Punjab University Journal of Zoology

OPEN ACCESS

39(2): 163-168 (2024)
https://dx.doi.org/10.17582/journal.pujz/2024/39.2.163.168

Research Article

Effect of Feeding Milk Replacer on the Productive Performance of Buffalo Newborn Calves in District Peshawar, Pakistan

Danyal Khan[1], Abdur Rahman[1], Muhammad Shuaib[2,3*], Sohaib Ul Hassan[4], Abubakar Sufyan[5], Wajid Ullah[1], Seema Jani[1], Obaid Ullah[6] and Shahrood Ahmed Siddiqui[7]

[1]Department of Livestock Management, Breeding and Genetics, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar, Pakistan
[2]Key Labortary of Animal Breeding, Reproduction and Molecular Design for Jiangsu Province, College of Animal Sciences and Technology, Yangzhou University, Yangzhou 225009, China
[3]Arid Zone Small Ruminants Research Institute, Ghulam Banda, Kohat, Pakistan
[4]College of Veterinary Sciences, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture Peshawar, Pakistan
[5]Department of Livestock and Poultry Production, Bahauddin Zakariya University Multan, Pakistan
[6]Department of Veterinary Clinical Sciences, Faculty of Veterinary and Animal Sciences, University of Poonch, Rawalkot 12350, Pakistan
[7]Vaccine Production Unit Sindh Tandojam, Livestock and Fisheries Department Government of Sindh

Article History
Received: December 09, 2023
Revised: August 25, 2024
Accepted: September 02, 2024
Published: October 11, 2024

Authors' Contributions
DK: Animal trial, laboratory work, and manuscript writing. AR: Supervision, study design, data evaluation, and statistical analysis. MS: Statistical analysis, data evaluation, data curation, original draft preparation and editing. SUH, AS, WU, SJ, OU, SAS: Data curation, manuscript writing and review.

Keywords
Buffalo, Milk replacer, Peshawar, Raw milk, Performance, Body condition score

Abstract | This study was designed to evaluate the productive performance of pre-weaned buffalo calves fed on different levels of milk replacers and their effects on feed intake, weight gain, body condition score, disease incidence, and overall profitability. Twelve calves were randomly selected and divided into four groups. Group A (control group) calves were fed with raw milk, while calves in groups B, C, and D were fed with milk replacer (MR) having levels of 13%, 16%, and 19% respectively. A Complete Randomized Design (CRD) was used to analyze the data statistically. Results revealed that total intake was significantly higher in groups B and C than in groups A and D. Total live weight change was the highest in group C followed by groups B, A, and group D. Whereas body condition score (BCS) change was higher in group C than in group D and B respectively. Group A recorded the lowest BCS. Group B had the highest average expenditure of the remaining groups. The difference between expenses and the worth of weight gain was the lowest in Group D followed by Group C while the highest difference was in Group B followed by Group A. The highest disease incidence was recorded in group D while the calves in group C were healthier and had a lower incidence of illness. It is concluded that buffalo newborn calves may be retained at the farm and fed milk replacer of 16% or 19% level and spare maximum milk for sale will give two folds profit to the farmers from the sale of raw milk and calves crops.

Novelty Statement | In the irrigation area of Khyber Pakhtunkhwa, buffalo farming is increasingly prevalent, and the high cost of buffalo milk pushes farmers to sell more than they need for calves. Insufficient milk feeding causes hunger, poor development,and high mortality. Thus, an appropriate milk replacer will meet the needs of a newborn calf and help it thrive without culling.

To cite this article: Khan, D., Rahman, A., Shuaib, M., Hassan, S.U., Sufyan, A., Ullah, W., Jani, S., Ullah, O. and Siddiqui, S.A., 2024. Effect of feeding milk replacer on the productive performance of buffalo newborn calves in district Peshawar, Pakistan. *Punjab Univ. J. Zool.*, **39**(2): 163-168. https://dx.doi.org/10.17582/journal.pujz/2024/39.2.163.168

Introduction

Buffalo population in Pakistan is 41.20 million in the whole country and 3.60 million in Khyber

Correspondence author: Muhammad Shuaib
shoaibwzr@gmail.com

Pakhtunkhwa (KP). The ratio of newly born calves is estimated at 0.80 million per year in KP (Khan, 2021). Meat is an important source of nutrition for many people around the world and the demand for it is increasing dramatically around the world. Meat output has more than quadrupled in the last 50 years. Each year, the globe generates more than 340 million tons (Ritchie *et al*., 2017). With rising demand for animal products, livestock output is fast increasing. As the human population increases similarly as per their need the demand for meat and milk also increases and these projections suggest a tremendous rise in animal protein consumption, which will be required to keep up with the growing human population (Fasih-ud-Din 2012). Newborn calves are the future producers of milk and meat for human consumption, however in Pakistan, particularly in Khyber Pakhtunkhwa, calf raising is frequently expensive and avoided due to higher prices of milk. Therefore, most of the livestock farmers in Khyber Pakhtunkhwa sell their male calves to the butchers within the first month of their age, while the owners of the commercial dairy farms sell their male calves in the first week of birth. The early disposal of calves is practiced with the idea of saving milk for sale which reduces the opportunity to generate better animals for future farming and to improve milk and meat production (Khan *et al*., 2012). The nutritional requirements of pre-ruminants vary depending on their stage of development. Pre-ruminants initially rely on liquid food such as milk due to anatomical and physiological changes in the stomach, and then gradually adjust to a solid diet. A milk replacer is a liquid food that is used to replace whole milk, whereas a calf starter is a supplement used for solid food and to replace milk replacer (Council) (NRC, 1989). Newborn calves cannot digest solid food and require liquid food such as milk or milk replacer for nutrition, the high demand for milk for human consumption severely limits the availability for pre-ruminant feeding. This inadequate amount of milk feeding results in starvation, poor growth, and high mortality (Ranjhan and Pathak, 1979). If the ingredients of milk are readily available, newborn calf mortality can be reduced to an acceptable level, and their nutrition can be improved. Alternatives to whole milk are industrial processed ingredients used. These techniques are not practical in 3rd world countries because of high pricing and the unavailability of milk by-products. Using a milk substitute (milk replacer) to save money and milk for human consumption is a sensible idea (Khan *et al*., 2012). People of Khyber Pakhtunkhwa consume more buffalo milk and give high preference to buffalo milk. The buffalo farming is relatively more in irrigated parts of Khyber Pakhtunkhwa province and the high cost of buffalo milk encourages the farmers to spare more milk for sale and less is used for the calves feeding. Deprived calves of milk make them weak and show less growth rate resulting in high mortality. Therefore, the current study was designed to determine the milk replacer effect on the performance of buffalo calves in the district of Peshawar, Pakistan.

Materials and Methods

Study area and selection of calves

This study was executed in the thick buffalo-populated areas of Peshawar Khyber Pakhtunkhwa (including but not limited to Nasir Pura, Jhagra phandu, Chamkani, Ring road Peshawar) and was conducted with the support of Directorate General (Extension) Livestock and Dairy Development Department, Khyber Pakhtunkhwa. A total 12 numbers of buffalo calves of the age ranging from (3-10 days) were randomly selected. It was ensured that all the calves were fed proper colostrum's. The selected calves' live body weight ranges from 35-45kg. All the calves were shifted to separate sheds on the same farm i.e., Waqar Dairy Farm Private Limited to easily manage them in a standardized way.

Calves grouping and feeding

These selected calves were randomly allocated into four equal groups (3 calves/group). Group A was the control group while groups B, C, and D were provided with 13%, 16%, and 19% milk replacer (MR). All the calves were properly tagged. All feeding treatments to four groups of calves were offered at 7.00 am morning and 3.00 pm and 11.00 pm. From the third week onward good quality hay was offered to all these calves at a rate of 25% of the required feed. Access to fresh water was twenty-four hours. Water troughs were cleaned every day twice morning and evening. All the calves were dewormed with Albendazole (5.0-10.0mg/kg BW) on the 40th day of the study.

Commercial milk replacer preparation

For preparation of 1 litter of milk replacer, 130 g of milk replacer powder (Lacto, Optimilk^{-1}) was added to 870 ml of fresh warm water (Khan *et al*., 2012). First of all half (50%) of the required powder and water was poured in a pot and thoroughly but gently mixed. The liquid MR was heated with continuous persistent gentle mixing. The remaining half (50%) of water and powder was added with thoroughly mixed. When the temperature reached up to 50°C the heating was stopped and the temperature down to 38-40°C. Prepared liquefied MR was poured into the bucket for the feeding calves. Such preparations were made three times a day for fresh feeding to every individual calf according to the following approved methodology. The quantity of MR was changed as the calf grew older. Normally 2 liters are required in 1st week, 4 liters are required up to the 4th week of age, 6 liters up to the 8th week of age, and 4 liters are required up to weaning (12th week) of age.

Performance parameters

All calf's live weight was recorded weekly following the FAO recommendations i.e., weighing was performed empty stomach. Therefore, weighing of calves was done

at 7.00 am. Weighing was recorded weekly by using a weighing scale (digital). All calves physical health and condition were weekly checked through body condition score (BCS) standard procedures. The BCS system used for calves was ranges from 1 to 5, with a score of 1 reflecting calf that are emaciated and a score of 5 reflecting calf that are obese. A quantified amount of milk or milk replacer was offered to all calves individually in each group. Milking was offered through a 10-liter bucket having a nipple length of 3.5-4.00 inches at 7.00 am, 3.00 pm, and 11.00 pm (night).

Dried grasses and concentrate feeding

All calves from the age of 4th week onward were offered 200-250gm of concentrates in the morning and evening which was gradually increased according to body requirement. Similarly, the dried grasses were offered abundantly. Data regarding milk replacer, hay, and starter ration was recorded daily till the lapse of the pre-weaning phase. The disease incidence in study calves was recorded daily. The body temperature, respiration, and pulse rate of each calf were measured daily using the standard procedures. Data regarding leftover milk or milk replacer or feed of individual animals was recorded daily.

Economics

The cost of all intakes was calculated for individual calves and their growth performance was compared to evaluate the efficiency of each group in terms of milk replacer feeding.

Statistical analysis

For descriptive analysis, the data was summarized using the pivot table of the Excel program. The data was exported to a statistical program for statistical analysis such as ANOVA using a Complete Randomized Design (Mead, 2017).

Results and Discussion

Results regarding the milk replacer and raw milk intake fed in different levels to the pre-weaned buffalo calves are presented in Table 1. Calves in groups B and C had the highest significant weekly and total milk replacer intake as compared to the other groups. Table 2 shows the results of weight gain of the pre-weaned buffalo calves fed on different levels of milk replacer and raw milk. During weeks 3rd, 4th, and 8th the calf's body weight was calculated (P<0.05) the highest in group B than in the remaining groups. Results regarding the body condition score of the pre-weaned buffalo calves are shown in Table 3. The weekly changes in the BCS among the groups were significantly affected and Group C showed the most prominent and progressive (%BCS change) result followed by Group D while calves in Group A were less healthy followed by Group B. Results of the economics of feeding various concentrations of milk replacer and raw milk to buffalo calves are presented in Table 4. Group B had the highest (p<0.05) economic expenditure as compared to the remaining groups. Comparison between expenses and live weight gain of buffalo are shown in Figure 1. Group B had the highest expenses (expenses of milk replacer, raw milk, medication, and other expenses) in all the groups followed by Group C while Group D had the lowest expenses followed by Group A. Worth (weight gain by the buffalo calves) was calculated the highest in the group B followed by Group C while Group D had the lowest level in worth followed by Group A. Disease incidence results of the pre-weaned calves fed on different concentrations of milk replacer and raw milk are presented in Table 5. The findings explained high disease incidence in group D followed by group B but the lowest in group C followed by group A. Group C was considered the healthiest group of this experimental trial because of the lowest disease incidence parameters recorded while group D was recorded with the most disease incidence parameters.

Table 1: Intake of milk replacer and raw milk (Liter) offered to buffalo calves in different concentration in seven weeks study (Mean±SE).

Week	Groups				P value
	A	B	C	D	
1	0.03 1. 45^{c}±0.03	2.20^{a} ± 0.02	2.16^{a} ± 0.04	1.92^{b} ± 0.12	0.050
2	1.68^{c}± 0.02	2.87^{a} ± 0.05	2.92^{a} ± 0.03	2.51^{b} ± 0.16	0.021
3	1.88^{c} ± 0.03	3.64^{a} ± 0.05	3.53^{a} ± 0.07	3.10^{b} ± 0.22	0.042
4	2.28^{c} ± 0.03	3.98^{a} ± 0.15	4.12^{a} ± 0.12	3.64^{b} ± 0.29	0.011
5	2.86^{c} ± 0.07	4.80^{a} ± 0.05	4.82^{a} ± 0.05	4.23^{b} ± 0.27	0.034
6	2.92^{c} ± 0.10	5.45^{a} ± 0.04	5.45^{a} ± 0.04	4.56^{b} ± 0.38	0.021
7	3.11^{c} ± 0.11	5.87^{a} ± 0.02	5.87^{a} ± 0.02	4.54^{b} ± 0.42	0.048
Mean total intake	113.26^{c}+8.34	201.67^{a}+7.22	202.09^{a}+6.42	171.50^{b}+7.32	0.032
Total intake	226.99	605.70	607.21	515.02	

P-values compare the feed intake of different groups at the row level (weekly effects). Group A (control), Group B (13%MR), Group C (16%), Group D (19%MR).

Table 2: Live weight (Kg) of buffalo calves offered different concentration of milk replacer and raw milk (Mean±SE).

Week	Groups				P value
	A	B	C	D	
Initial weight	38.65^{b}±8.68	43.63 ^{a}±8.57	37.73^{b}±0.64	41.20^{a}±1.85	0.032
1	39.40±10.93	45.73±9.18	39.60±2.26	38.12±2.75	0.063
2	42.05±11.68	47.07±8.41	42.43±2.45	43.42±5.29	0.073
3	44.05^{b}±9.48	49.93^{a}±7.77	45.23^{b}±2.80	45.97^{b}±5.52	0.021
4	46.30^{c}±8.12	52.70^{a}±8.13	47.33^{c}±2.79	49.20^{bc}±7.11	0.021
5	47.65±5.97	54.87±7.78	48.93±2.96	46.02±8.07	0.084
6	48.80±2.51	58.67±7.30	54.17±3.65	48.32±9.40	0.066
7	52.00±2.81	62.73±6.70	57.90±2.91	49.32±9.23	0.081
8	54.70 ^{c}±2.51	65.20^{a}±7.50	59.93^{b}±3.97	52.58^{c}±8.56	0.031
Live weight gain	16.05	21.57	22.2	11.38	
% Live weight gain	41.52%	49.43%	58.83%	18.59%	

P-values compare the live weight of different groups at the row level (weekly effects). A (control), Group B (13%MR), Group C (16%), Group D (19%MR).

Table 3: Change in the body condition score (BCS) of buffalo calves offered different concentration of milk replacer and raw milk (Mean±SE).

Week	Groups				P-value
	A	B	C	D	
1	2.50^{a} ±0.00	2.30^{b} ±0.10	2.23^{b} ±0.15	2.07^{c} ±0.07	0.032
2	2.60^{a} ±0.10	2.50^{b} ±0.00	2.57^{a} ±0.18	2.33^{c} ±0.17	0.022
3	2.50^{b} ±0.00	2.63^{a} ±0.07	2.60^{a} ±0.20	2.40^{c} ±0.21	0.043
4	2.50^{b} ±0.06	3.07^{a} ±0.07	3.33^{a} ±0.09	2.47^{b} ±0.23	0.008
5	2.75^{b} ±0.25	3.40^{a} ±0.10	3.60^{a} ±0.10	2.73^{b} ±0.15	0.005
6	3.00^{b} ±0.50	3.67^{a} ±0.09	3.70^{a} ±0.10	3.27^{b} ±0.15	0.048
7	3.40^{c} ±0.40	4.00^{a} ±0.12	4.03^{a} ±0.18	3.70^{b} ±0.21	0.035
% BCS change	36	73.9	80.7	78.7	

P-values compare the body condition score (BCS) of different groups at the row level (weekly effects). See Table 1 for group description.

Table 4: Mean expenditure (Rs) of buffalo calves offered different concentrations of milk replacer and raw milk (Mean±SE).

Week	Groups				P-value
	A	B	C	D	
1	2004^{ab} ±38.1	2258.8^{a} ±35.1	1846.7^{b} ±32.8	1435.2^{c} ±37.3	0.023
2	2158^{b} ±40.0	2804.4^{a} ±41.9	2270.8^{b} ±11.4	1691.2^{c} ±29.1	0.001
3	2431^{b} ±53.1	3273.4^{a} ±36.1	2582.5^{b} ±38.9	1925.5^{c} ±39.8	0.021
4	2864^{b} ±92.2	3931.5^{a} ±82.3	3153^{b} ±57.9	2393.8^{c} ±46.3	0.042
5	3598^{b} ±16.5	4559^{a} ±16.5	3691.5^{b} ±18.0	2921.5^{c} ±19.3	0.001
6	3330^{c} ±41.2	4830.4^{a} ±40.0	3831.3^{b} ±38.0	2680.7^{d} ±58.0	0.032
7	4111.2^{c} ±50.3	6157.7^{a} ±50.1	4864.5^{b} ±83.4	3131.2^{d} ±56.9	0.035
Total mean expenditure	20496.2^{c} ±52.3	27816.4^{a} ±58.4	22240.6^{b}±54.1	16179.3^{d}±57.2	0.024

P-values compare the feed intake of different groups at the row level (weekly effects). See Table 1 for group description.

Calves in groups B and C had the highest significant weekly and total milk replacer intake which is similar to the results of Qadeer *et al.*, (2021) who stated that the initial intake of liquid feed was high in calves fed with raw milk but the gradual intake of calves fed on milk replacers (15%) became high in the whole trial. Azevedo *et al.*, (2016) described that Increasing the concentration of total solid (milk replacer) in the liquid feed by up to 20.4% increased performance and body frame development in dairy heifers during the pre- and post-weaning periods and had no effects on solid feed intake or health. Quigley *et al.* (2006) also documented that the intake of feed was higher

Table 5: Disease incidence parameters of buffalo calves offered different concentration of milk replacer and raw milk.

Disease parameter	Period (weeks)	Groups			
		A	B	C	D
Body temperature	1-4	1	2	1	3
	5-9	2	1	1	2
Diarrhea	1-4	4	4	1	6
	5-9	2	3	2	5
Weakness	1-4	2	2	2	6
	5-9	2	2	2	6
Total		13	14	09	28

See Table 1 for group description.

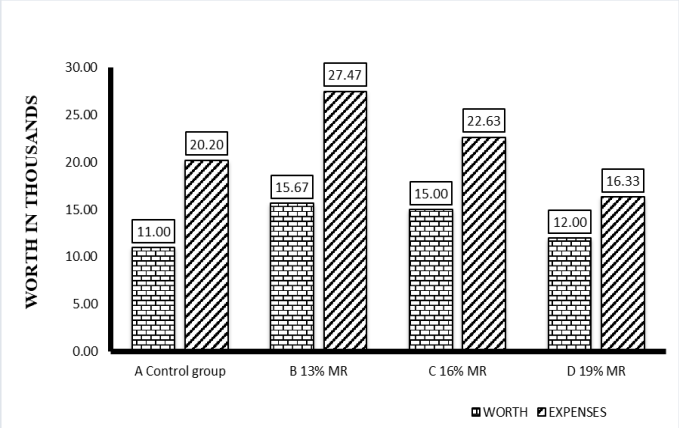

Figure 1: Economic comparison of expenses versus gain of buffalo calves offered different concentration of milk replacer and raw milk.

in the treatment group fed with calf milk replacer than that of the control group and calves fed with calf starter. Similarly, Bach *et al.* (2013) documented that the intake of liquid feed was almost the same in treatment groups hMR (offered 8L/d) and lMR (offered 6L/d) while the intake of solid feed was high in the lMR group. The calf's body weight was calculated (P<0.05) as the highest in group B than in the remaining groups and these findings are in coordination with Khan *et al.* (2012) who suggested significant changes in weight gain (In the initial week's control group fed with raw milk and the treatment group fed with additional milk replacers had the same weight gain but after 4th-week calves in the treatment group had more weight gain than the control group). Glosson *et al.* (2015) also stated that higher amounts of TS led to an increase in ADG and BW of dairy calves at 60 d of age. Similarly, Morrison *et al.* (2009) in the first four weeks recorded no significant differences in the weight gain of calves fed with increased protein level or lower protein level milk replacer. Bach *et al.* (2013) documented that at the pre-weaning stage treatment group hMR (offered 8L/d) had a higher growth rate than the treatment group lMR (offered 6L/d) while at the post-weaning stage, lMR overtook the hMR group in growth rate because of the early adaptability to the solid feed. Group C showed the most prominent and progressive (%BCS change) result which is in agreement with the result of Similarly, Lopez *et al.* (2008) who fed milk replacer to calves and suggested that whatever feeding regime is followed it will benefit the body conditions of the calves. Group B had the highest (p<0.05) economic expenditure which is similar to the findings of Anjum *et al.* (2012) who stated that calves fed on milk replacers having a concentration of 8% and 4% have higher expenses than the weight gain. In agreement with our results, Qadeer *et al.* (2021) presented greater total production cost in the pre-weaning stage of calves while lower in the post-weaning period. Similar to our results, Quigley *et al.* (2006) also reported high expenses including labor costs in all the treatment groups fed with milk replacers, calf starters, and additional milk replacers in the pre-weaning stage. In the present study the highest disease incidence was recorded in group D but the lowest in group C which is in line with the findings of Qadeer *et al.* (2021) who described higher disease incidence (scour incidence) in calves at the pre-weaned stage while lower after weaning. Amado *et al.* (2019) also documented that calves fed with high fat have a higher incidence of diarrhea than the calves fed with high lactose feed. Calves fed with additional calf milk replacers had clinical signs of pneumonia, salmonella, *E. coli*, and enteric infections and were identified as a cause of mortality. Similarly, de Passille *et al.* (2016); Azevedo *et al.* (2016), and Ollivett *et al.* (2012) also suggested that calves with elevated milk or MR intake during the pre-weaning period are less susceptible to illness.

Conclusions and Recommendations

Calves in group C exhibited a more suitable pattern of percent weight gain, more persistent body condition scores, healthier, and less infected with disease incidence during the experiment. Although the expenses were higher in all the groups than the worth gain, however, the percent expenses were found least in groups D and C. No mortality was found in this experiment among groups. Replacing raw milk with 16% milk replacer will be more beneficial if applied in controlled and hygienic conditions at a farm. Supplementation of other ingredients such as wheat bran along with milk replacer may enhance the gut development of the calves. A similar study with another locally manufactured milk replacer may also be executed to develop a strong extension message for the buffalo peri-urban farmers around district Peshawar.

Declarations

Acknowledgement

We acknowledge the staff of the Department of Livestock Management, Breeding and Genetics, Faculty of Animal Husbandry and Veterinary Sciences, The University of Agriculture, Peshawar-Pakistan, who

provided technical and laboratory facilities.

Funding

This study received no funds and is self-supported.

IRB approval

The experimental work was approved by the Board of Studies (BOS) (October 2022) and conducted at the Department of Livestock Management, Breeding and Genetics, Faculty of Animal Husbandry and Veterinary Sciences (FAHVS), The University of Agriculture Peshawar, KP, Pakistan.

Ethical statement

The experiment was approved by the ethical committee of the Faculty of Animal Husbandry and Veterinary Sciences (FAHVS), The University of Agriculture Peshawar before the practical execution of this experiment (October 2022).

Statement of conflict of interest

The authors have declared no conflict of interest.

References

Amado, L., Berends, H., Leal, L., Wilms, J., Van Laar, H., Gerrits, W. and Martín-Tereso, J., 2019. Effect of energy source in calf milk replacer on performance, digestibility, and gut permeability in rearing calves. *J. Dairy Sci.*, **102**: 3994-4001. https://doi.org/10.3168/jds.2018-15847

Anjum, M.I., Azim, A., Jabbar, M.A., Nadeem, M.A. and Mirza, I.H., 2012. Effect of low energy followed by high energy based total mixed diets on growth rate, blood haematology and nutrient digestibility in growing buffalo heifers. *Pak. J. Zool.*, **44**: 399-408.

Azevedo, R.A., Machado, F.S., Campos, M.M., Furini, P.M., Rufino, S.R.A., Pereira, L.G.R. and Coelho, S.G., 2016. The effects of increasing amounts of milk replacer powder added to whole milk on feed intake and performance in dairy heifers. *J. Dairy Sci.*, **99**: 8018-8027. https://doi.org/10.3168/jds.2015-10457

Bach, A., Terré, M. and Pinto, A., 2013. Performance and health responses of dairy calves offered different milk replacer allowances. *J. Dairy Sci.*, **96**: 7790-7797. https://doi.org/10.3168/jds.2013-6909

de Passille, A.M., Rabeyrin, M. and Rushen, J., 2016. Associations between milk intake and activity in the first days of a calf's life and later growth and health. *Appl. Anim. Behav. Sci.*, **175**: 2–7. https://doi.org/10.1016/j.applanim.2014.10.002

Fasih-ud-Din, 2012. *Effect of milk replacer on Holstein Friesian calves*. Thesis.

Glosson, K.M., Hopkins, B.A., Washburn, S.P., Davidson, S., Smith, G., Earleywine, T. and Ma, C., 2015. Effect of supplementing pasteurized milk balancer products to heat-treated whole milk on the growth and health of dairy calves. *J. Dairy Sci.*, **98**: 1127-1135. https://doi.org/10.3168/jds.2014-8567

Khan, R., Ghufranullah, S.A., Khan, B.D., Iqbal, M. and Pervez, K.F., 2012. Effect of milk replacer on performance parameters of different bovine breeds. *Pak. J. Nutr.*, **11**: 1190. https://doi.org/10.3923/pjn.2012.1190.1193

Khan, Z.U., 2021. The legal structure and role of livestock in Pakistan's Economy. *Pak. Vis.*, **22**: 59.

López, J.R., Elías, A. and Delgado D., 2008. The feeding system of buffalo calves. Its influence on the species efficiency. *Cuban J. Agric. Sci.*, **42**: 235-240.

Mead, R., 2017. *Statistical methods in agriculture and experimental biology*. CRC Press. https://doi.org/10.1201/9781315275772

Morrison, S.J., Wicks, H., Fallon, R., Twigge, J., Dawson, L., Wylie, A. and Carson, A., 2009. Effects of feeding level and protein content of milk replacer on the performance of dairy herd replacements. *Animal*, **3**: 1570-1579. https://doi.org/10.1017/S1751731109990437

NRC Council, 1989. *Nutrient requirements of dairy cattle*. National Academic Press, Washington, DC USA, pp.90.

Ollivett, T.L., Nydam, D.V., Linden, T.C., Bowman, D.D. and Van Amburgh, M.E., 2012. Effect of nutritional plane on health and performance in dairy calves after experimental infection with *Cryptosporidium parvum*. *J. Am. Vet. Med. Assoc.*, **241**: 1514–1520. https://doi.org/10.2460/javma.241.11.1514

Qadeer, M.K., Bhatti, S.A., Nawaz, H. and Khan, M.S., 2021. Effect of milk or milk replacer offered at varying levels on growth performance of Sahiwal veal calves. *Pak. J. Agric. Sci.*, **58**: 1905-1911. https://doi.org/10.1007/s11250-021-02666-7

Quigley, J., Wolfe, T. and Elsasser, T., 2006. Effects of additional milk replacer feeding on calf health, growth, and selected blood metabolites in calves. *J. Dairy Sci.*, **89**: 207-216. https://doi.org/10.3168/jds.S0022-0302(06)72085-9

Ranjhan, S. and Pathak, N.N., 1979. *Management and feeding of buffaloes*. Vikas Publ. House. New Delhi.

Ritchie, H., Rosado, P. and Roser, M., 2017. *Meat and dairy production*. Our world in data. https://ourworldindata.org/meat-production.