RESEARCH ARTICLE

Effect of Different Levels of Energy and Protein in Total Mixed Ration on Body Weight, Body Condition Score and Body Measurement in Crossbred Heifer-Calves

Pankaj G. Trivedi[1]*, Pravin M. Lunagariya[2], Palak P. Vaidh[1], Chirag P. Parmar[2], Kamlesh K. Sorathiya[1]

Abstract

The experiment was aimed to evaluate the impact of varying energy and protein levels in a total mixed ration on body weight, body weight gain, body condition score (BCS), and body measurement in crossbred heifer-calves. A total of 24 crossbred heifer-calves (75% Holstein Friesian x 25% Kankrej) 4-6 months old, with similar growth and body weight were randomly allocated to four treatment groups, each consisting of six calves. The calves in groups T_1, T_2, T_3, and T_4 were fed TMR having 12.60% crude protein (CP) & 2.028 Mcal metabolizable energy (ME)/kg feed, 14.30% CP & 2.131 Mcal ME/kg feed, 15.98% CP & 2.244 Mcal ME/kg feed, and 17.58% CP & 2.307 Mcal ME/kg feed, respectively, for 140 days. The mean body weight was not significantly ($p>0.05$) affected among treatment groups, while total body weight gain (kg) and heart girth gain (cm) were significantly ($p<0.05$) higher in high ME CP groups (T_3, T_4) than lower ME CP groups (T_1, T_2) of calves. The body condition score and daily body weight gain (kg/day) was significantly ($p<0.05$) higher in T_4 group followed by T_2 and T_3 groups and lowest in T_1 group. The body measurement (heart girth, height at wither, body length) and their gain (height at wither, body length) were statistically non-significant ($p>0.05$) among treatment groups. The higher energy and protein levels in total mixed ration increased total and daily body weight gain and body condition score in crossbred heifer-calves.

Key words: Body condition score, Body measurement, Body weight, Crossbred heifer calves, Energy and protein level, Total mixed ration.
Ind J Vet Sci and Biotech (2026): 10.48165/ijvsbt.22.1.15

Introduction

In addition to supplying transportation and animal waste, cattle provide around 13% of the world's calories and 28% of its protein through the production of meat, milk, and eggs (FAO, 2011). Due to population increase, urbanization, and rising affluence, there is a growing demand for cow products worldwide. Small-scale pastoral livestock keepers or mixed crop-livestock farmers in poor countries frequently use traditional techniques to generate foods derived from animals. Nutrition has a significant impact on the production, growth, and health of animals. The two most important nutrients in animal diets are protein and energy, which are necessary for growth, productivity, and reproduction. Optimizing resource intake and lowering nutrient output in manure, while enhancing development, feed efficiency and future lactation performance is the main goal of heifer rearing (Akins, 2016). Optimal body weight and calving age (22-24 months) reduce feeding costs while increasing productive life. Higher raising and feeding costs result from heifers' slower weight increase, which also raise the breeding and calving age. The very fast prepubescent body weight gain brought on by a high-density diet during 3-10 month period accumulate adipose tissue in the body and mammary gland, which in turn lowers mammary excretory tissue and milk output (Sejrsen *et al.,* 1982).

The optimum growth rate for Holstein breed is between 800-1000 g/d (Kertz *et al.,* 1987). The average growth rate for post-weaned crossbred calves at Livestock Research Station, Kamdhenu University, Anand (India) over the three years (2020, 2021, and 2022) was 470 g/d on farm feeding, 675.56 g/d on feeding 5-10% more nutrition (Lunagariya *et al.,* 2019), and 730 g/d for heifers fed 25% more energy and protein (Vaidh *et al.,* 2022). Given these realizations, an experiment was created to evaluate the effects of a total mixed ration with different protein and energy level on the body weight, body condition score (BCS), body weight increase, body measurement, and body weight gain of crossbred heifer-calves.

[1]Department of Animal Nutrition, College of Veterinary Science &Animal Husbandry, Kamdhenu University, Anand-388001, Gujarat, India

[2]Livestock Research Station, College of Veterinary Science & Animal Husbandry, Kamdhenu University, Anand-388001, Gujarat, India

Corresponding Author: Dr. Pankaj G. Trivedi, Junior Research Fellow, Livestock Research Station, College of Veterinary Science &Animal Husbandry, Kamdhenu University, Anand-388001, Gujarat, India. E-mail: dr.pankaj1911@gmail.com

How to cite this article: Trivedi, P. G., Lunagariya, P. M., Vaidh, P. P., Parmar, C. P., & Sorathiya, K. K. (2026). Effect of Different Levels of Energy and Protein in Total Mixed Ration on Body Weight, Body Condition Score and Body Measurement in Crossbred Heifer-Calves. Ind J Vet Sci and Biotech, 22(1), 77-81.

Source of support: Nil

Conflict of interest: None

Submitted 07/11/2025 **Accepted** 30/11/2025 **Published** 10/01/2026

Materials and Methods

The present experiment was conducted at the Livestock Research Station, Kamdhenu University, Anand (Gujarat, India), for 140 days (ten biweekly period) following approval of Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), New Delhi (408/LRS/2023 CPCSEA). The twenty-four crossbred (75% Holstein Friesian x 25% Kankrej) heifer-calves, 4-6 months old, with similar growth, and body weight were randomly assigned to four treatment groups (six in each). The calves in T_1, T_2, T_3, and T_4 groups were fed TMR with crude protein (CP) and metabolizable energy (ME)/kg feed as 12.60%, 2.028 Mcal; 14.30%, 2.131 Mcal; 15.98%, 2.244 Mcal; and 17.58%, 2.307 Mcal, respectively (Table 1). All crossbred heifer-calves were fed TMR twice daily at 10:30 AM and 2:00 PM. The calves in T_2 group were fed TMR at 3.5% of body weight on a dry matter basis at initial and increased at weekly intervals if less than 10% leftover remained. The heifer-calves in all other treatments were fed dry matter at a level similar to T_2. Fresh and clean water was provided during morning exercise (8:00 to 10:00 AM) and three times daily (12:00 PM, 3:00 PM, and 9:00 PM) at their tying place. The calves were weighed on an electronic weighing balance on a weekly basis at 07.00 h prior to feeding and watering. The weekly and biweekly weight was considered for feed adjustment and daily weight gain, respectively.

The heart girth, wither height and body length of heifer-calves were recorded at biweekly intervals prior to feeding and watering by placing heifers squarely on four feet with the head in an upright position. All measures were taken in centimeters. The body condition score (BCS) of all experimental calves was assessed using a 5-point scale as outlined by Edmonson *et al.* (1989) at initial, mid, and at the end of the experiment. The scoring scale ranged from 1 (emaciated) to 5 (obese), with increments of 0.25. To ensure accuracy, more than two scientists had assessed BCS, and the average was taken.

The data on the parameters studied during the experiment were presented as mean ± SE and were analyzed using standard methods (Snedecor and Cochran 2014) via one-way ANOVA with the Statistical Program for Social Science (SPSS). Differences between treatment means were considered significant at a probability level of <0.05.

Results and Discussion

The findings on body weight, body condition score, body measurements, and gain in body weight and body measurements are presented in Table 2.

Table 1: Ingredients and nutrients composition of total mixed ration (TMR) fed to crossbred heifer-calves

Sr. No.	Parameter	T1	T2	T3	T4
Ingredients proportion (kg)					
1	Compound concentrate mixture	27.50	37.00	46.30	56.30
2	Mineral vitamin premix	1.00	1.00	1.00	1.00
3	Salt	1.00	1.00	1.00	1.00
4	Bypass fat	0.50	1.00	1.70	1.70
5	Wheat straw	8.00	4.20	0.00	0.00
6	GNC straw (Gotar)	52.00	45.80	40.00	30.00
7	Hybrid Napier	10.00	10.00	10.00	10.00
Total		100	100	100	100
Price (₹/kg DM)		**20.93**	**24.52**	**27.87**	**30.60**
Concentrate to Roughage ratio		**30:70**	**40:60**	**50:50**	**60:40**
Chemical composition					
Dry matter %		71.71	71.14	71.86	71.71
Organic matter %		85.85	86.29	86.94	86.56
Crude protein %		11.92	13.39	15.07	16.74
Crude fibre %		28.95	28.02	23.27	22.54
Ether extract %		2.91	3.02	4.05	4.48
Ash %		14.15	13.71	13.06	13.44
Nitrogen free extract %		42.07	41.86	44.55	42.80
Calculated metabolizable energy (Mcal/kg)		2.028	2.131	2.244	2.307
Neutral detergent fibre%		56.01	56.06	53.12	54.56
Acid detergent fibre%		39.20	38.41	34.81	33.91
Total digestible nutrients%		54.61	56.13	57.05	57.81

Table 2: Mean and gain in body weight, body condition score (BCS), mean and gain in body measurements of crossbred heifer calves fed different TMRs

Parameter		T_1	T_2	T_3	T_4	P value
Body weight (kg)	Mean BW (kg)	200.49±7.91	208.76±7.96	213.94±8.08	223.02±8.40	0.255
	Total gain (kg)	119.50^{a}±8.22	134.77^{ab}±8.82	147.43^{bc}±6.54	163.40^{c}±7.65	0.006
	Mean daily BW gain (kg/day)	0.854^{a}±0.03	0.963^{b}±0.04	1.053^{b}±0.03	1.167^{c}±0.04	0.001
Body condition score		3.12^{a}±0.09	3.27^{ab}±0.08	3.36^{ab}±0.08	3.52^{b}±0.09	0.015
Mean body measurements (cm)	Heart girth	136.07±1.90	139.01±1.90	140.75±1.97	141.78±1.99	0.177
	Wither height	115.56±1.08	114.44±1.10	114.79±1.05	115.39±1.06	0.872
	Body length	123.88±1.75	123.98±1.46	126.01±1.58	127.99±1.54	0.214
Gain in body measurements (cm)	Heart girth	28.47^{a}±1.41	30.98^{ab}±1.43	35.10^{bc}±1.76	39.30^{c}±1.03	0.001
	Wither height	16.25±1.44	17.63±1.45	16.48±1.22	18.27±1.41	0.702
	Body length	22.82±1.39	21.97±1.11	24.87±0.97	26.28±2.13	0.185

BW= body weight; Mean with different superscripts within a row differ significantly ($p<0.05$).

Body Weight

The mean body weights (kg) of the crossbred heifer-calves though numerically increasing in treatment groups were statistically non-significant ($p>0.05$), as it is affected by the individual difference and interaction of the level of protein and starch in the diet (Zothanpuii *et al*., 2015). Similarly, Sunetha *et al.* (2024) reported non-significant ($p>0.05$) change in body weight of crossbred calves receiving a high plane of nutrition. Non-significant ($p>0.05$) findings for mean body weight was also observed in Holstein bull calves (Chen *et al.,* 2023), in crossbred heifers (Vaidh *et al.,* 2022), in Chinese Holstein heifers (Dong *et al.,* 2015), and in Angus × Chinese Xiangxi yellow cattle (Li *et al.,* 2014) when fed a high-density diet in terms of protein and energy. In contrast to the present findings, significantly higher mean body weights were observed by others in crossbred heifers (Lunagariya *et al.,* 2019), in Holstein dairy heifers (Williams *et al.,* 2022), and in growing Hereford x Friesian heifers (Armstrong *et al.,* 2001) on feeding densified diet.

The total body weight gain of crossbred heifer-calves was significantly ($p<0.05$) higher in T_4 group than T_1 and T_2 groups. The total body weight gain (kg) in T_3 was at par with T_4 and T_2 group, similarly T_2 was also at par with T_1 group (Table 2). These observations aligned with previous reports. Sunetha *et al.* (2024) found higher ($p<0.01$) total weight gain in crossbred calves and Vaidh *et al.* (2022) in crossbred heifers on feeding high plane of nutrition. Some other research studies also reported significantly higher total gain in BW in Holstein heifers (Williams *et al.,* 2022), in crossbred heifers (Lunagariya *et al.,* 2019), and in growing yaks (Medhi *et al.,* 2018) on feeding of densified diet (energy or protein or both). In contrast to our result, Chen *et al.* (2023) found a non-significant difference in body weight gain in Holstein bull calves fed diet with various proteins to starch ratios.

The daily body weight gain in crossbred heifer-calves was significantly ($p<0.05$) higher in T_4 group followed in T_3 and T_2, while T_1 had the lowest BW gain. The BW gain in T_2 and T_3 groups were at par with each other. Similarly higher daily body weight gain was reported by Sunetha *et al.* (2024) in crossbred calves (0.75±14.65 vs. 0.59±26.12; $p<0.01$) receiving a high plane of nutrition. Vaidh *et al.* (2022) also reported a significant increase ($p<0.05$) in daily body weight gain in crossbred heifers fed higher levels of crude protein and metabolizable energy. Other studies have also shown increase ($p<0.05$) daily body weight gain in male calves (Kim *et al.,* 2022), in crossbred heifers (Lunagariya *et al.,* 2019), and in crossbred bull calves (Akhter *et al.,* 2017) on feeding of diet with elevated energy and protein levels. In contrast to the present findings, non-significant ($p>0.05$) daily body weight gain was observed in Hanwoo fattening steers fed dietary different CP levels (Oh *et al.,* 2024), in Holstein bull calves (Chen *et al.,* 2023), in crossbred (Sahiwal x HF) heifers (Islam *et al.,* 2019), in Holstein heifers (Gabler and Heinrichs, 2003; Hoffman *et al.,* 2001), and in growing Angus × Chinese Xiangxi yellow cattle (Li *et al.,* 2014) when fed a diet densified with energy and protein.

Body Condition Score (BCS)

The body condition score of crossbred heifer-calves was significantly ($p<0.05$) higher in T_4 than T_1 group, while T_2 and T_3 were at par with each other and also par with T_1 and T_4 group. The BCS improved in the highest ME-CP TMR (T_4) compared to the lowest ME-CP TMR (T_1). Similar to our results, Williams *et al.* (2022) recorded higher BCS (3.83 vs 3.50; $p=0.02$) of Holstein dairy heifers fed high-energy diets compared to low energy diets. Richards *et al.* (2020) showed similarly improved BCS in Holstein cows fed a high energy diet. Increasing protein levels in the diet of Holstein heifers showed a decreasing trend in BCS (Hoffman *et al.,* 2001). In contrast to our result, statistically unaffected BCS was also reported in prepubertal Holstein heifers fed different CP:ME ratio (Gabler and Heinrichs, 2003), and in Hereford x Friesian heifers fed diet with low and high energy (Armstrong *et al.,* 2001).

Body Measurement

The mean and gain (cm) in body measurements (heart girth, height at wither, body length) of crossbred heifer-calves are presented in Table 2. The mean value of heart girth, mean height at wither, and mean body length of crossbred heifer calves differed non-significantly (p>0.05) among the treatment groups. Similar result for mean heart girth was reported by Chen *et al.* (2023) in Holstein bull calves. Vaidh *et al*. (2022) and Bilginturan (2020) also reported a non-significant (p>0.05) effect on mean heart girth of crossbred heifers and Holstein Friesian heifers, respectively fed elevated energy and protein diet. In contrast to the present findings, higher heart girth was reported in Angus × Chinese Xiangxi yellow-growing cattle (Li *et al.,* 2014), and in crossbred heifers (Lunagariya *et al.,* 2019; Islam *et al.,* 2019; Williams *et al.,* 2022) when fed densified diets.

The non-significant (p>0.05) result for wither height and body length were reported by Lunagariya *et al.* (2019) in crossbred heifers on feeding a 6% densified diet, and Bilginturan (2020) in Holstein and Guernsey breed calves fed different energy and protein levels. In contrast to the present result, significant (p<0.05) improvement in wither height and body length were reported by Vaidh *et al.* (2022) and Singh *et al.* (2015) in crossbred heifers fed energy and protein densified diet.

The heart girth gain observed in crossbred heifer-calves was significantly (p<0.05) higher in T_4 group than T_1 and T_2. The value in T_2 was at par with T_1 and T_3, likewise the T_3 value was at par with T_2 and T_4. Similar to our result, higher (p<0.05) gain in heart girth was also reported in crossbred heifers fed high energy and protein densified diets (Vaidh *et al.,* 2022), in crossbred heifers fed higher protein content diet (Islam *et al.,* 2019), in crossbred bull calves fed high energy and protein diet (Akhter *et al.,* 2017), and in Angus × Chinese Xiangxi yellow growing cattle fed high energy diet (Li *et al.,* 2014). In contrast with the results of this study, non-significant (p>0.05) changes in heart girth gain were obtained in Holstein dairy heifers fed energy densified diet (Williams *et al.,* 2022) and those fed protein densified diet (Hoffman *et al.,* 2001).

The gain of wither height and body length gain were statistically non-significant (p>0.05) among different treatment groups. There are many reports, which aligned with our non-significant (p>0.05) change in wither height gain and body length gain including Vaidh *et al.* (2022) in crossbred heifers fed energy and protein densified TMR, Williams *et al.* (2022) in Holstein dairy heifers fed energy-densified diet, Akhter *et al.* (2017) in crossbred bull calves fed different energy and protein levels in diet, and Li *et al.* (2014) in Angus × Chinese Xiangxi yellow growing cattle fed high energy diet. Contrary to the present findings, the wither height growth and body length gain reported were significantly (p<0.05) greater on feeding protein densified diet in crossbred dairy heifers (Islam *et al.,* 2019) and in Holstein heifers (Hoffman *et al.,* 2001).

Conclusion

The TMR with different levels of energy and protein (T_1: 12.60% CP, 2.028 Mcal ME/kg feed; T_2: 14.30% CP, 2.131 Mcal ME/kg feed, T_3: 15.98% CP, 2.244 Mcal ME/kg feed, and T_4: 17.58% CP, 2.307 Mcal ME/kg feed) fed to crossbred heifer-calves resulted in significantly higher gain in total and daily body weight, heart girth, and body condition score in high ME CP TMR (T_3, T_4) than low ME CP TMR (T_1, T_2) groups, without significant changes in mean value of body weight, body measurement and gain in witherheight and body length.

Acknowledgements

The authors acknowledge the funds and facilities provided by Kamdhenu University, Anand, Gujarat, India, for this research.

References

Akhter, M., Islam, M., Habib, M., Rashid, M., & Khandaker, Z. (2017). Effect of energy and protein supplementation on growth and nutrient requirement estimation in crossbred bull calf. *Bangladesh Journal of Animal Science*, *46*(3), 179-187.

Akins, M.S. (2016). Dairy heifer development and nutrition management. *Veterinary Clinics: Food Animal Practice*, *32*(2), 303-317.

Armstrong, D.G., McEvoy, T.G., Baxter, G., Robinson, J.J., Hogg, C.O., Woad, K.J., Webb, R., & Sinclair, K.D. (2001). Effect of dietary energy and protein on bovine follicular dynamics and embryo production *in vitro*: Associations with the ovarian insulin-like growth factor system. *Biology of Reproduction*, *64*(6), 1624-1632.

Bilginturan, S. (2020). Effects of different protein and energy levels in mixed feed on growth performance and reproduction characteristics of heifers. *Asian Journal of Dairy and Food Research*, *39*(3), 221-224.

Chen, X., Han, Z., Dong, J., Xiao, J., Zhao, W., Rong, J., Aschalew, N. D., Zhang, X., Qin, G., Zhen, Y., Sun, Z., & Wang, T. (2023). Dietary protein to starch metabolizable energy ratios alter growth performance and gastrointestinal microbiota of calves. *Frontiers in Microbiology, 14,* 1065721.

Dong, L.F., Zhang, W.B., Zhang, N.F., Tu, Y., & Diao, Q.Y. (2015). Feeding different dietary protein to energy ratios to Holstein heifers: Effects on growth performance, blood metabolites and rumen fermentation parameters. *Journal of Animal Physiology and Animal Nutrition*, *101*(1), 30-37.

Edmonson, A.J., Lean, I.J., Weaver, L.D., Farver, T., & Webster, G. (1989). A body condition scoring chart for Holstein dairy cows. *Journal of Dairy Science*, *72(1), 68-78*.

FAO (2011). World Livestock 2011 – Livestock in food security. FAO, Rome, Italy.Available at http://www.fao.org/docrep/014/i2373e/i2373 e00.htm [Verified 4 December 2015]

Gabler, M.T., & Heinrichs, A.J. (2003). Dietary protein to metabolizable energy ratios on feed efficiency and structural growth of prepubertal Holstein heifers. *Journal of Dairy Science*, *86*(1), 268-274.

Hoffman, P.C., Esser, N.M., Bauman, L.M., Denzine, S.L., Engstrom, M., & Chester-Jones, H. (2001). Effect of dietary protein on growth and nitrogen balance of Holstein heifers. *Journal of Dairy Science*, *84*(4), 843-847.

Islam, M.S., Habib, M.R., Islam, M.A., & Harun-ur-Rashid, M. (2019). Effects of protein concentrate supplementation-based diet on growth and nutritional status in dairy heifers. *Journal of the Bangladesh Agricultural University*, *17*(1), 45-49.

Kertz, A.F., Prewitt, L.R., & Ballam, J.M. (1987). Increased weight gain and effects on growth parameters of Holstein heifers from 3 to 12 months of age. *Journal of Dairy Science, 70,* 1612-1622.

Kim, W.S., Ghassemi Nejad, J., Peng, D.Q., Jo, Y.H., Kim, J., & Lee, H.G. (2022). Effects of different protein levels on growth performance and stress parameters in beef calves under heat stress. *Scientific Reports*, *12*(1), 8113.

Li, L., Zhu, Y., Wang, X., He, Y., & Cao, B. (2014). Effects of different dietary energy and protein levels and sex on growth performance, carcass characteristics and meat quality of F1 Angus × Chinese Xiangxi yellow cattle. *Journal of Animal Science and Biotechnology, 5,* 21.

Lunagariya, P.M., Shah, S.V., Hadiya, K.K., Sorathiya, K.K., & Patel, Y.G. (2019). Growth and feed conversion efficiency as influenced by high plane of nutrition in crossbred heifers. *International Journal of Current Microbiology and Applied Sciences, 8*(7), 1769-1775.

Medhi, D., Paul, V., & Deb, S.M. (2018). Effect of plane of nutrition on blood biochemical parameters and attainment of sexual maturity in growing yaks. *Indian Journal of Animal Sciences*, *88*(4), 81-84.

Oh, J., Cho, H., Jeong, S., Kang, K., Lee, M., Jeon, S., Kang, H., & Seo, S. (2024). Effects of dietary crude protein level of concentrate mix on growth performance, rumen characteristics, blood metabolites, and methane emissions in fattening Hanwoo steers. *Animals*, *14*(3), 469.

Richards, B.F., Janovick, N.A., Moyes, K.M., Beever, D.E., & Drackley, J.K. (2020). Comparison of prepartum low-energy or high-energy diets with a 2-diet far-off and close-up strategy for multiparous and primiparous cows. *Journal of Dairy Science, 103*(10), 9067-9080.

Sejrsen, K., Huber, J.T., Tucker, H.A., & Akers, R.M. (1982). Influence of nutrition on mammary development in pre-and postpubertal heifers. *Journal of Dairy Science*, *65*(5), 793-800.

Singh, V.P., Dubey, M., & Pandey, R.K. (2015). Effect of different feed combinations on the growth performance of crossbred heifer calves. *Asian Journal of Animal Science*, *9,* 225-232.

Snedecor, G.W., & Cochran, W.G. (2014). *Statistical Methods*. 8th edn., The Iowa State University Press, Ames, Iowa, USA.

Sunetha, S., Kumar, A., Tiwari, D.P., Mandal, B.C., Singh, D.V., Prakash, A., Singh, G., & Singh, M.K. (2024). Effect of plane of nutrition on the performance of crossbred calves. *Animal Nutrition and Feed Technology*, *24*(2), 431-440.

Vaidh, P.P., Lunagariya, P.M., Patel, J.H., Pandya, P.H., Khant, M.R., Sharma, N., & Wadhwani, K.N. (2022). Growth, reproductive performance, and health attributes of crossbred heifers fed high plane of energy and protein. *Biological Forum – An International Journal*, *14*(4), 579-585.

Williams, K.T., Weigel, K.A., Coblentz, W.K., Esser, N.M., Schlesser, H., Hoffman, P.C., Ogden, R., Su, H., & Akins, M.S. (2022). Effect of diet energy level and genomic residual feed intake on bred Holstein dairy heifer growth and feed efficiency. *Journal of Dairy Science*, *105*(3), 2201-2214.

Zothanpuii, K., Amonge, T.K., & Sarma, N.K. (2015). Performance of crossbred calves (Jersey x Assam local) at different levels of protein in calf starter. *Indian Journal Animal Research*, *49,* 378-382.