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EFFECT OF MINERAL SUPPLEMENTATION ON NUTRIENT UTILIZATION AND GROWTH PERFORMANCE OF LAMBS

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ABSTRACT

Mineral mixtures constitute an important component of animal feed. There is no any specific mineral mixture supplementation is available for lambs in India. The present study was conducted to evaluate the effect of mineral supplementation on growth, nutrient intake, feed efficiency and feed conversion ratio of growing lambs. The feeding trial was conducted for a period of 120 days on 18 male lambs (Body Weight 17.07 Kg and four-month-old) of Munjal breed which were randomly divided into two dietary treatment groups and a control group with six replicates per treatment. The treatment group-T₁ was fed with the conventional mineral mixture and the treatment group-T₂ was fed with BIS specified mineral mixture (Type-I) supplementations @ 2%, whereas, the control group (C) was fed without any supplementation. The proximate nutrient compositions of concentrate mixtures in all the three groups were identical in respect to CP, EE, CF and NFE. During digestion trials of 120 days for C, T₁ and T₂ groups, the mean body weight gains (kg) were observed as 08.79, 10.08, 10.32; the nutrient intakes of TDN and DCP (gm/day) were observed as 602.21, 628.96, 637.15 and 59.08, 61.38, 64.63, respectively. The feed efficiency (gain to feed ratio) were observed as 0.111, 0.126, 0.131, whereas, the feed conversion ratio was observed as 8.98, 7.94, and 7.66, respectively for C, T₁ and T₂ groups. Based on the

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results, it was concluded that BIS specific mineral mixture supplementation was found to have significant ($P<0.05$) and positive effect on the body weight gain, nutrient intake, feed efficiency and feed conversion ratio as compared to the control group, whereas, these parameters showed non-significant but apparently positive effect as compared to conventional mineral mixture. It was inferred that the supplementation of BIS specific mineral mixture in conventional diet of lambs was helpful in improvement of the daily body weight gain, feed efficiency and feed conversion ratio.

1 Introduction

India occupies 2.4% of the world's geographical area with a large percentage of its land under agriculture (Bhandari et al., 2007), however, availability of feed and fodder remain insufficient to meet requirement of growing animal population (Ramachandra et al., 2007). Indian livestock sector is one of the largest in the world with 56.7% of world's buffaloes, 12.5% cattle, 20.4% small ruminants, 2.4% camel, 1.4% equine, 1.5% pigs and 3.1% poultry (Birthal, 2008). Small ruminants form an important economic and ecological niche in small farm system and agriculture in rural parts of India (Devendra, 2001). In India, the total of 65.06 million sheep contributes around 12.71% of the total livestock population (DADH & F, 2012). One of the major challenges in sheep husbandry is shrinking grazing land coupled with poor quality feed resources especially widespread deficiency of macro- and micro minerals. Such limitations of nutrients prevent sheep from attaining their true growth and production potential and lower the immune system of animal making them prone for diseases (Garg et al., 2007; Tomlinson et al., 2008; Shinde & Sejian, 2013). In many animal production systems, approximately two-thirds of improvements in livestock productivity can be attributed to improved nutrition (Fitzhugh, 1978). The concentration of minerals in crops and forages depends on various interdependent factors i.e. genus, species, variety, soil type, climate and stage of maturity of fodder (McDowell, 1987; Gowda et al., 2001; Das et al., 2003). Mineral deficiencies or imbalances in soil or forages are responsible for low animal production and poor reproductive performance (Bhattacharyya et al., 1994; Garg et al., 2005; Sejian et al., 2014).

In India, livestock species are mainly maintained on grazing with little or no supplementation of mineral mixture, except common salt (Garg et al., 2005). Deficiency of minerals in sheep under grazing (Eruvbetine et al., 2003) and grazing plus concentrate supplementation (Shinde et al., 2006) has been reported. Supplementary need of minerals and concentrate mixture to sheep of various ages under grazing has also been advocated (Zhang et al., 2007). Therefore, in the present feeding system necessity of minerals is not satisfied and continuous ingestion of deficient, imbalance or excessively dry roughage cause mineral imbalance in the body tissue and fluids (Sharma et al., 2002). Minerals most

likely to be deficient under grazing conditions are Ca, P, Na, Co, Cu, I and Zn (McDowell, 1992). In sheep, mineral mixtures are usually mixed with concentrate @ 2% to improve their growth rate, reproduction efficiency, feed utilization efficiency, milk production, immune response and general health (Kalita et al., 2003) but it is very difficult to assess which mineral mixture is best for the animals since different mineral mixtures are available commercially with different brand names and formulations. Under the circumstances, mineral supplementation in sheep diet has been recommended by many workers (Kalita et al., 2003; Mark & Scott, 2006). To address this knowledge gap, the present study was envisaged to assess the effect of specified mineral mixture on growth, nutrient intake, feed efficiency and feed conversion ratio of growing lambs.

2. Materials and methods

2.1 Experimental design

In present study, eighteen healthy Munjal male lambs of 4-month age were selected from the sheep farm of the University. Lambs were weighed individually and divided into two dietary treatment groups (T_1 and T_2) and a control group (C) with six replicates in each. The selected lambs were shifted to individual pan in the sheep breeding farm for further nutritional trials. Standard animal management practices were followed in the farm.

2.2. Feeding trials

The feeding trials of the selected groups were continued for 120 days. The lambs of the control group (C) were maintained as on common conventional ration consisting of concentrates and gram straw mixture following ICAR (1985) specification. All the lambs were allowed eight-hours of continuous grazing uniformly. The concentrate mixture comprises of maize, groundnut cake, barley and common salt (Table 4). The overall proximate nutrient composition of concentrate mixture is presented in Table 1. The mineral composition of various feed ingredients fed to lambs under treatment and control groups are presented in Table 2. The ingredients of the concentrate mixture were oven dried and ground in wiley mill. Various proximate nutrients viz. dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and total ash (TA) were estimated (AOAC, 2012).

Table 1 Proximate composition (% DM Basis) of concentrate mixture

Attributes	Percent DM basis						
	DM	OM	CP	CF	EE	TA	NFE
Control	90.09	93.22	14.05	5.95	3.65	6.78	69.57
T₁	90.87	92.46	13.98	5.06	3.25	7.54	70.17
T₂	90.46	91.62	14.21	5.13	3.48	8.38	68.80

Table 2 Mineral composition of feed ingredients fed to the lambs

Ingredient	Maize	Barley	GNC	Gram straw
Ca (g/kg)	0.03	0.50	0.20	1.72
P (g/kg)	0.22	0.38	0.60	1.56
Mg (g/kg)	0.14	0.15	0.31	0.29
Cu (ppm)	4.00	9.00	16.00	55.80
Zn (ppm)	14.00	19.00	22.00	85.00
Fe (ppm)	30.00	85.00	169.00	523.00
Mn (ppm)	5.00	18.00	28.00	97.00

Table 3 Composition of mineral mixture supplement in different treatment groups

Inorganic salt (kg/qt.)	T ₁	T ₂
Di-calcium phosphate	53.00	62.00
Calcium carbonate	11.00	30.00
Zinc sulphate(monohydrate)	2.20	0.55
Ferrous sulphate(monohydrate)	1.25	1.80
Potassium iodate	0.05	0.60
Cupric sulphate	0.25	0.08
Manganese dioxide	0.20	0.13
Cobalt chloride(pentahydrate)	0.05	0.03
Magnesium carbonate	17.50	-
Sodium sulphate	8.00	-
AIA	6.50	4.81
Total	100	100

Table 4 Gross composition of concentrate mixture

Ingredient	Control	T ₁	T ₂
Maize	50	50	50
Barley	30	30	30
GNC	17	17	17
Starch	2	-	-
Common salt	1	1	1
Mineral mixture	-	2	2
Total	100	100	100

Feed and fodder samples were dried at 100°C in hot air oven and ground to 1 mm sieve and digested in tri-acid and volume was made to 50 ml. Calcium, magnesium, copper, zinc, manganese and iron in feed and fodder were estimated by atomic absorption spectrophotometer- model Pinnacle 900T, S/N PTAS13050201 of Perkin Elmer Company. Phosphorus in feed and fodder was estimated by UV spectrophotometer (AOAC, 2012). For estimation of calcium and magnesium digested volume was diluted in 0.1% lanthanum chloride in 1:51 ratio and iron, zinc, manganese, and copper were estimated in 1:11 dilution with distilled water.

The treatment groups were similar about composition of maize, barley and groundnut cake as concentrate mixture; however, in treatment group T₁ the conventional mineral mixture @ 2% has been added, whereas, in treatment group T₂ the BIS specific mineral mixture has been added @ 2%. The minerals were supplemented through individual salts (ICAR, 1985) and composition of mineral mixture (per 100 kg) is presented in Table 3. The overall composition (%) of the feed ingredients and mineral composition of the diets for various groups is presented in Table 5 and 6, respectively.

Table 5 Digestibility coefficients for dry matter and proximate nutrient in lambs under different dietary treatments

Parameter	Treatment		
	T1	T2	T3
Dry matter intake (g/d)			
Concentrate	474.59±2.16	478.08±2.21	475.73±2.41
Gram straw	425.10±2.41	423.59±2.01	426.70±2.70
Total	948.78±3.10	952.41±2.30	951.77±2.06
DMI(%BW kg)	3.68±0.11	3.47±0.05	3.46±0.03
DMI/kgW0.75 (g)	11.43±0.35	11.99±0.16	12.02±0.10
Nutrients Digestibility (%)			
DM	58.10a±0.55	60.81b±0.27	61.35b±0.25
CP	66.58 a ±0.52	69.01 b ±0.67	71.87c±0.62
CF	45.02±0.57	45.87±0.25	46.09±0.26
EE	69.78a±0.24	71.42b±0.24	72.18b±0.25
OM	64.25 a ±0.57	66.22 b ±0.29	65.70 b ±0.40
NFE	74.46 a ±1.03	78.49 b ±0.49	79.65 b ±0.48

Means bearing different superscripts in a column differ significantly (P<0.05)

Table 6 Mineral composition of concentrate mixture fed to the lambs (%DM basis)

Attribute	Ca (g/kg)	P (g/kg)	Mg (g/kg)	Zn (ppm)	Mn (ppm)	Cu (ppm)	Fe (ppm)
Control	3.50	3.25	1.68	7.00	16.00	70.00	12.00
T₁	7.25	5.56	2.68	17.00	150.00	145.00	32.00
T₂	9.30	6.10	1.70	14.00	60.00	170.00	30.00

2.3 Statistical analysis

Body weight gains, feed efficiency and feed conversion ratio were estimated fortnightly during growth period. The digestion trial was conducted to study the nutrient intake and retention among the different trial groups. The statistical analysis of data was performed using SPSS 21.0 version of Microsoft. One-way ANOVA was used to calculate the differences between the groups. Wherever, the P-values were found to be significant ($P < 0.05$), the Duncan's multiple range test was performed. All the data were expressed as mean $\pm$ standard errors.

3. Results and discussion

3.1 Effect on growth

The effect of various dietary treatments on growth pattern in lambs is presented in Table 7. The average initial body weight (kg) of lambs in control and treatment groups T_1 and T_2 were observed nearly similar as 16.96, 17.12 and 17.13, respectively. During the feeding trials, final body weight (kg) in control and treatment groups T_1 and T_2 at the completion of 60 days trial were observed as 21.3, 22.28 and 22.32, whereas, on completion of 120 days it was found to be 25.75, 27.21 and 27.45, respectively. The gain in body weight (kg) over the experimental periods of 120 days for control and treatment groups T_1 and T_2 were 8.79, 10.08, and 10.32, respectively. On statistical analysis, the differences between daily weight gain among the groups was significantly ($P \leq 0.05$) higher in treatment compared to control. (Table 7) Albeit, an apparently higher gain in body weight was noticed in the lambs of treatment groups T_2 as compared to T_1 . These observations revealed that supplementation of the BIS specific mineral mixture showed the growth in the body weight of the lambs in present feeding trials. The essential role of trace minerals for a wide variety of physiological processes regulating growth,

Table 7 Daily weight gain and average body weight gain in lambs fed under different dietary treatment groups

Parameter	Treatments		
	Control	T_1	T_2
Daily weight gain (g/d)			
1-60 days	72.27 ^a $\pm$ 1.02	85.88 ^b $\pm$ 0.60	86.48 ^b $\pm$ 0.73
61-120 days	74.22 ^a $\pm$ 0.72	82.16 ^b $\pm$ 0.91	85.58 ^b $\pm$ 1.36
1-120 days	73.25 ^a $\pm$ 0.65	84.02 ^b $\pm$ 0.69	86.02 ^b $\pm$ 1.18
Average body weight gain			
Initial b.w. (kg)	16.96 $\pm$ 0.13	17.12 $\pm$ 0.28	17.13 $\pm$ 0.25
Final b.w. (kg)	25.75 $\pm$ 0.07	27.21 $\pm$ 0.35	27.45 $\pm$ 0.26
Total (kg)	8.79 ^a $\pm$ 0.14	10.08 ^b $\pm$ 0.13	10.32 ^b $\pm$ 0.15

*Means bearing different superscripts in a row differ significantly ($P < 0.05$)

production, reproduction, and health is well established (Hatfield et al., 2001; Sejian et al., 2014). The present finding regarding body weight changes are in concurrence with other global studies, it has been also reported that sheep in the treatment group (receiving mineral supplement) gained more weight during the months of experiment compared with sheep in the control group (Hatfield et al., 2001). The supplementation of Ca, P, Zn, Cu and Mn in crossbred cattle was found to have a positive effect on growth related parameters (Satapathy et al., 2016; Meher et al., 2017). The marginal Zn deficiency can result in subnormal growth of grazing animals (Miller, 1988; McDowell 1992), whereas, the supplementation of zinc @ 45 mg/kg to a concentrate mixture containing 20.70 mg Zn/kg DM found to increase in growth performance (Maan & Sihag, 2014). The stall feeding of copper and zinc supplementation @ 2.5 and 10.0 ppm to lambs may result in average daily gain with similar dry matter intake and may be practiced under field condition (Mondal et al., 2013).

3.2 Effect on nutrient intake, feed efficiency and feed conversion ratio

Digestible Crude Protein (DCP) in control and treatment groups T_1 and T_2 were 59.08, 61.38 and 64.63, whereas, the Total Digestible Nutrients (TDN) was 602.21, 628.96 and 637.15(g/d), respectively. The higher intake was observed in treatment groups T_2 followed by T_1 and Control group. DCP intake were significantly ($P < 0.05$) higher in treatment group T_2 as compared to control (Table 5, 8). The percentage DCP was 6.22, 6.44 and 6.77, in control and T_1 and T_2 , respectively and T_2 were significantly ($P \leq 0.05$) higher as compared to other groups. The percent TDN in

Table 8 Nutrient utilization in lambs under different dietary treatment groups

Parameter	Treatments		
	Control	T_1	T_2
Nutrient Intake (g/d)			
DCP	59.08 ^a $\pm$ 0.29	61.38 ^b $\pm$ 0.18	64.63 ^c $\pm$ 0.38
TDN	602.21 ^a $\pm$ 2.23	628.96 ^b $\pm$ 2.83	637.15 ^b $\pm$ 3.10
Nutritive value			
DCP %	6.22 ^a $\pm$ 0.04	6.44 ^b $\pm$ 0.05	6.77 ^c $\pm$ 0.04
TDN %	63.46 ^a $\pm$ 0.47	66.04 ^b $\pm$ 0.27	66.77 ^b $\pm$ 0.24
FCE (LWG/DMI)			
1-60 days	0.125 ^a $\pm$ 0.01	0.147 ^b $\pm$ 0.01	0.148 ^b $\pm$ 0.01
61-120 days	0.100 ^a $\pm$ 0.05	0.110 ^b $\pm$ 0.02	0.114 ^b $\pm$ 0.02
1-120 days	0.111 ^a $\pm$ 0.03	0.126 ^b $\pm$ 0.02	0.131 ^b $\pm$ 0.01
FCR			
Concentrate	5.00 ^b $\pm$ 0.47	4.41 ^a $\pm$ 0.34	4.30 ^a $\pm$ 0.08
Gram straw	3.98 ^b $\pm$ 0.39	3.53 ^a $\pm$ 0.05	3.35 ^a $\pm$ 0.10
Total	8.98 ^b $\pm$ 0.08	7.94 ^a $\pm$ 0.08	7.66 ^a $\pm$ 0.18

*Means bearing different superscripts in a row differ significantly ($P < 0.05$)

control and treatment groups T₁ and T₂ were 63.46, 66.04 and 66.77, respectively and treatment groups T₁ and T₂ were significantly higher ($P < 0.05$) from control group (Table 8).

The feed efficiency (gain to feed ratio) in control and treatment groups T₁ and T₂ were 0.111, 0.126 and 0.131, respectively. Live weight gain per unit feed consumed was significantly ($P < 0.05$) higher in T₂ as compared to control group (Table 8). However, treatment T₁ and T₂ did not differ significantly. Feed to gain ratio from concentrate in control and treatment groups T₁ and T₂ was 5.00, 4.41 and 4.30, whereas, for gram straw as 3.98, 3.98, and 3.35, respectively. Feed consumed per unit gain was significantly ($P < 0.05$) higher in control as compared to treatment groups T₁ and T₂ (Table 8). However, the differences in feed to gain ratio between treatment groups T₁ and T₂ did not differ significantly. Hence, these results indicate that supplementation of mineral mixture significantly improved the feed utilization, but BIS specific mineral mixture supplementation (T₂) apparently improves further utilization of feed as compare to conventional mineral mixture (T₁).

The present finding regarding feed efficiency and feed conversion ratio is also in concurrence with other reports regarding lower feed intake with higher feed efficiency has in ewes that fed with chelated Cu 10 ppm and Zn 40 ppm (Hatfield et al., 2001). The supplementation of zinc @ 45mg/kg to a concentrate mixture containing 20.70 mg Zn/kg DM reported to increase in growth performance, feed conversion efficiency (Maan & Sihag, 2014).

Conclusion:

The supplementation of BIS specific mineral mixture in conventional diet of lambs was helpful in improvement of the daily body weight gain, feed efficiency and feed conversion ratio.

Conflict of Interest

Authors declare that there is no conflict of interests arising from this study.

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