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Health and performance of calves fed fresh colostrum from their dams compared to those fed stored colostrum from non-dams

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Abstract

The objective of this study was to assess the preweaning performance, health, and survival of calves fed fresh colostrum from their dams compared to calves receiving colostrum that was not from their dams, and had been stored frozen or refrigerated. A total of 182 Holstein heifer calves born during July and August 2010 at a north-central Florida dairy farm were included. Explanatory variables included colostrum source, adjusted colostrum score, total estimated IgG intake, time to colostrum feeding, and calf-serum total protein determination as a measure of colostral immunoglobulin absorption. Control variables comprised birth weight and dam parity number. Average daily weight gain (ADG) was not affected by colostrum source. Number of disease events was the only variable showing a significant negative association with ADG (P = 0.001), but there was a tendency to significance for lower-birth weight to be associated with a higher number of disease events; P = 0.08. Source of colostrum did not affect the number of disease events or the total number of days on treatment. Similarly, no significant association with calf mortality was found for colostrum source. Time to event analyses did not indicate any significant association between morbidity and mortality and any of the explanatory variables, including colostrum source. We concluded that colostrum source was not significantly associated with performance, health, and survival in this population of dairy calves.

Key words: colostrum source, calf, performance, health

Résumé

L'objectif était d'évaluer la performance avant sevrage, la santé et la survie de veaux nourris avec du colostrum frais de leur mère plutôt que du colostrum qui n'était pas de leur mère et qui avait été entreposé gelé ou réfrigéré. L'étude comportant un total de 182 veaux femelles Holstein nés entre juillet et août 2010 dans une ferme laitière du centre nord de la Floride. Les variables indépendantes incluaient la source de colostrum, le score ajusté de colostrum, la prise estimée totale d'IgG, le temps avant l'allaitement au colostrum et les protéines sériques totales des veaux en tant que mesure de l'absorption d'immunoglobulines du colostrum. Les co-facteurs incluaient le poids à la naissance et le rang de parité de la mère. Le gain moyen quotidien (GMQ) n'était pas affecté par la source de colostrum. Le nombre d'évènements de maladies était la seule variable négativement associée au GMQ (P = 0.001). Un faible poids à la naissance était marginalement associé à un plus grand nombre d'évènements de maladies (P = 0.08). La source de colostrum n'influençait pas le nombre d'évènements de maladies ou le nombre total de jour en traitement. La source n'influençait pas non plus le taux de mortalité des veaux. Selon des analyses du temps avant évènement, aucune des variables indépendantes n'était associée à la morbidité ou à la mortalité, incluant la source de colostrum. Nous concluons que la source de colostrum n'était pas associée à la performance, la santé et la survie dans cette population de veaux laitiers.

Introduction

Adequate colostrum feeding is the most important management factor determining calf health and survival.[12] Colostrum not only provides immunoglobulins, but is also an important source of nutrients, non-specific immune factors, and biologically active compounds, including maternal leukocytes and cytokines, insulin, IGF, and growth hormone, all of which protect the newborn calf against infectious disease in early life.[2,3,10,15] Several of the ingested hormones and growth factors have specific receptors localized in the mucosa of the small intestine and colon. Interestingly, the receptor numbers are influenced by early postnatal nutrition which, consequently, will affect gastrointestinal tract development in the calf.[2]

Colostrum storage is a common practice that provides a colostrum source when administration of dam colostrum is

impractical or when the quality of dam's colostrum is poor.[11] The most common methods of storage include refrigeration at 39°F (4°C) and freezing, and these practices have not been demonstrated to affect colostral IgG concentrations or serum IgG concentrations in neonatal calves.[6,9,11,14] Most studies analyzing the effect of storage on colostrum quality have centered on changes in IgG concentrations and general composition, but the effect of storage on other immunological factors remains unclear.[6,9,11] In a recent study, Ramirez-Santana et al[16] concluded that most bioactive immunological factors were retained in human colostrum after storage at 39°F (4°C) for 48 hours or freezing at -4°F (-20°C) or -112°F (-80°C) up to 6 months. However, long-term (12 mo) storage of frozen colostrum reduced the concentration of IgA, IL-8 chemokine, and TGF-B1.

The effect of variation in colostrum properties due to colostrum origin (dam vs non-dam) and preservation method on calf health and performance has not been extensively explored. Considering the potential role of non-immunoglobulin factors, our hypothesis was that dairy calves fed fresh colostrum from their dams would perform better than those receiving colostrum not from their dams that had been stored cold with preservative added. Consequently, the objective was to assess the preweaning performance (average daily weight gain), health (number of disease events, age at first disease event, and duration of treatment), and survival (and age at death) of heifer calves fed fresh colostrum from their dams compared to calves receiving colostrum that was not from their dam and had been treated with potassium sorbate preservative and stored frozen or refrigerated for up to 48 hours.

Materials and Methods

Study Animals, Farm Management, and Enrollment Procedures

Animal use and experimental procedures for this study were approved by the University of Florida Institutional Animal Care and Use Committee. This prospective cohort study was undertaken at a large north-central Florida dairy farm that maintains very accurate health records and clearly defined protocols for calf management. All female calves born between 6:00 AM and 4:00 PM from July 1 to August 31, 2010 were eligible for enrollment in the study. Calves were excluded from the study if they had any of the following conditions: born with physical deformities or as result of dystocia; were twins; weighed less than 66 lb (30 kg) or more than 110 lb (50 kg) at birth; or lived less than 48 hours. Newborn calves were removed from the dam immediately after birth, and colostrum was collected in a routine manner within 20 minutes of calving. After waiting 20 minutes, a colostrometer[a] was used on an aliquot of colostrum to estimate colostral immunoglobulin concentration. Because the colostrometer is designed to be used at 70°F (21°C) and colostrum in this study was approximately 90°F (32°C), a correction factor of +10 mg/mL was used to give an adjusted colostrum score (ACS).[13] All calves were fed 3.8 L of colostrum via esophageal feeder after the dam's ACS had been estimated.

Allocation of calves to colostrum source was made considering the farm calf management protocols that indicate heifer calves should be fed colostrum with an ACS ≥ 90 mg/mL. Consequently, this restriction was addressed at enrollment, and colostrum treatments were assigned by ACS of the dam of the calf as follows: 1) dam ACS ≥ 90 mg/mL: heifer received fresh colostrum from the dam; 2) dam ACS = 70 to 89 mg/mL: heifer received individually stored (refrigerated/frozen) ≥ 90 mg/mL colostrum. If the dam's ACS was not appropriate for the calf that was just born, stored colostrum (ACS ≥ 90 mg/mL) was placed in warm (120°F; 49°C) water for 15 minutes to bring the colostrum temperature up to 86°F (30°C) for feeding. Stored colostrum was maintained in 1.9 L containers and had potassium sorbate added (0.5% weight/volume) after assessment of ACS. In consequence, the 2 containers providing 3.8 L of colostrum may have originated from 2 different cows.

Calves were transported from the maternity facility twice daily and taken to the calf-rearing area of the farm. Heifers were housed in elevated stalls in an open-sided, mechanically-ventilated barn until weaning at about 60 days. Calves received milk (3.6 L) twice per day, and were fed 22% crude protein pelleted calf starter *ad libitum.*

Each calf was weighed at birth and again at 8 weeks of age. Disease events, defined as the presence of clinical signs of disease between birth and 60 days of age, were collected by calf-barn personnel and recorded in an on-farm computerized record system. Information consisted of disease diagnosis and date and duration of treatment, defined as number of days the calf was under treatment. Farm personnel from the calf-rearing unit were trained by the investigators using standardized diagnostic-treatment protocols to recognize and treat the most common calfhood diseases. Diagnostic skills of farm personnel were monitored closely by the investigators, and feedback was provided by assisting in diagnosis and treatment on a weekly basis. Diagnoses were also confirmed by performing necropsies on all calves that died (by the farm veterinarian or 1 of the authors). A blood sample was collected on day 4 ± 1 of age on all calves for serum total protein (STP) determination as a measure of colostral immunoglobulin absorption.

Outcome and Explanatory Variables

Main outcome variables were average daily weight gain (ADG) from birth to weaning, disease incidence (including number of days on treatment and age at first disease event), and death occurrence and age of death up to 60 days of life. The main explanatory variable of interest was colostrum source: fresh maternal vs stored and preserved from non-dams (refrigerated/frozen). Other explanatory variables included ACS (mg/mL), total estimated IgG intake, defined as the total IgG (g) provided by the colostrum (in the case of stored colostrum the average value for the two 1.9 L contain-

ers), time to colostrum feeding (minutes), and calf STP (g/dL). Control variables included birth weight (lb/kg) and dam parity number, as these are factors that could affect colostrum composition and health outcomes.

To facilitate the analyses, some continuous variables were categorized after examination of data distribution through the use of histograms and descriptive statistics (e.g., means, medians, and standard deviations). Variables were categorized as follows: adjusted colostrum score 90 to 120 mg/mL (medium), > 120 mg/mL (high); total estimated IgG intake < 490 g (low), 490 to 627 g (medium), > 627 g (high); time to colostrum feeding < 55 m (prompt), > 54 m (delayed); serum total protein < 5.50 g/dL (low), > 5.49 g/dL (high); birth weight < 83.6 lb (< 38 kg; low), 83.6 to 92.4 lb (38 to 42 kg; medium) > 92.4 lb (> 42 kg; high); dam parity primiparae, multiparae; and total days on treatment < 11 d (low), 11 to 17 d (medium), > 17 d (high).

Statistical Analysis

Continuous data were analyzed by multivariable linear regression and by analysis of variance (PROC GLM, SAS[b]). Considering the defined period at risk (birth to 60 days of life) and the binary nature of the outcome variables, logistic regression was used for the analyses of disease occurrence and death, and generalized linear models were fitted to the data. Categorical data were initially analyzed by chi-squared test (PROC FREQ) followed by multivariable logistic regression (PROC GLIMMIX, SAS) using generalized estimating equations for categorical responses. Time to event analyses were performed to test the association between interest variables and the time from birth to the first disease event and death (PROC LIFETEST and PROC PHREG, SAS). Covariates and interactions were considered when $P \leq 0.10$. Statistical significance for results was set at $P \leq 0.05$ and tendencies were declared at $P < 0.10$.

Results

A total of 182 heifer calves were included in the study, with 104, 17, and 61 calves receiving dam, frozen, and refrigerated colostrum, respectively. The average ACS was 104, 105, and 103 mg/dL for colostrum from dams, frozen, and refrigerated, respectively. The statistical analysis indicated that colostrum quality (ACS) was not significantly different between treatment groups. Overall, 46.1% of calves did not require any treatment from birth to 60 days of age; 50.0%, 3.9%, and 0% of the population received 1, 2, or 3 treatments, respectively. The most common disease event diagnosed was respiratory disease (47.2% of treated calves), followed by otitis media (35.1%), and diarrhea (9.2%). The distribution of the most common diagnoses for the first disease event was respiratory disease (46.9% of diagnoses), otitis media (36.7%), and diarrhea (10.2%).

Mortality from calving to 60 days was 4.4%, with the main causes of death being septicemia and clostridial infection, accounting for 44.4% and 22.2 % of the losses, respectively.

Average daily gain from birth to weaning was 1.23 ± 0.35 lb (0.56 ± 0.16 kg)/day; this parameter was not affected by colostrum source. Number of disease events was the only variable showing a significant negative association with ADG ($P = 0.001$), with a tendency to significance for birth weight (lower birth weight associated with a higher number of disease events; $P = 0.08$). The averages for days to the first disease event, number of disease events, and days from birth to death by colostrum origin are presented in Table 1. No association was found between source of colostrum and number of disease events or number of days on treatment. Similarly, calf mortality was not associated with colostrum source. Adjusted colostrum score, total estimated IgG intake, and time to colostrum feeding was not significantly associated with any outcomes under analysis. Similarly, calf STP was not associated with performance, health, or survival. Likewise, the test for homogeneity of survival curves in the time to event analyses indicated that none of the proposed explanatory variables had a significant association with time to the first disease event and time to death (Figure 1).

Discussion

A significant proportion of the enrolled calves were affected by at least 1 disease event before weaning. The incidence of respiratory disease was high compared to previous reports. On a survey of US dairy calf ranches, Walker et al[23] reported that respiratory disease was experienced by 9.0% of calves, with the median operation reporting 5.3% respiratory morbidity. In another recent study, 22% of calves were treated at least once for respiratory disease from the second to the

Table 1. Average days to the first disease event, proportion of calves affected, average number of disease events, days on treatment, average days to death, and proportion of calves that died by colostrum origin (n=182).

	Maternal	Frozen	Refrigerated
First disease event d	34	36	40
Proportion of calves with at least 1 disease event	58/104	10/17	30/61
Number disease events	1.0	1.0	1.1
Total d on treatment	7	6	6
Age at death (d)	11	11	42
Proportion of calves that died	5/104	2/17	1/61

12th week of life.[25] Prospective estimates for US dairy heifer calves found that 8.9% experienced respiratory disease in the first 8 weeks of life, whereas other studies have suggested that between 7.6% and 21% of heifer calves experience respiratory disease.[8,18,19] Otitis media had a high presentation in this trial; previous estimates for morbidity ranged from 1% to as high as 80% in individually housed calves.[24] *Mycoplasma bovis*, which in addition to causing mastitis in cattle occasionally causes pneumonia, otitis media, or arthritis in calves, has been reported as the main contributor to otitis media in this particular herd.[4,5,24] Other causative agents include *Histophilus somni*, *Pasteurella multocida*, *Streptococcus* spp, and *Trueperella* spp.[5,24] On the other hand, diarrhea incidence was in the low range of reported values. On calf ranches, diarrhea was experienced by 18% of calves and the median operation reported 20% diarrhea morbidity.[23] Cross-sectional studies of preweaned heifer calves on US dairy operations reported diarrhea morbidity of 23.9%.[21] Others have reported diarrhea morbidity of 15.2% in heifer calves up to 16 weeks of age and 35% up to 6 months of age.[8,18] The present trial was performed during summer in Florida, a period of elevated thermal stress for calves, which may explain in part the high levels of disease in the study. These specific conditions may limit the external validity of the study results.

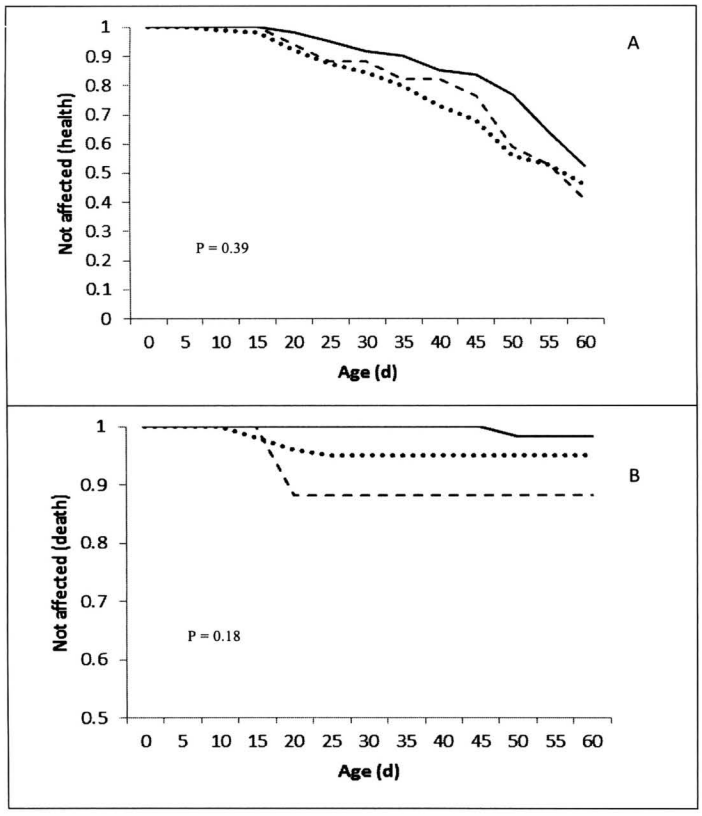

Figure 1. Survival curves for the interval from birth to the first disease event (A) and death up to 60 d (B) by colostrum source. Maternal (. . . .); refrigerated (___); frozen (---).

The level of mortality in this study was within ranges previously reported for heifer calves. A survey of US dairy calf ranches by Walker et al[23] found the overall operation-level median preweaning mortality to be 3.6%. Virtala et al[22] reported mortality incidence for NY operations similar to the present study (4.3% herd-specific median crude mortality), and the estimated mortality for heifer calves on US dairy operations in 2006 reached 7.8%.[20]

Values for ADG in the present study fall within ranges reported in a previous meta-analysis where it was concluded that the ADG was not significantly affected by colostrum source.[1] Our results indicated that ADG was significantly associated with number of disease events, with a tendency to significance for birth weight. In partial agreement with our results, Bateman II et al[1] reported decreased ADG in calves with high body weight at birth and in calves that had been sick. Similarly, Donovan et al[7] reported that the number of days on treatment had a negative effect on ADG.

Contrary to previous reports indicating an association between STP and health and survival, the number of disease events, days on treatment, and mortality level in this study were not affected by this parameter.[7,17] A possible explanation for absence of a significant association is the low proportion of calves showing a failure of passive transfer; only 4 calves had STP below 5.5 g/dL. Likewise, different levels of ACS, IgG intake, and time to colostrum feeding were not associated with outcomes in this study. Again, values for these variables were within acceptable ranges. Relevant to this study, no association was found between colostrum source, disease occurrence, and survival.

A limitation in the present study was that a completely random assignation of calves to colostrum treatment was not possible due to farm management restrictions. A proportion of cows calving during the study had colostrum quality below the farm's acceptable threshold ACS of 90 mg/mL for first-feeding heifers. It could be hypothesized that production of lower-quality colostrum could relate to suboptimal cow condition during gestation, and consequently calves born to these cows may have been compromised during gestation. However, our results in favor of the null hypothesis suggested that lack of randomization of calves had no effect on the study outcomes. It should also be noted that the moderate sample size in this study may be in part responsible for our failure to reject the null hypothesis.

Conclusions

We concluded that colostrum origin (fresh maternal vs stored from non-dams) was not significantly associated with preweaned calf performance, health, and survival in this population. This is a significant finding for dairy producers, as it simplifies colostrum management. Based on results of

this study, there is no need for prioritizing the use of maternal colostrum for calves, which may delay colostrum delivery to the newborn. Instead, colostrum can be collected and stored so that it is readily available for prompt feeding after birth.

Endnotes

[a]Colostrometer™, Biogenics, OR
[b]SAS Inst. Inc., Cary, NC; release 9.3

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