Frontiers of Agri and animal Innovation (FAAI), Vol 1, Issue 1, 2025

Contents lists available at Curevita Journals

Frontiers of Agri and animal Innovation

journal homepage: www.curevitajournals.com

To evaluate the effect of strategic nutrient supplementation on the growth performance of Murrah buffalo calves

Neeha Meena, Sandeep Nanavati, Mohabbat Singh Jamra, Ashok Kumar Patil, Nawal Singh Rawat, Danveer Singh Yadav,

Author Info: Meena Neeha, Research Scholar, Dr. Sandeep Nanavati, Professor, Dr.Mohabbat Singh Jamra, Assistant Professor, Dr. Ashok Kumar Patil, Associate Professor, Department of Animal Nutrition, Dr. Nawal Singh Rawat, Assistant Professor, Dr. Danveer Singh Yadav, Assistant Professor, College of Veterinary Science and A.H., (NDVSU), Mhow, Indore, (M.P.), India.

Articalinfo

Article history: Received 22 June 2025, Revised 18 Aug 2025, Accepted 20 Aug 2025, Published Sept 2025

Keywords: Strategic supplementation, Nutrients, Growth performance, Murrah buffalo, Calves.

Corresponding Author: Neeha Meena, Department of Livestock Production and Management, College of Veterinary Science and A.H., (NDVSU), Mhow, Indore, (M.P.), India.

Email: meenaneha602@gmail.com

Citation: Meena Neeha, Nanavati Sandeep, Jamra Mohabbat Singh Jamra, Patil Ashok Kumar, Rawat Nawal Singh, and Yadav Danveer Singh. 2025. To evaluate the effect of strategic nutrient supplementation on the growth performance of Murrah buffalo calves.Frontiers of Agri & Animal Innovation. 1,1,19-44..

Publisher: Curevita Research Pvt Ltd

Abstract

A total of eighteen Murrah buffalo calves, aged 6-9 months and with similar body weights, were randomly selected and assigned to three equal groups (n=6). In control group (T_0) animals were maintained on common feeding regimen consisting of required concentrate mixture and roughage as per requirement given by farmer during survey, in treatment group (T_1) was given basal ration and strategic macronutrients (based on deficiency of macronutrients observed during survey) and in treatment group (T_2) was given basal ration and strategic macronutrients and strategic micronutrients (based on deficiency of micronutrients observed during survey) for 90 days.

Indtroduction

Body weight changes, feed intake and average daily gain were recorded weekly to assess growth performance for 90 days of the experiment. Fortnightly body weights were measured using an electronic weighing balance to evaluate the animals' weight. The overall average body weight was 73.74 ± 6.27 for the T0 group, 79.2 ± 4.9 for the T1 group, and 81.67 ± 2.5 for the T2 group, with no statistically significant differences ($p > 0.05$) detected. However, numerically, growth was 7.43 and 10.75 percent higher in the T1 and T2 groups, respectively. The overall average daily gain was 247.08 ± 04.75 for the T_0 group, 418.17 ± 9.4 for T_1 group and 465.2 ± 6.81 for the T_2 group, with a statistically significant difference. The average feed conversion efficiency was 13.15 ± 0.32 for T_0 group, 8.22 ± 0.2 for T_1 group and 7.6 ± 0.15 for the T_2 group, with significant differences observed. The p-value for the feed conversion ratio was ($p \leq 0.01$).

Formulation of a strategic nutrient supplement for Murrah buffalo calves

Based on the results obtained in phase I, the availability of crude protein and TDN of calves was compared with the standard nutrient requirements of calves by ICAR (2013). There was a deficiency of CP and TDN to the tune of 79.17% and 49.86%, respectively. For the preparation of a strategic mineral mixture supplement, zinc sulphate, cobalt chloride, and sodium dihydrogen ortho phosphate dihydrate were used as per the requirements given by ICAR (2013) as shown in Table -1. The measured quantity of strategic mineral mixture was supplemented in the ration of calves of the treatment group. This strategic mineral mixture was then added in the ratio of six Murrah buffalo calves and a feeding trial was conducted.

Experimental animals: Eighteen Murrah buffalo calves of approximately similar age (6-9 months) and body weight as shown in Table-2, were selected and randomly allotted into three equal groups (6 in each group). All calves were maintained on a common feeding regime consisting of required concentrate mixture, wheat straw and green as per requirements given by ICAR (2013).

Housing and management

All the experimental calves were housed in a well-ventilated shed with provision of individual feeding and watering. Strict management and hygienic practices were adopted throughout the experimental period. Clean drinking water was provided *ad libitum* twice a day at about 10:00 a.m. and 5:00 p.m. daily.

Feeds and feeding

The calves were offered wheat straw, green and concentrate ration to meet their nutrient requirements in Table 03 recommendation for a body weight gain of 70kg/day. All the experimental calves were fed on a basal diet comprised of a concentrate ration, green and wheat straw. Weighed amount of concentrate ration was provided at 10 a.m. daily to meet *al*most their whole CP and a major part of TDN requirement. Wheat straw was provided *ad libitum* after complete consumption of the concentrate mixture. The amount of concentrate mixture required by each calf was adjusted at every fifteen-day interval based on their body weights.

Table-1: Composition of strategic micronutrient supplementation (animal/day) for Murrah buffalo calves

Composition	Quantity (mg)	P (mg)	Co (mg)	Zn (mg)
Zinc sulphate (363.6 mg/g)	36.3	-	-	13.2
Cobalt chloride (250 mg/g)	1.92	-	0.48	-
Sodium dihydrogen ortho phosphate dihydrate (172.5 mg/g)	10.72	1.85	-	-
Total supply		1.85	0.48	13.2

Table-2: Initial body weight (kg) of Murrah buffalo calves

S.No.	T_0	T_1	T_2
1	51.25	52.9	57.60
2	52.13	55.75	58.45
3	61.07	56.45	67.75
4	72.25	77.05	65.15
5	88.17	77.35	70.65
6	51.85	53.85	56.35
Overall mean ± SE	**62.79 ± 6.06**	**62.23 ± 4.76**	**62.66 ± 2.44**

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Table-3: The feeding schedule of experimental Murrah buffalo calves

Groups	No. of Calves	Feeding on	Period (days)
T_0	06	Basal Ration (Wheat straw+Green+Concentrate mixture)	90
T_1	06	Basal Ration + strategic macronutrients (based on deficiency of macronutrients observed during survey)	90
T_2	06	Basal Ration + strategic macronutrients + strategic micronutrients (based on deficiency of micronutrients observed during survey)	90

Recording of body weight, dry matter intake and feed conversion ratio

The body weight of all the experimental animals was recorded at fortnightly intervals during the morning time before offering them any feed and water. The measurement was made in kilograms by individually weighing the calves using an electronic weighing balance. Calves were offered a weighed amount of concentrate mixture, green and gram straw. Residue, if any was weighed after next day morning. Samples of concentrate mixture, green and gram straw were subjected for DM analysis once in a fortnight, to know their DM intake. The feed conversion ratio (Banerjee,1998) was calculated using the formula:

$$\text{FCR} = \frac{\text{Feed intake (g)}}{\text{Body weight gain (g)}}$$

Data were analyzed using one-way ANOVA and Duncan's multiple range test in SPSS 20.0.(Snedecor and Cochran, 1994)

Results and Discussion

Chemical composition of feedstuffs (% DM basis)

The average percentages of proximate components, including crude protein (CP), ether extract (EE), crude fiber (CF), total ash (TA), and nitrogen-free extract (NFE) on a dry matter (DM) basis, for the available feedstuffs are detailed in Table 04. The available feeds are wheat straw, gram straw, masoor straw, Green (Local grass), Green maize, compound feed, cottonseed cake and Wheat bran.

Among the straws, DM content of wheat straw was 92.83 ± 0.20 % and the crude protein (CP), ether extract (EE), crude fibre (CF), total ash (TA) and nitrogen-free extract (NFE) contents were 2.65 ± 0.28 %, 1.35 ± 0.14 %, 37.2 ± 0.61 %, 06.52 ± 0.22 % and 52.29 ± 1.19 %, respectively. Similarly, the DM content of gram straw was 91.38 ± 0.19 % and the CP, EE, CF, TA and NFE contents were 8.42 ± 0.21 %, 1.27 ± 0.20 %,38.22 ± 0.17 %, 11.50 ± 0.25 % and 40.58 ± 0.25 %, respectively. The DM content of masoor straw was 93.62 ± 0.18 % and the CP, EE, CF, TA and NFE contents were 6.47 ± 0.26 %, 2.37 ± 0.22 %, 39.30 ± 0.17 %, 09.43 ± 0.28 % and 42.43 ± 0.23 %, respectively.

Among the green roughages, DM content of local grass was 25.87 ± 0.62 % and the CP, EE, CF, TA and NFE contents were 6.53 ± 0.22 %, 1.39 ± 0.17 %, 34.63 ± 0.33 %, 09.40 ± 0.21 % and 48.04 ± 0.63 %, respectively. Similarly, the DM content of green maize was 20.38 ± 0.19 % and the CP, EE, CF, TA and NFE contents were 6.12 ± 0.12 %, 1.35 ± 0.22%, 30.27 ± 0.30%, 11.81 ± 0.18 % and 50.45 ± 0.26 %, respectively.

Among the concentrate feeds, DM content of compound feed was 91.93 ± 0.43 % and the CP, EE, CF, TA and NFE contents were 18.73 ± 0.23 %, 2.45 ± 0.26 %, 11.95 ± 0.36 %, 10.7 ± 0.32 % and 56.17 ± 0.41 %, respectively. Similarly, the DM content of cotton seed cake was 91.12 ± 0.46 % and the CP, EE, CF, TA and NFE contents were %, 24.93 ± 0.07 %, 3.32 ± 0.18 %, 22.57 ± 0.35 %, 04.80 ± 0.04 % and 44.39 ± 0.16 %, respectively. The DM content of wheat bran was 92.37 ± 0.21 % and the CP, EE, CF, TA and NFE contents were %, 13.26 ± 0.17 %, 3.45 ± 0.21 %, 12.37 ± 0.16 %, 04.58 ± 0.18 % and 66.35 ± 0.13 %, respectively.

Table 04: Chemical composition of feedstuffs (% DM basis)

Sample	DM (%)	CP (%)	EE (%)	CF (%)	TA (%)	NFE (%)
Wheat Straw	92.83 ± 0.20	2.65 ± 0.28	1.35 ± 0.14	37.2 ± 0.61	06.52 ± 0.22	52.29 ± 1.19
Gram straw	91.38 ± 0.19	8.42 ± 0.21	1.27 ± 0.20	38.22 ± 0.17	11.50 ± 0.25	40.58 ± 0.25
Masoor straw	93.62 ± 0.18	6.47 ± 0.26	2.37 ± 0.22	39.30 ± 0.17	09.43 ± 0.28	42.43 ± 0.23
Green (Local grass)	25.87 ± 0.62	6.53 ± 0.22	1.39 ± 0.17	34.63 ± 0.33	09.40 ± 0.21	48.04 ± 0.63
Green maize	20.38 ± 0.19	6.12 ± 0.12	1.35 ± 0.22	30.27 ± 0.30	11.81 ± 0.18	50.45 ± 0.26
Compound feed	91.93 ± 0.43	18.73 ± 0.23	2.45 ± 0.26	11.95 ± 0.36	10.7 ± 0.32	56.17 ± 0.41
Cotton seed cake	91.12 ± 0.46	24.93 ± 0.07	3.32 ± 0.18	22.57 ± 0.35	04.80 ± 0.04	44.39 ± 0.16
Wheat bran	92.37 ± 0.21	13.26 ± 0.17	3.45 ± 0.21	12.37 ± 0.16	04.58 ± 0.18	66.35 ± 0.13

Average mineral content of feedstuffs (% DM basis)

The mean mineral content in feedstuffs is given in Table 05. Among straws, wheat straw had the highest P (0.15 ± 0.01 %) and Mn (43.23 ± 2.5) whereas lowest Ca (0.45 ± 0.03 %), and Co (0.07 ±0.00 ppm), while gram straw had the highest Ca (1.46 ± 0.16 %), Cu (8.35 ± 0.18ppm) and Co (0.63 ± 0.07 ppm) and lowest P (0.11 ± 0.02 %), Fe (360.63 ± 1.37 ppm), Zn (5.26 ± 0.17ppm) and Mn (35.45 ± 0.28). Masoor straw was found to have the highest Fe (606.63 ± 2.998 ppm) and Zn (23.04 ± 0.05ppm), there after lowest Cu (4.48 ± 0.14 ppm). In concentrate feeds, cotton seed cake had the lowest Cu (8.68 ± 0.35 ppm) and Mn (32.28 ± 0.25 ppm) while highest Co (0.53 ± 0.013ppm). Wheat bran had the highest Zn (62.07 ± 0.17 ppm) and Mn (130.68 ± 0.36 ppm) but the lowest Co (0.2 ± 0.05 ppm) and Ca (0.22 ± 0.05 ppm). The compound feed was notable for the highest P (0.81 ± 0.05ppm), Fe (744.9 ± 0.82 ppm), Cu (18.53 ± 1.07 ppm) and Ca (0.91 ± 0.05 ppm), while the lowest Zn (20.23 ± 1.17 ppm). Among green roughages, green maize fodder had the highest Ca (0.55 ± 0.13 %), Mn (130.73 ± 1.34 ppm) and Cu (8.33 ± 0.14 ppm) while local grasses were found to have higher Zn (12.23 ± 0.71 ppm) and P (0.17 ± 0.01ppm) compared to other green feeds.

Nutritional status of Murrah buffalo calves body weight and feed intake

The body weight and dry matter (DM) intake (kg/day) from different feed ingredients for Murrah buffalo calves are displayed in Table 05. The average body weight of the calves was 64.16 ± 1.35 kg. The average total DM intake was 1.38 ± 0.01 kg/day. The average DM intake (kg/day) from wheat straw, green forage and concentrate was 1.04 ± 0.01, 0.20 ± 0.01, and 0.15 ± 0.01, respectively.

Table-5: Dry matter intake (kg/d) of different feed ingredients offered to Murrah buffalo calves

Animal no.	Body weight (kg)	Wheat straw (kg)	Green (kg)	Concentrate(kg)	Total DMI (kg)
1	59.95	1.03	0.17	0.13	1.33
2	62.53	1.00	0.16	0.17	1.33
3	61.67	1.00	0.19	0.11	1.30
4	62.75	1.06	0.13	0.15	1.34
5	58.87	1.05	0.25	0.17	1.47
6	61.75	1.05	0.18	0.16	1.39
7	62.90	1.03	0.19	0.12	1.34
8	65.75	1.05	0.17	0.13	1.35
9	55.87	1.02	0.20	0.17	1.39
10	65.85	1.08	0.24	0.12	1.44
11	73.75	1.05	0.25	0.14	1.44
12	63.35	1.16	0.19	0.15	1.50
13	67.85	1.00	0.22	0.16	1.38
14	63.45	1.03	0.21	0.11	1.35
15	66.75	1.05	0.2	0.14	1.39
16	65.65	1.00	0.21	0.15	1.36
17	79.75	1.01	0.17	0.17	1.35
18	56.35	1.00	0.27	0.17	1.44
Overall mean ±SE	64.16 ± 1.35	1.04 ±0.01	0.20 ±.01	0.15 ± 0.01	1.38 ± 0.01

Table 06: Average daily nutrient availability to Murrah buffalo calves

Animal no.	Body weight (kg)	DM intake (kg)	CP (g)	TDN (g)	Ca (g)	P (g)	Fe (mg)	Cu (mg)	Zn (mg)	Mn (mg)	Co (mg)
1	59.95	1.33	56.62	572.76	6.12	2.56	492.1	9.97	10.86	62.82	0.11
2	62.53	1.33	57.34	572.68	6.08	2.56	498.06	9.39	10.56	62.23	0.15
3	61.67	1.30	58.43	570.64	6.63	2.56	460.00	9.87	10.95	62.17	0.16
4	62.75	1.34	58.88	570.64	6.75	2.98	468.06	9.67	10.78	62.17	0.12
5	58.87	1.47	58.49	570.94	6.85	2.89	486.03	9.98	10.81	62.67	0.12
6	61.75	1.39	57.64	570.74	5.98	2.67	492.07	8.85	10.89	62.06	0.08
7	62.90	1.34	58.32	571.94	6.63	2.45	484.01	8.86	10.96	62.56	0.04
8	65.75	1.35	58.86	570.54	5.95	2.89	485.56	9.67	10.87	62.13	0.36
9	55.87	1.39	57.88	572.83	6.34	2.83	499.12	9.89	10.63	62.72	0.13
10	65.85	1.44	58.67	570.84	6.45	2.65	472.06	10.79	10.89	62.87	0.12
11	73.75	1.44	59.89	570.83	6.64	2.75	591.03	9.98	10.71	62.87	0.06
12	63.35	1.50	58.45	571.77	6.46	2.83	496.01	10.62	10.92	62.11	0.03
13	67.85	1.38	58.96	572.82	6.22	2.45	596.11	9.45	10.84	62.47	0.07
14	63.45	1.35	56.98	572.57	6.81	2.34	489.08	9.54	10.72	62.32	0.09
15	66.75	1.39	58.73	570.74	6.84	2.98	589.04	10.89	10.77	62.86	0.14
16	65.65	1.36	58.83	571.94	6.75	2.56	587.11	10.95	10.74	62.11	0.12
17	79.75	1.35	59.67	572.94	6.76	2.22	594.23	9.67	10.82	62.84	0.12
18	56.35	1.44	56.34	569.74	5.87	2.56	492.05	9.97	10.86	62.31	0.11
Overall mean ±SE	64.16±1.35	1.38 ± 0.01	58.26±0.23	571.55±0.24	6.45±.08	2.65±0.05	515.10±11.74	9.89±0.14	10.81±0.03	62.46±0.07	0.12±0.02

Table 7: Average daily requirements and availability of nutrients in Murrah buffalo calves

	Body weight (kg)	DM (kg)	CP (g)	TDN (g)	Ca (g)	P (g)	Fe (mg)	Cu (mg)	Zn (mg)	Mn (mg)	Co (mg)
Requirements (ICAR,2013)	70	1.8	287	1140	5.1	4.5	500	9.00	24.00	42.00	0.60
Availability (Per animal per day)	64.16	1.3	58.26	571.55	6.45	2.65	515.10	9.89	10.81	62.46	0.12
Excess /Deficient			(-)228.74	(-)568.45	(+)1.35	(-)1.85	(+)15.10	(+)0.89	(-)13.20	(+)20.46	(-)0.48
Excess/Deficient%			(-)79.70	(-)49.86	(+)26.47	(-)41.11	(+)3.02	(+)9.83	(-)54.96	(+)0.48	(-)79.5

Excess (+), Deficient (-)

Nutrient availability

The average daily nutrient intake and body weight of Murrah buffalo calves are summarized in Table 06. The average body weight of the calves was 64.16 ± 1.35 kg, with an average dry matter (DM) intake of 1.38 ± 0.01 kg/day. The calcium and phosphorus intake averaged 6.45 ± 0.08 g and 2.65 ± 0.05 g, respectively. Among the trace minerals, iron intake was the highest at 515.10 ± 11.74 mg, followed by manganese at 62.46 ± 0.07 mg, zinc at 10.81 ± 0.03 mg, copper at 9.89 ± 0.14 mg and cobalt at 0.12 ± 0.02 mg. These values indicated the overall nutrient availability from the feed ration provided to the calves.

Nutritional deficiency/excess

The nutritional deficiency/excess data for minerals in a 64.16 kg (as analysed and presented in Table 09) body weight is presented in Table 08. The calves exhibited a deficiency of CP (228.74g,79.70%), TDN, (568.45kg, 49.86%), P(1.85g, 41.11%), Co (0.48mg, 79.5%) and Zn (13.20mg, 54.96%). Conversely, there was an excess of Ca (1.35 g,26.47%), Fe(15.20mg, 3.20%), Cu (0.89 mg, 9.83%), and Mn(20.46 mg, 0.48%).

Effect of strategic nutrient supplementation on dry matter intake (kg/d) of Murrah buffalo calves

The fortnightly feed intake (kg) of animals across the experimental groups is summarized in Table 08. At the beginning (0 fortnight), feed intake(kg/d) in the control group (T_0) was 2.46 ± 0.03, while treatment groups T_1 and T_2 showed significantly higher values of 2.52 ± 0.05 and 2.65 ± 0.06, respectively ($p \leq 0.05$). The average dry matter intake (kg/d) in control (T_0) and treatment (T_1 and T_2) groups during the 1st ,2nd, 3rd, 4th fortnights were 2.70 ± 0.03, 2.75 ± 0.06 and 2.81 ± 0.06; 3.08 ± 0.06, 2.92 ± 0.05 and 3.02 ± 0.04; 3.32 ±

0.05, 3.21 ± 0.07 and 3.41 ± 0.06; 3.43 ± 0.06, 3.48 ± 0.08 and 3.64 ± 0.08. In 5^{th} fortnight, the average feed intake (kg/d) recorded was 3.27 ± 0.06 in T_0, 3.76 ± 0.10 in T_1 and 3.83 ± 0.09 kg in T_2, with $p \leq 0.01$) indicating a higher significant difference. In the 6^{th} fortnight, T_0 had an average feed intake(kg/d) of 3.42 ± 0.05, while T_1 and T_2 showed higher feed intake of 3.95 ± 0.10 and 4.04 ± 0.10, respectively, with ($p \leq 0.01$).

The overall mean feed intake (kg/d) was 3.10 ± 0.03 for T_0, compared to significantly higher averages of 3.23 ± 0.07 (T_1) and 3.34 ± 0.06 (T_2). In the present study, significantly increased DMI was observed in the treatment groups in comparison to the control group.

The current study's findings are consistent with those of Zhou *et al.* (2015) , who reported higher intakes of DM in cows fed on a high-energy diet than on low low-energy feed diet. Similarly, Hailu *et al.* (2011) and Tufarelli *et al.* (2011) also observed higher DM intake in sheep fed higher levels of concentrate. Wang *et al.* (2019) reported that lambs' diet supplemented with 0.5 kg extra concentrate per day had significantly higher DM intake than those fed on the control diet. Furthermore, several other reports suggest that DM intake was significantly increased in buffaloes and sheep fed concentrate with an elevated crude protein (CP) content. Guire *et al.* (2013), Sweeny *et al.* (2014), Kang *et al.* (2015).

The probable explanation for the higher DM intake owing to the fact that, the customized supplement has sufficient fermentable energy and trace minerals to support and create a conducive environment for the growth of rumen microbes, leading to optimized rumen fermentation. Microbial growth and dry matter intake (DMI) were found to be strongly positively correlated (Seo *et al.*, 2013 and Uddin *et al.*, 2015). Similar results were also reported by Chandra *et al.* (2015), Ojha *et al*. (2015) and Mahfuz *et al.* (2018).

In contrast to current findings, Kalita *et al*. (2010) discovered that there was no significant variation in dry matter intake between the two groups in nondescript male calves. Group I and Group II were fed a restricted amount of concentrate ration with and without mineral mixture at a 2% level, respectively. According to Sharma *et al*. (2011), there was no discernible variation in the overall dry matter consumption of the various animal groups. Likewise, Nagabhushana *et al*. (2008) reported that dry matter intake in crossbred calves showed no significant variation among the treatment groups. Similarly, Mohapatra *et al*. (2012) found that supplementing cows with an area-specific mineral mixture had no significant effect on their dry matter consumption. Similarly, Mishra *et al*. (2016) found no significant difference ($p > 0.05$) in dry matter (DM) intake between the dietary regimens. According to Hassan *et al*. (2016), there was no discernible variation in the total amount of feed consumed by the several groups of growing buffalo calves.

Contrary to our findings, no significant difference in dry matter intake between the treatment and control groups was documented by various authors Kumar *et al*. (2015), Sahoo *et al*. (2017) and Dixit *et al*. (2021).

Growth performance of Murrah buffalo calves and effect of strategic nutrient supplementation on the body weight (kg) of Murrah buffalo calves

The fortnightly changes in body weight of calves across the experimental groups are illustrated in Table 09. At the beginning of the study (0 fortnight), the body weight (kg) in the control group (T_0) was 62.79 ± 6.07, while the treatment groups T_1 and T_2 had initial weights of 62.23 ± 4.77 and 62.66 ± 2.45, respectively, the statistical analysis specifies no significant differences ($p > 0.05$) among the groups.

As the experiment progressed, body weight consistently increased across all groups. By the 1st fortnight, body weight (kg) reached 66.11 ± 6.16 in T_0, 66.59 ± 4.99 in T_1, and 67.41 ± 2.45 in T_2. The body weight (kg) changes in control (T_0) and treatment (T_1 and T_2) groups during the 2nd, 3rd, 4th, 5th fortnights were 69.85 ± 6.26, 71.73 ± 5.12, and 73.07 ± 2.50; 73.82 ± 6.35, 78.12 ± 5.06, and 80.05 ± 2.57; 77.45 ± 6.41, 84.47 ± 4.79 and 87.81 ± 2.51; 81.1 ± 6.34, 91.86 ± 4.8 and 96.1 ± 2.52, respectively. At the final measurement in the 6th fortnight, T_0 calves weighed(kg) less 85.03 ± 6.31, as compared to 99.55 ± 4.79 in T_1 and 104.54 ± 2.60 in T_2, with treatment groups showing significantly higher values than the control ($p \leq 0.05$).

Overall, the mean body weight (kg) throughout the study was 73.74 ± 6.27 for the control group (T_0), 79.22 ± 4.9 for T_1, and 81.67 ± 2.5 for T_2. While T_1 and T_2 showed higher average body weights than T_0, these differences were not statistically significant ($p > 0.05$) across the experimental period. Though the difference in average body weight was not significant, groups T_1 and T_2 exhibited 7.43% and 10.75% higher growth, respectively.

Similar to our findings, Nagabhushana *et al.* (2008) reported no discernible variation in body weight between treatment groups. The control group received a basal diet of wheat straw *ad libitum* with a concentrate mixture, without cobalt or mineral supplementation. The other two groups received the same basal diet and concentrate but were supplemented with cobaltous chloride at 1 ppm cobalt and 6 ppm cobalt, respectively. Likewise, Khan *et al.* (2015), reported that differences in body weight at all stages were no significant. Singh *et al.* (2015), dietary protein supplementation was found to have no significant impact on body weight in buffalo heifers. In crossbreed calves, similarly, Nagalakshmi *et al.* (2018), supplementation of (80 ppm Zn) in the control group and (60 ppm Zn) in the experimental group had comparable between the dietary groups.

Contrary to our finding, Tewari *et al.* (2014) concluded that calves' body weight changes were considerably ($p < 0.01$) substantial in the treatment group than in the control group. Similarly, Hassan *et al.* (2016) found that claves fed a supplemented zinc sulphate or zinc methionine feed had significantly higher body weights ($p < 0.05$) than those fed a control ration Gouda *et al.* (2017) found that supplemented groups had significantly ($p \leq 0.05$) higher body weights than the control group when the later were fed ASMM @ 50 g per day while the former were kept in accordance with the farmer's traditional practices (straw-baseddiet with locally available concentrate) without any nutritional supplementation.

Effect of strategic nutrient supplementation on average daily gain (g/d) of Murrah buffalo calves

The fortnightly average daily gain (ADG) in T_0, T_1, and T_2 groups is presented in Table 11. In the first fortnight, the average daily gain (g) for the control group (T_0) was 221 ± 10.31, while in the treatment groups T_1 and T_2, the ADG values were significantly higher at 290.78 ± 15.99 and 316.78 ± 15.83, respectively ($p \leq 0.01$). This trend of higher ADG (g) in the treatment groups continued in the 2nd fortnight, where T_0 recorded an ADG of 250.34 ± 11.33, whereas T_1 and T_2 showed significantly higher gains of 343.12 ± 15.6 and 377.67 ± 11.53, respectively ($p < 0.01$). Weight gain (g) in T_0, T_1, and T_2 during the 3rd, 4th, 5th, and 6th fortnights were 264.11 ± 21.67, 425.78 ± 36.48 and 464.92 ± 14.30; 241.67 ± 7.67, 443.78 ± 28.27 and

517.08 ± 10.25; 243.45 ± 17.25, 492.78 ±11.58 and 553.00 ± 18.03; 261.89 ± 9.35, 512.78 ± 12.37 and 562.23 ± 13.8. The overall mean average daily gain across the study period was 247.08 ± 4.75 for T_0, 418.17 ± 9.4 for T_1, and 465.28 ± 6.81 for T_2, indicating significant differences among the groups ($p \leq 0.01$). ADG (g) was considerably ($P<0.05$) higher in treatment groups than in the control group, despite the fact that overall body weight changes did not differ significantly across groups because of considerable differences within the group.

Consistent with the present study, Meyer *et al*. (2010) reported a significant ($P<0.05$) improvement in average daily gain among supplemented groups compared to the control group. When 0.5 g of area-specific mineral mixture was supplemented. Similarly, when given a basal diet in the control group and supplemented with Fe, Mn, Zn, Cu, I, Co, Se, vitamin-A, vitamin-D, and vitamin-E in the treatment group, Mishra *et al*. (2016) observed a substantial ($p < 0.01$) increase in average daily gain in the T group compared to the control (C) group. According to Gouda *et al*. (2017), the average daily gain of the supplemented groups was significantly ($p \leq 0.05$) higher than that of the control group when the latter were fed ASMM @ 50 g per day per animal while the former were kept in accordance with the farmer's traditional practices (straw-based diet with locally available concentrate) without any nutritional supplementation. Similarly, according to Sahoo *et al*. (2016), there was a significant difference ($p < 0.05$) was observed in the average daily gain (g) between all treatment groups and the control group. In this study, the control group (C) was managed according to traditional farmer practices, while the treatment groups received additional supplementation. The T1 group was supplemented with 50 g of mineral mixture per day per animal, and the T2 group was given 100 g of bypass fat per animal per day in combination with 50 g of mineral mixture. Similarly, Hassan *et al.* (2016) found that calves fed a supplemented zinc-methionine or zinc sulphate ration had significantly higher average daily gain ($p \leq 0.05$) than those fed a control ration. This was because the supplemented zinc-methionine ration increased methionine absorption and stimulated the activities of enzymes involved in nutrient digestibility, feeding value, and feed efficiency. Similarly, Rojita Yengkhom *et al.* (2018) found that the commercial and booster-mineral supplement group's average daily increased during the 135-day period was considerably higher ($p < 0.01$) than the control groups in kid. Chaudhary *et al.* (2024) reviewed that the average daily gain was markedly higher ($p \leq 0.01$) in the novel feed supplement group compared to the basal roughages and concentrate mixture 20% of DMI as per the farmers' practices (control group).

In contrast to our results, Mandal *et al.* (2008) found no discernible variation in the body weight growth of crossbred calves across groups. In crossbred calves of different groups, Sharma *et al.* (2010) showed no significant difference in average daily weight growth; for G 1, G 2, and G 3, the average daily weight gain was 509, 556, and 496 g, respectively. According to Meher *et al.* (2017), there was no discernible difference ($P>0.05$) in the crossbred cows' average daily weight gain (g) between the control and treatment groups. In this study, the control group (T0) followed the farmer's traditional practices without additional nutritional intervention. In the T1 group, animals were supplemented daily with 50 g of an ASMM per animal. In the T2 group, animals also received this mineral mixture, and, in addition, each animal was administered an injection of fat-soluble vitamins (Vitamin A, D3, and E) on both day 0 and day 7 of the experiment. Similarly, Mudgal *et al.* (2008) revealed that the average daily gain was found to be similar ($p > 0.05$) among the four groups. Contrary to our findings, a nonsignificant difference in average daily gain between the treatment and control groups was reported by various authors, Lammer and Heinrichs *et al*. (2000), Hadiya *et al*. (2009) and Das *et al*. (2014).

Effect of strategic nutrient supplementation on the feed conversion ratio of Murrah buffalo calves

The feed conversion ratio (FCR) at fortnightly intervals is presented in Table 12. The FCR in the first fortnight for the control and treatment groups was 12.33 ± 0.57, 9.58 ± 0.54 and 8.99 ± 0.53 in groups T_0, T_1, and T_2, respectively, and it was statistically significant ($P \leq 0.01$) between the groups. FCR in T_0, T_1 and T_2 during the 2nd, 3rd, 4th, 5th, and 6th fortnights were 12.49 ± 0.72, 8.6 ± 0.44 and 8.06 ± 0.28;13.02 ± 1.15 for T_0, 7.81 ± 0.70 for T_1, and 7.35 ± 0.25; 14.26 ± 0.49, 7.96 ± 0.48 and 7.04 ± 0.18;13.67 ± 0.78, 7.63 ± 0.19 and 6.95 ± 0.21; 13.14 ± 0.53, 7.74 ± 0.31 and 7.19 ± 0.09 for T_2, with statistically significant differences ($p \leq 0.01$) between the control and treatment groups.

The overall average FCR across all fortnights was 13.15 ± 0.32 for T_0, 8.22 ± 0.2 for T_1, and 7.6 ± 0.15 for T_2, with the treatment groups (T_1 and T_2) demonstrating significantly improved feed conversion efficiency compared to the control group ($p \leq 0.01$). These findings indicate that nutrient supplementation enhanced the feed conversion ratio in the treatment groups, resulting in a more efficient utilization of feed.

According to Sawant *et al*. (2013), the feed conversion efficiency was lowest ($p < 0.05$) in the control group and highest ($p \leq 0.05$) in the heifers of group T3, followed by T2. The control group's heifers were given 1.0 kg of concentrate, 5 kg of green fodder, and Jowar kadbi at will. The same was given to the treatment group (T2), along with an extra 30 g of mineral mixture; the heifers in the treatment group (T3) also received 30 g of minerals mixed with vitamins. Similarly, Hassan *et al.* (2016) showed that supplementing growing buffalo calves with zinc methionine or zinc sulphate increased feed conversion efficiency significantly ($p < 0.05$) when compared to a control diet devoid of supplements.

In contrast, earlier research by Das *et al.* (2014), concluded that the feed conversion ratio was found to be similar in all three groups. Similarly, Mishra *et al.* (2016) studied that feed conversion efficiency did not differ significantly between groups when fed a basal diet in the control group and supplemented with Fe, Mn, Zn, Cu, I, Co, Se, vitamin-A, vitamin-D, vitamin-E in the treatment group. Contrary results were also summarized by various authors, including Basra et al. (2003), Chaturvedi et al. (2009), and Singh et al. (2015), who reported a non-significant difference in feed conversion ratio between the treatment and control groups.

Conclusions

Dietary supplementation with strategic nutrients significantly improved body weight, dry matter intake, average daily gain, and feed conversion ratio in the treatment groups.

Table 08: Effect of strategic nutrient supplementation on dry matter intake (kg/d) of Murrah buffalo calves

Fortnights	T_0	T_1	T_2	p value
0	$2.46^{a} \pm 0.03$	$2.52^{ab} \pm 0.05$	$2.65^{b} \pm 0.06$	0.03
1	2.70 ± 0.03	2.75 ± 0.06	2.81 ± 0.06	0.29
2	3.08 ± 0.06	2.92 ± 0.05	3.02 ± 0.04	0.11
3	3.32 ± 0.05	3.21 ± 0.07	3.41 ± 0.06	0.07
4	3.43 ± 0.06	3.48 ± 0.08	3.64 ± 0.08	0.11
5	$3.27^{a} \pm 0.06$	$3.76^{b} \pm 0.1$	$3.83^{b} \pm 0.09$	0.01
6	$3.42^{a} \pm 0.05$	$3.95^{b} \pm 0.1$	$4.04^{b} \pm 0.10$	0.01
Overall mean ± SE	$3.10^{a} \pm 0.03$	$3.23^{ab} \pm 0.07$	$3.34^{b} \pm 0.06$	0.01

Means bearing different superscripts in a row differ significantly ($p \le 0.05$)
Means bearing different superscripts in a row differ significantly ($p \le 0.01$)

Table 09: Effect of strategic nutrient supplementation on body weight (kg) of Murrah buffalo calves

Fortnights	T_0	T_1	T_2	P value
0	62.79 ± 6.07	62.23 ± 4.77	62.66 ± 2.45	1.00
1	66.11 ± 6.16	66.59 ± 4.99	67.41 ± 2.45	0.98
2	69.85 ± 6.26	71.73 ± 5.12	73.07 ± 2.50	0.90
3	73.82 ± 6.35	78.12 ± 5.06	80.05 ± 2.57	0.66
4	77.45 ± 6.41	84.47 ± 4.79	87.81 ± 2.51	0.33
5	81.10 ± 6.34	91.86 ± 4.80	96.10 ± 2.52	0.11
6	$85.03^{a} \pm 6.31$	$99.55^{b} \pm 4.79$	$104.54^{b} \pm 2.60$	0.03
Overall mean ± SE	73.74 ± 6.27	79.22 ± 4.90	81.67 ± 2.50	0.51
Percent increase (%)		7.43	10.75	

Mean bearing different superscripts in a row differ significantly ($p \le 0.05$)

Table 11: Effect of strategic nutrient supplementation on average daily gain (g/d) of Murrah buffalo calves

Fortnights	T_0	T_1	T_2	p value
1	221.00^{a} ± 10.31	290.78^{b} ± 15.99	316.78^{b} ± 15.83	0.01
2	250.34^{a} ± 11.33	343.12^{b} ± 15.60	377.67^{b} ± 11.53	0.01
3	264.11^{a} ± 21.68	425.78^{b} ± 36.48	464.92^{b} ± 14.30	0.01
4	241.67^{a} ± 07.67	443.78^{b} ± 28.27	517.08^{c} ± 10.25	0.01
5	243.45^{a} ± 17.25	492.78^{b} ± 11.58	553.00^{c} ± 18.03	0.01
6	261.89^{a} ± 09.35	512.78^{b} ± 12.37	562.20^{c} ± 13.80	0.01
Overall mean ± SE	247.08^{a} ± 04.75	418.17^{b} ± 09.40	465.28^{c} ± 06.81	0.01

Mean bearing different superscripts in a row differ significantly ($p \leq 0.01$)

Table 12: Effect of strategic nutrient supplementation on the feed conversion ratio of Murrah buffalo calves

Fortnights	T_0	T_1	T_2	p value
1	12.33^{a} ± 0.57	9.58^{a} ± 0.54	8.99^{b} ± 0.53	0.01
2	12.49^{a} ± 0.72	8.60^{a} ± 0.44	8.06^{b} ± 0.28	0.01
3	13.02^{a} ± 1.15	7.81^{a} ± 0.70	7.35^{b} ± 0.25	0.01
4	14.26^{a} ± 0.49	7.96^{a} ± 0.48	7.04^{b} ± 0.18	0.01
5	13.67^{a} ± 0.78	7.63^{a} ± 0.19	6.95^{b} ± 0.21	0.01
6	13.14^{a} ± 0.53	7.74^{a} ± 0.31	7.19^{b} ± 0.09	0.01
Overall mean ± SE	13.15^{a} ± 0.32	8.22^{a} ± 0.20	7.60^{b} ± 0.15	0.01

Mean bearing different superscripts in a row differs significantly ($p \leq 0.01$)

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