Highly significant difference

The average chest measurement of the two Jersey heifer calves was 34.25 inches for the blood meal ration; 35.50 inches for the meat meal ration 36.75 inches for the linseed meal ration and 37.75 inches for the regular ration and milk at the end of the 16 week period. The two Jersey heifer calves on the blood meal ration, the meat meal ration and the linseed meal ration were 90.72 per cent; 94.04 per cent and 97.35 per cent respectively, of the chest measurement of the two Jersey heifer calves fed the control ration plus milk at the end of the 16 week period. The control ration plus milk was considered 100 per cent.

The average chest measurement of the two Holstein heifer calves at 16 weeks of age was 39.75 inches for the blood meal ration; 40.50 inches for the meat meal ration; 42.00 inches for the linseed meal ration and 42.75 inches for the control ration plus milk. The two Holstein heifer calves on the blood meal ration, the meat meal ration and the linseed meal ration were 92.98 per cent; 94.73 per cent and 98.24 per cent respectively, of the chest measurements of the two Holstein heifer calves fed the control ration plus milk at the end of the 16 week period. The control ration plus milk was considered to be 100 per cent.

The average chest measurement of the two Holstein steers at 16 weeks of age was 40.87 inches for the blood meal ration; 41.69 inches for the meat meal ration; 42.50 inches for the linseed meal ration and 41.75 inches for the control ration plus milk. The two Holstein steers on the blood meal ration, the meat meal ration and the linseed meal ration were 97.86 per cent; 99.85 per cent and 101.79 per cent respectively, when compared to the chest measurements of the two Holstein steers fed the control ration plus milk at the end of the 16 week period. The control ration was considered to be 100 per cent.

Table VI shows the effect of rations on chest measurements according to the analysis of variance. When the chest measurements were analyzed statistically, it was found that the differences between periods and sex-breed differences were highly significant, differences between rations and sex-breed-ration were significant but that the other factors were not significant.

Table VI. Effect of Ration on Chest Measurement When Analyzed According to Analysis of Variance

Variation Due To	Degrees Of Freedom	Sums Of Square	Means Square	F Value
	Chest Measurements			
Period	4	2153	538.2	276.0**
Ration	3	16.8	5.6	2.87*
Sex-breed	2	509	254.5	130.51**
PX Sex-Breed	8	4.0	.5	.256
PXR	12	27.6	2.3	1.18
Sex-breed X R	6	28.2	4.7	2.41*
PX Sex-breed X R	24	25.1	1.04	.53
Error	60	117.3	1.94	-
Total	119	2881	-	-

* - Significant difference

** - Highly significant difference

In comparing the average of the two Jersey heifers, two Holstein heifers and two Holstein steers in each ration group with Ragsdale growth Standard (page 33) on body weight, chest measurements and height of withers the following comparisons resulted:

When comparing body weight, nine pair of calves exceeded the Ragsdale Standards in body weight, however, the two Jersey heifers and two Holstein steers on the blood meal ration and the two Holstein heifers on the meat meal ration were three pounds or (2.02; 1.17 and 1.28 per cent respectively) below the weight standards.

When comparing height of withers, all of the groups of calves exceeded the Ragsdale Standards on height of withers except the two Holstein heifers on the meat meal ration which were .26 of one inch or .74 of one per cent below the Ragsdale Standards.

When comparing chest measurements, the two Jersey heifers and two Holstein heifers on the blood meal, meat meal and linseed meal rations were: Jersey heifers, 3.05; 1.80 and .55 inches or 8.17; 4.82 and 1.47 per cent respectively, and Holstein heifers, 2.40; 1.85 and .35 inches or 5.66; 4.36 and .82 per cent respectively, below the Ragsdale Standards. The two Holstein steers were 2.13 inches or 4.9 per cent, on the blood meal ration, 1.31 inches, or 3.0 per cent, on the meat meal ration, .50 inches, or 1.2 per cent on the linseed ration and 1.25 inches, or 2.9 per cent on the regular ration below the Ragsdale Standards.

Growth Standards Used for Calves at 112 Days of Age
as Calculated From Ragsdale Standards

Body Weight for Jersey heifers 148 pounds, Holstein heifers 233 pounds and Holstein steers 255 pounds.

Chest Measurements for Jersey heifers 37.3 inches, Holstein heifers 42.35 inches and Holstein steers 43.0 inches.

Height of Withers for Jersey heifers 32.0 inches, Holstein heifers 35.7 inches and Holstein steers 36.0 inches.

Results of Individual Calves

No. 646 - a Jersey heifer calf born November 27, 1957 and weighed 48 pounds at birth. This calf was on whole milk, hay ad libitum and the regular grain Ration IV throughout the experiment. She gained 146 pounds with 1.3 pounds average daily gain. She weighed 194 pounds at the end of the experiment.

No. 647 - a Holstein steer born November 29, 1957 and weighed 65 pounds at birth. This calf was on whole milk, hay libitum and the regular grain Ration IV throughout the experiment. This calf had the lowest birth weight of any Holstein calf on the experiment. This calf gained 185 pounds with a 1.66 pounds average daily gain and weighed 250 pounds at the end of the experiment.

No. 648 - a Holstein heifer calf born December 1, 1957 and weighed 81 pounds at birth. This calf was on a ration of whole milk, hay ad libitum and the regular grain Ration IV throughout the experiment. She gained 205 pounds with a 1.83 pounds average daily gain and weighed 286 pounds at the end of the experiment.

No. 652 - a Holstein heifer calf born December 21, 1957 and weighed 74 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the meat meal Ration II starter ration. On January 11 this calf had a fever and was treated by a veterinarian. Her milk feeding was reduced to six pounds daily for five days. She gained 149 pounds with a 1.33 pounds average daily gain. She weighed 223 pounds at the end of the experiment.

No. 653 - a Holstein steer calf born December 24, 1957 and weighed 93 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the meat meal Ration II starter ration. On December 30 she was sick and the amount of milk fed was reduced to seven pounds daily for six days. She gained 162 pounds with a 1.44 pounds average daily gain and weighed 255 pounds at the end of the experiment.

No. 655 - a Jersey heifer calf born December 25, 1957 and weighed 45 pounds at birth. She was the lightest weight Jersey calf at birth. This calf was on whole milk for seven weeks, hay ad libitum and the meat meal Ration II starter ration. On January 13 this calf was sick and was treated by a veterinarian. The milk feeding was reduced to four pounds daily for three days. She gained only 97 pounds with a .87 pound average daily gain and weighed 142 pounds at the end of the experiment.

No. 656 - a Jersey heifer calf, born December 26, 1957, and weighed 49 pounds at birth. She was on whole milk for seven weeks, hay ad libitum and the blood meal Ration II starter ration. On January 13 this calf was sick and was treated by a veterinarian. The milk feeding was reduced to two pounds daily for two days and four pounds daily for one day before going back on regular feeding of five pounds daily. She gained only 87 pounds with a

.77 pound average daily gain. She weighed only 136 pounds at the end of the experiment.

No. 657 - a Jersey heifer calf born December 28, 1957 and weighed 54 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the linseed meal No. III starter ration. She gained 122 pounds with a 1.08 pounds average daily gain. She weighed 176 pounds at the end of the experiment.

No. 658 - a Holstein heifer calf born December 28, 1957 and weighed 78 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the blood meal No. I starter ration. This calf scoured for two days following removal from its dam. She gained 146 pounds with a 1.3 pounds average daily gain. She weighed 224 pounds at the end of the experiment.

No. 659 - a Jersey heifer calf born January 11, 1958. She weighed 52 pounds at birth. This calf was on whole milk, hay ad libitum and the regular grain ration No. IV for the entire experiment. She gained 157 pounds with a 1.4 pounds average daily gain. She weighed 209 pounds at the end of the experiment.

No. 662 - a Jersey heifer calf born January 18, 1958 and weighed 56 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the meat meal No. II starter ration. She gained 139 pounds with a 1.24 pounds average daily gain and weighed 195 pounds at the end of the experiment.

No. 663 - a Holstein steer calf born January 21, 1958 and weighed 82 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the blood meal No. I starter ration. This calf was sick for two days following removal from its dam. This calf gained 148 pounds with a 1.32 pounds average daily gain and weighed 230 pounds at the end of the experiment.

No. 664 - a Holstein heifer calf born January 26, 1958 and weighed 83 pounds at birth. She was on whole milk for seven weeks, hay ad libitum and the linseed meal No. III starter ration. She gained 153 pounds with a 1.36 pounds average daily gain and weighed 236 pounds at the end of the experiment.

No. 665 - a Holstein heifer calf born January 29, 1958 and weighed 95 pounds at birth. This calf was on whole milk, hay ad libitum and the regular grain ration No. IV throughout the experiment. She gained 181 pounds with a 1.6 pounds average daily gain and weighed 276 pounds at the end of the experiment.

No. 666 - a Jersey heifer calf born February 3, 1958 and weighed 59 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the blood meal No. I starter ration. On May 3rd she was treated for bloat. She gained 96 pounds with a .86 pound average daily gain. She weighed 155 pounds at the end of the experiment.

No. 668 - a Holstein steer calf born February 8, 1958 and weighed 100 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the linseed meal No. III starter ration. On April 6 this calf bloated slightly. On April 15 it bloated and was treated. At feeding time on April 23 this calf ate its grain and appeared to be normal. Later in the evening, the calf was bloated and died before the veterinarian could arrive. Record of gain up to death can be found in Appendix table.

No. 669 - a Holstein steer born February 9, 1958 and weighed 100 pounds at birth. This calf was on whole milk, hay ad libitum and the regular grain ration No. IV throughout the entire experimental period. On February 15 and 16 this calf was treated for scours. He gained 208 pounds with a 1.76 pounds average daily gain and weighed 308 pounds at the end of the experiment.

No. 670 - a Holstein heifer calf born February 9, 1958 and weighed 88 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the meat meal No. II starter ration. She gained 150 pounds with a 1.34 pounds average daily gain and weighed 238 pounds at the end of the experiment.

No. 671 - a Holstein steer calf born February 12, 1958 and weighed 97 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the meat meal No. II starter ration. He gained 183 pounds with a 1.63 pounds average daily gain and weighed 280 pounds at the end of the experiment.

No. 672 - a Holstein steer calf born February 19, 1958 and weighed 91 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the blood meal No. I starter ration. Because of scours, the milk was cut to four pounds on February 27 for two days. This calf gained 184 pounds with a 1.64 pounds average daily gain and weighed 275 pounds at the end of the experiment.

No. 675 - a Holstein steer calf born February 25, 1958 and weighed 100 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the linseed meal No. III starter ration. This calf bloated slightly on April 24 but was not treated. He gained 184 pounds with a 1.64 pounds average daily gain and weighed 284 pounds at the end of the experiment.

No. 678 - a Jersey heifer calf born March 12, 1958 and weighed 62 pounds at birth. This calf was on whole milk for seven weeks, hay ad libitum and the linseed meal No. III starter ration. She gained 126 pounds with a 1.12 pounds average daily gain and weighed 188 pounds at the end of the experiment.

No. 679 - a Holstein heifer calf born March 18, 1958 and weighed 86 pounds at birth. She was on whole milk for seven weeks, hay ad libitum and the blood meal No. I starter ration. This calf gained 168 pounds with a 1.50 pounds average daily gain. She weighed 254 pounds at the end of the experiment.

No. 683 - a Holstein heifer calf born March 28, 1958 and weighed 90 pounds at birth. She was on whole milk for seven weeks, hay ad libitum and the linseed meal No. III starter ration. This calf scoured on April 5. Her milk was reduced to five pounds daily for three days. She gained 190 pounds with a 1.69 pounds average daily gain and weighed 280 pounds at the end of the experiment.

DISCUSSION

The results of this experiment are similar to those obtained by Brown et al (7) in that calves were raised successfully on calf starter rations containing 16 per cent crude protein. As may be expected in experiments of this kind there was considerable variation in the rates of growth of the calves. Several factors may have been responsible for some of this variation. The fact that no two individuals will measure a calf exactly the same every time may account for some of the variation, because three different staff members of the dairy department weighed and measured calves during the experimental period. Errors may also occur by the inhaling and exhaling of the calves while the chest measurement is being taken. Digestive upsets may have caused some of the variation. There was some bloating noticed in the calves on starter Ration No. III containing linseed meal. Calf No. 668 fed the linseed meal starter ration, died during the experiment from bloat. Scours also occurred in some of the calves during the experiment. It was the practice that the calves be treated for scours by the college veterinarian when their temperature reached 103 degrees.

Jersey calves No. 655 and 656 were inclined to suck each other at every opportunity throughout the experiment. This may have had some effect on their growth being under Ragsdale Standards.

The Ragsdale growth standards give the body weight, chest measurement and height of withers for calves of different breeds and sex at monthly intervals. Growth measurements were calculated to give the comparative standard where calves are fed to 112 days of age rather than to 121 days or four months of age.

Since most of the calves in each group compared very favorably with the Ragsdale Standards in body weight and height of withers, it would appear these calves were no more variable than calves in similar trials involving the rates of growth of calves (5, 6, 15, 21, 25). The majority of the calves were below the standards in chest measurements. This may be in part due to variation in taking chest measurements or a genetic inheritance of small heart girth of calves in this experiment.

At the beginning of the experiment, the alfalfa hay was chopped and fed in individual boxes. Because of the amount of hay wasted by the calves, individual hay feeding was discontinued and long alfalfa hay was fed ad libitum for the remainder of the trial. The amount of hay consumed and the cost of hay eaten by the calves during the experimental period were not included in figuring the cost of a pound of gain.

Since most of the alfalfa hay grown in this area of Montana is usually low in phosphorus, mono-sodium phosphate and steamed bone meal were added to the starter rations to insure an adequate supply of phosphorus for the calves.

Sorting of grain by calves was a problem. The oats and barley were rolled and the other ingredients were of a finer texture. At each feeding, the grain fed was mixed with any fine materials left in the feed boxes. This mixing seemed to improve the eating of the finer grain particles by the calves. These finer grain particles may not have been