GROWTH, FEED CONVERSION EFFICIENCY, HEMATOBIOCHEMICAL PROFILE, AND IMMUNE STATUS OF BLACK BENGAL MALE GOATS SUPPLEMENTED WITH INORGANIC AND ORGANIC ZINC IN DIET

Kamdev Sethy[1], K. Behera[2], S.K. Mishra[3], R.K. Swain[4], D. Satapathy[5], J.K. Sahoo[6]

ABSTRACT

Zinc is an essential micro-mineral, required to maintain optimum physiological functions in goats similar to other livestock, and need continuous supplementation, as it is not stored in the body. Zinc in various forms, such as inorganic Zn, organic Zn, and nano Zn are usually administered in diet, but the results have been found to be contentious depending on the targeted animal, source of Zn and its concentration due to differential metabolic behavior of Zn in the body, and thus needs optimization in targeted animals. This experiment was undertaken to evaluate the effect of supplementation of inorganic Zn (Zinc oxide) and organic Zn (Zinc methionine) in the diet on growth, haematology, metabolic profile, and immune status in Black Bengal male goats. Fifteen Black Bengal male goat kids (2-3 months of age, 6.13 ± 0.26 kg average body weight) were divided in to three equal groups of 5 animals in each group, and fed a basal diet comprising concentrate mixture and paddy straw, containing 24.7 ppm and 10.3 ppm of Zn, respectively on DM basis. T1 served as control (without Zn supplementation). T2 and T3 groups were supplemented with 40 mg /kg DM as zinc oxide (ZnO) and zinc methionine (Zn-Met) respectively. The experiment continued for 90 days. Results revealed that the effect of Zn supplementation on final body weight (kg), average daily gain in body weight (g), feed conversion efficiency (DMI/ADG/Day, g), haematological parameters, *viz*., Hb (g/dl) and PCV (%), and metabolic parameters, *viz*., total protein (g/dl), albumin (g/dl), globulin (g/dl), urea (mg/dl), and A/G ratio was non-significant ($P \geq 0.05$), where as, serum glucose concentrations (mg/dl) in Zn supplemented (T2 & T3) groups were significantly ($P \leq 0.05$) higher than the T1 (control). The cell mediated immunity (CMI) status, measured as skin fold thickness (cm), and the humoral immunity, measured as haemagglutination (HA) titre were the highest in T3, followed by T2 and T1, with each group differing significantly ($P \leq 0.05$) from other. It is concluded that supplementation of both ZnO and Zn-Met @ 40ppm significantly enhanced the immune status of Black Bengal male goats, but goats supplemented with Zn-Met had a superior immune profile than goats supplemented with ZnO.

KEY WORDS

Black Bengal Goat, Growth, Immunity, Metabolism, Zinc supplementation

Author attribution: [1,2]Assistant Professor, [3]Associate Professor, [4]Professor & Head, [5,6] MVSc Scholar, Department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha, India- 751003. [1]Corresponding author (E-mail: babuivri@gmail.com). Received: 10 January 2016, Accepted: 5 May 2016. pp.91-99

INTRODUCTION

Zinc is a nutritionally essential trace element for goats, as it assumes critical role for ensuring proper feed intake and nutrient utilization, growth and skeletal development, hair and skin integrity, reproduction, nutrient metabolism, and immune competence (Neathery et al., 1973; O'Dell, 2000; Tabatabaie et al., 2007; Jia et al., 2009; Habeeb et al., 2013; Sahoo et al., 2015).

Zn plays a significant role in the functioning of immune system by virtue of its role in the functioning of T-cells and B-cells (Droke and Spears, 1993). The immuno-stimulatory effect of Zn is mainly due to its role in lymphocyte and natural killer cells function, and production of cytokines and lymphokines (Hambidge et al., 1998).

Zinc is not stored in the body, thus needs continuous supplementation, as it is essential to maintain optimum physiological functions in animals (Spears and Kegley, 2002; Zalewski et al., 2005). Zinc is supplemented in livestock diet in the form of inorganic Zn (ZnO or $ZnSO_4$), organic Zn (Zinc-methionine, Zinc-yeast) or nano zinc oxide (nZnO), out of which bioavailability of organic Zn and nano ZnO are better than inorganic zinc due to higher retention potential resulting in better growth and feed conversion efficiency (G/F) in ruminant livestock (calves and lambs), pigs, and poultry, albeit with controversial results based on source and dose concentration indicating differential metabolic behavior in the body, and thus the need to optimize the requirement of zinc in targeted animals, since deficient or excess concentration of Zn in diet moderates the performance (Cao et al., 2000; Mandal et al., 2007; Garg et al., 2008; Jia et al., 2009; Richards et al., 2010; Song et al., 2010; Habeeb et al., 2013; Zaboli et al., 2013; Nitrayova et al., 2015; Sahoo et al., 2015).

Keeping this in view, this study was conducted in Black Bengal male kids to assess the effect of inorganic zinc (ZnO) and organic zinc (Zn-Met) in equal doses on growth, feed conversion efficiency, blood chemistry, and immunity, due to non availability of information in this breed. The effect of Zn is more profound in males than in females due to its involvement in sperm production, libido, and proper development of sex organs in males (Neathery et al., 1973).

MATERIALS AND METHODS

Experimental animals: The experiment was conducted on 15 Black Bengal male kids (2-3 months of age with mean body weight of 6.13 ± 0.26 kg at the Instructional Livestock Farm, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha.

Feeding regimen: These kids were kept on the experimental diet (concentrate mixture with *ad libitum* paddy straw) for a period of one month for adaptation. The kids were divided into three groups of five in each group on the basis of their body weights following randomized block design. They were kept in a well ventilated shed with individual feeding and watering arrangements. Kids in all the groups were fed on concentrate mixture and paddy straw to meet their nutrient requirements for 50 g daily weight gain (NRC, 2007).

The concentrate mixture of the feed consisted of crushed maize grain (30%), soybean meal (35%), wheat bran (32%), mineral mixture (2%) and common salt (1%). Zinc was administered along with the concentrate mixture.

T1 (control) group did not contain supplemented Zn in the diet. T2 group was supplemented with 40 ppm Zn as Zn oxide in the diet. T3 group was supplemented with 40 ppm Zn as Zn methionine in the diet. All the kids were offered 100 g of maize (*Zea mays*) fodder once a week to meet their vitamin A requirement. Clean and fresh drinking water was provided twice a day to all the kids. This feeding practice continued for 90 days.

Proximate analysis of feed samples: Feed samples (Concentrate mixture and Paddy straw) were analyzed for proximate principles (Table-1) as per (AOAC, 2000).

Body weight: The kids were weighed at fortnightly intervals up to 90 days in the morning before offering feed or water.

Hemato-Biochemical analysis: About 10 ml blood was collected from the jugular vein of each kid in the morning (before watering and feeding) at 90 days of the experimental feeding. The serum was collected in vials and kept at -40°C until further analysis.

Haemoglobin (Hb) content and packed cell volume (PCV) were determined as per Schalm et al. (1975) and Jain (1986), respectively. The serum biochemical parameters like glucose, total protein, albumin, globulin, A/G ratio, and urea concentrations were estimated by using Crest Biosystems (Goa, India) kit.

Immunoassay: The kids, at 90 days of the experimental period were, injected with 100 µg of Phytohaemaglutinin-P (PHA-P) in 0.1 ml of normal saline intradermally in the neck region to measure the cellular immune response. The humoral immunity was assessed from the antibody production against sheep red blood cell (SRBC) by using micro titration hemagglutination (HA) technique.

Statistical analysis: Statistical analysis of the data was done by SPSS ver. 7.5 by using one way analysis of variance.

Table-1. Chemical composition (% DM basis) of concentrate mixture and paddy straw fed to Black Bengal goats.

Nutrients	Concentrate mixture	Paddy straw
Organic matter	90.10	85.70
Crude protein	18.20	2.70
Ether extract	2.20	1.14
Neutral detergent fibre	33.28	76.50
Acid detergent fibre	10.70	56.42
Hemicelluloses	22.58	20.08
Cellulose	9.46	44.18
Total ash	9.90	14.30
Calcium	1.62	0.65
Phosphorus	0.78	0.19
Zinc (ppm)	24.70	10.30

RESULTS AND DISCUSSION

Growth: Growth characteristics (Table-2) with respect to average final body weight (kg) and average daily body weight gain (g) in T1 (9.67, 39.11), T2 (9.74, 40.55) and T3 (9.92, 41.77) groups were numerically higher in Zn supplemented groups over the control (T1), and was higher in T3 (40 ppm Zn-Met) than in T2 (40 ppm ZnO), but the differences between the groups were statistically non-significant ($P \geq 0.05$).

Feed Conversion Efficiency: The feed conversion efficiency (FCE) estimated as DMI (g)/ADG/Day (Table-2) was the highest in T3 (8.32) group, followed by T2 (8.45) and T1 (8.64) groups, but the differences between the groups were non-significant ($P \geq 0.05$).

Similar to our results, Engle et al. (1997) observed that diet containing 17 ppm Zn did not support normal growth in calves, Nocek et al. (2006) reported non-significant effect of Zn on body weight gain, when Zn was fed either as inorganic (sulfate) or organically chelated (amino acid complex) in dairy cattle. Similarly Kegley and Spears (1995) in lambs and Mandal et al. (2007) in calves did not observe significant effect of Zn supplementation on weight gain. The effect of Zn (ZnO or nZno) on feed intake and average daily gain has also been reported to be non-significant in Markhoz goats (Zaboli et al., 2013). Such results are attributed to adequate Zn concentration in the diet, and consequently in the blood leading to normal growth, as observed in Egyptian Zaraibi goats (Habeeb et al., 2013).

In our experiment, the feed offered to the kids contained 24.7 (ppm) Zn in conc. mixture, and 10.3 (ppm) Zn in paddy straw on dry matter basis, which could have been enough to meet the requirement for growth, since lower or excess dietary concentration of Zn could have affected growth performance in the experimental animals, as observed in nursery pigs

(Carlson et al., 2004) and in Egyptian Zaraibi goats (Habeeb et al., 2013).

Sahoo et al. (2015) have observed in broiler chickens that inorganic zinc (15 ppm), organic zinc (15 ppm and 7.5 ppm), nano zinc (0.06 ppm and 0.03 ppm) induced better growth, as reflected from significantly ($P \leq 0.05$) higher body weight over the control. Organic zinc (15 ppm) induced better growth than inorganic zinc (15 ppm), and nano zinc (0.3 ppm, 0.03 ppm), but did not significantly ($P \geq 0.05$) differ from organic zinc (7.5 ppm) and nano zinc (0.06 ppm). Thus, the growth ameliorative effect of organic zinc at the levels of 7.5 ppm and 15 ppm, and nano zinc (0.06 ppm) were similar, and can be used for substitution with each other.

Our results with respect to FCE did not agree with the results of Sahoo et al. (2015), who reported that broiler chicks supplemented with zinc (inorganic, organic and nano zinc) had better ($P \leq 0.01$) FCR (6^{th} week) than the control group, which was not supplemented with Zn.

Haemato-Biochemical parameters: The haematological parameters (Hb and PCV) and the biochemical parameters (glucose, total protein, albumin, globulin, A/G ratio, and urea) presented in Table-3, indicated that the level of glucose (mg/dl) in T3 (57.51) and T2 (55.3) were significantly ($P \leq 0.05$) higher than in T1 (48.05), but the difference between T2 and T3 groups was non-significant ($P \geq 0.05$).

Haematological constituents change with the change in physiological or pathological state of the animal. These changes are indicators of the response of farm animals to various physiological situations, such as adaptability to adverse environmental conditions including stress (Etim et al., 2014).

Results of haematological parameters studied in this experiment indicated that the mean Hb and PCV values were in normal range and did not differ ($P \geq 0.05$) between the groups. Similar to our results, addition of 40 mg Zn/kg of diet did not affect blood haemoglobin or PCV in chicks (Sridhar et al., 2015). But, Sobhanirad and Naserian (2012) observed higher Hb and PCV values in Holstein dairy cows supplemented with 500 mg Zn/ kg DM as Zn-sulphate or Zn-methionine. This might be due to higher concentration of Zn in supplemented groups than in control.

The overall mean values of total protein, albumin, globulin, A:G ratio, and urea were found to be similar ($P \geq 0.05$) in the two groups and were within the normal range indicating that supplementation of Zn had no effect on these parameters, whereas the serum glucose level increased in all the supplemented groups than the control animals.

Similarly, Mandal et al. (2007) in cross bred calves, Engle et al. (1997) in heifers, and Shinde et al. (2012) in Malpura sheep did not observe any significant effect of Zn–methionine supplementation on total protein, albumin, globulin, albumin:globulin ratio, and urea concentration.

In our study, serum glucose concentration increased significantly

($P \leq 0.05$) in Zn supplemented groups than non-supplemented control animals. This agreed with the results of Elamin et al. (2013) in Sudanese goats. The increased glucose concentration may be due to alteration in molar proportion of volatile fatty acid (VFA) in the rumen with an increase in propionate production (Aliarabi and Chhabra, 2006). Further, serum glucose is a ready source of energy, and is utilized by tropical male goats (*Capra hircus*) to modulate immunity and reproduction (Ghosh et al., 2013).

Table- 2. Growth performance and feed conversion efficiency of Black Bengal goats on zinc supplemented diets.

Attributes	Dietary group			SEM	P value
	T1	T2	T3		
Initial Body Weight (kg)	6. 15	6. 09	6.16	0. 26	0.210
Final Body Weight (kg)	9.67	9.74	9.92	0. 33	0.160
Total weight gain (kg)	3.52	3. 65	3.76	0.18	0.840
Average Daily Gain in wt (g)	39.11	40.55	41.77	1.59	0.621
Total DMI / Day, g	337.91	342.65	347.52	9.13	0.245
FCE (DMI/ADG)/ Day, g	8.64	8.45	8.32	0.30	0.172

Table- 3. Haemato-biochemical profile of Black Bengal goats on zinc supplemented diets.

Attributes	Dietary group			SEM	P value
	T1	T2	T3		
Haemoglobin (g/dl)	9.71	10.00	9.86	0.90	0.139
PCV (%)	27.50	27.80	29.10	2.15	0.241
Glucose (mg/dl)*	48.05^{a}	55.30^{b}	57.51^{b}	2.01	0.040
Total Protein (g/dl)	6.10	6.42	6.66	0.50	0.147
Albumin (g/dl)	3.30	3.54	3.62	0.38	0.262
Globulin (g/dl)	2.80	2.88	3.04	0.36	0.088
A/G ratio	1.18	1.23	1.20	0.22	0.102
Urea (mg/dl)	21.88	20.63	22.05	1.56	0.358

*Means bearing different scripts in a row differed significantly at $P \leq 0.05$.

Table-4. Immune response of Black Bengal goats on zinc supplemented diets.

Attributes	Dietary group			SEM	P value
	T1	T2	T3		
CMI (Skin Fold thickness in cm)*	0.32^{a}	0.51^{b}	0.67^{c}	0.02	0.01
Haemagglutination titre*	4.11^{a}	5.88^{b}	6.90^{c}	0.10	0.03

*Means bearing different scripts in a row differed significantly at $P \leq 0.05$.

Immunne status: Our study revealed that the cell mediated immunity (CMI) status, measured as skin fold thickness (cm) in Zn supplemented T3 (0.67) and T2 (0.51) were significantly ($P \leq 0.05$) higher than the T1 control group (0.32). The CMI in T3 group was significantly ($P \leq 0.05$) higher than the T2 group indicating the superiority of Zn-Met over ZnO.

The status of humoral immunity, measured as haemagglutination (HA) titre in Zn supplemented T3 (6.9) and T2 (5.88) groups were also significantly ($P \leq 0.05$) higher than the T1 control group (4.11). The HA titre of T3 group was significantly ($P \leq 0.05$) higher than the T2 group indicating the superiority of Zn-Met over ZnO.

Our results are similar to the report of Mandal et al. (2007), who had observed increased cell mediated ($P \leq 0.05$) and humoral ($P \leq 0.05$) immune response in crossbred calves supplemented with Zn propionate as compared to the animals receiving Zn sulfate. Kala (2009) had also observed increased cell mediated immune response and humoral immune response in kids supplemented with 26.75 mg Zn/kg DM. Increased immunity is attributed to increased thymulin production, essential for maturation and proliferation of lymphocytes (Shinde et al., 2006).

CONCLUSION

The present results indicated that the basal diet formulated by us contained adequate amount of Zn to support growth and feed conversion efficiency in Black Bengal male goats. Supplementation of 40 ppm of ZnO and Zn-Met enhanced the immune status, Zn-Met being superior to ZnO.

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