Effects of dietary nickel supplements on use of a low-protein diet in the West African dwarf goat

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ABSTRACT
The effects of dietary nickel supplements on feed intake, nitrogen metabolism, and blood composition in the West African dwarf (WAD) goats while on a low-protein diet were examined. Three dietary groups (two treatments plus a control) of four animals per group were used in a completely randomized design digestibility study. Each of the treatment groups received a (8.4 per cent CP) diet that was supplemented with 10 ppm elemental nickel as nickel sulphate hexahydrate ($NiSO_4.6\ H_2O$) or nickel - sodium monoflourophosphate complex (Ni-SMFP). The unsupplemented group served as control. Serum urea-nitrogen concentration was significantly ($P<0.05$) raised by the effects of nickel-sodium monofluorophosphate complex. Average daily feed intake, nitrogen digestibility, and nitrogen retention increased slightly ($P>0.05$) while serum total protein and glucose concentrations were unaffected by the effects of the nickel treatments. The results indicated that the inorganic nickel salt and the nickel complex had a tendency to cause an increase in feed intake and nitrogen metabolism in the goats on low-protein diets.

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RÉSUMÉ
YOUSUF, M. B. & ADELOYE, A. A. : *Effet des suppléments de nickel diététiques sur utilisation de régime faible en protéine dans la chèvre de West African dwarf.* Les effets des suppléments de nickel diététiques sur la consommation de ration, le métabolisme d' azote et la composition sanguine dans les chèvres de West African dwarf (WAD), pendant qu'ils suivaient un régime faible en protéine, étaient examinés. Trois groupes diététiques (deux traitements plus un contrôle), de quatre animaux par groupe étaient utilisés dans un dessin complètement choisi au hasard d' une étude de digestibilité. Chacun des groupes de traitement recevait un régime (de 8.4 pour cent CP) qui était supplémenté avec 10 ppm de nickel élémentaire comme hexahydrate de sulfate de nickel ($NiSO_4 .\ 6\ H_2O$) ou complexe de monofluorophosphate de sodium-nickel (Ni - SMFP). Le groupe non-supplémenté servait comme contrôle. Une concentration d' azote - urée de sérum était considérablement ($P< 0.05$) élevée par les effets du complexe de monofluorophosphate de sodium-nickel (Ni - SMFP). La consommation moyenne de ration quotidienne, la digestibilité d'azote et la rétention d'azote augmentaient légèrement ($P> 0.05$) alors que la concentration de protéine totale de sérum et le niveau de glucose n'étaient pas affectés par les effets des traitements de nickel. Les résultats indiquaient que le sel de nickel inorganique et le complexe de nickel avaient une tendance de causer une augmentation de consommation de ration et de métabolisme d' azote dans les chèvres suivant les régimes faibles en protéine.

Introduction

Tropical feeds and pastures are characterized by low nutrient and digestibility values. Leng (1984) observed that the rumens of ruminant animals in the tropics are often deficient in such critical nutrients as ammonia and certain trace minerals that are required for optimum efficiency. The essentiality of nickel has been widely reported (Solomon *et al.*, 1982; Nielsen, 1991) in human and animal nutrition. Nickel has a low molecular weight of 57.8 which falls within the range of 48 to 68, the molecular weights of most of the established essential trace minerals. Nickel is physiologically involved in the action of vitamin

B-12 and biotin during the metabolism of odd-chain fatty acids in animals (Nielsen, 1991). Besides this physiological role, nickel also influences microbial population in the rumen.

Rumen urease enzyme was extremely low in lambs fed a diet low in nickel, but was many times higher in lambs receiving supplemental nickel (Spears, Smith & Hartfield, 1977). The urease enzyme hydrolyses urea that is recycled from blood and saliva so as to provide additional nitrogen for microbial cell synthesis. The chelated form of nickel was suggested (Nielsen, 1974) to be more important in metabolism than nickel in its free ionic form. Nickel exists in human serum mainly as nickel-plasmin and nickel-albumin complexes (Callan & Sunderman, 1973).

The main objectives of this study were to determine the influence of dietary nickel supplements on use of a low-protein diet, and to compare the efficacy of a nickel complex with that of a nickel salt in the indigenous West African dwarf (WAD) goats.

Materials and methods

Animals and experimental treatments

Twelve WAD goats with average initial liveweight of 7.61 ± 0.81 kg were divided into three dietary groups of four animals (three males and one female) per group, in a completely randomized design. The goats were housed individually, in wooden metabolism cages that allowed for separate faeces and urine collections. The treatment consisted of 13. 59 mg of nickel sulphate hexahydrate ($NiSO_4.6H_2O$) or 17.01 mg of nickel - sodium monofluorophosphate complex (Ni-SMFP), each equivalent to 10 ppm elemental nickel in a (300 g) corn - based basal diet (Table 1). The control group received no nickel supplement. The goats were fed 300 g/head of the experimental diets at 0800 and 1400 h daily. Fresh, clean drinking water was provided free-choice throughout the 28 days' period.

Collection of samples and measurements

Records of daily feed intake were kept during the last 7 days of the study. Faecal matter produced by each animal during the collection period was weighed, dried to constant weight, and ground to fine particle size. Ten per cent of the ground faecal sample was retained and stored in air-tight plastic container to subsequently determine nitrogen content. Urine plastic containers were acidified daily with 5 ml of a 30 per cent (v/v) HCl. Ten per cent of the daily urine production was retained and stored separately for each goat in air-tight plastic bottle to determine nitrogen content. On the 28th day of the experiment, blood samples were drawn from each goat through a jugular vein puncture and collected in an all-plastic bottle to determine blood serum parameters.

TABLE 1

Composition of Basal Diet

Ingredient	*% composition of diet*
Ground maize grain	70
Rice bran	27
Salt: bone meal (1:1)	3
Analyzed components	
Crude protein	8.4
Crude fibre	23.1
Ether extract	3.8
Ash	8.6
Gross energy (Kcal/gDM)	4.8

Calculated mineral composition[1]
Major minerals (g/100 g): Ca, 0.48; P, 0.29
Trace minerals (mg/100 g): Mn, 42.80; Zn, 27.10; Cu, 6.60; Fe, 46.42; Ni, 0.03
Source: NRC (1985)

Chemical analyses

The diet, faeces and urine samples were analyzed for crude protein by the micro-kjeldahl procedure (AOAC, 1980). Gross energy of diet was determined in a Gallenkamp ballistic bomb calorimeter with benzoic acid as standard. Serum total protein concentration was estimated by the Biuret method (Weichselbaum, 1946), while serum urea-nitrogen and glucose concentrations were measured by the Urease and Benedict methods, respectively (Sigma Chemical Co., 1974).

Statistical analysis

The data were subjected to analysis of variance (Steel & Torrie, 1980). Treatment means were separated by Duncan's multiple range test (1955).

Results

Table 2 shows the data on average feed intake, body weight change, and efficiency of feed conversion. There were no significant (P>0.05) treatment effects on the feed intake and body weight responses of the goats. Both were, however, slightly higher for the goats on nickel-supplemented diets. Feed conversion efficiency also tended to be improved (P>0.05) by adding nickel to the control diet.

TABLE 2

*Effect of Dietary Nickel Supplements on Performance Characteristics in the Goats**

Parameter	*Control*	*$NiSO_4.6H_2O$*	*Ni-SMFP*
Initial live weight, kg	7.55 ± 0.41	7.43 ± 0.70	7.85 ± 0.52
Final live weight, kg	8.47 ± 0.52	8.40 ± 0.63	8.86 ± 0.61
Total weight gain, kg	0.92 ± 0.11	0.97 ± 0.37	1.00 ± 0.12
Daily weight gain, g	32.86 ± 1.91	34.64 ± 0.64	35.71 ± 0.77
Daily feed intake, g	209.10 ± 1.91	215.95 ± 1.73	220.13 ± 0.28
Efficiency of feed conversion (feed: gain)	6.36 ± 0.54	6.23 ± 0.68	6.16 ± 0.47

*Values are the means of four goats ± standard error of mean

The influence of the dietary nickel-supplements on parameters monitored for nitrogen metabolism (Table 3) were not significant (P>0.05). The values for nitrogen digested and nitrogen balance were only slightly (P>0.05) lower for the goats on the unsupplemented (control) diet. Serum urea-nitrogen content was significantly (P<0.05) raised by the effects of nickel-sodium monofluorophosphate supplement, but serum total protein concentration was unaffected. The effects of the nickel supplements on serum glucose concentration showed no definite pattern.

TABLE 3

*Effects of Dietary Nickel Supplements on Nitrogen Metabolism and Serum Parameters in the Goats**

Item	*Control*	*$NiSO_4.6H_2O$*	*Ni-SMFP*
Nitrogen metabolism (g/d)			
Nitrogen intake	2.57 ± 0.07	2.65 ± 0.11	2.70 ± 0.08
Feacal nitrogen excretion	0.97 ± 0.04	0.99 ± 0.05	0.88 ± 0.05
Urinary nitrogen excretion	0.79 ± 0.04	0.78 ± 0.06	0.80 ± 0.05
Nitrogen digested	1.62 ± 0.06	1.16 ± 0.11	1.82 ± 0.08
Nitrogen balance	0.83 ± 0.06	0.88 ± 0.12	1.02 ± 0.08
Nitrogen utilization coefficient (%)			
Intake	32.30 ± 0.86	32.21 ± 1.02	37.78 ± 1.01
Digested	51.23 ± 0.96	53.01 ± 0.88	56.04 ± 1.02
Serum parameter (mg/100 ml)			
Urea nitrogen	2.60 ± 0.26	2.95 ± 0.22	3.05 ± 0.27
Total nitrogen	4.35 ± 0.20	4.40 ± 0.36	4.45 ± 0.30
Glucose	63.25 ± 0.93	63.10 ± 0.68	62.80 ±0.55

*Values are the means of four goats ± standard error of mean

Discussion

The goats on nickel-supplemented diets tended to consume more feed and gain more weight than those on the control diet. A similar response to dietary nickel supplement has been reported in lambs (Spears *et al.*, 1978). Anke *et al.* (1974) had a significant increase in body weight gain of goats fed a corn - based diet that was supplemented with nickel at 10 ppm level. Although positive body weight response to a 5-ppm dietary nickel supplement was also reported in lambs (Spears *et al.*, 1979), the mineral requirements of breeds of animals from the tropics could be higher than those of the temperate breeds which provided the base-line information for this study.

The tendency for increased nitrogen retention in the goats receiving nickel supplements with a corresponding tendency to gain in live weight suggests a relatively better use of dietary protein. The high serum urea-nitrogen concentration recorded for goats on the nickel-sodium monofluoro-phosphate supplemented diet is unexpected, as nickel has been reported (Houpt, 1970) to facilitate the transfer of urea-nitrogen from blood to the rumen. Blood plasma and saliva are the two major sources of endogenous urea that is recycled to the rumen (Spears *et al.*, 1979). However, Nolan & Stachiv (1979) noted that plasma urea entering the rumen of sheep on straw-based (low-protein) diet were relatively small. The data on serum total and glucose concentrations in the three groups were similar and agreed with findings from earlier studies (Spear *et al.*, 1978, 1979).

It was concluded that although their effects were insignificant, the two nickel supplements tended to improve the use of a low-nitrogen, corn-based diet in the goats.

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