The utilization of all the colostrum produced by a dairy herd for feeding the calves
by Earl J Peace

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

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Colostrum was substituted for milk by equal weight in Group I with no scouring effect due to the colostrum. The calves, at the beginning of every sixteen-day cycle, were changed from their regular milk to 100 percent first milking colostrum.

Total digestible nutrients were computed for each calf every four days for the milk, hay, and grain. The calves were weighed every four days.

Analysis based on total digestible nutrients consumed and gains in weight indicate no significant difference between the groups. The results reveal that considerable saleable milk can be saved if the surplus colostrum is utilized in feeding calves.

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ABSTRACT

Thirty-six Holstein calves were fed in three groups from birth for eighty days. Group I was fed colostrum and whole milk intermittently, Group II was fed whole Holstein milk intermittently from different cows, and Group III was fed whole Holstein milk from one cow continuously.

Colostrum was substituted for milk by equal weight in Group I with no scouring effect due to the colostrum. The calves, at the beginning of every sixteen-day cycle, were changed from their regular milk to 100 percent first milking colostrum.

Total digestible nutrients were computed for each calf every four days for the milk, hay, and grain. The calves were weighed every four days.

Analysis based on total digestible nutrients consumed and gains in weight indicate no significant difference between the groups. The results reveal that considerable saleable milk can be saved if the surplus colostrum is utilized in feeding calves.

INTRODUCTION

Milk is the main cash crop of the dairy farmer.

Most dairy calves are fed normal whole saleable milk starting immediately after the colostrum feeding period and sometimes continuing up to six months of age. If a satisfactory substitute of less value than milk can be used as a replacement for feeding calves, the dairy farmer could market more milk and thus increase his income. Many dairymen who market Grade A milk do not separate any of it. They find it much simplier to feed saleable whole milk to young calves regardless of the expense.

Shortening the milk feeding period by the use of dry calf starters is probably the most popular present day method of overcoming the high consumption of marketable whole milk.

Colostrum is not marketable. On many dairy farms it is usually wasted. If a satisfactory method of calf feeding could be devised to utilize colostrum, it would result in saving Grade A whole milk that could be sold.

Allen (3) found that during the first three days following calving a cow will produce approximately 1.15 times the birth weight of the calf in colostrum. An average Holstein calf will weigh approximately 94 pounds at birth, according to Eckles (25). Therefore, its dam will produce about 108 pounds of colostrum. If the calf is started by feeding 8 percent of the body weight of the calf in colostrum daily during the first three days and the remaining 85 pounds can be satisfactorily substituted for whole milk pound for pound, there would be 85 pounds of saleable whole milk saved for every cow freshening in the herd.

Several investigators have fed colostrum continuously (1, 86, 93) to calves. However, this requires the colostrum to be stored.

This study was undertaken to determine if all the colostrum produced by the dairy herd can be used to feed calves without incurring the problem of storing the colostrum. In this investigation, an attempt was made to determine if it is economical, feasible, and practical to feed all surplus colostrum produced to calves intermittently as a substitute for whole normal milk during the milk feeding period. Other factors considered were whether colostrum possesses any particular growth-promoting properties not contained in whole milk.

REVIEW OF LITERATURE

Colostrum is generally considered, according to Sutton and Kaeser (93), to be the secretion produced by the cow during the first three days following parturition. Studies of the principal constituents during the transition period from colostrum to normal milk indicate rapid changes at first, with relatively smaller changes after the third day (32, 39, 54, 65, 66, 72, 74, 80, 82). In this discussion the term "colostrum" will refer to all secretion obtained during the first four days following parturition.

The Food and Drug Department (99) has defined milk as "...the whole, fresh lacteal secretion obtained by the complete milking of one or more healthy cows, excluding that obtained within fifteen days before or five days after calving or such longer period as may be necessary to render the milk practically colostrum-free."

This definition implies that the secretion produced by a cow the first five days after calving is a mixture of colostrum and milk. The constituents of the secretion as shown in Table 1 show a continuous progression from colostrum to milk. The constituents on the first day represent colostrum, whereas on the fourth day they very nearly represent milk.

In most cases, colostrum contained more nutrients than normal milk due to a higher concentration of proteins, minerals, and sometimes fat. Considerable variation was found in values for yield and for the properties of colostrum collected from different individuals at the same postpartal period. Fat was the most variable constituent.

Variability in secretions from different individuals decreased as transition to normal milk progressed. Table 1 shows specific gravity, total solids, solids-not-fat, total protein and ash decreased rapidly during the first three days, but only a relatively small decrease was noticed throughout the remainder of the transition period (32, 39, 66, 72, 74, 80, 82). Lactose changed in approximately an inverse ratio to the other constituents. The first milking postpartum is about

Table 1. Specific Gravity and Concentrations of Various Constituents in Colostrum and Early Milk from Samples of 111 Cows of Holstein, Ayrshire, Jersey, and Guernsey Breeds (66)

Number of Milking	Specific Gravity	Solids	Fat	Solids-Not-Fat	Total Protein	Lactose	Ash
	%	%	%	%	%	%	%
1	1.062	25.3	5.7	19.3	16.0	2.4	1.16
2	1.045	20.4	5.6	14.5	10.0	3.5	1.02
3	1.038	15.5	4.7	10.8	5.7	4.3	0.91
4	1.035	14.5	4.6	9.9	4.5	4.6	0.86
5 & 6	1.034	14.4	4.6	9.8	4.2	4.8	0.84
7 & 8	1.034	14.5	4.8	9.7	4.1	4.9	0.84
15 & 16	1.033	14.3	4.9	9.4	3.6	4.9	0.81
27 & 28	1.032	13.9	4.8	9.1	3.3	5.0	0.79

25 percent total solids. This is rapidly reduced to about 15 percent on the second day.

Parish, et al. (66) found that on an energy basis proteins contribute two to three times more to the total nutritional value of colostrum than to that of normal milk. Albumin gives colostrum a thick sticky consistency. The immunizing functions of colostrum are closely associated with the protein globulins. Table 2 shows the percent of albumin and globulin in colostrum.

Table 2. Percent of Albumin and Globulin in Colostrum (76)

	Time After Calving							
	At Once	6 Hrs.	12 Hrs.	24 Hrs.	30 Hrs.	36 Hrs.	48 Hrs.	72 Hrs.
Albumin & Globulin %	11.34	6.30	2.98	1.48	1.20	1.03	0.99	0.97

Hibbs, et al (39) found there was no significant difference in the composition of colostrum between cows that freshened normally and those which developed milk fever.

The qualitative and quantitative distribution of fatty acids in the fat from colostrum collected during the first four days after parturition closely resembles that customarily found for mature cow milk fat, according to Baldwin, et al (9).

Table 3 shows that there was no essential difference between the amino acid pattern of the first colostrum and that obtained 24 hours postpartum. (23, 72).

Table 3. The Essential Amino Acids in Colostrum and Milk Proteins. Samples from Fifteen Cows, Percent of Total Protein (23).

	Colostrum		Milk	
Amino Acid	0 Hours	24 Hours	60 Days	Terminal
	%	%	%	%
Arginine	4.89	4.82	4.07	3.99
Histidine	2.63	2.76	2.80	2.76
Isoleucine	5.32	5.85	6.69	6.84
Leucine	8.40	8.57	9.58	8.72
Lysine	7.56	7.65	7.89	7.51
Methionine	1.80	1.88	2.18	2.33
Phenylalanine	4.56	4.61	4.71	4.80
Threonine	7.43	7.45	4.66	5.40
Tryptophane	1.76	1.66	1.50	1.36
Valine	8.31	8.17	7.36	7.49

The high protein content of colostrum is due to its high content of globulin. Sutton and Esh (91) found that colostrum globulin is similar but not the same as blood globulin which carries the protective antibodies.

Colostrum is also a potent source of riboflavin (91). Immune globulins are absent in the blood of newborn calves but are present in colostrum and have appeared in the circulation of the newborn as early as three hours after feeding colostrum, according to Smith and Little (85). Smith (83) reported that the principal proteins of milk, casein, and B lactoglobulin or lactalbumin are present only in the mammary secretion, and these proteins are distinct from any known plasma proteins. Casein is the only milk protein which on coagulation forms a curd in the stomach. Espe (27) stated that why milk should be so low in globulin and high in casein is difficult to explain unless it is important physiologically to the calf that a curd mass form in the stomach and act as a reserve food supply until the rumen begins to function.

Parrish, et al (64) reported that the decrease in concentrations of the protein fractions of mammary secretions during the transition period tend to follow a logarithmic curve for the first four to six milkings. In general, the longer the dry period of the cow, the more potent the colostrum, according to Sutton (91). Parrish, et al (64) found that feeding low and high protein rations for the seven weeks previous to parturition does not effect a significant difference in the levels of total protein, of casein, and of albumin-globulin fractions of colostrum and early milk.

A simple turbidity test for serum has been developed. This test was sensitive to the presence of the immune lactoglobulins after ingestion by a newborn calf of 200 ml. of the non-fatty fraction of the colostrum, according to Aschaffenburg (7). Immune lactoglobulins are not present in the blood serum at birth.

It has been observed that levels of vitamin A and carotenoids generally are high in the initial colostral fat. Vitamin A is frequently 10 to 100 times greater than in later milk. And carotene is about seventy times greater (17, 66). They decrease rapidly as the mammary secretions change to normal milk (17, 22, 30, 39, 45, 57, 65, 71, 73, 88, 89, 90, 94, 95).

The vitamin A content of blood plasma of the calf is low at birth, but at the end of twenty-four hours usually shows about a fivefold increase with the intake of colostrum (10, 41, 43, 56, 60, 98). Maximum vitamin A and carotene values are shown at about three days of age, after which there is a gradual decrease (41, 56, 60, 93). Peirce (68) reported that the mean concentration of vitamin A in the blood plasma of lambs increased from 8 ug. per 100 ml. at birth and before nursing to as much as 70 ug. per 100 ml. following nursing. Table 4 shows the effect of colostrum on blood plasma vitamin A, and carotene of calves for the first week.

The intake of colostrum probably gives the calf a chance to build

Table 4. Effect of Colostrum on Blood Plasma Vitamin A, and Carotene of Calves for the First Week (56)

Age (days)	Number of Calves	Vitamin A	Carotene
		ug. / 100 ml.	
0	17	3.3	1.8
1	17	15.6	14.9
2	16	16.8	17.4
3	17	15.9	18.8
4	16	15.0	19.1
5	15	14.4	18.7
6	16	13.2	17.4
7	13	13.8	16.5

up a considerable reserve of vitamin A in the liver. If the calf does not receive the colostrum, that reserve is not built up and may have considerable to do with the health of the calf during the first two months of life before hay is consumed to any great extent.

Cases have been noted by Moore and Berry (56) in which the colostrum was apparently consumed but neither blood plasma vitamin A, nor carotene values showed an increase. These calves died from infection.

Both vitamin A and carotene decrease markedly in the cow blood plasma at the time of parturition and beginning lactation. The maximum decrease in blood plasma carotene is reached one week following parturition and amounts to nearly 50 percent of the three week prepartum level. The maximum decrease in blood plasma vitamin A is reached three days following parturition and is over 50 percent of the prepartum level. The total output of vitamin A and carotene in the colostrum during the first three days postpartum was found by Sutton (94) to average 48,800 mg. of vitamin A and 56,500 mg. of carotene.

When the dam is fed supplemental vitamin A or feeds high in vitamin A before calving, an increase is shown in the blood plasma levels of vitamin A, and there is also a greater liver storage of vitamin A in the calves (24, 60, 91).

The decrease of vitamin A and carotenoid content of colostral fat was rapid during the first eight milkings, both following a similar logarithmic pattern. Tables 5 and 6 show the carotene and vitamin A content of cows' colostrum and milk at successive milkings.

Table 5. The Carotene Content of Cows' Colostrum and Milk at Successive Milkings (95) (ug. / 100 ml.)

Breed	Number of Cows	Successive Milkings 1	2	3	4	5	6	7	8	9	10	20
Ayrshire	6	373	393	172	123	102	058	063	038	042	037	025
Guernsey	8	864	472	260	170	129	102	089	064	067	063	052
Holstein	9	289	173	113	098	085	057	042	042	041	035	030
Jersey	7	335	288	180	185	148	155	093	065	060	052	043
Brown Swiss	5	497	420	209	109	109	087	066	053	041	039	041
All Breeds	35	473	329	182	136	113	090	069	057	052	046	041

Table 6. The Vitamin A Content of Cows' Colostrum and Milk at Successive Milkings (95) (ug. / 100 ml.)

Breed	Number of Cows	Successive Milkings 1	2	3	4	5	6	7	8	9	10	20
Ayrshire	6	182	212	117	098	074	042	048	039	036	038	048
Guernsey	8	279	129	086	055	040	033	032	027	026	027	021
Holstein	9	169	129	075	073	068	049	042	045	045	042	045
Jersey	7	144	136	105	097	097	084	068	044	044	039	052
Brown Swiss	5	348	247	120	098	070	054	044	039	035	027	051
All Breeds	35	240	162	096	079	068	051	046	038	037	035	040

Occasionally, cows parturient for the first time secrete atypical colostrum in which vitamin A and carotenoids are nearly twice as high as normal (17, 34, 38, 65).

There is no marked difference, according to Moore and Berry (56), in Vitamin A content of the blood plasma at comparable ages between breeds of dairy calves, except that the carotene content of the blood plasma of the Jersey and Guernsey is three to four times higher than that of the Holstein.

Butter churned from cream obtained from colostrum produced during the summer contains up to 3,500 I.U. of carotene and vitamin A, 400 I.U. of vitamin D, and 900 I.U. of vitamin E per gram. This butter was used as a vitamin supplement and also to treat digestive disorders (44, 79).

Parrish, et al (65) reported that vitamin A and carotenoids are concentrated primarily in the fat. Thomas, et al (96) found indications that on certain diets plasma vitamin A levels were not a reliable indicator of intake. Calves placed on a diet deficient in carotene and vitamin A showed the blood plasma level increased temporarily--for four to twenty-four days--and remained above levels that existed when on the adequate diet, according to Thomas (96).

The National Research Council (98) stated that healthy calves under one year of age show 6 to 8 mg. inorganic phosphorus per 100 ml. of blood serum.

The plasma phosphate content of the calf at birth is higher than that of the dam. Calves' blood phosphorus increases until about six months, when a decrease sets in and continues until a normal range for mature cattle is reached (4, 42, 55, 61, 71, 100).

Anderson (4) reported that normal dairy calves under one month of age had about 5.20 mg. inorganic phosphorus per 100 ml. blood plasma and 12 to 15 mg. calcium per 100 ml. blood plasma. Samples were taken during the summer, fall, and winter months.

Malan (48) found the inorganic blood phosphorus of nine calves to average 5.2 mg. per 100 ml. at birth. These calves averaged 6.3 mg. at one week, 6.8 at two weeks, 7.2 at three weeks, 6.7 at four weeks, 6.7 at five weeks, 6.8 at six weeks, 6.7 at seven weeks, and 6.6 mg. per 100 ml. of blood at eight weeks.

Johnson (38) investigated twenty-six calves ranging from one to seven months of age and averaging 4.2 months and found that they had 6.42 mg. inorganic phosphorus per 100 ml. with a range of 5.4 to 7.4 mg. per 100 ml. blood plasma.

Frequent and large fluctuations occur from day to day (37, 61). The inorganic blood phosphate in individual cattle may vary considerably from hour to hour, even when the blood is drawn under apparently identical conditions (61).

The ingestion of carbohydrates causes a decrease in blood phosphates (36, 50, 61, 69, 87). Exercise causes marked changes in blood phosphate of cattle (61, 37). Feeding (other than carbohydrates) has a small but significant effect on the inorganic phosphate content.

On an energy basis, colostrum proteins contribute two to three times more to the total nutritive value of colostrum than do the proteins of normal milk. On the other hand, lactose contributed 2.5 to 0.5 times as much to the total energy in milk as it did in colostrum, whereas fat in the milk constituted 10 to 50 percent more of the total energy than it did in colostrum. The ratio of ash to total solids was higher in milk than in colostrum.

Colostrum from the Holsteins and Jerseys, according to Parrish, et al (66) has an energy content of about twice that of normal milk. Colostrum from Ayrshires and Guernseys has an energy content of about 1.5 times that of later milk.

There was an immediate increase in the blood serum gamma globulin of calves following the ingestion of colostrum during the first twenty-four hours of life. If these materials were fed to calves after they had reached twenty-four hours of age, there was no measurable increase in this serum protein, according to Hansen, et al (33). Table 7 shows the effect upon the blood plasma of calves receiving milk or colostrum at varying ages.

Parrish, et al (66) stated that, based on equal weights of dry matter, milk has an energy value either the same as or higher than colostrum. If the calf nurses and, as usual, does not empty the mammary gland, it receives the secretion of lower fat content in a variable quantity, according to Parrish, et al (62).

Apparent absorption of vitamin A at all periods was greater than

Table 7. Effect of Feeding Various Milks Upon the Blood Plasma of New-born Calves (40). Results are Expressed as Grams of Nitrogen in 100 ml. of Blood.

Calf A - Receiving Colostrum	Total Nitrogen	Globulin	Albumin	Non-Prot. Nitrogen
5 hrs. after birth. No colostrum	0.596	0.167	0.376	0.053
Age 11 hr. - 6 hr. after colostrum	0.838	0.505	0.280	0.053
1 day	1.028	0.765	0.210	0.053
2 days	0.962	0.656	0.253	0.053
Calf B - Whole Milk First, Colostrum at 21 Hours				
5 hrs. - nothing	0.605	0.141	0.390	0.074
21 hrs. - 16 hrs. after whole milk	0.633	0.173	0.386	0.074
26 hrs. - 5 hrs. after colostrum	0.632	0.216	0.363	0.053
43 hrs. - 17 hrs. after colostrum	0.668	0.222	0.393	0.053
4 days	0.687	0.312	0.332	0.053
Calf C - Mother Milked Continuously				
At birth	0.595	0.197	0.350	0.048
6 hrs. - No milk	0.625	0.157	0.415	0.053
17 hrs. after nursing	0.647	0.231	0.363	0.053
47 hrs. old, 24 after nursing	0.668	0.183	0.332	0.053
2 days	0.643	0.223	0.367	0.053
3 days	0.611	0.225	0.323	0.053

that of carotenoids. The averages were 80 to 96 percent for vitamin A and 40 to 60 percent for carotenoids, according to Parrish, et al (62). Table 8 shows the apparent coefficients of digestion of colostrum and milk constituents fed to calves.

Table 8. Apparent Coefficients of Digestion of Colostrum and Milk Constituents Fed to Calves (62).

	Days After Calving			
	1 and 2	3 and 4	5 and 10	14 and 18
	%	%	%	%
Protein	93	85	90	93
Ether Extract	97	95	98	97
Carbohydrates	98	97	99	100
Ash	95	97	95	100

According to the literature reviewed, no satisfactory substitute for colostrum has been found.

Mortality is undoubtedly a better measure of the immunizing fractions in colostrum. Feeding colostrum to newborn mammals was found to decrease enormously mortality (14, 76). The death rate is extremely high among animals which do not receive colostrum; this indicated that it is essential for newborn calves to receive colostrum (8, 14, 26, 40, 70, 84, 85, 103).

Although Howe (40) in 1921 stated that the most common explanation of the value of colostrum is that it acts as a purgative, Ehrlich (26) in 1892 found that newborn mammals can directly absorb the immune bodies from colostrum.

Colostrum serves the special function of increasing the resistance of newborn calves to infectious disease (8, 14, 70, 76, 84). Smith (83) has shown this by the high concentration of immune lactoglobulins in the colostrum which are absent in newborn calves (40, 70, 85) but which have appeared in the circulation as early as three hours after feeding colostrum. These lactoglobulins pass from the intestinal tract of the calf to its blood stream, where they may persist for many months (84, 85). The immune lactoglobulins of bovine milk and colostrum have been isolated and compared with respect to their physical and chemical properties. Ragsdale and Brody (70) reported that globulins and immune bodies pass into the blood of newborn calves unchanged in the alimentary canal.

Smith (84) stated that intestinal infections are among the major causes of death among newborn calves. It is against these infections that colostrum gives protection.

The serum of a newborn calf does not possess any gamma globulin, and this appears only after the ingestion of colostrum (36, 79). Colostral immune globulin is different from colostral gamma globulin. The protein which appears in the blood stream of the calf after ingestion of colostrum possesses the electrophoretic mobility of the immune lactoglobulin and not that of gamma globulin. Smith (84) reported that in a calf fed colostrum only during the first day of its life, the immune component at twenty days had decreased to about one-half its initial concentration and persisted there for many months. This calf showed a large amount of colostral globulin after two days, which thereafter decreased steadily. Calves fed two pounds of the non-fatty fraction of colostrum followed by the standard diet based on dried skim milk grew normally, according to Aschaffenburg, et al (6).

When calves are fed colostrum during the first twenty-four hours of life, an immediate increase in the blood serum globulins occurs, but after they reach twenty-four hours of age, no measurable increase in the serum protein was observed by Hansen, et al (33).

Calves have been raised without colostrum, using as a substitute skim milk with 25,000 I.U. vitamin A supplemented with ascorbic and nicotinic acid. (33, 35). Table 9 shows that this amount of vitamin A produced blood levels similar to the colostrum fed calves (35, 40).

Table 9. Calves Raised on A Colostrum Substitute (35)

Treatment	1	2	3	4	5	6
	10,000 I.U. Vit. A		25,000 I.U. Vit. A			Colostrum and Whole Milk
	Vit. A Only	Nicotinic Acid	Vit. A Only	Nicotinic Acid	Nicotinic Acid & Biotin	
Number of calves	3	6	13	16	7	4
Blood Plasma vit. A Concentrate ug/100 ml.						
Birth	2	5	4	4	—	4
1-2 Days	4.5	6	9	10	—	10
6-14 Days	—	12	11	11	—	10
No. cases diarrhea	3	5	9	11	5	—
No. cases given sulfathiazole	3	5	7	9	4	
No. cases survived	1	3	9	12	6	4
Percent Survival	33	50	69	75	86	100

Aschaffenburg (5) reported that calves receiving only reconstituted colostral powder failed to grow satisfactorily and many of them died.

Gamble, et al (31) had partial success from feeding blood serum from animals of the same species. Blood serum contains antibodies similar to those found in colostrum and gives a passive resistance to disease.

In calves without access to colostrum, the various blood serum fractions do not approach normal values until about eight weeks of age, according to Hansen (33).

Bustad, et al (14) removed pigs from the mother at birth and placed them on a synthetic milk diet containing all the known vitamins with plasma or serum as colostrum. None survived longer than twenty-two days. A severe diarrhea developed in all the pigs, however. Maintaining extremely sanitary conditions made it possible to raise 82.25

percent of the pigs born in a control laboratory without any colostrum, according to Young, et al (103). This, substantiated by the raising of human babies without colostrum, indicates the major function of colostrum is to give a resistance to disease and that to raise young mammals without colostrum, extremely sanitary conditions are necessary.

The average pH of first colostrum from fifty-seven cows was 6.28 with a range of 6.00 to 6.61. The pH of the early postpartum mammary secretion from twenty cows was found by McIntyre, et al (54) to increase gradually from an average of 6.32 in the first colostrum to 6.50 in the milk produced fourteen days after calving.

Pasteurization does not change the properties of colostrum to any appreciable extent, according to Ragsdale and Brody (70). However, it is advisable to pasteurize at a low temperature, since proteins coagulate at high temperatures.

Laskowski, et al (46) discovered the presence of large amounts of trypsin inhibitor in bovine colostrum. This offers an explanation for the mechanism of transmission of the immune globulins from the colostrum to the blood. Howe (40) stated that it explains how the immune globulins can escape proteolytic digestion, particularly if one takes into account the low gastric acidity in the stomach of the newborn and consequently the impaired peptic digestion.

In comparing the tocopherol concentration of the first mammary secretion with that of the eighth day, it was found that for cows receiving no supplemental tocopherols, the average level of these substances was seven times higher in the first lactation than in the later. Decreases in concentrations were logarithmic for the first four days (63, 93).

Colostrum stored in a frozen condition is entirely satisfactory as a substitute for marketable milk for feeding calves during any part of the milk feeding period, according to Allen, et al (2).

Crawford (16) stated that hydrogen peroxide, when added to milk, will prevent spoilage for an extended time (16). "Winger Process" milk is preserved for human consumption by adding hydrogen peroxide (67). Milk with the addition of 0.1 to 0.15 percent hydrogen peroxide kept three to four times as long as milk which was pasteurized one-half hour at 70° C. The same milk without hydrogen peroxide spoiled regularly in twenty-four to forty-eight hours, according to Mueller (58). Hydrogen peroxide must be of high purity, of 30 percent concentration, stable and free from lead, arsenic, or any other heavy metals. Add 0.2 percent of hydrogen peroxide by weight to the milk and stir thoroughly (28).

Mainardi (47) stated that milk centrifuged and preserved with hydrogen peroxide constitutes a practical and economical method for preserving milk. Feeding experiments demonstrate that calves fed with hydrogen peroxide preserved milk show normal increases in weight.

Much attention has been given to keeping the colostrum in a sweet condition until fed, but sour milk which is somewhat comparable to colostrum has been fed with good results (21, 49, 77, 78). If the colostrum could be fed within seven to ten days, there is little need to keep it sweet. Sweet cows' milk is capable of neutralizing to a great extent the acid of the gastric juice, and in this way seriously impairing normal digestive functions (49, 51, 52, 53, 77, 78, 81). Souring of the milk does not affect the nutritive value of the milk to any extent (97). Fermented milks are considered to be of some therapeutic value in special diets, and they do have increased digestibility, according to a statement by the National Dairy Council (59).

Dann (21) found that soft curd milk, buttermilk and evaporated milk travel farther more rapidly and disappear more quickly in the intestines than does hard curd milk. Curd tension has received much attention as an important factor in feeding calves. There are several ways of reducing curd tension, such as adding water (101), boiling (13), and acidifying (20).

Weight gains of calves fed colostrum continuously closely paralleled those of whole milk calves (41, 86), when the amount of colostrum fed was based on its dry matter content.

Comparing continuous colostrum feeding with conventional feeding caused a greater incidence of scours among the calves in the colostrum group. The feces were abnormally soft for a longer period than were those in the whole milk group. Apparently the extra antibodies of immunizing fractions which are contained in colostrum did not prevent scours, but the mortality was less. Jacobson, et al (41) reported on one trial that five out of twenty-six calves on whole milk died, while no colostrum-fed calves died.

Undiluted colostrum has been fed continuously for nine weeks with good results. Calves getting colostrum made a pound gain on 8.5 pounds of colostrum, whereas those fed a conventional way required 10.6 pounds of milk for one pound of gain. Calves fed colostrum by Smith (86) appeared sleek and typical of whole milk calves. The rate of gain was essentially the same.

Extending the colostrum feeding period to ten or fifteen days has produced calves with more vitality than those fed colostrum the usual three day period (1, 93).

At the Ohio Experiment Station, the general herd of calves is being fed colostrum as it is produced, according to Sutton and Kaeser (93). When colostrum is not available, the herd is fed whole Holstein milk without digestive disturbances. However, where it is available, its inclusion in the diet to the point of 100 percent of the feed caused no digestive disturbances, even when of very high test value.

In weight gains, Kaeser (43) reports 1.76 pound daily for calves fed colostrum under this method, as compared to 1.58 for calves fed the usual way. Calves will not scour from colostrum (43).

Wise, <u>et al</u> (102) reported that reconstituted skim milk may serve as a liquid with which to dilute colostrum on a half and half basis. This mixture may be interchanged abruptly with some slight physiological upsets. This mixture is slightly laxative, but not to the extent of being objectionable. This is a good substitute to use during the whole milk period. Using this system, a cow's colostrum will last twenty to twenty-five days for her calf, after which skim milk or other milk substitutes may be successfully used.

EXPERIMENTAL PROCEDURE

Thirty-six dairy calves from birth to twenty-four hours of age were divided into three groups. Each group consisted of six bull and six heifer calves and were fed for an eighty day experimental period. These groups were subdivided into females and males. Group I females were designated by I-F, Group I males by I-M, Group II females by II-F, Group II males by II-M, Group III females by III-F, and Group III males by III-M.

The calves were designated for a group by placing consecutive numbers on them in the order of their arrival and applying these to a table of random numbers (19).

Each four consecutive days were called sections. The first four sections were grouped together and formed a complete cycle. One cycle consisted of four sections each of four days in length or a total of sixteen days. The feeding methods were identical for each of the cycles.

Group I was fed alternately colostrum and fresh Holstein whole milk as indicated in Table 10 to determine the feasibility of feeding fresh colostrum when available.

Group II was fed alternately fresh whole Holstein milk from one cow for a four-day period, followed by fresh whole Holstein milk from another cow for three consecutive four-day periods to determine the effect of changing from one cow's milk to that of another. Table 11 shows the relationship of the period, days, and the feeding schedule.

Table 10. Group I Feeding Schedule by Period, Days, and Type of Milk Fed.

Period			
Cycle -	Section	Days	Feed
1	A	1 - 4	Dam's Colostrum
	B	5 - 8	Holstein Whole Milk
	C	9 - 12	Holstein Whole Milk
	D	13 - 16	Holstein Whole Milk
2	A	17 - 20	Colostrum
	B	21 - 24	Holstein Whole Milk
	C	25 - 28	Holstein Whole Milk
	D	29 - 32	Holstein Whole Milk
3	A	33 - 36	Colostrum
	B	37 - 40	Holstein Whole Milk
	C	41 - 44	Holstein Whole Milk
	D	45 - 48	Holstein Whole Milk
4	A	49 - 52	Colostrum
	B	53 - 56	Holstein Whole Milk
	C	57 - 60	Holstein Whole Milk
	D	61 - 64	Holstein Whole Milk
5	A	65 - 68	Colostrum
	B	69 - 72	Holstein Whole Milk
	C	73 - 76	Holstein Whole Milk
	D	77 - 80	Holstein Whole Milk

Table 11. Group II Feeding Schedule by Period, Days, and Type of Milk Fed.

Period Cycle	Period Section	Days	Feed
1	A	1 - 4	Dam's Colostrum
	B	5 - 8	Holstein Whole Milk Cow #1
	C	9 - 12	Holstein Whole Milk Cow #1
	D	13 - 16	Holstein Whole Milk Cow #1
2	A	17 - 20	Holstein Whole Milk Cow #2
	B	21 - 24	Holstein Whole Milk Cow #1
	C	25 - 28	Holstein Whole Milk Cow #1
	D	29 - 32	Holstein Whole Milk Cow #1
3	A	33 - 36	Holstein Whole Milk Cow #3
	B	37 - 40	Holstein Whole Milk Cow #1
	C	41 - 44	Holstein Whole Milk Cow #1
	D	45 - 48	Holstein Whole Milk Cow #1
4	A	49 - 52	Holstein Whole Milk Cow #4
	B	53 - 56	Holstein Whole Milk Cow #1
	C	57 - 60	Holstein Whole Milk Cow #1
	D	61 - 64	Holstein Whole Milk Cow #1
5	A	65 - 68	Holstein Whole Milk Cow #5
	B	69 - 72	Holstein Whole Milk Cow #1
	C	73 - 76	Holstein Whole Milk Cow #1
	D	77 - 80	Holstein Whole Milk Cow #1

Group III was the check group and was fed a conventional method of feeding under similar conditions. It was fed colostrum for four days, and whole Holstein milk from one cow for the remainder of the experimental period. Table 12 shows the relationship of the period, days, and the feeding schedule.

The calves were fed milk or colostrum that had been carefully warmed to 98° F at 5 a.m. and 5 p.m. They were fed milk or colostrum in open pails.

Grain, followed by hay, was fed immediately after the milk was

Table 12. Group III Feeding Schedule by Period, Days, and Type of Milk Fed.

Period Cycle	- Section	Days	Feed
1	A	1 - 4	Dam's Colostrum
	B	5 - 8	Holstein Whole Milk Cow #1
	C	9 - 12	Holstein Whole Milk Cow #1
	D	13 - 16	Holstein Whole Milk Cow #1
2	A	17 - 20	Holstein Whole Milk Cow #1
	B	21 - 24	Holstein Whole Milk Cow #1
	C	25 - 28	Holstein Whole Milk Cow #1
	D	29 - 32	Holstein Whole Milk Cow #1
3	A	33 - 36	Holstein Whole Milk Cow #1
	B	37 - 40	Holstein Whole Milk Cow #1
	C	41 - 44	Holstein Whole Milk Cow #1
	D	45 - 48	Holstein Whole Milk Cow #1
4	A	49 - 52	Holstein Whole Milk Cow #1
	B	53 - 56	Holstein Whole Milk Cow #1
	C	57 - 60	Holstein Whole Milk Cow #1
	D	61 - 64	Holstein Whole Milk Cow #1
5	A	65 - 68	Holstein Whole Milk Cow #1
	B	69 - 72	Holstein Whole Milk Cow #1
	C	73 - 76	Holstein Whole Milk Cow #1
	D	77 - 80	Holstein Whole Milk Cow #1

consumed. All feeds were weighed carefully. The unconsumed hay was weighed at the end of every day.

Much care was exercised that the calves not receive any feed other than the regular milk, hay, and grain that had been carefully weighed for each individual calf.

The calves had fresh water available at all times except when they were tied for their regular feedings. The calves were turned loose for exercise each day except for a two or three hour period after feeding.

Only clean dry straw was used for bedding. The stalls were carefully cleaned once a day, and when they were tied the manure was cleaned from under them and replaced with clean straw as necessary.

The barn was fairly well lighted and ventilated. It was also used for maternity cases and other cows when it was desirable to keep them in, which created a few drafts when doors were opened for the cows to enter and leave. However, these cows helped to provide warmth in the barn which had no other source of heat.

When spring came, the calves were turned out afternoons for exercise onto a dry lot.

The first calves were started on experiment December 25, 1951. Some of these calves scoured. In an attempt to keep them away from drafts, they were placed in a different part of the barn which happened to have a wooden floor but which was near a good source of heat. While several calves were in this location, one died of an unknown cause on January 12, 1952 at six days of age and another died of white scours on January 15, 1952 at eight days of age. Since this area had a wooden floor and was impossible to disinfect satisfactorily, the calves were again moved. The healthy calves were moved back into the regular calf barn, and the sick ones were moved when they became healthy.

All calves born after January 19, 1952, were placed in a large stall and isolated as well as possible for about two weeks before they were moved to the general calf barn. Four calves were started in each large stall, one tied in each corner. This large stall was thoroughly scrubbed with lye water before and after each group of calves. A serious attempt was made not to contaminate the calves in this stall or these calves with others. A pan of lye water was placed in the doorway to help prevent carrying contamination on a person's boots from one pen to another.

About the time this method of starting the calves was working satisfactorily, a high rate of general scouring appeared in the main calf herd. This was controlled when the calves were fed only three to three and one-half pounds of milk twice a day, although several of the calves weighed over 100 pounds and should have been getting over five pounds of milk twice a day.

The entire calf barn was thoroughly scrubbed with lye water, and on February 24, 1952, the calves were moved into these cleaned stalls. Four days after this, there were less calves scouring than had been for several days, and on the tenth day there was a definite decrease in the incidence of scours among the calf herd (Table 60).

The last week in April, the incidence of scours rose very sharply, until, on May 2, 1952, one calf became ill with white scours. This calf was saved, although it was not used on the experiment. The next day the entire calf barn was scrubbed with lye water, and again it produced very significant lowering of the incidence of scours.

One calf died January 18, 1952, at eight days of age from a navel infection. Another was lost January 28, 1952, at 35 days of age due to strangling. One died from an unknown cause on March 6, 1952, at 37 days of age. Pneumonia caused the death of a calf 13 days old on June 15, 1952. It did not appear to be ill and was apparently breathing and eating normally a few hours before death.

A total of forty-four calves were started. Six were lost, and thirty-eight were raised. Thirty-six were used on the experiment, and the other two were raised, partly in accordance with the above agreement and partly to be used for records in the event that other calves died.

The colostrum was stored in covered paper containers placed in a cold storage compartment where a temperature of -15° F was maintained. Twelve hours before feeding, it was removed from the freezer and kept at room temperature until feeding time; the milk was then rapidly warmed to 98° F and fed at this temperature. It was fed in chronological order, i.e., milk produced the first day after calving was fed the first day in the colostrum feeding period, the second day's production fed the second day, etc.

The colostrum for the first day after freshening was mixed together and saved as first day milk. The same procedure was used for the second day, the third, and the fourth day milk.

The daily colostrum production for each cow was well mixed and a sample taken for analysis. Each sample was analyzed for carotene, vitamin A, fat, protein, ether extract, ash, moisture, phosphorous, and calcium. The vitamin A and carotene determinations were made following the procedure explained by Boyer, et al (11).

The calves were seldom fed more than eight pounds of milk per day, although many of them attained a final weight of 180 pounds or more. All of the calves were Holsteins, and the initial weights seldom were less than 90 or more than 100 pounds. With this uniform group of calves most of them were fed five to six pounds of milk daily for the first five to ten days. Most calves were getting eight pounds per day before the end of the first cycle or at sixteen days of age. It has been previously explained that most of the calves would scour when fed at the rate of one pound of milk for ten pounds of body weight. However, these calves maintained satisfactory health and growth rates when fed a smaller quantity of milk. After this tendency to scour was discovered, no calves were fed more than eight pounds of milk per day.

The following grain mixture was fed for the duration of the experiment:

Rolled Oats	40 pounds
Rolled Barley	30 pounds
Wheat Bran	20 pounds
Linseed Oil Meal	10 pounds
Salt	1 pound
Steam Bone Meal	1 pound

After receiving their milk, the calves were immediately fed in individual feed boxes all the grain they would eat in a few minutes. They were not fed grain until they were 20 days of age.

A small representative sample was taken from several parts of each batch of feed mixed and was kept together until the final batch had been sampled. This was thoroughly mixed by rolling a portion