Growth Performance of Crossbred Calves Fed A Conventional and Total Mixed Ration With Varying Concentrate Level

Comment [a1]: Short the title Needed

ABSTRACT:

Aim-The experiment was planned to investigate the effect of different concentrate to roughage ratios and conventional feeding systems in total mixed ration on nutrient intake, water intake, growth, feed conversion, and cost of feeding in crossbred dairy calves.

Place and Duration of Study- The present study was carried out at Livestock Research Station, Anand Agricultural University, Anand, Gujarat for a period of 84 days.

Methodology- A total of 24 healthy (8 days old) preweaned (HF×Kankrej) crossbred calves were distributed randomly into the four experimental treatments. The calves of the T_1 (control) group were fed with the conventional system and group T_2, T_3, and T_4 groups were fed TMR with the concentrate roughage ratio of 85:15, 75:25, and 65:35, respectively. The feed intake, growth, feed conversion, and cost of feeding the crossbred calves were recorded.

Results- The daily, percent, and metabolic body weight basis intake of dry matter (DM), total digestible nutrients (TDN), and water intake was significantly ($p<0.05$) lower in the TMR feeding system than conventional feeding in crossbred calves. The initial and final body weight (kg), height at withers, heart girth, and body length (cm) did not differ significantly among the treatments. Total and daily body weight gain of crossbred calves were significantly higher with T4 TMR (65:35 ratio) compared to the conventional system of feeding. The requirement of dry matter to gain each kilogram of live weight was significantly lower in the 65:35 ratio (T_4) group compared to the control group (T_1). The calves of the T_4 group showed a 21.81 % (Rs 73.55/kg weight gain) lower cost of feeding as compared to the T_1 group.

Conclusion- The feeding TMR with concentrate to roughage ratio of 65:35 (T4) resulted in reduced dry matter, TDN, and water intake with better weight gain and feed conversion compared to the convention (T1) feeding system with a 21.81 percent reduction in feed cost.

1. INTRODUCTION:

The development of the reticulo-rumen and associated microbial population is important in ruminant calves for adequate utilization of dry and forage-based feeding regimes [1]. Ingestion of solid feed promotes the modification from a pre-ruminant animal to a functioning ruminant [2]. A feeding program including roughage and concentrate feed should be useful to calves alongside milk supply to provide early rumen development [3]. Less roughage and higher concentrate consumption result in fat deposition in the animal body and will reduce feed conversion ratios [4]. Roughages could be used for the normal development of the rumen during the preweaning period [5]. During the preweaning period, the use of roughages may have an inspiring effect on rumination [6]. It may improve rumen action, volume, muscularity, support epithelium and papillae development [7].

A total mixed ration can be described as a mixture of both roughages and concentrate ingredients to meet the needs of the animal. The adequate structural fiber content in TMR is important for stimulating chewing activity, and salivary production, all necessary for healthy ruminal function [8]. TMR feeding is therefore utilized in calf nutrition. Van Ackeren *et al.*

(2010) [9] stated that early feeding dry TMR containing 15% alfalfa hay and weaning at 8 weeks shows better weight gain at 15 weeks as compared to those fed with the conventional system. The feeding of TMR with lower concentrate to roughage ratio growth promotes and cost-reduction effect in the dairy calve raising system [10,11] in comparison to the higher proportion of concentrate. The experiment was planned to evaluate the effect of the conventional system of feeding and total mixed ration with various concentrate to roughage ration on feed intake, growth, feed conversion efficiency, and cost of feeding in crossbred calves.

MATERIALS AND METHODS

The present study was carried out at Livestock Research Station, Anand Agricultural University, Anand, Gujarat, after obtaining permission from Institutional Animal Ethics Committee (348/LRS/2021). A total of twenty-four crossbred calves of similar body weight were selected and randomly blocked in four treatment groups with six animals each. The mean initial body weight (31.30 ± 1.67, 33.10 ± 1.17, 32.77 ± 0.76, and 32.80 ± 0.76) of crossbred calves were similar. The experiment started from the 8th day of age of crossbred calves.

In all four treatments, each calf was fed colostrum 4.0 liter per day up to the first 3 days of age. The fresh milk was offered 4.0, 6.0, 4.0, and 2.0 liter per day during 4-15 days, 16-42 days, 43-63 days, and 64-91 days of the age of calves, respectively in equal two halves at 06:30 and 17:00 hrs using nipple bucket.

Compounded concentrate mixture (CCM), Jowar hay, and Hybrid Napier (HN) was used as feed. The T_1 group was fed concentrate and roughage separately as per the conventional method, whereas T_2, T_3, and T_4 groups were fed with a concentrate roughage ratio of 85:15, 75:25, and 65:35, respectively. The calves of the T_1 group (control) were offered concentrate and dry roughage *ad-lib* separately from the 8th and 15th day, respectively as per the conventional feeding system, whereas chaffed green fodder was offered at @500 g/d from the 42nd days onwards. TMR was offered *ad-lib* from the 8th day to the calves of the T_2, T_3, and T_4 groups. The calves consumed the total quantity of milk offered, whereas the consumption of solid feeds viz. concentrates, dry fodder, green fodder, and the total mixed ration was calculated by deducting leftovers. The calves were offered *ad-lib* water daily at 10:00 am and 03:00 pm in a plastic bowl. The quantity of water consumed was calculated after subtracting leftovers from the measured water offered. The TMR, feed, and fodder ingredients were analyzed for proximate and chemical composition as per AOAC (2005) [12].

Comment [a2]: Clarify with supportive reference

Comment [a3]: Please mention for DCP, TDN, analysis, & estimation method

The cost of feeding was estimated based on daily feed consumption and the actual procurement cost of milk, feeds, and fodder. The costs of milk, CCM, jowar hay, HN, T_2, T_3, and T_4 calculated were 35.00, 28.00, 8.00, 1.00, 24.70, 22.50, and 20.30 Rs/kg, respectively. Experimental data generated using a completely randomized design was analyzed as per Snedecor and Cochran (1994) [13].

RESULTS AND DISCUSSIONS:

Composition of Feed, Fodders, and Total Mixed Ration (TMR)

The proximate and chemical composition of milk feeds, fodders, and TMR are presented in Table 1. As the roughage proportion increased in the TMR, the dry matter, crude protein, calcium, and phosphorus concentration decreased and the crude fiber level increased.

Dry Matter and Nutrients Intake of Crossbred calves

The daily, percent and metabolic body weight basis intake of dry matter (DM) and total digestible nutrients (TDN) was significantly ($p<0.05$) lower in the TMR feeding system than in conventional feeding in crossbred calves (Table 2) whereas different concentrate to roughage ration of TMR (T2, T3, T4) did not influence the intake. The daily and percent intake of DCP did not differ significantly among the treatments. Water intake (L/d, L/100 kg, ml/kg $BW^{0.75}$) was significantly higher in the conventional method of feeding as compared to the TMR method.

Similar to our findings, lower TDN intake was reported in crossbred calves fed TMR than convention system [14], and various concentrate: roughage ratios in TMR did not influence DM intake in crossbred calves [15] and Murrah buffalo calves [16]. In contrast to the present findings, higher DMI was reported in Holstein heifers fed lower concentrate-to-roughage ratio in diet [17] whereas Abdel Raheem *et al.* (2018) [18], and Karami *et al.* (2021) [19] found significant ($P < 0.05$) higher DMI (kg/d) on feeding TMR with higher concentrate to roughage ratios in Buffalo calve and Holstein female calve, respectively. The feeding of diet with higher concentrate: roughage ratio to growing calves improved DCP and TDN intake [16] also contrasting the present findings.

Growth Performance of Crossbred calves

The growth Performance of calves raised on TMR with different concentrate to roughage ratios is presented in Table 3. The initial and final body weight (kg), height at withers, heart girth, and body length (cm) did not differ significantly among the treatments. Total and daily gain in body weight (kg) of crossbred calves were significantly higher on feeding TMR with a 65:35 concentrate to roughage ratio as compared to conventional (T1) feeding and other TMR (T2, T3) groups.

The daily higher growth rate was observed on a feeding diet with lower concentrate to roughage ratios in Angus male caves [10] and male Buffalo calves [11] supporting the present findings. However, Singh *et al.* (2000) [15] and Rashid *et al.* (2015) [20] observed a non-significant effect on body weight gain in growing to calve fed TMR with different concentrate to roughage ratios. Whereas Abdel Raheem *et al.* (2018) [18] and Karami *et al.* (2021) [19] reported higher body weight gain in calves fed with a higher concentrate to roughage ratio TMR. The body measurements *viz*., height at withers, heart girth, and body length did not influence by different concentrate to roughage ratios in Holstein heifers [17] and growing calves [21], supported the present finding. However, Karami *et al.* (2021) [19] reported a linearly increased in the final heart girth and withers height with higher concentrate level in the diet, contraindicated with the present findings.

Feed Conversion Ratio and Feeding Cost

The values on the feed conversion ratio (FCR) and feed cost of the T_1, T_2, T_3, and T_4 groups are presented in Table 4. The requirement of digestible crude protein and total digestible nutrients to gain a kilogram of live weight was differ non-significantly. However, the requirement of dry matter to gain each kilogram of live weight was significantly higher in the control group (T_1) as compared to the 65:35 ratio (T_4) group and did not differ with different concentrate to roughage ratios. The total cost of feeding (Rs. /animal), cost per animal (Rs. /day), and cost per kg gain (Rs./animal) did not differ significantly among the treatments. The calves of the T_4 group showed a 21.81 % lower cost as compared to the T_1 group. Also, the calves of the T_2 group showed a 13.06 % lower cost of feeding compared to the T_1 group.

The reports supported the present findings that the different concentrate to roughage ratios did not influence significantly the feed conversion efficiency in male buffalo calves [15, 18]. The different concentrate to roughage ratios (70:30, 60:40, 50:50, and 75:25, 60:40, 55:45) diet did not influence the feed cost per kilogram weight gain in buffalo calves [15,18]. Similarly, Rashid *et al*. (2015) [20] found that feed cost per kg weight gain in crossbred calves did not differ between 75:25 and 65:35 ratios which supports the present finding.

CONCLUSIONS

The feeding TMR with concentrate to roughage ratio of 85:15 (T2), 75:25 (T3), and 65:35 (T4) in comparison to the convention (T1) to crossbred calves during 8th to 91st days of age resulted in reduced dry matter, TDN and water intake in TMR feeding system. The weight gain was higher and the feed required for weight gain was lower with a reduction of 73.55 Rs per kg weight gain in T4 TMR compared to the conventional system of feeding.

ETHICAL APPROVAL

The present study was carried out at Livestock Research Station, Anand Agricultural University, Anand, Gujarat, after obtaining permission from Institutional Animal Ethics Committee (348/LRS/2021).

REFERENCES

Comment [a4]: Write down the References as per journal guideline

1 Heinrichs, A. J., & Lesmeister, K. E. (2005). Rumen development in the dairy calf. In: *Calf and heifer Rearing: principles of rearing the modern dairy heifer from calf to calving. 60th University of Nottingham Easter School in Agricultural Science, Nottingham, UK. 23rd-24th March, 2004*, 53-65.

2 Montoro, C., Miller-Cushon, E. K., DeVries, T. J., & Bach, A. Effect of physical form of forage on performance, feeding behavior, and digestibility of Holstein calves. Journal of Dairy Science. 2013; 96(2), 1117-1124.

3 Cozzi, G., Gottardo, F., Mattiello, S., Canali, E., Scanziani, E., Verga, M., & Andrighetto, I. The provision of solid feeds to veal calves: I. Growth performance, forestomach development, and carcass and meat quality. Journal of Animal Science. 2002; 80(2), 357-366.

4 Basaran, H. & Gurbux, A. The effects of feeding type and time on fattening performance of Holstein bulls fattened during different seasons. Tarla Bitkileri Merkez Araştırma Enstitüsü Dergisi. 2000; 9(1-2), 1-10.

5 Coverdale, J. A., Tyler, H. D., Quigley III, J. D., & Brumm, J. A. Effect of various levels of forage and form of diet on rumen development and growth in calves. Journal

of Dairy Science. 2004; 87(8), 2554-2562.
6 Lyford, S. J., & Huber, J. T. (1988). Digestion, metabolism and nutrient needs in preruminants. The Ruminant Animal: Digestive Physiology and Nutrition (Ed. DC Church). Prentic-Hall, Englewood Cliffs, New Jersey, USA, 401.
7 Tafaj, M., Maulbetsch, A., Zebeli, Q., Steingaß, H., & Drochner, W. Effects of physically effective fibre concentration of diets consisting of hay and slowly degradable concentrate on chewing activity in mid lactation dairy cows under constant intake level. Archives of Animal Nutrition. 2005; 59(5), 313-324.
8 Tamate, H., McGilliard, A. D., Jacobson, N. L., & Getty, R. Effect of various dietaries on the anatomical development of the stomach in the calf. Journal of Dairy Science.1962; 45(3), 408-420.
9 Van Ackeren, C., Steingass, H., Hartung, K., Funk, R., & Drochner, W. (2010). Effect of weaning age on feed intake and ruminal fermentation patterns of calves fed a dry total mixed ration with ad libitum access to grass hay. Archives of Animal Nutrition. 2010; 64(4), 293–303.
10 Fernández H. T. Growth, blood metabolites and hormones in calves fed diets with different amounts of energy and protein during the pre- or post-weaning periods. African Journal of Agricultural Research. 2012; 7(25), 3739–3746
11 Mahmoudzadeh, H., & Fazaeli, H. Growth response of yearling buffalo male calves to different dietary energy levels. Turkish Journal of Veterinary and Animal Sciences. 2009; 33(6), 447–454.
12 AOAC. Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists.., Washington, DC,USA, 2005.
13 Snedecor, G. W. & Cochran, W. G. Statistical methods. (8th Ed.). The IOWA State University press, Ames, Iowa, USA, 1994.
14 Kadam, S. S., Hol, B. G., Patil, M. B., Kank, V. D., Gadegaonkar, G. M., & Chavan, S. S. Effect of complete feed with different roughages: Concentrate ratios on the performance of crossbred dairy calves. The Journal of Bombay Veterinary College. 2005;13(1and2), 8–11.
15 Singh, R., Singh, B., Wadhwa, I. V. L., & Bakshi, I. S. Effect of roughage to concentrate ratio in pelleted diet on the productive performance of buffalo calves. Buffalo Journal. 2000;6(2), 131-137.
16 Nampoothiri, V. M., Mohini, M., Malla, B. A., Mondal, G., & Pandita, S. Growth performance, and enteric and manure greenhouse gas emissions from Murrah calves fed diets with different forage to concentrate ratios. Animal Nutrition. 2018;4(2), 215–221.
17 Zhang, J., Shi, H., Wang, Y., Li, S., Zhang, H., Cao, Z., & Yang, K. Effects of limit-feeding diets with different forage-to-concentrate ratios on nutrient intake, rumination, ruminal fermentation, digestibility, blood parameters and growth in Holstein heifers. Animal Science Journal. 2018;89(3), 527–536.
18 Abdel Raheem, S., Hassan, E., & Farghaly, M. Effect of dietary concentrate to roughage ratio on nutrient digestibility, rumen fermentation, growth performance and serum acute phase protein in growing buffalo calves. Egyptian Journal of Nutrition and Feeds. 2018;21(1), 15–23.
19 Karami, A., Alikhani, M., Khorvash, M., Hashemzadeh, F., Sadeghi-Sefidmazgi, A., Rafiee, H., & Ferraretto, L. F. Effects of different forage to concentrate ratios on performance, plasma metabolites, and feeding behaviour of weaned dairy calves from 70 to 120 days of age. Italian Journal of Animal Science. 2021;20(1), 1317–1327.
20 Rashid, M. M., Huque, K. S., Hoque, M. A., Sarker, N. R., & Bhuiyan, A. (2015). Effect of concentrate to roughage ratio on cost effective growth performance of

Brahman crossbred calves. Journal of Agricultural Science and Technology. 2015; 5(4), 286-295.
21 Kehoe, S. I., Breaker, J. D., & Suen, G. Effects of corn silage inclusion in preweaning calf diets. Journal of Dairy Science. 2019;102(5), 4131-4137.

Table 1: Proximate and chemical composition of feeds, fodder, milk and TMR (%DM basis)

Parameters	CCM	JH	HN	Milk	T2	T3	T4
Dry matter	90.00	85.00	22.22	12.60	73.77	65.90	59.59
Crude protein	24.74	4.96	9.44	27.78	22.11	20.35	18.60
Ether extract	6.06	2.41	3.52	33.33	5.59	5.28	4.97
Crude fibre	9.70	34.79	31.11	0.00	13.18	15.50	17.83
Nitrogen free extract	50.83	49.89	46.00	33.34	50.41	50.14	49.84
Ash	8.67	7.95	9.93	5.55	8.71	8.73	8.76
Acid insoluble ash	2.33	3.85	3.59	-	3.18	3.05	3.85
Calcium (g%)	1.70	0.46	0.37	-	1.34	1.21	1.10
Phosphorus (g%)	0.84	0.27	0.29	-	0.66	0.61	0.54

CCM = Commercial concentrate mixture, JH = Jowar hay, HN = Hybrid Napier

Table 2: Nutrients intake and water intake of crossbred calves fed TMR with different Concentrate to roughage ratio

Intake	T_1	T_2	T_3	T_4
DM intake (kg/d)	$1.38^{y} \pm 0.12$	$1.12^{x} \pm 0.08$	$1.08^{x} \pm 0.06$	$1.11^{x} \pm 0.07$
DCP intake (kg/d)	0.210 ± 0.013	0.207 ± 0.010	0.193 ± 0.008	0.191 ± 0.007
TDN intake (kg/d)	$1.04^{y} \pm 0.07$	$0.905^{x} \pm 0.049$	$0.869^{x} \pm 0.040$	$0.886^{x} \pm 0.041$
DM intake (%BW)	$2.53^{y} \pm 0.13$	$2.00^{x} \pm 0.08$	$1.96^{x} \pm 0.06$	$1.91^{x} \pm 0.07$
DCP intake (%BW)	0.408 ± 0.014	0.381 ± 0.011	0.366 ± 0.009	0.345 ± 0.008
TDN intake (%BW)	$1.98^{y} \pm 0.08$	$1.66^{x} \pm 0.05$	$1.63^{x} \pm 0.04$	$1.58^{x} \pm 0.04$
DM intake (g/kg $BW^{0.75}$)	$68.25^{y} \pm 4.03$	$54.29^{x} \pm 2.52$	$53.11^{x} \pm 2.08$	$52.48^{x} \pm 2.13$
DCP intake (g/kg $BW^{0.75}$)	$10.85^{y} \pm 0.42$	$10.29^{y} \pm 0.34$	$9.80^{xy} \pm 0.26$	$9.33^{x} \pm 0.23$
TDN intake (g/kg $BW^{0.75}$)	$52.84^{y} \pm 2.32$	$44.80^{x} \pm 1.52$	$43.77^{x} \pm 1.24$	$42.85^{x} \pm 1.21$
Water intake (L/d)	$2.38^{y} \pm 0.16$	$2.05^{x} \pm 0.15$	$1.91^{x} \pm 0.13$	$1.95^{x} \pm 0.14$
Water intake (L/100 kg)	$4.38^{y} \pm 0.24$	$3.53^{x} \pm 0.21$	$3.35^{x} \pm 0.18$	$3.22^{x} \pm 0.19$

Water intake (ml/kg $BW^{0.75}$)	118.31^{y}±6.81	97.08^{x}±6.01	91.62^{x}±5.22	89.48^{x}±5.35

Means with different superscripts (x and y) in the row differ significantly (P<0.05)

DM-Dry matter, DCP- Digestible crude protein, TDN- Total digestible nutrients, $BW^{0.75}$ – Metabolic body weight

Table 3: Growth performance of crossbred calves fed TMR with different concentrate to roughage ratio

Growth performance	T_1	T_2	T_3	T_4
Body weight				
Initial body weight (kg)	31.30 ± 1.67	33.10 ± 1.17	32.77 ± 0.76	32.80 ± 0.76
Final body weight (kg)	72.80 ± 5.27	78.97 ± 1.92	74.77 ± 3.26	83.70 ± 3.25
Total gain in body weight (kg)	41.50^{x} ± 4.25	45.87^{xy} ± 1.46	42.00^{x} ± 3.37	50.90^{y} ± 2.53
Weight gain (kg/d)	0.494^{x} ± 0.028	0.546^{xy} ± 0.030	0.500^{x} ± 0.030	0.606^{y} ± 0.033
Body measurements				
Initial height at withers (cm)	75.25 ± 0.73	77.33 ± 1.58	76.58 ± 1.21	78.08 ± 0.78
Final height at withers (cm)	92.75 ± 1.76	97.42 ± 0.97	95.58 ± 0.85	95.67 ± 0.65
The total gain in height at withers (cm)	17.50 ± 1.24	20.08 ± 1.19	19.00 ± 1.40	17.58 ± 1.00
Initial heart girth (cm)	72.75 ± 1.04	74.00 ± 0.65	74.33 ± 0.81	72.92 ± 0.81
Final heart girth (cm)	95.67 ± 1.71	100.17 ± 0.95	98.58 ± 1.08	99.67 ± 1.05
The total gain in heart girth (cm)	22.92 ± 1.68	26.17 ± 1.38	24.25 ± 1.46	26.75 ± 0.78
Initial body length (cm)	67.83 ± 1.38	71.00 ± 2.28	71.00 ± 1.34	69.67 ± 1.01
Final body length (cm)	91.00 ± 0.97	94.33 ± 1.75	92.75 ± 1.64	93.17 ± 0.91
Total gain in body length (cm)	23.17 ± 0.78	23.33 ± 1.14	21.75 ± 1.67	23.50 ± 1.22

Means with different superscripts (x and y) in the row differ significantly (P<0.05)

Table 4: Feed conversion ratio and feeding of crossbred calves fed TMR with different Concentrate to roughage ratio

Intake	T_1	T_2	T_3	T_4
FCR				
Kg DMI/kg gain	3.46^{y}±0.43	2.68^{xy}±0.30	2.87^{xy}±0.24	2.21^{x}±0.23
Kg DCPI/kg gain	0.54±0.06	0.52±0.06	0.54±0.05	0.39±0.03
Kg TDNI/kg gain	2.65±0.30	2.27±0.28	2.40±0.21	1.78±0.16
Feeding cost				
Daily feed cost (Rs/d)	157.49±2.58	159.60±2.08	157.39±1.98	157.69±1.23
Feed cost/kg gain (Rs/kg)	337.29±38.33	293.25±6.28	327.17±31.24	263.74±14.40
Total feed cost (Rs.)	13228.77±217.01	13406.79±174.43	13221.05±166.68	13245.97±103.13

Means with different superscripts (x and y) in the row differ significantly (P<0.05).