Volume 3, Number 1, 2026
Pages 1-9
Bioscience Insights
ISSN: 3080-3489 (Print)
ISSN: 3080-3497 (Online)
BiosciInsights.com

# COMPARATIVE EFFECTS OF WHOLE MILK, MILK REPLACER, AND THEIR BLEND ON DRY MATTER INTAKE, AVERAGE DAILY GAIN, AND FEED CONVERSION RATIO IN JERSEY CROSSBRED CALVES

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**Article Information**

***Article History***

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|---|---|
| Received: | January 11, 2026 |
| Revised: | February 09 2026 |
| Accepted: | May 03, 2026 |
| Available Online: | June 30, 2026 |

**Keywords:**
Whole Milk, Milk Replacer, Weight Gain, Dry Matter Intake

**Abstract**

The increasing cost of whole milk has prompted dairy producers to explore milk replacers as a more economical feeding option for young calves. This study investigated the effects of feeding whole milk, a 50:50 blend of whole milk and milk replacer, or milk replacer alone on dry matter intake (DMI), average daily gain (ADG), and feed conversion ratio (FCR) in Jersey crossbred calves. Eighteen newborn calves were randomly assigned to three dietary treatments, with six calves in each group. Calves received their respective liquid diets until 120 days of age, while calf starter containing 19% crude protein was offered from 20 days of age and green fodder from 60 days onward. Calves fed whole milk and the whole milk–milk replacer blend showed comparable performance throughout the experimental period. Daily DMI averaged 937.83 and 934.17 g/day in the whole milk and blended groups, respectively, compared with 924.67 g/day in calves fed milk replacer alone ($P < 0.05$). Similarly, ADG was higher in calves receiving whole milk (268.67 g/day) and the blended diet (267.50 g/day) than in those fed only milk replacer (247.50 g/day). Feed efficiency followed a similar pattern, with lower FCR values observed in the whole milk (3.49) and blended (3.49) treatments compared with the milk replacer treatment (3.74). The findings indicate that replacing up to 50% of whole milk with milk replacer does not compromise feed intake, growth performance, or feed efficiency in Jersey crossbred calves. Partial substitution of whole milk with milk replacer therefore represents a practical and cost-effective feeding strategy that can reduce rearing costs while maintaining satisfactory calf performance.

**INTRODUCTION**

For the sustainability and profitability of any dairy production system, efficient calf rearing is crucial. Proper nutrition in pre-weaning phase is a crucial determinant of the future growth, health, reproductive performance and productivity of dairy cattle. Whole milk is the feed normally fed to young calves and the rising value of the milk has significantly increased the cost of calf rearing (Chapelain et al., 2026; Jiang et al., 2025). This means that dairy producers are disinclined to provide whole milk to their calves for their growth and development, which indicates the need for more economical feeding options (Azim et al., 2011).

The amount and frequency of milk feeding in early life is important in the growth, health, behavior and physiological development of calves. Nutritional management during the pre-weaning phase affects dry feed intake, average daily gain, gastrointestinal development, mammary gland growth, and future milk production potential (Hemmert et al., 2026; Khan et al., 2007). However, calves are typically weaned from their dams soon after they are born, given colostrum and then fed liquid feeds via buckets or nipple feeders in the modern dairy production system. Nipple feeding is preferred for most calves as it permits the calf to express its natural suckling behaviour, and may enhance animal welfare (Khan et al., 2007). The amount of milk that is recommended for dairy calves is about 10% of their body weight so they can grow and develop (Bartlett et al., 2024).

Nutrition, management, housing and disease control (Heinrichs et al., 1995) are all factors that affect calf health and performance. Nutrient deprivation in the neonatal period can have detrimental impacts on growth rate, disease susceptibility and pubertal development. Thus, early intake of appropriate and balanced liquid diet is important for optimum calf performance and long-term productivity (Mainau et al., 2025).

To compensate for this, a group of alternative feeding products, called milk replacers, have been created for feeding dairy calves. Some of the benefits of their use include reduced feeding costs, ease of storage and handling, enhanced disease control and the potential to see more of the saleable milk in the market (BAMN, 2002). The nutrient intake and composition of milk replacers, as well as feeding strategy, have been found to have a significant effect on the growth performance, nutrient utilization, health status and behaviour of calves in previous studies (Brown et al., 2005; Khan et al., 2007). In addition, adequate milk replacers can produce adequate growth rates, and minimize the economic cost of whole milk feeding (Heinrichs et al., 1995).

Although milk replacers have been utilized in the feeding of dairy calves, little information has been available about the partial replacement of whole milk with milk replacer in Jersey crossbred calves under local production conditions. It was hypothesized that feeding whole milk with partial replacement with milk replacer would not negatively affect calf performance or feed efficiency, but would still maintain growth performance. With this in mind, the current study was undertaken to investigate the effect of feeding the Jersey crossbred calves, under the management conditions of Livestock Research and Development Station, Swabi, Khyber Pakhtunkhwa, with whole milk, a 50:50 whole milk–milk replacer mixture, and milk replacer only on DMI, ADG and FCR.

## MATERIALS AND METHODS

### Study Area

The experiment was carried out at Livestock Research and Development Station, Swabi, Khyber Pakhtunkhwa, Pakistan.

### Experimental Animals

Eighteen newborn Jersey crossbred calves were selected for the experiment. All calves were fed sufficient colostrum on or before the first three days after birth. The calves were fed whole milk at 10% of their body weight for a period of 15 days after the colostrum feeding period. Calves were individually housed in well-ventilated pens with continuous availability of clean drinking water during the experimental period. Calf starter was fed from 20 days until 120 days and green fodder was fed ad libitum from 60 days to 120 days.

### Experimental design and feeding treatments

The experimental design used was Completely Randomized Design (CRD). Six calves were assigned to each of three dietary treatments with the 18 calves being randomly allotted to the various treatments.

The dietary treatments were:

- Treatment A (Whole Milk): Calves were given whole milk at 10% of their weight.
- Treatment B (Whole Milk + Milk Replacer Blend): Whole milk and milk replacer blend (50/50) fed at 10% of body weight.
- Treatment C (Milk Replacer): Calves were fed milk replacer at the rate of 10% of body weight.

Until 120 days of age, liquid diets were provided twice a day in feeding buckets with soft rubber nipples.

### Chemical composition of experimental diets

The composition of the milk replacer and calf starter fed during the experiment is shown in Table 1.

**Data Collection**

The amount of calf starter and green fodder eaten by the animals was observed during the experimental period. DMI was determined by the feed consumed per calf (Table 2).

The body weights were taken at the start of the experiment and then each week on a calibrated weighing scale. ADG was determined by dividing the difference in body weight by days on experimental period.

The FCR was used to calculate the ratio of dry matter intake to body weight gain by the method described by Lamb (2009).

**Statistical Analysis**

Data were analyzed using analysis of variance under a Completely Randomized Design with SAS software (Version 9.1). Treatment means were compared using the Least Significant Difference test, and differences were considered statistically significant at $P < 0.05$.

The statistical model used was:

$Yij = \mu + Ti + eij$

**Table 1:** Chemical composition of milk replacer and calf starter (% dry matter)

| Ingredient | Milk Replacer | Calf Starter Ration |
|---|---|---|
| DM | 95.00 | 90.00 |
| CP | 23.50 | 19.00 |
| Fat | 9.00 | 4.00 |
| Ash | 7.50 | 9.00 |
| ME (Kcal/kg) | 3300 | 2800 |

**Table 2:** Composition of Calf Starter

| Ingredient | Percent (%) |
|---|---|
| Broken Wheat | 10.00 |
| Wheat Bran | 40.00 |
| Khesari | 24.00 |
| Til oil cake | 15.00 |
| Fishmeal | 3.00 |
| Soymeal | 5.00 |
| Salt | 0.50 |
| DCP | 0.50 |
| Oyster shell | 2.00 |
| Total | 100.00 |

## RESULTS

### Dry Matter Intake

Dry matter intake differed significantly among treatments (Table 3). The calves receiving whole milk (Treatment A) had the greatest DMI (937.83 ± 2.30 g/day) followed by calves receiving the 50% whole milk blend with 50% milk replacer (Treatment B; 934.17 ± 3.46 g/day). The calves that consumed milk replacer only (Treatment C) had the lowest DMI (924.67 ± 2.30 g/day).

### Average Daily Gain

The feeding treatments ($P < 0.05$) significantly influenced ADG as measured in Table 3. The highest ADG (268.67 ± 2.19 g/day) for calves fed whole milk was similar to those fed the whole milk–milk replacer mix (267.50 ± 1.77 g/day). Calves raised on milk replacer only had the lowest ADG (247.50 ± 2.46 g/day).

### Feed Conversion Ratio

The dietary treatment ($P < 0.05$) significantly affected feed conversion ratio (Table 3). Treatment A (3.49 ± 0.03) and Treatment B (3.49 ± 0.03) had the lowest FCR, which is better feed utilization efficiency. Treatment C (Milk replacer alone) had the highest FCR (3.74 ± 0.04), indicating that the calves fed milk replacer alone showed poorer feed conversion efficiency.

### Whole Performance

Figure 1 shows the overall performance of the Jersey crossbred calves fed the three different feeding programs. Milk replacer alone fed calves had lower feed intake, ADG and higher FCR compared to calves fed whole milk and whole milk–milk replacer blend which had similar feed intake, growth performance and FCRs. Based on these results, 50% of whole milk could be replaced with milk replacer without compromising calf performance for the period of the experiment.

**Table 3.** Growth performance and feed efficiency of Jersey crossbred calves fed different liquid diets

| Parameters | Treatment A (Whole Milk) | Treatment B (50% WM+ 50%MR) | Treatment C (Milk Replacer) |
|---|---|---|---|
| **Total DMI (g)** | 937.83a ± 2.30 | 934.17a ± 3.45 | 924.67b ± 2.30 |
| **Average Daily weight Gain (g)** | 268.67a ± 2.18 | 267.50a ± 1.76 | 247.50b ± 2.45 |
| **FCR** | 3.4918b ± 0.02 | 3.4929b ± 0.02 | 3.7379a ± 0.03 |

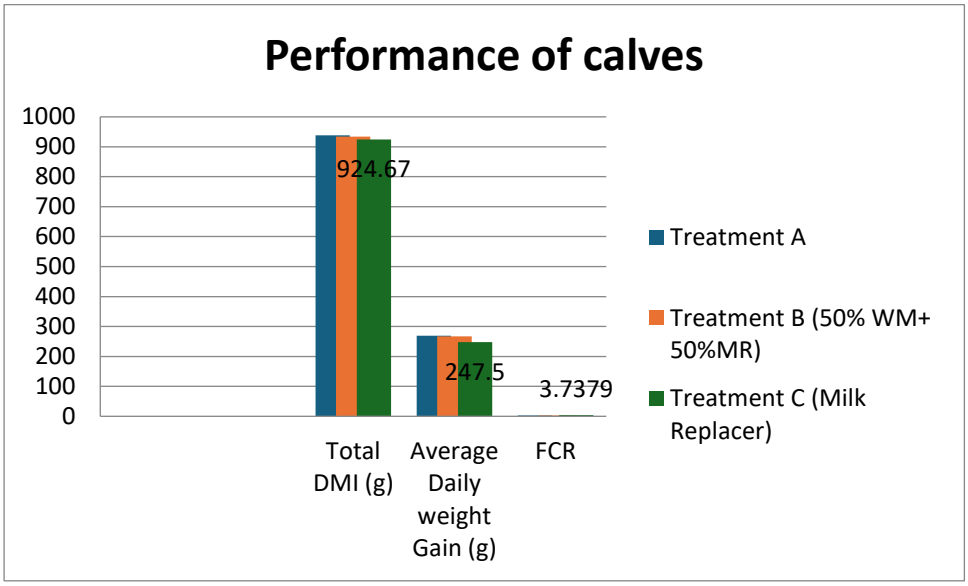


**Figure 1:** Effect of whole milk, a whole milk–milk replacer blend, and milk replacer on DMI, ADG and FCR of Jersey crossbred calves.

**DISCUSSION**

Dry matter intake is a significant measure of nutrient intake and growth performances of young calves. In the current experiment, calves fed the whole milk and whole milk–milk replacer combination had significantly more DM intake than the milk replacer-only fed calves. This increased DMI in Treatments A and B may have been explained by the increased palatability, digestibility and utilization of nutrients in whole milk compared to milk replacer. Hill et al. (2008a) also reported that calves fed diets containing more desirable nutrient composition had higher feed intake and greater growth performance. The comparable DMI observed between the whole milk and blend groups suggests that replacing 50% of whole milk with milk replacer did not negatively affect feed consumption.

Average daily gain showed a similar trend as seen for DMI. The weight gain of the calves fed whole milk and milk replacer plus whole milk was significantly higher than that for calves fed milk replacer alone. Growth rate of young calves is primarily dependent on nutrient intake and nutrient digestibility. This increased ADG in Treatments A and B, therefore, might be linked to a higher intake of nutrients and better use of dietary nutrients in these treatments. Similar results have been reported by Hill et al. (2008b) who found that calves fed nutritionally adequate liquid diets had improved growth performance. The higher energy and protein intake during the pre-weaning phase also had a positive effect on the growth of dairy calves as reported by Brown et al. (2005). There was no difference between the whole milk and blend groups, suggesting that partial substitution of whole milk with milk replacer can result in similar growth as whole milk feeding.

Feed conversion ratio is commonly used as an indicator of feed utilization efficiency. The current study showed that calves receiving the whole milk or the whole milk–milk replacer mix had significantly smaller FCR values, suggesting better feed conversion efficiency to gain body weight, than when fed milk replacer, alone. The reduced feed efficiency of the milk replacer group could be attributed to the differences in the ingredients and nutrient availability. The milk replacer fed in this study was a mixed animal/plant product milk replacer that could have influenced nutrient digestibility and utilization versus whole milk. The findings are in line with those of Jeong et al. (2024) who showed that feed efficiency of growing calves may be greatly affected by the diet offered.

The results of this study showed that 50% of whole milk could be replaced with milk replacer without affecting feed intake, growth rates or feed efficiency in Jersey crossbred calves. An economic consideration of the partial substitution of whole milk is that dairy farmers may have an opportunity to lower their feeding costs and still achieve satisfactory calf performance. Additionally, milk replacers can help to boost the quantity of milk that is available for sale to humans, which can help to improve the profitability of the farm. The results are corroborating previous reports that milk replacers can be used as an effective and cost-efficient substitute for whole milk if they have been properly formulated and managed (Heinrichs et al., 1995; BAMN, 2002).

## CONCLUSION

In the present study, the intake of dry matter, the average daily gain and the feed conversion ratio were similar when using a 50% whole milk–50% milk replacer formula fed to Jersey crossbred calves as compared with feeding whole milk. On the other hand, calves fed milk replacer provided as the sole liquid diet showed reduced feed intake, growth performance and an increased feed conversion ratio. The results show that as much as 50% of whole milk could be replaced with milk replacer and calf performance would not be affected. Partial replacement of whole milk with milk replacer would therefore be a practical and economical feeding system for Jersey crossbred calves as it may help dairy farmers to lower feeding cost without compromising growth performance and provide more marketable milk for human consumption.

## Authors' Contribution

Safiullah, Ashrafullah, Muhammad Daud, Zubair Ali, and Muhammad Ilyas Khan conducted the research work, animal management and data collection during the experimental period. Arsalan Khan contributed in draft preparation.

## Conflict of Interest

None.

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