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Effects of Varying Dietary Levels of Zinc on Performance of Growing West African Dwarf Kids

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Abstract

Zinc is an essential dietary mineral for growth and pregnancy in livestock. However, its requirement for indigenous livestock has not been given adequate attention. Therefore, zinc requirement for growth in West African Dwarf (WAD) kid was investigated. Five forage crops; Panicum maximum, Andropogon gayanus, Pennisetum purpureum, Leucaena leucocephala and Gliricidia Sepium,and commercial rations from four different feed mills, were analyzed to provide baseline zinc levels to which goats are exposed. An isonitrogenous and isocaloric diets, varied by levels of Zn (mg/kgDM). 44.0 (basal), 104.0, 134.0, 164.0, 194.0, 224.0 and 254.0 were formulated. Twenty-one weaned WAD female kids, aged 5-6 months and weighing 4.8-5.6kg were allotted to the treatment diets, using three replicates in a completely randomized design. Animals were transferred to individual metabolic cages for separate collection of feaces and urine 14 and 15 weeks later. Parameters determined were, dry matter intake, weight gain, feed conversion ratio nitrogen retention and haematological parameters. Panicum maximum, Andropogon gayanus, Pennisetum purpureum, Leucaena leucocephala and Gliricidia Sepium, contained 31.2±5.0; 29.1± 3.0;34.6± 6.0; 45.0± 5.0 and 47.1±4.0mg Zn/kg DM respectively. Growing WAD kids fed 134.0 mg/kg DM had significantly ($p<0.05$) higher DM1 (%) of 8.2 as compared with kids fed 44.0, 104.0, 164.0, 194.0, 224.0 and 254.0mg Zn/kg DM which recorded 7.7, 7.9,7.4,7.3,7.1 and 4.3 respectively. The same trend was observed with WG (g/day*) of 128.3 which was significantly (p<0.05) higher than others which recorded 57.1. 71.4, 78.8, 92.9, 64.3 and 9.0 respectively Nitrogen retention (%) of 84.06 was significantly (p<0.05) higher than others which recorded 79.88, 81.70, 83.17, 83.07, 83.11 and 65.97 respectively while the kids fed 134.0 and 164.0mg Zn/kg DM recorded significantly (p<0.05) lower FCR of 6.00 as compared with others fed 44.0, 104.0, 194.0, 224.0 and 254.0mg Zn/kg DM, which recorded 11.93,10.00.6.20.10.67 and 13.6 respectively. Haematological parameters significantly (p<0.05) reduced in values as zinc concentration in feed increased. Growing WAD kids required 134mgZn/kg DM for efficient feed utilization and consequent optimal growth.*

Keywords: *Dietary Zinc, Requirement, West-African dwarf goat, Feed Utilization.*

Introduction

The high demand for animal protein can be met most rapidly by increasing ruminant livestock population. Ruminants have major role in balanced agricultural system as converters of low quality feeds to highly desired protein food of high biological value for the benefit of man. Ruminants, because they have pre-gastric fermentative digestion of feed, generally ideally, do not compete with man for vital quality feed resources. It is easier to increase the population of small ruminants such as goats and sheep than large ruminants such as cattle and buffalos (Devendra, 1980). This is because the capital investments for a small ruminant enterprise is relatively lower, average land holdings are usually smaller, the reproductive turnover of small ruminants is high and the species can be easily managed by family labour. Often small ruminants economically meet the requirement of limited resources of producers better than large ruminants, this is because they are small and attain maturity earlier, they can produce milk and meat in more manageable and readily utilized amount. Small ruminants can therefore make a good contribution to food, energy and income security of West Africa. Appropriate research and development activities are therefore needed to increase small ruminant productivity.

There has been paucity of information on mineral requirements of goats under different production conditions (Haelein, 1980). This assertion has attracted serious attention by livestock production scientists to search for more information to enhance adequate feeding and management of goat for better production of meat, milk and fibre. In animal and man, numerous factors have a marked effect on Zn absorption. Most studies on Zn bioavailability are related to zinc as Sulphate (Wedekind and Naker, 1990) and only a few studies address the absolute apparent bioavailability.

Recently the absolute bioavaialbility was established to be about 22% for zinc acetate (Poulsen and Larsen, 1995; Poulsen and Carlson, 2001). The knowledge of average level of zinc and its common or major antagonists in the tropical forages, ingredient and water, as well as the establishment of their consistencies at these levels, therefore, become essential, for the determination of optimal level of Zn required by the animal.

Copper and Zinc are the only mineral deficiencies in animals, which are easily diagnosed by blood, feacal and urine analyses. It is important however, to verify that there is no infection or inflammation, which can cause non-nutritional increases in plasma copper and decreases in plasma Zn (Lamand, 1987; NRC 1998). Since zinc is known to be necessary for the activities of more than 100 enzymes associated with carbohydrate and energy synthesis, nucleic acid synthesis, hemebiosynthesis, carbon dioxide transport, function and maintenance of skin, pancreas and male reproductive organs (Salmon, 1988; Hambridge *et al* 1986). – Exact level of Zn (mg Zn/ kg DM) must be determined to enhance a good number of advantages of goat rearing and eradicate problems associated with WAD goat productivity, especially those concerned with dairy, since sub-normal level result in appearance of deficiency symptoms and low productivity (Solomon, 1988) and higher than adequate levels are progressively toxic and consequently lethal (Lamand, 1987). Ranking of criteria to assess bioavailability of zinc from different sources were described by Sandoval *et al* (1987) for broilers and by Swinkels *et al* (1994) for pigs. They showed that concentration of zinc in bones was closely related to the bioavailability followed by zinc content in liver and pancreas. The relative biological value of Zn sources evaluated by tibia ash content, as observed by Jongbloed *et al* (2002), revealed 100mg/kg zinc sulphate, 58mg/kg zinc carbonate, 42mg/kg zinc chloride, 95mg/kg zinc oxide and 102mg/kg zinc amino acid chelate. Besides the chemical compound, numerous interactions between zinc and other feed component exist-Hexa and penta phosphate derivatives of inositol (phytic acids) affect Zn absorption in non-ruminants because insoluble zinc phytate complexes are formed. The absorbability of zinc depends not only on the concentration of phytate, but also of calcium magnesium and phosphorus. The zinc bioavailability is also influenced by high amounts of copper and iron in the diet. In similar way a nickel oversupply leads to signs of zinc deficiency (Anke *et al* 1995; 2002). It seems that an oversupply of divalent cations influences the metabolism of zinc. Consequently the reported recommendations for zinc may vary among studies owing to the differences in the absorption of supplemental zinc sources and the use of ingredients that interfere with absorption and/or utilization of zinc under study. In previous experiments, a dietary zinc concentration of 8 to 9mg/kg feed DM for growth of suckling calves and 10-14 mg/kg is necessary to maintain normal plasma zinc levels (Hambridge, 1986). In field observations, the zinc requirement is higher. Zinc supplementation of a barley ration containing 29-33 mg/kg DM increased the growth rate of heifers and steers (Hambridge, 1986). Weigand and Kirchgessner (1982) calculated the dietary zinc requirement for a 600kg dairy cow, producing 30kg milk per day would be 40-50 mg/kg DM. In most attempts zinc requirement was estimated using dose response relationship. Weigand and Kirchgessner (1982) estimated zinc requirements for dairy cows by a factorial method. This was earlier done by Underwood and Somers (1969) and more recently by the NRC (2001). Weigand and Kirchgessner (1982) calculated with a utilization for zinc between 0.40 and 0.25, whereas NRC (2001) calculated with an efficiency of absorption of 0.5 for pre-ruminant calves, 0.3 for growing ruminants and 0.2 for adult ruminants.

Zinc requirement seems to be higher if there is a high phytate concentration in the total diet or if there is a high calcium or copper content (Meyer and Coenen, 2002).

Most of the recommended requirements were based on limited research works on goats and to a large extent extrapolated data from sheep and cattle (Kearl, 1982), hence, the main objective of this work is to determine the quantity of zinc (mg/kg DM) required for optimal performance of the growing West African dwarf kids.

Materials and Methods

Location

The experiment was conducted at the goat unit of Lagos State Polytechnic, Ikorodu. Ikorodu is situated in the Southern part of Nigeria at an elevation of 200m above sea level and lies between 7^{o}26’N and 3^{o}.54’E (Google Earth, 2006). Ikorodu is a tropical region with high amount of rainfall and a dry season of three to five months duration (November – March), under normal circumstances. Being a tropical region with a very little temperature variation, it supports the growth of various microorganisms and vegetation, which is highly enhanced during raining season. The soil is loamy and the common grass is Panicum maximum

The Experimental Animals

The West African Dwarf kids were sourced from Iwo in Osun State and transported to Ikorodu before mid-day. The kids were purchased from various homes and the choice was based on size, age and physical condition. On arrival at the experimental site, they were administered with PPR vaccine and penstreps for 5 days.

Experimental Animals and their Management

Twenty-one growing West African Dwarf (WAD) kids, 5-6 months of age, weighing 4.8-5.6kg were randomly allotted into 7 treatments and labeled based on gradation in the level of zinc, each replicated thrice in a completely randomized design. The animals were allowed six weeks to acclimatize to the farm conditions and were dewormed with levamisol and ivomec super to prevent ectoparasitic infection.

The animals in treatments A-G were fed ad-libitum with the experimental basal diet (Table 1), varied by gradations (mg/kg dm) 44.0, 60.0, 90.0, 120.0, 150.0, 180.0 and 250.0, in the level of dietary zinc inclusion and daily, at sun-set were allowed into a well-secured pasture (solely panicum maximum), for grazing and exercise. Wood shavings as beddings were changed in pens weekly.

Table 1: Gross Composition (%) of Basal diets and Chemical Composition of Concentrate and Guinea Grass (g/100g dm)

INGREDIENTS:	BASAL DIET
Soybean meal	13.50
Wheat Offal	20.00
Palm Kernel Cake	36.00
Brewers' Dried Grain	25.00
Bone meal	1.50
Oyster Shell	3.50
Premix	0.50
Salt	0.50
Total	**100.00**
Zinc (ppm)	44.00
Fe (ppm)	73.18
Cu (ppm)	12.72

	CONCENTRATE	GUINEA GRASS
Dry matter	90.20	
Crude Protein	15.28	4.40
Crude Fibre	38.90	41.80
Ether Extract	4.83	2.70
Ash	4.07	16.10
Nitrogen Free Extract	26.92	35.00
Metabolizable Energy (Kcal/kg)	2,533.75	

DIET A:	Basal Level of Zn in the experimental diet	- 44.0ppm
DIET B:	Experimental diet with additional	- 60.0ppm Zn
DIET C:	Experimental diet with additional	- 90.0ppm Zn
DIET D:	Experimental diet with additional	- 120.0ppm Zn
DIET E:	Experimental diet with additional	- 150.0ppm Zn
DIET F:	Experimental diet with additional	- 180.0ppm Zn
DIET G:	Experimental diet with additional	- 250.0ppm Zn

Collections of Feaces and Urine

At weeks 14 and 15, each animal was placed in individual metabolic cage modified for separate collection of feaces and urine (Akinsoyinu, 1974). A week was allowed for adjustment to the cages before collection of feaces and urine daily for the next 7 days. Aliquot (10%) of the total feaces collected each day was retained, samples were dried in an oven at 65°C to constant weight and then bulked for each animal and stored in a bottle with an air-tight cover at room temperature until required for chemical analyses. Total urinary output was weighed and saved with 3ml of 10% H_2SO_4 to curtail microbial activities. Daily collection of urine was also bulked for 7 days for each animal in plastic bottles kept in a deep freezer till required for chemical analyses. Nitrogen content of samples were determined using Kjeldahl procedure (AOAC, 1990). The samples were ashed by charring in muffle furnace at 500°C for about 3 hours (AOAC, 1990). The ether extract and crude fibre of the samples were analysed as described by AOAC (1990).

Data Analysis

Data obtained were subjected to analysis of variance in a completely randomized design, using the SAS (1999) package and the means were separated using Duncan multiple range test of the same software.

Results and Discussion

Table 2: Performance of Animals Fed Varying Dietary Levels of Zinc

PARAMETERS:	A(44)	B(104)	C(134)	D(164)	E(194)	F(224)	G(294)	SEM
Mean DM1(g/day)	682.50^{c}	714.00^{b}	765.00^{a}	465.00^{c}	575.00^{d}	685.00^{c}	195.00^{f}	3.94
Mean Live Weight (kg)	8.90^{b}	9.10^{a}	9.60^{ba}	6.30^{d}	7.90^{c}	9.70^{a}	4.60^{c}	0.24
Mean DM1 (% of liveweight)	7.70^{b}	7.90^{a}	8.20^{a}	7.40^{b}	7.30^{b}	7.07^{c}	4.30^{d}	0.25
Mean Body Weightgain (g/day)	57.10^{f}	71.40^{d}	128.33^{a}	78.80^{c}	92.90^{b}	64.30^{c}	14.3^{g}	0.87
DMI/BWG Ratio	11.93^{b}	10.00^{d}	6.00^{f}	6.00^{f}	6.20^{e}	10.67^{c}	13.6^{a}	0.07.

a,b,c………Means in the same row with different superscripts differ significantly ($p<0.05$).

DM I = Dry Matter Intake
SEM = Standard Error of Means
WAD = West African Dwarf
Values in parenthesis represent analysed content of Zn in diet

Mean voluntary DM1 value (g/day) of the kids varied from 195 to 765. Treatment effects were significant ($p<0.05$). Animals on dietary Zn of 134.0ppm recorded the highest DM1 value of 765g/day. All the kids consumed 4.6-9.6% of their body weight as dry matter. Although the variations were appreciable ($p<0.05$) the values were greater than 3.0% (NRC, 1982) and 3.0 to 5.3% (Perera, et al, 1996) as the minimum recommended for maintenance and growth respectively. The trends however depicted a decline in DM1 beyond 134.0ppm of dietary Zn inclusion. This expressed that a dietary Zn content of 134.0ppm would be adequate for growth, this could be attributed to the fact that Zn is instrumental to the activation of enzymes, including digestive enzymes (Solomon, 1988), as well as activation of metabolism (Miller, 1979, Evans *et al*, 1975), thereby, enhancing rapid digestion of feed and creating desire for more feed intake – resulting in the exceptionally high dry matter intake, recorded in Table 2.

Weight gains (g/d) of 14.3 to 128.0 were observed in the study. The variations were highly significant ($p<0.01$). There was also a declining trend in gains beyond dietary Zn content of 134.0ppm, resulting from progressive decline in iron absorption with subsequent decline in carbohydrate metabolism (Evans *et al*) leading to subsequent and progressive retardation in the body physiologic activities as zinc absorption was approaching toxicity, as also observed by Hambidge *et al* (1986).

Mean feed conversion ratio of the kids varied from 6.00 and above (table 3, treatment G with 14.30 g/day body weight gain). Treatment effect was significant ($p<0.05$). Animals on dietary Zn content of 134.0ppm and 164.0ppm recorded the lowest feed conversion ratio of 6.00. The trend however depicted a decline in feed efficiency beyond 134.0 and 164.0ppm of dietary Zn inclusion.

From the previous parameters, dietary Zn content of 134.0ppm has been consistent in supporting optimal performance, making it the optimal dietary Zn intake level between the two that offered the lowest feed conversion ratio.

Table 3: Haematological Data on Wad Kids Fed Varying Dietary Levels of Zinc

PARAMETERS	**A (44)**	**B (104)**	**C (134)**	**D (164)**	**E (194)**	**F (224)**	**G (294)**	**SEM**
RBC x $10^6/mm^3$	27.42^a	24.05^b	21.38^c	17.33^d	16.93^{ed}	16.39^e	9.51^f	0.59
WBC x$10^3/mm^3$	17.39^c	18.13^{bc}	17.67^c	19.46^b	16.80^c	17.03^c	20.76^a	0. 51
Hb (g/dl)	15.82^a	15. 87^a	14.01^b	12.25^c	10.89^d	9.52^e	6.57^f	0.43
PCV (%)	43.00^a	34.30^b	37.67^b	35.67^{ba}	34.67^b	30.00^c	22.67^d	0.67

a,b,c………Means within the same row with any identical superscripts are not significant($P<0.05$).

Haematology of WAD kids fed varying levels of Zn during growth is depicted by Table 3. Mean red blood cell count (x $10^6/mm^3$) of the kids varied from 9.51 to 27.42. Treatment effects were significant ($p<0.05$). Animals on dietary Zn content of 134.0ppm recorded a value of 21.38 x $10^6/mm^3$ which is in agreement with the range of red blood cell count of 14 to 22 x $10^6/mm^3$ recommended for goat (Mitruka and Rawnsley, 1977). Mean white blood cell count ($10^3/mm^3$) (Table 3) of the kids varied from 16.80 to 20.76. The variations were not significant. The lowest value of 16.80 x $10^3/mm^3$ (Table 3) was higher than the value 3 – 14 x $10^3/mm^3$ recommended by Mitruka and Rawnsley, 1977. These higher value could have been indication of infection. Mean haemoglobin value (g/dl), (Table 3) of the kids varied from 6.57 to 15.87. Treatment effect were significant ($p<0.05$). Animals on dietary Zn content of 134.0ppm recorded a value of 14.01g/dl which fell in line with the value 13.50g/dl to 15.00g/dl recommended for goat (Mitruka and Rawnsley, 1977). Evans et al (1975); and later Wedekind and Baker (1990) observed a negative correlation between the absorptions of iron-Copper pair and zinc at the intestinal lumen, creating an optimal level for haemoglobin when the absorption of iron-copper pair balances with zinc absorption. At this optimal level of haemoglobin formation, carbohydrate metabolism and hence energy generation becomes optimal, enhancing the animals physiological and metabolic activities. Mean packed cell volume (%) (Table 3) of the kids varied from 22.67 to 43.00.

Treatment effect was significant ($p<0.05$) only between animals on dietary zinc contents of (44.0ppm and 104.0ppm), (224.0ppm and 294.0ppm). There were insignificant variations among the PCV of animals on dietary Zn contents of 134.0ppm, 164.0ppm and 194.0ppm. Nevertheless, animals on dietary Zn content of 134.0ppm recorded a PCV value of 37.67% which is the highest within the range 23-38% recommended for goat (Mitruka and Rawnsley, 1977).

Conclusion

Copper and zinc are the only deficiencies in animals, which are easily diagnosed by blood, feacal and urine analyses. It is important, however, to verify that there is no infection or inflammation which can cause non-nutritional increases in plasma copper and decreases in plasma zinc, as also suggested by Lamond, (1987) and NRC (1988). Since zinc is now known to be necessary for the activities of more than 100 enzymes, associated with carbohydrates, and energy metabolism, protein degradation and synthesis, nucleic acid synthesis hemebiosynthesis, carbon dioxide transport, function and maintenance of skin, pancreas and male reproductive organs as evident from weight gain and mean feed conversion ratio (Table 2) and the influence of zinc on red blood cell counts white blood cell counts, haemoglobin concentration and PCV (Table 3), as agreed with by observation of Solomon (1988) and Hambidge *et al*, (1986), it becomes imperative to ensure that the exact level of Zn (mg Zn/kg DM) must be determined to enhance a good number of advantage s of goat rearing and eradicate problems associated with WAD goat productivity especially those concerned with dairy, since sub-normal levels result in appearances of deficiencies symptoms and low productivity ad higher than adequate levels are progressively toxic and consequently lethal (Table 2 & 3).

References

Akinsoyinu, A.O. (1974), “Studies on protein and energy utilization of West African Dwarf goat”. Ph.D University of Ibadan.

Anke, M, Angelow, L., Glei, M. Miiller, M., Illig, H. (1995): The biological importance of nickel in the food chain. J. Anah Chem. 152, 92-96.

Anke, M.Triipschuch, A. Arnold, W., Dorn, W, Hopper, C. (2002). Die Auswikungen eines reichlichen Nickelamgebotes auf den zink – Magnesium – and mangastatus des Hulnes und der Eier. (The effect of a nickel-rich offer on the zinc, magnesium and manganese status of the hen and their eggs). Ber. 7. Tagung Schweine-und Geflingelernahrung, martin-Luther University at Halle – Wittenberg 7, 210-212.

Association of Official Analytical Chemists (1990): Official methods of analysis AOAC, Washington, D.C.

Devendra, C (1980). Milk Production in goats compared to buffalo and cattle in humid tropics.J. Dairy Sci. 63: 1755-1767.

Google Earth, (2006) http: //WWW . google/earth. html

Haelein, G.F.W. (1980). Mineral Nutrition of Goats. A review J. Dairy Sci. 63: 1729-1748.

Hambridge, K.M., Casey, C.E. and N.F. Krebs (1986): Zinc. In: Mertz (ed): Trace Elements in human and animal nutrition, Vol. 2 Academic Press, Sam Diego, pp. 1-137.

Herrera, M, Rodero, E., Gutierrez, M.J., Pena, F., and J.M. Rodero (1996). Application of \Multifactorial discriminant analysis in the morphostructural differentiation of Andalusian Caprine breeds. Small Ruminant Research 22:39-47.

Jongbloed, A.W; Kemme, P.A. and Z Mroz (2002); The role of Microbial phytases in pig production. In Wenk, G, Boessinger, M., ED., Enzymes in animal nutrition, kartanse itingen, thurgan, swutzerland.pp. 173 - 180.

Kearl, L.C.(1982). Nutrient requirements of nutrients in developing countries. Inter –feedstuff Inst. Utohustate University – Logen.

Lamard, M.J. (1987): La pathologic lice aux careness on oligoelements (pathology) Relative to trace element deficiencies, p. 415-423. In: YVORE P. and PERRING (ed.) Les Maladics de la clevre, colloegue international, Oct. 9-11, 1984, Niort (France).

Meyer, H. and R. Coenen (2002): Liver iron depletion without copper loss in swine for excess Zinc, J. Nutr. 77, 225-228.

Mitruka, B.M. and H.M. Rawnsley (1977) : Clinical, biochemical and Hematological reference value in normal experimental animal mass on Publishing Company, New York.

NRC (1982). United States – Canadian Tables of Feed Composition: 3rd Ed. National Research Council – National Academy of Sciences, Washington, D.C.

National Research Council (1984). Nutrient requirement of Dairy Cattle. Seventh Revised Edition, 2001. National Academy Press, Washington, D.C.

Poulsen, H.D. and M.S. Carlson (2001) Early- and traditional Weaned nursery pigs benefit from phase-feeding pharmacological concentrations of zinc oxide: Effect on metallothionein and mineral concentrations. J.Anim. Sci. 77s, 1199-1207.

Poulsen, H.D. and R.B. Larsen (1995). Zinc oxide for weaning pigs. ActaAgric. Scandinavica Sect. A, 45, 159-167. “Recommended Dietary Allowances”, 8th ed. Natl. Acad. Sci. Washington, D.C.

Sandova, V.A. P Edwards R.A. and E.R. Beecher (1997). The indigenous livestock of Eastern and Southern Africa. Tech. Common and Bur.

Animal breeds Genet Edinburgh No. 14, Farnaham Royal Bulks Co., PW Wealth Agroc. Bureaux XV151,pp 48V plates.

SAS (1999) SAS/STAT. Guide for Personal Computers (Cary North Carolina SAS Institute)

Solomon, M.B (1988); Simultaneous histochemical determination of three fiber types in single sections of ovine, bovine and porcine skeletal muscle. J. Anim. Sc. sc. 66: 255.

Swirikelo, J.R. Voikler, L. and J.R. Todd (1994) – Schwene Auflage, Frankfurt and Main.

Underwood, E.J. and M. Somers (1969): Effects of zinc deficiency on spermatogenesis in Ram. Aust. J. Agric. Res. 20, 889.

Wedekind, K.J. and D.H. Baker (1990): Zinc bioavailability in feed-grade Sources of zinc. J. Animal Science 68,684-689.

Weigand, L.M. and M. Kirchgessner (1982): Tierphysiol, tierernaechr. Futtermitelked. 29,65 and 77.