ISSN 1819-1878

Asian Journal of Animal Sciences

Knowledgia
SCIENTIFIC
A Place to Publish Outstanding Research

http://knowledgiascientific.com

Asian Journal of Animal Sciences 6 (6): 263-277, 2012
ISSN 1819-1878 / DOI: 10.3923/ajas.2012.263.277

Performance of Grazing West African Dwarf Goats on Moringa Multinutrient Block Supplementation

[1]V.O. Asaolu, [2]J.A. Akinlade, [2]O.A. Aderinola, [2]A.T. Okewoye and [2]J.A. Alalade
[1]Department of Animal Nutrition and Biotechnology, [2]Department of Animal Production and Health, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

Corresponding Author: V.O. Asaolu, Department of Animal Nutrition and Biotechnology, Faculty of Agricultural Sciences, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Oyo, Nigeria

ABSTRACT

The performance of grazing West African Dwarf (WAD) goats on Moringa Multi Nutrient Block (MMNB) supplementation was assessed relative to cassava peels (CPL) and corn starch residues (CSR), using a complete randomized design with four replicates per treatment. Performance indices were supplement intake and experimental animals' weight and haematological changes. Statistical ($p<0.05$) differences were observed in supplement intakes, which were 11.08, 23.61 and 34.53 g^{-1} $kg^{0.75}$ for MMNB, CPL and CSR respectively. MMNB however had higher nutrient contents. Weight changes were positive across treatments. Mean weight gain for animals on MMNB supplementation (38.10 g day^{-1}) was however significantly ($p<0.05$) higher than those of the animals on the reference supplements, which showed no statistical ($p>0.05$) difference. Only MMNB supplementation resulted in a significant ($p<0.05$) increase in Packed Cell Volume (PCV) at the end of the study although all values fell within the range considered normal for clinically-healthy WAD goats. Each of the three supplements resulted in significant ($p<0.05$) increases in Haemoglobin (Hb) and Red Blood Cell (RBC) counts, although the magnitudes of the increases were most pronounced with MMNB. Animals on CSR maintained relatively comparable levels of WBC at both the commencement and end of the study. However, CPL supplementation resulted in higher ($p<0.05$) WBC values at the end of the study whereas MMNB supplementation resulted in corresponding lower ($p<0.05$) values. Hence, adoption of the MMNB feeding technology by small ruminant keepers could be a panacea to the nutritional and health hardships faced by the animals during the usually long dry season.

Key words: *Moringa oleifera,* multinutrient blocks, grazing WAD goats, corn starch residues, cassava peels

INTRODUCTION

Domesticated goats (*Capra hircus*) play a significant role in providing animal protein for the human population and they are found generally in every region of the world (Akinsoyinu, 1985). Goat meat is healthy and nutritious and is exceptionally low in fat and calories compared with other meats (Celik *et al*., 2003). The West African Dwarf (WAD) goat is the commonest and most important indigenous goat breed in eighteen countries of West and Central Africa (ILCA, 1987). Nigeria hosts the largest WAD goat population with approximately 11 million in the humid zone of Eastern Nigeria (Chiejina and Behnke, 2011). They are generally kept in small herds on mixed farms, usually by women and children within rural households and provide their owners with a broad range of products and socio-economic services such as cash income, security, gifts and manure for their crops (Peacock, 1996; Chiejina and Behnke, 2011). In South West Nigeria, they are used for customary rites and religious purposes in addition to meat production (Odeyinka and Ajayi, 2004). Any intervention aiming to improve goat productivity will, therefore, have an immediate socio-economic impact on rural communities, especially the poorest of these, for whom goats represent the only livestock they can afford to raise (Chiejina and Behnke, 2011).

Feed shortage poses a major constraint to goat production in Nigeria (Belewu *et al*., 2007; Ahamefule and Elendu, 2010). Even where fodder resources abound, seasonal fluctuations in nutritive value make sustainable gains in production from good management and disease control programs unrealistic (Alli-Balogun *et al*., 2003). The crude protein contents of principal forages such as gamba (*Andropogon gayanus*) and guinea grasses (*Panicum maximum*) fall to as low as 2% for the most part of the dry season, alongside reduced mineral and energy contents (Leng, 1989; Pond *et al*., 1995). In addition, the crop residues and agro-industrial by-products that are used in supplementing these principal forages during the usually extended dry season are usually fibrous, low in digestibility and devoid of most essential nutrients which are required for increased rumen microbial fermentation and improved performance of the host animal (Osuji *et al*., 1995; Lanyasunya *et al*., 2006). The resultant effects, as widely acknowledged, are reduced intake and digestibility of dry matter and productivity of the animals. There is thus the need to search for and utilize other alternative low cost feeds for ruminants at such critical periods (Ngi *et al*., 2006). The roles and limitations of feed supplementation strategies with concentrate mixtures, mineral and vitamin supplements as well as the use of leaves of fodder trees have already been highlighted by Asaolu (2012). Formulation and utilization of multinutrient blocks based on low cost and locally available feed resources have been described as very promising by Makkar (2007) in this regard.

Multinutrient blocks represent a vast reservoir of cheap nutrients, particularly for ruminants (Hendratno *et al*., 1989) and they have been advocated as a panacea to the protein and energy deficiencies in ruminants, especially during the extended dry season (Onwuka, 1999). Although the first systematic trial on the use of multinutrient blocks was reportedly (Sansoucy and Hassoun, 2007) conducted in South Africa in 1960, the use of such blocks was recorded as early as the 1930s (Ben Salem *et al*., 2007). During the early periods, the blocks contained only urea and salts. Later, addition of molasses and minerals occurred (Makkar, 2007). Urea-molasses multinutrient blocks provide a readily available source of energy in the form of molasses, nitrogen (both from protein and non-protein sources), fibre and minerals (Saddul and Boodoo, 2001). However, the unavailability of molasses, which constitutes between 40 and 50% of the molasses-urea blocks, in many local areas where sugarcane cultivation is practically non-existent, has been the major limiting factor to their adoption and utilization by smallholders in these areas (Habib, 2004). Makkar (2007) reported that in the early 1980s, with the realization of the significance of the blocks for smallholders in developing countries, work on simplification of block technology gained momentum. The Joint FAO/IAEA Division, FAO and UNDP thereafter promoted various forms of the multinutrient block technology, with and without molasses, in many Asian, African and Latin American countries (Hadjipanayiotou *et al*., 1993; Makkar, 2007).

Although, the use of multinutrient blocks as supplements to poor-quality basal diets for ruminants is relatively new in Nigeria (Mohammed *et al*., 2007), pioneering research efforts on multinutrient block formulation and utilization in Nigeria include those of Onwuka (1999), Mohammed *et al*. (2007) as well as Aye and Adegun (2010). Asaolu (2012) reported on the development of moringa multinutrient blocks as dry season feed supplements for ruminants. The most desirable moringa multinutrient blocks were produced from a formula containing 37.0% wheat offals and 35.0% moringa leaf powder with cement inclusion at 15.0% as the binder. Lime powder, urea and salt inclusion levels were 5.00% each. The crude protein and predicted metabolizable energy contents were relatively high, with the contents of the analyzed minerals being higher than the critical levels for goats.

Cassava peel is an important by-product available from the processing of cassava (*Manihot esculentus*) root for food uses and starch and has been used in feeding various classes of livestock (Akinfala and Tewe, 2004). Corn starch residue is a by-product in the local production of corn pap from corn/maize (*Zea mays*) and has been found (Odeyinka *et al*., 2003) as an effective replacement for groundnut cake and bran in the diet of WAD goats. This study was therefore designed to assess the performance of grazing WAD goats on moringa multinutrient block supplementation, with cassava peels and corn starch residues as reference supplements. Performance indices were intakes of the supplements, weight changes of experimental animals as well as changes in their haematological parameters.

MATERIALS AND METHODS

Experimental site: The study was carried out at the Teaching and Research Farm of the Ladoke Akintola University of Technology, Ogbomoso, Oyo State, in the south western part of Nigeria, between the third week of March and late May 2011. Ogbomoso has a maximum temperature of 33°C and a minimum temperature of 28°C. The humidity of the area is high (74%) all year round except in January, when the dry wind blows from the north and the annual rainfall is over 1000 mm (Olaniyi, 2006).

Procurement and preparation of the supplements: Fresh cassava peels were collected from a garri processing plant at Iluju, a location within 20 km radius of the University campus. They were subsequently air-dried to constant weight between 5 and 8 days, depending on the prevailing weather conditions. Dried corn starch residues were sourced from women processors of corn pap (locally called “ogi”); a wet, starchy, breakfast gruel prepared from fermented, wet milled maize/corn at the household level (Odeyinka *et al*., 2003). Moringa multinutrient blocks were prepared from 37% wheat offals, 35% moringa leaf powder, 15% cement; with 5% inclusion levels each of lime, urea and salt as described by Asaolu (2012).

Animals and their management: Twelve WAD growing goats (6 males and 6 females; 6.9±0.3 kg) were purchased, neck-tagged and quarantined for 3 weeks. During this period, oxytetracycline and a multivitamin preparation were administered at the rate of 1 mL/10 kg b.wt. through intramuscular route for prophylactic treatment. Ivermectin was also administered subcutaneously at the rate of 0.2 mL per 10 kg b.wt. against external and internal parasites. The animals were grazed for about 5 h daily from about 10.00 a.m. until around 3.00 p.m. and subsequently had a free choice access to cassava peels, corn starch residues and moringa multinutrient blocks till the following morning. In order to avoid the possibility of mating, the males and females were grazed separately and they were also group-fed based on sex till the following morning. The animals were thereafter grouped into 3 of 4 goats each, balanced for weight and sex and allotted to three feeding regimes in a six-week feeding trial using a complete randomized design with four replicates per treatment. All the animals were allowed to graze between the hours of 10.00 a.m. and 3.00 p.m. after which they were brought into individual pens equipped with feeding and watering facilities. The goats in groups 1, 2 and 3 were offered cassava peels, corn starch residues and moringa multinutrient blocks respectively as supplements *ad libitum* from around 3.00 pm till the following morning, after which the refusals were measured to determine the daily supplements' intakes. Each moringa multinutrient block, when freshly-supplied, weighed 1.00±0.05 kg and was replaced when the refusal weighed 0.20±0.05 kg. All the animals were allowed to adapt to the pens and feeding regimes for 14 days prior to the commencement of the study. Fresh and clean water was made permanently available to the animals in their pens.

A paddock at the University's Teaching and Research Farm planted to *Panicum maximum* cv. Ntchisi was used for animal grazing. It was cut back in March 2011 and divided into two equal parts to allow for separate grazing of the male and female animals. A re-growth period of six weeks was allowed before the commencement of the study.

Performance measurements and procedures: The experimental animals were weighed at the commencement of the study and subsequently weekly throughout the duration of the study between 9.00 am and 9.30 am, before releasing them for the day's grazing. The weight data were regressed against time to obtain the growth rates. Dry matter and nutrient intakes from the supplements were computed from the daily total intakes. Blood samples for haematological studies were collected at the beginning and at the end of the trial. Blood samples were collected from the jugular vein of each of the animals using sterilized needles and syringe. About 3 mL was collected into plastic bottles, containing an anticoagulant {Ethylenediaminetetraacetic Acid (EDTA)}, for haematological evaluation. The bottles were immediately capped and the contents agitated gently for about a minute by repeated inversion or rocking. Packed Cell Volume (PCV) was determined by the micro-haematocrit method as described by Schalm *et al.* (1975) and Dacie and Lewis (1984). Erythrocytes (RBC) were counted using the improved Neubauer haemocytometer (Dacie and Lewis, 1984). Haemoglobin concentration (Hb) and Leucocytes counts (WBC) were determined as described by Jain (1986).

Chemical analyses: Samples of *Panicum maximum* forage from the experimental paddocks were randomly collected at the beginning, mid-way through and at the end of the study, dried and pooled together. They were subsequently ground with a hammer mill to pass through a 2 mm mesh and sampled for proximate contents using the standard methods of AOAC (2000). Dried samples of cassava peels and corn starch residues were also sampled for proximate contents using the same procedures. About 50 g representative samples from three randomly selected multinutrient blocks at the commencement of, mid-way through and at the end of the study respectively, were separately pulverized, pooled together and sampled for their respective proximate contents, also using the standard methods of AOAC (2000). Metabolizable Energy (ME) values of the feed supplements (cassava peels, corn starch residues and moringa multinutrient blocks) and the basal *P. maximum* forage were predicted from the equations of Abate and Meyer (1997); $\text{ME (MJ kg}^{-1}\text{ DM)} = 5.34-0.1365\text{ CF}+0.6926\text{ NFE}-0.0152\text{ NFE}^2+0.0001\text{ NFE}^3$ and $\text{ME (MJ kg}^{-1}\text{ DM)} = 8.11+0.1341\text{ CP}-0.1065\text{ ASH}$, respectively.

Statistical analyses: Weight and supplement intake data were subjected to analysis of variance using the general linear model of SAS (1998). Significant differences between means were separated using the Duncan's New Multiple Range Test of the same package. Haematological indices at the commencement and the completion of the study for each treatment were compared using the students' t-test of SAS (1998).

RESULTS

Ingredient and nutrient compositions of experimental supplements: Table 1 shows the ingredient composition of the moringa multinutrient blocks that were used in the study. Wheat offals and moringa leaf powder were the major ingredients at 37 and 33% levels of inclusion respectively. Each of the other ingredients (lime powder, urea and salt) was used at 5% inclusion level, while cement was used as a binder at 15 % inclusion level. The nutrient compositions of the experimental supplements were as contained in Table 2. The crude protein contents ranged from 5.63 to 20.60% for cassava peels and moringa multinutrient blocks, respectively with *Panicum maximum* and corn starch residue containing around 10 % crude protein. Predicted ME (MJ kg^{-1} DM) appeared comparable for corn starch residues and moringa multinutrient blocks with corresponding values of 14.32 and 14.40, while it was least for *Panicum maximum* (8.24). Crude fibre was however highest in *Panicum maximum* (35.50%) while it was almost negligible in corn starch residue (1.50 %) with moringa multinutrient blocks containing a rather moderate level (5.07%). Total ash was highest for moringa multinutrient blocks (29.80%) while it was least for cassava peels (4.86%) with corresponding values of 7.67 and 10.40% for corn starch residue and *Panicum maximum,* respectively.

Average supplements' intakes and weight changes: The daily supplement intake data and weight changes of the experimental animals were as shown in Table 3. Average daily dry matter intake, in absolute terms and when expressed on the basis of metabolic body weight, was highest ($p<0.05$) for animals on CSR supplementation (151.78 g day^{-1} 34.53 g/$kg^{0.75}$) while it was least ($p>0.05$) for animals on MMNB supplementation (52.20 g day^{-1} 11.08 g/$kg^{0.75}$). The corresponding

Table 1: Ingredient composition of moringa multinutrient blocks*

Ingredients	Composition in multinutrient block (%)
Wheat offals	37
Moringa leaf powder	33
Cement	15
Lime powder	5
Urea	5
Salt	5
Total	100
Water (L/10 kg mixture)	6.50

*Formula as developed by Asaolu (2012)

Table 2: Nutrient compositions of *Panicum maximum* cv. Ntchisi, cassava peels, (CPL) corn starch residues (CSR) and moringa multinutrient blocks (MMNB)

Nutrient (%)	*P. max*	CPL	CSR	MMNB
Dry matter	31.46	89.15	89.07	86.30
Crude protein	9.20	5.63	10.08	20.60
Crude fibre	35.50	20.92	1.50	5.07
Ether extract	5.42	0.99	1.58	2.76
Nitrogen free extract	39.48	67.60	79.17	41.40
Total ash	10.40	4.86	7.67	29.80
Acid detergent fibre	59.76	14.22	42.27	10.30
Neutral detergent fibre	35.10	23.73	57.51	24.30
Predicted Metabolizable energy (MJ kg^{-1} DM)	8.24	11.59	14.32	14.40

Table 3: Weight data and supplement intakes of grazing WAD goats offered cassava peels (CPL), corn starch residues (CSR) and moringa multinutrient blocks (MMNB) as supplements

	Supplements				
Parameters	CPL	CSR	MMNB	SEM	p-value
Weight data					
Initial weight (kg)	7.00	6.60	7.10	0.1777	0.5344
Final weight (kg)	8.00^{b}	7.80^{b}	8.70^{a}	0.1257	0.0002
Total weight gain (kg)	1.00^{b}	1.20^{b}	1.60^{a}	0.0890	0.0036
Average daily weight gain (g day^{-1})	23.81^{b}	28.57^{b}	38.10^{a}	1.8835	0.005736
Average daily supplement intake data					
DMI (g day^{-1})	107.02^{b}	151.78^{a}	52.20^{c}	12.72	5.79E-06
DMI (g/kg$^{0.75}$)	23.61^{b}	34.53^{a}	11.08^{c}	2.92	4.77E-06
DMI (% b.wt.)	1.43^{b}	2.11^{a}	0.66^{c}	0.18	3.48E-12
CPI (g day^{-1})	10.38^{c}	15.18^{a}	11.48^{b}	0.77	0.0091
ADFI (g day^{-1})	15.22^{b}	64.16^{a}	5.47^{c}	7.77	2.48E-10
NDFI (g day^{-1})	25.40^{b}	87.29^{a}	12.12^{c}	9.93	1.27E-09

Means in the same row with the same superscript are not statistically different at $p<0.05$ DMI: Dry matter intake, CPI: Crude protein intake, ADFI: Acid detergent fibre intake, NDFI: Neutral detergent fibre intake

values for the animals on CPL supplementation were 107.02 g day^{-1} and 23.61 g/kg$^{0.75}$, respectively. When expressed as percentages of body weight, the supplement intake levels were 0.66, 1.43 and 2.11% for MMNB, CPL and CSR, respectively. The average daily intakes of the fibre components followed a similar pattern. The average daily ADF and NDFI intakes of the animals on CSR supplementation were 64.16 and 87.29 g day^{-1} while the corresponding values for animals on MMNB supplementation were 5.47 and 12.12 g day^{-1}, respectively. However, while the average daily crude protein intake was highest (15.18 g day^{-1} $p<0.05$) in the animals on CSR, it was least (10.38 g day^{-1}) for the animals on CPL supplementation.

Weight changes were positive for all the experimental treatments, with total weight gains ranging from 1.00 to 1.60 kg for animals on CPL and MMNB supplementations, respectively. These represented corresponding average daily weight gains of 23.81 to 38.10 g day^{-1}, respectively. The value for the animals on MMNB supplementation was significantly (38.10 g day^{-1} $p<0.05$) higher than those of the animals on the two reference supplements which showed no statistical ($p>0.05$) difference. The average daily weight gain of the animals on CSR supplementation was 28.57 g day^{-1} while that of the animals on CPL supplementation was 23.81 g day^{-1}.

Haematological changes: The haematological parameters of the experimental animals at the commencement and end of the study are presented in Table 4. The mean PCV values of all the animals across the three treatments ranged between 21.00 and 35.20%. The Hb values ranged between 7.10 and 13.30 g dL^{-1}. RBC counts (×10^{6} mL^{-1}) were also high and followed a trend similar to that observed for Hb. While animals on MMNB maintained relatively comparable levels of WBC (×10^{3} mL^{-1}) at both the commencement (24.75) and end (24.00) of the study, significant ($p<0.05$) variations were observed for the animals on CPL and CSR supplementations. CPL supplementation resulted in higher WBC (×10^{3} mL^{-1}) values at the end of the study (8.45 vs. 13.30) whereas CSR supplementation resulted in corresponding lower values (17.50 vs. 15.35).

Table 4: Summary of haematological indices of grazing WAD goats offered cassava peels (CPL), corn starch residues (CSR) and moringa multinutrient blocks (MMNB) as supplements

	CPL		CSR		MMNB		
Haematological parameters	COT	EOT	COT	EOT	COT	EOT	SEM
PCV (%)	21.50	22.50	21.50	22.50	21.0^b	32.50^a	1.23
Hb (g dL^{-1})	7.10^b	10.00^a	9.80^b	12.00	7.15^b	13.30^a	0.58
WBC ($\times 10^3$ mL^{-1})	8.45^b	13.30^a	17.50^a	15.35	24.75	24.00	1.81
RBC ($\times 10^6$ mL^{-1})	3.58^b	5.98^a	4.92^b	9.43^a	4.00^b	10.98^a	0.61

Means in the same row with the same superscript are not statistically different at $p<0.05$, COT: Commencement of trial, EOT: End of trial, PCV: Packed cell volume, Hb: Haemoglobin, WBC: White blood corpuscles, RBC: Red blood corpuscles

DISCUSSION

Ingredient and nutrient compositions of experimental supplements: The moringa multinutrient block formula was developed by Asaolu (2012). It was found to be the most desirable of the eight investigated formulae in terms of hardness, compactness and cost, with possibilities of on-farm adoption due to the simplicity in its production technology. The ingredients used in the formulation of multinutrient blocks and their proportions determine their physicochemical characteristics and hence affect acceptability and intake by ruminants (Herrera *et al.*, 2007). The relative contributions of each ingredient and its level of inclusion in moringa multinutrient blocks, as contained in Table 1, on the physicochemical characteristics of the blocks are already elucidated by Asaolu (2012). The nutrient composition of the blocks (Table 2) was described (Asaolu, 2012) as indicative of a high quality feed supplement, with high levels of crude protein and predicted metabolizable energy. Cassava peels and corn starch residues were however lower in crude protein and ash contents with cassava peels containing much more crude fibre (Table 2). The proximate contents of cassava peels that were used in this study fell within reported ranges (Tewe, 1987; Asaolu and Odeyinka, 2006). There is a dearth of information on the nutrient composition of corn starch residues. However, the proximate composition of the corn starch residue that was used in this study was observed to be at variance from a "conventional analysis" as reported by Anonymous (2012) The "conventional analysis" reported higher contents of DM (96.87 vs. 89.07%), CP (18.65 vs. 10.08%) and EE (22.75 vs. 1.58%) but a lower ash content (5.33 vs. 7.67%). Such differences were attributed by the CRA (2006) to factors such as changes in corn composition, geographical distribution, processing and storage conditions. Hence, conventional or typical values do not represent guaranteed compositions (CRA, 2006). Although the observed protein level in corn starch residue was higher than the minimum range of 7.00 to 8.00% recommended for the efficient functioning of rumen microorganisms (Van Soest, 1994), it was lower than the range of 11.0-13.0 % known to be capable of supplying adequate protein for maintenance and moderate growth performances in goats (NRC, 1981). Predicted metabolizable energy contents of the three test supplements were all higher than the value of 10.0 MJ kg^{-1} DM reported by Close and Menke (1986) for alfalfa forage at the pre-bloom stage. The basal forage, *Panicum maximum,* is one of the most common grasses in the derived savannah region of Nigeria (Ajayi and Babayemi, 2008). The proximate contents of the *P. maximum* forage used in this study were within reported ranges (Odedire and Babayemi, 2008; Ajayi and Babayemi, 2008). Its crude protein fell within acceptable range for ruminant performance (NRC, 1981). It was, however, observed to be relatively high in fibre components; NDFI and ADF (Table 2). High levels of fibre have been acknowledged (McDonald *et al.*, 1995) to be inversely related to feed digestibility and nutrient availability.

Average supplements' intakes and weight changes: Moringa multinutrient block intake was observed to be 0.66% of body weight (Table 3). However, in an earlier on-farm demonstration of the benefits of MMNB in the nutrition of small ruminants in the Western Region of The Gambia (Asaolu *et al*., 2010), reliable animal block intake figures could not obtained due to poor block handling by the participating farmers, apparently due to the less-than-satisfactory hardness of the blocks at the time. Observations showed that intakes could have been over-estimated. The probable danger of animals consuming the MMNB too rapidly due to their less-than-satisfactory hardness was not lost to the researchers, with the likely problem of urea toxicity. The observation led to the development of the blocks considered suitable for on-farm adoption by ruminant farmers in terms of desired hardness, compactness and cost, while aiming at a nutritional complementarity among the different ingredients (Asaolu, 2012) that were evaluated in this study.

An optimum total dry matter intake value of 4 to 5% has been recommended by Devendra and Burns (1983) for meat type goats. Growing goats have been reported to consume up to 5% of their body weight when fed exclusively on high-protein tree and shrub forages (Kouch *et al*., 2003). The balances of the total dry matter intakes by the animals in this study were obtained while grazing on *Panicum maximum*. Generally, feed intake increases with increasing dietary crude protein level (Cheema *et al*., 1991). Hence, CSR, with a higher crude protein level, was consumed at a higher level relative to CPL. The intake levels of CSR and CPL could also be regarded as an indication of their palatability levels; indicating that CSR was more palatable than CPL and hence, more relished by the goats. Odeyinka *et al*. (2003) reported comparable dry matter intake levels by WAD goats offered GNC-based and CSR-based concentrates. The level of intake of MMNB (0.66% of body weight) further confirmed earlier reports (Sansoucy and Aarts, 1987) that multinutrient blocks alone cannot constitute the only feed, hence the need for a minimum of forage. The intake of a multinutrient block is reportedly (Sansoucy and Aarts, 1987) affected by its hardness and has been observed to vary with the type of animal. When three multinutrient block formulations based on *Tithonia diversifolia* were offered as supplements to Djallonke sheep on a basal diet of *Brachiaria ruziziensis* (Zogang *et al*., 2012), intake levels ranging from 26.08 to 32.06 g/kg$^{0.75}$ were reported. These values were comparable to the intake levels of CPL and CSR in this study but were much higher than the intake of MMNB. However, none of the multinutrient blocks based on *Tithonia diversifolia* contained urea. With an NPN source such as urea in moringa multinutrient blocks (Table 1), intake may be limited but ruminants would be expected to be able to synthesize their sulphur-containing amino acids (Onwuka, 1999). In addition, the high ash content in moringa multinutrient block (Table 2) could be taken as an indication of adequate mineral presence and availability and many of them, particularly Ca, P and Na, are reportedly (Ghazanfar *et al*., 2011) essential for small ruminants to attain optimum productivity. Asaolu (2012) reported higher levels of Ca, Mg, Zn and Cu in moringa multinutrient blocks than the critical levels for goats (McDowell, 1985). These minerals along with some others have also been reported (Makkar and Becker, 1997; Asaolu *et al*., 2011) to be higher in moringa leaves, one of the major components of moringa multinutrient blocks, than critical levels for small ruminants. On the contrary, the levels of Ca, Na, K and Zn reported for cassava peels by Oboh (2006) were much lower relative to the nutritional needs of ruminants while there is a dearth of information in this regard in the literature on corn starch residues. Even though consumed in a relatively smaller amount, moringa multinutrient blocks would be expected to have led to increased consumption of *Panicum maximum* probably due to increased degradation of the forage and rate of passage of digesta by the rumen as a result of increased activity of cellulolytic rumen microflora (Van Soest, 1994). The consumption of *Panicum maximum* could have been limited by the deficiency of minerals and marginal nitrogen level (Leng, 1992; Given and Moss, 1995). *Panicum maximum* was also observed to be relatively high in fibre components; NDFI and ADF (Table 2). High levels of fibre have been acknowledged (McDonald *et al.*, 1995) to be inversely related to feed digestibility and nutrient availability. Possible correction of these deficiencies by moringa multinutrient blocks would be expected to have positively and significantly impacted on the consumption and overall utilization of the basal *Panicum maximum* forage. In a performance study with goats, Faftine and Zanetti (2010) observed an increased consumption of maize stover with multinutrient blocks.

Asaolu *et al.* (2010) observed mean growth rates of 28.0 and 35.0 g day^{-1} for grazing bucks and rams that were offered daily supplements of MMNB between March and June 2008, a period corresponding to the peak of the dry season in the country of study, The Gambia. A higher growth rate reported for goats on MMNB supplementation in this study (38.10 vs. 28.00 g day^{-1}) could have been due to variations in the compositions of the moringa multinutrient blocks that were evaluated. It should also be noted that the current study was conducted on-station while the Gambian study (Asaolu *et al.*, 2010) was done on-farm and it is widely acknowledged that experimental variations are subject to less control under field conditions. Liu *et al.* (2007) reviewed the Chinese experiences with feed supplementation blocks. Liu *et al.* (1995) was reported to have worked on two groups of goats which grazed together on hill pasture during the day and were offered rice straw *ad libitum* in stalls at night. One group had access to urea-mineral block licks along with the rice straw at night. Goats with access to the blocks performed better than those without the blocks. Live-weight gains were significantly higher in animals with blocks compared with those without blocks (95 vs 73 g day^{-1}). Similar observations were also reportedly made by Xu *et al.* (1994), Zhang *et al.* (1999), Yu *et al.* (1998) and Lu and Gao (2001) when multinutrient blocks were provided as supplements to either grazing goats or sheep.

Haematological changes: The observed PCV values fell within the range of 21.0-36.9% reported for clinically-healthy WAD goats (Taiwo and Ogunsanmi, 2003; Daramola *et al.*, 2005). It should be noted however, that only MMNB supplementation resulted in a significant ($p<0.05$) increase in PCV at the end of the study; suggesting that MMNB offered the grazing animals a better plane of nutrition. Such high PCV values have been regarded (Addass *et al.*, 2010) as signs of healthier and more productive animals. Going by an earlier report (Ikhimioya and Imasuen, 2007), only goats on MMNB supplementation could probably have a high tendency for a return of PCV to normal level following an infection through compensatory accelerated production; as they were the only animals with a PCV value above 32% documented by Frandson (1974) to be normal for circulatory system in sheep. All the Hb values of 7.10 to 13.30 g dL^{-1} fell within the normal range of values (7.00 to 15. 00 g dL^{-1}) reported by Tambuwal *et al.* (2002) for WAD goats, although the initial values (7.10-9.80 g dL^{-1}) were closer to the normal lower borderline value (7.00 g dL^{-1}). The feeding of each of the three experimental supplements (CPL, CSR and MMNB) resulted in significant ($p<0.05$) increases in Hb, the magnitude of the increase was however most pronounced with MMNB. This would have translated to an advantage in favour of the animals on MMNB supplementation. Such an observation was regarded by Opara *et al.* (2010) as an advantage in terms of the blood's oxygen-carrying capacity. A deficiency of haemoglobin in the red blood cells decreases blood oxygen-carrying capacity, leading to symptoms of anemia (Aaron *et al.*, 2003). RBC counts were also high and followed a trend similar to that observed for Hb; indicating that none of the three supplements resulted in anemia. Red blood cell indices aid in the characterization of anemia (Siegmund, 1979). They have been described by Foster and Smith (2011) as the tiny workhorses responsible for carrying oxygen to the body's tissues. Final higher RBC values, as observed for animals on CSR and MMNB supplementation, had been attributed in some earlier studies to a higher plane of nutrition. Rekwot *et al.* (1987) observed that White Fulani cattle that were fed a high protein diet (14.45% CP) had higher erythrocyte values than those on low protein diet (8.51%). Even though all the animals in this study grazed on the same pasture with a CP content of 9.20%, there were variations in the protein quantity and quality of the three experimental supplements. While MMNB had a CP content of 20.60%, corresponding values were 10.80 and 5.63% for CSR and CPL respectively. As observed earlier on, the animals on MMNB supplementation would be expected to be able to synthesize sulphur-containing amino acids with an NPN source such as urea (Onwuka, 1999). The observed WBC values were within earlier reported ranges for WAD goats (Daramola *et al.*, 2005). West African Dwarf goats seem to possess protective system, providing a potent and rapid defense against any infectious agent and this is probably the physiological basis for the adaptation of this species to this ecological zone characterized by high prevalence of diseases (Opara *et al.*, 2010).

CONCLUSION

MMNB supplementation offered grazing WAD goats a better plane of nutrition relative to the two reference supplements, thereby supporting higher growth rates. The haematological indices indicate that the animals on MMNB supplementation were healthier and with a greater capacity to return to normal health following an infection. An adoption of the MMNB technology by small ruminant keepers in the tropics could therefore be a panacea to the nutritional and health hardships faced by the animals during the usually long dry season. An investigation of the effects of MMNB supplementation on sexual development and reproductive attributes in the dry season would be desirable as WAD goats are known to breed all-year round. Possible roles of the blocks in strategic helminths' control programs could also be investigated as parasitic nematodes have been widely acknowledged to remain as one of the main constraints to goat production in the temperate and tropical countries.

ACKNOWLEDGMENTS

The assistance of the support staff at the University Teaching and Research Farm is appreciated. The contributions of Mrs. Folaranmi and her team members in the laboratory are also appreciated.

REFERENCES

AOAC, 2000. Association of Official Analytical Chemists: Official Methods of Analysis. 6th Edn., AOAC, Washington, DC., USA.

Aaron, S.D., K.L. Vandemheen, S.A. Naftel, M.J. Lewis and M.A. Rodger, 2003. Topical tetracaine prior to arterial puncture: A randomized, placebo-controlled clinical trial. Respir. Med., 97: 1195-1199.

Abate, A.L. and M. Meyer, 1997. Prediction of the useful energy in tropical feeds from proximate composition and *in vivo* derived energetic contents 1. Metabolisable energy. Small Ruminant Res., 25: 51-59.

Addass, P.A., A. Midau and D.M. Babale, 2010. Haemato-biochemical findings of indigenous goats in Mubi, Adamawa State, Nigeria. J. Agric. Social Sci., 6: 14-16.

Ahamefule, F.O. and C. Elendu, 2010. Intake and digestibility of West African Dwarf bucks fed cassava leaf-maize offal based diets. J. Anim. Vet. Adv., 9: 535-539.

Ajayi, F.T. and O.J. Babayemi, 2008. Comparative *in vitro* evaluation of mixtures of *Panicum maximum* cv Ntchisi with stylo (*Stylosanthes guianensis*), Lablab (*Lablab purpureus*), Centro (*Centrosema pubescens*) and Histrix (*Aeschynomene histrix*). Livestock Res. Rural Dev., Vol. 20, No. 6.

Akinfala, E.O. and O.O. Tewe, 2004. Supplemental effects of feed additives on the utilization of whole cassava plant by growing pigs in the tropics. Livestock Res. Rural Dev., Vol. 16, No. 10.

Akinsoyinu, A.O., 1985. Nutrient requirements of sheep and goats in Nigeria. Proceedings of the National Conference on Small Ruminant Production, October 6-10, 1985, Zaria, Nigeria.

Alli-Balogun, J.K., C.A.M. Lakpini, J.P. Alawa, A. Mohammed and J.A. Nwanta, 2003. Evaluation of cassava foliage as a protein supplement for sheep. Niger. J. Anim. Prod., 30: 37-46.

Anonymous, 2012. Study of application of corn starch residue in laying hens diet. Agricultural Science Research Paper. http://www.agrpaper.com/study-of-application-of-corn-starch-residue-in-laying-hens-diet.htm

Asaolu, V.O. and S.M. Odeyinka, 2006. Performance of West African Dwarf sheep fed cassava peel based diets. Niger. J. Anim. Prod., 33: 230-238.

Asaolu, V.O., A.K. Jarju, A. Joof, S.M. Odeyinka, J. Manne, D. Darboe and M. Jallow, 2010. *Moringa oleifera*-horticulture-livestock integration approach to improving incomes and livelihoods of women farmers: The Gambian experience. http://idl-bnc.idrc.ca/ dspace/ handle/ 10625/44856.

Asaolu, V.O., R.T. Binuomote, J.A. Akinlade, O.S. Oyelami and K.O. Kolapo, 2011. Utilization of *Moringa oleifera* fodder combinations with *Leucaena leucocephala* and *Gliricidia sepium* fodders by West African dwarf goats. Int. J. Agric. Res., 6: 607-619.

Asaolu, V.O., 2012. Development of moringa multi-nutrient block as a dry season feed supplement for ruminants. Livestock Res. Rural Dev., Vol. 24, No. 3.

Aye, P.A. and M.K. Adegun, 2010. Digestibility and growth in West African dwarf sheep fed *Gliricidia*-based multinutrient block supplements. Agric. Biol. J. North Am., 1: 1133-1139.

Belewu, M.A., B.R. Orisameyiti and K.A. Ajibola, 2007. Effect of feeding graded levels of tigernut (*Cyperus esculentus*) seed meal on the performance characteristics of West African dwarf goat. Pak. J. Nutr., 6: 528-529.

Ben Salem, H., A. Nefzaoui and H.P.S. Makkar, 2007. Feed Supplementation Blocks for Increased Utilization of Tanniniferous Forages by Ruminants. In: Feed Supplementation Blocks: Urea-Molasses Multinutrient Blocks: Simple and Effective Feed Supplement Technology for Ruminant Agriculture, Makkar, H.P.S., M. Sanchez and A.W. Speedy (Eds.). Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN-13: 9789251054383, pp: 185-205.

CRA, 2006. Corn Wet Milled Feed Products. 4th Edn., Corn Refiners Association, Washington, DC., USA., pp: 19-23.

Celik, K., I.E. Ersoy and F. Savran, 2003. Feeding of urea treated wheat straw in saanen goat male kids. Pak. J. Nutr., 2: 258-261.

Cheema, A.U., M.L. Galyean, J.S. Caton and A.S. Freeman, 1991. Influence of protein levels and naloxone on intake, nitrogen metabolism and digestion kinetics in lambs fed hay or barley straw. Small Rum. Res., 5: 35-46.

Chiejina, S.N. and J.M. Behnke, 2011. The unique resistance and resilience of the Nigerian West African Dwarf goat to gastrointestinal nematode infections. Parasites Vectors, Vol. 4.

Close, W. and K.H. Menke, 1986. Selected Topics in Animal Nutrition: A Manual. Institute for Animal Nutrition, University of Hohenheim, Stuttgart, Germany.

Dacie, J.V. and S.M. Lewis, 1984. Practical Haematology. 6th Edn., Churchill Livingston, Edinburgh, Melbourne and New York, pp: 24-36.

Daramola, J.O., A.A. Adeloye, T.A. Fatoba and A.O. Soladoye, 2005. Haematological and biochemical parameters of West African Dwarf goats. Livestock Res. Rural Dev., Vol. 17.

Devendra, C. and M. Burns, 1983. Goat Production in the Tropics. Farnham Royal, Commonwealth Agricultural Bureaux, UK., pp: 90-114.

Faftine, O.L.J. and A.M. Zanetti, 2010. Effect of multinutrient block on feed digestibility and performance of goats fed maize stover during the dry season in south of Mozambique. Livestock Res. Rural Dev., Vol. 22, No. 9.

Foster, R. and M. Smith, 2011. Blood cells and Complete Blood Counts (CBC) in animals. Foster and Smith Inc., Wisconsin. http://www.peteducation.com/article.cfm?c=2+2116&aid=987.

Frandson, R.D., 1974. Anatomy and Physiology of Farm Animals. 2nd Edn., Lea and Febiger, Philadelphia, pp: 174-225.

Ghazanfar, S., A. Latif, I.H. Mirza and M.A. Nadeem, 2011. Macro-mineral concentrations of major fodder tree leaves and shrubs of District Chakwal, Pakistan. Pak. J. Nutr., 10: 480-484.

Given, D.I. and A.R. Moss, 1995. The nutritional value of cereal straw for ruminants. A review. Nutr. Abstr. Rev., 65: 793-811.

Habib, G., 2004. Mulberry fruit-based feed blocks: A key supplement for livestock in mountainous regions. Mt. Res. Dev., 24: 106-109.

Hadjipanayiotou, M., L. Verhaeghe, A.R. Kronfoleh, L.M. Labban and M. Amin *et al.*, 1993. Urea blocks. II Performance of cattle and sheep offered urea blocks in Syria. Livestock Res. Rural Dev., 5: 6-15.

Hendratno, C., T. Tjiptosumirat and L.A. Sofian, 1989. Effective use of molasses blocks as supplements for Etawah-cross bred goats. Proceedings of the Conference on Ruminants and Small Ruminants, (RSR'89), Research Institute for Animal Production, Bogor, Indonesia.

Herrera, P., B. Birbe, C. Dominguez and N. Martinez, 2007. Experiences with Multinutrient Blocks in Venezuelan Tropics. In: Feed Supplementation Blocks: Urea-Molasses Multinutrient Blocks: Simple and Effective Feed Supplement Technology for Ruminant Agriculture, Makkar, H.P.S., M. Sanchez and A.W. Speedy (Eds.). Food and Agriculture Organization, Rome, Italy, pp: 1-12.

ILCA, 1987. Annual Report of the International Livestock Centre for Africa. ILCA, Addis Ababa, Ethiopia.

Ikhimioya, I. and J.A. Imasuen, 2007. Blood profile of West African dwarf goats fed *Panicum maximum* supplemented with *Afzelia africana* and *Newbouldia laevis*. Pak. J. Nutr., 6: 79-84.

Jain, N.C., 1986. Schalm's Veterinary Haematology. 4th Edn., Lea and Febiger, Philadelphia.

Kouch, T., T.R. Preston and J. Ly, 2003. Studies on utilization of trees and shrubs as the sole feedstuff by growing goats: Foliage preferences and nutrient utilization. Livest. Res. Rural Dev., Vol. 15,

Lanyasunya, T. P., W.H. Rong, S.A. Abdulrazak, P.K. Kaburu, J.O. Makori, T.A. Onyango and D.M. Mwangi, 2006. Factors limiting use of poultry manure as protein supplement for dairy cattle in smallholder farms in Kenya. Int. J. Poult. Sci., 5: 75-80.

Leng, R.A., 1989. Recent Advances in Applied Aspects of Ruminant Physiology and Nutrition. In: Ruminant Physiology and Nutrition in Asia, Devendra, C. and E. Imaizumi (Eds.). Japan Society of Zootechnical Science, Japan, pp: 1-26.

Leng, R.A., 1992. Drought Feeding Strategies: Theory and Practice. Penambul Books, Armidale, Australia.

Liu, J.X., Y.M. Wu, X.M. Dai, J. Yao, Y.Y. Zhou and Y.J. Chen, 1995. The effects of urea-mineral lick blocks on the liveweight gain of local Yellow cattle and goats in grazing conditions. Livestock Res. Rural Dev., 7: 9-13.

Liu, J.X., R. Long and D. Zang, 2007. Feed Supplementation Blocks-Experiences in China. In: Feed Supplementation Blocks: Urea-Molasses Multinutrient Blocks: Simple and Effective Feed Supplement Technology for Ruminant Agriculture, Makkar, H.P.S., M. Sanchez and A.W. Speedy (Eds.). Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN-13: 9789251054383, pp: 89-109.

Lu, A.D. and L. Gao, 2001. Investigation on the effect of feeding of mineral lick block on growth rate of finishing goats. Yunnan J. Anim. Husbandry Vet. Med., 1: 32-35.

Makkar, H.P.S. and K. Becker, 1997. Nutrients and anti-quality factors in different morphological parts of the Moringa oleifera tree. J. Agric. Sci., 128: 311-322.

Makkar, H.P.S., 2007. Feed Supplementation Block Technology-Past, Present and Future. In: Feed Supplementation Blocks: Urea-Molasses Multinutrient Blocks: Simple and Effective Feed Supplement Technology for Ruminant Agriculture, Makkar, H.P.S., M. Sanchez and A.W. Speedy (Eds.). Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN-13: 9789251054383, pp: 1-21.

McDonald, P., R.A. Edwards, J.F.D. Greenhalgh and C.A. Morgan, 1995. Animal Nutrition. 5th Edn., Longman Singapore Publishers (Pvt.) Ltd., Singapore.

McDowell, L.R., 1985. Nutrition of Grazing Ruminants in Warm Climates. Academic Press, Orlando, FL., USA., ISBN-13: 9780124833708, pp: 443.

Mohammed, I.D., M. Baulube and I.A. Adeyinka, 2007. *Multi-nutrient* blocks I: Formulation and production under a semi-arid environment of North East Nigeria. J. Boil. Sci., 7: 389-392.

NRC, 1981. Nutrient Requirements of Goats.12 National Academy of Science, Washington, DC., USA., pp: 1-10.

Ngi, J., J.A. Ayoade and O.I.A. Oluremi, 2006. Evaluation of dried cassava leaf meal and maize offal as supplements for goats fed rice straw in dry season. Livestock Res. Rural Dev., Vol. 18, No. 9.

Oboh, G., 2006. Nutrient enrichment of cassava peels using a mixed culture of *Saccharomyces cerevisae* and *Lactobacillus* sp. solid media fermentation techniques. Electr. J. Biotechnol., 9: 46-49.

Odedire, J.A. and O.J. Babayemi, 2008. Comparative studies on the yield and chemical composition of *Panicum maximum* and *Andropogon gayanus* as influenced by *Tephrosia candida* and *Leucaena leucocephala*. Livestock Res. Rural Dev., Vol. 20,

Odeyinka, S.M. and D.A. Ajayi, 2004. A survey of feedstuffs for goats in Osun State. Trop. J. Anim. Sci., 7: 161-168.

Odeyinka, S.M., O.J. Oyedele and P.A. Olubunmi, 2003. The performance of West African Dwarf goats on soybean milk residue, cowpea seed testa and corn starch residue. Livestock Res. Rural Develop., Vol. 15.

Olaniyi, J.O., 2006. Influence of phosphorus and nitrogen fertilizers on seed yield and quality of egusi melon (*Citrullus lanatus*) Thunb in Ogbomoso, Southwestern Nigeria. Ph.D. Thesis, University of Ibadan, Nigeria.

Onwuka, C.F.I., 1999. Molasses block as supplementary feed resource for ruminants. Archivos de Zootecna, 48: 89-94.

Opara, M.N., N. Udevi and I.C. Okoli, 2010. Haematological parameters and blood chemistry of apparently-healthy West African Dwarf (WAD) goats in Owerri, South Eastern Nigeria. NY Sci. J., 3: 68-72.

Osuji, P.O., S. Fernandez-Riviera and A. Odenyo, 1995. Improving Fibre Utilisation and Protein Supply in Animals Fed Poor Quality Roughages. ILRI Nutrition Research and Plans. In: Rumen Ecology Research and Planning, Wallace, R.J. and A. Lahlou-Kassi (Eds.)., Vol. 1. International Livestock Research Institute, Addis Ababa, pp: 1-22.

Peacock, C., 1996. Improving Goat Production in the Tropics: A Manual for Development Workers. Oxfarm/FARM Africa Publ., UK., Ireland, pp: 1-20.

Pond, W.G., D.C. Church and K.K. Pond, 1995. Basic Animal Nutrition and Feeding. 4th Edn., John Wiley and Sons Publishers, NY., USA., Pp: 415-450.

Rekwot, P.I., J. Kumi-Diaka, O. Akerejola and O. Oyedipe, 1987. Haematological values of Bunaji and Friesian Bunaji bulls fed two levels of protein diets. Nig. Vet. J., 18: 63-72.

SAS, 1998. SAS User's Guide Statistics. SAS Inc., Cary, North Carolina.

Saddul, D. and A.A. Boodoo, 2001. Response to urea-molasses multinutrient blocks as a supplement in the diet of goats. Proceedings of the 1st Annual Meeting of Agricultural Scientists, May 3-4, 2001, Food and Agricultural Research Council, Reduit, Mauritius, pp: 245-248.

Sansoucy, R. and G. Aarts, 1987. Molasses/urea blocks. Animal Feed Resources Information Systems, http://www.fao.org/ag/AGA/AGAP/FRG/AFRIS/Data/557.HTM.

Sansoucy, R. and P. Hassoun, 2007. The Block Story. In: Feed Supplementation Blocks, Makkar, H.P.S., M. Sanchez and A.W. Speedy (Eds.). FAO, Animal Production and Health Div., Rome Italy.

Schalm, O.W., N.C. Jain and E.J. Carrol, 1975. Veterinary Aematology. 3rd Edn., Lea and Febiger, Philadelphia, USA., pp: 15-81.

Siegmund, O.H., 1979. The Merck Veterinary Manual: A Handbook of Diagnosis and Therapy for the Veterinarian. 5th Edn., Merck and Co. Inc., Rahway, NJ., USA., ISBN-13: 9780911910520, Pages: 1680.

Taiwo, V.O. and A.O. Ogunsanmi, 2003. Haematology, plasma, whole blood and erythrocyte biochemical values of clinically healthy captive-reared grey duiker (*Sylvicapra grimmia*) and West African Dwarf sheep and goats Ibadan, Nigeria. Israel J. Vet. Med.,

Tambuwal, F.M., B.M. Agaie and B. Bangana, 2002. Aematological and biochemical values of apparently healthy red sokoto goats. Proceedings of 27th Annual Conference of Nigerian Society for Animal Production, Mar. 17-21, Akure, Nigeria, pp: 50-53.

Tewe, O.O., 1987. Cassava Peels Utilization in Poultry Diets. In: Root Crops and the African Food Crisis, Arene, O.B. (Ed.). International Development Research Centre, Canada, pp: 150-153.

Van Soest, P.J., 1994. Nutritional Ecology of the Ruminant. 2nd Edn., Cornell University Press, New York, Pages: 476.

Xu, Z.C., Y.J. Tian and H. Wang, 1994. Use of multinutrient lick blocks in goats and sheep. Sichuan Pasture, 3: 27-29.

Yu, Z.X., Y.G. Chen and Y.Z. Feng, 1998. Effect of supplementary lick block containing urea and molasses on gain of fattening Tibetan sheep in autumn grazing. Qinghai J. Anim. Husbandry Vet. Med., 28: 1-2.

Zhang, B., L.L. Li, C.Y. Liu, D.M. Lin, G.W. Chen and C.L. Huang, 1999. Effect of multinutrient lick blocks on performance of growing goats. Anim. Ecol., 20: 4-8.

Zogang, B.F., B. Boukila, C. Sawa, F. Tendonkeng, G.Z. Tovignon and E.T. Pamo, 2012. Caracteristiques physiques et appetibilite des blocs multinutritionnels a base de *Tithonia diversifolia* associes a la paille de *Brachiaria ruziziensis* chez la brebis Djallonke [Palatability and physical characteristics of multinutrient blocks based *Tithonia diversifolia* associated with *Brachiaria ruziziensis* straw in sheep Djallonke]. Livestock Res. Rural Dev., Vol. 24.