Research Article

The Effect of Colostrum Feeding Quantities on Calf Immunity and Health

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Abstract | This study aimed to investigate the impact of colostrum feeding quantity on the immunity and health of crossbred Holstein Friesian calves. Fifteen calves were divided randomly into three groups (A, B, and C) and given 3, 3.5, and 4 liters of colostrum, respectively, within 30 minutes of birth. After the colostrum feeding, the calves were fed a calf starter ration and milk for 55 days. The study found that the group C calves, which received 4 liters of colostrum, had higher body weight, average daily weight gain, and total weight gain than groups A and B. Additionally, the total feed intake, average daily feed intake, total serum protein, and serum antibody IgG levels of group C were also higher than those of groups B and A. The study also found that two calves in group A, one calf in group B, and one calf in group C had health issues such as diarrhea and pneumonia. The findings suggest that providing 4 liters of colostrum to crossbred Holstein Friesian calves within 30 minutes of birth can improve their immunity and health. This study provides evidence for farmers to consider increasing colostrum feeding quantity in their management practices to improve the health and growth performance of their calves. Information aids farmers raising crossbred Holstein Friesian calves; cut vet expenses, boost calf productivity, and increase profitability. Overall, this study highlights the importance of adequate colostrum feeding in the early life of calves, which has significant implications for their long-term growth and development.

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Introduction

Dairy calves do not develop immunity until they reach adulthood, as there is no transfer of immunoglobulins across the placenta from the dam to the fetus (Cortese, 2009). This means that newborn immunity must be passively acquired by calves via the intake of colostral IgG (Baumrucker *et al*., 2010). Control of colostrum is the single most relevant factor of management for evaluating calf survival and wellbeing (Godden *et al*., 2009). The percentage of dairy calves that are passively failing immunoglobulin transfer (FPT) from colostrum is derived, contributing to disproportionately high mortality until weaning, in addition to other pertinent losses in the short and long term, rates of health, protection, and efficiency of the animals are all important considerations. Proper colostrum management would enable manufacturers to ensure that, in the first few hours of life, calves regularly have ample amounts of clean, high-quality colostrum (Chigerwe *et al*., 2008; McGuirk and Collins, 2004). Since high concentrations of FPT (serum IgG 10.0 mg/ml) have been recorded in calves left to suckle the dam, the methods of feeding colostrum can influence the time to first feeding, volume consumed, and likely pathogen exposure, all of which can affect passive transfer of IgG and calf health (Besser et al., 2020). Within 1 to 2 hours of birth, the calf should be separated from the dam and fed a known volume of clean colostrum through a nipple bottle or esophageal feeder (McGuirk *et al*., 2004). Several weeks before parturition, the colostrogenesis process takes place, which regulates the release of immunoglobulins from the bloodstream to the dam's mammary secretions during that period (Barrington *et al*., 2001). Passive transfer failure is a condition that predisposes a newborn to the development of disease syndromes (PTF) (Gelsinger et al., 2021). To ensure the health and well-being of the newborn calf, it is important to have a sufficient amount of high-quality colostrum (Weaver *et al*., 2000). Since the bovine placenta separates the flow of maternal and fetal blood, the calf must absorb colostrum to gain adequate immunity and defense from pathogenic species after 3 to 4 weeks of self-immunization at the age of (Godden, 2008). Calves are usually fed and managed in two phases: the calf phase and the weaning stage, which includes calves born between 60 and 180 days. In these two phases, the calf's body organs have not fully engaged, the body's defense system is not yet fully functional, and disease resistance is poor (Huang *et al*., 2017). Colostrum is a nutritionally essential byproduct of the mammary glands metabolic byproducts generated during the prepartum period. Colostrum is one of the most important nutrients for increasing the chances of survival (Furman *et al*., 2011). All of these components have more volume in the first milked colostrum and gradually decrease in volume over the next six milking components (transition milk). The nutrients in colostrum are normally less concentrated in whole milk (Hill et al., 2017). It would be simple to monitor using a colostrometer. Although a blood test is required to determine if immunity is passed on passively (Vasseur *et al*., 2010). Most of the research has concentrated on the effects of dietary and management strategies on colostrum quality in beef cows during their dry period (McGee *et al*., 2006). The effects of these strategies on the dairy cows progeny, however, are scarcely known (Nowak *et al*., 2012). Due to the fact that dairy cows face different metabolic challenges during the peripartum period than beef cows (Mann *et al*., 2016), it is important to conduct further research to determine the optimal strategies for improving colostrum quality in dairy cows. Several factors can affect colostrum quality in dairy cows, including the cow's nutrition and health status during the prepartum period, as well as the timing and method of colostrum collection and feeding (Baumrucker *et al*., 2010). Feeding a balanced diet during the prepartum period can help ensure that the cow has adequate nutrient reserves to support colostrogenesis and produce high-quality colostrum (Bach *et al*., 2018). Additionally, managing the cow's health during the prepartum period can help reduce the risk of intramammary infections, which can negatively impact colostrum quality (Reinhardt *et al*., 2011). Timing and method of colostrum collection and feeding are also important factors in ensuring high-quality colostrum for dairy calves. Collecting colostrum within the first few hours after calving can help ensure that the calf receives sufficient levels of immunoglobulins (McGuirk et al., 2014). Using a clean collection method and storing colostrum properly can help reduce the risk of bacterial contamination and spoilage (Gelsinger et al., 2015). Feeding colostrum via a nipple bottle or esophageal feeder can help ensure that the calf consumes an adequate volume of colostrum, which is important for passive transfer of immunoglobulins (Godden *et al*., 2009).

Materials and Methods

Study location and duration

The experiment was conducted at Dairy Land Private Limited in Peshawar, and the Veterinary Research Institute's Microbiology Laboratory was used for laboratory tests. The duration of the study was 55 days.

Animal selection and grouping

Male crossbreed Holstein Friesian calves (n=15) were randomly selected and divided into three groups (A, B, and C) of five calves each. Each calf in each group was fed a specific amount of colostrum via an esophageal tube (Table 1). Ear tags were used to identify the calves.

Table 1: *Experimental design.*

Groups	Colostrum feeding quantity
A	3L/calf
B	3.5L/calf
C	4L/calf

Housing and bedding

The initial body weight of each calf was determined using a digital weighing balance prior to colostrum feeding. All the calves were housed in a cage system with rubber ped bedding. Throughout the study, all calves received the same bedding and housing.

Colostrum feeding

Each calf received colostrum through an esophageal tube within thirty minutes of birth, as per the suggested experimental plan (Table 1).

Blood collection

After 24 hours of feeding the first colostrum, blood samples (5ml) were taken from each calf in each group. The samples were taken directly from the jugular vein and placed in a vacutainer before being transported to the Microbiology lab to be tested for IgG levels using a radio immune assay.

Feeding of calves

From the second to the 55th day of the study, calves were fed calf starter (Vanda) up to 1 kilogram as well as milk at 10% body weight.

Parameters measured

The following parameters were recorded: total serum protein brix refractometer (mg/dl), IgG through radio-immune essay (mg/dl), feed intake, weight gain (g), and incidence of diarrhea and pneumonia.

Total serum protein brix refractometer (mg/dl)

Total protein concentrations were determined by the enzymatic kit Proteinas Totais - Ref. 99, by end-point spectrophotometry, with an absorbance filter of 540 nm.

Radial immunodiffusion test

Anti-IgG antibody was dissolved in an agarose gel for radial immunodiffusion testing. Samples were pipetted into small wells punched in the gel and allowed to precipitate. The diameter of the rings produced by antibody complex precipitation was calculated and compared to the size rings formed by known concentrations of IgG. This method has been found effective for bovine serum IgG (Chelack *et al*., 1993).

Statistical analysis

All data were collected and analyzed using a one-way ANOVA test with statistical software Statistic version 8.1.

Results and Discussion

Body weight (kg) of crossbred Holstein calves supplemented with various colostrum feeding quantity

The effect of various levels of colostrum feeding on average body weight (kg) of crossbred Holstein calves is determined, and the results are described in Table 2. The average body weight of crossbred Holstein calves in groups A, B, and C was 30.7kg, 30.6, and 30.8 kg, respectively from the 13th to the 55th day of the trial, the average body weight of crossbred Holstein calves increased significantly in both classes (A, B and C). Calves in group C gained more body weight (60.9 kg) than calves in groups B (56.16kg) and A (54.1kg).

Table 2: *Average body weight (kg) of crossbred Holstein Friesian calves supplemented with various colostrum feeding quantity.*

Groups	Initial	13th day	26th day	39th day	55th day
A (3-liter colostrum/calf)	30.7±0.28[a]	33.98±0.335[b]	39.5±0.32[b]	45.8±0.36[b]	54.1±0.45[c]
B (3.5-liter colostrum/calf)	30.6±0.18[a]	34.1±0.24[b]	39.7±0.23[b]	46.6±0.22[b]	56.1±0.25[b]
C (4-liter colostrum/calf)	30.8±0.27[a]	36.6±0.53[a]	43.1±0.57[a]	50.5±0.56[a]	60.9±0.56[a]
LSD @ 0.05	0.76	1.19	1.24	1.23	1.36
SE±	0.349	0.55	0.57	0.56	0.62

Average daily weight gain (g) and total weight gain (kg) of crossbred Holstein calves supplemented with various colostrum feeding quantity

Table 3 shows the effects of colostrum feeding at different levels on average daily weight gain (g) and total weight gain (kg) in crossbred Holstein calves. Group C (546 g) had a higher average daily weight gain than groups B (466g) and A (426 g) of crossbred Holstein calves. However, group C (30.04kg) had a higher average overall weight gain than groups B (25.5kg) and A (23.4 kg) of crossbred Holstein calves.

Table 3: *Average daily weight gain (g) and total weight gain (kg) of crossbred Holstein Friesian calves supplemented with various colostrum feeding quantity.*

Groups	Daily weight gain (g)	Total weight gain (kg)
A (3-liter colostrum/calf)	426±0.004^{c}	23.41±0.197^{c}
B (3.5-liter colostrum/calf)	466±0.002^{b}	25.51±0.115^{b}
C (4-liter colostrum/calf)	546±0.008^{a}	30.04±0.400^{a}
SE±	0.0059	0.38
LSD @ 0.05	0.0167	0.821

Feed intake (kg) of crossbred Holstein calves supplemented with various colostrum feeding quantity

Table 4 shows the effects of different levels of colostrum feeding on average feed intake (kg) of crossbred Holstein calves. From the 13th to the 55 th day of the trial, the total feed intake of crossbred Holstein calves in all groups increased significantly (A, B and C). Group C calves consumed the most feed (10.87 kg), followed by groups B (10.05 kg) and A (8.81 kg).

Table 4: *Average feed intake (kg) of crossbred Holstein Friesian calves supplemented with various colostrum feeding quantity.*

Groups	13th day	26th day	39th day	55th day
A (3-liter colostrum/calf)	3.25±.040^{c}	3.88± 0.021^{c}	5.17± 0.018^{c}	8.81± 0.022^{c}
B (3.5-liter colostrum/calf)	3.75±.010^{b}	4.21± 0.033^{b}	5.82± 0.012^{b}	10.05± 0.048^{b}
C (4-liter colostrum/calf)	3.89±.022^{a}	4.79± 0.021^{a}	6.46± 0.015^{a}	10.82± 0.023^{a}
LSD @ 0.05	0.084	0.081	0.048	0.104
SE±	0.039	0.037	0.022	0.048

Average daily feed intake (g) and total feed intake (kg) of crossbred Holstein calves supplemented with various colostrum feeding quantity

Table 5 shows the effects of different levels of colostrum feeding on average daily feed intake (g) and total feed intake (kg) of crossbred Holstein calves. Group C (470g) had a higher average daily feed intake than groups B (432g) and A (384g) of crossbred Holstein calves. However, group C (25.95kg) had a higher average total feed intake than groups B (23.8kg) and A (21.1 kg) of crossbred Holstein calves.

Table 5: *Average daily feed intake (g) and total feed intake (kg) of crossbred Holstein Friesian calves supplemented with various colostrum feeding quantity.*

Groups	Daily feed intake (g)	Total feed intake (kg)
A (3-liter colostrum/calf)	384±0.004^{c}	21.1±0.071^{c}
B (3.5-liter colostrum/calf)	432±0.002^{b}	23.8±0.068^{b}
C (4-liter colostrum/calf)	470±0.000^{a}	25.95±0.049^{a}
LSD @ 0.05	0.0049	0.196
SE±	0.0016	0.085

Total serum protein (mg/dl) and serum IgG (mg/dl) of crossbred holstein friesian calves

Table 6 shows the effects of different levels of colostrum feeding on total serum protein and serum IgG concentrations in crossbred Holstein calves. Total serum protein levels in crossbred Holstein calves were higher in group C (9.78 mg/dl) than in groups B (8.26mg/dl) and A (7.16 mg/dl). However, overall serum IgG levels in crossbred Holstein calves were higher in group C (16.5 mg/dl) than in groups B (15.5 mg/dl) and A (14.5 mg/dl).

Table 6: *Average total serum protein (mg/dl) and serum IgG (mg/dl) of crossbred Holstein Friesian calves supplemented with various colostrum feeding quantity.*

Groups	Total serum protein (mg/dl)	Serum IgG (mg/dl)
A (3-liter colostrum/calf)	7.1600±0.166^{c}	14.598±0.215^{c}
B (3.5-liter colostrum/calf)	8.2600±0.103^{b}	15.504±0.196^{b}
C (4-liter colostrum/calf)	9.7800±0.095^{a}	16.500±0.086^{a}
LSD 0.05	0.541	0.387
SE±	0.248	0.178

Table 7: *Two of the calves in group A had diarrhea, and one had pneumonia. One calf had Diarrhoea, and another had pneumonia in group B. One of the calves in group C, however, had diarrhea.*

Group	Diarrhoea	Pneumonia
A	2 calves	1 calf
B	1 calf	1 calf
C	1 calf	0

Diarrhoea and pneumonia

Two of the calves in group A had diarrhea, and one had pneumonia. One calf had Diarrhoea, and another had pneumonia in group B. One of the calves in group C, however, had diarrhea.

Crossbred Holstein calves in group C (4 liters of colostrum) gained more body weight than those in groups B (3.5 liters of colostrum) and A (3 liters of colostrum) in the current sample. The most recent discovery is in line with previous findings (Chigerwe *et al*., 2009). They said that calves who were fed colostrum gained more weight than calves who were not fed colostrum (control). A similar outcome was recorded by (Godden *et al*., 2009). They said that giving colostrum as the first feeding causes calves to gain more weight because their immunity to harmful foreign particles improves and their overall performance improves. Weight gain will not be impaired if we feed extra colostrum in the first twelve hours of calf life, which will increase overall serum protein levels after the first eight hours of colostrum feeding since the bacterial count will be neutralized. As a result, growth efficiency will improve, which is linked to increased nutrient intake in the feed (Quigley et al., 2012). When compared to calves who are fed colostrum with less than 85mg Ig/ml, those who consume more colostrum have higher immunoglobulin levels and gain more weight. Higher weight gain is due to increased energy consumption from liquid feed, as well as a lower fecal score due to higher immunoglobulin levels (Berge *et al*., 2005). The current research discovered that group C (4 liters of colostrum) had the highest overall serum protein concentration IgG concentration than groups B (3.5 liters of colostrum) and A (3 liters of colostrum). The findings of this study are backed up by (Shah *et al*., 2019). They concluded that feeding colostrum significantly increased serum IgG levels above those seen in the control group (who did not receive colostrum). When colostrum-fed calves were compared to non-fed calves, the weight of the calves was also higher. The findings of this investigation were compared to the findings of a previous report (Chigerwe *et al*., 2012; Beam *et al*., 2009). They said that giving calves colostrum in the first few days after birth improves their health significantly (Besser et al., 2020). Colostrum feeding produces two types of antibodies, IgG and IgE, which can aid in the defense mechanism against a foreign pathogen that can attack a newborn calf and cause a variety of problems, including pneumonia, Diarrhoea, and other respiratory illness (McGuirk et al., 2004) However, (Adem et al., 2014) The performance of a newborn calf provided colostral feeding is likely to increase throughout the calves life. Calves that eat >2 L of elevated colostrum or have a higher serum IgG level on the first day of life have lower morbidity and mortality rates than calves who consume insufficient amounts of high-quality colostrum. Low therapeutic pre-weaning rates and high weight gain have been related to adequate passive immunity transfer (Wells *et al*., 1996).

Diarrhoea was found in 2, 1, and 1 calf in groups A (3 liters of colostrum), B (3.5 liters of colostrum), and C (4 liters of colostrum), respectively, while pneumonia was found in 1 and 1 calf in groups A and B. The current experiment's findings are consistent with previous findings. Godden *et al*. (2009) according to them, calves' mortality rates can differ depending on the birth season and dam's health. Immunoglobulin concentrations in the intestine must be sufficient to provide resistance to such infectious agents (Brignole et al., 2011). Feeding colostrum with high immunoglobulin concentrations to milk calves is another effective management tool for reducing the incidence rate of pneumonia. The calf defense mechanism, the environment up and down, and environmental infectious agents all play a role in the incidence of pneumonia in the calf. Viruses strike the calf first, followed by bacteria, which causes the animals' bodies to malfunction (Tyler *et al*., 2000). The concentration of IgG in the blood plays a major role in one's wellbeing (McGee *et al*., 2006). In this study, a link was discovered between serum IgG concentration and health problems. After 48 hours of birth, both calves received 50 mg/ml immunoglobulins and showed no signs of passive transfer failure (Priestley *et al*., 2013).

Conclusions and Recommendations

Based on the findings of the experiment, it was determined that group C, which received more colostrum, had greater feed consumption, weight gain, and immunity. In conclusion, improving colostrum quality is critical for promoting the health and wellbeing of dairy calves. Further research is needed to determine the optimal strategies for improving colostrum quality in dairy cows, including the timing and method of colostrum collection and feeding, as well as the cow's nutrition and health status during the prepartum period.

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Novelty Statement

This study demonstrates that providing 4 liters of colostrum to crossbred Holstein Friesian calves within 30 minutes of birth improves immunity, health, body weight, and growth performance, providing valuable insights for farmers to optimize management practices and enhance profitability.

Author's Contribution

Samin Ullah, Huma Rizwana Atique Ahmed Behan designed the research, Muhammad Naeem, Ghulam Shabbir Barham has co-supervised the research work, Abdul Hafeez Bukero, Shafiq ur Rahman shah, Naseeb Ullah.
Analysed the data Abdul Kabir, Anees ur Rahman, wrote the manuscript. All authors reviewed and approved the final manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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