Effects of Milk, Pasteurized Milk, and Milk Replacer on Health and Productivity of Dairy Calves

L. Hulbert, S. Trombetta, J. Noel, S. Moisá, S. Montgomery, G. Hanzlicek, and B. Bradford

Summary
Our objectives were to determine the health and blood parameters before, during, and after weaning of 114 Holstein heifers fed either accelerated milk replacer (MR; 28% CP, 18% fat) or non-saleable milk (3.59 ± 0.28% true protein; 4.12 ± 0.37% fat) that was either pasteurized (PM) or raw (RM; refrigerated and fed <24 h after collection). Calves were randomly assigned to feeding treatments at birth. Colostrum (1 L) was fed less than 14 hours after birth (MR and PM = pasteurized colostrum; RM = raw colostrum). All calves were bottle-fed 1.8 ± 0.20 L, 3 times daily; all calves were provided fresh water and grain *ad libitum* throughout the experiment. Calves began step-down weaning at age 5 weeks and completed weaning at age 6 weeks. Blood samples were collected at ages 3, 5, and 7 weeks and were analyzed for complete blood counts (CBC) using a Procyte Idexx Analyzer (IDEXX Laboratories, Inc., Westbrook, ME). Fecal scores were observed twice daily, on a 1 to 3 scale (FS1 = normal, FS2 = loose, FS3 = scours). Results showed that MR-fed calves had more ($P < 0.01$) observations (%obs) with FS > 2 than the PM- and RM-fed calves (2.3 vs. 1.6 and 1.7 ± 0.2 %obs, respectively). In addition, there were no differences in body weight or shoulder or hip height between treatments, but a treatment × week interaction ($P = 0.05$) occurred for grain consumed, with a noticeably higher increase between 6 and 7 weeks of age for MR calves. When CBC was considered, there were no differences in blood cell types, but MR-fed calves had greater mean corpuscular volume (MCV) than the other calves ($P < 0.01$), leading to higher resistance for iron deficiency anemia. In conclusion, these findings suggest that calf performance and feed intake are not affected by the administration of raw milk, pasteurized milk, or milk replacer. Moreover, CBC health parameters showed no significant changes due to administration of the different types of milk sources.

Key words: milk replacer, pasteurization, calves, hematology, fecal score

Introduction
It has become increasingly common for dairy producers to utilize non-saleable milk for feeding calves. This practice has been less common on small dairies, which sometimes struggle with variability in the supply of non-saleable milk and lack the scale to afford high-throughput pasteurization systems, but smaller-scale pasteurization systems are now available and are becoming more widely used on relatively small dairies.

Some research has been conducted to evaluate the effects of using pasteurized non-saleable milk to feed calves. Efficacy of pasteurization (i.e., reduction in bacteria load) has been tested on numerous commercial dairies, and results generally have been favorable when protocols were followed carefully. Several studies have demonstrated increased growth rates for calves fed milk compared with those fed milk replacer, even when fat, protein, and lactose concentrations were nearly equal between the milk and milk replacer[1]. However, many calf experts now recommend "accelerated" feeding programs based on the utilization of milk replacers with more protein than fat (often 28% protein, 18 to 20% fat on a dry basis). To our knowledge, no university studies have been conducted to compare the performance of dairy heifers fed these newer-generation milk replacers compared with those fed milk.

Experimental Procedures

Heifers born at the Kansas State University Dairy Teaching and Research Center during a 12-month period were enrolled in a randomized complete block design study. Heifers with birth weights <60 lb and those born with calving scores >2 were excluded from the study; approximately 114 heifers were enrolled prior to this analysis. After receiving colostrum twice in the first 14 hours after birth (MR and PM = pasteurized colostrum; RM = raw colostrum), calves were randomly assigned to one of three treatments: raw milk (RM), pasteurized milk (PM), or milk replacer (MR). Milk used for RM and PM came from the non-saleable milk supply at the dairy, and MR was Mother's Pride (Hubbard Feeds, Mankato, MN), which contains 28% protein and 18% fat on a DM basis and was mixed per label directions to achieve 14.2% total solids. This formulation provides the same metabolizable energy per unit of volume as milk; therefore, treatments were fed on an equal-volume basis. From a macronutrient perspective, treatments differed primarily in protein supply. Calves were fed 3 times daily: 3 pints per feeding for calves <80 lb and 4 pints per feeding for calves >80 lb. Heifers were housed individually in hutches and milk/MR and starter intake was recorded daily. Heifers were weaned no earlier than 6 weeks of age and continued to receive treatment milk/MR until they consumed at least 2 lb of starter for 3 consecutive days. Intakes were recorded through weaning, although the study formally ended at 6 weeks of age. After weaning, all calves were managed uniformly.

Samples of all treatment milk/MR were collected once weekly for nutrient analysis, and pre-/post-pasteurization PM samples were collected for total bacterial counts on these days. Fecal scores were recorded twice daily on a 1 to 3 scale (FS1 = normal, FS2 = loose, FS3 = scours) to assess gastrointestinal health, and all diseases and treatments were recorded. Body weights and hip and shoulder heights were recorded weekly at birth until 24 weeks of age.

Statistical analysis was conducted using mixed effects models to assess treatment effects on blood cell profiles, the proportion of observations with abnormal fecal scores, body weight, hip height, shoulder height, milk/MR intake, and starter intake. Fixed effects were treatment, week, and treatment × week interaction. Calf nested within treatment was the random effect.

Results

Calf growth results showed only a week effect on body weight and hip and shoulder height, with no differences due to feeding raw milk, pasteurized milk, or milk replacer (Figure 1).

[1] Lee et al. 2009. Influence of equalizing the gross composition of milk replacer to that of whole milk on the performance of Holstein calves. J. Anim. Sci. 87:1129–1137.

Mean Corpuscular Volume (MCV) was the only hematological value that was affected by treatment × week interaction (Table 1). No treatment effect was detected on blood cell type percentages related to immune response (neutrophils, monocytes, lymphocytes, etc.). These blood cell types were affected by week, with a decrease in percentage for neutrophils over time and increases in the proportions of monocytes and lymphocytes (Table 1). In contrast, there was a treatment effect with higher numbers for hemoglobin (HGB), hematocrit (HCT), MCV, and Eosinophils for MR-calves and lower values for MR-calves compared with other treatments for mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), and platelets count (PLT).

Grain consumed was affected by a treatment × week interaction ($P = 0.05$), with differences mainly due to a week effect with a more dramatic increase in grain consumed from 6 to 7 weeks of age in MR calves (Figure 2).

The proportion of fecal scores higher than 2 on the 1 to 3 scale is presented in Figure 3 as percentage of total observations (twice daily). Results showed that calves that received milk replacer had more frequent occurrence of diarrhea than calves fed with pasteurized milk or raw milk ($P = 0.003$).

Discussion

Different treatments did not affect the growth performance of the calves. Calves grew at a similar rate, with no differences in height between animals fed milk or milk replacer; moreover, intake behavior increased exponentially after 6 weeks of age for all treatments. These results fail to demonstrate any advantage of the additional preweaning protein intake in the MR group.

The MCV is a measure of the average volume of red blood cells. The measure is obtained by multiplying a volume of blood by the proportion of blood that is cellular (HCT) and dividing that product by the number of erythrocytes (red blood cells) in that volume. MCV measurement allows classification of the different types of anemia. Our results showed that milk replacer-fed calves had higher MCV values compared with other treatments for all time points analyzed, with treatment affecting parameters that determine absence of anemia such as higher hemoglobin, higher hematocrit, and higher main corpuscular volume for MR-calves, suggesting that milk replacer-fed calves might be receiving higher amounts of iron through the fortified trace minerals complex of the milk replacer, which leads to an animal less prone to suffer iron deficiency type of anemia (microcytic anemia). Across species, iron is among the most limiting nutrients in milk when consumed as a complete diet.

It was previously established that feeding milk replacer may increase fecal scores in preweaned calves, particularly within the first 2 weeks of life. Presence of diarrhea might lead to dehydration that produces a falsely high hematocrit that disappears when proper fluid balance is restored. Our results were consistent with these observations (Figure 4), which might be related to the difference in protein content between milk replacer and pasteurized or raw milk.

Conclusions

These results failed to provide any evidence of differences in heifer calf growth and feed intake in response to feeding milk replacer or non-saleable milk that is raw or pasteurized. Milk replacer-fed calves might be less prone to iron deficiency anemia based on mean corpuscular volume. However, milk replacer-fed calves had a higher proportion of loose fecal scores, suggesting that the higher protein content increased the visual appearance of diarrhea.

In conclusion, if managers must choose between the use of a milk replacer or non-saleable milk based on the results of this study, they might have a hard time trying to take a decision due to the slight differences perceived in terms of calves' performance and their health status between treatments.

Table 1. Hematological values (mean) for calves that received milk replacer (MR), pasteurized milk (PM), and raw milk (RM) at weeks 3, 5, and 7

	Week 3			Week 5			Week 7				*P*-values		
	MR	PM	RM	MR	PM	RM	MR	PM	RM	SEM	Treat.	Week	T × W
WBB (%)	24.54	26.09	27.85	23.96	19.88	21.97	24.34	22.61	24.70	2.97	0.37	0.67	0.49
HGB (g/dL)	10.28	9.00	9.27	10.56	9.23	9.56	11.11	10.22	9.90	0.25	<0.01	<0.01	0.28
HCT (%)	32.28	26.72	27.72	32.99	27.06	28.17	33.51	29.66	27.81	1.01	<0.01	0.85	0.29
MCV (fL)	38.79	35.76	36.42	37.37	34.38	34.87	36.42	34.96	34.85	0.46	<0.01	<0.01	<0.01
MCH (pg)	12.47	12.37	12.33	12.06	12.11	12.09	12.22	12.33	12.23	0.24	0.54	0.23	0.40
MCHC (g/dL)	32.24	34.81	33.95	33.69	35.73	35.07	33.69	35.47	35.72	0.87	0.01	0.02	0.39
RDW (%)	40.33	40.97	41.40	40.20	41.49	41.66	40.66	42.59	42.46	0.48	0.03	<0.01	0.14
PLT (K/uL)	431	530	527	396	518	491	450	556	456	27	<0.01	0.42	0.09
Neutro (%)	43.61	42.32	43.29	40.72	39.78	37.97	37.93	34.65	37.27	1.59	0.50	<0.01	0.73
Lymph (%)	44.78	48.00	47.18	45.63	46.79	46.50	46.33	49.50	47.26	1.44	0.19	0.44	0.69
Mono (%)	10.15	9.00	8.67	12.11	12.61	11.93	15.05	15.39	15.04	0.68	0.61	<0.01	0.27
Eosin (%)	0.82	0.36	0.53	1.41	0.63	1.41	0.61	0.40	0.47	0.19	0.01	<0.01	0.28
Baso (%)	0.65	0.31	0.36	0.14	0.17	0.10	0.10	0.08	0.07	0.10	0.25	<0.01	0.12

WBB = whole blood bactericide (%); HGB = hemoglobin (g/dL); HCT = hematocrit in percentage of cells vs. plasma; MCV = mean corpuscular volume (fL); MCH = mean corpuscular hemoglobin (pg); MCHC = mean corpuscular hemoglobin concentration (g/dL); RDW = red cell distribution width calculated CV%; PLT = platelets count (K/uL); Neutro = neutrophils (%); Lymph = lymphocytes (%); Mono = monocytes (%); Eosin = eosinophils (%); Baso = basophils (%); SEM = standard error of the mean.

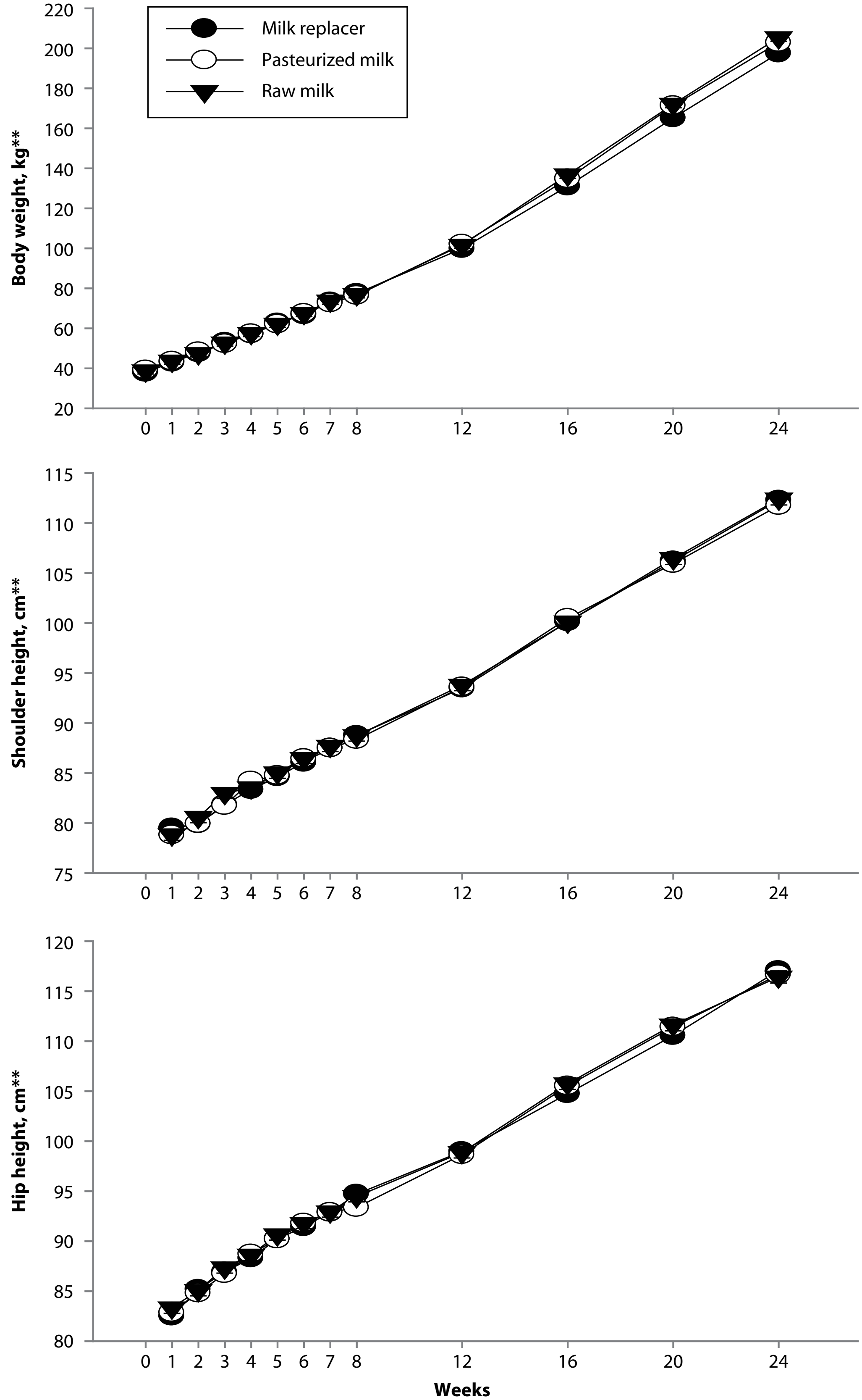

Figure 1. Body weight and shoulder and hip height for calves that received milk replacer, pasteurized milk, and raw milk. Treatments were fed from birth through weaning (6 weeks), and growth was monitored until 24 weeks of age.

P-value < 0.05: * treatment effect, ** week effect, *** treatment × week effect.

SEM = 1.91 for body weight, 0.63 for shoulder height, and 0.63 for hip height.

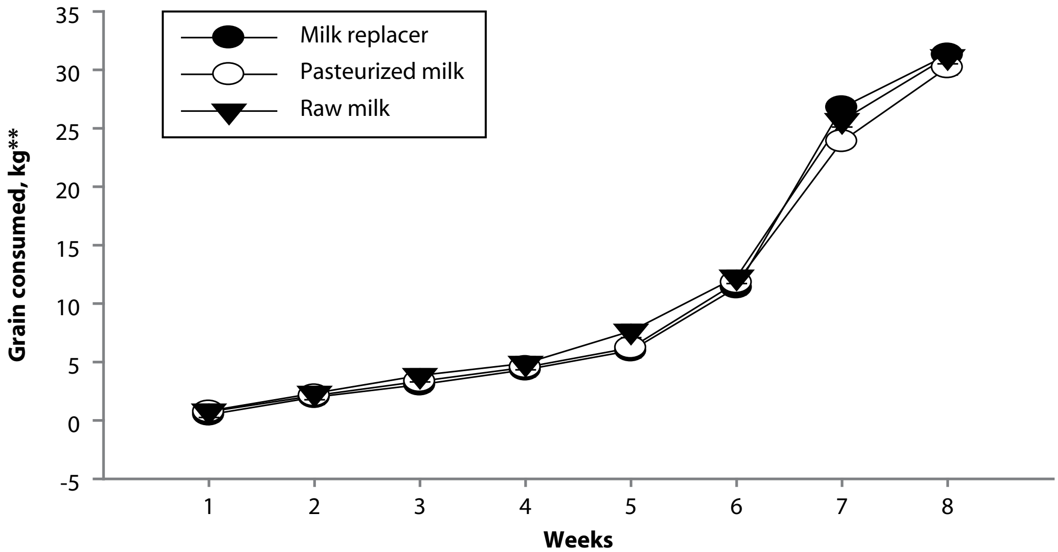

Figure 2. Grain consumed for calves that received milk replacer, pasteurized milk, and raw milk. Starter intake was recorded daily from birth until all calves were weaned (8 weeks of age).

P-value < 0.05: * treatment effect, ** week effect, *** treatment × week effect. SEM = 0.61.

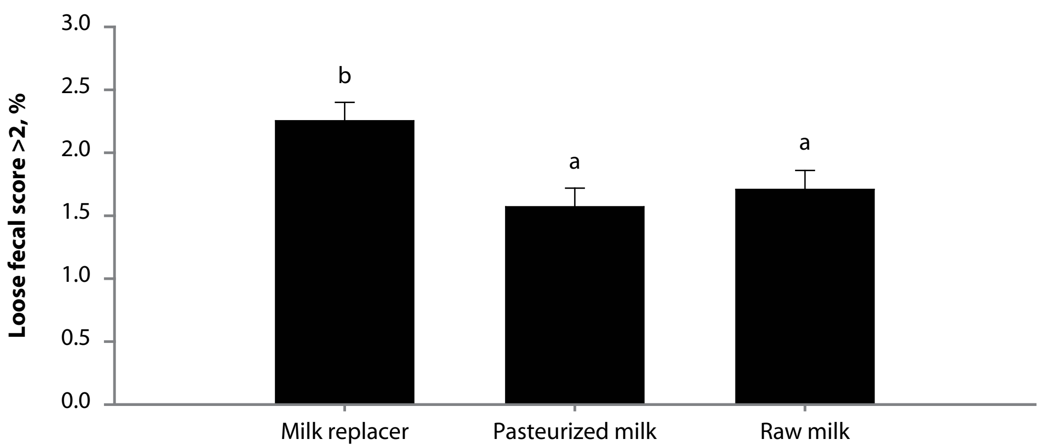

Figure 3. Percentage of observed fecal score higher than 2 on a 1 to 3 scale (FS1 = normal, FS2 = loose, FS3 = scours). Diarrhea appearance was observed twice daily in calves that received milk replacer, pasteurized milk, and raw milk.

Means denoted by different letters differed at *P* < 0.05.

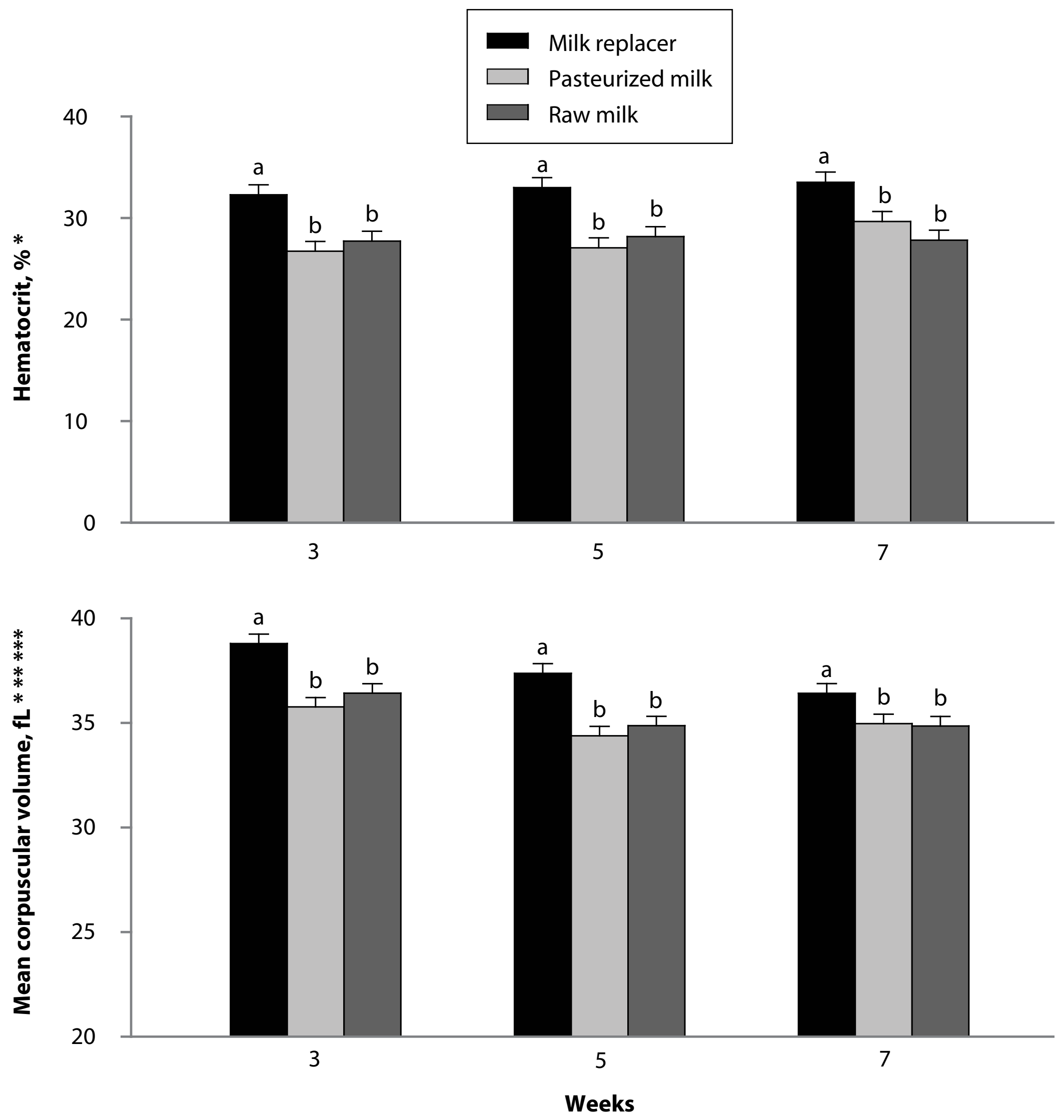

Figure 4. Percentage of hematocrit and mean corpuscular volume at 3, 5, and 7 weeks of age in calves that received milk replacer, pasteurized milk, and raw milk.
Means denoted by different letters differed at $P < 0.05$. * treatment effect, ** week effect, *** treatment × week effect.