Nutrient Needs of the Pre-Ruminant Calf

J. T. Huber, *D.V.M.*
Department of Dairy Science
Michigan State University
East Lansing, Michigan 48824

First Feed Must Be First Colostrum

Perhaps the most important nutrient to maintain the life of a calf is the first colostrum. The passive immunity imparted to the calf through colostral immunoglobulins (Ig) are absolutely necessary for survival. It is imperative that colostrum enter the digestive tract before any other material. Calves born in loose housing on wet, unsanitary bedding (or in the muck) are infected with pathogenic organisms before colostrum is ingested. There is evidence to suggest that prior consumption of any material will markedly decrease the efficiency of immunoglobulin absorption into the blood. In one study we compared conditions in high and low mortality herds, the factor most closely related to death loss in calves was moisture content of the bedding with a correlation of .72. Of the high mortality herds, 12 of 16 were calving their cows in group pens, while all 13 low mortality herds were calving in box stalls. As noted in Table 1, death loss in calves was about four-fold higher for the "group pen" calvings than "box stalls" where the bedding was much drier and sanitation superior.

Feed at Least 4 lbs. Colostrum by 12 Hours, But Don't Stop

Between birth and 24 hrs. of age the circulating blood of a baby calf should increase in Ig content from 0 to 60 g (1.5 g/100 ml). Thereafter, little or no increase is noted. To achieve this Ig level, the calf must be fed at least four lbs. of undiluted colostrum by 12 hrs. First colostrum will contain 10 to 12% Ig, so four lbs. would furnish 200 g Ig. Efficiency of absorption of Ig has been shown to be about 25%. In one study we noted a 50% rise in Ig between 12 and 24 hrs. After 24 hrs., the intestinal epithelium becomes impermeable to Ig. Also, the intestinal proteases start to digest the Ig compounds with greater efficiency making them ineffectual as antibodies.

Table 1

Mortality as Related by Where Calves are Born and Wetness of Bedding (Ferris and Thomas, 1974)

	Calving Area	
	Box Stalls	Group Pens
Death loss (%)[1]	8	27
Bedding moisture (%)	33	65

Colostrum Production and Preservation

Immunoglobulin content of colostrum falls rapidly after the first milking, but the next five milkings (which are unsaleable) are higher than normal milk in solids, protein, fat, vitamins and minerals which are all nutritionally important to the baby calf. The large dose of vitamin A, B_{12} and iron obtained from colostrum are particularly beneficial because they will sustain the calf over periods when normal feeds are low. Management of the colostrum supply so it provides most of all of the liquid feed herd replacements receive until weaning is a sound practice for reducing mortality and raising healthier calves at a lower cost.

Production: The question has arisen as to how much colostrum is actually available to the dairymen. In a recent study we conducted at MSU, colostrum from the first six milkings was collected from 18 first-calf heifers and 18 cows. Overall production averaged 82 lbs.; the heifers gave 72 and the cows 92 lbs. (Table 2). Highest yield for a heifer was 99 lbs. and for a cow was 123 lbs. The solids content of the composited colostrum averaged 18%, the fat 5%, and the protein 7%. Dilution of two parts colostrum to one part of water would make the solids similar to whole milk and yield 50% more liquid for feeding. Hence, a cow giving 100 lbs. of colostrum would yield 150 lbs. of milk equivalent; a sufficient amount to feed her calf (seven-eight lbs./day) for three weeks. For a dairyman who keeps only his heifers, the feeding period could extend to five-six weeks.

Preservation: The preferred method of preserving colostrum is by freezing. Purchase of a used 15-18 cu. ft. freezer for storage of the colostrum supply in gallon containers which can be thawed before feeding is a reasonable and economical system. A second mode of preservation which has received considerable atten-

Table 2

Colostrum Production* and Composition (Plog, Huber and Oxender, 1974)

	Colostrum	Solids	Protein	Fat
Cows (lb.)	93	16.4	5.9	4.6
(%)	---	17.7	6.3	5.0
Heifers (lb.)	72	13.3	5.6	3.6
(%)	---	18.7	7.9	5.0

*6 milkings average from 18 cows and 18 heifers.

tion recently is fermentation. This system has been successfully used in controlled studies and in the field. Many calf programs have been completely turned around from disaster to success by initiation of feeding fermented colostrum. Compared to freezing colostrum, fermenting does not require the cost of acquiring and operating a freezer; nor is the demand for labor and prior planning as great in order to keep sufficient frozen colostrum thawed and ready to feed when needed.

However, several precautions should be taken in the fermenting of colostrum. These are: 1) Milk cows under sanitary conditions. Pathogenic organisms invading the ferment could be disastrous to the fermentation and to calves fed the material; 2) Don't ferment colostrum from cows treated with mastitis. The reason for this is obvious; there won't be a fermentation, probably just putrefaction; 3) Mix the colostrum from several milkings from a number of cows so as to maintain a constant composition. Large variations from feeding to feeding in the solids content of colostrum can cause digestive disturbances in calves; 4) Stir the ferment before feeding and when adding colostrum to it. The clotted material will rise to the top and feeding this material could lead to calf digestive upsets; 5) Keep in a covered container at about room temperature (40-70°F) in both the summer and winter. Cooler temperatures will freeze and higher temperatures will result in an unstable fermentation; 6) Dilute with water before feeding because the 18% solids of colostrum will tend to scour baby calves. Mixing two parts of colostrum to one part of water approximates the solids content of whole milk; 7) Don't feed fermented colostrum from the same container for over four weeks. The protein will break down (Figure 1), mold contamination is greater and calf performance is poorer.

Calf Performance on Colostrum

Recently, there have been several research studies comparing colostrum to milk or milk replacers for baby calves. Table 3 lists growth data from several of these studies where equal solids were fed on the different liquid systems. In two comparisons calves on fermented colostrum gained twice to three-times as fast as those on milk replacer. Whole milk outperformed fermented but not frozen colostrum one trial; whereas, fermented and frozen were equal in a second study. Basically the results show that feeding colostrum (either frozen or fermented) to weaning was equal to whole milk and superior to milk replacers in starting baby calves.

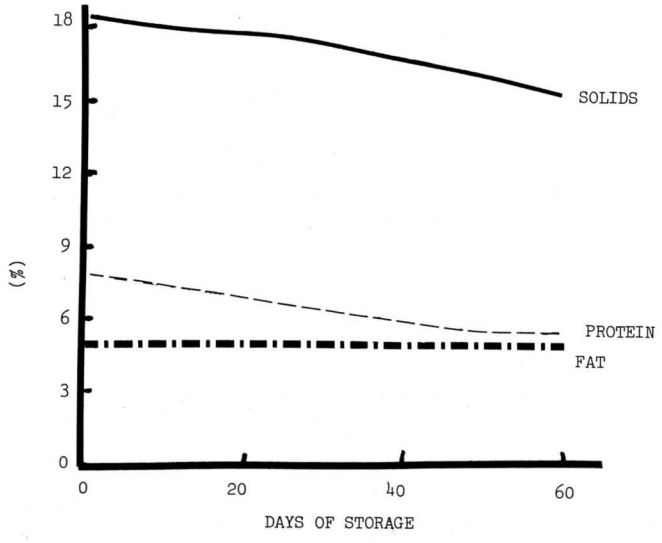

Figure 1. Change in composition of fermented colostrum during storage.

In addition to good growth from colostrum feeding, we have observed very low mortality rates in our calves. In two studies at Michigan State, there were no death losses in 56 calves fed colostrum for three or four weeks after birth compared to normal mortality in our calf barn of about 10%. A possible reason for the decreased mortality of calves on the colostrum system is the bathing of the intestinal cells with colostral antibodies resulting in a local defense against infections. Such an effect has been indicated in swine but needs further study in the bovine.

Perhaps the most compelling reason for the dairymen to wean calves on colostrum is the savings in feed costs (Table 4). At current prices, the cost of milk or milk replacer needed to feed calves to four weeks are about $22 and $11, respectively. While there is no direct charge for the colostrum, there is obviously an expense for storage. This varies with different farms but should not amount to over $1 to $2 per hundredweight. If managed right, labor required for feeding colostrum shouldn't be much more than for feeding milk replacer.

In summary, benefits from weaning calves on colostrum are: 1) savings in feed cost; 2) decreased calf mortality; 3) defense against local infections in the digestive tract; 4) superior calf performance.

General Nutrient Requirements For Pre-Ruminant Calves

Dr. LaVerne Schugel very aptly presented the nutritional needs of the pre-ruminant calf in the 1973 Conference Proceedings, so I will briefly summarize suggested allowances.

Table 5 shows recommended digestible energy (DE) and digestible protein (DP) allowances for non-ruminating calves and the suggested protein to calorie (mg DP/Kcal DE) ratio. Remember that milk replacer contains about 2000 Kcal/lbs. and whole milk 350. Diluted colostrum is about equal to whole milk. The recommended protein: calorie ratio for liquid rations is 30-40. Most veal milk replacers (20% or more fat) are in this range, but those of around 10% fat probably are wasting protein for the amount of energy furnished. For herd replacements and dairy beef, it might be desirable to feed the higher fat replacer considering the little difference in cost of the 10 and 20% fat products.

Table 6 presents the suggested mineral allowances for young calves. Note that milk products are low in

Table 3

Calf Gains on Colostrum Feeding Trials

Research Station	Calves/ Treatment	Whole Milk	Milk Replacer	Fermented Colostrum	Frozen Colostrum
				-----lb/day-----	
Nebraska (21 days)[1]	40	.56	---	---	.62
Michigan (28 days)	8	.46	---	.25	.62
Minnesota (28 days)	18	---	.22	.46	---
Purdue (40 days)	10	---	.30	.92	---
Kansas (35 days)	9	---	---	.93	.87

[1]Number in parenthesis represents the length of the feeding period to weaning.

Table 4

Comparative Costs of Liquid Feeds for Baby Calves (to 28 Days)

Milk replacer	-	30 lb. x $.36	=	$10.80
Whole milk	-	250 lb. x $.09	=	$22.50
Colostrum	-	163 lb. x $.01[1]	=	$ 1.63

[1]Cost of storage.

Table 5

Digestible Energy and Protein Allowances for Nonruminating Calves

	Maintenance (50 kg B.W.)	Maintenance + Gain of: .5 kg	1.0 kg
Dig. energy (kcal)	2300	4000	5700
Dig. protein (g)	31	113	195
Protein:Energy (mg/Kcal)		28.3	34.2

Table 6

Suggested Mineral Allowances for Young Calves

Macrominerals	(%)	Microminerals	(ppm)
Calcium	.40	Iodine	.6
Phosphorus	.30	Manganese	15.0*
Potassium	.70	Copper	6.0
Magnesium	.20*	Cobalt	0.1
Salt	.30	Zinc	25.0
Sulphur	.15	Iron	100.0*
		Selenium	0.1

*Deficient in milk products.

magnesium, manganese and iron, but for herd replacements on early weaning systems which consume starter after several days of age, no special supplementation would be needed for the liquid ration. Veal calves present a different problem, but are not supplemented with Fe because it darkens the meat.

Recommended vitamin allowances are given in Table 7. As noted, milk products are deficient or low in all the vitamins except Riboflavin. Again, calves fed starter early will consume sufficient in their dry feed, but veal rations should be supplemented in practically all the vitamins.

Table 7

Suggested Vitamin Allowances for Young Calves (Per 100 lb. B.W.)

	Fat Soluble
A	2000 IU*
D	500 IU*
E	20 mg*
	Water Soluble
Thiamine	4.0 mg*
Riboflavin	2.0 mg
Niacin	13.0 mg+
Pyridoxine	3.0 mg+
Biotin	.2 mg+
Pantothintic acid	10.0 mg
Choline	1200 mg+
Folic Acid	0.6 mg+
B_{12}	40 ug*

*Deficient in milk products. + Borderline in milk products.

Table 8

Ingredient Composition of a Typical Calf Starter for Dairy Calves

Ingredient	% of Total
Ground shelled corn	38
Crimped oats	24
Soybean meal (50%)	15
Linseed meal	12
Liquid molasses	8
Dicalcium phosphate	1
Trace mineralized salt[1]	1
Vitamin A, D, E mix[2]	1

[1]Contains (in %): 0.50 manganese; 0.30 zinc; 0.22 iron; .04 copper; .01 iodine; .01 cobalt.
[2]Contains 100,000 IU/lb. of vitamins A and D_3 and 2000 IU/lb. of alpha tocopheryl acetate (vitamin E).

Limit Feed Milk to Encourage Starter Consumption

Approximately one gallon daily of milk, milk replacer or colostrum for the first three to six weeks is sufficient for most calves. Feeding too much liquid is usually more of a problem than feeding too little. The calf's appetite increases as it grows, but the amount of liquid ration should not be increased in order to promote starter and hay consumption and encourage early rumen development. The earlier a calf begins to consume dry feed in preparation for weaning, the lower the feed costs and the healthier the calves.

Table 9

Approximate Feed Requirements for Holstein Heifers on Alfalfa Hay or Corn Silage[1]
(Partially Adapted from Hillman, et al., MSU Ext. Bull. 412, "Raising Calves," Nov. 1971)

Months of Age	Milk	Grain	Hay Systems	Corn Silage Systems[2]
	lb.	lb.	lb.	lb.
1 and 2	300	80	45	---
3 and 4	0	190	200	---
5 and 6	0	180	425	995
7 and 8			600	1400
9 and 10			880	2060
11 and 12			1050	2460
Total to 1 year	300	450	3200	6915
13 and 14	0		1180	2760
15 and 16			1280	3000
17 and 18			1400	3275
19 and 20			1500	3500
21 and 22			1590	3700
23 and 24		300	1350	3160
Total 1 to 2 years		300	8300	19395
Total: Birth to 2 years	300	750	11500	26310

[1]Clean, fresh water should be available at all times.
[2]Assume corn silage of 33% dry matter supplemented with soybean meal or NPN (urea or ammonia) to contain at least 13.5% crude protein. Feed according to hay system up to 4 months. Corn silage fed heifers do not need grain during 5 to 6 months. Supplement corn silage with protein, dicalcium phosphate and trace mineralized salt.

Because milk is shunted past the rumen directly into the true stomach (abomasum) via the esophageal groove, no amount of milk (or liquid replacer) fed to calves will stimulate rumen function. Dry feed which passes directly into the rumen is necessary for establishment of the rumen microbial population and growth of the rumen papillae and musculature. Concentrates are more effective than hay in encouraging rumen development so the calf should be coaxed to consume starter very early in life.

When To Wean

If a calf is eating 1 to 1½ lbs. starter daily, it is ready to wean from the liquid ration regardless of age. Some calves are ready to wean at three weeks, but this varies greatly with individual calves and the palatability of starter. However, don't risk loss of the calf by forced weaning when it is not ready, because benefits that might be derived from early weaning would be rapidly erased if increased mortality resulted.

We recommend that the dairymen begin feeding starter and high quality hay at two to three days of age. Don't be alarmed if the calf won't eat much hay during the first six weeks of life, but consumption will rapidly increase thereafter.

When milk is withdrawn, the calf will bawl and appear upset for the first few days and may not gain weight during the first week after weaning but grain consumption will rise sharply from the 1 to 1½ lbs. the calf is consuming when weaned to three to four lbs. and the calf will rapidly complete its transition to a ruminant.

Characteristics of Good Calf Starter

Remember that the key to early weaning and money savings is early consumption of calf starter. Palatability is very important for a starter. The calf should like the taste so it will commence eating at an early age. Several considerations for preparing a palatable starter are: 1) Make it chewy. At least one-half of the grain should be in the cracked or rolled form; 2) Add molasses (7-10%). The calf likes a sweet-tasting feed; 3) A variety of ingredients sometimes aids palatability. Variety is more important in a calf starter than in a milking cow ration; 4) Pelleting is another method which may be used for increasing palatability; particularly if ingredients to be used are finely ground.

A good starter should be high in energy and low in fiber. The starter must support life when the calf goes off milk so it needs to have quite a high energy concentration. Concentrates are also best to support growth of the rumen tissue. The idea that hay is needed for good rumen development just isn't true. Table 8 lists a typical calf starter. Starters with steamed grains or pelleted components may encourage early consumption by calves and are worth more than those of just meal form.

The crude protein content of starters should be about 18%. Younger animals have a higher protein requirement than older ones. A switch to the herd ration can be made after three months. Don't use urea in the starter for calves before they are three months old. After three months the rumen is well enough developed for calves to handle urea.

The starter should contain vitamins A, D (about 1000 IU/lbs. of each) and E (20 IU/lbs.), in addition to supplemental calcium, phosphorus and trace-mineralized salt.

Feeding Heifers From Three Months to Calving

Heifers can grow at an adequate rate on high quality forage, but grain is needed if forage is poor or below average. Some liberties can be taken to use low quality feeds in feeding heifers from about 4 to 24 months. However, don't stunt skeletal and muscle growth. Moreover, the low quality ingredients should be fed for only limited periods to use them up and not included in heifer rations as routine practice. For a heifer to reach breeding size (800 lbs. for Holsteins) by 14 months, it must gain about 1.7 lbs./day from birth; so that poor quality feeds cannot comprise the major portion of the overall ration.

Feeding large amounts of grain to growing heifers (so they become fat) is both uneconomical and damaging to their lifetime productivity. Experiments and several research stations have demonstrated lower lifetime milk production and poorer longevity of heifers fed very high energy levels early in life. In addition to decreased milk yields, poorer conception rates and more calving problems have been associated with fat heifers.

Good heifer growth on corn silage systems (silage plus protein and minerals) has been shown. Silage treated with non-protein nitrogen (urea or ammonia solutions) have also produced good growth. In corn-growing areas feed costs for raising heifers using a maximum of NPN-treated corn silage are lower than the conventional hay-grain system. Table 9 gives the approximate amounts of feed consumed by a dairy replacement heifer raised on a hay or a corn silage regime. Perhaps the most desirable system is a combination of hay and corn silage.

Summary

1. **Feed at least four lbs. of the first colostrum to the calf by 12 hrs.**
2. **Colostrum must be the first material to enter the digestive tract.**
3. **Best calf growth resulted from feeding colostrum till weaning.**
4. **Saving in feed cost compared to whole milk is $20/calf.**
5. **Frozen colostrum appears superior to fermented.**
6. **Bathing the intestine with colostral antibodies gives defense against local infections.**
7. **A protein: energy ratio of 30-40:1 is best. Milk replacers with 20% protein and 20% fat achieve this.**
8. **Certain vitamins and minerals should be added to milk rations fed for long periods.**
9. **Use starter consumption and not age as criterion for weaning calves.**
10. **Starter should be palatable and high enough in energy and protein to keep the calf growing when weaned from liquid.**
11. **Keep heifers growing at 1.6 to 1.8 lbs./day. Don't overfatten. Have them large enough to breed (700-800 lbs.) by 14 months.**

Milk Replacers for Pre-Ruminant Calves, Formulations, Problems, Economics

LaVerne Schugel, *D.V.M.*
President, Royal Milk, Inc.,
2850 Metro Drive
Minneapolis, Minnesota 55420

When marketing calf milk replacers, there are three prime concerns, (1) must meet the nutritional requirements of the calf, (2) must be more economical than whole milk, (3) must have physical characteristics that make it convenient to use. These concerns should be ranked in this order. However, they often are not by both manufacturers and consumers. All three must be achieved in such a way so as not to jeopardize the satisfactory fulfillment of the other two.

Milk has long been referred to as the most perfect food, and has and will continue to be widely used as human food. This has made milk a valuable human food. As a result, since right after the turn of the century, attempts have been made to develop replacements for milk to be fed to calves to both lower cost, and at the same time, free the milk for human consumption. Originally these formulas were based on such products as linseed oil meal, wheat middlings, wheat red dog, wheat flour, oat flour, and soybean meal. These early products were really not milk replacers, but rather milk extenders. They were often fed as a gruel. These milk extenders, to be successful, needed to be accompanied by large amounts of whole milk, or in those days when the majority of dairymen separated milk, skimmilk. Unless large amounts of milk were used, these milk extenders would be disastrous failures.

As time progressed, milk ingredients appeared in the milk extenders in ever increasing amounts. About 1950 the first true milk replacers were developed and marketed. About this time, because whole milk pric-