USE OF BLACK CLAY AS BINDER IN PRODUCTION OF MINERAL BLOCKS FOR SMALL RUMINANTS IN ADAMAWA STATE

Alex Midau
Department of Animal Production
Adamawa State University, Mubi.

Kangare Jehaziel Bandavi
Department of Agricultural Economics and Extension
Adamawa State University, Mubi

Amos James Wadzu
Department of Agricultural Economics and Extension
Adamawa State University, Mubi

Gideon Yohanna
Department of Agricultural Economics and Extension
Adamawa State University, Mubi

***Corresponding author:**
Alex Midau
Department of Animal Production
Adamawa State University, Mubi.

ABSTRACT
The study was conducted in Adamawa State University Livestock Teaching and Research Farm. The aim of the study was to produce a medicated multimineral blocks (MMBs) for use in ruminants. The multimineral block was of mediun (M) compactness. Minerals are inorganic nutrients, usually required in small amounts from less than 1 to 2500 mg per day, depending on the mineral. As with vitamins and other essential food nutrients, mineral requirements vary with animal species. Animals as vertebrates need large amounts of calcium for construction and maintenance of bone and normal function of nerves and muscles. Phosphorus is an important constituent of adenosine triphosphate (ATP) and nucleic acid and is also essential for acid-base balance, bone and tooth formation. Red blood cells cannot function properly without iron in haemoglobin, the oxygen-carrying pigment of red blood cells. Iron is also an important component of the cytochromes that function in cellular respiration. Magnesium, copper, selenium, zinc, iron, manganese and molybdenum are important co-factors found in the structure of certain enzymes and are indispensable in numerous biochemical pathways. Vertebrates need iodine to make thyroid hormones. Sodium, potassium and chlorine are important in the maintenance of osmotic balance between cells and the interstitial fluid. Magnesium is an important component of chlorophyll in plants and in animals. Also, severe shortages or self-prescribed minerals can alter the delicate balance in body functions that promotes health. The knowledge of the biochemistry of the mineral elements is essential. This paper could also serve as a ready source of literature review for researchers involved in nutritional sciences.

Keywords: *Production, medicated multinutrients block, evaluation, ruminants*

Introduction

Background of the study

Block technology has been very popular among teachers and students at Agricultural Universities around the world. The number of research experiments conducted in developing countries, although not exactly known, is quite impressive. It has led to many scientific publications in various international journals. In one journal alone the electronic journal *Livestock Research for Rural Development* more than 30 articles have been published on the subject. In the framework of the International Foundation for Sciences (IFS) programme, various research grants have been for studies on blocks.

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

Cited as: Midau, A; Bandavi, K. J; Wadzu, A. J. & Yohanna, G. (2024) Use of Black Clay as Binder in Production of Mineral Blocks for Small Ruminants in Adamawa State, *International Journal of Applied Economics, Finance and Management, 9*(S1), 1-17. Special Issue: Sustainable Finance and Green Economy: "Pathways to Environmental and Economic Resilience".

Strong interest from individuals and research institutes has led to all kinds of investigations. Studies have been conducted on the feeding value of multinutrient blocks and their effects on the nutritional status and animal production (milk, meat, growth), physiology (reproduction) and health (when anthelmintics were added in the blocks). Also, experiments have been done to test the manufacture of blocks using new local ingredients or binders. All experimental work has shown positive effects on production, health and reproductive parameters.

International and national meetings on multinutrient blocks have been organized by various organizations (FAO, IAEA, Guanare University in Venezuela (Cardozo and Birbe, 1994). The meetings have helped to spread the technology and its results among research and extension workers. Multinutrient blocks have been a tremendous tool for extension of knowledge on feeding principles and practices for ruminant animals, and particularly regarding supplementation of the unbalanced diets that are common in developing countries. For this purpose, extension material documents have been prepared in most countries and in local languages for teaching farmers and small-scale manufacturers (Garcia and Restrepo, 1995) concerning manufacture and use of the blocks. It is difficult to evaluate the global impact of the block technology on livestock production as the number of manufacturing units and of farmers feeding multinutrient blocks to their animals is not exactly known. However, it is certain that the technology been a great success. Efforts are ongoing and will continue. This book presents snapshots of aspects of the current state of knowledge, and should be of great help for both beginners and experienced people working on the subject.

Chicken eggshells: The chicken eggshell consists of the cuticle, crystal layer, spongy calcareous layer pores, cores and mammillary layer. The membranes located on the inner surface of the eggshell appear like a single layer but can be divided into two distinct layers of fibrous material. One layer surrounds the albumen while the other is attached to the "tips" of the calcified material of the shell. They are regarded as the inner and outer shell membranes respectively (Hamilton, 1986). The membranes can be used as an adsorbent for the removal of reactive dyes from colored waste effluents and to remove heavy metal ions from dilute wastewaters (Schaafsma *et al.*, 2000). The eggshell membranes also consist of collagen as a component which when extracted can be used for diverse purposes such as; medicine, biochemical, pharmaceutical, food, and cosmetics industries (King'ori, 2011).

Therefore, the efficacy of converting eggshells to beneficial use becomes an idea worth investigating. The eggshell is composed of about 95.1% inorganic matter and 3.3% protein. The eggshell was reported to weigh on average 1.6% of the total chicken egg-based on wet weight (Adeyeye, 2009) with a thickness between

0.33 and 0.35 mm (Tadesse *et al.*, 2015). Eggshells vary widely in texture but, it is predominantly made up of calcium carbonate and glycoprotein matrix. The outside of the shell is a thin proteinaceous layer, the cuticle that blocks the entrance of bacteria from entering the embryo (Al-awwal and Ali, 2015).

Primarily, the eggshell provides nutrient, a perfect package, and protection to the enclosed embryo from mechanical damage and contamination. It is being used on a moderate scale as an additive in foods (Hunton, 2005). Chicken eggshells are agricultural wastes which could lead to environmental pollution when not properly disposed of (Mtallib and Rabiu, 2009; Phil and Zhihong, 2009). They are found in hatcheries, homes and fast food industries; readily abundantly available for collection (King'ori, 2011). There are numerous challenges associated with its disposal which ranges from a cost of disposal, availability of disposal sites, odor, flies, and abrasiveness (Phil and Zhihong, 2009). However, it can be processed into more useful products such as fertilizer, animal feeds, medicines, and building materials.

It can also be used as a food flavor in the food industry for human consumption, especially in this era of ever-increasing endeavors to convert waste to wealth (Mtallib and Rabiu, 2009).

Eggshell can be used in the artwork for the production of mosaics, glue in musical instruments, and photography aids in photography (King'ori, 2011). The eggshell membrane powder can also be used in the paper industry, or in agriculture as a lime substitute or calcium supplement. Other possible uses of eggshell include the production of biodegradable plastics from eggshell membrane proteins; altering of the food-borne bacterial pathogen that is of heat resistance with an eggshell membrane bacteriolytic enzyme; as human dietary calcium supplement especially for post-menopausal women (Dudusola, 2010).

Proximate composition of eggshells: Eggshells have been found to contain calcium, magnesium, copper, iron, manganese, molybdenum, sulfur and many more other useful elements. However, the proportions have not been reported in the literature and, it could be a natural source of calcium (King'ori, 2011). Calcium, one of the content in eggshell had been clinically tried to provide effective prevention of osteoporotic fractures in elderly community-dwelling residents (Chang *et al.*, 2007). It is an acceptable practice for eggshell to be dried and used as a source of calcium in animal feeds. The recycling of the nutrients of eggshell back into the animal portends that the nutritional composition of various eggshells should be evaluated to establish its suitability as animal feed (Adeyeye, 2009)

The importance of mineral elements: Minerals are inorganic nutrients, usually required in small amounts from less than 1 to 2500 mg per day, depending on the mineral. As with vitamins and other essential food

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

nutrients, mineral requirements vary with animal species. For example, humans and other vertebrates need large amounts of calcium for construction and maintenance of bone and normal function of nerves and muscles. Phosphorus is an important constituent of adenosine triphosphate (ATP) and nucleic acid and is also essential for acid-base balance, bone and tooth formation. Red blood cells cannot function properly without iron in haemoglobin, the oxygen-carrying pigment of red blood cells. Iron is also an important component of the cytochromes that function in cellular respiration. Magnesium, copper, selenium, zinc, iron, manganese and molybdenum are important co-factors found in the structure of certain enzymes and are indispensable in numerous biochemical pathways. Vertebrates need iodine to make thyroid hormones. Sodium, potassium and chlorine are important in the maintenance of osmotic balance between cells and the interstitial fluid.

Minerals in Livestock and Poultry Production: Trace minerals play a critical role in the metabolic functions of livestock and poultry. These functions help support growth and development, immune function and the reproductive performance in livestock and poultry. In addition to improving reproductive and production performance parameters, minerals are also essential to supporting several enzymatic systems.

The beneficial responses from proper mineral supplementation can be observed throughout an animal's life. The proper amount of bioavailable minerals needs to be supplemented to support the hemostatic state of the animal during all phases of life. Minerals need to be supplemented at the correct concentrations throughout the life cycle to support the loss of minerals during energy expenditure and everyday production performance (e.g. milk production, egg production, immune response).

Mineral supplements are routinely added to rations to support livestock and poultry production and performance as an insurance against feedstuffs lacking the complete mineral composition. Many minerals are continually supplemented due to the lack of bioavailable minerals in feeds not meeting the nutritional requirements due to local soil composition and climactic effects.

Minerals Essential to Most Livestock and Poultry: Calcium, Chloride, Chromium, Cobalt, Copper, Iodine, Iron, Magnesium, Manganese, Phosphorus, Potassium, Selenium, Sodium, Sulfur and Zinc

Clay minerals: Clay minerals are important in many facets of our society. Their properties such as structure and chemical composition, type of exchangeable ion and particle size determine their various uses. The healing powers of clay were known for centuries and are now being rediscovered (Antoine *et al.*, 2012). The practice of eating clay by animals in the wild for the detoxification of the body and alleviation of gastrointestinal infections was well documented. Initially, clays were introduced to farm animal nutrition as binding agents for feeding pellets and then used as feed additives to promote growth and health of the animals. The actual use of clay and clay minerals are directed towards the production of selective sorbents applicable to both human and veterinary medicine. Clay minerals were modified against gastrointestinal disorders (Antoine *et al.*, 2012). T**he study was to; p**roduce mineral licks using locally available feedstuff, determine Physical characteristics of the mineral blocks, evaluate nutrient composition of the feeds material and to determine the production cost per unit.

MATERIALS AND METHODS

Location of the study area

The study was conducted in the Animal Nutrition Laboratory, Adamawa State University. The study area lie within Northern Guinea Savannah zone of Nigeria and located at latitude10°00 north, longitude 13°30 east and about 305m above sea level, with an area of 961.39 km^2. The dry season in this area commences early October and last up to April. The raining season begins from May and attains its peak between July and August and declines in September. The mean annual rainfall is 1050 mm, while the relative humidity is extremely low 20-30% between January and March and starts increasing as from April and reaches a peak of about 80% in August and September. Relative humidity starts to decline from October following the cessation of rains. The maximum temperature can reach 40°C particularly in April, while minimum temperature is about 18°C between December and January. A variety of livestock include cattle, sheep, goats and pigs (Adebayo, 2004).

Necessary Ingredients needed for Salt and minerals block

i. Black clay – 3 kg
ii. Salt – 0.5 kg
iii. Maize Flour – 1 kg
iv. Egg shell powder – 0.5 kg
v. Water- as per needed

Preparation method

Collection, drying and processing of locally available materials was done in the laboratory.

i. Black clay was Mince into dust, screen it before use.
ii. Minced egg shell

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

iii. Mixed dust of red clay, dust of egg shell, salt and white flour in a container. Add adequate water to shape it as cake/block, note that thinner mixture is difficult to prepare a cake/block.
iv. Shape of Cake/blocks was made rectangular
v. After 4-5 days, the prepared mineral cakes/blocks was ready for use.

The hardness and compactness of the blocks was simply measured by three persons independently after manufacturing following the method of Hassoun (1989). Hardness was assessed by pressing with the thumb in the middle of the block. Each block was characterized soft (S), medium (M) or good (G) when the thumb penetrated easily, very little or only with greater pressure, respectively. The compactness was assessed by trying to break the block by hand. A block was characterized as null (N), medium (M), fairly good or good (G) when it was broken easily, with difficulty or with great effort, respectively. Physical characteristics Appearance/ colour, texture, aroma and taste was determined independently by three persons according to Hadjipanayiotou (1994) methods. Mineral and proximate composition was carried out as described by (AOAC, 2000) and fibre fractions (Van Soest *et al.,* 1991) and CT (Makkar, 2000).

Statistical Analysis

The results obtained was subjected to analysis of variance (Snedecor and Cochran 1994) and data analyzed using SPSS (Version 11.0, SPSS Inc, Chicago, USA). Cost of block production was calculated based on the current prices of locally available feed ingredients at the time of blocks formulation and preparation.

RESULT AND DISCUSSION

Production of mineral blocks

Till the 1970s, the blocks were produced mostly by feed manufacturing companies, thus expensive, and their use in developing countries was negligible. In the early 1980s, with the realization of the significance of the blocks for smallholders in developing countries, work on simplification of the block production technology gained momentum through the efforts of the Joint FAO/IAEA Division, Professor Leng from Armidale University, Australia, and the National Dairy Development Board, Gujarat, India. The Joint FAO/IAEA Division, FAO and UNDP promoted block technology in many Asian, African and Latin American countries. During the initial phase, up to the mid-1980s, the “hot process” of block production was promoted, despite the high cost of the heating process. In 1986, the FAO Feed Resources Group modified the process to one that did not require heating of the ingredients, and this became known as the “cold process”. The cold process used solidifying agents such as calcium and magnesium oxide, calcium hydroxide, di-ammonium phosphate, cement or bentonite. Although the cold process was available, the use of the hot process continued into the mid-1990s. However, use of the hot process could not be sustained because of increasing energy costs, and interest in block technology diminished. In the late 1990s, with the promotion of the cold process through FAO/IAEA Regional Technical Cooperation (TC) Projects RAF/5/041, RAS/5/030 and RAS/5/035, the use of the block technology picked up in many Asian and African countries. Countries like Nigeria, Pakistan and several other countries shifted to the cold process for block production (FAO, 1997). Manufacturing process and method of offering the blocks levels typically vary from 4 to 10 percent, and the binder vary from 30 to 45 percent and 6 to 15. The manufacturing process differs substantially from country to country, depending on the scale of operation. To mix the ingredients, various approaches have been used, ranging from use of a shovel or even bare hands, to mechanical mixing using a dough mixer or concrete mixer. Similarly, moulds made up from metal, wood, cardboard and plastic, with square, rectangular or cylindroid shape, have been used, and in some countries, car and truck tyres and buckets have been used to give shape to the blocks.

In Multi-Nutrient Blocks for example particularly the concentration of the binder, blocks have been hardened without or with the use of pressure. If used, pressure is generally applied either by foot by standing on the moulds, or through mechanical devices such as a car jack, screw-driven press or lever. Electrical, steam or diesel motors have also been used in countries such as Viet Nam, Malaysia and Mongolia to compress the blocks. To avoid losses due to rats, birds, insects and fungal growth in high humidity areas, polyethylene packing has been the most used method when it is necessary to store blocks for a long period. In most countries, when the farmers have to buy the blocks, a smooth surface and good quality packing are preferred. The blocks have been offered to animals in a wooden box or bucket of dimensions slightly larger than that of the block, which restricts biting of the block by animals. The hanging of blocks in front of the animal using a wire passing through the centre of the block has been another approach. In Venezuela, blocks weighing as large as 25 kg have been offered to animals in rangelands. These blocks are kept under shade and near the water source. The daily consumption per animal varies: 500 to 800 g for cattle and buffaloes, 60 to 125 g for sheep and goats, and 400 to 600 g for yak. The block should be hard enough to ensure that the animal gets a slow release of nutrients through the licking process. This slow release of nutrients, particularly of nitrogen and carbohydrates, increases the efficiency of utilization of these nutrients. However, in Indonesia, a variation to produce soft blocks has also been found to be popular and effective in increasing milk production. The soft block, weighing about 500 g, is broken into two or three pieces and given to cattle at different times of the day. Soft blocks have also been used in China by some workers (Liu, Long and Zhang, 1998). In this the ingredients were sourced locally, a wooden mortar was used to mince the clay and

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

albendazole tablet, the eggshell was grinded in a well cleaned grinding machine and all other preparation were made manually. Hand mixing was employed.

The components of the multimineral block

The components of multi-nutrient blocks are black clay, salt, eggshell, maize flour, and water as required. Red clay was used as a binder and maize flour as source of energy and binder (Hadjipanayiotou, *et al.,* 1993). The use of black clay and maize flour as binders ensures the slow release of the mineral and chemical components of the block as opined by (Onwuka, 1997). Multimineral block is an excellent way of providing readily available minerals to ruminant animals and can increase digestibility and feed intake of fibrous feeds by up to 20% and 25 - 30%, respectively.

Table 1. Proximate composition of the ingredients

Constituents (%)	Maize	Eggshell
Moistures	12.0±0.010	1.9±0.03
Ash	1.1±0.001	32.8±0.02
Crude protein	9.0±0.240	1.8±0.20
Crude fat	3.4±0.200	1.1±0.01
Crude Fibre	1.0±0.001	3.4±0.20
Total carbohydrates	74.5±0.220	49.8±0.03

The chemical composition of a multi nutrient block depends on the quantity and the kind of ingredients used in the fabrication. Analyses made on the feed ingredients showed that the composition of the finished blocks may be related to that of the individual ingredients even though no proximate analysis was made on the blocks due some constraints. The chemical composition of a block determines its feeding value as a supplement. The proximate composition of the feed ingredients is presented in Table 3. The lower moisture observed means higher DM values which indicate that when fed to animals, they will eat less to obtain their requirement as earlier posited by (Sansoucy *et al.,* 1986).

Advantages of the multimineral block

Benefits of block supplementation: The use of the blocks as a supplement has resulted in economic benefits to the farmers. Block supplementation with crop-residue-based diets has resulted in increased milk production, with a favourable cost benefit ratio, varying from 1:2 to 1:5, depending on the purchase price of ingredients and selling price of milk. Invariably, an increase in milk fat content by 0.2 to 0.8 percentage

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

units on feeding the blocks also brought a higher price for the milk. Increase in lactation length has also been observed. Decreases in inter-calving days and in the age at first calving are additional beneficial effects of feeding the blocks. Feeding of crop residues with UMMBs can sustain a milk yield of up to 4 or 5 litres per day in cattle. For high production animals, blocks containing ‘rumen undegradable protein’ sources (“by-pass” protein sources), such as fishmeal, cottonseed meal, etc., have been developed and used in India, Venezuela and Pakistan.

In some situations, supplementation of the blocks has allowed a reduction of up to 50 percent in green fodder or a substantial reduction in concentrate mixture (as up to 30 percent of total crude protein requirement can come from the blocks) without sacrificing milk yield or live weight gain, giving additional benefit to farmers through reduced input costs. Uptake of the block technology has been easier and faster for dairy cattle compared with beef cattle because of an immediate increase in milk yield from the third or fourth day of feeding the blocks, giving additional profit to the farmers. An increase in milk yield of the order of 1 to 1.5 litre per day on giving about 500 g of block has been recorded. Factors such as animal species and basal diet influence the beneficial effects of feeding the blocks. In general, the effects are most pronounced in cattle, then buffalo, yak and sheep (in that order), and least in goats. The greater ability of goats to browse different trees and browses containing leaves with high protein content could be responsible for the apparent lower efficiency of nitrogen utilization from blocks in this species. Similarly, supplementation of the blocks with diets of good composition has also resulted in poor response in cattle, buffalo and sheep. In such a situation, an attractive option is to decrease the costs of inputs by replacing concentrate mixture or green fodder with the block, and getting the same milk yield. This approach has been used in practical situations in countries such as Bangladesh, India, Indonesia and Sri Lanka for animals of medium milk yield. Maximum gains from supplementing with multimineral blocks are achieved during the dry period in tropical countries, when the farmers have nothing except crop residues and poor quality grasses and weeds.

Substantial enhancement of reproductive performance has been obtained in buffaloes following pre- and postpartum block supplementation. In most countries, the extension of the block technology to farmers has been through demonstration of increased milk yield, or better body weight gain and hence greater meat production. However, the adoption of the block technology may be through demonstration of the impact on reproductive performance, with a spillover effect being enhanced milk yield. Widespread reproductive problems in ruminants, which is attributed to poor nutrition, can be overcome through an appropriate, low cost and simple technology like multimineral blocks (Brar and Nanda, 1996).

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

Advantages of blocks in emergency situations: In the recent past, a unique role for multinutrients blocks as a supplement to the basal diet during the severe feed shortages during dry season is paramount. This can decreased the number of deaths in animals. The blocks have also prevented deaths during the drought periods and after floods in countries that have included India, the Sudan and Zimbabwe. During drought periods, only crop residues and other highly lignified fibrous materials are available for feed. Through blocks, the supply of nitrogen, minerals and vitamins to rumen microbes enhances the availability of energy supply to the animal from fibrous materials. The simplicity of the method of block production and compact nature of the blocks, and hence their fast production and ease in transport from nonemergency to emergency situations, are some of the advantages of this technology in disaster situations.

The mineral composition of the ingredients used in the production of multimineral block is presented in table 4.

Table 4. Mineral composition of the samples

Minerals (mg/100g)	Maize	Eggshell	Black clay	Salt
P	299.6 ± 57.8	6.3575 ± 0.013	0.37±0.030	
K	324.8 ± 33.9	7.25 ± 1.0	4.91±0.110	-
Ca	48.3 ± 12.3	1.074 ± 0.2	8.28±0.200	0.71±0.011
Mg	107.9 ± 9.4	0.0575 ± 0.1	1.55±0.020	0.28±0.013
Na	59.2 ± 4.1	6.000 ± 0.2	1.37±0.021	98.55±1.22
Fe	4.8 ± 1.9	5.10	1.87±0.110	-
Cu	1.3 ± 0.2	0.45	38.20±0.021	-
Mn	1.0 ± 0.2	-	207.81±0.013	-
Zn	4.6 ± 1.2	3.30	96.44	

Determine Physical characteristics of the mineral blocks

Hardness and compactness of blocks were measured by three persons independently. Most of the blocks were medium (M) compactness and hardness. The result obtained from this research revealed that the blocks are of medium compactness. This is similar to what was reported by Hadjipanayiotou *et al.* (1993). If they are too soft, there may be risks of toxicity resulting from the high intake of elements. If they are too hard, the intake is too low to have any effect on the animals.

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

This shows that good compression is needed to obtain multi nutrient blocks of good strength despite the role binders' play. The combinations of binders (Black clay and maize flour) gave the blocks medium strength. This has the advantage of ensuring gradual release of nutrients to animals when fed such feed blocks, otherwise, toxicity will occur, and also becomes more convenient for packaging, storage, transport and ease of feeding as noted by Sansoucy *et al*. (1986).

However, it indicates that clay can replace cement as it is more expensive and most animal welfare advocates are against the usage of cement in animal feed preparation. The drying was done under open ventilation to avoid direct sunlight as this might result in a loss of nutrient elements like vitamin C, the blocks did not grow mouldy. This may be attributed to the minimum amount of water used for fabrication. This emphasizes on the fact that provided minimum amount of water used for multi nutrient block fabrication, blocks can be stored for months (Kunju, 1986). This implies that when fabricated towards the end of the rainy season, they could be used up to the beginning of the next rainy season, where more feed will be available for ruminants.

The blocks were of good strength. The consistency observed in the final blocks mixtures was due to the premixing of the clay in water before adding to mixture. This also tends to ensure an even spread of the clay in the feed mixture which facilitates and improves uniform hardening of blocks, this also ensured that the ingredients were held together reasonably. (Sansoucy *et al*., 1986).

Production cost

Table 5. Cost effectiveness of producing 5kg mixture (1block)

Ingredients	Cost in Naira (₦)
black clay (3kg)	-
Salt (0.5kg)	50
Maize Flour (1kg)	150
Eggshell powder (0.5kg)	100
Total	300

A unit of 5kg block on average costs about N300. The average cost of each block was estimated seems to be highly affordable among the smallholder farmer in the semi-arid environment.

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

CONCLUSION AND RECOMMENDATIONS

Conclusion

The findings of this experiment revealed that the rumen requirement of ruminants could be met at a very convenient and affordable way in terms of cost and availability of required minerals in rations fed to animals. Multi-mineral blocks obtained from local feed ingredients have the tendency to enhance the activities of microorganisms by increasing the number of the resident microbes in the rumen for better utilization of low quality roughages especially during dry season, when livestock are often dependent on crop residues which are low in crude protein and high in fiber and as such, peasant agro-pastoralists should augment the basic mineral requirement of their ruminant animals using locally produced multi-mineral blocks from locally available ingredients.

Recommendations

Based on the findings of this experiment, the use of formulated multi–mineral block as supplement can provide rumen microorganism requirement for ruminants and could reduce the cost of supplementary feeding of concentrates which are generally more expensive. Thus, use of multi-mineral blocks is strongly recommended in feeding regimen of ruminant animals in regions with poor quality roughages and crop residues.

REFERENCES

Adebayo A.A. (2004). A geographical synthesis of Mubi region published by paraclete pulishers Yola-Nigeria.

Adeyeye, EI. (2009). Comparative study on the characteristics of eggshells of some bird species. Bulletin of the Chemical Society of Ethiopia 23, 159-166.

Al-awwal, NY. and Ali, UL. (2015). Proximate analyses of different samples of eggshells obtained from Sokoto market in Nigeria. International Journal of Science and Research (IJSR) 4, 564-566.

Alexander, G.I. (1972). Non-protein nitrogen supplements for grazing animals in Australia. *World Animal Review*, 4: 11–14.

Anindo, D., Toe, F., Tembely, S., Mukasa-Mugerwa, E., Lahlou-Kassi, A. and Sovani, S. (1997). Effect of molasses-urea-block (MUB) on dry matter intake, growth, reproductive performance and control of gastrointestinal nematode infection of grazing Menz ram lambs. *Small Ruminant Research*, 27(1): 63–71.

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng

AOAC, (2000). Official methods of analysis (16th ed.). Association of Official Analytical Chemists. Washington, DC.

Araque, C.A.H. and Rosos, L.R.O. (1993). Evaluacion de bloques multinutricionales con y sin antihelmintico en la alimentacion de mautas. *Zootecnia Tropical*, 11(1): 49–58. See: www.ceniap.gov.ve/ztweb/zt1101/texto/evaluacion.htm

Brar, P. S., Nanda, A. S. and Juyal, P. D. (2006). Reproductive performance of dairy buffalo receiving supplements of urea molasses multinutrient block (UMMB). *In improving animal productivity by supplementary feeding of multinutrient blocks, controlling internal parasites and enhancing utilization of alternate feed resources*, pp. 39–50, Vienna, IAEA-TECTOC-1495, International Atomic Energy Agency, Vienna, Austria.

Beames, R.M. (1963). Provision of urea to cattle in a salt/urea/molasses block. *Queensland Journal of Agricultural Science*, 20: 213–230.

Beames, R.M. and Morris, J.G. (1965). Effect of salt/urea blocks on body-weight, body composition and wool production of sheep fed low-protein native grass hay. *Queensland Journal of Agricultural Science,* 22: 369–379.

Cardozo, A.F. and Birbe, B. (1994). Bloques multinutricionales. p. 119, *in*: Memorias de la primera conferencia internacional, Guanare, Venezuela, 29–31 July 1994.

Chang, F., Li, G., Haws, M. and Niu, T. (2007). Element concentrations in the shell of Pinctada margaritifera from French Polynesia and evaluation for using as a food supplement. Food Chemistry 104, 1171-1176.

Dudusola, I.O. (2010). Comparative evaluation of internal and external qualities of eggs from quail and guinea fowl. International Research Journal of Plant Science 1, 112-115.

Dinh Van Binh, Bui Van Chin and Preston, T.R. (1991). Molasses urea blocks as supplements for rabbits. *Livestock Research for Rural Development*, 3(2): 13–18. See www.cipav.org.co/lrrd/lrrd3/2/viet1.htm

Doan Duc Vu, Le Xuan Cuong, Chung Anh Dung and Pham Ho Hai. (1999). Use of urea-molasses-multinutrient block and urea-treated rice straw for improving dairy cattle productivity in Viet Nam. *Preventive Veterinary Medicine*, 38(2–3): 187– 193.

FAO. (2012). Crop residue based densified total mixed ration – A user-friendly approach to utilize food crop by-products for ruminant production, [by T.K. Walli, M.R. Garg and Harinder P.S. Makkar]. FAO Animal Production and Health Paper No. 172. Rome, Italy.

Filippi, B.G., Amici, A. and Machin, D. (1992). Initial studies on the production and use of molasses blocks in the feeding of forage fed rabbits. *Journal of Applied Rabbit Research*, 15: 1053–1057.

Garcia, L.O. and Restrepo, J.I.R. (1995). Multinutrient block handbook. *FAO Better Farming Series*, No. 45. 38 pp. See www.fao.org/ag/aga/agap/frg/facts/bfs45/ bl1.pdf

Ghosh, A., Alam, M.G.S. and Akbar, M.A. (1993). Effect of urea-molasses-mineral block supplementation on postpartum ovarian activity in zebu cows. *Animal Reproduction Science,* 31(1–2): 61–67.

Hassoun, P. and Ba, A.A. (1990). Mise au point d'une technique de fabrication de blocs multinutritionnels sans mélasse. *Livestock Research for Rural Development,* 2(2). See www.cipav.org.co/lrrd/lrrd2/2/hassoun.htm

Hendratno, C., Nolan, J.V. and Leng, R.A. (1991). The importance of urea-molasses 20 *The block story* multinutrient blocks for ruminant production in Indonesia. *In:* Proceedings of an international symposium on nuclear related techniques for animal production and health. International Atomic Energy Agency, Vienna, Austria, 15–19 April 1991.

Ho Quang Do, Vo Van Son and Preston, T.R. (2002). Blocks or cakes of urea-olasses as supplements for Sindhi × Yellow growing cattle fed rice straw and cut grass or cassava foliage. *Livestock Research for Rural Development,* 14 (2). See www.cipav.org.co/lrrd/lrrd14/2/do142.htm

Houmani, M. and Tisserand, J.L. (1999). Complémentation d'une paille de blé avec des blocs multinutritionnels: effets sur la digestibilité de la paille et intérêt pour des brebis taries et des agneaux en croissance. *Annales de Zootechnie,* 48: 199–209.

Hunton, P., (2005). Research on the eggshell structure and quality: A historical overview. Brazilian Journal of Poultry Science (Revista Brasileira de Ciência Avícola) 7, 67-71.

Hamilton, RMG., (1986). The microstructure of the hen's eggshell - A short review. Food Structure 5, 99-110.

Habib. G. and Roomi. I. (2000). New experience in development of mulberry based multinutrient blocks for feeding ruminant livestock. *J. Sci. Technol. Dev.*, 19: 58–60.

Habib, G., Basit, A.S.S., Wahidullah, J.G. and Ghufrunullah. (1991). The importance of ureamolasses blocks and by-pass protein in animal production: the situation in Pakistan, *In Isotope and related Techniques in animal production and health*, pp. 133–144, Vienna, IAEA.

Hadjipanayiotou, M. (1996). Urea Blocks made of a variety of by-products and binders. *Livest. Res. Rural Dev.,* 8(5): 16-18.

Hadjipanayioutou, M. (1994). Voluntary Intake and Performance of Ruminant Animals Offered Poultry Litter Silage. *Livest. Res. Rural Dev.*, 6(2): 24.

Hassoun, P. (1989). Manufacture of urea blocks without molasses. Mimeograph, FAO, Rome, Italy.

Kunju, P.J.G. (1986). Urea molasses block lick: a feed supplement for ruminants. pp. 261–274, *in:* M.N.M. Ibrahim & J.B. Schiere (eds). *Rice straw and related feeds in ruminant rations*. Proceedings of an International Workshop, Kandy, Sri Lanka, 24–28 March 1986.

Kayouli, K. and Buldgen, A. (2001). Elevage durable dans les petites exploitations du Nord-Ouest de la Tunisie. Coopération belgo-tunisienne FASAGx-INATAPEL. Faculté universitaire des Sciences Agronomiques, Unité de Zootechnie, Gembloux, Belgique. pp. 96–105.

King'ori, AM., (2011). A review of the uses of poultry eggshells and shell membranes. International Journal of Poultry Science 10, 908-912.

Kunju, P.J.G. (1986a). Urea molasses block lick: a feed supplement for ruminants. pp. 261–274, *in:* M.N.M. Ibrahim & J.B. Schiere (eds). *Rice straw and related feeds in ruminant rations*. Proceedings of an International Workshop, Kandy, Sri Lanka, 24–28 March 1986.

Liu, L., Oza, S., Hogan, D., Perin, J., Rudan, I., Lawn, J. E., Black, R. E. (2015). Global, regional, and national causes of child mortality in 2000-13, with projections to inform post-2015 priorities: An updated systematic analysis. The Lancet, 385(9966), 430–440. https://doi.org/10.1016/S0140-6736 (14) 61698-6

Leng, R.A. (1986). *Drought feeding strategies: theory and practice.* Armidale, Australia: Penambul Books. 162 pp.

McBeath, D.G., Preston, N.K. and Thompson, F. (1979). Studies in sheep on the efficacy of fenbendazole administered via feed-block carrier. *British Veterinary Journal,* 135(3): 271–278.

Mtallib, MOA. and Rabiu, A. (2009). Effects of eggshells ash (ESA) on the setting time of cement. Nigerian Journal of Technology 28, 29-38.

Nguyen Van Thu. (2000). Urea-molasses based supplements for multipurpose buffaloes. Doctoral thesis. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Onwuka, C. F. I. (1999). Molasses blocks as supplemental feed resources for ruminant. Arch zootec. 48: 89 – 94.

Osuna, D.B., Ventura, M.S. and Casanova, A. (1996). Alternativas de suplementacion para mejorar la utilizacion de los forrajes conservados. II. Efecto de diferentes concentrationes de dos fuentes de energia en bloques nutricionales sobre el consumo y ganancia de peso de ovinos en crecimiento. *Revista de la Facultad Agronomia (LUZ),* 13(2): 191–200. See http: //redpav-fpolar.info.ve/fagroluz/

Perez, R. (1990). Manual de crianza: Conejos. Ministerio del Azucar, Havana, Cuba.

Phil, G. and Zhihong, M. (2009). High-value products from hatchery waste. In: RIRDC (Ed.), United State of America. 79 pp.

Salman, A.D. (1997). The role of multinutrient blocks for sheep production in integrated cereal-livestock farming system in Iraq. pp. 209–219*, in*: Second FAO electronic conference on tropical feeds. 9 September 1996–28 February 1997. See www.fao.org/ag/aga/agap/frg/tfconf2.htm

Sansoucy, R. (1986). The Sahel: Manufacture of molasses-urea blocks. *World Animal Review,* 57: 40–48.

Sansoucy, R. (1995). New development in the manufacture and utilization of multinutrient blocks. *World Animal Review,* 82: 78–83.

Sansoucy, R. (1986). The Sahel: manufacture of urea-molasses blocks. *World Animal Review,* 57: 40–48.

SAS. (2003) Guide for personal computer version, 6th Edition. Statistical Analysis System Institute, Inc. Cary, North Carolina, USA, 2003.

Schaafsma, A., Pakan, I., Hofstede, GJH., Muskiet, FAJ., Van Der Veer, E. and De Vries, PJF., (2000). Mineral, amino acid, and hormonal composition of chicken eggshell powder and the evaluation of its use in human nutrition. Poultry Science 79, 1833-1838.

Speedy, A. and Pugliese, P.L. (1992). Legume trees and other fodder trees as protein sources for livestock. *FAO Animal Production and Health Paper,* No. 102. 339 pp. See www.fao.org/ag/aga/agap/frg/AHPP102/ahpp102.htm

Tadesse, D., Esatu, W., Girma, M. and Dessie, T., (2015). Comparative study on some egg quality traits of exotic chickens in different production systems in East Shewa, Ethiopia. African Journal of Agricultural Research 10, 1016-1021.

Vargas, J.E. and Rivera, J.G. (1994). Efecto del bloque multinutricional sobre el comportamiento productivo en ovejas africanas. *Livestock Research for Rural Development,* 6(2). See www.cipav.org.co/lrrd/lrrd6/2/vargas2.htm

Van Soest, P. J., Robertson, J. B. and Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. *J. Dairy Sci.*, 74: 3583-3597.

Makkar, H.P.S. (2000). Quantification of tannins in tree foliage. *A laboratory manual*. Joint FAO/IAEA working document, IAEA, Viena. pp 1-26.

McDowell, L.R. (1997). *Minerals for Grazing Ruminants in Tropical Regions*. University of Florida. Gainesville.

Mohammed, I.D., Baulube, M. and Adeyinka, I.A. (2007). Multinutrient blocks 1: Formulation and production under a semi-arid environment of North East Nigeria. *J. Biol. Sci.*, 7**(2)**: 389 – 392.

@A Publication of the Department of Economics, ADSU, Mubi. ISSN- Print: 2550- 7869; ISSN-Online: 3043-5323. Journal homepage: https://ajaefm.adsu.edu.ng