NUTRITIONAL MANAGEMENT OF A WHOLE MILK FEEDING PROGRAM
PART 1: WHOLE MILK FORTIFICATION

Introduction

The commercial availability of on-farm pasteurizers has allowed producers to reduce the various risks associated with feeding non-saleable milk (i.e., hospital milk, waste milk) to preweaned calves. Pasteurized waste milk can be a high quality feed for pre-weaned calves provided that proper pasteurization procedures are followed, some of which include regular monitoring of pasteurizer performance and maintenance of strict pasteurizer sanitation practices. Additional challenges with implementing a pasteurized waste milk feeding program involve managing the daily variation in nutrient composition as well as waste milk supply short-falls, while recognizing that whole milk provides insufficient amounts of certain minerals and vitamins.

Variation of Waste Milk Composition

The nutrient composition of waste milk is highly variable because fresh cows (transition milk), cows with mastitis, and (or) cows being treated for illness produce milk with markedly different composition compared with saleable milk. A recent study examined waste milk composition and variability by collecting raw and pasteurized waste milk from 31 commercial dairy and calf rearing operations (Jorgensen et al., 2005). This study revealed that fat, protein, and lactose concentrations (% of dry matter) in pasteurized waste milk varied from 22.3 to 37.6, 23.1 to 40.8, and 30.2 to 38.4%, respectively. Therefore, protein and energy intake is likely to vary considerably from day-to-day or week-to-week depending on the cow population contributing to the waste milk supply. This variation in nutrient intake – fat, in particular – may affect calf starter intake and the incidence of nutritional scours in young calves. Providing a consistent ration to young calves is ideal, but monitoring and adjusting for variable fat, protein, and lactose content in waste milk is often impractical on-farm.

Minerals and Vitamins in Waste Milk

Whole milk contains adequate amounts of B-complex vitamins, vitamin A, and macrominerals such as calcium, phosphorus, magnesium, sodium, potassium, and chloride compared with requirements (Davis and Drackley, 1998; NRC, 2001). However, whole milk is lacking in a number of minerals and vitamins important for optimal growth and immune function, such as iron, manganese, zinc, copper, iodine, cobalt, selenium, vitamin D, and vitamin E compared with established recommendations for pre-weaned calves. The functions and symptoms of inadequacy (Davis and Drackley, 1998; NRC, 2001) associated with these minerals and vitamins are as follows:

Iron – Functions: component of hemoglobin and myoglobin, required for function of key metabolic enzymes; **Symptoms of inadequacy:** listlessness, poor feed intake and weight gain, increased morbidity and mortality due to depressed immune function.

Manganese – Functions: Required for cartilage and bone formation, component of an antioxidant enzyme (manganese superoxide dismutase); **Symptoms of inadequacy:** impaired growth, skeletal abnormalities.

Zinc – Functions: required for activity of several metabolic enzymes, regulates several cellular function and immunity; **Symptoms of inadequacy:** reduced feed intake, depressed growth.

Copper – Functions: required for function of key metabolic enzymes, bone and connective tissue formation, hemoglobin synthesis, production of a key antioxidant enzyme (superoxide dismutase); **Symptoms of inadequacy:** loss of hair pigmentation, scours, anemia, fragile bones, poor growth, depressed immune function.

Iodine – Functions: required for the synthesis of thyroid hormones (thyroxine and triiodothyronine) that regulate energy metabolism, especially important for allowing calves to increase basal metabolic rate during cold weather.

Symptoms of inadequacy: decreased production of thyroid hormones (decreased energy utilization), goiter (enlarged thyroid), weakness.

Cobalt – Functions: component of vitamin B_{12}; **Symp-toms of inadequacy:** growth depression, unthriftiness, weight loss.

Selenium – **Functions:** component of a key antioxidant enzyme (glutathione peroxidase), required for thyroid hormone function, optimal immune function, muscle function; **Symptoms of inadequacy:** white muscle disease, poor growth, general unthriftiness, diarrhea.

Vitamin D – Functions: involved in regulation of calcium and phosphorus metabolism, required for bone formation and growth, supports immune function; **Symptoms of inadequacy:** enlarged and painful joints (rickets).

Vitamin E – Functions: cellular antioxidant, involved in maintenance of cellular membranes, fatty acid metabolism, immune function, works synergistically with selenium; **Symptoms of inadequacy:** white muscle disease, impaired immune function.

A clear disparity exists between mineral and vitamin requirements and the amounts supplied by whole milk. In **Table 1**, requirements for select minerals and vitamins are compared with the average concentrations found in whole milk (NRC, 2001). In **Table 2**, mineral and vitamin intakes were predicted for calves fed either 1.25 lbs/day (as-fed basis) of a 20:20 milk replacer powder (96% dry matter) or 1 gallon of whole milk (12.5% solids).

Based on these estimates, calves fed whole milk do not receive adequate amounts of iron, manganese, copper, iodine, cobalt, selenium, vitamin D, or vitamin E, whereas zinc intake could be considered deficient as well. Ways to correct these deficiencies include promoting starter intake, increasing the liquid feeding rate, or fortifying whole/waste milk. Intake of a high-quality starter would augment mineral and vitamin consumption, although calves do not consume appreciable amounts of starter until at least 2 weeks of age. In addition, starter intake by whole/waste milk-fed calves is likely to be lower due to the high fat content of whole/waste milk compared with a conventional milk replacer. Simply feeding more whole/waste milk is not an effective approach to meet the calf's mineral and vitamin requirements because of the large difference between amounts supplied by whole/waste milk and the calf's requirements.

TABLE 1. Recommended mineral and vitamin concentration of milk replacer compared with typical mineral and vitamin concentration of whole milk.

	Concentration Recommended by NRC (2001)[1,2]	**Concentration in Whole Milk[2]**
Minerals	------------------------ **ppm** ----------------------	
Iron	100	3.0
Manganese	40	0.2-0.4
Zinc	40	15-38
Copper	10	0.1-1.1
Iodine	0.50	0.1-0.2
Cobalt	0.11	0.004-0.008
Selenium	0.30	0.02-0.15
Vitamins	------------------------ **IU/lb** ----------------------	
A	4082	5215
D	272	139
E	23	3.6

[1]Recommendations for a milk replacer fed at 1.17 lbs of dry matter per day to a 100 lb calf.
[2]Values from NRC (2001).

TABLE 2. Predicted mineral and vitamin intake by pre-weaned calves fed either milk replacer or whole milk.

	Mineral and Vitamin Intake: Milk Replacer[1,3]	**Mineral and Vitamin Intake: Whole Milk[2,3]**
Minerals	----------------------mg/day------------------	
Iron	54.4	1.46
Manganese	21.8	0.10-0.20
Zinc	21.8	7.31-18.5
Copper	5.4	0.05-0.54
Iodine	0.27	0.05-0.10
Cobalt	0.06	0.002-0.004
Selenium	0.16	0.01-0.07
Vitamins	-----------------------IU/day -----------------	
A	4898	5607
D	327	150
E	27.2	3.9

[1]Milk replacer feeding rate = 1.25 lbs/calf/day of powder, 96% dry matter
[2]Whole milk feeding rate = 8.6 lbs/calf/day (1 gallon/calf/day), 12.5% solids
[3]Calculated from concentrations in NRC (2001).

Should I Use a Whole Milk Fortifier?

Classic symptoms of mineral and vitamin deficiencies are not likely to occur if producers strive to wean calves from whole milk at 6-8 weeks of age, a high-quality starter is offered, and starter intake is not delayed due to excessive fat intake. However, inadequate mineral and vitamin intake may lead to depressed growth performance and immune function. Fortification of whole or waste milk with the aforementioned minerals and vitamins is an effective approach to provide the calf with required amounts of these nutrients. The benefits of mineral and vitamin supplementation were demonstrated by Jones et al. (1955), where whole milk-fed calves (fed at 10% of body weight) supplemented with iron, copper, cobalt, iodine, manganese, and zinc had greater growth through 8 weeks of age compared with unsupplemented calves.

Commercially-available whole milk fortifiers can not only provide important minerals and vitamins lacking in whole milk, but fortifiers are an effective tool to boost the content of B-complex vitamins and may contain other beneficial ingredients such as mannan oligosaccharides. Supplementing B-complex vitamins to levels above NRC recommendations reduced the need for antibiotic treatment in veal calves (Wood et al., 2007), whereas mannan oligosaccharide supplementation improved starter intake and health of pre-weaned calves (Heinrichs et al., 2003).

Conclusions

- Pasteurized whole/waste milk can be a high-quality source of protein and energy for dairy calves, but nutrient composition is highly variable

- Deficiency of several important minerals and vitamins in pasteurized whole/waste milk, while unlikely to cause classic deficiency symptoms, may depress immune function and growth performance

- Calf health and performance may be improved by fortifying pasteurized whole/waste milk with minerals, vitamins, and additional ingredients that support calf health

References

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