



Zinc and Copper Supplementation Effect in Lambs
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Effect of Organic Zinc and Copper Supplementation on Growth Performance, Nutrient Utilization and Minerals Balance in Harnali Lambs

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ABSTRACT

To assess the comparative efficacy of inorganic and organic sources of minerals, an experiment was conducted on sixteen Harnali male lambs randomly divided into two groups of 8 animals each. All lambs were maintained on basal ration comprising of green fodder, gram straw and concentrate mixture. The mineral mixture of group-I had Zn and Cu from inorganic sources ($ZnSO_4$ and $CuSO_4$) while zinc methionate and copper methionate served as source of Zn and Cu in mineral mixture of group-II. Feeding trial lasted for a period of 180 days. Body weight changes of animals were recorded at fortnightly intervals. At the end of the feeding trial, a metabolism trial of 5 days duration was conducted to evaluate the effect of organic zinc and copper on nutrients digestion and balance of nutrients. Total DM intake and digestibility of dry matter did not vary significantly between the groups. Digestibility(%) of organic matter and crude fibre was 66.7 and 61.6 in group-I, respectively and 68.5 and 63.2 in group-II, respectively and there was significant ($P<0.05$) difference between the two groups. Faecal-N as well as urinary-N value and N-balance did not vary significantly between the groups. Intake of TDN was 919.6 and 968.0 g/day in group - I and II, respectively and it was significantly ($P<0.05$) higher in group – II. Significant ($P<0.05$) difference in average body weight gain was observed between groups. Feed efficiency in terms of kg DM/kg gain was 13.0 and 11.9 in group-I and II, respectively. Results of the study showed that organic source of Zn and Cu improved their respective absorption by 38 and 34.5% and also improved digestibility of nutrients and growth performance of lambs.

KEY WORDS: Copper, Growth performance, Lambs, Mineral, Organic zinc

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INTRODUCTION

Trace minerals are necessary for the biochemical processes of the body that support proper growth and maintenance. Trace elements requirement of livestock depends on feedstuffs and mineral supplements, however the potential availability and absorption of the minerals from the gastrointestinal tract and the mineral's utilization by the animal tissues varies considerably. The potentially absorbable fraction of a mineral is greatly influenced by species of animal, intake of mineral relative to amount required, chemical form of the mineral, and the amount and proportions of other dietary compounds. Zinc (Zn) is part of a number of enzymes which play an important role in the metabolism of nutrients in animals (Jia et al., 2008). As Zn and Cu are not

stored in the body, a continuous dietary supply is necessary for proper physiological functions (Zalewski et al., 2005). The deficiency of Zn in ruminant diet leads to reduced feed intake, growth rate and feed efficiency (McDowell et al., 1993). Copper is a vital trace element involved in various physiological and biochemical processes. However, animals can only absorb a small fraction of copper and the most is excreted, Copper (Cu) is a crucial trace element in animals; however, it cannot be stored in the body, thus a regular dietary supplement is required. In addition, feed ingredients are commonly deficient in Cu; hence, provide the essential amount of Cu in a biologically dynamic form, which in turn depends on the physical and chemical properties of the form of the supplement in which the Cu is given in the diet. Livestock are often supplemented with

trace minerals in the form of inorganic salts such as oxides, chlorides, sulfates and carbonates. Studies showed that Zn and Cu supplementation through mineral amino acid chelates as organic sources which effectively had higher retention (Lardy et al., 1992; Gowda et al., 2014), more bioavailability (Spears, 1989) and tissue concentrations (Cao et al., 2000; Pal et al., 2010) relative to inorganic sources. Present research was thus undertaken to study the effects of inorganic and organic sources of Zn and Cu in mineral mixture on the performance of lambs and bioavailability of these elements.

MATERIALS AND METHODS

The experimental work of the study was carried out at the Animal farm, Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar (Haryana). Sixteen Harnali ram lambs of comparable body weight were randomly divided into two groups of 8 each. They were housed in semi covered sheds. An adjustment period of fifteen days was given before the start of experiment. All the lambs were maintained on basal ration comprising green fodder, gram straw and concentrate mixture (Maize grain, groundnut

cake, barley, wheat bran, mineral mixture and common salt in the ratio of 15: 35: 20: 27: 2: 1). Experimental diets were differing only in terms of mineral mixture offered in the concentrate mixture. The mineral mixture of group G - I had Zn and Cu from inorganic sources ($ZnSO_4$ and $CuSO_4$) while zinc methionate and copper methionate served as source of Zn and Cu in mineral mixture of group - II. Feed ingredients used for ration formulation were evaluated for various proximate nutrients viz. dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and total ash (TA). Table 1 depicts the chemical composition of different feedstuffs used in preparing the experimental diets. Feeding trial lasted for a period of 180 days and lambs were fed as per ICAR (2013). Feed intake was calculated at weekly interval by subtracting residue from the offered amount of feed throughout the experiment. The lambs were weighed individually at fortnightly intervals before feeding and the body weights were recorded to calculate body weight gain up to 180 days of the experimental period. Feed conversion ratio (FCR) for each lamb was calculated as g DM consumed per g weight gain.

Table 1. Chemical composition of feeds offered to experimental lambs

Feeds	% CP	% EE	% CF	% Ash	% NFE	Cu (ppm)	Zn (ppm)
Gram straw	4.65	2.34	30.32	15.10	47.59	6.8	22.4
Berseem	17.6	4.12	22.4	12.3	43.4	4.5	18.8
Conc. Mix. (Group - I)	20.4	5.42	9.76	9.45	54.9	18.3	52.7
Conc. Mix. (Group - II)	20.4	5.34	9.68	9.68	54.8	18.5	52.9

At the end of the feeding trial, a metabolism trial of 5 days duration was conducted to evaluate the effect of organic zinc and copper on nutrients digestion and balance of nutrients. A preliminary period of 3 days was given for adaptation of the lambs to new system of housing and management, followed by a collection period of 5 days. The proximate composition of feeds and faecal samples was determined (AOAC, 2000). The availability of nitrogen was calculated by dividing the amount of retained nitrogen (ingested nitrogen - excreted

nitrogen) with the amount of ingested nitrogen. Similarly, Zn and Cu balance were also calculated.

For estimation of Zn and Cu, feed, faeces, urine and serum samples were digested with nitric and perchloric acid (4:1) mixture. The concentration of Zn and Cu in samples was estimated using Perkin Elmer Atomic Absorption Spectrometer (PinAAcle 900T). Blood samples were collected from lambs in non-heparinised tubes. Serum was separated by centrifugation at 3000 rpm for 15 minutes and stored at -20°C in aliquots for biochemical analysis. Serum

Zn and Cu were determined by auto analyzer using commercial kits. Data were analyzed statistically using general linear model procedure of statistical package for social sciences (SPSS) and comparison of means tested using Duncan's multiple range test (DMRT) and significance was considered at $P < 0.05$

(Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Feed intake and nutrients digestibility

The mean values of dry matter intake and nutrient digestibility are depicted in Table 2.

Table 2. Effect of feeding organic copper and zinc on feed intake, nutrients digestibility, nitrogen balance and mineral retention in Harnali lambs

Parameter	Group - I	Group - II
DM intake		
DM intake (g/d)	1434 ± 26.9	1483 ± 18.7
DM intake (% BW)	3.98 ± 0.16	3.84 ± 0.11
Digestibility of nutrients (%)		
Dry matter	65.3 ± 0.28	66.2 ± 0.32
Organic matter	66.7 ^b ± 0.36	68.5 ^a ± 0.27
Crude protein	67.6 ± 0.29	67.9 ± 0.58
Ether extract	72.1 ± 0.84	73.2 ± 1.02
Crude fibre	61.6 ^b ± 0.30	63.2 ^a ± 0.24
NFE	71.5 ± 0.32	71.5 ± 0.29
Nitrogen balance (g/d)		
N intake	36.2 ± 0.15	36.9 ± 0.15
Fecal N	11.8 ± 0.14	11.8 ± 0.08
Urinary N	6.97 ± 0.22	6.99 ± 0.16
N balance	17.4 ± 0.19	18.1 ± 0.18
% Retention	48.23	49.05
Zinc retention (mg/d)		
Zn intake	54.2 ± 0.31	54.5 ± 0.18
Fecal Zn	47.8 ± 0.20	46.4 ± 0.24
Urinary Zn	2.26 ± 0.18	2.27 ± 0.21
Zn retained	4.15 ^b ± 0.007	5.76 ^a ± 0.16
Absorption (%)	7.65 ^b ± 0.13	10.5 ^a ± 0.25
Serum Zn (ug/ml)	4.02 ^b ± 0.11	5.78 ^a ± 0.17
Copper retention (mg/d)		
Cu intake	17.5 ± 0.09	17.8 ± 0.11
Fecal Cu	15.4 ± 0.10	15.2 ± 0.04
Urinary Cu	0.99 ± 0.006	1.05 ± 0.04
Cu retained	1.12 ^b ± 0.04	1.53 ^a ± 0.03
Absorption (%)	6.37 ^b ± 0.20	8.57 ^a ± 0.17
Serum Cu (ug/ml)	1.10 ^b ± 0.04	1.46 ^a ± 0.04

^{a,b}Means bearing different superscripts in a row differ significantly ($P < 0.05$)

Total DM intake was 1434.1 and 1483.6 g/day in group-I and II, respectively and it did not vary significantly between the groups. DM intake as % of body weight was 3.98 and 3.84, respectively and it also did not vary significantly between the groups. Digestibility of dry matter was 65.38 and 66.28 % in group-I and II, respectively. No significant difference was observed in the digestibilities of dry matter, crude protein and ether extract between the groups supplemented with Zn and Cu either in the form of inorganic or organic sources. Contrary to present findings Wang et al. (2013) reported improved DM degradability after addition of Zn as organic source. Digestibility of organic matter and crude fibre was significantly ($P < 0.05$) higher in group-II. Garg et al. (2008) found that supplementation of 20 mg organic Zn/kg DM improved digestibility of ADF and cellulose significantly ($P < 0.05$). The improvement may be due to the positive role of organic Zn supplementation on fiber degradation. Similarly, Jia et al. (2008) found that ADF digestibility in Zn-Methionine group was significantly ($P < 0.05$) higher than other groups. Digestibility of crude protein, ether extract and NFE did not vary significantly between the two groups. The unchanged digestibility of DM and EE with Zn supplementation in the present study is in consistent with previous studies using steer (Mandal et al., 2007) and lambs (Garg et al., 2008) who found that DM and EE digestibility were comparable between groups fed organic or inorganic Zn sources. Contrarily, Maan and Sihag (2014) reported higher apparent digestibility of CP in dairy goats supplemented with Zn methionine (1 g/day) as compared with non-supplemented goats. Mallaki et al. (2015) reported that the digestibility of dry matter, organic matter and ether extract in lambs was not affected by the source of supplemented zinc, except that for crude protein and NDF digestibility's which were improved with organic Zn supplementation. Similarly Hassan et al. (2016)

reported that supplemented Zn methionine at dose (30 ppm/head/day) in growing buffalo calves increased significantly ($p < 0.05$) all nutrients digestibility as compared with control group. The average value of nitrogen intake, faecal N, urinary nitrogen and nitrogen retained are presented in Table 2. Results indicated that the differences in nitrogen intake were not significant between groups. Fecal-N as well as urinary-N value and N-balance did not vary significantly between the groups. Garget al. (2008) and Nagalakshmi and Himabindu (2013) also reported that nitrogen balance value was similar between lambs fed control diet and those supplemented with Zn methionine. Contrarily, improvement in nitrogen retained in Zn-Methionine group was reported by Nunnery (2002).

Growth performance

Intake of crude protein was 152.0 and 156.9g/day in group-I and II, respectively. Intake of TDN was 919.6 and 968.0 g/day in group - I and II, respectively and it was significantly higher in group-II fed organic sources of minerals. Results presented in Table 3 showed that the average body weight gain (BWG) was 110.2 and 124.6 g/day and it differed significantly ($P < 0.05$) between groups. Average daily gain (ADG) was significantly ($P < 0.05$) higher in Zn-methionine group than $ZnSO_4$ group. Diets supplemented with Zn-methionine improved the average daily gain of lambs by 13 % as compared with control group. These results are in agreement with Garg et al. (2008) and Puchala et al. (1999) who observed that the average daily gain was increased with supplemented Zn-methionine as compared to $ZnSO_4$. Contrarily, Jia et al. (2008) reported no difference between organic and inorganic sources of Zn. The same results were observed by Abdelrahman et al. (2003) who found no significant differences in the daily gain and feed conversion ratio between groups of lambs fed Zinc-methionine or ZnO.

Table 3. Effect of feeding organic copper and zinc on body weight, nutrients intake and economics of feeding in Harnali lambs under different dietary treatment groups

Parameter	Group - I	Group – II
Body weight changes		
Initial body weight (kg)	16.1 ± 0.35	16.2 ± 0.28
Final body weight (kg)	35.9 ± 0.29	38.6 ± 0.31
Body weight gain (g/day)	110 ^b ± 1.9	124 ^a ± 2.4
Nutrients intake (g/day)		
CP intake	152 ± 2.8	156 ± 3.1
TDN intake	919 ^b ± 12.4	968 ^a ± 10.3
Economics of feeding		
FCR (DMI/weight gain)	13.0	11.9

^{a,b}Means bearing different superscripts in a row differ significantly (P<0.05)

Feed efficiency in terms of kg DM/kg gain was 13.0 and 11.90 in group-I and II, respectively supplemental Zn-methionine improved significantly (P<0.05) feed conversion efficiency as compared with lambs fed ZnSO₄. The improvement in feed conversion of group fed Zn-methionine may be attributed to higher daily gain in this group. Results of our study are in contrary with those recorded by Nagalakshmi and Himabindu (2013), who found that source of Zn had no significant effect on weight gain and feed efficiency in lambs. Stobart et al. (1987) also did not observe any difference in live weight gain or feed efficiency between lambs fed zinc methionine and those fed control diet.

Minerals profile

Intake of zinc did not vary significantly in both the groups. Excretion of zinc in faeces was higher in group supplemented with inorganic source of Zn and Cu, however urinary Zn did not vary between the groups. Retention of zinc was 4.15 and 5.76 mg/day. Absorption of Zn (as % of intake) was 7.65 and 10.56 in group-I and group-II, respectively. Supplemental Zn-methionine improved absorption by 38 %. Serum Zn was significantly (P<0.05) higher in Zn-methionine (5.78) fed group as compared to ZnSO₄ (4.02) fed group. Garg et al. (2008) also showed that retention of Zn as well as its concentration in the serum was higher in Zn-methionine group, suggesting higher bioavailability

of Zn from Zn-methionine as compared to ZnSO₄. Similarly, Hassan et al. (2016) found that the level of serum Zn of buffalo calves was significantly increased (P<0.05) in Zn-methionine group as compared with Zn-sulphate. Spears (1989) explained the higher value of plasma Zn in a diet supplemented with Zn-methionine due to a slower release of Zn from the Zn-meth and resulted in increasing Zn absorption by preventing Zn from forming insoluble complexes in the digestive tract, besides facilitating Zn transport across the intestinal mucosa. Contrarily Ryan et al. (2002) did not find any difference in the plasma Zn concentration in adult sheep that were supplemented daily with 75 and 150 mg of Zn either as Bioplex Zn (chelated Zn) or inorganic Zn (ZnSO₄). Similarly Mandal et al. (2007) did not find any difference in serum Zn levels in cattle calves supplemented with 35 mg Zn/kg DM as ZnSO₄ or Zn-propionate.

Copper intake did not vary much between the groups. Faecal excretion was more in group-I while urine excretion was slightly higher in group-II. Retention of copper (mg/d) was 1.12 and 1.53 in group-I and II, respectively and it was significantly (P<0.05) higher in group-II. Supplemental Cu-methionine improved absorption by 34.5 %. Serum Cu was significantly (P<0.05) higher in Cu-methionine (1.46) fed group as compared to CuSO₄ (1.10) fed group.

CONCLUSION

Results of the study showed that organic source of Zn and Cu improved their respective absorption by 38 and 34.5%. Performance of Harnali lambs in terms of growth performance and FCR was better in group fed organic Zn and copper as compared to those given inorganic sources of these minerals.

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