



Effect of dietary supplementation of organic and inorganic copper on growth and nutrient utilization in crossbred female calves

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ABSTRACT

Crossbred female calves (15), aged 12 to 15 months with average body weight of 134 kg, were randomly divided into 3 uniform groups of 5 each. All the calves were fed *ad lib.* green oats and measured quantity of concentrate mixture. The calves in group 2 were supplemented with 25 mg organic copper/calf/day as copper propionate and in group 3 were supplemented with 50 mg inorganic copper/calf/day as copper sulphate whereas calves in group 1 kept as control. The feeding trial lasted for 90 days, including six days digestion trial. The daily average DMI during entire feeding trial was 5.60 ± 0.05 , 5.68 ± 0.14 and 5.73 ± 0.04 kg in groups 1, 2 and 3, respectively and there was no significant difference in DMI among different groups. The digestibility of DM, OM, EE, NFE and NDF were significantly higher in group 3 than in group 1, and comparable with group 2. However digestibility of CF and ADF was significantly higher in group 3 than groups 1 and 2. The CP digestibility differed significantly among different groups. Total weight gain and FCR were significantly improved in groups 2 and 3 supplemented with copper as compared to control. From the present studies, it may be concluded that copper supplementation as copper sulphate or copper propionate in the ration of crossbred calves had better performance in terms of growth, nutrient utilization and feed efficiency under existing feeding.

Keywords: Crossbred calves, Growth, Inorganic copper, Nutrient utilization, Organic copper

Copper deficiency causes reduced appetite, growth and impairment of several metabolic enzyme activities. Commonly feeds and fodder fed to animals are deficient in copper (Sharma *et al.* 2009). The bioavailability of copper is also affected due to its sources (Gowda *et al.* 2004). Dietary supplementation of copper improved the growth and nutrient utilization performances of crossbred heifers (Saxena *et al.* 2010a) as well as blood copper status (Saxena *et al.* 2010b). Highly available copper supplements are needed to overcome deficiencies caused by naturally low concentrations in feeds and forages or deficiencies induced by elevated dietary Cu antagonists like Mo and S (Underwood and Suttle 1999). The dietary supplements of Cu-salts more than the requirement improved performance and nutrient utilizations in broiler chickens even with a high energy finisher diet and Cu-propionate showed better performance and nutrient utilizations compared to copper sulphate (Das *et al.* 2010).

The supplementation of copper through inorganic form had less bioavailability than the organic form, which may be due to physiological advantage afforded by organic Cu compounds which had unique coordination chemistry, formation of highly soluble, chemically stable products that resist digestion and interaction with antagonist in the guts (Brown and Zeringue 1994). Keeping this in view, the present study was conducted to assess the effect of supplementation of copper propionate (organic) and copper sulphate (inorganic) in crossbred female calves.

MATERIALS AND METHODS

Fifteen crossbred female calves aged 12 to 15 months with an average body weight of 134 kg, selected from the instructional dairy farm of university were divided into 3 uniform groups of 5 calves each on the basis of body weight and age. All the calves were fed *ad lib.* green oats as a source of roughage and allowance of concentrate mixture as per Kears (1982) requirements. Green oats and measured quantity of concentrate mixture were offered daily at 10 AM to all the calves. The calves in group 2 were given 50 g ground maize containing 25 mg of organic copper in the form copper propionate whereas in group 3 calves were given 50 g ground

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maize containing 50 mg of inorganic copper in the form of copper sulphate penta-hydrate along with concentrate mixture. The calves of group 1 (control group) were given 50 g ground maize only along with concentrate mixture without copper supplementation. All the calves were provided fresh clean drinking water *ad lib.* twice a day in morning and evening. The feeding trial lasted for 90 days. All the calves were housed in a well ventilated shed having concrete floor with individual feeding arrangements and tied with iron chain at such a distance that they had freedom for free movement but prevented them from getting access to the manger of other calves. Daily feed intake was recorded. The body weight of all the animals were recorded at fortnightly intervals for 2 consecutive days prior to feeding and watering in the morning, however all the calves were weighed for 3 consecutive days at the start and end of feeding trial. A digestion trial was also conducted for 6 days after 84 days of

feeding trial to know the nutrient utilization. During digestion trial the quantitative amount of feed offered, residue left and faeces voided were recorded daily. The representative samples of feed offered, residue left and faeces voided daily were collected and analyzed for proximate principles (AOAC 1995) and fibre fractions (Goering and Van Soest 1970) to determine the digestibility of different nutrients. The data obtained were analyzed statistically and subjected to test of significance as per methods described by Snedecor and Cochran (1994) by using GraphPad InStat (2003) software.

RESULTS AND DISCUSSION

The chemical composition of green oats and concentrate mixture are presented in Table 1. The average daily dry matter intake during feeding trial are given in Table 2, and during digestion trial in Table 3. There was no significant difference in daily dry matter intake among different groups of calves. The dry matter intake per 100 kg body weight and per kg metabolic body size during feeding trial and digestion trial were also similar in different groups. These results are in confirmation with the findings of Arthington (2005) who also did not find any significant difference in voluntary forage dry matter intake between Cu supplemented and non-supplemented groups of heifers over a 12 week period. However, in the first 2 week of the study, heifers provided no supplemental Cu had a lesser voluntary forage dry matter intake compared with heifers receiving copper through copper sulphate. On the contrary Hansen *et al.* (2008) reported more dry matter intake in Cu supplemented steers compared to control steers. Engle *et al.* (2000) reported increased feed intake in growing and finishing steers due to copper supplementation at levels as low as 10 ppm.

The average daily total digestible nutrient (TDN) intakes

Table 1. Chemical composition of feeding stuffs (% dry matter basis)

Nutrients	Feedstuffs	
	Green oats	Concentrate mixture
Dry matter	21.08	85.66
Organic matter	90.07	87.68
Crude protein	10.43	19.53
Ether extract	1.09	1.50
Crude fibre	35.80	11.90
Nitrogen-free extract	42.75	54.75
Ash	9.93	12.32
Neutral detergent fibre	61.30	39.20
Acid detergent fibre	45.50	16.80
Hemicelluloses	15.80	22.40

Table 2. Average daily dry matter intake and concentrate: roughage ratio in crossbred female calves fed ration supplemented with organic and inorganic copper during feeding trial of 90 days

Particulars	Groups /treatments			SEM±
	1	2	3	
Initial body weight (kg)	132.50±8.97	133.10±9.97	135.10±7.70	—
Final body weight (kg)	188.40±9.27	194.00±11.21	199.60±9.92	5.57
Total weight gain (kg) *	55.90 ^{ab} ±1.32	60.90 ^{ab} ±1.57	64.50 ^a ±3.06	1.47
Body weight gain (kg/day)*	0.62 ^b ±0.01	0.68 ^{ab} ±0.02	0.72 ^a ±0.03	0.02
Feed conversion ratio (kg DM consumed/kg weight gain)**	9.04 ^b ±0.16	8.40 ^a ±0.12	8.13 ^a ±0.08	0.15
Feed efficiency**	0.11 ^b ±0.003	0.12 ^{ab} ±0.002	0.13 ^a ±0.002	0.002
Average body weight (kg)	160.40±9.02	163.60±10.60	167.30±8.77	5.14
Roughage DM intake (kg)	3.62±0.03	3.66±0.07	3.64±0.03	0.03
Concentrate DM intake (kg)*	1.97 ^b ±0.02	2.02 ^{ab} ±0.04	2.08 ^a ±0.02	0.03
Total DMI (kg)	5.60±0.05	5.68±0.14	5.73±0.04	0.05
DM intake/100kg BW (kg)	3.53±0.19	3.51±0.14	3.45±0.14	0.08
DM intake/kg W ^{0.75} (g)	125.40±5.81	125.00±3.19	124.00±3.98	2.39
Concentrate : roughage ratio*	1:1.84±0.02	1:1.82 ^{ab} ±0.03	1:1.75 ^b ±0.01	0.02

^{ab} values bearing different superscripts in a row differ significantly from each other, *P<0.05, **P<0.01.

Table 3. Average daily nutrients intake and concentrate: roughage ratio in crossbred female calves fed ration supplemented with organic and inorganic copper during digestion trial

Particulars	Groups /treatments			SEM±
	1	2	3	
Average BW (kg)	177.70±4.61	186.40±11.79	186.70±6.72	—
Roughage DM intake (kg)	3.98±0.08	3.97±0.24	4.00±0.06	0.08
Concentrate DM intake (kg)*	2.02 ^b ±0.04	2.06 ^{ab} ±0.05	2.16 ^a ±0.04	0.04
Total DM intake (kg)	6.00±0.12	6.02±0.31	6.17±0.08	0.11
DM intake/100kg BW (kg)	3.40±0.01	3.25±0.09	3.31±0.07	0.04
DM intake/ kg W ^{0.75} (g)	123.28±0.65	119.61±2.89	122.30±1.99	1.18
Concentrate : roughage ratio**	1:1.97 ^a ±0.03	1:1.93 ^{ab} ±0.02	1:1.85 ^b ±0.02	0.03
TDN intake (kg)	3.39±0.13	3.57±0.17	3.77±0.09	0.09
TDN intake/100kg body weight (kg)	1.90±0.09	1.92±0.13	2.02±0.13	0.03
TDN intake/kg W ^{0.75} (g)*	69.47 ^b ±1.61	70.77 ^{ab} ±2.16	74.56 ^a ±1.86	1.16
DCP intake(kg)*	0.52 ^b ±0.03	0.57 ^{ab} ±0.02	0.61 ^a ±0.02	0.02
DCP intake/100kg BW (g)*	290.20 ^b ±9.19	308.30 ^{ab} ±7.26	326.50 ^a ±8.44	7.11
DCP intake/kg W ^{0.75} (g)*	10.59 ^b ±0.36	11.36 ^{ab} ±0.25	12.04 ^a ±0.25	0.27

^{ab} Values bearing different superscripts in a row differ significantly from each other, *P<0.05;**P<0.01.

Table 4. Average digestibility coefficient (%) of nutrients in crossbred female calves-fed-ration supplemented with organic and inorganic copper during digestion trial

Particulars	Groups /treatments			SEM±
	1	2	3	
Dry matter*	60.11 ^b ±1.41	61.67 ^{ab} ±0.93	64.99 ^a ±0.79	0.79
Organic matter*	63.64 ^b ±1.31	65.33 ^{ab} ±0.81	67.90 ^a ±0.95	0.73
Crude protein**	63.67 ^c ±1.76	70.75 ^b ±0.89	75.21 ^a ±0.28	1.41
Ether extract**	48.50 ^b ±2.03	61.55 ^a ±2.51	67.85 ^a ±2.53	2.49
Crude fibre*	58.33 ^{ab} ±1.83	56.80 ^b ±1.39	63.15 ^a ±0.57	1.03
Nitrogen- free extract*	65.24 ^b ±1.13	69.00 ^a ±0.96	69.28 ^a ±0.69	0.69
Neutral detergent fibre*	51.15 ^b ±0.68	54.30 ^{ab} ±0.48	57.20 ^a ±1.71	0.88
Acid detergent fibre**	46.71 ^b ±1.23	48.13 ^b ±0.35	56.17 ^a ±1.01	1.22
Hemicellulose	54.89±5.55	63.64±4.13	61.50±3.38	2.57

^{abc} Values bearing different superscripts in a row differ significantly from each other, *P<0.05;**P<0.01.

in groups 1, 2 and 3 did not differ significantly among 3 treatment groups (Table 3) but numerically higher intake in groups 2 and 3 than in group 1. However, TDN intake/kg W^{0.75} was significantly (P<0.05) higher in group 3 supplemented with inorganic copper than in group 1 (control). However, Mondal and Biswas (2007) reported higher TDN intake with the increased dose of Cu either from copper sulphate or copper propionate.

The average daily digestible crude protein (DCP) intake and per 100 kg body weight were significantly (P<0.05) higher in group 3 supplemented with inorganic copper than in control group however DCP intake did not differ between groups 1 and 2 and groups 2 and 3 (Table 3). Similar trends were also observed in DCP intake per kg metabolic body size. No effect on intakes of crude protein and organic matter were reported due to source of copper i.e copper sulphate vs. copper propionate (Dutta *et al.* 2007).

Digestibility coefficient of different nutrients and fibre fractions are presented in Table 4. There was significantly (P<0.05) higher digestibility in group 3 supplemented with copper sulphate (inorganic copper) as compared to group 1 (without copper supplementation) for DM, OM, CP, EE, NFE, NDF and ADF. Further calves of group 2 provided organic copper as copper propionate also had similar digestibility with group 1 for DM, OM, CF, NDF and ADF and group 3 for DM, OM, EE, NFE and NDF. Numerically, calves in group 2 and 3 had higher digestibility than in group 1 for CP, EE and NFE. There was significant difference in the digestibility for CP, CF and ADF between group 2 and 3. Crude fibre digestibility in calves of group 3 was significantly (P<0.05) higher than in calves of group 2. Overall digestibility of nutrients was higher in copper supplemented groups as compared to control group. Similar findings were reported by Mondal and Biswas (2007) and observed that

supplemental dose of Cu linearly improved digestibilities of DM, OM, EE and NFE and nutrient utilization were more pronounced with copper propionate than CuSO_4 supplementation. The improvement in digestibility of dry matter, crude fibre and organic matter was also observed by Dutta *et al.* (2007) with different dose of Cu supplementation. In the present study significant ($P < 0.01$) improvement in ether extract digestibility in groups 2 and 3 supplemented with organic and inorganic copper, respectively, which may be due to higher lipase and phospholipase-A activity, an important function of Cu (Dove 1995). Ho and Elliot (1974) suggested that Cu enhances the specific activities of fatty acyl desaturase system, thus altering the composition of fat depot. The improved fat digestibility resulting from Cu supplementation could lead to the increased absorption of fatty acids and fat soluble vitamins and affects the other aspects of nutrient metabolism in the body and therefore stimulate growth. However, Arthington (2005) reported that supplementation of copper over the above requirement via Cu oxide bolus had reduced apparent digestibility of forage NDF and CP. This response may be related to subclinical Cu toxicity associated with the Cu oxide bolus. On the other hand Lopez-Guisa and Satter (1992) found that the digestibility of low quality forages was increased with the addition of a supplemental blend of Cu and Co at concentrations greater than NRC (1989) recommendations (12.22 and 0.25 ppm of Cu and Co, respectively). Mondal *et al.* (2004) reported that digestibility of nutrients, N retention and nutritive value were improved significantly ($P < 0.05$) when the diet was supplemented with Cu-propionate rather than CuSO_4 as compared to those fed basal diet in Black Bengal kids. Supplementation of minerals in organic form like proteinates of copper, zinc and manganese at a rate 50% less than NRC (2001) recommendation with 150 ppm phytase than inorganic trace minerals supplementation increases intake and digestibility of nutrients in cows (Biswas and Biswas 2009).

The total body weight gain and feed efficiency in groups 1, 2 and 3 are given in Table 2. The calves supplemented with copper as copper sulphate (group 3) had significantly ($P < 0.05$) higher body weight gain as compared to group 1, whereas calves in group 2, supplemented with copper propionate had nonsignificantly higher body weight gain as compared to group 1, but it was statistically similar with group 3. This could be due to the fact that in group 2 the dose of copper supplementation was half (25 mg/day/calf) of group 3 (50 mg/day/calf). Similar trend was also observed for feed efficiency. Ward and Spears (1997) reported that Cu supplementation at 5 mg/kg DM to a high-concentrate diet (basal diet contained 3 mg Cu/kg DM) for 49 d increased ($P < 0.08$) average daily gain in body weight and gain: feed ratio during the finishing period relative to that of unsupplemented steers. Zhou *et al.* (1994) reported that Cu given either intravenous or oral increases serum mitogenic

activity (mitogenic peptides, an indicator of blood growth factor activity) in weanling pigs and numerically increased pituitary growth hormone and mRNA concentration. Hansen *et al.* (2008) also found improvement in average daily gain and feed conversion efficiency in steers by Cu supplementation regardless of source as compared to control. In contrary, Cu supplementation to growing and finishing steers at 20 or 40 mg Cu/kg DM from different Cu sources (organic and inorganic) reduced ($P < 0.05$) average daily body weight gain, feed intake and gain: feed ratio (Engle and Spears 2000). However, reason for these conflicting results on performance in cattle consuming high-concentrate diets supplemented with Cu is unclear.

In the present study, copper supplemented calves had better performance in terms of growth and nutrient utilization than control group. It is suggested that under the existing feeding system, supplements of copper either organic or inorganic is inevitable for improving the growth and nutrient utilizations.

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