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Effect of Feeding Different Milk Types on Pre-Weaning Performance of Kundi Buffalo Calves in Pakistan

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Buffalo, Cow, Milk, Calves, Growth rate, Pre-weaning

ABSTRACT

Rearing buffalo calves with a low-cost feeding regime remains a major challenge in many buffalo production systems of the world. The current study aimed to evaluate the effect of feeding different milk types on pre-weaning performance of Kundi buffalo calves in Pakistan. Sixteen newly born calves were randomly allocated to two treatment groups; buffalo milk feeding (BMF) and cow milk feeding (CMF). Each was individually fed milk at 15% of their body weight, adjusted weekly, until 6 weeks of age (up to a maximum of 5 L/day). Weight gain at 8 weeks of age was higher ($P < 0.001$) in BMF calves (33.71 kg ± 1.28 kg) compared to CMF calves (25.44 ± 1.19 kg). Similarly, the cost of rearing at 8 weeks of age was also significantly ($P < 0.001$) higher in BMF calves (Rs 10528 ± 254) compared to CMF calves (Rs 8578 ± 237). However, the cost/ kg of beef production at 8 weeks of age was lower for BMF calves (Rs 314 ± 10 kg) compared to CMF calves (Rs 341 ± 9 kg). Whilst rearing buffalo calves on whole buffalo milk was more expensive than using whole cow milk, the increased input costs were offset by producing heavier weaning weights and a superior cost per kilogram of beef production. Therefore, the present study concludes that feeding buffalo milk to buffalo calves increases productive potential and is more economical than feeding cow milk.

INTRODUCTION

Rearing buffalo calves with a cost-effective feeding regime, whilst maintaining a low mortality, is still a major challenge in many buffalo rearing systems around the world. In Pakistan, buffalo milk is approximately 20% more expensive than cow milk (Bilal *et al*., 2006) due to its higher fat content, 5.3-15.0g/100g versus 3.3-6.4g/100g (Gantner *et al*., 2015). Therefore, many dairy farmers prefer to sell their buffalo milk instead of feeding it to their calves (Bilal et al., 2019). This leads to problems with rearing buffalo calves in their first few critical months of life when immunity is being built and mortality rates are at their highest. This is especially important for female calves who are being kept for future dairy replacements (Ahmed *et al*., 2009). Due to poor feeding regimes in the smallholder farming system of Pakistan, female buffalo often have a delayed onset of puberty and their lifetime productivity is compromised. The problem is exacerbated with male calves in commercial enterprises across Pakistan, as the market for a weaned male buffalo is usually less than half the milk feeding cost to weaning (Ahmed *et al*., 2009). This leads to many male animals being sold on the day of birth, not offered milk (Ahmed *et al*., 2009) and majority of them being slaughtered when they are just 5-15 days old (Khan *et al*., 2002). Both the compromised productivity of female calves and the slaughter rate of male calves have huge impacts in terms of the economic losses to smallholder dairy farmers across the country.

One approach for dealing with the challenges and costs of calf rearing is to use milk replacers, these products are used in some farms in developed dairy sectors but the quality (fat%, protein%) of these replacers is very variable. Although, not readily available throughout Pakistan; milk replacer products have been available for the last decade

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and have been demonstrated to reduce the feeding cost of calves during the preweaning period (Bhatti *et al*., 2012; Quigley *et al*., 2018). Results of these studies show that the growth performance and health of calves fed on milk replacer during the preweaning period is inferior to calves fed on milk at an equivalent protein and energy basis (Sattar, 2020). Similarly, the use of milk replacers in buffalo calves resulted in poor weight gain at weaning (Bhatti *et al*., 2013). Most of the milk replacers have ingredients derived from plant sources (wheat gluten, soybean powder, vegetable oil, soy flour, wheat flour, protein modified soy flour etc.) which have significant adverse effects on the growth performance of calves compared to milk protein (Huang *et al*., 2015). Furthermore, the handling, processing and standard hygienic measures for milk replacer preparation and feeding makes it very challenging for Pakistani smallholder dairy farmers to adopt this technology.

Rearing of buffalo calves on their dams' milk is a simple, adoptable and practical approach to reduce mortality and achieve optimal growth rates (Ali *et al*., 2021). Buffalo milk substitutes with similar characteristics and milk protein sources have not yet been reported for animals in this farming system. In Pakistan, farmers rear cows along with buffaloes and hence there is an opportunity to feed cow milk to buffalo calves instead of their dams' milk. Before recommending this practice to the wider farming community it is important to investigate the effect of feeding cow milk on the pre-weaning performance of buffalo calves. Therefore, the objective of the present study is to evaluate the effect of feeding different milk types on pre-weaning performance of Kundi buffalo calves in Pakistan.

MATERIALS AND METHODS

Animals, housing and management

The experiment was conducted at the research farm of Sindh Agriculture University, Tandojam, Pakistan (latitude 25°25 N; longitude 68°32 E). Sixteen multiparous Kundi buffalo (*Bubalus bubalis*) near parturition, 4–10 years old, 450-600 kg were randomly selected from a herd of 250 animals at the large peri-urban commercial dairy farm, Hyderabad. All parturitions occurred in the presence of trained project staff and 11 female calves and 5 male calves were born. At Hyderabad, the calves received fresh colostrum *ad libitum* immediately after birth and twice a day (milking) from the same dam through nipple drinkers until day 3. The calves were housed under hygienic conditions with ample clean rice straw bedding and their navel cords were disinfected before being transported to the university farm by the trained project staff three days after birth. Calves were then housed in separate calf pens (183×152×112 cm). The study was conducted in the winter months December 2013 to March 2014 (average temperature highest 31ºC lowest 11ºC). The calf housing areas were covered with thick curtains overnight (when ambient temperature fell below 20°C) in order to maintain thermoneutrality throughout the trial.

Pre-weaning feeding

Sixteen calves were randomly allocated and evenly divided into two treatment groups; buffalo milk feeding (BMF) and cow milk feeding (CMF). Both types of milk were given twice a day sourced from a nearby farm in the presence of trained staff. The treatment groups were individually fed their respective milk type at a rate of 15% of their body weight, adjusted weekly, until 6 weeks of age with a maximum of 5 L/day. At 6 weeks of age the allowance of milk in both groups was gradually tapered by feeding 5.0% and 2.5% of body weight during weeks 7 and 8, until weaning at 8 weeks of age.

Calves were offered calf starter (big feed® pvt. Ltd.) containing 19.7% CP and 3.1 Mcal/kg of ME from day 1. They were provided with free access to clean water and berseem hay (Egyptian clover: *Trifolium alexandrium*; CP: 16.1%) *ad libitum*. Intake of milk, water and starter ration was measured on a daily basis. Calves were weighed weekly on a digital scale before the morning feed to monitor their growth and for calculating the quantity of milk to be fed during the subsequent week.

Post-weaning feeding

After eight weeks of age, calves were randomly allocated and evenly divided into two treatment groups; fresh berseem feeding (FBF) with 18.6% DM and hay berseem feeding (HBF) with 81.3% DM. The treatment groups were provided free access to their respective berseem type, with *ad libitum* water and starter ration until 14 weeks of age. Consumption was measured daily, and the calves were weighed weekly.

Health management

All calves were vaccinated against hemorrhagic septicemia, using an S.C. injection of killed *Pasteurella multocida* vaccine (sourced from Veterinary Research Institute, Lahore, Pakistan). Fecal score was performed on a daily basis according to Suarez-Mena *et al*., (2011). Briefly; fecal scoring was based on a 1 to 5 scoring system: (1) being normal with thick consistency (2) normal but less thick (3) abnormally thin but not watery (4) watery and (5) watery with abnormal color. Calves with fecal scores ≥ 3 were given oral electrolytes using an esophageal tube. Animals with body temperature > 39.5°C were treated with Ceftiofur sodium antibiotics (Excenel, Pfizer, Exton, PA) and the anti-pyretic flunixin meglumin (i.v; Fluxin,

Pfizer, Exton, PA).

Statistical analysis

All statistical analyses were conducted using RStudio version 1.2.1335 R version 3.6.0 (R Studio Inc., 2019). One subject (BMF group) was excluded from the analysis due to illness leaving a total of n = 15 animals in the data analysis. To investigate the effect of milk type on pre- and post-weaning total weight gains, total feed costs and cost per kilogram of beef production, data was analysed using linear models with milk type as a fixed factor. To investigate the effect of milk type on pre- and post-weaning weekly weight gains, data was analysed using a linear model with milk type and week as fixed factors. To investigate the effect of berseem type on post-weaning total weight gains, total feed costs and cost per kilogram of beef production, data was analysed using linear models with berseem type as a fixed factor. Gender was analysed as a fixed factor in all linear models and was subsequently excluded from the final models as there was no statistically significant influence ($P < 0.05$) on dependent variables. Results are presented as predicted means ± standard error of the mean and declared statistically significantly at $P < 0.05$.

RESULTS

Mortality and health

There was no calf mortality recorded for the duration of this study. One male calf from the BMF group had diarrhoea for two weeks with a fecal score > 3 and body temperature > 39.5 °C. The calf recovered after treatment, however the data for this animal was excluded from the analysis.

Pre-weaning (Birth to week 8)

BMF calves gained over 8 kg more than CMF calves (Table I; $P < 0.001$), and the total cost of feeding BMF calves was almost 25 % greater than the total cost of feeding CMF calves (Table I; $P < 0.001$). However, the cost per kilogram of beef production was comparable for both milk types (Table I; $P = 0.070$). Based on the linear model for weekly weight gain, there was a statistically significant week x milk type interaction ($F_{1,131} = 15.8$, $P < 0.001$). BMF calf weights were higher than CMF calf weights from week 3 to week 8 and these differences were statistically significant (Fig. 1A; $P < 0.007$).

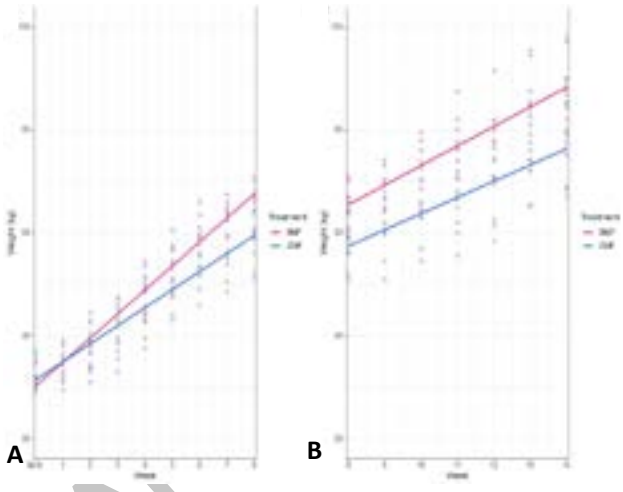

Fig. 1. Scatter plots of BMF (pink) and CMF (purple) calf weights (kgs) across Weeks at pre-weaning (A) and post-weaning (B). The solid lines are fitted linear regressions with Milk Type and Week as fixed factors. Lines have been fitted to raw BMF (pink dots) and CMF (purple dots) calf weights. Error bars represent the standard errors of predicted means from the linear regression.

Post-weaning (week 8 to week 14)

Total weight gains were similar between the two milk types, with BMF calves gaining around 4 kg more than CMF calves (Table I; $P = 0.154$). The total feed cost for BMF calves was also comparable to the total feed cost for CMF calves (Table I; $P = 0.440$); however, the cost per kilogram of beef production for BMF calves was almost 15 % less than for CMF calves (Table I; $P = 0.044$). Based on the linear model for weekly weight gain, there was no statistically significant week x milk Type interaction ($F_{1,101} = 1.18$, $P = 0.279$), however week and milk type were statistically significant predictors ($P < 0.001$, $P < 0.001$). Predicted means are presented with the interaction (Fig. 1B)

Table I. Pre-weaning and post-weaning predicted Means ± SEM of the mean for calf total weight gain, total feed cost and cost/kg of beef production by buffalo milk feeding (BMF) and cow milk feeding (CMF).

Milk type	Pre-weaning period		Post-weaning period	
	BMF	CMF	BMF	CMF
Total weight gain (kg)	33.71 ± 1.28a	25.44 ± 1.19b	22.07 ± 1.81a	18.31 ± 1.70a
Total feed cost (Rs)	10,528 ± 254a	8,578 ± 237b	1,811 ± 157a	1,640 ± 147a
Cost/kg of beef (Rs/kg)	314 ± 10 a	341 ± 9 a	81 ± 5a	94 ± 5b

Means ± SEM with different superscripts on the same row were significantly different (P < 0.05).

included to be consistent with the figure for pre-weaning. BMF calf weights were higher than CMF calf weights from week 8 to week 14 and these differences were statistically significant ($P < 0.001$). Berseem type (HBF * FBF) was also shown to impact costs in a similar manner. Although the price of berseem hay was more expensive than fresh berseem, the total cost of feeding calves (1639 ± 80a) and the resulting cost/kg of beef production (74 ± 3a) for HBF calves were smaller, even though there was no difference in weight gains between groups (Table II).

Table II. Post-weaning predicted Means±SEM of the mean for calf total weight gain, total feed cost and cost/kg of beef production by hay berseem feeding (HBF) and fresh berseem feeding (FBF).

Berseem type	HBF	FBF
Total weight gain (kg)	21.93 ± 1.84a	18.44 ± 1.72a
Total feed cost (Rs)	1639 ± 80a	1791 ± 189a
Cost/kg of beef (Rs/kg)	74 ± 3a	101 ± 9b

Means±SEM with different superscripts on the same row were significantly different ($P < 0.05$).

DISCUSSION

The present study clearly illustrates that the pre-weaning performance of buffalo calves was affected by different milk types fed from birth to weaning, as BMF calves gained more weight than CMF calves during pre-weaning. As the feeding regimes were identical, pre-weaning weight gain should have been the same for BMF and CMF calves if the milk type was not an influence. This finding suggests that feeding better milk to calves leads to superior pre-weaning growth rates. The larger weight gains achieved with buffalo milk feeding compared to cows could be due to its higher fat content, 5.3-15.0g/100g versus 3.3-6.4g/100g (Gantner *et al*., 2015). Similarly, another Pakistan based study found that buffalo calves fed 100% whole buffalo milk yielded daily weight gains of 457.38g ± 110g (birth to 120 days age) compared with 426.67 g ± 78 g for animals calves fed 50 % whole buffalo milk with 50 % milk replacer (Abdullah *et al*., 2013). Whilst these results further support the use of buffalo milk for optimal pre-weaning performance, the study also indicates that this high-fat milk gave calves a post-weaning performance advantage. The impact of feeding different milk types on post-weaning performance was also captured in the current study. The influence of milk type was not seen to significantly influence the post-weaning weight gain in the same way as pre-weaning weight gain, as the results were comparable for both treatment groups. However, the data illustrates that CMF calves were unable to catch up to the body weights of BMF calves. There is no opportunity for compensatory growth to occur when buffalo calves are fed with the whole cow milk alternative. An inability to catch up to the expected body weight following periods of undernutrition compromises production potential and subsequent financial outcomes (Baruselli *et al*., 2018). Therefore, the feeding of buffalo milk to buffalo calves from birth to weaning is a practice that should be implemented to increase pre- and post-weaning performance.

The superior growth rates of BMF calves were met with higher feeding costs from birth to weaning, however the cost/kg of beef production was comparable to that of CMF calves. These results suggest that while whole buffalo milk is initially more expensive than whole cow milk, the provision of better milk offsets the increased input costs by producing calves with heavier weaning weights. Previous findings that align with the present study indicated that Sahiwal calves fed with whole milk had higher weaning weights compared to calves fed milk replacer (51.6 ± 0.8 vs 35.2 ± 0.8 kg, respectively) and were healthier during the pre-weaning period (Bhatti *et al*., 2012). Healthy calves with higher weaning weights are vital for generating more profit at sale (Miller and Pfeiffer, 1999). Thus, low feeding costs should not be the only criteria used for choosing a nutritional regime for buffalo calf-rearing. Rather, the selection of cheaper milk alternatives to minimise short-term costs should be cautioned and decisions should be based on the long-term profitability of the system, existing resources and goals. The results of the current study advocate that the use of buffalo milk for calf-rearing, as opposed to inexpensive substitutes, is an economically viable strategy.

The costly long-term implications of using cow milk for buffalo calf-rearing was exemplified by the notably higher post-weaning cost/kg of beef production. To minimize this figure, farmers should be encouraged to invest more money into feeding calves whole buffalo milk because the initial outlay is counterbalanced by the increased production and following profits. Strengthening this recommendation, we found that whilst total feed costs of BMF calves were significantly higher during pre-weaning, they were comparable to that of CMF calves during post-weaning, demonstrating that the increased costs of feeding buffalo milk are temporary. Berseem type was also shown to impact costs in a similar manner. Although the price of berseem hay was more expensive than fresh berseem, the total cost of feeding calves and the resulting cost/kg of beef production for HBF calves were smaller, even though there was no difference in weight gains between groups. This is likely due to the increased dry matter % of the hay

berseem that increases the concentration of nutrients in the fodder. This knowledge can help inform decisions when selecting a low-cost feeding regime for buffalo calves and reiterates that the cheapest option is not always the most economical. Kundi buffalo calves should be fed buffalo milk and berseem hay during pre-and post-weaning for optimal growth and profitability.

A simple, but important result of this study, was that it was one of very few buffalo calf-rearing trials conducted within a developing dairy system that reported a calf mortality rate of 0 %. Although a fundamental goal of any calf-rearing operation, this can be a challenge in resource poor systems, particularly those where information about improved rearing practices are limited and unreliable. High buffalo calf mortality rates are a well-documented issue in Pakistan and other developing countries, with rates of 81.09 % found in India (Tiwari et al., 2007); 9.4 % reported at a well-managed government livestock farm in Pakistan (Zaman et al., 2006) and many research trials in Pakistan presenting high mortality rates, especially where buffaloes calves were purchased from market (Rashid et al., 2013).The causes for high buffalo calf mortality have not been investigated in these studies, however it could potentially be associated with poor colostrum management and feeding practices (Ahmad *et al*., 2009). Three basic principles of colostrum feeding (quantity, quality and quickly) are highly critical to reduce calf mortality (He et al., 2018). One of the critical reasons for no mortality in the current study was that special attention was given to the protocol and management of calves in the first few days of life including providing ad libitum colostrum immediately after birth from the same dam until three days after birth. This finding concurs with a previous study that found colostrum management is the single most important management factor to determine calf health and survival and hence feeding ad lib colostrum at birth should be considered as a fundamental practice when rearing calves in any system (Barry et al., 2019).

Although the results of this study clearly show that buffalo calves have higher growth rates when fed buffalo milk, it also demonstrates that these calves can be weaned at eight weeks of age on cow milk. Further investigation into feeding cow milk to buffalo calves, coupled with improved nutritional strategies like supplementation of high protein and energy calf starter ration provides a potential opportunity to reduce pre-weaning feeding costs. If comparable growth rates can be achieved whilst having no adverse effects on animal health, this could potentially reduce the cost of production in buffalo calves and improve the profitability of smallholder dairy farmers in Pakistan.

CONCLUSION

Whilst rearing buffalo calves on whole buffalo milk was more expensive than using whole cow milk, the increased input costs were offset by producing heavier weaning weights and a superior cost per kilogram of beef production. During post-weaning, the calves fed the cow milk alternative were unable to catch up to the higher body weights of calves fed buffalo milk. Therefore, the present study concludes that feeding buffalo milk to buffalo calves increases productive potential and is more economical than feeding cow milk.

DECLARATIONS

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IRB approval

The study was approved by the Institutional Review Board of Department of Animal Nutrition, Sindh Agriculture University, Tandojam.

Ethical statement

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Statement of conflict of interest

The authors have declared no conflict of interest.

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