J. Meat Sci. 2020, 15(1):45-49 Research Paper

Effect of Dietary Supplementation of Different Levels of Zinc on Feed Intake, Growth Performance, Carcass Characteristics and Physical Quality of Meat in Sheep

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ABSTRACT

An experiment was conducted in Deccani ram lambs to study the effect of supplementing different levels of zinc (Zn) in the diet on growth performance, feed intake, carcass characteristics and meat quality. Twenty-four weaned native Deccani ram lambs weighing around 12-15 kg were divided into four groups of six each. They were fed with adlib finely chopped maize straw and concentrate feed @ 1% of body weight for 120 days. Concentrate feed offered to different groups differed in the zinc content which was supplemented in the form of $ZnSO_4.7H_2O$. Group 1 was used as negative control where no mineral mixture was added in the concentrate mixture. In Group 2 (control), mineral mixture was used @ 2%. In group 3 and 4, in addition to mineral mixture, $ZnSO_4.7H_2O$ was added @ 70g and 140g per 100 kg concentrate mixture respectively. Feed intake and body weights of animals were recorded during the entire experimental period. After the feeding trial, animals were slaughtered to study the carcass characteristics and meat quality parameters. The results indicated that additional zinc supplementation did not show any effect ($P>0.05$) on feed intake or body weight gain between groups. Carcass characteristics were also similar ($P>0.05$) between the groups There was significant ($P<0.01$) decrease in shear force value with increased Zn level in the diet indicating that tenderness of meat was influenced by Zn supplementation in sheep diets.

Keywords: *Feed, Meat quality, Sheep, Zinc*

Received: 27/05/2020 Accepted: 21/08/2020

INTRODUCTION

Zinc (Zn) is an essential mineral that plays a vital role in many biological processes such as enzyme activity, cell membrane stabilization, gene expression, and cell signalling (Swain *et al*., 2016; Uniyal *et al*., 2017). Zinc is the only metal that appears in all six enzyme classes viz oxidoreductase, transferase, hydrolase, lyase, isomerase and ligase (Wapnir, 1990; Broadley *et al*., 2007). Zinc has role in the structure and activation of many enzyme systems, particularly for the synthesis of DNA, RNA and proteins. Deficiency of zinc reduces immune responses (Chesters, 1997; Keen and Gershwin, 1990) and also impairs the antioxidant defence system of the body (Miller *et al*., 1993). It is an essential trace element for normal animal performance, growth, milk production and nutrient digestibility in the rumen and is required for several metabolic functions. An adequate amount of zinc is essential for all the livestock and a deficiency may adversely affect their health and performance. A dietary deficiency of Zn has been associated with increased morbidity and mortality in animals (Kincaid *et al*., 1997). Zn supplementation is also assumed to influence the feed intake, growth performance and meat quality of different livestock and poultry. In the present study an experiment was conducted in growing ram lambs to study the effect of supra nutritional supplementation of zinc in the form of $ZnSO_4.7H_2O$ on the growth performance, carcass parameters and meat quality.

MATERIALS AND METHODS

Twenty-four weaned native Deccani ram lambs weighing around 12-15 kg were randomly divided into four groups with six animals per group in a completely randomized design. The animals were dewormed and vaccinated for EnteroToxemia (ET) before start of the experiment. Animals in all the groups were offered *ad lib* finely chopped maize straw along with concentrate feed @ 1% of the body weight to meet the nutrient requirements of growing sheep (ICAR, 1998). Concentrate feed offered to different groups differed in the zinc content which is supplemented in the form of $ZnSO_4.7H_2O$. Group 1 was used as negative control where

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DOI : 10.5958/2581-6616.2020.00007.9

no mineral mixture was added in the concentrate mixture. In Group 2 (control), mineral mixture was used @ 2% level of concentrate mixture. In group 3 and 4, in addition to mineral mixture, $ZnSO_4.7H_2O$ was added @ 70g and 140g per 100 kg concentrate feed respectively to maintain an incremental difference of around 150 to 160 ppm of Zn between the groups. Overall, the Zn contents in concentrate mixtures fed to different groups were 27, 183, 344 and 505 ppm respectively. Feeding trial was conducted for a period of 120 days. Body weights of animals were recorded at fortnightly intervals. At the end of the feeding trial, animals were slaughtered according to traditional Halal method to assess the carcass characteristics and meat quality parameters. Meat quality analysis was carried out with the Longissimus dorsi (LD) muscle of all the samples to assess the pH after slaughter, ultimate pH (i.e pH after 24 hrs), thaw loss, drip loss, cooking loss, and shear force value.

Table 1: Composition of concentrate mixtures

	Group 1	Group 2	Group 3	Group 4
Maize (%)	40	40	40	40
Rice Polish (%)	35	32	32	32
GNC (%)	24	25	25	25
Min mixture (%)	0	2	2	2
Salt (%)	1	1	1	1
Vit. mix (g/100 Kg)	25	25	25	25
$ZnSO_4.7H_2O$ (g/100kg)	0	0	70	140

***Drip loss and thaw loss*:** For measurement of drip loss, 50g each of meat samples 24 hours post mortem were cut perpendicular to the muscle fibres, placed in individual plastic bags and kept at 4^0C. After 24 hours, the samples were removed from the bags, dried on absorbent paper and reweighed. Amount of drip loss 48 hours post mortem was expressed as percentage decrease in the weight of the sample (Honikel, 1998). Thaw loss was measured as percentage decrease in the weight of frozen samples after they were thawed at 4^0C for 16 hours.

***Cook loss*:** Meat cubes were sealed in low-density polyethylene bags and cooked to an internal temperature of 72°C in a water bath maintained at 100°C. The weights of the samples were measured before and after cooking and cooking loss were expressed as percentage.

***Shear force*:** The cooked samples were chilled overnight at 4±1°C, equilibrated to room temperature and six cores of 1.25 cm diameter were taken per sample using a tissue borer with muscle fibres parallel to the direction of the borer. The WBSF of the cores were measured using Texturometer (Model H1KF, Tinius Olsen, Redhill, England) with V-shaped stainless steel blade (60° angle) and triangular hole in the middle. The cores were sheared perpendicular to the muscle fibre orientation with 75 Newton (N) load range and a crosshead speed set at 200 mm/min. The force required to shear the sample was recorded in Newton (N).

***Statistical analysis*:** The data obtained were analyzed by applying univariate GLM procedure of SPSS 17.0 for a completely randomized design with each animal in the group as a replicate and the level of Zn in the diet as a source of variation.

RESULTS AND DISCUSSIONS

The concentrate feeds offered to animal contained 27, 183, 344 and 504ppm of zinc in groups 1,2,3, and 4 respectively. The Zn content in the maize straw was 13 ppm. This resulted in an average intake of 8.64, 35.7, 62.48 and 89.7mg of zinc per animal per day in respective groups during the experimental period. For sheep, Zn requirements between 10 and 33 ppm were suggested for normal physiological functions, growth and wool production (Underwood and Suttle,1999) and the tolerance levels of zinc for sheep range between 750 and 1000ppm (NRC, 1985; Underwood and Suttle, 1999). In this study, the Zn levels supplied by different diets could comfortably meet the Zn requirements of animals and are far below the maximum tolerance levels.

Over the period of 120 days, the animals in different groups consumed an average of 490, 507.5, 510 and 513.75 g dry matter per day respectively. The slight increase in DMI with increase in Zn content of the diet was not statistically significant ($P>0.05$). The Average Daily Gain (ADG) in ram lambs was similar ($P>0.05$) between the groups and ranged between 39.53 and 46.83g (Table 2). Decani breed of sheep being a dual purpose breed which produces course wool, the growth performance and feed intake was in tune with the findings of Bharambe and Burte (2012) who reported an ADG of 22.5, 28.89 and 38.33 g per day under extensive, semi intensive and intensive systems of rearing with DMI of 573, 676 and 710 g/day respectively in Deccani sheep. Garg *et al.*, (2008) also did not find any difference in DMI when Zn was supplemented either in inorganic form (ZnSo4) or organic form (Zn-Methionine). Droke *et al.*, (1998) reported that zinc supplementation, either as ZnO or Zinc-Methionine, did not result ($P>0.05$) in improved growth in sheep. Similarly, Kessler *et al*. (2003); Henry *et al*. (1997); and Solaiman and Min (2019) also observed no effect of Zn supplementation on feed intake, growth performance or feed conversion efficiency. However, Alimohamady *et al*. (2019) reported an increase in feed intake and body weight gain in sheep when zinc was supplemented in the diet in organic form.

The dressing percentage, hot carcass weight, meat: bone ratio and meat: fat ratio were similar between the groups (P>0.05). The dressing percentage on live weight basis ranged between 47.71 and 51.97 and on empty body weight basis ranged from 55.79 to 57.94 in different groups (Table 3). Proximate composition of meat was also not affected by the supplemental zinc in the diet of lambs (Table 4).

Table 2: Weight gains and feed intake of animals in different groups

	Group 1	Group 2	Group 3	Group 4	SEM	P
Initial Wt. (Kg)	12.87	14.30	14.45	14.10	0.64	0.857
Final Wt. (Kg)	17.61	19.19	20.07	19.69	1.14	0.916
Average Daily Gain (g)	39.53	40.72	46.83	46.56	5.35	0.962
DMI (g/day)	490	507.5	510	513.75	9.61	0.45
Zn intake /day (mg)	8.64	35.07	62.48	89.7	5.53	0.00

Table 3: Carcass parameters

	Group 1	Group 2	Group 3	Group 4	SEM	P
Live Wt. at slaughter (Kg)	17.09	18.71	19.45	18.99	1.115	0.922
Empty B.Wt. (Kg)	14.60	16.01	16.89	17.03	0.962	0.844
Hot Carcass Wt. (Kg)	8.31	8.95	9.39	9.91	0.585	0.834
DP on Live Wt %	48.43	47.78	48.81	51.97	0.872	0.325
DP on Empty B.Wt. (%)	56.74	55.79	55.80	57.94	0.543	0.509
Meat:Bone Ratio	2.36	2.74	2.52	2.60	0.078	0.385
Meat:Fat Ratio	6.87	8.76	5.80	6.38	0.688	0.531

Table 4: Meat proximate composition

	Group 1	Group 2	Group 3	Group 4	SEM	P
Crude Protein %	19.85	18.83	20.07	19.45	0.54	0.902
Fat %	0.98	0.93	0.78	0.89	0.09	0.927
Total Ash %	0.89	0.95	0.93	1.08	0.04	0.245

Meat pH, ultimate pH, drip loss, thaw loss and cook loss were not affected (P>0.05) by the supplementation of zinc in the diets (Table 5). These observations were similar to the findings of Kessler *et al*., (2003) who reported that Zn supplementation in the diets did not show any influence on carcass characteristics or meat quality parameters. Shear force value of meat decreased (P< 0.01) as the Zn level in the diet increased indicating that tenderness of meat was influenced by zinc supplementation to the animals. Meat tenderness is affected by myofibril proteins and by the quantity and composition of the intramuscular connective tissue, size of muscle fibres, myogenesis and adipogenesis during growth of the animal as well as by the effect of the metalloproteinases of the matrix (MMPs) dependent on Zn. Metzincins are a group of zinc dependent proteases which are involved in regulation of many biological processes including muscle, adipose and connective tissue development. (Chavey *et al*., 2003; Purslow, 2005; Christensen and Purslow, 2016). The decrease in muscle shear force due to dietary supplementation of zinc was also reported by Rodríguez *et al*., (2019) in lambs, Liu *et al*., (2011) in poultry and Spears and Kegley (2002) in steers. Mortimer *et al*., (2014) opined that increased marbling due to zinc supplementation in lambs might be the cause of increase in tenderness. In contrast, Kessler *et al*., (2003); Salim *et al*., (2011); Qudsieh *et al*., (2018) did not find any effect of Zn supplementation on meat shear force value, while Koohmaraie (1990) reported increase in shear force of meat in animals supplemented with zinc indicating that further research is required in large sample sizes to evaluate the exact mechanism of action of zinc on meat tenderness.

Table 5: Meat quality parameters

	Group 1	Group 2	Group 3	Group 4	SEM	P
pH 45	6.48	6.55	6.57	6.45	0.04	0.896
Ultimate pH	5.56	5.52	5.63	5.43	0.03	0.139
Drip loss (%)	1.65	1.42	0.82	1.11	0.22	0.585
Thaw loss (%)	4.81	3.74	4.18	4.01	0.26	0.567
Cook loss (%)	34.02	34.59	36.33	34.96	0.88	0.887
Shear Force Value (N)	23.10	21.22	19.24	17.61	0.76	0.006

CONCLUSION

The present study found that supplementing lamb diets with additional inorganic zinc in the form of zinc sulphate (ZnSO4.7H2O) did not influence the feed intake or growth rate in deccani lambs. The carcass yields and meat quality parameters were also not affected by zinc supplementation. However, shear force value of meat decreased as the zinc content in the diets increased suggesting for further studies in large samples to understand the effect of zinc supplementation in sheep diets on tenderness of the meat.

COMPETING INTERESTS

The authors have no competing interests either technical, financial or personal between themselves or others that might bias the work

ETHICAL STATEMENT

Slaughtering of experimental sheep has been approved by Institute Research Committee of ICAR-National Research Centre on Meat, Hyderabad.

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