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Organic and Inorganic Cu Sailts Utilization in Fattening Goats

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Abstract
A 90-day nutritional balance trial was conducted, with 12 West Africa Dwarf goats weighing between 12.3 and 12.8kg. The animals were grouped into 4 dietary treatments of 3 goats per group, using copper salts-Cu proteinate, CuSO4, $CuNO_3$ as test ingredients, applied at 100g/50kg feed. The experiment assessed the effects of the different Cu salts when compared with control on Cu bioavailability, average daily gain (ADG), dry matter intake (DMI), water consumption, heart and liver weights, faecal Cu, glucose and protein concentration, PCV,RBC,WBC, and Hb. Each of the 4 groups was randomly assigned to a Cu salt - based diet while the control (T1) had no Cu salt inclusion. Results indicate that all the salts - treated goats exhibited significantly (P<0.05) higher performances than the control group in all parameters considered. Copper proteinate significantly (P<0.05) induced the highest dry matter intake (0.306kg/d),ADG(0.046kg/W $^{0.75}$ kg),highest Cu bioavailability in the serum(119.7mg/l) and optimum FCR(1.12).Cu proteinate seems to induce better responses in the goats than other Cu salts. Cu proteinate can be suggested as a salt of choice in case of Cu deficiency, depletion or anaemia condition in goats. About 100g Cu proteinate /50kg feed is therefore recommended in the diet of growing WAD goats.
Keywords: Bioavailability, Cu proteinate, Haematological and Serological parameters.

INTRODUCTION

Ruminant farmers in the tropics make use of the natural grazing and agricultural by – products that are available and try to feed their animals as best as they can. In the tropics, ILCA (1983) observed that, native rangelands though provide the cheapest source of nutrients for ruminants, for a greater part of the year, grassland do not supply sufficient minerals and other nutrients to stock for greater productivity. Minerals likely to be highly involved are Mg and Cu (McDowell *et al*., 1977).

The Important roles of Cu in nutrition is well documented. Some deficiency symptoms have been identified, however excessive amounts have also been associated with deleterious effects. In view of this, scientists have recognized the need for the inclusion of certain recommended levels of either organic or inorganic Cu salts in animal diets to improve performances. From literature, similar to many organic minerals, Cu from Cu proteinates is more readily available to livestock than their inorganic counparts. However, there are conflicting reports regarding their advantages compared with $CuSO_4$, $CuNO_3$ and other Cu salts (Vandergrift, 1991).

This study aimed to estimate the relative bioavailability of Cu in the blood from three different Cu salts - (i) $CuSO_4$, (ii) $CuNO_3$ and (iii) Cu proteinate, their effects on fattening of goats, dry matter intake, water consumption, feed conversion ratio and average daily gain as well as assessing the haematological parameters-PCV, Hb, RBC, WBC, total serum protein

Materials and Method

The study was conducted in The Small Ruminant Section of the Animal Science Department, Teaching and Research Farm of Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. (06o 'N-01033'W), altitude 261.4m above sea level (Addo-Fordjour et al.,2007)Twelve WAD Billy goats were used for 90 days nutritional studies excluding 10 days adjustment period to the experimental diets. The animals initial weights (12.3-12.8kg) were taken, isolated for 8 weeks when they were given prophylactic treatment of terramycine and perperazin against bacterial infection and worm infestation. Animals were treated against ectoparasites, vaccinated against PPR, were maintained on dry cassava peels, pito mash, occasional supply of guinea grass for 8 weeks and offered water *ad lib*. At the end of 8 weeks adjustment period to the environmental periob, 10 millimeters of blood samples was collected from each goat through a jugular vein puncture (Sawati and Dagash, 1994). 5mls of each blood sample was used to estimate PCV, RBC, WBC, Hb of each animal. The remaining 5mls left to stay overnight, the serum harvested to determine Cu concentration, glucose and protein levels. Goats were thereafter transferred into metabolic cages for 3days to collect faecal samples before dietary treatment. Faecal samples collected from one animal/replicate treatment were mixed together, oven dried and milled to determine the Cu level in each sample. The animals were grouped into four dietary treatments of 3 goats/group and allocated to individual goat per pen for the experimental period.

Complete randomized design (CRD) was used and data analyzed as (CRD)

Dietary treatment

The experimental diets were made up of pito mash, wheat bran, palm kernel cake and different copper salts (Table1).

Table 1 composition of experimental diets (kg)

INGREDIENTS	T_1 CONTROL)	T2COPPER PROTEINATE-BASED)	T_3 (COPPER NITRATE-BASED)	T_4 COPPER SULPHATE-BASED
Pito mash	12.5	12.5	12.5	12.5
Wheat bran	25.0	24.9	24.9	24.9
Palm kernel cake	12.5	12.5	12.5	12.5
Copper salt	00	0.1	0.1	0.1
	50.0	50.0	50.0	50.0

Table 2 Proximate and Chemical Analysis of Palm Kernel Cake, Wheat bran and Pito mash

Composition	Palm kernel cake	Wheat bran	Pito mash
Protein (%)	13.79	15.54	24.29
Fiber (%)	18.90	9.95	8.90
Ether extract (%)	9.70	11.0	15.85
Cu cont. (mg/kg)	12.95	ND	5.41

ND – Not Detected

The results of the proximate analysis and chemical composition of each ingredient of the experimental diet indicate that, each of them contains adequate amounts of those nutrients to serve as concentrate supplements for goats (NRC, 2001). The high crude protein content of pito mash could make it a better feed ingredient for non-ruminants.

The recommended dietary concentration of Cu for goats is 10 – 15mg/kg dietary DM for goats (GFE, 2003). The Cu content in palm kernel cake and pito mash fall within the recommended levels. This implies that the experimental diet could meet the requirement for Cu in goats.

Data collection

Body weights were taken every fortnight after withdrawing of feed only for 16 hours after the initial body weights have been taken. Blood samples were collected for the determination of the haematological and serological parameters. Faecal samples were collected prior to the commencement of the dietary treatments and 10 weeks after the animals have been on the experimental diets. These were oven dried at 65 ^{0}C to constant weight, milled and stored for subsequent analysis. The quantity of feed and water supplied each day were recorded. The leftovers were subtracted from supply to record the feed intake and water consumed. Feed Conversion Ratio (FCR), Average Daily Gain (ADG) and dry matter intake (DMI), were computed. One goat from each group was randomly picked, stunned and slaughtered. Liver and heart organs removed, weighed and oven dried at 65^{0}C to constant weight milled and the Cu content determined.

Results and Discussion

Table 2. Record of performance of experimental goats

PARAMETERS	T_1	T_2	T_3	T_4	SEM	Level of significance
Mean initial body weight(kg	12.3	12.5	12.8	12.5	3.71	NS
Mean final body weight (kg)	12.9	16.2	15.4	15.3	3.78	NS
Body weight change (kg)	0.6^c	3.7^a	2.6^b	2.8^b	1.33	**
Average daily gain(g)	6^c	41^a	29^b	31^b	0.2	*
Feed intake (kg)	0.131^c	0.306^a	0.264^b	0.267^b	0.0001	*
DMI(Kg/W0.75Kg)	0.020^c	0.046^a	0.039^b	0.040^b	0.0001	*
FCR	3.83^c	1.12^a	1.85^b	1.29^b	1.62	*
Average water intake (litre/day)	1.41	1.49	1.18	1.69	0.015	NS
Weight of heart (g)	80	60	58	55	--	--
Weight of liver (g)	270	250	235	200	--	--
Initial faecal Cu (mg/kg)	46.57	32.82	33.02	38.94	0.64	NS
Final faecal Cu (mg/kg)	42.41^c	588.02^b	728.91^a	788.26^a	23.4	*
Heart Cu (mg/kg)	7.10	16.73	51.13	45.47	--	--
Liver Cu (mg/kg)	354.30	647.68	677.36	834.16	--	--

a,b,c, means within the same row bearing different superscripts are significantly different (* P< 0.05; **P< 0.01), NS = Not significant. SME. = Standard Error of the mean .NS = Not significant

Table3. Haematological responses of the experimental goats to dietary treatments.

PARAMETERS	T1	T2	T3	T4	SEM	SIGN.
Initial PCV (%)	26.67	29.67	33.67	30.33	2.49	NS
Final PCV (%)	31.7	37.7	36.3	35.3	0.019	NS
Initial RBC(10^{12}/l)	8.33	8.53	9.00	9.00	0.104	NS
Final RBC(10^{12}/l)	8.67	8.83	7.57	9.23	0.755	NS
Initial WBC(10^{9}/l)	5.37^{b}	9.10^{a}	7.80^{a}	5.93^{b}	1.04	**
Final WBC(10^{9}/l)	13.4	10.4	10.9	8.9	2.49	NS
Initial Hb(g/dl)	8.0	8.0	9.1	8.9	0.46	NS
Final Hb (g/dl)	9.8	10.7	9.3	11.4	1.66	NS

a,b,c, means within the same row bearing different superscripts are significantly different (* P< 0.05; **P< 0.01), NS = Not significant. SEM =Standard Error of mean.

Table 4. Serologigal responses of the experimental goats to dietary treatments.

PARAMETERS	T_1	T_2	T_3	T_4	SEM	SIGN
Initial serum Cu (mg/l)	9.63	9.39	6.89	8.24	1.09	NS
Final serum Cu (mg/l)	73.00^{c}	119.17^{a}	80.3^{b}	91.17^{b}	5.42	*
Initial serum glucose (%)	10.4	12.2	13.8	10.8	0.61	NS
Final serum glucose (%)	1.0^{b}	10.3^{a}	7.8^{a}	10.7^{a}	3.63	**
Initial serum protein (mg/l)	0.0399	0.0339	0.0549	0.0215	0.0002	NS
Final serum protein (%)	0.0078	0.0158	0.0106	0.0138	0.00002	NS
Dietary Cu conc.(mg/kg)	2.30	26.30	27.60	22.21	--	--
Cu intake (mg/kg)	0.012	0.392	0.332	0.272		
Apparent Cu retention (mg/kg)	2	9.56	11.45	8.77	--	--

a,b,c, means within the same row bearing different superscripts are significantly different
SEM =Standard Error of mean.

DMI, FCR and ADG were significantly (P<0.05) higher in the Cu treated group than the control. Implying that Cu salt inclusion in the diets encouraged improved performance (Tab.2).This agrees with Witttenberg *et al.* (1990) who observed that steers fed on Cu proteinate inclusion diet recorded a higher weight gain, as a results of Cu based diets which might have provided the ideal rumen Cu concentration to enhance rumination. The faster growth rate of Cu supplemented animals might be due to improved feed utilization rather than feed consumption. Feed consumption among Cu- treated group seemed to show similar even though, growth performance differed. Significant (P<0.05) improvement in DMI and FCR, which eventually improved ADG in goats offered Cu salts-based diets.

Copper proteinate salt-based diet was the most efficiently utilized. This could be due to more readily released Cu in proteinate for efficient physiological and metabolic activities. The lowest DMI and ADG (0.020kg $W^{0.75}$ kg, 0.006kg respectively) of the control resulted in the poorest FCR (3.85), indicating that Cu source inclusion in the diet of goat is important. This could be due to low Cu content in the diet or the Cu might have been in form that could not be made available to the goats.

The heart weights in relation to the heart Cu content showed no regular trend. The control which recorded the least heart Cu content (7.10mg/kg) registered the heaviest heart weight. Among the Cu – treated groups,Cu proteinate though showed the least heart Cu deposit (16.73mg/kg), promoted the heaviest heart weight (60g) followed by $CuNO_3$ (58g) and $CuSO_4$ (55g) respectively. Heart Cu content for $CuNO_3$ (51.13mg/kg) was higher than that of $CuSO_4$ (45.47mg/kg).The liver weight varied in trend, with the control showing the highest liver weight (270g) followed by Cu proteinate (250g), $CuNO_3$ (235g) and $CuSO_4$ (200g), respectively. The decreased liver weights from 270-200g might have been due to increased liver Cu concentration from 354.30-834.16mg/kg.These results agree with Georgievskii *et al.*(1982) who indicated that Cu supplementation of 4 groups of fowls resulted in increased liver Cu content from 14.3-395.2mg/kg with corresponding decreased in liver weight 100-70g).

The packed cell volume (PCV) (26-37.7%) and Hb (8.0-11.4/l) compared favourably with recommended values for healthy goats (Heath and Olusanya, 1988, 1999).The goats were neither anaemic nor suffered any physiological disorders. Final haematological parameters except RBC showed an improvement over the values before the experiment. This could be attributed to the Cu inclusion in the diets,since Cu is noted for facilitating Fe absorption and release from storage organs into the blood for its normal utilization (Brander *et al.*,1991; Campbell *et al.*, 20003). The PCV, Hb after the experiment were consistently higher than before, suggesting an inherent positive correlation between them.

The Copper- proteinate treated goats recorded the highest Cu serum availability (119.17mg/l: Tab.4). This could

be attributed to the advantages Cu proteinate was perceived to have over the inorganic copper salts - $CuSO_4$ and $CuNO_3$ (Mills and Henry, 1999).This could have accounted for Cu proteinate promoting the optimal feed conversion that induced the highest growth rate. The $CuSO_4$-based diet showed better performance, than $CuNO_3$ based diet. This agrees with Jongboed *et al.* (2002) that, CuSO4 inclusion in the diet of goats made more Cu available than other inorganic Cu salts. The increased RBC and other haematological parameters showed that the goats never suffered from any form of anaemia. And that the concentration of Cu in the diets was adequate enough to maintain normal physiological and haematological functions in the treated goats.
Copper deposit were higher in liver than heart (Tab. 3), because the main target organ for Cu deposit is the liver (Davis and Mertz, 1987). The $CuSO_4$ and $CuNO_3$ fed goats recorded a higher liver Cu deposit than Cu proteinate fed goats, but Cu proteinate inclusion released more Cu in serum. The results agree with Eckert et al. (1999) report that ewes fed with increasing levels of Cu from $CuSO_4$ deposited more Cu in the liver than ewes fed with Cu proteinate. The Cu from Cu – proteinate resulted in greater ceruloplasmic activity than from $Cuso_4$. The liver and heart Cu deposits were lower in the control group. This could be due to the fact that, Cu deposit in these organs are related to dietary Cu intake, so low feed intake and naturally low Cu availability for most ingredients might have accounted for that.
Significant ($P< 0.05$) faecal output was observed in all Cusalt- treated goats, while Cu-protienate inclusion diet recorded the least. This could suggest more efficient utilization of the serum Cu for physiological and metabolic activities in Cu-protienate-treated goats hence decreased loss of Cu through faecal output. High faecal Cu output by $CuSO_4$ and $CuNO_3$ based diets (788.26 and 728.9mg/kg, respectively) as against their corresponding low availability of serum Cu (91.17 and 80.3mg/l respectively), might be due to an interactions of Cu with S and or other minerals or compounds which did not make Cu available for utilization. This seems to agree with Shuttle (1974) that dietary S can reduce Cu bioavailability by 30-35%.This unavailable Cu to ruminants and be lost through excretory pathway. Expected higher S content in $CuSO_4$ –based diet as against $CuNO_3$-inclusion diet might have influenced the S-Cu interaction hence higher faecal Cu deposit in $CuSO_4$ than $CuNO_3$. High faecal Cu output confirms Aoyagi et *al.* (1995) record that the bile is the major pathway for Cu excretion.

CONCLUSION

The study suggested that copper in copper proteinate is readily released for utilization by the experimental goats than the other types of all salts. Whereas in other salts (nitrate and sulphate copper could have been bonded to other radicals or some chemical components of the basal diet, as such copper was not readily released as compared to the proteinate. This might have contributed to large deposits of copper in the faeces, which invariably were loss to the animals.

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