Scientific Research Publishing

Open Journal of Animal Sciences, 2022, 12, 712-720
https://www.scirp.org/journal/ojas
ISSN Online: 2161-7627
ISSN Print: 2161-7597

Colostrum Supplementation as an Aid for Improving Health and Growth Performance of Preweaned Holstein Dairy Calves

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How to cite this paper: Constantin, G. and Mihaela, R. (2022) Colostrum Supplementation as an Aid for Improving Health and Growth Performance of Preweaned Holstein Dairy Calves. *Open Journal of Animal Sciences*, **12**, 712-720.
https://doi.org/10.4236/ojas.2022.124049

Received: July 22, 2022
Accepted: October 23, 2022
Published: October 26, 2022

Abstract

The adjective of this study was to determine the effect of partial replacement of whole milk with second- and third-milking colostrum on the health status and growth performance of preweaned Holstein dairy calves. A minimum of 110 calves of 2 - 3 days old Holstein Friesian calves were enrolled and randomly allocated to two treatment groups 1) CS—colostrum supplement group and 2) UC—unsupplemented control group. The CS group of calves received pooled second and third milking colostrum with Brix reading between 19 and 24% (mean 21.8% ± 1.75%) as colostrum supplement (one liter mixed with 3 L of whole milk), and UC group of calves received 4 L of whole milk in each of the 2 daily meals for 14 days. Serum IgG levels were determined to evaluate passive transfer of immunity. Milk and grain consumption was recorded for 28 days by research personnel. All calves were weighted at entry of the trial, at 28 days and at weaning (65 days). Calves receiving supplemental colostrum had less diarrhea and respiratory disease than control calves. Also, the results indicated that health problems were associated with low serum IgG levels and low-weight calves. Grain consumption and average daily gain (ADG) over 28 days of life were greater in CS group of calves compared with UC group of calves. Colostrum supplementation during the first 14 days of life in calves was effective in reading diarrheal and bovine respiratory diseases and in the use of antimicrobials. Further studies are needed to identify the molecular mechanisms involved in beneficial effects of colostrum supplementation on calf growth and health.

Keywords

Colostrum, Dairy Calf, Diarrhea, Bovine Respiratory Disease

1. Introduction

Bovine colostrum contains nutrients, and several bioactive compounds includ-

ing immunoglobulins, bioactive peptides, lactoferrin, oligosaccharides, hormones growth factors, and immune related microRNA which play critical roles in the health and development of the calf [1] [2] [3]. Early feeding of colostrum is essential because of the progressive decline in the uptake of immunoglobulin (large molecule of IgG, IgA and IgM), during the first days of life due to gut closure [4].

There are concerns that prophylactic uses of antimicrobial drugs in food animal production increase antimicrobial, resistance with potential adverse effects on human health [5] [6].

Dairy animal industries are being encouraged to reduce the use of all types of antimicrobial drugs, to find new alternatives for therapeutic needs, and to optimize animal health through management approaches [7].

One area of focus in dairy farms is calves being reared as dairy heifers' replacements or as calves for beef. Successfully rearing these animals is to ensure adequate intake of colostrum. At birth, calves have an immature immune system, and need a passive transfer of immunity from their dams through colostrum until their own active immune system develops [8]. Passive immunity must be acquired by calves through the ingestion and absorption of antibodies (predominantly IgG) found in colostrum. Successfully acquiring passive immunity is influenced by a number of factors, which include the IgG content of colostrum, timing of feeding as well as the volume provided [9].

Extended feeding of colostrum during the first 2 weeks of life can be beneficial to dairy calves. Chamarro *et al.* (2017) [10] reported that feeding milk replacer enriched with 150 g of colostrum powder during the first 2 weeks of life did not increase body weight or average daily gain, but reduced the occurrence of abnormal feces, abnormal respiration and antibiotic treatment before weaning period. Jones *et al.* (2004) reported higher feed efficiency and a tendency to gain more BW in calves receiving IgG via maternal colostrum compared with calves that received the same amount via colostrum substitute in the first week of life. Similar to colostrum, transition milk contains an abundance of bioactive compounds [11] [12]. The transition milk may be an alternative to colostrum for feeding calves when extra colostrum is unavailable.

There is evidence that antibodies remaining in the gut lumen also provide local immunity and may enhance intestinal villus development [13] [14]. We hypothesized that extended colostrum feeding is beneficial to calves in the preweaning period.

The objective of this study was to evaluate the effect of colostrum supplementation as an aid for improving health status, and growth performance in the preweaning period of Holstein dairy calves.

2. Materials and Methods

2.1. Study Herd

This study was done in the research dairy farm of Agricultural research and De-

velopment Station (ARDS) Simnic, Craiova, Romania. The experiments were performed in compliance with European Union Directive 86/609/Ec on Holstein Friesian dairy calves. The research dairy farm has a 140-cow milking herd. Experiments were conducted from January 2019 to December 2020. Calves were individually housed in clean, sanitized wooden hutches, arranged in rows of 12 hutches.

All cows were milked twice a day.

2.2. Colostrum Collection and Handling

Fresh cows were moved to milking area within 2 hours of calving. Cow preparation was identical to routine parlor practices. Milking equipment was sanitized between cows and milking. All milked colostrum was put into an ice bath after dumping from collection pail. Fresh maternal colostrum is fed within one-half hour after it is harvested. Fresh maternal first-milking colostrum with Brix reading 25% or higher is fed on its own, and with Brix reading between 18% - 24% is supplemented with colostrum powder.

In this form, first-milking colostrum is used to make the high-quality colostrum and second- and third-milking colostrum from older cows was used as colostrum supplement in this study. The second- and third-milking colostrum was refrigerated in clean sanitized self-sealing plastic bags. We fill a 3 L size bags with just one liter (L) of colostrum. Then, when these are frozen laid flat in the freezer, they are thin and throw quickly.

Please do not revise any of the current designations.

2.3. Study Design and a Farm Procedure

Sample size for a significant difference among the two groups of calves estimated for multiple comparisons at a power of 95% and alpha of 0.5 and a minimal detectable difference, resulted in a simple size of 50 calves per group. Adding an additional 10% to account for attrition, the total sample size of 55 calves per group was estimated. A minimum of 110 calves of 2 - 3 days old Holstein Friesian calves were enrolled and randomly allocated to two treatment groups: 1) colostrum supplement (CS group 1) and 2) unsupplemented control (UC group 2). The CS group received pooled second- and third-milking colostrum with Brix reading between 19% and 24% (mean 21.8% ± 1.75%) as colostrum supplement (one liter mixed with 3 L of whole milk) and UC group received 4 L of whole milk, (no addition of colostrum supplement) in each of the 2 daily meals for 14 days. Research personnel were in charge of all feedings.

Calves were each evaluated daily by research personnel blinded to calf treatment group [7]. Calves were evaluated for morbidity, which included fecal consistency hydration and respiratory scores using WI bovine respiratory disease clinical scoring system, summarized in **Table 1** [15].

A member of the research team entering the hutch to measure the calf's body temperature and manipulate the calf's larynx to determine if a cough can be

Table 1. Summary of the scoring system for bovine respiratory disease (BRD) designed at the University of Wisconsin. Clinical signs scored "0" are considered to be clinically normal.

Signs	Score*:			
	0	1	2	3
Cough	None	Single induce	Multiple induced. Few occasional spontaneous	Multiple spontaneous
Nasal discharge	None	Small amount of unilateral cloudy discharge	Bilateral cloudy or excessive, mucus discharge	Copious bilateral mucopurulent discharge
Ocular discharge	None	Small amount of ocular discharge	Moderate amount of bilateral discharge	Heavy ocular discharge
Ear and heat carriage	Normal carriage	ear flick or head shake	Slight unilateral droop	Head tilt or bilateral droop
Rectal temperature ˚C	38.2	38.3 - 38.8	38.9 - 39.3	≥39.4

*Add scores for all clinical signs, if total score is ≥ 5 calf maybe positive for BRD.

induce. Calves suspected to have BRD (score ≥ 5) were classified as clinically positive for BRD.

Diarrheal disease was defined as watery and/or bloody feces. All treatments in the first 28 days were performed and recorded by research personnel, based on farm treatment protocols.

All calves we weighted on a mechanical scale at entry into the trial, at entry into the trial, at 28 days, and at wearing (65 days). Also, blood samples from all calves were collected at entry into the trial to evaluate passive transfer of immunity status. Serum Ig G levels were determined using a commercial radial immune diffusion assay (Immuno-check).

Milk and grain consumption was recorded for 28 day by research personnel. After 28 days management of the calves was taken over by dairy farm personnel. Research personnel returned to measure wearing weight.

2.4. Data Analysis

Health and treatment data were recorded in a spreadsheet Excel program and analyzed using statistical software program. Ninety percent confidence intervals were calculate for main effects estimates. Interactions between main effects were also tested.

Passive transfer of immunity

Passive transfer of immunity status was classified as partial failure of passive transfer (PFPT) for values of IgG from 351 to 999 mg/dl, and adequate passive transfer (APT) for IgG ≥ 1000 mg/dl [7].

Initial weight

Calf weights taken when the calves enter in the trial were classified as law for

weights ≤ 37.5 kg, mid for weights between 37.6 and 43.9 kg and high weight s ≥ 44 kg.

Mortality

Mortality in calves during the first 28 days was evaluated using univariate Kaplan-Meyer survival plots [7].

Hazard rate ratio and 90% confidence intervals for the main effect (treatment group) and covariate (weight category and serum IgG category), were determined.

Morbidity

The percentage of days that the calves had diarrhea and were treated for diarrhea was calculated. Treatment group was the main effect evaluated, confounding variables included: calf initial weight category and calf IgG category. The days to first antimicrobial treatment for diarrhea conditional on treatment group, including the same confounding variable, was evaluated. Also, difference in respiratory morbidity between treatment groups was assessed for trend.

Average daily gain (ADG) and Grain intake

The least squares means were calculated and used to compare treatment differences in ADG up to 28 days of age and at weaning (65 days). Grain consumption was measured daily for 28 days and the average daily intake was calculated. The same main effect and covariate set were used to evaluate ADG and grain intake.

3. Results

This trial included 110 calves (55 in CS group and 55 in UC group).

Passive transfer of immunity status in the study calves was 15.45% (n = 17) and 84.55% (n = 93) in IgG categories PFPT and APT respectively (Table 2). Initial weight categories were 25.45%, 45.45% and 29.10% for low, mid and high respectively (Table 2).

Mortality

Mortality rate over the first 28 days of the trial were 5.45% and 7.24% in CS and UC groups (no significant influence of colostrum supplement on mortality).

Table 2. Descriptive statistics of serum IgG category and initial weights in the two groups evaluating the efficacy of feeding maternal colostrum supplement in whole milk for 14 days to preweaned calves.

Treatment group[1]	Serum IgG mg/dl		IgG category[2], n (n dead)			Initial weight, kg		Weight category[3], n		
	Mean	SD	Total	APT	PFPT	Mean	SD	Low	Mid	High
CS	1180	990	55 (3)	47 (1)	8 (2)	41.7	4.7	10	25	20
UC	1188	992	55 (4)	46 (1)	9 (3)	42	5.2	18	25	12
TOTAL	1182	990	110 (7)	93 (2)	17 (5)	41.8	5.1	28	50	32

[1]CS = Colostrum supplement, UC = unsupplement control; [2]APT = adequate passive transfer: IgG ≥ 1000 mg/dl, PFTP = partial failure of passive transfer. IgG between 555 and 999 mg/dl; [3]Low ≤ 37.5 kg; mid between 37.6 and 43.9 kg; high ≥ 44 kg.

Mortality percent in PFPT IgG category was 29.4%, compared with 2.1% in APT IgG category. Overall mortality percent was 6.36%. The hazard of dying calves with PFPT IgG category was 14 times greater than in calves with APT IgG category (data not shown).

Morbidity

Over the 28 days period, the overall percentage of days that diarrhea was observed was 10.9%. The colostrum supplemented group having the low percentage of diarrhea days (8.1% versus 13.7% for UC group).

Percentage of diarrhea days (8.1% versus 13.7% for UC group).

Calves with PFPT had increased risk for diarrhea compared with calves with APT. Low- and mid-weight calves also tended to have greater risk for diarrhea than high weight calves. All calves were treated with antimicrobials for approximately 12% of the total study calf-days.

The risk for being treated antimicrobials was increased for low-weight calves (compared with high-weight calves). Also for calves with PFPT the risk for being treated with antimicrobials was increased (compared with APT calves). Bovine respiration disease was present in 1.24% of the observation calf-days (Table 3).

ADG and grain intake

A greater ADG to 28 days of age was 0.250 g for CS group of calves compared with 0.230 g for UC group of calves (Table 4).

Table 3. Descriptive statics of total calf study calf days (total days), number (%) of days calves observed with diarrhea and respiratory disease, number (%) of days calves treated with antimicrobials (treatment days) by treatment group evaluating the efficacy of feeding a colostrum supplement in whole milk for 14 days to preweaned calves.

Treatment group[1]	Diarrhea		Resp days n (%)	Treatment days (%)
	Total study calf-days	Days, n (%)		
CS	1494	122 (8.1)	15 (1.0)	137 (9.2)
UC	1478	202 (13.7)	22 (1.5)	224 (15.1)
TOTAL	2972	324 (10.9)	37 (1.24)	361 (12.1)

[1]CS = colostrum supplement; UC = unsupplement control.

Table 4. Descriptive statistics of ADG, and average grain and milk intake by treatment group evaluating the efficacy of feeding a colostrum supplement in whole milk for 14 days to preweaned calves.

Treatment group[1]	ADG kg				Daily feed consumption at 28 days of age	
	Day 28		Day 65			
	mean	SD	mean	SD	kg	L
CS	0.250	0.18	0.500	0.2	0.211	4
UC	0.230	0.17	0.460	0.17	0.200	4
Total	0.240	0.15	0.420	0.18	0.205	4

[1]CS = colostrum supplement; UC = unsupplement control.

The average daily grain intake for the first 28 days was greater in CS group of calves (0.211 kg versus 0.200 kg), compared with UC group of calves. Low-weight calves had grater ADG compared with high-weight calves (results not shown). Calves with PFPT had lower ADG compared with APT calves. At weaning (65 days) the factors affecting ADG were IgG status.

- *Passive transfer of Immunity*

The majority of calves in this study had APT (84.5%). PFPT was an important predictor of mortality and morbidity. Improved nutrient intake has been associated with improved immune function [16]. Berger *et al.* (2009) [7] reported similar results to the current study.

- *Morbidity*

Colostrum supplement added to whole milk for the first 14 days of life reduced the number of days the calves had diarrhea and decrease the use of antimicrobial treatment. This effect was due to the presence of colostrum immunoglobulins. Extended colostrum feeding reduces the susceptibility to diarrhea and bovine respiratory disease, stimulating morphological growth and functional maturation of the gastrointestinal tract [14] [17] and promotes the establishment of beneficial bacteria [18] [19] [20].

- *Mortality*

There was no difference in mortality between the treatment groups. The most important factor associate with mortality was PFPT [7].

- *ADG and Grain consumption*

The early ADG (by 28 days) difference for CS calves may be due to additional nutrients from colostrum supplement [21] and the observed increased grain consumption in this group. Disease causing inflammation resulting in the release of cytokines can activate homeorhetic responses to direct nutrients from tissue deposition toward immunologic defense function [22].

In low-weight calves, ADG was greater because these calves received more milk per kilogram of body weight (BW) than heavier calves.

4. Conclusions

Colostrum supplementation during 14 days of life in calves was effective in reducing diarrheal disease and bovine respiratory disease and the use of antimicrobials.

The ADG up to 28 days of age in colostrums-supplemented calves was greater compared with that in control calves because of the combination of greater energy intake from liquid feed, increased grain intake and fewer days with diarrhea.

Further studies are needed to identify the molecular mechanisms involved in beneficial effects of colostrum supplementation on calf growth and health.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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