Effects of varying dietary zinc levels on energy and nitrogen utilization in 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 energy and nitrogen utilization in West African dwarf (WAD) kid was investigated. Forage crops and commercial rations from four different feed mills, were analyzed to provide baseline zinc levels to which goats were exposed. Twenty-one weaned WAD female kids, aged 5-6 months and weighing 4.8-5.6kg were randomly assigned to seven dietary treatments and were further replicated three times. 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 (DMI), energy utilization and nitrogen utilization. The mean±SE of 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 body weight) 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. This trend was observed for energy utilization (77.40) which was significantly ($p<0.05$) higher than other dietary treatments which recorded 74.40. 75.20. 70.10, 65.37, 64.10 and 49.42 respectively. Animals on dietary Zn content of 134.0ppm and 164.0ppm recorded the lowest feed conversion ratio of 6.00. Therefore, growing WAD kids required 134mgZn/kg DM for optimal growth and physiological performance.

Keywords: Dietary Zinc, Requirement, West-African Dwarf goat, Performance

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, , 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). The long association between the goats and humans indicates the varieties of services that goats can provide. Like many other domestic animals, goat was first used for meat production and it also preceded the cow as a dairy animal (Devendra and Burns, 1983). The rearing of goats therefore provided a small but nevertheless significant supply of animal protein in the form of milk and meat.

Goats are small, hardy animals and are easier to maintain than cattle. The wide distribution of goats in the tropics and sub-tropics reflects their ability to adapt to a variety of environments. The dwarf goat unlike other species thrives throughout the humid tropics and must be specially adapted to humid environment (Devendra and Burns, 1970). The inherent characteristic of goats such as resistance to dehydration, preference for browse and wide-range feeding habits enables them to thrive in region of low rainfall. Goats do not compete with humans for food sources. Goat skins have many local uses, such as bedding materials and locally produced handicrafts. The genetic variability among tropical goat breeds is so great that selection for improved animal productivity is possible and if this is combined with improved feeding and health, overall production gains could be high. Therefore relatively low inputs to improve health and feeding could produce relatively high gains in productivity.

There has been paucity of information on mineral requirements of goats under different production conditions (Haelein, 1980). This assertion should attract serous attention of livestock production scientists to search for more information for enhancing adequate feeding and management of goat for better production of meat, milk and fibre (Allen, 1982) Most of the recommended requirements were, based on limited research work 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/kgDM) required for optimal utilization of energy and nitrogen in the growing West African Dwarf kids.

Materials and methods

Animals and their management

Twenty-one growing West African dwarf (WAD) kids, 5-6 months of age, weighing 4.8-5.6kg were randomly divided into 7 treatments of 3 replicates each in a completely randomized design.

The animals were allowed six weeks to acclimatize to the farm during which they were kept under an intensive system of management.

The animals were dewormed with levamisol.Ivomec super was also administered to prevent ectoparasitic infections. Woodshaving beddings were changed in pens weekly.

Experiment and diets

Diets with varying levels of zinc were formulated as follows:

DIET A: Level of Zn in the conventional rations - 44.0ppm

DIET B: Conventional ration with additional - 60.0ppm Zn = 104.0ppmZn

DIET C: Conventional ration with additional - 90.0ppm Zn = 134.0ppmZn

DIET D: Conventional ration with additional - 120.0ppm Zn = 164.0ppmZn

DIET E: Conventional ration with additional - 150.0ppm Zn = 194.0ppmZn

DIET F: Conventional ration with additional - 180.0ppm Zn = 224.0ppmZn

DIET G: Conventional ration with additional - 250.0ppm Zn = 294.0ppmZn

The plans of the experiment and diets above depicts a planned administration of the same diet, but distinguished into seven (7) different diets by graded inclusions of dietary zinc.

Table 1 confirms the interpretation of the experimental plans above by showing the uniformity in the ingredients compositions of diets A to G and their disparities on the basis of graded levels of dietary zinc inclusions – which is the subject under consideration in this study.

Collections of feaces and urine

At weeks 14 and 15, each animal was placed in individual cage, modified for separate collection of faeces and urine (Akinsoyinu, 1974). A week was allowed for adjustment to the cages before collection of faeces and urine daily for the next 7 days. Aliquot (10%) of the total faeces collected each day was retained for

Table 1. Experimental diets fed to WAD kids.

Ingredients	A	B	C	D	E	F	G
Soybeanmeal	13.50	13.50	13.50	13.50	13.50	13.50	13.50
Wheatoffal	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Palmkernel Cake	36.00	36.00	36.00	36.00	36.00	36.00	36.00
Brewers' Dried Grain	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Bonemeal	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Oystershell	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Premix	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Zinc (ppm)	44.00	104.00	134.00	164.00	194.00	224.00	294.00
Iron (ppm)	73.18	73.18	73.18	73.18	73.18	73.18	73.18
Copper (ppm)	12.72	12.72	12.72	12.72	12.72	12.72	12.72

analysis. 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, loss of nitrogen and precipitation of ions. Daily collection of urine was also bulked for 7 days for each animal in plastic bottles and kept in a deep freezer till required for chemical analyses.

Analytical procedure

For residual moisture determination, 2g of the ground samples of feed, forage and feaces were further oven-dried at 105°C to constant weight prior to analyses. The ground samples of feed forage and feaces were analyzed for their proximate compositions (AOAC, 1990). Gross energy values of samples were determined using a Gallenkamp Oxygen Ballistic Bomb calorimeter with thermo-chemical grade benzoic acid as a standard.

Statistical analysis

Data obtained were subjected to analysis of variance, using SAS (1999). Differences among treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955).

Results and discussions

Table 2 presents the nutritive values of both the concentrates and the guinea grass (*Panicum maximum*), fed to the experimental animals. The determined nutritive value of the guinea grass is in agreement with that of Amole*, et al*.(2013). The average responses of the animals to various levels of dietary zinc inclusion, as depicted by weight gain, dry matter intake

Table 2: Chemical compositions of experiment diets and grass (g/100gdm) fed to wad kids and gross energy (kcal/kg) of diets.

Parameters	Concentrates	Grass
Dry Matter	90.20	94.70
Crude Protein	15.28	4.40
Crude Fibre	38.90	41.80
Ether Extract	4.83	2.70
Ash	4.07	16.10
NFE	26.92	35.00
Gross Energy	2,533.75	2,130

and feed conversion ratio are presented on Table 3.

Mean voluntary DM1 value (g/day) of the kids varied from 195 to 765 (Table 3). 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 4.3 - 8.2% 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, especially as affirmed by favourable values of other parameters, like feed conversion ratio and weight gain at the same level of zinc inclusion of 134.00ppm.

Weight gains (g/d) of – 42.90 to 128.0 were observed in the study, the value, -42.90g/d depicted a loss in weight. The variations were highly significant ($p<0.01$). There was also a declining trend in gains beyond dietary Zn content of 134.0ppm. This correlates with the findings obtained for dry matter intake.

Mean feed conversion ratio of the kids varied from 6.00 and above (table 3, treatment G with – 42.20 g/day body weight loss). 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. Dietary Zn content of 134.0ppm has been consistent in supporting optimal performance, making it the optimal dietary Zn level.

Table 4 shows the effect of dietary zinc intake by the experimental animals on their various energy utilizations which has a positive correlation on their metabolic and physiological abilities and activities, hence their productivities.

Energy utilization by the growing kids is shown in Table 4. Dietary energy intake (kcal/gDM/day) of the kids varied from 331.5 to 1494.83. Treatment effects were significant ($p<0.05$).

Energy utilization (% of intake) of 49.42 to 77.40 was observed in the study. The variations were significant ($p<0.05$). The highest value was also obtained for kids on dietary Zn content of 134.0ppm. There were declining trends in energy utilization below and beyond dietary Zn content of 134.0ppm..

Table 3. Performance of animals fed varying dietary levels of zinc

Parameters	A(44.00)	B(104.00)	C(134.00)	D(164.00)	E(194.00)	F(224.00)	G(294.00)	SEM
Mean DMI(g/day)	682.50^{c}	714.00^{b}	765.00^{a}	465.00^{e}	575.00^{d}	685.00^{c}	195.00^{f}	3.94
Mean Live Weight(kg)	8.90^{bc}	9.10^{b}	9.60^{ab}	6.30^{d}	7.90^{c}	9.70^{a}	4.60^{e}	0.24
Mean DMI (% 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 Weight Gain(g/day)	57.10^{f}	71.40^{d}	128.33^{a}	78.80^{c}	92.90^{b}	64.30^{e}	-42.90^{g}	0.79
Feed Conversion Ratio	11.93^{a}	10.00^{c}	6.00^{de}	6.00^{de}	6.20^{d}	10.67^{b}	_	0.07

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

Table 4. Energy utilization by wad kids fed varying levels of zinc

Utilization Parameters Partition of Energy (Kcal/g/day)	A (44.00)	B (104.00)	C (134.00)	D (164.00)	E (194.00)	F (224.00)	G (294.00)	SEM
Dietary Energy Intake	1296.5^{c}	1366.6^{b}	1494.83^{a}	873.50^{e}	1082.5^{d}	1278.97^{c}	351.50^{f}	7.51
Feacal Energy Loss	409.50^{b}	418.40^{b}	418.93^{b}	282.33^{d}	355.00^{c}	433.53^{a}	156.00^{e}	3.12
Urinary Energy Loss	26.60^{a}	25.07^{b}	21.80^{c}	15.90^{e}	20.07^{d}	256.75^{b}	11.70^{f}	0.17
Digestible Energy Intake	887.25^{c}	948.20^{b}	1075.90^{a}	591.17^{e}	727.50^{d}	845.44^{c}	175.50^{f}	7.58
Metabolizab Energy Intake	860.65^{c}	923.13^{b}	1054.10^{a}	575.27^{e}	707.43^{d}	819.87^{c}	163.80^{f}	9.18
Energy Utilization (% of Intake)	74.40^{c}	75.20^{b}	77.40^{a}	70.10^{d}	65.37^{e}	64.10^{e}	49.42^{f}	0.10

$^{a,b,c..d.:}$ Means in the same row with different superscripts differ significantly ($p<0.05$).

Table 5 shows responses of experimental animals to changes in dietary zinc inclusion, to determine at what level of zinc inclusion the animal would display the most economic utilization of protein nitrogen.

Utilization of nitrogen by the growing kids is depicted on Table 5. Mean nitrogen intake (g/day) followed the same trend as dry matter intake, varying from 4.13 to 16.10. Treatment effects were also significant ($p<0.05$). Animals on dietary Zn content of 134.0ppm recorded the highest mean nitrogen intake of 16.10 g/day. Nitrogen retention of 65.97 to 84.06% was observed in the study. The highest value of 84.06% of nitrogen retention was obtained for kids on dietary Zn content of 134.0ppm, although, between dietary Zn of 134.0ppm and 224.0ppm there were variations which were not significant, but below 134.0ppm and beyond 224.0ppm treatment effects were significant ($p<0.05$), depicting the dietary Zn content of 134,0ppm as optimal.

As stated earlier in this report, there is paucity of information on Zn requirements in WAd kids, there are a good number of figures that indicate Zn requirements for kids, but of different species and they are majorly temperate breeds which are not comparable with the interest in this study. Adequate references have been made on

Table 5: Nitrogen utilization by wad kids fed varying dietary levels of zinc

Utilization Parameters. Partition of Nitrogen (g/day)	A (44.00)	B (104.00)	C (134.00)	D (164.00)	E (194.00)	F (224.00)	G (294.00)	SEM
Nitrogen Intake	14.33^{c}	15.33^{b}	16.10^{a}	9.69^{e}	11.91^{d}	14.39^{c}	4.13^{f}	0.179
Feacal N-Loss	1.31^{b}	1.43^{a}	1.44^{a}	0.96^{d}	1.08^{c}	1.42^{ab}	0.61^{e}	0.04
Urinary N-Loss	1.58^{a}	1.38^{b}	1.14^{c}	0.67^{f}	0.84^{e}	1.01^{d}	0.79^{e}	0.03
Nitrogen Retained	11.45^{d}	15.30^{a}	13.54^{b}	8.06^{f}	10.01^{e}	11.96^{c}	2.72^{g}	0.14
Nitrogen Retention (% of Intake)	79.88^{d}	81.70^{c}	84.06^{a}	83.17^{b}	84.07^{a}	83.11^{b}	65.97^{e}	0.428

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

recorded values for DMI, which serve as justifiable basis for the values obtained for energy utilization and nitrogen retention to establish the value for Zn requirement in this study. In conclusion, dietary Zn content of 134.0ppm will support optimal performance of West African Dwarf kids. However, more research should be conducted in this area of ruminant nutrition, for the establishment of useful values for micro-minerals requirements of West African dwarf kids.

The mechanism of zinc absorption and its control has been illuminated by the work of Evans *et al*(1973). They have described a low molecular weight micro minerals binding ligand in the pancreas;

a. The pancreas secretes a ligand into the intestinal lumen
b. In the lumen minerals bind to the ligand
c. Complexed with the ligand minerals are transported through the intestinal microvilli and into the epithelial cells
d. In the epithelial cells minerals are transferred to binding sites on the basolateral plasma membrane
e. Metal-free albumin interacts with the plasma membrane and removes minerals in quantities that are dependent on the body requirements.

Evans and Hahn(1974) suggested that the quantity and quality of metal-free albumin available at the basolateral plasma membrane determine the amount of metal, e.g. zinc, that is removed from the intestinal epithelial cells and thus regulates the quantities of zinc and other metals entering the body.

From the fore-going and considering the values recorded on Table 3, dry matter intake, mean live weight gain increase with increasing in level of dietary zinc intake and suddenly dropped with a further increase in zinc level, an observation similar to that of Hahn and Evans (1975) and which is attributable to the fact that at an zinc inclusion level of 134.00mg/Kg, optimal absorptions of iron and copper were allowed, giving room for optimal haematopoiesis, which makes available abundant chemical energy for all necessary physiological syntheses and metabolic activities, and when the value of feed conversion ratio at 134.00mg/Kg was considered, high metabolic efficiency brought about afore-stated physiological condition was confirmed.

This same trend can be used to explain the values recorded for energy and nitrogen utilizations in the experimental animals and it is therefore suggested in conclusion that for optimal performance of West African dwarf kids a dietary zinc inclusion level of 134.00mg/Kg is recommended.

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