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Effect of Feeding Different Forms of Zinc on Growth Performance of Male Crossbred Calves

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ABSTRACT

The experiment was conducted to determine the effect of replacing inorganic zinc with lower level of organic and nano zinc on feed intake, growth performance, FCR and feeding economics of male growing calves. Fifteen male crossbred calves (75%HFX25% Kankrej, 2nd Generation, 93.4±3.19 kg; 8-10 months) were randomly allocated into three groups (n=5). These calves were fed with basal diet consisting of total mixed ration (TMR) having 50:50 roughage to concentrate ratio with 2 kg of green fodder (Hybrid Napier, cutting every 42-60 days). Along with basal diet experimental groups were provided with additional Zn sources *i.e.,* zinc sulphate (ZnSO4, @40 ppm) in T1, Zn-glycinate (@20 ppm) in T2 and nano ZnO (@10 ppm) in T3 at 50% and 25% level of inorganic Zn supplementation, respectively, for the period of 98 days. All the calves were weighed bi-weekly. Among the groups, dietary Zn supplementation did not affect the feed intake, average daily gain and FCR of the animals significantly (P>0.05) in all the groups receiving different sources and levels of zinc supplementation. Cost per kg weight gain was found to be lower in the nano ZnO supplemented group. It may be concluded that, supplementation of nano ZnO (@10 ppm), Zn-glycinate (@20 ppm) and ZnSO4 (@40 ppm) showed comparable (P>0.05) results on growing crossbred calves without any adverse effect.

KEYWORDS: Crossbred calves, Growth, Nano ZnO, TMR

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INTRODUCTION

Zn is also required for structural and functional integrity of more than 2000 transcription factors and 300 enzymes; hence, almost all metabolic pathways are in some way dependent on at least one Zn requiring protein (Ranasinghe et al., 2015). Zn is the only metal encountered in all 6 enzyme classes established by the International Union of Biochemistry (Vallee and Falchuk, 1993). The Zn can be supplemented through feed either in inorganic, organic or nano form. Bioavailability of inorganic sources of Zn is around 6-12% (Spears et al., 2004; Singh, 2018) results into excessive Zn excretion which causes environmental contamination (Pierce et al., 2005). Furthermore, high Zn supplementation may affect the balance of other trace elements in the body especially copper (Case and Carlson, 2002). Chelated minerals are bound to a chelating agent, which are typically organic compounds or amino acids which improves the absorption and prevents minerals from interacting with other compounds. Zn availability is higher in organic form compared to inorganic form (Schell and Kornegay, 1996; Cao et al., 2000; Mohanta, and Garg, 2014). In this scenario, finding an alternative source of Zn which can address Zn deficiency in animals is a challenging task.

Zn oxide nano particles are the specially prepared mineral salt having particle size of 1 to 100 nm which is used in various fields i.e. nutrition, biomedical fields, ceramic industries (Bunglavan et al., 2014; Abedini et al., 2018; Swain et al., 2016; Adegbeye et al., 2019). Feeding of Zn nanoparticles to livestock and poultry has produced encouraging responses on growth, production, reproduction and immunity. Considering this background and above facts, the present study was conducted on growing crossbred calves to evaluate the possible effects of the dietary supplementation with high-surface nano-ZnO at lower dosage, as an alternative to ZnSO4 (inorganic source) and Zn glycinate (organic source) on growth performance of crossbred calves.

MATERIAL AND METHODS

The experiment was conducted at Animal Nutrition Research Station (ANRS), College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand, Gujarat, India with the approval of Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), New Delhi. (Experiment No. 314/ANRS/2020-CPCSEA dated 31/07/2020). In completely randomised design fifteen male crossbred calves (75%HFX 25%Kankrej, 2nd Generation, average body weight of 93.4±3.19 kg, 8-10 months old) were divided into three treatment groups of five animals in each. Two kg of green fodder (Hybrid Napier, cutting every 42-60 days) along with total mixed ration (Table 1) having 50:50 roughage to concentrate ratio was provided (mineral mixture except any zinc source was added in TMR) as a basal diet to all the calves for 98 days of experimental period excluding the adaptation period and pre-experimental feeding of 21 days according to the nutrient requirements as per ICAR (2013) feeding standards. In addition, all these animals in respective groups were given toppings of various sources of Zn over the feed. Group T1 was provided with inorganic zinc (ZnSO4) @ 40 mg/kg DM, whereas, zinc glycinate as an organic source of Zn @ 20 mg/kg DM and nano ZnO @ 10 mg/kg DM as a nano form Zn was provided to treatment groups T2 and T3, respectively. Nano Zn was procured from Department of Nanotechnology, Anand Agricultural University, Anand – 388 110,Gujarat. It was produced in this lab with particle size of less than 100 nm. Thus, the level of Zn in T2 and T3 was adjusted to 50 and 25% level of T1, respectively. Animals were kept in well ventilated barn having individual feeding facilities. Fresh water was offered *ad libitum* twice daily to all the animals. Quantity of ration provided was adjusted individually on the basis of body weight changes recorded biweekly. Deworming of all the animals was carried out using broad spectrum anthelmintic, before initiation of the experiment.

Table 1. Ingredient's composition of TMR

Ingredients	Quantity (kg /100kg)
Jowar straw	50
Soybean meal	20
Maize	10
DORB	10
Molasses	9
Mineral mixture	1

The daily feed intake was recorded for each calf during the entire feeding trial by subtracting the left-over feed from feed offered to the animals at every 24 hours. Nutrients present in the feed were analyzed for proximate principles and Van Soest et al. (1991) analysis on regular intervals and the average values were presented in Table 2.

All the experimental calves were weighed and measured at bi-weekly interval in the morning before feeding and watering in order to assess the changes in body weight, average daily gain and body measurements of animals. The feed conversion ratio was calculated for all the animals by dividing the total nutrient intake of animals with weight gain attained by animals. Economics of feeding was also calculated from the records of daily feed consumption and by considering the procurement price of feeds and fodder used for feeding of experimental calves.

Table 2. Chemical composition of TMR and green fodder

Parameter (%)	TMR	Green Fodder
Moisture	11.8	77.8
Organic matter	87.9	80.2
Crude protein	12.0	10.0
Ether extract	2.20	1.23
Crude fibre	21.8	27.9
Nitrogen-free extract	51.9	39.8
Total ash	12.0	20.1
Neutral detergent fibre	51.2	67.8
Acid detergent fibre	26.3	39.5
Calcium	1.81	0.41
Phosphorus	0.47	0.13
Zinc (ppm)	58.6	40.5

Except moisture all the values are on dry matter basis, TMR, Total Mixed Ration

STATISTICAL ANALYSIS

The experimental data were subjected to one-way analysis of variance (ANOVA) as per the methods of Snedecor and Cochran (1994). The Completely Randomized Design was followed. Treatment means were compared using the standard error of the difference between means for significance (P<0.05).

RESULTS AND DISCUSSION

Chemical Composition of Feedstuffs

The proximate composition and fibre fraction of TMR and green fodder offered to experimental animals is given in the Table 2. CP composition of TMR and green fodder was 12.06 and 10.06%, respectively. Whereas, Zn content of both the feeds were 58.60 and 40.50 ppm.

Feed Intake of Animals

Data pertaining to the nutrient intake of three groups is given in Table 3.

Table 3. Nutrient intake in crossbred calves

Parameters	Treatments			SEM*
	T1	T2	T3	
DMI (kg/day)	4.69±0.27	4.67±0.25	4.78±0.23	0.09
DMI (%BW)	3.86±0.09	3.83±0.07	3.89±0.06	0.03
DMI (g/kg $BW^{0.75}$)	127.54±1.82	126.8±1.76	129.0±1.65	1.22
CPI (g/day)	520.6±16.54	516.8±16.83	531.1±17.90	11.31
CPI (g/100 kg BW)	427.7±5.26	424.3±4.65	431.2±4.52	3.93
CPI (g/kg $BW^{0.75}$)	14.1±0.14	14.04±0.17	14.3±0.16	0.14
DCP (g/day)	290.5±9.23	288.4±9.39	296.3±9.99	6.31
DCPI (g/100 kg BW)	238.7±2.94	236.7±2.59	240.6±2.52	2.19
DCPI (g/kg $BW^{0.75}$)	7.89±0.08	7.49±0.09	7.67±0.08	0.07
TDNI (kg/day)	2.59±0.08	2.57±0.08	2.64±0.09	0.05
TDNI (%BW)	2.13±0.03	2.11±0.02	2.14±0.02	0.03
TDNI (g/kg $BW^{0.75}$)	70.27±0.70	69.8±0.77	71.0±0.74	0.67

DMI, dry matter intake, CPI, crude protein intake, DCPI, digestible crude protein intake, TDNI, Total digestible nutrients intake, *Standard Error of Mean

It revealed that supplementation of various sources of zinc at different levels did not affect (P>0.05) the feed intake of male crossbred calves. Similar results were also reported by several authors such as Spears (1989), Wright and Spears (2004), Mandal et al. (2008), Cope et al. (2009), Dass et al. (2009), Gaafar et al. (2011) etc. who observed that supplementation of Zn did not affect the nutrient intake of animals. Nagalakshmi et al. (2017) replaced lower level of organic Zn with inorganic Zn supplementation and did not find any significant (P>0.05) effect on nutrients intake of buffalo calves. No significant effect was also reported by supplementation of reduced level of nano Zn sources compared to ZnSO4 and control by Mishra (2017) and Anil et al. (2017).

Growth performance and FCR

Results on growth performance showed that overall body weight gain (kg) and ADG (g) obtained during an experiment period of 98 days was comparable (P>0.05) among the groups along with numerical improvement in nano ZnO supplemented group (Table 4). Jadhav et al. (2008) documented that optimum level of Zn in feed is required for growth and reduced level of Zn in feed may negatively affect the growth performance and feed intake. No significant effect was reported by replacing ZnSO4 with 75% level of organic Zn (Nagalakshmi et al., 2017) and 25 and 50% level of nano Zn (Mishra, 2017) in growing buffalo calves. However, positive response was reported by Shakweer et al. (2010), Hassan et al. (2016), Anil et al. (2017) and Kumar et al. (2018) after Zn supplementation. This indicated that supplementing Zn-glycinate and nano ZnO at reduced level of 50 and 25% of ZnSO4 supplementation did not have any adverse effect on feed intake and growth performance of animals. This might be due to higher bioavailability of Zn from nano ZnO and Zn-glycinate compared to ZnSO4 which results in providing sufficient Zn for normal physiological functions.

The effect of various sources of Zn on FCR is given in Table 4 which indicated that minimum values of FCR on DM basis was obtained in T3 (5.60±0.18) followed by T2 (5.76±0.16) and T1 (5.78±0.21). This lower FCR was might be due to better growth attained by the animals of nano ZnO supplemented group. However, FCR obtained was statistically similar (P>0.05) among the groups. FCR on CP, DCP and TDN basis also followed the same trend as of FCR on DM basis without any significant (P>0.05) difference. These results were supported by Mandal et al. (2008), El Ashry et al. (2012) and

Table 4. Growth performance and FCR of male crossbred calves

Parameters	Treatments			SEM*
	T1	T2	T3	
Body Weight (kg)				
Initial BW	93.3±7.01	93.5±4.92	93.3±5.81	3.19
Final BW	172.8±9.71	172.8±7.97	176.9±7.62	4.56
Weight gain	79.4±3.28	79.3±3.92	83.6±2.62	3.32
ADG (g)	810.9±37.55	810.1±43.12	853.8±40.20	36.059
FCR				
DMI/kg BW gain	5.78±0.21	5.76±0.16	5.60±0.18	0.184
CPI/kg BW gain	0.64±0.02	0.64±0.02	0.62±0.02	0.021
DCPI/kg BW gain	0.36±0.01	0.34±0.01	0.33±0.01	0.012
TDNI/kg BW gain	3.19±0.11	3.18±0.09	3.08±0.10	0.102

ADG, average daily gain, DMI, dry matter intake, CPI, crude protein intake, DCPI, Digestible crude protein intake, TDNI, total digestible nutrients intake, *Standard Error of Mean

Nagalakshmi et al. (2017) with supplementation of organic Zn sources. Mishra (2017) also reported that replacing the inorganic zinc with lower level of nano zinc had no adverse effect on FCR of buffalo calves.

Initial and final body measurements were also found to be statistically similar (P>0.05) among the treatments (Table 5).

Table 5. Body Measurements (cm)

Parameters	Treatments			SEM*
	T1	T2	T3	
Initial HG	114.3±3.10	113.0±1.65	114.9±2.74	1.39
Final HG	130.4±3.59	130.6±1.29	128.3±2.71	1.47
Initial BL	100.3±2.21	97.50±3.10	99.1±3.07	1.54
Final BL	115.0±4.09	118.7±4.25	116.8±1.29	1.91
Initial HW	96.9±1.74	96.8±1.95	97.9±1.25	0.90
Final HW	110.6±2.85	109.7±1.46	111.5±1.88	1.16

HG, heart girth, BL, body length, HW, height to withers, * Standard Error of Mean

Similar to our results, Osorio et al. (2012) and Singh et al. (2018) also reported that supplementation of Zn did not affect the body measurements of growing calves. However, height at withers was recorded significantly higher (P<0.05) by Osorio et al. (2012) in the group kept on high plane of nutrition with trace minerals supplementation. This might be due to feeding of high plane of nutrients which may fasten the growth of animals.

Economics of feeding

Daily feed cost and cost per kg weight gain was found to be comparable (P>0.05) among the groups. It was found that in spite of the higher values for the overall feed cost and feed cost per day in the group T3, the values of the feed cost per weight gain was lowest in the group T3 compared to T1 and T2. This may be due to better bioavailability of nano ZnO which results in improvement in the weight gain in the group T3. Similar to our results, Shakweer et al. (2010), Hassan et al. (2016) and Anil et al. (2017) found that in spite of higher feed cost per day, lower feed cost per kg weight gain was obtained in the Zn supplemented groups. In animal feeding economics is very important as it constitutes major cost. In future, it is expected that prices of nano Zn will be down which will again helps to cut down the cost of feeding supplements. By this it is possible to heap more benefits in terms of body weight gain, production and reproduction by inclusion of low cost nano Zn in livestock feeding.

Table 6. Economics of feeding (in Rupees)

Parameters	Treatments			SEM*
	T1	T2	T3	
Overall cost of feeding	11301.51±661.19	11222.48±611.92	11530.25±568.44	330.59
Daily feed cost	115.32±6.75	114.52±6.24	117.66±5.80	62.76
Cost/kg BW gain	142.14±5.21	141.42±3.97	137.71±4.70	46.59

* Standard Error of Mean

CONCLUSIONS

From the results it was concluded that average daily DM intake along with CP, DCP and TDN intake, overall ADG, weight gain during an experiment, body measurements, FCR and economics of feeding remained similar between the three treatment groups. Therefore, supplementation of nano ZnO (@10 ppm), Zn-glycinate (@20 ppm) and ZnSO4 (@40 ppm) showed comparable (P>0.05) results in terms of nutrients intake, ADG, FCR and economics of feeding on growing crossbred calves without any adverse effect.

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