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Impact of milk feeding regimens on growth, intake, efficiency, and costs in pre-weaned crossbred calves

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ABSTRACT

The high milk (20% of weight) feeding in initial life is beneficial for growth, feed efficiency, and welfare of calves. The experiment aimed to evaluate the impact of different milk-feeding regimens on the growth, intake, physiological responses, blood and faeces attributes, feed efficiency, and feeding cost in crossbred calves. Thirty (n=30) healthy pre-weaned crossbred calves (75% HF × 25% Kankrej) were divided into five groups using a completely randomized design. The calves were fed milk 10% of body weight (T_1); 4 L/day during the entire experiment (T_2); 6,4,2 L/day during 2-6, 7-9, and 10-13 weeks of age (T_3); and early weaning protocols 7, 5 L/day during 2-6, and 7-9 weeks of age (T_4); as well as 8, 4 L/day during 2-6, and 7-9 weeks of age (T_5), respectively after an adaptation of seven days. The feeding of concentrate, dry, and green fodder was common in all groups. The effect of milk-feeding regimens on body weight, body measurements, intake, and feed efficiency were non-significant. The evaluation of physiological responses, faecal consistency score, and blood haematology indicated that it was safe to feed different milk regimens. The milk feeding up to 13 weeks of age (T_1, T_2, T_3) significantly lowered the cost of feeding for weight gain than the early weaning protocol (T_4, T_5). Among them, the feeding of T_3 regimen was economical for weight gain without affecting the growth performance, feed efficiency, and health attributes of crossbred calves.

Keywords: Crossbred calves, Feed efficiency, Feeding cost, Growth, Intake, Milk feeding regimens

Raising healthy and productive calves is the key to the long-term success of dairy farm enterprises as calves are the future replacement stock. Conventional milk feeding restricts the milk intake up to 10% of body weight, resulting in poor body growth. To achieve the genetic potential of livestock, they need to be provided with greater protein and higher volumes to enhance biological growth after meeting their physiological and behavioural needs (Anderson 2011). The amount of milk feeding has played a vital role in the development of pre-weaning calves. High (20% of weight) or *ad lib.* milk feeding in initial life has shown improvement in pre-weaning growth, feed efficiency, and welfare in heifer calves (Groenendijk *et al*. 2018) which leads to early weaning. Endocrine and metabolic alterations are potentially induced by higher milk feeding in the early life of calves (Bartlett *et al*. 2006). Intensified feeding and early weaning show a faster growth rate (Khouri and Pickering 1968) and better rumen development (Cheema *et al.* 2016) which will help to attain full genetic potential in terms of growth and age of first calving at an early age without negatively affecting health. For affordable livestock production, high-milk feeding coupled with early weaning can be a better alternative because it is more cost-effective during the pre-weaning period (Cheema *et al.* 2016). The results on the effect of high milk feeding on growth performance in Indian conditions are very meager. The experiment was planned to evaluate the effect of different milk-feeding regimens on the growth, intake, feed efficiency, feed cost, and welfare of crossbred calves.

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MATERIALS AND METHODS

The present research was conducted at Livestock Research Station, Anand Agricultural University, Anand, Gujarat for 112 days (eight biweekly periods) after approval of Institutional Animal Ethics Committee (IAEC; approval No. 349/LRS/2021). A total of thirty (n=30) healthy pre-weaned crossbred calves (75% Holstein Friesian × 25% Kankrej) were randomly allotted to different milk-feeding regimens having six calves in each from 8 to 119 days of age after seven days of adaptation.

The first-week liquid feeding was common to all groups of calves, each calf having 4 L of colostrum and milk during the first three days and 4-7 days, respectively using a bucket. The calves of T_1, T_2, and T_3 groups were weaned at 91 days of age and that of T_4 and T_5 were at the age of 63 days. The water was given in a pail twice daily at 10.00 AM and 3.00 PM. All calves were dewormed on the 15th, 30th day and subsequently every month with broad spectrum dewormer. All calves were housed in well-

Table 1. Feeding schedule of calves during the experiment

No. of week	Milk feeding regimens (L/day)					Concentrate	Dry fodder	Green fodder (g/d)
	T_1	T_2	T_3	T_4	T_5			
2-6	10% of B.wt.	4	6	7	8	*Ad lib.*	*Ad lib.* (15 days onwards)	-
7-9			4	5	4			100-200
10-13			2	-	-			200-500
14-17	-	-	-	-	-			500

ventilated pucca north-south direction house and were tied at manger with iron chains having individual feeding facilities. The floor of the shed was cleaned daily with standard disinfectant. The calves were weighed at weekly intervals in the morning (8:00- 8:45 AM) before feeding and watering on the electronic weighing balance. The weekly body weight was used for the milk feeding schedule (Table 1) and biweekly data was used for statistical analysis. The wither height, body length, and heart girth (cm) were measured with a standard measuring tape at biweekly interval before feeding and watering. The dry matter intake was the summation of dry matter from milk, dry feed, and green fodder after substracting leftovers. The water intake was measured at biweekly intervals after substracting water left in a pail. The proximate principles (Supplementary Table 1) of total mixed rations-TMRs, concentrate, and roughage were analyzed as per AOAC (2005).

The blood samples (4 ml) were collected in a heparinized vacutainer at fortnight intervals to analyze haematological parameters. The rectal temperature (°F), pulse rate (no./min), and respiration rate (no./min) were recorded by a clinical thermometer, stethoscope, and flank movement, respectively in morning at biweekly intervals. The faecal consistency was observed individually every day as faecal score: 1=Normal, 2=Semi-solid, 3= Runny/ Spready, 4=Watery (Larson *et al.* 1977). The behaviour was observed individually after milk feeding and scored as: 1=Urination, 2=Standing Up/Down, 3=Licking of the abdomen, 4=Kicking of the abdomen, 5=Biting of the abdomen, 6=Cross/ Sucking, 7=Sitting, and 8=Defecate (Ellingsena *et al.* 2016). The experimental data was analyzed as a one-way ANOVA (Snedecor and Cochran 2014) using WASP 2.0 (Jangam and Wadekar 2004). The probability of less than 0.05 was considered significant.

RESULTS AND DISCUSSION

Growth performance of crossbred calves

Body weight: Average body weight, gain in total, and

Table 2. Body weight, body measurement and intake of crossbred calves during the experiment

Parameter	T_1	T_2	T_3	T_4	T_5	P- value	CD 5%
Body weight (kg)							
Average	69.484±5.54	58.811±7.04	63.778±1.96	72.631±2.90	66.067±3.99	0.297	NS
Total gain	78.033±5.60	63.067±11.16	69.467±2.19	73.367±3.90	69.967±5.28	0.571	NS
Daily gain	0.656±0.04	0.530±0.04	0.585±0.03	0.617±0.03	0.588±0.03	0.076	NS
Heart girth (cm)							
Gain	37.00±2.24	32.75±4.15	37.42±1.00	34.67±1.96	35.67±2.36	0.705	NS
Average	94.80±1.93	89.55±3.28	92.95±0.72	96.53±1.00	95.09±1.32	0.119	NS
Body length (cm)							
Gain	35.25±1.31	30.08±4.42	32.17±1.61	31.50±1.73	34.67±2.29	0.575	NS
Average	89.77±2.07	85.87±3.14	88.19±0.66	90.83±0.77	89.09±1.73	0.441	NS
Wither height (cm)							
Gain	26.67±1.59	27.42±3.33	27.75±1.62	25.50±1.77	28.58±1.53	0.866	NS
Average	92.22±1.48	89.31±2.24	90.69±0.99	94.04±1.06	92.55±1.71	0.283	NS
Intake							
DMI kg/d	2.46±0.27	2.16±0.29	2.38±0.18	2.50±0.19	2.45±0.20	0.844	NS
DMI kg/100 kg B. wt.	3.15±0.29	3.27±0.25	3.37±0.29	3.21±0.27	3.52±0.26	0.883	NS
DMI g/kg W0.75	92.78±8.59	91.77±7.14	97.09±7.96	94.72±7.70	100.79±7.20	0.925	NS
CPI kg/d	0.36±0.02	0.31±0.03	0.34±0.01	0.36±0.01	0.38±0.01	0.216	NS
CPI kg/100 kg B wt.	0.51±0.03	0.53±0.03	0.53±0.03	0.52±0.03	0.61±0.03	0.117	NS
CPI g/kg W0.75	14.77±0.67	14.51±0.52	14.97±0.63	14.82±0.74	17.05±0.76	0.081	NS
TDNI kg/d	1.85±0.16	1.58±0.18	1.73±0.10	1.82±0.10	1.86±0.11	0.607	NS
TDNI kg/100 kg B. wt.	2.51±0.17	2.57±0.16	2.62±0.17	2.50±0.17	2.89±0.18	0.495	NS
TDNI g/kg W0.75	72.52±4.95	70.84±3.83	73.92±4.70	72.51±4.66	80.96±4.55	0.564	NS
Water intake L/day	4.14±0.71	3.51±0.32	3.98±0.41	4.52±0.53	4.08±0.47	0.731	NS

DMI, Dry matter intake; CPI, Crude protein intake; TDNI, Total digestible nutrient intake; $W^{0.75}$, metabolic body weight.

daily body weight of crossbred calves (Table 2) differed non-significantly(p>0.05) from each other, indicating that milk-feeding regimens did not influence the body weight of calves. Similar findings were reported by Alimirzae *et al*. (2020) in HF heifer calves and by Groenendijk *et al*. (2018) in crossbred calves fed different quantities of milk. The higher body weight and daily gain were reported by Arens *et al*. (2023) in dairy heifer calves, contrasting present findings.

Body measurement: The gain and average values in heart girth, body length, and wither height (Table 2) of the crossbred calves were differing non-significantly among the treatment groups, suggesting that calf body measurements are unaffected by milk-feeding regimens. Similar findings were reported by Daneshvar *et al.* (2017) in HF male calves on different milk-feeding regimens. In contrast, Jafari *et al*. (2021) observed higher body measurements in Holstein calves fed a higher quantity of milk.

Feed and water intake: The difference in dry matter intake-DMI of crossbred calves (Table 2) of treatment groups was statistically non-significant, indicating milk feeding regimens did not impact dry matter intake. A review on the effect of high milk-feeding practices in dairy calves revealed lower dry matter intake (Welk *et al*. 2022) as an inverse relationship exists between milk and solid feed intake (Khan *et al*. 2010). While Khan *et al.* (2007) and Rashad *et al.* (2022) observed improved feed intake on high milk feeding during the suckling phase. The lower or higher dry matter intake may result from the quantity of milk that occupies gastro intestinal tract active space and the passage rate of nutrients. In the present experiment, the overall effect was non-significant on dry matter intake may be due to moderate intake of milk (body weight basis) in crossbred calves. The crude protein and total digestible nutrient intake followed the same trend. The daily water intake of calves of different groups differed non-significantly (Table 2). Similarly, a non-significant difference in water intake in crossbred calves was reported by Shah (1989) whereas higher water intake was observed (De Passille *et al.* 2011) in the low milk-feeding regime.

Physiological response: The milk-feeding regimens did not influence the respiration, heart rate, and rectal temperature of experimental calves (Table 3) and fell within the normal physiological range (Piccione *et al*. 2010, Silva *et al*. 2016) under different milk-feeding regimens. The physiological responses of calves were in normal range indicating the safety of various milk-feeding regimens on health.

Haematological parameter: The milk-feeding regimens did not influence the blood value of white blood cells, red blood cells, hemoglobin, and hematocrit in preweaned crossbred calves during the experimental periods (Table 3) and were within the normal physiological range of calves (Mohri *et al*., 2007; Kaneko, 2008). Similarly, Panigrahi *et al*. (2004) revealed a non-significant influence of milk-feeding methods and frequency in calves. The blood haematology value in crossbred calves suggested that milk-feeding regimens are safe for calves, as it indicates normal health.

Faecal evaluation: Different treatment regimens did not influence the faecal consistency score (Supplementary Table 2). Similarly, Yavuz *et al*. (2015) also reported non-significant differences in faecal consistency among various milk-feeding treatment groups. In contrast, Lingyan *et al*. (2019) observed a greater faecal score in calves fed higher reconstituted milk. The results indicated that milk-feeding regimens were safe for intestinal health.

Behaviour of calves: The normal behavior signs were urination, sitting, and defecation whereas discomfort was exhibited as standing up and down, licking, kicking, and

Table 3. Physiological response and haematological parameters of crossbred calves during the experiment

Parameter	T_1	T_2	T_3	T_4	T_5	P-value	CD value at 5%
Physiological response							
Respiration no./minute	67.86±6.33	62.06±0.67	62.51±0.65	61.94±0.87	68.22±6.48	0.652	NS
Heart rate/minute	96.88±2.35	99.14±2.66	104.37±7.85	98.37±4.81	98.02±1.71	0.789	NS
Rectal temp. (°F)	101.94±0.06	102.10±0.03	102.01±0.03	102.01±0.05	102.12±0.06	0.066	NS
Haematological parameters							
WBC (10^3/uL)	12.05±1.11	10.58±0.88	10.50±1.18	10.29±0.93	9.56±0.69	0.496	NS
RBC (10^6/uL)	9.75±0.23	10.50±1.73	8.59±0.73	8.09±0.85	8.79±0.39	0.402	NS
Hb (g/dl)	9.85±0.26	9.14±0.62	8.75±0.46	8.92±0.46	9.12±0.12	0.438	NS
HCT (%)	11.42±0.57	10.21±0.79	10.87±0.66	9.65±0.41	9.51±0.69	0.202	NS

Table 4. Feed conversion efficiency of crossbred calves during the experiment

Parameter	T_1	T_2	T_3	T_4	T_5	P-value	CD at 5%
DMI kg/kg gain	3.81±0.36	4.51±0.70	4.08±0.30	4.12±0.37	4.24±0.32	0.849	NS
CPI kg/kg gain	0.57±0.03	0.68±0.10	0.59±0.02	0.60±0.04	0.67±0.05	0.565	NS
TDNI kg/kg gain	2.85±0.21	3.37±0.53	2.97±0.17	3.01±0.23	3.24±0.24	0.748	NS
Feed cost ₹/day/calf	225.32^c±16.70	171.60^d±4.63	180.19^d±1.87	260.39^b±1.97	310.88^a±2.43	0.000	23.07
Feed cost ₹/kg gain	343.78^b±7.73	326.71^b±83.79	309.31^b±9.20	428.37^{ab}±23.06	528.72^a±53.15	0.011	133.64

₹, Indian rupees (1 USD=83.80₹).

biting of the abdomen as well as cross-sucking. Overall, no major difference in signs of discomfort was observed in the present experiment (Supplementary Table 3), indicating milk-feeding regimens are safe, as higher milk resides in the abomasum and does not seep into the rumen to disturb the digestion and health (Ellingsena *et al.* 2016).

Feed conversion and cost of feeding: The feed utilization for weight gain in crossbred calves of different groups (Table 4) was not influenced by milk-feeding regimens. Similarly, the report on different milk-feeding methods indicated in Holstein Friesian calves (Daneshvar *et al*. 2017, Jafari *et al.* 2021) did not influence feed conversion efficiency. The daily feed cost showed a significant effect of milk feeding regimens and in descending order was in T_5, followed by T_4, T_1, T_3, and least in T_2. The feed cost per kilogram weight gain was lower in T_1, T_2, and T_3 groups compared to T_5 whereas T_4 was comparable to T_5 as well as other lower-cost groups. The feed cost per unit weight gain was lowest in T_3 group.

The milk feeding regimens had a non-significant effect on body weight, body measurements, feed, intake, faecal consistency score, and feed efficiency and were found safe as indicated by physiological response and blood haematology. The T_3 milk feeding regimen (6,4,2 L/day during 2-6, 7-9, and 10-13 weeks of age) was more economical for weight gain in crossbred calves than other regimens. Farmers can rear the calves at a lower cost without affecting growth, feed efficiency, and health.

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