Evaluation of mineral status in feed resources and effects of supplementation to farm animals in northern Ghana

N. KARBO, A. ADDO-KWAFO & J. BRUCE
CSIR-Animal Research Institute, Nyankpala Station, P. O. Box 52, Tamale, Ghana

ABSTRACT

A survey was conducted on the mineral concentration of available feed resources at three locations in the northern Guinea Savannah Zone between 1992 and 1997. The feeds were categorized into cereal crop residues, legume crop residues, grass forages, legume forages, and legume browse and agro-industrial by-products. Experiments carried out involved balanced groups (age, sex and breed) of sheep using some of such forages and with or without access to commercial mineral licks. The animals were monitored for any changes in their live weight performance. Dry matter (DM) intake by sheep of supplementary fed rice straw was also determined. Average concentration of calcium (Ca) in the feed samples surveyed was highest in the browse forages (1.21%) and legume forages (1.13%). The lowest was recorded for the agro-industrial by-product (0.20%). However, phosphorus (P) was highest (1.6%) in the browse forages compared to that recorded in the cereal crop residues (0.06%). Copper (Cu) levels of 2.57, 7.1, and 7.6 mg kg^{-1} DM were observed for cereal forages, legume crop residues, legume forages and browse forages, respectively. The cereal crop residues contained 40.7 mg kg^{-1} of zinc (Zn) compared to 24.33 mg kg^{-1} in the browse forages. Manganese (Mn) concentration was 97.5, 143.3, 163.7, 231.4, 271.2, and 314.4 mg kg^{-1} DM for agro-industrial by-products, browse forages, grass forages, legume crop residues, forage legumes, and cereal crop residues in that order. Sheep exposed to commercial mineral lick consumed 4.7-8.0 g $head^{-1}$ day^{-1}. However, total supplementary rice straw intake was 7.0 per cent lower in animals on mineral lick. Sheep in the study generally consumed 13.5 per cent more of straw in the dry season (November-February) compared to the wet season (July -October). Sheep on natural grazing in the dry season and supplemented with rice straw with or without mineral lick gained 65.5 and 63.7 g $head^{-1}$ day^{-1}, respectively. A significantly (P< 0.001) lower daily gain of 26.7 g $head^{-1}$ was recorded for sheep grazing natural pasture without any form of supplementation.

RÉSUMÉ

KARBO, N., ADDO-KWAFO, A. & BRUCE, J.: *Evaluation de la condition minérale dans les resources alimentaires et les effets de régime complémentaire sur les animaux d'élevage dans le nord du Ghana.* Une étude sur la concentration minérale de resources alimentaires disponibles à trois emplacements dans la zone savanne-guineenne du nord était menée entre les années 1992 et 1997. Les régimes étaient classés par catégories en résidues de culture céréales, résidues de culture légumineuse, fourrage végétal, fourrage légumineuse et brout légumineuse et les sous-produits d'agro-industries. Des expériences comprenant les groupes équilibrés (âge, sexe et espèce) de moutons utilisants certains de ce fourrage et avec ou sans accès au léchage de minéral commercial étaient conduites. Les animaux étaient surveillés pour tout changement dans leur performance de poids vif. La matière sèche (MS) de la paille du riz de régime complémentaire consommée par les moutons était également déterminee. La concentration moyenne de calcium (Ca) dans les échantillons alimentaires étudiés étaient les plus élevés dans les fourrages de brout (1.21%) et les fourrages légumineuses (1.13%). La plus basse était notée pour le sous-produit d'agro-industrie (0.20%). Cependant, le phosphore (P) était le plus élevé (1.6) dans le fourrage de brout comparé à ce qui est noté pour les residues de culture céreale (0.06%). Les niveaux de cuivre (Cu) de 2.57, 7.1 et 7.6 mg kg^{-1} (MS) étaient observés respectivement pour les fourrages de céréales, les residues de culture céréale, les fourrages légumineuses et les fourrages de brout. Les résidues de culture céréale avaient 40.7 mg kg^{-1} de zinc (Zn) en comparaison de 24.33 mg kg^{-1} dans le fourrage de brout. La concentration de manganèse était 97.5, 143.3, 163.7, 231.4, 271.2 et 314.4 mg kg^{-1} MS pour les sous-produits d'agro-industrie, le fourrage de brout, le fourrage végétal, le résidue de culture légumineuse, le fourrage légumineuse et le résidue de culture céréale dans cet ordre logique. Les moutons exposés au léchage de minéral commercial consommaient 4.7-8.0 g $tête^{-1}$ $jour^{-1}$. La consommation totale de la paille du riz complémentaire était toutefois 7.0% plus faible dans les animaux mis sur le léchage de minéral. Les moutons de l'étude consommaient dans l'ensemble 13.5% plus de paille dans la saison sèche (Novembre-Février) en comparaison de la saison des pluies (Juillet-Octobre). Les moutons mis sur le pâturage naturel dans la saison sèche et complémenté avec la paille du riz avec ou sans le léchage minéral avaient pris de poids de 65.5 et 63.7 g tête^{-1} jour^{-1} respectivement. Une prise de poids quotidienne considérablement (P<0. 001) plus faible de 26.7 g tête^{-1} était noté pour les moutons mis sur le pâturage naturel sans aucune sorte de régime complémentaire.

Original scientific paper. Received 20 Nov 98; revised 18 Oct 07.

Introduction

During the nearly 120 years of research and production achievements in the area of world or global zootechnical science, the need to provide adequate levels of energy, protein, minerals and vitamins in the diets of farm animals to ensure good health and increased productivity has been well explained. Particularly for the minerals and vitamins, though known not to be sources of energy or protein, they play very important roles in the metabolic processes and immune or defense systems in the body of animals (Maynard & Loosli, 1956; Georgievski, 1979; Underwood, 1981; McDowell, Conrad & Loosli, 1983). Suffice it to say that there is no known single chemical reaction in the body in which minerals are not involved. They are present in body fluids and are responsible for the *p*H, buffers and osmotic balances as well as in enzyme systems, hormones and tissues, especially the bones.

In spite of all this, research and development in ruminant mineral nutrition since the pre- and post-independence times seem not to have received the needed attention for technical and socio-economic advancement of the industry in Ghana. In the farming systems of the northern Guinea Savannah Zone where over 75 and 45 per cent of the country's population of cattle and small ruminants, respectively, reside (Otchere, Karbo & Bruce,1997), there is a large vacuum of information on macro- (Ca, P, Mg, Na, K) and micro-mineral (Zn, Cu, Mn, I, etc.) concentrations in the feed sources on which the animals largely depend for their growth and production.

The farming systems in the zone are subject to changes due to increasing human population pressure and the need to put more land under arable cropping. The changes could still be more drastic in the 21st century with increasing urbanization and as smallholder crop-livestock producers become more market oriented. New crop varieties and livestock breeds are being introduced into the farming systems, every now and then. In line with this, livestock rearing systems will, therefore, change toward intensification.

The extensive grazing management systems observed in the zone will shift toward more intensive restricted grazing, complete confinement with 'cut and carry' or strategic feed supplementation or both. All these changing systems will definitely affect any mineral balance in the soil-herbage-animal relationship.

The need, therefore, is to keep track and periodically evaluate the mineral levels in aspects of the farming systems.

The objective of this study was to provide the needed baseline information on the mineral status of available feed resources used in feeding ruminants in the zone, and to determine the need for any mineral supplementation for improved production.

Materials and methods

Study location

The main areas of the study covered Tamale, Savelugu and Nyankpala in the Northern Region. Situated about 250 m above sea level, the climate is generally described as sub-humid savanna. The average annual rainfall is about 1100 m. The rains start in April/May with a peak in August/ September and ends in October. The rest of the months in the year experience dry weather conditions.

The soils in this zone are formed from the Voltaian Basin parent material and consist mainly of sand and stones. Three soil types have been described, namely sedentary soils of the summit and upper slope sites, colluvial soils of middle to lower slopes, and alluvial-colluvial soils on depressional and valley bottoms (Halm & Asiamah, 1992). The colluvial soils are most extensively used for crop and livestock production.

The farming system of the zone is largely characterized by a sedentary mixed smallholder crop-livestock system. Compound farms and bush farms exist. The crops grown include maize, sorghum, rice, millet, cassava, yam, groundnuts, cowpea, cotton, and soybean. Cattle, sheep and goats are the ruminant animal species kept under semi-intensive systems of management. The natural pasture-grazing areas in the study locations are on the decline because of increased cropping and urban development pressure.

Feed collection and analysis

Feed samples under the categories of crop residues and agro-industrial by-products were collected for chemical analysis during visits to farms in which such feeds were tested in diets for dry season feeding strategies. Most forage grasses were harvested from plots as straw after they had senescence. The legumes were also harvested from plots on the Nyankpala station at the end of the growing season. All the samples were analyzed for crude protein (CP) and minerals at the Chemistry Laboratory of the CSIR-Savanna Agricultural Research Institute, Nyankpala. The Kjeldahl method was used to determine nitrogen for the CP computation. The macro- and micro-mineral levels were determined using the Atomic Absorption Spectrophotometer (AAS).

Information from secondary sources on the mineral levels of feed resources in the stated categories in the zone was also collected for this study. A total of 20 feeds characterized as crop residues, agro-industrial by-products, forage (grasses and legumes), and browse legumes were analyzed for CP, calcium (Ca), phosphorous (P), potassium (K), sodium (Na), manganese (Mn), zinc (Zn), copper (Cu), and iron (Fe).

Mineral lick supplementation to sheep

Two feed experiments involving sheep were used to test the null hypothesis that such animals kept under semi-intensive management conditions in the zone will not respond in live weight performance to supplementary commercial mineral lick exposure. The mineral lick (Peter Hand GB Ltd, England) contained 96 per cent salt, 1 per cent Fe, 340 mg kg^{-1} Mn, 80 mg kg^{-1} Cu, 460 mg kg^{-1} Zn, and 98 mg kg^{-1} I. In Experiment 1, six Djallonke weaners on rice straw basal diet were put into two equal groups, 11-11.3 kg initial weight, and used in a mineral or no mineral supplementation trial for 180 days.

In another trial, which lasted 80 days, 30 weaned lambs of Djallonke × Sahel crosses with an average weight of 15.3 kg were put into three balanced (sex, weight) groups of 10 and randomly allotted to one of the following treatments: sheep grazing on natural pasture 3-4 h with roughage (rice straw) plus cottonseed and mineral lick supplementation, sheep on pasture 3-4 h with only roughage and cottonseed supplementation, and sheep on pasture 7-8 h without any type of supplementation. Before the start of experiment, all animals were dewormed and washed with an acaricide. The supplements were provided in the individual pens and animals had free access to them before and after grazing. Initial body weights of animals were taken and subsequent weight change was monitored fortnightly using a Salter scale.

The supplemental feed and mineral lick intake was monitored during the experimental period. Feed leftovers were weighed daily for 3 consecutive days and the average subtracted from the quantity offered to determine the quantity consumed.

Analysis of data

The simple arithmetic means of data for mineral concentrations in the available feeds were calculated and given descriptive analysis; thus, comparing the various fodder categories in the zone. Furthermore, mineral concentrations in feeds were compared with values from secondary sources on the recommended standard values in similar zones to judge for excess, normal, or sub-normal levels in animal requirements.

For the data on supplementation, a unifactor experiment arranged in a completely randomized design was assumed, with each animal considered as an experimental unit. The supplemental roughage intake and live weight changes were subjected to ANOV A (Dospekhov, 1984).

Results

Crude protein (CP), macro- and micro-mineral concentrations

Tables 1 and 2 present the concentrations of crude protein, macro- and micro-minerals in the available feed sources for ruminants in the study location. Average crude protein levels were different for the various categories of feeds and were in the graded order of browse forage> agro-industrial by-products> forage legumes> legume crop residues> grass forages> cereal crop residues. Among the agro-industrial by-products, dry cassava peels recorded the lowest CP (58.1 g kg^{-1} DM), but seemed superior when compared to feeds under grass forages or the cereal crop residues. The concentration of 230 g CP kg^{-1} DM in whole cottonseed compared favourably with that contained in the browse forages.

Calcium concentration in the feeds seemed good in minimum requirements by sheep. Of all the feedstuffs examined in this study, only 25 per cent showed Ca concentrations lower than 0.18 per cent DM. The browses and legumes had higher levels of Ca than the other categories. Phosphorus concentration in general was low, and 70 per cent of the sampled feeds recorded levels below 0.15 per cent DM. However, the browses, agro-industrial by-products and legumes provided better sources of P. The picture was critical for Na. Out of the 45 per cent of feeds analyzed for Na, 88.9 per cent had values far below the 0.04 per cent DM level. Sodium requirement by ruminants for body growth and milk production was 0.08-0.1 per cent of dry diet (Underwood, 1981). The high values of Ca recorded in the browses and legumes were not observed for Mg. Low (0.04% DM) values of Mg were recorded for feeds in these categories. Copper showed 30 per cent of the feeds studied to contain values below the requirement 5.0 mg kg^{-1} DM. However, the legume forages and cottonseed were good sources for Cu. Fifty-five per cent of the feeds studied showed Zn values above 20 mg kg^{-1} DM, the minimum required. All (100%) of the feeds studied had values well above 30 and 20 mg kg^{-1} DM for Mn and Fe, respectively.

Supplemental roughage-based diet intake by sheep

Sheep exposed to the commercial mineral lick blocks consumed on average 4.7-8.0 g $head^{-1}$ day^{-1}. Table 3 presents data on supplemental roughage (rice straw) consumption by Djallonke weaner rams exposed to mineral lick block or not.

Total supplementary rice straw intake was 7.0 per cent lower ($P > 0.05$) in Djallonke sheep exposed to mineral lick. Similar trend was observed with the Djallonke × Sahel crosses. Rice straw consumption on average was 16.7 per cent (212.5 vrs 248.1 g $head^{-1}$ day^{-1}) lower in crosses exposed to the lick in the dry season. Djallonke sheep in general showed the tendency to consume 13.5 per cent more straw in the dry season (November -February) compared to the wet season (July-October).

Live weight performance

Djallonke × Sahel weaner sheep on natural pasture for a limited time of the day (3- 4 h) in the dry season and receiving supplements of rice straw with or without mineral lick gained 65.5 and 63.9 g $head^{-1}$ day^{-1}, respectively. A significantly lower ($P < 0.001$) daily gain of 26.7 g $head^{-1}$ day^{-1} was recorded for their counterparts grazing natural pasture (7-8 h) without any form of supplementation (Table 4). Young Djallonke rams

TABLE 1

Protein and Macro-mineral Concentrations in Ruminant Feed Resources in Northern Ghana

Feed	*Crude protein % DM*	*Macro-mineral, % DM*				
		Ca	*P*	*K*	*Na*	*M*
Crop residue (cereal)						
Rice straw	3.38	0.22	0.06	2.08	ND	0.15
*Maize straw	2.88	0.03	0.08	1.15	ND	0.16
Sorghum stover	2.88	0.15	0.11	2.13	0.021	0.20
Average	3.05	0.13	0.08	1.79	0.021	0.17
Range	2.88-3.38	0.03-0.22	0.06-0.11	1.15-2.13	-	0.15-0.2
Crop residue (legumes)						
Groundnut haulm	14.13	1.31	0.13	1.74	0.013	0.74
Cajanus waste	8.38	0.72	0.07	ND	ND	0.03
Average	11.25	1.02	0.10	1.75	0.013	0.39
Range	8.38-14.13	0.72-1.31	0.07-0.13	-	-	0.03-0.74
Forage						
Andropogon tecterum	3.63	0.42	0.09	0.86	0.004	0.19
Digitaria	5.0	0.43	0.15	1.40	0.11	0.16
Hyparrhein rufa	2.75	0.23	0.05	0.69	0.008	0.16
Cenchrus ciliaris	2.57	0.16	0.09	0.78	ND	0.17
Average	3.48	0.31	0.10	0.93	0.041	0.17
Range	2.57-5.0	0.16-0.43	0.05-0.15	0.69-1.40	0.004-0.11	0.16-0.43
Forage (legumes)						
Stylosanthes hamata	9.68	1.19	0.07	0.50	0.0046	0.03
Stylosanthes guianensis	13.75	0.90	0.12	0.06	0.0036	0.03
Vigna unguiculata	14.94	1.77	0.13	0.85	0.07	0.05
Centrosema pubescens	13.88	1.26	0.12	0.48	0.0043	0.04
Average	13.06	1.13	0.11	0.47	0.021	0.04
Range	9.68-14.94	0.90-1.26	0.07-0.13	0.05-0.85	0.0036-0.07	0.03-0.05
Agro-industrial by-product						
Cassava peels	5.81	0.35	0.07	1.56	ND	0.01
Whole cotton	23.06	0.13	0.63	1.55	ND	0.39
Pito mash	13.25	0.11	0.30	ND	ND	ND
Average	14.04	0.2	0.33	1.56	-	0.2
Range	5.81-23.06	0.11-0.35	0.3-0.63	1.55-1.56	-	0.01-0.39
+ Browse (legumes)						
Sesbania sesban	24.88	1.89	1.87	ND	ND	0.03
Cajanus cajan	26.63	0.62	1.88	ND	ND	0.03
Leucaena leucocephala	18.69	1.82	1.13	ND	ND	0.06
Gliricidia sepium	23.06	1.18	1.50	ND	ND	0.04
Average	23.32	1.38	1.60	-	-	0.04
Range	18.69-26.63	0.62-1.89	1.13-1.88	-	-	0.03-0.06

* = SARI Lab., 1997 + Karbo, Barnes & Rudat (1996) ND = Not determined

TABLE 2

Micro-mineral Concentrations in Ruminant Feed Resources in Northern Ghana

Feed resource	*Micro-mineral, mg kg^{-1} DM*			
	Mn	*Zn*	*Cu*	*Fe*
Crop residue (cereal)				
Rice straw	828.4	95.7	9.9	713.0
*Maize stalk	34.47	9.81	ND	ND
Sorghum stover	80.33	16.53	ND	ND
Average	314.4	40.68	9.9	713.0
Range	34.47-828.4	9.81	-	-
Crop residue (legumes)				
Groundnut haulm	179.8	15.27	7.14	ND
Cajanus cajan	283.0	30.0	7.0	ND
Average	231.4	22.64	7.07	-
Range	179.8-283	15.27-30	7.0-7.14	-
Grass forage				
Andropogon tecterum	77.7	13.97	0.49	ND
Digitaria decumbens	333.74	15.56	1.69	ND
Hyperhenin rufa	ND	11. 64	1.5	ND
Cenchrus ciliaris	79.7	83.1	6.6	724.0
Average	163.7	31.07	2.57	724.0
Range	77.7-333.74	11.14-83.1	41.67-109.23	-
Forage (legumes)				
Stylosanthes hamata	145	23	Trace	243
Stylosanthes guianensis	289	13	10	860
Vigna unguiculata	385	60	10	601
Centrosema pubescens	268	40	10	540
Average	271.15	34	7.50	561
Range	145-385	13-60	Trace - 10	243-860
Agro-industrial by-product				
Cassava peels	155	30	Trace	383
Whole cottonseed	39.9	149	16.6	1153
Pito mash	ND	ND	ND	ND
Average	97.45	89.5	16.6	768
Range	39.9-155	30-149	Trace - 166	383-1153
+Browse (legumes)				
Sesbania sesban	268	36	7	430
Cajanus cajan	106	27	7	1106
Leucaena leucocephala	133	27	13	452
Gliricidia sepium	66	7	3	139
Average	143.25	24.25	7.5	531.75
Range	66-268	7.0-36.0	3-13	139-1106

* SARI Lab., 1997 + Karbo, Barnes & Rudat (1996) ND - Not determined

under a similar management system of 3-4 h grazing and receiving supplements of straw plus cottonseed with mineral lick initially returned in 90 days, 26.5 per cent more in average daily gain (47.8 vrs 37.8 g head^{-1} day^{-1}) compared to those on supplements without the mineral lick blocks. However, as the animals grew older (180 days) in experimentation, the superiority in weight gain reduced to 7.9 per cent (35.4 vrs 32.8 g head^{-1} day^{-1}).

There was no difference in total weight gain (2.2 ± 0.36 vrs 2.2 ± 0.34 kg) between young rams

TABLE 3

Average Roughage Consumption by Djallonke Sheep With or Without Mineral Lick Block Supplementation, g head^{-1} day^{-1}

Season	*Treatment**		
	- Mineral block	*+ Mineral block*	*Average*
Wet (July-October)	336.7 ± 22.6	352.5 ± 17.4	344.6
Dry (November-February)	394.2 ± 17.7	387.9 ± 26.8	391.1
Percentage change, %	17.1	10.0	-

* (-) = Without mineral lick
(+) = With mineral lick

TABLE 4

Effect of Roughage and/or Mineral Supplementation on Body Weights of Djallonke x Sahel Young Rams

Parameter	*Grazing only*	*Grazing + straw + cottonseed*	*Grazing + straw + cottonseed + mineral*
Number of animals, head	8	8	8
Initial av. live weight, kg	15.9±0.5	14.1±0.6	15.9±0.8
Final av. live weight, kg	18.1±0.6	19.4±0.6	21.4±0.8
Average body weight gain, kg head^{-1}	2.2±0.3^{a}	5.3±0.2^{b}	5.4±0.4^{b}
Average daily gain, g head^{-1}	26.7±3.1^{c}	63.9±2.6^{d}	65.5±5.1^{d}

a - d, Means in row with different superscripts are significantly different at P < 0.001

and gimmers grazing without any supplementation. However, there was the tendency for young rams that received supplements with or without mineral lick block to gain weight 27.0 per cent (6.1± 0.18 vrs 4.8 ±0.68 kg) and 12.0 per cent (5.6±0.18 vrs 5.0±0.32 kg), respectively, more than the gimmers (P > 0.05) under the same management systems.

Discussion

The observed heterogeneity in nutrient composition of the analyzed feedstuffs emphasizes the need for adopting multi-component diets for ruminants in the zone if requirements in protein and minerals are to be met in needed proportions for increased animal productivity. The differences (excesses or sub-normal) in forage nutrient concentrations have been attributed to the nature of soils in which plants are grown, climate, plant genus, species, varieties and agro-techniques (Reid &Horvath, 1980; Kabaija & Little, 1989).

Ruminants in the study area depend largely on crop residues and dry grass forages for their nutrient requirements for most part of the year in the dry season. However, these categories of feedstuffs in the study showed limited concentrations of essential elements such as N, P, Na and Cu in animal requirements (Kearl, 1982; McDowell *et al*., 1983). The CP content of 28-30 g kg^{-1} DM recorded needs supplementation. Topps (1993), therefore, indicates that the supplement should contain CP 230 g kg^{-1} DM or more to ensure that the diet contains at least 80 g CP kg^{-1} DM. The information from the chemical analysis suggests that the browses, forage legumes and whole cottonseed are favourites for supplementation to roughages. The browses sampled were found to be rich in most minerals and can provide adequate amounts of Ca, P, Mn and Fe, but not Mg (Tables 1 and 2). A major reliance on only browsing on range to

TABLE 5

Dry Season Growth Response by Sheep (Djallonke x Sahel) to Mineral Lick Supplementation in Northern Ghana

Group	*N*	*Final wt, kg*	*Initial wt, kg*	*Gain, kg*	*ADG, GM*
			Males		
No supplement	3	18.0	15.4	2.6	31.4
Straw supplement	4	18.75	13.4	5.35	64.45
Straw suppl. + min.	4	22.25	16.1	6.12	73.8
			Females		
No supplement	5	18.2	16.05	2.15	25.9
Straw supplement	6	20.33	14.48	5.85	70.5
Straw suppl. + min.	5	21.9	16.30	5.6	67.5
			Mixed sexes		
No supplement	8	18.1	15.8	2.3	28.1
Straw supplement	10	19.7	14.1	5.65	68.1
Straw suppl. + min.	9	22.1	16.2	5.8	70.2

supplement the diets of small ruminants may not favour sheep or cattle or both who are known to be grazers. A 'cut and carry' system as is practised in the zone may be most appropriate.

The browse trees or shrubs, because of their deep rooting systems, seem to act as mineral pumps, thereby vertically transporting from deep below ground minerals to the surface for the horizontal flows in the biogeochemical food chain. Reductions in the browse tree ecology in the zone, because of clearing for farming and other activities, could jeopardize the mineral requirements for herbaceous plants and subsequently in ruminant animals.

Forage legumes in the study showed marginal to deficient levels in only Na and Mg (Kearl, 1982). However, the low Mg in legumes, and not cereals, seems to contradict the indications by Underwood (1981). The introduction of forage legumes into the farming systems of the zone could serve as an important source for proteins and the micro-minerals, especially Cu and Mn, for all categories of ruminant animals. Sillanpaa (1982), who worked earlier in areas of southern Ghana, put the country among the international data system as deficient in Cu and Zn.

Sodium was limiting across the feedstuffs in this study, and the need to provide ruminants in the zone with common salt has been shown (Karbo, Alebeyika & Bruce, 1996). McDowell *et al.* (1983) observed that over 73 per cent of Latin American feeds sampled had borderline to deficient levels in P. Similar findings were observed in this study. Soil P in the zone is known to be low (Adu, 1957), and could partly account for the low plant P status. A low P soil and plant level in most tropical countries has been shown (McDowell *et al.*, 1983). Grain concentrates or seeds are known to provide sources for P. The analysis in this study indicates that cottonseed can provide P when supplemented to grazing animals.

Mineral nutrition in general has its complexities. The concentration of mineral nutrients in the plant or fodder is one thing; whether they are available to the animal optimally when ingested is another. Their synergistic and antagonistic interaction in the digestive tract and at the tissue level of metabolism has been observed (Georgievski *et al.*, 1979). Supplementation is, therefore, a difficult exercise including cost considerations, especially when the baseline levels of the minerals in the feeds or tissues of grazing animals are unknown. The analysis of blood plasma, hair and bone tissues could have presented a better picture for judgement on the mineral status (Khalili, Lindgren & Varvikko, 1993) and the need to appropriately provide supplements. Nevertheless, this study, besides the chemical analysis of the forages, also relied on the productive response of the animals to the mineral supplements for the purpose. Weaner lamb mortality (20%) during experimentation was recorded from the group on natural grazing without any form of supplementation. The observed slight body weight gains by sheep receiving mineral lick besides limited grazing with forage supplementation could have been influenced by the type of feed supplement. This study showed that rice straw and cottonseed as supplements contained higher levels of Cu, Mn, Fe and Zn, but not Na. The commercial lick additionally provided these minerals, except Cu which was absent. Though there was reduction ($P > 0.05$) in straw consumption by animals with access to the commercial lick, the slight improvement in weight gain and general body condition of sheep could suggest improved rumen function, leading to better digestibility and absorption of nutrients from the roughages.

The response of animals to mineral supplements for meat production is low compared to dairy animals (Davies & Chandrasekaran, 1980; Karbo, 1988).

The high tendency for young Djallonke × Sahel rams to respond better in weight gains than their counterpart gimmers with access to commercial lick in the study could not be explained immediately. However, the indications or implications are that the use of mineral licks in the zone could be strategized or stratified along sex, type and breed of recipient animal, as well as the basal supplementary diet provided to enhance its efficient use.

Conclusion

In the farming systems of the northern Guinea Savannah Zone, dry season grazing management of sheep will require some level of feed supplementation for better animal growth performance. Some mineral inadequacies, especially Na, P, Mg and Cu observed in the common feeds need to be corrected by feeding common salt and other feeds rich in these elements for improved animal health and growth performance.

Acknowledgement

This study forms part of the Animal-Based Farming Systems project on protein and mineral supplementation under the National Agricultural Research Project (NARP).

REFERENCES

Adu, S. V. (1957) *Report on the detailed soil survey of Central Agricultural Station, Nyankpala*. SRI, Kwadaso.

Davies, H. L. & **Chandrasekaran, M.** (1980) Investigations on the effects of copper, cobalt and phosphorus on the growth and grazing Hereford cattle in Coastal New South Wales. *7th Proc. Australia Soc. Anim. Production, Sydney* **13**, 217 - 220.

Dospekhov, B. A. (1984) *Field experimentation*. Statistical procedures. Mir Publishers. 349 pp.

Georgievski, V. I., Annenkov, B. N. & **Samokhin, V. T.** (1979) *Mineral nutrition of animals*. M. Kolos. 471 pp.

Halm, A. T. & **Asiamah, R. D.** (1992) Soil erosion in savannah zone of Ghana. In *Improving farming systems in the interior savannah zone of Ghana* (ed. D. K. Acquaye and NAES). Nyankpala Agricultural Research Reports (8). pp.179-188.

Kabaija, E. & **Little, D. A.** (1987) Potential of agricultural by-products as source of mineral nutrients in ruminant diets. In *Overcoming constraints to the efficient utilization of agricultural by-products as animal feed* (ed. A. N. S. and R. H. Dzowela). Proc. 4th Annual Workshop of ARNAB, Institute of Anim. Res., Nankon Station, Bamenda, Cameroun, 20-27 October 1987.

Karbo, N. (1988) *The peculiarities of mineral nutrition in ruminant animals* (PhD Thesis). Moscow Agricultural Academy, Moscow, USST (Russian).

Karbo, N., Alebeyika, M. & **Bruce, J.** (1996) *Effect of feeding a locally composed salt lick to small ruminants under village management systems in northern Ghana.* ACDEP-AIS collaborative On-farm Adaptive Research, Tamale, Ghana.

Karbo, N., Barnes, P. & **Rudat, H.** (1996) Evaluation of browse forage preferability by sheep and goats in the Northern Guinea Savannah Zone of Ghana. *Bull. Anim. Prod. Afr.* 225-230.

Kearl, L.C. (1982) *Nutrient requirements for ruminants in developing countries*. International

Feedstuff Institute, Utah Agricultural Experiment Station, Utah State University, Logan, Utah 84322, USA.

Khalili, M., Lindgren, E. & **Varvikko, T.** (1993) A survey of mineral status of soils, feeds and cattle in Selale Ethiopian Highlands. I. Macro-elements. *Trop. Anim. Hlth Prod.* **25,** 162-172.

Maynard, L. A. & **Loosli** (1956) *Anim. Nutr.*, 4th edn. Library of Congress Catalog Card No. 55- 12109.

Mc Dowell, L. R., Conrad, J. H., G. L. & **Loosli, J. K.** (1983) *Minerals for grazing ruminants in tropical regions*. Bulletin. Library of Congress Catalog Card No. 84 - 70238.

Otchere, E. O., Karbo, N. & **Bruce, J.** (1997**)** Cattle rearing in Northern Region of Ghana: A case study. In *Visite d'etude sur les systemes d'elevage dan les zones humides et subhumides d'Afrique* (ed. G. Van Vlaenderen). CTA.

Reid, R. L. & **Horvath, D. J.** (1980) Soil chemistry and mineral problems in farm livestock: A review. *Anim. Feed Sci. Technol.* **5**(2), 95-167.

Sillanpaa, M. (1982) *Micronutrients and the nutrient status of soils: A global study*. FAO Soils Bull. Rome. **48**, 355-361.

Underwood, E. J. (1981) *The mineral nutrition of livestock*, 2nd edn. Commonwealth Agricultural Bureau. Slough-England. 180 pp.