RESEARCH ARTICLE

Effect of Feeding Fortified Milk Replacer on Dry Matter Intake and Nutrient Utilization in Crossbred Dairy Calves

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Abstract

The study was carried out to investigate the influence of fortified milk replacer on the growth performance and nutrient digestibility of pre-ruminant HF crossbred dairy calves. Fourteen male and female crossbred calves were allocated at random to two groups, T1 (Control) and T2 (Treatment), each having seven calves. The T1 group received whole milk for 120 days, whereas the T2 group was offered reconstituted fortified milk replacer with essential vitamins, minerals, amino acids, lysolecithin and probiotics to enhance nutrient utilization, fat digestibility and gut health. Calves were fed at a rate of 1/10th of body weight for the first six weeks, 1/15th for the next four weeks and 1/20th for the last two weeks, according to the feeding regimen. According to ICAR (2013) guidelines, both groups received green fodder (Hybrid Napier CO3) and a calf starter (23% crude protein, 70% TDN) during the trial. Unlimited access to fresh drinking water was provided. The two groups did not differ significantly ($p>0.05$) in terms of feed intake, growth performance, and digestibility of dry matter and crude protein. However, the T2 group showed a significantly higher ($p<0.05$) digestibility of ether extract, neutral detergent fibre and acid detergent fibre. Moreover, the cost of feed per kg body weight gain was notably lower ($p<0.05$) in the T2 group than in T1 group. In summary, fortified milk replacer demonstrated itself as a cost-effective option for rearing pre-ruminant crossbred calves, delivering similar growth and dry matter intake, along with enhanced nutrient digestibility, without compromising performance.

Key words: Crossbred calves, Growth performance, Digestibility, Economics, Fortified milk replacer.

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Introduction

The future productivity of a dairy herd depends on its calves and successful rearing relies more on effective management practices than merely acquiring high-quality animals. Nevertheless, raising healthy calves remains a major challenge in dairy farming. New-born calves have weak immune systems, making them particularly susceptible to infections. To support proper immune development, it is essential that every calf receives high-quality colostrum within the first 6 h after birth. This colostrum must contain an immunoglobulin G (IgG) concentration exceeding 50 mg/mL to ensure sufficient passive transfer of antibodies (Godden, 2008).

After the initial colostrum feeding, traditional approaches for rearing dairy replacement calves have typically emphasized minimizing expenses while ensuring adequate growth until weaning. This stage is financially demanding and the conventional approach involves limiting liquid feed to encourage the consumption of solid feed, which in turn stimulates rumen development. However, since calves digestive systems are still developing, they cannot efficiently process solid food in early life. While whole milk is considered the gold standard for calf nutrition, economic constraints often prevent farmers from providing it in adequate amounts. In such cases, fortified milk replacers serve as an important alternative (Priestley *et al.,* 2013).

Milk replacers are commonly formulated using skim milk and whey protein to closely mimic the nutrient profile of cow's milk, ensuring bioavailability and digestibility. To overcome the limitations of vegetable oils & proteins (Godden *et al.,* 2005) and enhance calf growth and health, milk replacers are fortified with essential micronutrients (vitamins and minerals), functional amino acids, direct-fed microbials (probiotics) and emulsifying agents (lysolecithin), thereby aligning their nutrient composition closely with that of whole milk (Reis *et al.*, 2021). Fortifying milk replacers not only supports optimal calf growth and health but also offers a more economical feeding strategy compared to whole milk. This cost-effective approach makes it especially suitable

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for dairy farmers aiming to reduce input costs during the pre-weaning phase without compromising performance. This research was planned to evaluate the effect of feeding fortified milk replacer on the growth and nutrient utilization of pre-ruminant crossbred calves as a cost-effective alternative to whole milk.

Materials and Methods

Experimental Design

Fourteen HF crossbred dairy calves, aged seven days old and of either sex, were selected and randomly divided into two equal groups, *viz.,* control (T1) and treatment (T2). All calves were kept in separate, well-ventilated stalls under uniform management conditions throughout the experimental period of 120 days. The T1 group received whole milk, while the T2 group was offered reconstituted fortified milk replacer. In both groups, liquid feed (whole milk or milk replacer) was provided at a rate of one-tenth (1/10th) of the calf's body weight during the first six weeks of life. This quantity was gradually reduced to one-fifteenth (1/15th) of body weight during the following four weeks, and then to one-twentieth (1/20th) during the final two weeks of the experiment. In addition to the liquid feed, a weighed quantity of calf starter and green fodder (Hybrid Napier CO3) was offered to all calves in both groups as per ICAR (2013) guidelines.

Table 1: Ingredient composition of milk replacer

Ingredients	Parts
Skimmed milk powder	31
Dried whey	44
Soy protein isolates	8
Coconut oil	14
Supplevite-M	1.25
Calcite	1.25
Salt	0.5
Total	**100**

Supplevite - M (250 gram) contains 5,00,000 I.U. of Vitamin A, 1,00,000 I.U. of Vitamin D3, 0.2 g of Vitamin B2, 75 units of Vitamin E, 0.1 g of Vitamin K, 0.25 g of Calcium pantothenate, 1 g of Nicotinamide, 0.6 g of Vitamin B12, 15 g of Choline chloride, 75 g of Calcium, 2.75 g Manganese, 0.1 g of Iodine, 0.75 g of Iron, 1.5 g of Zinc, 0.2 g of Copper, 0.045 g of Cobalt.

The ingredient composition of milk replacer (23% crude protein) used is given in Table 1. The milk replacer was reconstituted by mixing one portion of dry powder with seven portions of warm water. At the time of feeding, probiotic powder containing *Lactobacillus rhamnosus* (0.2×10^8 CFU) and lysolecithin (4 g) were incorporated into the reconstituted milk replacer each day and then fed to each calf. The amounts of whole milk and reconstituted milk replacer were adjusted fortnightly as per the body weight of calves and fed in two equal servings, given daily at 9.00 AM in the morning and 3.00 PM in the afternoon. The concentrate mixture and green fodder were given simultaneously from 8th day onwards till the end of experiment. The concentrate mixture and green fodder (Hybrid Napier CO3) was given according to ICAR (2013) standards. In addition to this, strict hygiene was maintained throughout the experimental period, including the cleanliness of stalls, feeding equipment and the surrounding area, to help prevent disease occurrence. All calves were dewormed before the commencement of experiment.

Recording Growth Parameters

Body weights of the calves were recorded at fortnightly intervals during the trial and individually weighed quantities of the whole milk, reconstituted fortified milk replacer, calf starter and chaffed green grass based on body weight were offered to each animal.

Dry Matter Intake and FCR

Dry matter intake (DMI) from all feed components (liquid feed, concentrates and green fodder) was calculated after estimation of dry matter of each component separately. Any remaining feed in the manger was collected manually and weighed to analyse moisture content and estimate dry matter intake. DMI was calculated at fortnightly intervals as g/d, kg/100kg body weight and g/kg $W^{0.75}$ in both treatment groups and feed conversion ratio (FCR) was calculated at fortnightly intervals.

Digestibility Trial

A digestibility trial of five days was conducted in the 12th week of the feeding trial using total collection method to determine digestibility of nutrients. Representative samples, amounting to 10 % of the total quantity, were thoroughly mixed and stored in double-lined polythene bags. These samples were then stored in a deep freezer at -20°C for further analysis. At the end of the trial, samples of dung collected over the five consecutive days from each animal were pooled, thoroughly mixed and representative samples were analysed for proximate principles as per AOAC (2016) and fibre fraction by Van Soest method (Van Soest *et al*., 1991).

Statistical Analysis

Statistical analysis of the data collected in different fortnights was analysed as per Snedecor and Cochran (1994) using the software Statistical Package for the Social Sciences (SPSS) version 24.0 by independent sample t test.

Results and Discussion

Chemical Composition of Feed Ingredients

The detailed chemical composition of feed ingredients is provided in Table 2. The milk replacer composition was according to the nutrient density recommendations of the NRC (2001), while the calf starter met the standards outlined by ICAR (2013). These formulations ensured that the experimental diets provided balanced nutrients for ideal growth of the calves.

Growth Performance

The summarized data on body weight, dry matter intake (DMI) and feed conversion ratio (FCR) after the 120-day experimental period are provided in Table 3. The initial body weights on the 8th day after birth and final body weights after 120 days of the trial period were similar (p>0.05) between the two groups. Average daily gain (ADG), total weight gain and final body weight did not differ significantly (p>0.05) across the groups. The results were consistent with earlier research by Bach *et al.* (2013) and Suresh (2022), who reported no significant difference in growth performance when calves were reared on milk replacer. Contradictory outcomes were also reported by Bharti *et al.* (2012) and Kamalahasan (2018), who reported higher ADG in calves given whole milk compared to those given milk replacer, attributing this to the superior nutritive value and more efficient utilization of nutrients in whole milk.

No significant difference (p> 0.05) was observed between the treatment groups for average daily DMI, per 100 kg body weight or per metabolic body weight (Table 3). These findings indicate that the palatability, total solids content and nutrient composition of the milk replacer were comparable to those of whole milk, as noted by Jaster *et al.* (1990). Similar findings were reported by Abdullah *et al.* (2013) and Jaeger *et al.* (2020), who found no significant difference in DMI when calves were fed milk replacer containing whey protein. However, Shukla *et al.* (2017) reported higher DMI in calves fed whole milk, attributing this to the inherent properties of milk as a natural food source for pre-ruminant calves. The feed conversion ratio (FCR) was 3.57 ± 0.25 for T1 and 3.43 ± 0.35 for T2, indicating comparable efficiency in feed utilization between the groups.

Nutrient Digestibility Coefficient

The digestibility coefficients of nutrients in the experimental rations are presented in Table 4. The digestibility coefficients of dry matter (DM) and crude protein (CP) were similar (p>0.05) in between the two groups. The utilisation of dairy-based protein sources (whey protein and skim milk powder) in the milk substitute, which had a nutritional composition and palatability similar to whole milk, may account for this resemblance. Similar DM and CP digestibility coefficients in calves raised on milk replacer were also observed by Suresh (2022) and Abhijith (2022). The digestibility coefficient for ether extract (EE) was significantly higher (p<0.01) in the T2 group. This improvement in EE digestibility is attributable to the supplementation of lysolecithin (4 g/day/calf), which enhances fat digestibility and absorption by forming micelles in the small intestine, as explained by Thornsberry *et al.* (2016). Furthermore, lysolecithin might have aided in the digestive system's growth (Reis *et al.*, 2021).

Table 2: Chemical composition of feed stuffs (% DM Basis, Mean ±SE, n = 7)

Attributes	Milk replacer	Calf starter	Green grass
Dry matter	91.83 ± 0.04	90.21±0.07	20.46±1.00
Crude protein	23.48 ± 0.24	23.82±0.35	11.90±0.11
Ether extract	18.66 ± 0.03	4.56±0.01	2.07±0.04
Neutral detergent fibre	10.09 ± 0.09	23.29±0.12	60.26±0.41
Acid detergent fibre	3.83 ± 0.16	12.68±0.05	38.60±0.04
Calcium	1.38 ± 0.04	1.78±0.05	0.62±0.01
Phosphorus	0.68 ± 0.02	0.86±0.01	0.32±0.01

Table 3: Body weight, dry matter intake and feed conversion ratio of experimental crossbred calves maintained on two dietary treatments

Parameter	T1 (Control)	T2 (Milk Replacer	P value
Initial body weight (kg)	34.49±2.17	34.57±1.33	0.974^{ns}
Final body weight (kg)	78.11±2.71	80.20±4.98	0.719^{ns}
Total weight gain (kg)	43.63±3.02	45.63±3.85	0.690^{ns}
Average daily gain (g)	389.54±26.95	407.40±34.39	0.690^{ns}
DMI (kg/day)	1.345±12.54	1.327±30.71	0.612^{ns}
DMI (kg/100 kg body weight)	2.222±0.04	2.217±0.09	0.955^{ns}
DMI (g/kg$^{0.75}$)	0.062±0.001	0.061±0.001	0.866^{ns}
Feed conversion ratio	3.57±0.25	3.43 ±0.35	0.760^{ns}

Mean values are of seven replicates with SE, ns-non significant (p>0.05).

Table 4: Data on the digestibility coefficient (%) of nutrients of the experimental crossbred calves maintained on the two dietary treatments

Nutrient	Treatment		P value
	T1	T2	
Dry matter	77.33 ± 0.61	77.98 ± 0.43	0.406
Crude protein	79.73 ± 0.56	80.72 ± 0.37	0.163
Ether extract	81.35 ± 0.50	88.37 ± 0.51	<0.001
Crude fibre	60.65 ± 0.82	67.42 ± 0.65	<0.001
Nitrogen free extract	80.80 ± 0.49	79.25 ± 0.48	0.043
Neutral detergent fibre	64.63 ± 0.68	67.76 ± 0.59	<0.001
Acid detergent fibre	53.75 ± 1.50	58.50 ± 0.71	0.020

Mean values are of seven replicates with SE, ns-non significant (p>0.05), *Significant at 5 % level **Significant at 1 % level

The digestibility coefficients for neutral detergent fibre (NDF) and acid detergent fibre (ADF) were significantly higher (p<0.01) in the T2 group in contrast to the T1 group. This improvement in fibre digestibility might be linked to the early introduction of solid feeds in calves fed milk replacer, which allows their digestive systems to adapt better to fibrous materials. Furthermore, milk replacers often contain probiotics that support rumen health and foster a beneficial microbial environment for fibre digestion. Similar findings were reported by Dar *et al.* (2022) and Nageshwar *et al.* (2016).

Despite the higher digestibility of fat and fibre seen in the T2 treatment, this didn't result in enhanced growth performance. This discrepancy might result from the potential lack of high-quality animal derived proteins and vitamins in the milk replacer which is critical for growth. Additionally, the total caloric intake from the milk replacer may not have been enough for optimal growth. Digestive efficiency is not always associated with nutrient absorption and utilization and if the calves digestive systems were not fully absorbing the available nutrients, growth could be limited. Furthermore, factors like genetics, health status and environmental conditions can influence growth and issues with rumen microbial adaptation might also reduce the effectiveness of improved digestibility.

Economic Efficiency

The economic efficiency of production within the two experimental groups of crossbred calves is presented in Table 5. The total cost of feed per kg body weight gain was significantly (p<0.05) lower for T2 calves (Rs. 273.18 ± 23.46) compared to T1 calves (Rs. 411.63 ± 41.30). This result was consistent with earlier research by Shukla *et al.* (2017), Jadav and Gaur (2022) and Bharti *et al.* (2012), who reported that the cost of feed and overall rearing expenses were significantly lower in formulated milk replacer compared to commercial milk replacer and whole milk feeding.

Conclusion

In conclusion, the study found that using a fortified "milk replacer" for feeding crossbred dairy calves is economically more efficient than feeding whole milk. Although no significant difference in growth or feed intake in between the two groups observed, the calves received milk replacer showed better digestibility of fat and fibre, which may help their long-term health. This approach could be a valuable strategy for dairy farmers aiming to balance performance and economic sustainability in calf management.

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Table 5: Economics of production in two experimental groups of crossbred calves

Parameter	T1	T2	P value
Total cost of liquid feed (Rs./calf)	13328.35±608.87	7913.499±353.11	0.001**
Total cost of calf starter (Rs./calf)	2759.00±13.46	2955.41±48.33	0.002**
Total cost of grass (Rs./calf)	1149.52±8.78	1063.65 ± 30.08	0.018**
Total cost of feed (Rs/calf)	17236.87±602.401	11932.56±415.62	0.000**
Feed Cost (Rs./calf/day)	153.90±1.54	124.99±4.53	0.001**
Feed cost per kg b.wt. gain (Rs./kg)	411.63±41.30	273.18±23.46	0.013**

Mean values are of seven replicates with SE, ns-non significant (p>0.05); *Significant at 5 % level, **Significant at 1 % level

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