The Effect of Feeding Calves Milk Replacer 2x, 3x, or Pasteurized Milk.

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ABSTRACT

Dairy calves are the future of each dairy operation, yet are often overlooked as an extra expense for the first two years of their life. This study aimed to look at the potential differences between several treatments involving pre-weaned calves. In this study, 104 Jersey and Holstein heifer calves were enrolled in one of three programs over the course of nine months. Calves were fed milk replacer MR twice daily, milk replacer 3x daily, and pasteurized waste milk twice daily. Calves were monitored for scouring rates and duration in regards to each treatment. Calves fed pasteurized waste milk tended to have lower scouring rates and scoured for fewer days than other groups of calves. Breed was not a determining factor for morbidity in calves. Pasteurized waste milk has the potential to offset inputs while providing an adequate diet for young calves.

INTRODUCTION

Typical calf feeding practices focus on factors involving average daily gain, weaning age, feeding frequency, and type of milk fed to calves (Appleby, et. al. 2014, Conneely, et. al. 2013, Kehoe, et. al. 2007, Kmicikewycz, et. al. 2014, Silper, et. al. 2013, Terre, et. al. 2007). Most sources have pointed towards feeding at higher rates to achieve a more rapid preweaning rate of gain, which would in turn result in greater first lactation performance (Soberon, et. al. 2012). This study aimed to look three specific methods of feeding calves and the effect it has on general health and wellbeing of the calf during the pre-weaning phase. The objective was to observe any clear differences each of the three treatments had in regards to morbidity and mortality.

REVIEW OF LITERATURE

Current practices for feeding dairy calves typically involve feeding milk replacer at a rate of 10% body weight BW: (Appleby, et. al. 2014; Conneely, et. al. 2013; Terre, et. al. 2007). For numerous reasons including cost, performance, and ease of use dairy farms are trending toward feeding higher rates, (Appleby, et. al. 2014; Conneely, et. al. 2013; Terre, et. al. 2007) higher concentrations (Hill, et. al. 2009; Silper, et. al. 2013), or pasteurized waste milk. (Elizondo-Salazar et. al. 2013; Moore, et. al. 2014) Along with different intakes, calves are also subject to how these practices affect their behavior and social interaction. (Appleby, et. al. 2014)

Appleby, et. al. (2014) compared performance and feeding behavior between calves fed ad libitum from a teat or 10% daily of their BW. The researcher's objective was to see how nursing behavior differed and what would happen as a result of one group receiving a higher plane of nutrition.

The result of the different amounts of milk consumed by the calves was significantly different. The group of calves fed from the bucket gained 0.36kg/day versus 0.85kg/day in the ad libitum group. Another curious finding was the huge variation in milk consumption in the ad libitum group. Intakes ranged from 6.4L/day to 16.4L/day. According to the researchers this disparity was positively, but not strongly correlated to the individual calf's weight. Disease incidence was also monitored throughout the first six weeks of life and resulted in ad libitum calves having three fewer days than with diarrhea than calves fed in buckets. The final result of their study was in regard to rate and quantity of consumption during each feeding for the ad

libitum group. This group of calves ate 74% of their daily meals during their first and fourth feeding.

It was expected that the group fed ad libitum would have higher average daily gain (ADG) than their counterpart due to more solid consumption. With this higher plane of nutrition it makes good sense that this group of calves also had fewer illnesses, whether it be attributed to the saliva produced from suckling, the direct flow into the abomasum, or the reduced average pH of the gut. Intakes had a high variation and may present problems on other farms. Without the use of intake tracking some calves could get left behind and perform poorer than their bucket fed counterparts. If 74% of feed occurred during two feedings, it could be worthy to attempt a study looking at feeding the same solid content to calves in two feedings to try and reduce labor costs.

Conneely, et. al. (2013) looked at calf growth when fed 10% of their BW once daily OD or 15% BW OD or twice daily TD after 3 weeks of age. The aim of their study was to evaluate how each of these treatments would affect the calves' growth and health status.

When weights were recorded at specified intervals the researchers found that calves fed 10% OD weight less than the 15% OD and TD treatment, 2.5kg less. Throughout all three groups of calves there was no significant difference on the health status of the calves.

Similar to other studies the result that calves fed a higher percent of their birth weight gained more during the same period as calves fed less. The reasoning for this is that typical feeding programs that limit feed calves are balanced to feed at a percent of biological capability for growth in an attempt to initiate greater grain intake and rumen development. The reason for the gap in growth is the fact that the age of the calf dictates how much grain the animal can consume and digest. If a calf is prompted to eat more grain but does not have the digestion

capability all benefits are lost. The research group found that disease incidence was similar for each group, but this finding is not as significant as it may seem. The study did not start until calves reached three weeks of age. More than 90% of calf health disorders are recorded prior to 21 days of age, most of them occurring from 7-14 days of age; it was interesting that this study found that there was no significant difference in growth rate when calves were fed 15% OD after three weeks of age. This finding could be a result of expanded abomasal capacity allowing for full consumption of a OD feeding in addition to grain.

Kmicikewycz, et. al. (2014) aimed at determining if feeding frequency had an effect on calf growth between conventional milk replacer MR and a modified 26% protein 20% fat MR.

Calves were fed one of four diets, the first group consisted on conventional MR, 20% fat 20% protein, fed either twice daily or four times at 1.5% of BW. The second group was fed modified MR either twice daily or four times at 2% of BW. All calves received an 18% protein textured grain ad libitum. The outcome of the study showed that both groups of calves fed 2% of their BW had higher average DM intakes and therefore higher growth rates compared to the 1.5% treatment. There was no observed difference within treatments when calves were fed either twice or four times daily. Starter intake differed among the 1.5% and 2% groups but not within twice and four time feedings. The started intake was higher for calves fed 1.5%, but DM consumption was the same.

The study does a good job showing that calves' digestion efficiency is similar regardless of the number of daily feedings. One thing that may have affected that is the times at which the calves were fed. Instead of being fed every six hours for the four-time rate, the calves were fed at three-hour increments over the coarse of a 12-hour period. One of the most notable advantages of

spreading out feedings to young calves is the balancing of abomasal pH, allowing for a reduced incidence of scours. Unless this is done for the 24-hour period the effects are minimized.

Silper, et. al. (2013) looked at four experimental feeding strategies: 4L until day 60, 4L until day 29 followed by 6L until 60 days, 6L until day 29 followed by 4L until day 60, and 6L until day sixty. The research team wanted to see how MR intake affected fore-stomach size at specific intervals, how the calf's energy balance was affected, and the growth rate of each group. Starter grain and water were fed ad libitum.

Among each of the four groups, starter and water consumption were the same. The intake of started increased from 0.065kg/day in the first month to 0.386kg/day in the second month to 2.07kg/day after weaning. Calves receiving 6L/day during the first 29 days had the greatest bodyweight and largest fore-stomach. After day 29 the calves fed either six or four liters did not differ in average daily gain, but the calves on the six-liter diet did have a more favorable energy balance.

The research group concluded that economically the 4L until day 60 treatment was the most profitable and was their recommendation among the four. I find it curious that they dismissed the notion of a healthier energy balance for the 6L calves until day 29. This is the period when calves are most susceptible to different diseases and with a protocol that could reduce treatment this situation could have the largest economic impact if properly implemented on a dairy. Once starter intake rises in the day 29-60 group, MR could be lessened as it is the most expensive per pound of dry matter.

Elizondo-Salazar et. al. (2013) looked at the effectiveness of pasteurization on six commercial dairy farms in Pennsylvania. They took milk samples for 15 consecutive days in

regard to the following: standard plate counts, coagulase-negative streptococci, environmental streptococci count, coliform count, gram-negative coliform count, staphylococcus aureus, and streptococcus agalactiae.

Two major indicators of the cleanliness of milk, SPC and coliform count were evaluated and in 68% of samples taken prior to pasteurization and contained and SPC of <20,000cfu/mL and 39% of samples contained <100cfu/mL of coliform bacteria. After pasteurization 96% of samples had an SPC of <20,000cfu/mL and 92% of samples had <100cfu/mL of coliform bacteria. Within the samples that did not meet these criteria some of those samples increased in bacterial counts from the time the milk was pasteurized to the time it was fed.

The researchers concluded that with proper cleaning and maintenance of pasteurizing and feeding equipment along with timely feeding after pasteurization, waste milk could be successfully fed to calves to offset the cost of more pricey milk replacers. This study leaves a gap in that the research team did not conduct a full audit and monitor the health of calves that correlated to each sample.

Walker, et. al. (2012) looked at mortality, morbidity, antibiotic usage, and biosecurity among calf ranches containing either only heifers or heifers and bulls. They wanted to compare and contrast the differences and similarities between calf ranches and dairy farms.

Mortality was recorded as 6.9% for a yearly average among the responding ranches. 18% of calves experienced some type of diarrhea pre-weaning with 78% receiving an antibiotic. 9% of calves had some form of respiratory disease with 82% receiving an antibiotic. In many instances calf ranches had superior biosecurity. The ranches used fences, boot and tire washing stations, quarantine of new animals, and broad vaccination protocols.

The results of the study showed that calves on calf ranches had lower average mortality and morbidity than typical dairy farms. Biosecurity was also a greater priority with almost 50% of farms testing for passive immunity and eliminating possible common routes for passing disease. Calf ranches did have a higher rate of antibiotic and antimicrobial usage, which could be responsible for greater survival rates, and things such as medicated milk replacer could be responsible for reduced morbidity.

Terre, et. al. (2007) wanted to determine the difference in digestibility and post-weaning performance between calves fed a conventional diet and an enhanced-growth feeding program. They wanted to see if feeding higher rates of MR for a shorter time period could reduce overall costs and maintain post-weaning performance.

Calves were enrolled on either a conventional milk replacer diet containing 25% protein and 19% fat at a rate of 4L/day from day 0-29 and 2L/day until weaning in 12.5% solution, or an enhanced-growth program using the same powder but fed at 18% concentration at a rate of 4L/day from 0-6 6L from day 7-13, 7L/day from 14-20, 6L/day from day 21-28, and 3L/day from day 29-35. Calves were fed a 20% protein starter ad libitum from day zero and intakes were recorded. Calves had a higher body weight at weaning in the enhanced diet group 88.6kg versus 81.2kg in the conventional diet group. Calves fed the conventional diet consumed more starter grain during the weaning period and after milk was removed from the diet had a higher rate of nutrient absorption.

The research team concluded that calves fed an enhanced diet with higher daily consumption of milk replacer had a higher average daily gain. This conclusion follows in line with many other studies. This study also showed that calves eating more grain most likely had

greater rumen development and would then in turn have higher dry matter intakes following weaning. This creates a new train of thought that if we inhibit consumption of milk during late pre-weaning we can maximize the calf's ability to consume forages post weaning.

Soberon, et. al. (2012) wanted to see if phenotypic expression was altered by the amount of milk or milk replacer fed and how average daily gain (ADG) affected first lactation performance in the Cornell research heard and a commercial herd in New York.

1244 heifers from the Cornell herd and 624 heifers from the commercial herd were analyzed according to their 305 lactation performance records and their ADG. In the pre-weaning period ADG ranged from 1.0kg to 1.58kg and was strongly correlated to lactation performance. For every 1kg of weight added in the pre-weaning period first lactation increased by 850kg, and for 235kg for every Mcal. consumed above maintenance.

The research team concluded that if calves could be fed on a higher plane of nutrition in some variation, be it higher MR consumption or higher grain consumption, and gained more weight before weaning and continued that growth until maturity they would be higher producers in their first lactation and most likely their subsequent lactations as well. The findings of this study help to promote the idea of feeding calves on a higher plane of nutrition not just to help prevent illness, but also that it has astronomical paybacks later in their lifetime.

Hill, et. al. (2009) investigated what the optimal ratio of methionine, lysine, and threonine in one group of calves and if reducing overall CP content could successfully be accomplished if amino acids were balanced while in a second trial looked at the optimal ratio of protein to energy in relation to feed efficiency.

In trial one 45 calves were used per trial and fed a MR that was 23, 25, or 27% CP from whey protein. Each MR contained the same percentage of the three amino acids and was fed at .681kg/day. Trial two 96 calves were fed one of the following eight MR powders: 23%, 25%, 27%, and 29% all at .545kg/day and each concentration again at .654kg.day. Calves were weaned at 28 days after birth and monitored until 56 days of age. In trial one pre-weaning Add and feed efficiency declined as CP declined, post-weaning performance did not differ among treatments. Trial two resulted in ADG that were greater at the high MR feeding rate, but also corresponded with lower started intakes. Pre and post-weaning ADG was greater as CP content increased in the groups.

Trial one concluded that reducing CP had reductions in ADG and feed efficiency. The group determined this was due to either a limiting amino acid or overall MP being the limiting factor on growth. In trial two it was concluded that the most feed efficient group of calves fed the lower DM diet was the 25% CP group while the higher DM group was the 27% CP diet. This study helped present new information on feed efficiency as it used day old calves whereas other studies typically used calves after 14 days of age to reduce variation from illness.

Kehoe, et. al. (2007) looked at the effect of weaning calves early and different variances of early weaning. The group measured structural sizes and weights of the calves to determine if growth patterns were similar and monitored blood glucose and insulin levels to determine energy balance.

In the first trial, 124 Holstein heifer and bull calves were weaned at three, four, five, and six weeks of age. The milk replacer fed was mixed at 12.5% solids with 22% protein and 15.6% fat fed at a rate of 10% BW twice daily until one week prior to weaning when intake was

reduced to 5% BW. Trial two used the same composition of MR but at 14 days of age calves were cut to once-daily feedings at 10% BW and one week prior to weaning reduced to 5% BW. In trial one calves weaned at each week interval had similar growth rates and blood glucose. Trial two presented similar results with no observed difference between growth in weaning groups.

This study somewhat contradicts other material showing that calves fed a higher plane of nutrition will have higher weaning weights compared to other groups. Other studies have demonstrated similarly that early weaning is not detrimental if calves are fed on a high plane of nutrition, but the ration that the calves were fed in this study was subpar. It would be interesting to repeat this study and include a third group of calves fed to that higher plane of nutrition while simultaneously recording morbidity data. The researchers also noted that the calves weaned at three weeks of age had a much more difficult time adjusting to and consuming grain. Daily weights would be interesting post-weaning to see how calves adjusted after going off milk.

Moore, et. al. (2014) looked at the quality of waste-milk used on dairy farms and calf ranches fed to pre-weaned calves. They wanted to see how different setups and management techniques affected the safety of the milk and the overall nutrition that the calves received.

In the study, 12 dairies supplying milk and calves to one calf ranch were evaluated for the following: total solids, bacterial counts, coagulation with ethanol, somatic cell counts, and pH. Bacterial counts provided relatively little useful information as they typically had high bacteria counts. Total solids was a high varying factor as some farms would send in a low sample and therefore reduce the DM consumption of the calves for that day.

The researchers formed the conclusion that although feeding waste milk to calves can have positive economic benefits there are many risks associated with feeding this milk and a lack of monitoring can exacerbate the situation. When farms use proper tools such as pasteurization and monitoring of solid content along with correcting it with some form of MR bacterial counts and total solids, the major problem of the study, can be offset. The group called for more readily available testing strips to check for pH and other important factors.

MATERIALS AND METHODS

The trial was performed on California Polytechnic's dairy, which consisted of 100 milking registered Jersey and 100 milking registered Holstein cattle. Calves were housed in individual hutches until three months of age when they moved to open lots with access to free-stalls for the remainder of their life. Management strategies mimic common practices found in large commercial California dairies.

The study was conducted during the spring, summer, and fall of 2012 and consisted of 104 heifer calves arranged in three separate feeding strategies. Three different strategies were used to mimic common practices and to observe notable differences. Twice daily feeding was used because it is the most common in the industry, but has received scrutinization as many programs lack proper nutritional needs of the calves. Three daily feedings has recently gained attention as it has generated improved health results and the ability to feed higher volume of dry matter. Pasteurized waste-milk also has gained recent popularity with the need for a cheap source of nutrition for calves, but has been noted with challenges in managing bacterial counts in the milk.

55 Jersey and 49 Holstein heifer calves were subjected to one of three feeding strategies over the course of nine months at the Cal Poly dairy. Calves were housed in individual hutches separated far enough to prevent contact with other calves. Wheat-Straw was used as bedding and added at minimum of once/week or as needed. Before calves entered hutches the hutch was power-washed and sprayed with 3-5% sodium hypochlorite and placed on a base-layer of high calcium lime. Calves were weaned at six weeks of age and remained in their hutch until three months of age, at which time they moved into a group of eight calves fed the same starter at a rate of five lbs/day and free choice alfalfa hay. Calves were fed ad-libitum water and grain 18%CP from Cargill. The water and grain were emptied and filled 2x/day. During all nine months and three treatments, the sick calf protocol for the calves remained the same. The protocol used common drugs used on calf ranches and other dairies (Walker, et. al. 2012). The protocol was as follows: at first sign of scours calves received 10cc of a solution administered orally with milk containing 50% spectinomycin and 50% bismuth subsalicylate. Scours was defined as a loosening of manure, showing either wateriness or abnormal consistency. Rectal temperatures were also monitored and if at any point the temperature rose above 39.7 degrees Celsius calves received Baytril(Enrofloxacin)(2cc) and Banamine(Flunixin Meglumine)(1cc) every other day until fever dropped; calves also received free choice electrolytes (Diaque) after feeding. Naval infections were treated with Penicillin Procaine G. Respiratory issues were treated with Baytril(2cc) and Banamine(1cc); colostrum was tested with a Brix refractometer and discarded if a visual blemish was observed or it tested <24 on the refractometer. Jersey calves were fed 3.3L with two hours of birth and Holsteins were fed 4.25L. Colostrum was unpasteurized during the first two treatments and pasteurized during the third. Dry cows were vaccinated using a veterinarian approved protocol meant to vaccinate for a wide range if

pathogens. Calves themselves received an oral vaccination at birth for respiratory ailments and an oral pill (First Defense) to help prevent against E. Coli and Rota/Corona virus; sanitization during all three trials remained the same. Sanitization of dirty equipment was initially rinsed with water to remove organic matter then scrubbed with a hot soapy solution and rinsed. To ensure reduction in pathogen content, sodium hypochlorite mixed at a 3-5% solution was run over all surfaces.

The first treatment, which occurred from March 28th until June 14th of 2012 consisted of 19 Jersey and 12 Holstein heifers. This group of calves were fed Land O' Lakes milk replacer containing 26% protein and 20% fat fed at a rate of 0.68kg DM/day 2x daily at 0500 and 1700 hours. The milk replacer was mixed to 15% solids and fed at five pints/feeding. Mixing was performed using a vertical electric mixer with water from the tap or a water heater. Scouring events were recorded for each calf along with mortality.

The second treatment occurred from June 15th until September 25th 15 Jersey and 18 Holstein heifers were fed the same milk replacer from the first trial but at a rate of 0.61kg of DM for the first two weeks and 0.81kg/day until weaning. This was accomplished by mixing the milk at 15% DM and feeding three pints/feeding 3x/day and four pints/feeding 3x/day. To make it easy for student labor the youngest eight calves always received the lower feeding rates. This usually ended when the calves were roughly two weeks of age. Feeding times were 0500, 1300, and 2100 hours.

The third treatment used a Dairy-Tech 37.85 liter pasteurizer. This model allowed for pasteurization of colostrum and waste milk. Due to the inconsistency of calving and the potential to not have the two gallons minimum required to run the pasteurizer, colostrum was placed in

bags designed to withstand the high temperature. Colostrum was pasteurized at 60 degrees Celsius for one hour while was milk was pasteurized at 63 degrees Celsius for 30 minutes. The pasteurizer had an automatic control center for all operations and an agitator. Calves were fed waste milk from hospital cows that were not permitted in the milking string due to the following reasons: antibiotic withdrawal, high somatic cell count, transition milk, and/or lameness. Solid percent was monitored, but not corrected to a threshold. Calves were fed 2xdaily at a rate of 4.7L/day.

RESULTS AND DISCUSSION

Groups of calves are separated by breed and by each trial. Table one displays that scour rates were similar along all trials with 3x feeding having the highest scour rate, but 2x feeding resulted in the highest mortality rate.

Table 1. Number of calf scour events, scouring rates, mortality rates, and number of calves by twice daily(2x), three time daily(3x), and pasteurized milk(P) treatments by breed.

Treatment	Number of Calves	# Scour Inc.	Scouring Rate	Mortality Rate
		Holsteins		
2x	12	41	75%	8%
3x	18	61	83%	0%
P	19	53	79%	0%
		Jerseys		
2x	19	78	79%	26%
3x	15	59	87%	20%
P	21	53	71%	0%

Scouring rates were then broken down and looked at in regards to length of duration in table 2. Calves fed twice daily scoured for longer duration in each breed while calves fed pasteurized waste milk scoured for the fewest days among both breeds. Jersey scour rates tended to be highest among all feeding strategies.

Table 2. Median, Mean, Standard Deviation, and Coefficient of Variation in regard to the number of scour incidences by breed.

Treatment	Median	Mean	Standard Dev.	Coefficient of Variation
		Holsteins		
2x	3	3.42	2.60	0.76
3x	3	3.39	2.36	0.70
P	3	2.79	1.96	.70
		Jersey		
2x	5	4.11	2.73	.67
3x	3	3.94	2.46	.63
P	4	2.52	1.89	.75

Two and three time feeding groups tended to have larger deviations in both breeds.

Among the three trials calves had fewer health ailments when fed pasteurized waste milk 2x daily versus other feeding regiments. The calves had fewer digestive upsets that lasted for a shorter duration and were less in severity allowing for a lower mortality rate. This effect was prominent between both breeds. Consideration must be given to management of colostrum during each of the trials. Colostrum was unpasteurized during the first two trials and pasteurized during the final trial. Pasteurization is known to lessen the effect of microbial contamination and has the potential for better absorption (Elizondo-Salazar et. al. 2013). If this was the case during trial three, the calves gained an unfair advantage in having a greater protection against common pathogens the other two groups may have been susceptible to; environmental temperature may have played a role in all three of the groups. Group one was subjected to wetter conditions than any of the other groups, which may have resulted in a greater ability for growth and spread of pathogens. Treatment group two was subjected to the hottest temperatures with temperature rising above 90 degrees on occasion. Treatment group three was subjected to the lowest temperatures and periodic rain. Temperatures during this time frame dropped to lows in the mid-thirties. The milk replacer fed to calves also had the potential to set calves up for failure. Reasoning would warrant the whole milk from cows is a more digestible source of nutrients for a young calf. This train of thought follows the results that calves fed whole milk have a more balanced and regulated digestive system allowing for fewer and less severed incidences of

scours. Feeding times could have negatively influenced trial two as the second of the three feedings occurred at 1p.m. during the heat of the summer. Calves tended to be lethargic and refuse some of their milk.

Table 4. Least Square Means

Treatment	scour LSMEAN
2	3.76[a]
3	3.66[a]
"P"	2.66[b]

Table 3. SAS analysis by treatment, breed, and treatment*breed

Source	DF	Mean Square	F Value	Pr > F
Treat.	2	13.52	2.36	.10
Breed	1	2.61	.46	.50
Treat*Breed	2	2.38	.42	.66

Using the SAS system for statistical analysis, three treatment levels of 2, 3, and P were separated by breed, H (Holstein) and J (Jersey). A total of 104 observations were recorded and used. The study had an R-Square of .06 and the significance is shown in Table 3. Table 4 displays the least square means and shows a difference between the sour rate for the pasteurized treatment from the 2x and 3x treatments.

With any study like this, more information would be useful in determining what other factors could or did have an effect on why calves performed better than other groups. Setting up a more rigorous recording system to allow for greater statistical testing would increase the significance of this study. Testing of colostrum antibody content along with the calf's blood serum content would have been useful, but expensive, to determine if that were a factor. Culturing of scours would have been helpful in determining if specific pathogens were prominent during or more of the trials. Other important factors such as average daily gain and rumen development have proven a worthwhile measurement (Soberon, et. al. 2012, Kmicikewycz, et. al. 2014, Conneely, et. al. 2013) allowing to truly evaluate performance on a wider spectrum.

CONCLUSION

Calves fed pasteurized whole milk twice daily had fewer incidences of scours and less severe cases than calves fed milk replacer two or three times daily. The use of waste milk was a good way to offset costs for this dairy and implement a more easily managed calf program that allowed for increased calf performance.

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