EFFECT OF DIETARY COPPER SUPPLEMENTATION ON SERUM COPPER LEVEL AND PERFORMANCE OF FEMALE WEST AFRICAN DWARF (*Fouta djallon*) GOATS

A.B.J. AINA,* AND A.O. AKINSOYINU

Department of Animal Science, University of Ibadan, Ibadan, Nigeria

Received 7 December, 1994; Accepted 29 December, 1995

ABSTRACT

The effects of dietary copper supplementation on serum copper level and performance were studied in a 174-day feeding experiment involving 16 female West African dwarf goats using depletion - repletion approach. The results obtained showed a significantly lower ($P < 0.05$) but traces of serum copper after depletion combined with predepletion (1.70 to 1.90 Ug/dl serum) and after 42 days of dietary repletion (1.28 to 2.50 Ug/dl serum). The best responses in terms of growth rate (0.114 kg/day) highest dry matter intake ($0.046 \text{ kg/W}^{0.75}$) and dietary copper intake (1.43 Ug/g feed DM) were induced by 240.68 Ug Cu/g DM of feed. The maintenance requirement for copper was 5.033 UgCu/W^{0.75} while the dietary copper supplementation requirement was 240.68 Ug Cu/g DM of feed for optimum weight gain, growth rate and dry matter intake.

Key words: dietary copper, serum copper, performance, goats.

INTRODUCTION

Blood cells contain copper (Cu) but the content of the red blood cell is constant while that of the serum is highly variable, about 90 Ug/dl (Harper, 1975). Maro and Kategile (1980) observed an elevation in blood Cu from 0.26 to 0.91 mg/l in sheep and goats fed 50mg dietary Cu as EDTA salt over a 5-month period. Copper has been recognised as dietary essential in ruminant nutrition and is indispensable in the formation of haemoglobin (Underwood, 1971). Experimental animals on a Cu - deficient diet could lose weight and diet (Poole, 1970).

There is however, some paucity of information on Cu utilization by goats in general and West African dwarf (WAD) goats in particular. This experiment therefore examines the effects of dietary Cu supplementation on serum Cu level and performance of female WAD goats using Cu depletion and repletion method. It is believed that the result would contribute to the existing knowledge on nutrient requirements of goats.

MATERIALS AND METHODS

Animals and their management

The experiment was conducted with 16 female WAD goats, aged 6 to 12 months and weighing 6 to 12 kg. The goats were managed for 3 months on the University of Ibadan farm's standard diets before the experiment. They had free access to salt licks and water.

At the end of 3 months, each goat was placed in individual metabolic cage for separate collection of faeces and urine for 7 days. Blood samples were taken once via jugular vein and subjected to haematological tests. About 10% of total urine samples of each was bulked for each animal for analysis of their metabolites according to Gelson and Philip, 1975).

Body Mineral depletion

After haematological and urine tests, the goats were randomised into 4 groups of 4 such that mean weights were similar. Each group was then fed 0.50kg per head of dried, ground maize cobs (2.28% crude protein, 0.79% ether extract, 37.01% crude fibre, 2.98% ash, 0.11% Ca, 0.04% P, 703 ppm Mg, 11 ppm Cu and 57.14% nitrogen free extract). Residue was weighed to estimate intake. The body depletion of Cu lasted 42 days. Body weights were taken weekly before morning feeding.

*Current address and for correspondence
Department of Animal production and health, University of
Agriculture, Abeokuta, Nigeria

Collection of Blood Serum

On day 42 of depletion, each animal was weighed before feeding and blood samples were taken via jugular vein from which serum was harvested. The serum samples were analysed for their content of Cu with Perkin - Elmer Atomic Absorption Spectrophotometer Model 290. Serum, rather than plasma was used since there was no appreciable difference in specific activity of Cu in serum and plasma (Lueker and Lofgreen, 1961).

Repletion diets

There were four isonitrogenous and isocaloric diets. The first (D1) was a control diet (12.77 Ug Cu/g DM). The other three diets contained (Ug Cu/g DM), 20, 30, 40 obtained by addition of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ while the levels of other minerals including Fe were constant in the diet. The composition with proximate analysis of the experimental diets is in Table 1

Data Collection.

The goats were weighed fortnightly between 08.00 and 09.00h before feeding. Blood samples from the repleted goats were taken on days 21 and 42 of repletion by jugular veinipuncture. Serum was harvested and preserved at -5°C until required for analysis. Faeces and urine from each goat were collected daily for 7 days. About 25% of weighed total daily faecal output was dried at 80°C and bulked in bottles rinsed with dil H_2SO_4 for each animal and stored at -5°C until required for analysis.

Procedures of Chemical and statistical analyses.

Samples of the urine, ground experimental diets and faeces were analysed for their proximate components (AOAC, 1980). The Cu concentrations of the serum samples were determined on Perkin Elmer Atomic Absorption Spectrophotometer Model 290.

TABLE 1: COMPOSITION OF THE EXPERIMENTAL DIETS (%)

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Maize grain	60.00	60.00	60.00	60.00
Maize offal	12.00	12.00	12.00	12.00
Dry <i>Gliricidia sepium</i> leaves	12.00	12.00	12.00	12.00
Palm Kernel meal	15.00	15.00	15.00	15.00
Mineral-Vitamin premix	0.50	0.50	0.50	0.50
Common Salt	0.50	0.50	0.50	0.50
$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	-	a	a	a
Total	100.00	100.00	100.00	100.00
Chemical Analysis (g/100g DM)				
Crude protein	15.00	16.50	15.50	15.30
Crude Fibre	11.60	12.00	11.00	11.90
Gross Energy (Kcal/g)	4.60	4.70	4.20	4.30
Cu(Ug/g DM)	12.77	191.66	238.85	240.68

a = added to diets to have in (UgCu/g DM) 191.66, 238.85 and 240.68 for treatments D2, D3 and D4 respectively.

Copper repletion

Each of the 4 groups of animals was assigned to one of the four diets for 42 days. They were fed daily 0.60 kg per head. Residue was weighed before morning feeding to estimate intake. Water was supplied *ad libitum*.

The serum Cu concentrations were subjected to the analysis of variance using Randomised Complete Block Design (Wahua, 1981).

Copper retention was computed while maintenance requirement for Cu was determined from the regression of Cu balance on Cu intake (Wahua, 1981).

RESULTS AND DISCUSSION

Pre-depletion haematological and Urinary Parameters

The mean values of the blood and urinary metabolites (Table 2) were similar to the findings of Sach, Jain and Carroll (1975) on non-anaemic and apparently healthy female goats, aged 9 to 30 months. The values of the haematological parameters obtained in this study indicated that the depleted goats were not anaemic and were healthy. The urine metabolite indicated the absence of traces of protein, urobilinogen nitrite and bilirubin and confirmed that the goats were free from any patho-physiological problems. The pH and specific gravity values obtained were similar to

published values (Frandsen, 1974; Heath and Olusanya, 1988) for healthy animals. It appeared that in the two tests, the goats were in good health and that any response obtained would be within reasonable limit, largely attributed to the treatment effects.

Body weight loss, dry matter intake and serum Cu level before and during depletion

There was a decreasing body weight and declining DM intake as the animals were continuously fed the dried maize cobs. (Table 2). This was accompanied by occasional staggering gait, uncoordination of movement and depigmentation of hair in some of the goats.

TABLE 2: HAEMATOLOGICAL AND URINARY ANALYSIS OF FEMALE WEST AFRICAN DWARF GOATS BEFORE DEPLETION

Parameters	Range	Mean
PCV(%)	27.00 - 30.00	28.50 ± 1.99
+ WBC (cumm) x 10 ³	5.80 - 7.60	6.58 ± 1.01
+ + RBC (cumm) x 10 ⁶	7.38 - 13.62	12.58 ± 3.85
fibrinogen (gm/%)	0.10 - 0.20	0.17 ± 0.05
Urea (mg/dl)	21.35 - 35.13	28.37 ± 7.76
Total Protein (g/dl)	5.00 - 6.10	5.60 ± 0.88
+ + + SGOT (Cabaud Unit)	43.00 - 55.00	51.67 ± 6.31
+ + + + SGPT (Cabaud Unit)	12.00 - 14.00	13.00 ± 1.50
K ⁺ (meq/l)	1.08 - 2.37	1.51 ± 1.05
Na ⁺ (meq/l)	73.00 - 104.00	83.36 ± 17.76
Urinary Protein (%)	a	a
Mean specific gravity (Urine)	1.003	1.003
Mean urinary pH	7.83 - 8.14	8.12
Urinary urobilinogen	a	a
Urinary Nitrite	a	a
Urinary bilirubin	a	a

PCV = Packed Cell Volume
 + WBC = White Blood Cell
 + + RBC = Red Blood Cell
 + + + SGOT = Serum glutamate oxaloacetate transaminase
 + + + + SGPT = Serum glutamate pyruvate transaminase
 a = absence of any traces

TABLE 3: SUMMARY OF BODY WEIGHT LOSS AND DRY MATTER INTAKE BEFORE AND DURING DEPLETION OF GOATS

Group	Mean body weight before depletion (kg)	Dry matter intake before depletion (kg/W ^{0.75} kg)	Mean body weight after depletion (kg)	Dry matter intake during depletion (Kg/W ^{0.75} kg)
1.	8.20 ± 0.11	0.037	9.93 ± 0.02	0.026
2.	8.67 ± 0.13	0.035	20 ± 0.01	0.023
3.	9.45 ± 0.21	0.040	7.93 ± 0.02	0.025
4.	9.25 ± 0.14	0.027	7.93 ± 0.04	0.018

The range of serum Cu concentration (1.60 to 1.90 Ug/dl serum, Table 4) before depletion was very close to 2 Ug/dl blood in most animal species (Church, 1971 and Harper, 1975). The serum analysis after 42 days of body mineral depletion depicted zero traces of serum Cu (0Ug/dl serum, table 4). The staggering gait, uncoordination of movement and depigmentation of hair have been attributed to Cu deficiencies in cattle and sheep (Fontenote *et al*, 1989). cunba, *et al*, (1964) also indicated loss of body weight as one of the symptoms of Cu deficiency in cattle. Santana *et al*, (1987) observed that a non-digestible fibre diet could depress absorption of most minerals and increase faecal losses of minerals. Thus, the goats have responded to the fed maize cobs (crude protein 2.28%; Cu is 11ppm) accordingly, while the apparently zero serum Cu concentration indicated during depletion could be attributed to low traces in the serum which could not be detected by the spectrophotometer.

Copper repletion

After 21 days on repletion diets the serum Cu ranged from ($P < 0.05$ to 1.25 Ug/dl/serum (Table 4). This range was higher ($P > 0.05$) than the level (0 Ug/dl/serum) at the end of depletion period. Some of the goats on groups 1,2 and 3 still had lower serum Cu levels than 1.12Ug/dl, which indicated deficiency 1.12 Ug/dl (Harper, 1975). The serum Cu increased and reached the maximum level (2.50 Ug/dl/serum) after 42 days on the test diets.

The dry matter intake increased with dietary Cu supplementation (Table 5), while the highest DM intake ($0.046\text{kg/W}^{0.75}\text{kg}$) and dietary Cu intake (1.43 Ug Cu/g DM) were induced by 240.68Ug Cu/g DM. The does on zero Cu supplementation (12.77 UgCu/g DM) depicted the lowest growth rate (0.080kg/day) implying the beneficial effect of Cu supplementation in diets of goat. However, there was no significant difference ($P > 0.05$) between the responses of the goats on 240.68 UgCu/g DM and those on 238.85UgCu/gDM

TABLE 4: MEAN SERUM COPPER LEVELS IN FEMALE WEST AFRICAN DWARF GOATS BEFORE DEPLETION, AFTER DEPLETION AND AFTER REPLETION

Group	Before depletion (Ug Cu/dl)	After depletion (Ug/Cu/dl)	After 21 days repletion (Ug Culd)	After 42 days repletion (Ug Cu/dl)
1.	1.60 ± 0.010^a	0 ^b	0.50 ± 0.001^b	1.28 ± 0.003^a
2.	1.90 ± 0.040^a	0 ^b	0.88 ± 0.003^b	1.29 ± 0.003^a
3.	1.80 ± 0.040^a	0 ^b	1.00 ± 0.003^a	1.48 ± 0.30^a
4.	1.70 ± 0.020^a 0 traces	0 ^b	1.25 ± 0.020^a	2.50 ± 0.050^c

a,b,c, means along the same row with any identical superscript are not significant ($P > 0.05$)

TABLE 5: SUMMARY OF THE PERFORMANCE OF FEMALE WEST AFRICAN DWARF (*Fouta djallon*) GOATS ON COPPER SUPPLEMENTATION DIETS

Parameter	Diet 1	Diet 2	Diet 3	Diet 4	+SE
Mean initial body weight (kg)	6.20	8.65	8.40	8.40	0.574
Mean final body weight (kg)	9.56	12.29	12.81	13.19	0.822
Mean Weight gain (kg)	3.36	3.74	4.41	4.79	0.322
Growth rate (kg/day)	0.080^a	0.089^a	0.105^a	0.114^b	0.008
Dry matter intake ($\text{kg/W}^{0.75}\text{kg}$)	0.029^a	0.044^b	0.044^b	0.046^b	0.004
Feed conversion ratio	3.75	6.40	5.42	5.18	0.547
Copper intake (Ug CulgDH)	0.04	1.10	1.36	1.43	0.322
Urinary Cu output (Ug Cu/dl urine)	0.75^a	0.75^a	1.20^b	2.55^c	0.426
Faecal Cu output (Ug Cu/g faeces)	36.00^b	27.00^b	390.00^a	33.00^b	89.47
Cu retention (Ug Cu/kgW ^{0.75}) (balance)	-3.039	-2.168	-3.082	-2.587	0.215

a,b,c, means along the same row with any identical superscript are not significant ($P > 0.05$)

in terms of DM intake, dietary Cu intake and growth rate.

The urinary and faecal Cu excretion by the goats did not follow any consistent pattern. The goats voided less urinary Cu than faecal Cu while the goat on 238.85 Ug Cu/g DM excreted more ($P < 0.05$) faecal Cu (390 Ug Cu/g faeces) than the goats on other diets suggesting endogenous production of Cu that led to negative Cu balance in each treatment. The most likely source of endogenous production is through bile or wears and tears of the linings of the intestinal tract. It should be noted that the sera analysis after repletion showed that the goats were not deficient in Cu, neither did the goats show any sign of Cu deficiency in their performance. The use of radioactive Cu could however enhance a more accurate assessment of Cu requirements in WAD goats. There could not be any appreciable interaction between Cu and Fe since the levels of Fe and other minerals were constant while only that of Cu was varied. The Cu requirement for maintenance in this study was $5.033 \text{ Ug/W}^{0.75} \text{ kg}$ while the dietary requirement for maximum growth rate was 240.68 UgCu/g DM.

In conclusion, a diet containing 240.68 Ug/gDM induced highest serum Cu concentration, dry matter intake and growth rate in female WAD goats. However, Cu deficiency in WAD does that resulted in loss of body weight, appetite and serum Cu deficiency below 1.12 UgCu/dl could be rectified through a 42-day dietary Cu repletion period.

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