



Productive Response of Rabbits to Supplemental Copper in a Diet Based on Tropical Feedstuffs

A.A. Onifade¹, O.A. Abu²

¹Department of Animal Science, University of Ibadan, Ibadan, Nigeria

²Department of Animal Science, University of Maiduguri, Maiduguri, Nigeria

(Received May 24, 1997; accepted September 20, 1997)

Abstract

Onifade, A.A. and Abu, O.A. 1998. Productive response of rabbits to supplemental copper in a diet based on tropical feedstuffs. J. Appl. Anim. Res., 13: 129-135.

Effects of supplemental copper in a diet based on tropical feedstuffs on productive performance, carcass measurements and haematology of rabbits were investigated in a 70d trial. Copper as $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ was supplemented at 0, 125, 250 and 375 mg kg^{-1} into a basal diet. The basal diet served as control treatment. Eight rabbits, each constituting a replicate, were fed on one of the experimental diets. The results showed that daily weight gain and feed intake of the rabbits fed 250 and 375 mg kg^{-1} supplemental copper were the highest followed by rabbits fed 125 mg kg^{-1} and the basal diet. Relative weights of the selected organs were similar except for the brain that tended to be lower in rabbits fed 250 and 375 mg kg^{-1} copper. Haemoglobin, packed cell volume and red blood counts were lower on 375 mg kg^{-1} , however, haematological indices in rabbits fed 125 and 250 mg kg^{-1} were superior to other treatments. The results indicated that supplemental copper in a diet based on tropical feedstuffs improved performance, supported adequate organ development and might adversely affect haematopoiesis in rabbits at 375 mg kg^{-1} rate of inclusion.

¹Corresponding author and present address : Department of Biological Sciences, Faculty of Science, Kuwait University, P.O. Box 5969, Safat 13060, Kuwait.

Keywords: Supplemental copper, tropical feedstuffs, performance, haematology, rabbits.

Introduction

Matching rabbit production with available local feed resources appears an appropriate strategy to achieve sustainable production of high quality animal protein in marginal agro-ecosystems and developing economies. Pertinently, Onifade and Tewe (1993) and Abu and Onifade (1996) have established satisfactory performance of rabbits on various tropical feedstuffs. This study investigated the supplemental effects of copper in a diet based predominantly on high fibre tropical feedstuffs. This is because copper had been documented to enhance performance of rabbits (Omole, 1976) and pigs (Zhou *et al.*, 1994a;b; Coffey *et al.*, 1994). The possibility that fibrous feedstuffs may impair bioavailability of copper to exert its growth stimulating impact further confirmed the propriety of this study.

Materials and Methods

Thirtytwo 5-6 weeks old New Zealand White rabbits weighing an average of 559g were randomly allotted to four dietary treatments. Each rabbit was housed individually in a metal cage. Prior to the commencement of the trial, the rabbits were dewormed and adjusted on the mash diets for one week. The rabbits were later offered diets and water *ad libitum* throughout the 70-day trial.

A basal diet (Maize, 30; corn offal, 20; brewers dried grains, 15; palm kernel meal, 15; groundnut cake, 10; blood meal, 4.5; palm oil, 2; oyster shell, 1.5; bone meal, 1.0; salt 0.5 and vitamin-mineral premix, 0.5%; dry matter, 89.5; crude protein, 18.7; crude fibre, 8.3; ether extract, 4.2; ash, 8.3%; metabolizable energy, 11.41 MJ/kg) formulated from tropical feed resources was incrementally supplemented with copper in the form of $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ at 0, 125, 250 and 375 mg kg^{-1} rate. The four diets were fed as mash and served fresh every day. The chemical composition of the diets was determined according to A.O.A.C. (1990).

Voluntary feed intake per rabbit was determined daily while body weight and weight gain were determined on weekly basis. Carcass and organ measurements were determined in four rabbits per treatment at the end of the 70-day trial. The organs were expressed as per cent of the live weights (%LW). The haematological samples were collected on the 70th day from the

ear vein into EDTA-treated sample bottles. Packed cell volume (PCV), red blood cell count (RBC) and haemoglobin (Hb) were determined using Wintrobe's microhaematocrit, improved Neubauer haemocytometer and cyanomethaemoglobin methods, respectively. Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were computed according to Jain (1986).

Data collected were subjected to regression analysis and means were separated by Duncan's multiple range test (SPSS, 1988; Steel and Torrie, 1980).

Results and Discussion

Rabbits fed supplemental copper at 250 mg kg⁻¹ attained the heaviest weight gain ($P < 0.001$), consumed the second highest quantity of feed ($P < 0.03$) and protein ($P < 0.05$), converted feed ($P < 0.01$) and protein more efficiently than the unsupplemented basal diet, but the values were similar to those fed 375 mg kg⁻¹ copper (Table 1). Rabbits fed 125 mg kg⁻¹ copper were intermediate in their performance. There was a linear improvement in all performance indices with increasing level of supplemental copper. These observations are consistent with previous studies (Omole, 1976; Coffey *et al.*, 1994; Zhou *et al.*, 1994a;b). Increased feed intake observed in this study represents one of the mechanisms by which copper enhances growth performance (Kornegay *et al.*, 1989; Coffey *et al.*, 1994; Zhou *et al.*, 1994a;b). Feed conversions of rabbits fed supplemental copper were similar and significantly ($P < 0.05$) better than the basal group. The enhanced feed conversion and higher feed intake synergistically explicate the mechanistic basis of growth promotion by dietary copper. Zhou *et al.* (1994b) recently elucidated the direct action of copper on growth hormone in pigs as an additional mechanism of action while the antimicrobial or bacteriostatic action remains legendary.

Carcass yield (Table 2) increased with copper supplementation. Zhou *et al.* (1994a) reported enhanced yield of longissimus muscle of pigs fed 250 mg kg⁻¹ supplemental copper. Relative weight of the brain decreased ($P < 0.04$) linearly with supplemental copper. Similar findings had been reported by Zhou *et al.* (1994a) in pigs fed 400 mg kg⁻¹ copper; and this may portend direct influence of copper on brain development and/or toxic implications. Liver, kidneys, spleen, adrenals and skin of rabbits fed experimental diets did not respond differently to supplemental copper.

Table 1

Effects of supplemental copper on performance characteristics of rabbits fed diets based on tropical feedstuffs

Copper mg kg ⁻¹	0	125	250	375	SEM
Diets	1	2	3	4	
Initial live wt., g	588	560	559	558	
Weight gain, g	15.3 ^c	16.8 ^b	18.6 ^a	18.1 ^a	0.24
Feed intake, g	63.5 ^c	66.9 ^b	70.4 ^a	71.9 ^a	0.63
Feed: gain, g:g	4.15 ^c	3.99 ^b	3.79 ^a	3.97 ^b	0.02
Protein intake, g	11.9 ^c	12.5 ^b	13.2 ^a	13.4 ^a	0.08
Protein efficiency Ratio	1.29 ^c	1.34 ^b	1.41 ^a	1.35 ^b	0.01

Linear regression equations of the performance characteristics of rabbits on supplemental copper levels

Performance characteristics	Linear equations ¹	r ²	P value ³
Weight gain	Y = 15.63 + 0.008X	0.81	0.001
Feed intake	Y = 63.85 + .023X	0.97	0.034
Feed: gain	Y = 4.09 - 0.001X	0.42	0.013
Protein intake	Y = 11.94 + 0.004X	0.97	0.047
Protein efficiency ratio	Y = 1.31 + 0.0002X	0.43	0.013

^{a,b,c}Means in the same row not followed by the same superscript are significantly (P<0.05) different.

¹Prediction equations for performance characteristics (Y) at specified (X) copper levels.

²Coefficient of determination of the regression equations.

³Probability values are considered significant at P≤0.05.

Haematological indices were preponderantly superior except for RBC in rabbits fed 250 mg kg⁻¹ copper (Table 3). This substantiates the direct relationship between haematological indices and performance (Onifade and Tewe, 1993; Olorede *et al.*, 1996). However, 375 mg kg⁻¹ copper significantly (P<0.05) depressed PCV, Hb, MCV and MCHC compared with other treatments (Table 3). The above pattern of haematological and erythrocytic indices according to Graitcer *et al.* (1984) suggest iron deficiency and/or

Table 2
Effects of supplemental copper on carcass yield and relative weights of selected organs of rabbits fed diets based on tropical feedstuffs¹

Copper mg kg ⁻¹	0	125	250	375	SEM	P value ²
Diets	1	2	3	4		
No. slaughtered	4	4	4	4		
Slaughter weight, g	1630 ^c	1730 ^b	1860 ^a	1845 ^a	17.7	0.001
Carcass yield ³ , %	52.80 ^c	53.50 ^b	54.10 ^a	53.89 ^a	0.08	0.052
Head, %	9.75	9.63	9.81	9.58	0.01	0.701
Brain, %	0.52 ^a	0.50 ^{a,b}	0.49 ^b	0.43 ^c	0.01	0.044
Liver, %	3.50	3.52	3.64	3.58	0.01	0.678
Kidneys, %	0.80	0.84	0.83	0.85	0.02	0.721
Spleen, %	0.07	0.08	0.08	0.08	0.001	0.743
Heart, %	0.22	0.23	0.22	0.21	0.001	0.815
Adrenals, %	0.03	0.03	0.03	0.04	0.001	0.833
Pelt, %	8.25	8.35	8.46	8.44	0.02	0.778

^{a,b,c}Means in the same row not followed by the same superscript are significantly ($P < 0.05$) different.

¹Linear regression equations of carcass and organ measurements are not shown because most of the parameters were not significantly different as revealed by P values.

²Probability values are considered significant at $P < 0.05$.

³All values as percent of live weight.

impairment of iron metabolism. Kornegay *et al.* (1989) and Zhou *et al.* (1994a) found that haemoglobin concentration was depressed at 400 ppm supplemental copper. Therefore, a mild chronic toxicity of copper at 375 mg kg⁻¹ might have predicated the depression of haematological indices observed in this study. The contraindication of copper supplementation at levels higher than 250 mg kg⁻¹ even in fibrous diets were presented by the reduced growth performance and predominant inverse relationships between haematological indices and copper levels.

It is concluded that the growth promotion of rabbits induced by supplemental copper in fibrous diet was optimal at 250 mg kg⁻¹ and levels higher than this may compromise performance through haematopoietic depression and potential chronic toxicity.

Table 3
Effects of supplemental copper on the haematological indices of rabbits fed diets based on tropical feedstuffs

Copper mg kg ⁻¹	0	125	250	375	SEM
Diets	1	2	3	4	
PCV, %	36.52 ^b	37.45 ^b	40.24 ^a	34.10 ^c	0.38
Hb, %	11.35 ^b	11.66 ^b	12.58 ^a	10.33 ^c	0.14
RBC, 10 ⁶ /μL	5.54	4.82	5.10	4.89	0.02
WBC, 10 ³ /μL	5.25 ^c	5.89 ^b	6.12 ^a	5.78 ^b	0.06
MCV, fL	80.44 ^a	77.70 ^b	78.90 ^b	69.73 ^c	0.79
MCH, pg	31.08 ^a	31.14 ^a	31.26 ^a	30.29 ^{a,b}	0.05
MCHC, %	25.00 ^a	24.19 ^b	24.67 ^b	21.12 ^c	0.31

Linear regression equations of haematological indices of rabbits on supplemental copper levels

Performance characteristics	Linear equations ¹	r ²	P value ³
PCV	Y = 37.75 - 0.004X	0.05	0.051
Hb	Y = 11.80 - 0.002X	0.09	0.046
RBC	Y = 4.64 + 0.001X	0.55	0.129
WBC	Y = 5.49 + 0.002X	0.41	0.045
MCV	Y = 81.33 - 0.025X	0.70	0.001
MCH	Y = 31.28 - 0.002X	0.43	0.075
MCHC	Y = 25.42 - 0.01X	0.65	0.053

^{a,b,c}Means in the same row not followed by the same superscript are significantly (P<0.05) different.

¹Prediction equations for performance characteristics (Y) at specified (X) copper levels.

²Coefficient of determination of the regression equations.

³Probability values are considered significant at P<0.05.

References

- Abu, A.O. and Onifade, A.A. 1996. Effects of cassava waste substitution for maize in weaner rabbits diets. *Bull. Anim. Hlth. Prod. Afr.* (In press).
- A.O.A.C. 1990. *Official Methods of Analysis*. 13th ed. Association of Official Analytical Chemists. Washington, D.C.
- Coffey, R.D., Cromwell, G.L. and Monegeu, H.J. 1994. Efficiency of a copper-lysine complex as a growth promotant for weanling pigs. *J. Anim. Sci.*, 72: 2880-2886.

- Graitcer, P.L., Goldsby, J.B. and Nichaman, M.Z. 1981. Haemoglobins and haematocrits: are they equally sensitive in detecting anaemia. *Am. J. Clin. Nutr.*, 34: 61-64.
- Jain, N.C. 1986. *Schalm's Veterinary Haematology*. 4th ed. Lea and Febiger, Philadelphia, USA.
- Kornegay, E.T., Van Hengten, P.H.G., Lindemann, M.D. and Blodgetts, D.J. 1989. Effects of biotin and copper levels on performance and immune response of weanling pigs. *J. Anim. Sci.*, 67: 1471-1477.
- Oloredo, B.R., Onifade, A.A., Okpara, A.O. and Babatunde, G.M. 1996. Growth, nutrient retention, haematology and serum chemistry of broiler chickens fed sheabutter cake or palm kernel cake in the humid tropics. *J. Appl. Anim. Res.*, 10: 173-180.
- Omole, T.A. 1976. The effect of graded levels of copper in the diets of growing rabbits on their performance characteristics, carcass and organ measurements. *Nig. J. Anim. Prod.*, 3: 91-95.
- Onifade, A.A. and Tewe, O.O. 1993. Alternative tropical energy feed resources in rabbit diets: Growth performance, diet's digestibility and blood composition. *Wld. Rabbit Sci.*, 1: 17-24.
- SPSS 1988. *Statistical package for social science*, SPSS Inc., Chicago, IL.
- Steel, R.G.D. and Torrie, J.H. 1980. *Principles and Procedures of Statistics. A biometric approach*. McGraw Hill Book Company, New York, 2nd edn. 633 pp.
- Zhou, W., Kornegay, E.T., Van Laar, H., Swinkels, J.M.G.M., Wong, E.A. and Lindemann, M.D. 1994a. The role of feed consumption and feed efficiency in copper-stimulated growth. *J. Anim. Sci.*, 72: 2385-2394.
- Zhou, W., Kornegay, E.T., Lindemann, M.D., Swinkel, J.M.G.M., Welten, M.K. and Wong, E.A. 1994b. Stimulation of growth by intravenous injection of copper in weanling pigs. *J. Anim. Sci.*, 72: 2395-2403.

ए०ए० ओनिफाडे, ओ०ए० अबू । उष्णकटिबंधी खाद्यों पर आधारित आहार में ताम्र पूरक पर शशकों की उत्पादन अनुक्रिया ।

शशकों पर एक 70 दिन के प्राशन परीक्षण में उष्णकटिबंधी खाद्यों पर आधारित आहार में ताम्र पूरक का उनके उत्पादन निष्पादन, वधज माप एवं रुधिर गुणों पर प्रभाव का अध्ययन किया गया । सल्फेट के रूप में ताम्र पूरक का 0, 125, 250 एवं 375 मिग्रा प्रति किलोग्राम आहार में मिलाया गया । आहार में 250 और 375 मिग्रा ताम्र पाने वाले वर्गों के शशकों में अधिकतम शरीर भार वृद्धि पाई गयी । सभी व्यक्तित्व अंगों के भार लगभग तुलनात्मक थे परन्तु मस्तिष्क का भार 250 और 375 मिग्रा ताम्र वर्गों में कम था । आहार में 125 और 250 मिग्रा प्रति किग्रा ताम्र पूरक वर्गों के शशकों के रुधिरिय सूचकांक श्रेष्ठ थे, परन्तु यह मात्र 375 मिग्रा बढ़ाने पर हीमोग्लोबिन, निचित कोशा आयतन और लाल रुधिर कोशाओं की संख्या में निरव्यय आई । परिणामों से प्रतीत हुआ कि उष्णकटिबंधी खाद्यों पर आधारित आहार में ताम्र सल्फेट की लगभग 250 मिग्रा मात्रा प्रति किग्रा आहार की दर से शशकों के निष्पादन में सुधार हुआ परन्तु 375 मिग्रा से रुधिरिय सूचकांकों पर कुप्रभाव पड़ा ।