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Calf Note #146 – Waste milk vs. milk replacer, revisited

Introduction

A question frequently considered by calf raisers is the use of waste milk for liquid fed calves. Waste milk – also called non-saleable milk or hospital milk – is milk that can't be sold for human consumption, but still contains significant nutrients that can be used by calves. Along with the nutrients, however, come potential pathogens as well as a lot of variation that must be accounted for to properly utilize this product. A number of Calf Notes, Extension publications and research papers have dealt with aspects of using waste milk. Some recent research provides further insight into the value of waste milk compared to milk replacers and the nature of the differences observed in research.

Survey of Research

A study from the University of Minnesota in 2005 (Godden et al., 2005) compared performance and health of 438 calves fed either pasteurized waste milk (**PWM**) or a calf milk replacer (**CMR**). The CMR was non-medicated and contained 20% crude protein and 20% fat. The CMR was mixed at 0.45 kg/3.8 L of water (1 lb/gallon).

Waste milk used in the study was collected at one dairy farm and transported to the calf ranch (where calves were raised) daily. Batches of milk were heated to 62.8°C and held for 30 minutes, then cooled to feeding temperature (40.6°C, 105°F).

Both the CMR and PWM were fed 2x/day. The volume fed was adjusted according to the outside ambient temperature – researchers fed 1.9 L/feeding when temperature was above -4.4°C (24°F); from -4.4°C to -15°C (5°F), calves were fed 2.4 L/feeding; and below -15°C, calves were fed 2.8 L/feeding. Calves had free access to water and either a calf starter (birth to 3 weeks of age) or calf grower (3 weeks and older).

Results are in Table 1. Clearly, there were profound differences in animal health and performance. Calves fed PWM grew faster (0.47 kg/d vs. 0.35 kg/d), were weaned earlier and were heavier at weaning compared to calves fed CMR. More striking was the difference in animal health. Calves fed PWM had less morbidity and mortality than calves fed CMR. This was particularly striking in winter months. In the winter, calves fed PWM had a mortality of 2.8% compared to 21% for calves fed CMR.

Why was there such a significant health difference between calves fed PWM and CMR? All calves were fed colostrum after birth and there was no difference between treatments in total serum protein (5.8 g/dl). This would suggest that differences in animal performance were not due to differences in calf health at the start of the study.

Table 1. Growth and performance of calves fed calf milk replacer (**CMR**) or pasteurized waste milk (**PWM**) in MN.

Item	*CMR*	*PWM*	*P*
n	215	223	…
BW on d 1, kg	40.4	40.1	NS
Age at weaning, day	47.3	46.1	0.01
BW at weaning, kg	60.8	66.8	0.01
ADG, kg/d	0.35	0.47	0.01
Morbidity, % of calves	32.1	12.1	0.01
Summer morbidity	12.7	4.4	0.02
Winter morbidity	52.4	20.4	0.01
Mortality, % of calves	11.6	2.2	0.01
Summer mortality	2.7	1.7	NS
Winter mortality	21.0	2.8	0.01

Differences in health from summer to winter can give us some clues as to the causes of differences between groups. Calves fed CMR were fed less total solids, less protein and less energy than calves fed PWM. It's to be expected – whole milk (3.2% protein, 3.7% fat on a 12.5% solids basis) would provide 25.6% protein and 29.6% fat compared to 21% protein and 21% fat for a "standard" CMR.

In winter, calves exposed to the cold temperatures of Minnesota were fed additional liquid, as noted above. However, if the amount of total ME provided by the liquid diet (and especially CMR) was insufficient to meet the additional energy demands of cold weather, calves would be markedly stressed as they mobilized body fat and muscle to provide energy for thermoregulation. Many studies have shown that energy deficit stress can depress immunity, making calves more vulnerable to pathogens in the environment. It's noteworthy that calves fed CMR had much higher morbidity and mortality in winter compared to summer.

Differences in nutrient concentration of PWM and CMR in this study were very significant and probably accounted for a majority of the differences between treatments. However, other possibilities exist between CMR and PWM that could account for at least some of the differences between treatments. Before we discuss differences between these two forms of nutrition, let's look at another study comparing milk and CMR.

In a recent study by Lee et al. (2009) performance of heifer calves fed CMR or whole milk was compared. Unlike the MN study, calves in this study (conducted at a research institute in Korea) were fed similar amounts of either whole milk (**WM**) or CMR both on a solids and liquid basis. The CMR was formulated to provide similar amounts of protein, fat, Ca and P. In addition, the composition of the CMR was formulated to contain the same amount of nutrients as WM. Calves were fed 4 times daily to 25 days, then number of feedings was reduced to weaning at d 49. Calves were monitored to d 70. Calves were weighed at the start of the study, at weaning and on day 70 (end of the trial). All calves were fed colostrum prior to starting the study. Calves also had access to water, starter and hay for ad libitum consumption

In this study (see Table 2 for performance data), calves were fed similar amounts of liquid that contained the same amount of protein and fat. Consequently, intake of DM, energy, protein and free water and starter intake did not differ between the two treatments. Even though intake of nutrients was similar, calves fed WM still grew faster than calves fed CMR. By 49 days, calves fed WM were heavier, taller, longer and wider than calves fed CMR. These differences were maintained through the end of the study at d 70. Interestingly, however, there were no differences in health of calves on these two treatments. Calves were generally health with no mortality during the study.

Table 2. Growth and performance of calves fed calf milk replacer (CMR) or whole milk (WM) in Korea.

Item	*CMR*	*WM*	*P*
n	10	10	…
BW on d 1, kg	41.9	42.1	NS
BW at d 49, kg	64.0	72.2	0.03
BW at d 70, kg	81.9	89.8	0.02
Hip height, d 1	78.9	79.1	NS
Hip height, d 49	89.0	93.5	0.03
Hip height, d 70	91.2	95.5	0.03
Scour days	7.2	6.9	0.14
Respiratory score	1.2	1.1	NS
Rectal temp., °C	38.7	38.6	NS

So, what's going on?

Results of these two studies are consistent in the observation that calves fed milk (whole or pasteurized waste milk) grew faster than calves fed CMR, whether or not the composition of gross nutrients were the same. In the MN study, calves fed limited nutrients from CMR had greater morbidity and mortality, particularly in winter. In the Korean study, calves had similar health but still grew faster. So, how do we account for what's happening in these two studies?

We can readily conclude that the large differences in nutrient intake in the MN study could account for differences in performance and health. This is especially true since health problems were worst when calves were most energy deficient – during the cold winter months.

The Korean study was interesting because gross nutrient intake was standardized between the WM and CMR treatments. Therefore, it appears that some factors other than protein and fat content of the two feeds must account for differences. In addition to gross nutrient content, other potential differences between CMR and milk include:

1. presence of extra-nutritional factors (immune cells, growth factors, hormones, etc.);
2. differences in nutrients that were not monitored in research;
3. digestibility and metabolizability of nutrients;
4. presence of vegetable proteins;

We'll consider each of these potential reasons in turn.

Presence of extra-nutritional factors. Milk is a complex mixture of nutrients as well hormones, growth factors, immune cells, immunoglobulins and other compounds that can inhibit attachment of intestinal pathogens, boost the intestinal and systemic immune system, and provide non-specific immune support. Researchers have alluded to the possibility that extra-nutritional factors (**ENF**) could account for improved performance of calves fed whole milk compared to CMR. This seems entirely possible; however, few studies have actually measured the content of compounds such as lactoferrin, IGF-1, IgG, etc. in growth studies comparing CMR with milk. Another confounding factor is the content of such compounds may actually be HIGHER in CMR than in milk. During cheese manufacturing, casein and whey proteins are separated and the whey fraction is either dried to make 12% whey or concentrated to make 34% whey protein concentrate. Therefore, if the proteins are fractionated with the whey fraction, it is possible that the content of the proteins could actually be greater in CMR than in whole milk if only whey proteins are used in CMR formulas (as is the case in the U.S.). This assumes, of course, that the content of the protein is not degraded during processing, including fractionation and drying. For example, based on published content of lactoferrin in whey and whey protein concentrate, it's possible that CMR formulas could have more lactoferrin than whole milk. Lactoferrin is, of course, only one example and many growth factors and hormones in milk could be denatured during processing and manufacturing of whey. It's likely that at least some growth factors are denatured during processing of whey and whey protein concentrate.

The PWM used in the MN study was an accumulation of non-saleable milk, transition milk and colostrum. It is possible (though not measured in the study) that significant IgG, IgM and IgA from transition milk and colostrum provided additional immune support to calves prior to weaning. However, since whole, saleable milk was used in the Korean study, this could not account for differences observed in that study.

Differences in nutrients not measured. The MN research didn't evaluate the nutrient content of PWM; therefore, it wasn't possible to know unequivocally how much nutrient intake varied. The Korean study monitored intake of crude protein and crude fat. But, nutrition is more than just protein and fat! Important differences in amino acid profiles, fatty acid profiles, amount of lactose, and important vitamins and minerals could contribute to the observed differences. Most modern CMR formulas in the U.S. (and the formulas used in the Korean research) rely exclusively on whey proteins as the source of protein. Whole milk contains both whey and casein proteins. Although Lammers et al. (1998) reported that calves fed CMR containing only whey proteins performed similarly to calves fed CMR containing dried skim milk, neither treatment necessarily provided the exact composition of digestible amino acids as whole milk. Differences in digestibility or metabolizability due to processing could account for at least some of the differences observed here.

In addition to amino acids and fatty acids, modern CMR are typically supplemented with various vitamins and minerals to meet or exceed NRC nutrient requirements. It's possible that differences between these nutrients and the nutrients found in milk could contribute to some of the observed differences.

Differences in digestibility or metabolizability. When milk ingredients are processed and dried, there is the potential for a reduction in digestibility due to the heat of drying. Most research suggests that commercial whey and whey protein concentrate ingredients are highly digestible; however, even a small change in digestibility could contribute to differences in growth. Neither study evaluated the digestibility of the CMR used in these studies, so it is unclear what the digestibility of the CMR actually was.

Digestibility of fat depends on proper emulsification. Most modern CMR formulations utilize sophisticated emulsifiers to ensure that fats are properly suspended. However, variation in mixing temperatures, time after mixing and other management factors can affect how effective emulsification is on the farm.

Similarly, metabolizability of nutrients can depend on timing of nutrients provided to the intestine for absorption. Researchers have long known that curd formation slows the outflow of protein and fat from the abomasum, potentially improving delivery of nutrients to the intestine and improve metabolizability of the diet. This may be particularly true when liquid is fed at rates greater than 450 grams of solids per day. It's possible that differences in delivery of nutrients to the gut could contribute (at least partially) to differences observed these studies.

Vegetable proteins. The Lee study used a CMR that contained 12% wheat protein and 5.5% soy protein concentrate. The crude fiber content of the formula was 2.1%. Many research studies have reported that some vegetable proteins can contain anti-nutritional factors such as trypsin inhibitor, glycinin and others that reduce digestion, growth and health. It's quite likely that at least some of the observed differences were due to the presence of vegetable proteins.

Summary

Differences in animal performance between whole milk (saleable or non-saleable) and CMR cannot only be accounted for by the content of gross nutrients such as protein and fat. A deeper understanding of more nutrients (amino acids, fatty acids, vitamins, etc.) seems necessary to better understand whether nutrition or non-nutritional components of milk contribute to this greater growth. With that said, it does appear that feeding WM or PWM can provide additional growth for calves. However, it's very important to understand the risks associated with feeding non-saleable milk. Non-saleable milk is a major source of infection causing pathogens such as Mycoplasma, *Mycobacterium avium* subsp. *paratuberculosis* (the organism that causes Johne's disease) and many others. Further, variation in PWM due to variation in source liquid (milk, waste water, transition milk, etc.) and the degree of decomposition that occurs from time of collection to time of feeding must be factored into the decision to use waste milk.

References

Godden, S. M., J. P. Fetrow, J. M. Fiertag, L. R. Green, and S. J. Wells. 2005. Economic analysis of feeding pasteurized nonsaleable milk versus conventional milk replacer to dairy calves. JAVMA. 226:1547-1554.

Lee, H. J., M. A. Khan, W. S. Lee, S. H. Yang, S. B. Kim, K. S. Ki, H. S. Kim, J. K. Ha, and Y. J. Choi. 2009. J. Animal Sci. 87:1129-1137.

Lammers, B. P., A. J. Heinrichs, and A. Aydin. 1998. The effect of whey protein concentrate or dried skim milk in milk replacer on calf performance and blood metabolites. J. Dairy Sci. 81:1940-1945.

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