Multi Nutrient Block Supplementation for Ruminants: Formulation and Manufacturing

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Abstract

This study seeks to formulate and manufacture multi nutrient blocks for ruminants using different types and levels of binders. In a factorial arrangement of the treatment, two binders (quick lime and cement) at two studied. The results reveal that without a good mould and compression, the strength of the multi nutrient blocks would not be consistent despite the type, amount and combination levels of binders. Premixing of the cement in water before adding to mixture ensured that the ingredients are held together. Hardening of blocks increased with advancing storage period. Quick lime can replace most cement, as most animal welfare advocates are against the usage of cement in animal feed preparation.

Keywords: multi nutrient blocks, compression, strength, binders, mould

1.0 Introduction

Ruminant livestock production systems in Ghana are mainly the extensive and semi-intensive system. Ruminants are particularly adapted to feed on forages and good forage is indispensable for their survival. In the tropics including Ghana, annual and seasonal variations in the forage availability impose ‘stop go’ sort of growth pattern which is characterized by alternate gains and losses in animals’ body weight (Liu, Wu & Xu, 1995)

Native and natural grasslands provide the basic diets for much of the ruminant livestock in the tropics. A majority of these are located in regions of erratic rainfall patterns and varying periods of extreme draught and often grow on soils of poor fertility unsuited for cropping. These conditions impose a direct influence on the amount and quality of forage available during the year. The quantity and quality of nutrients in tropical forages are influenced by a number of factors including the stage and season of growth, climatic conditions, soils etc as well as the genotypes of the forage itself. As the forage matures the protein content and the soluble carbohydrates decreases leading to increase in the structural carbohydrates. This result in the lignification of the forage which makes it less digestible (Leng, Prestson, Sansoucy & Kunju, 1991).

The nutritional deficiency in tropical grasses are mainly protein, energy and mineral being the most widespread due variability of soils from place to place. The performance of an animal subsisting on low protein is further accentuated by widespread mineral deficiency particularly calcium and phosphorous (Leng *et al.,* 1991). Pastures in Ghana are mainly grasses which have established and grown naturally. The general practice is to graze the animals on unimproved pastures and rangelands during both rainy and dry seasons. Despite the differences which exist from place to place the pastures are low in nutritive value. Liu *et al.* (1995) observed that hay that is prepared from natural pastures had similar content of N and digestibility of dry matter (DM) comparable to rice straw.

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A major constraint to ruminant livestock production is severe scarcity of feeds and fodders both in quantity and quality especially during the dry season.

In the wet tropical regions, minerals are often deficient in cut and carry grass or crop residue feeding systems. Grasses from roadsides or wastelands are particularly low in minerals as generally, no fertilizer is used and the grasses have often been cut for decades for ruminant production, thus depleting the reserves of both soils and plants.

There are several possibilities for improving animal performance through simple dietary manipulations. These techniques include physical (chopping, grinding etc.), chemical (alkali and urea) and biological treatments. Excess feeding and supplementation is also known to be of immense help in improving the productivity of animals. Various supplements of carbohydrates, protein and non-protein nitrogen are used to supply balance nutrients for improving productive performance of animals.

Leng (1986) proposes two major strategies for improving ruminant production in animals fed residues or mature tropical pastures.

- To supplement nutrients to ensure efficient rumen function.
- To provide bypass supplements to those available from fermentative digestion.

These strategies aim to ensure maximum intake and efficiency of utilization of the absorbed nutrients by the animal.

Non-protein nitrogen (NPN) such as urea and readily available energy sources such as molasses which is in short supply in Ghana optimize rumen function. Urea is probably the most common source of supplementing fermentable N, and can be sprayed onto low quality fibrous feed or may be mixed with available energy supplements. The use of urea/molasses blocks is a convenient way of avoiding the excessive intake of urea (Leng & Preston, 1984).The beneficial effect of NPN and urea/molasses mixture on dry matter intake (DMI) and digestibility are well documented (Winter & Pigden, 1971).

Although the NPN and readily available energy optimize rumen function, Preston (1986) and others have shown that growing and lactating animals have a very high requirement for amino acids, glucose and long-chain fatty acids and that high growth rate and milk production cannot be supported on the products of fermentative digestion alone. Preston & Leng (1987) have pointed out the importance of protein-nitrogen in promoting growth rate in growing animals and milk production in lactating animals. Bypass protein supplements are now considered essential to take advantage of volatile fatty acids (VFA) energy generated from roughage fermentative digestion.

Multi nutrient block fabrication, the technique is to mix the supplement ingredients in a container and to pour the mixture in moulds to solidify into blocks. The feeding of the blocks is a convenient and inexpensive method of providing a range of nutrients required by both the rumen microbes and the animal, which may be deficient in the diet. The main justification for using the block depends on their convenience for packaging, storage, transport and ease of feeding.

Molasses-urea blocks (MUB) provide nutrients to the rumen microbes and to the animal in small amounts throughout the day (Preston & Leng 1987). Despite promising results from MUB feeding, their wider application is restricted due to lack of molasses in certain countries and/or areas within countries. Molasses in our region is in short supply and if available is expensive. As a result, urea block manufacturing without any molasses was promoted by the Food and Agricultural Organization of the United Nations in different parts of the world (Hassoun, 1989). This is an important feature when animals are on high- fibre, low-nitrogen cereal straws, since the nutrients in the block are available while the basal diet is being fermented.

Apart from providing non-protein nitrogen, the block can also be a source of rumen bypass protein, macro and micro-minerals, vitamins, pharmaceuticals and additives to manipulate rumen fermentation. Blocks can be manufactured with a wide variety of by-products, promoting therefore their utilization in different localities.

Poor quality roughage comprises the only part of the diet for ruminant animals in many parts of the world for a considerable part of the year (Preston & Leng, 1987). Animals on such diet are in negative energy balance and supplementary feeding with energy and nitrogen has been used for improving their nutritional status (Capper, Thomson & Rihawi, 1989).

It has also been shown that multi nutrient lick block supplementation of straw based diets increases digestibility, feed intake, live weight gain and net return and that micro and macro elements can easily be incorporated in it thereby correcting multi-nutritional deficiencies of ruminants in developing countries(Wanapat, Petlum & Pimpa, 1990).

By considering the above strategies and factual information, the objectives of this study are to:

- Formulate and manufacture multi nutrient blocks using different levels of binders,
- Assess the strength of the multi nutrient blocks and
- Analyze the chemical composition of the multi nutrient blocks

2.1 Supplementation

An alternative approach to increase to the utilization of structural carbohydrates in ruminants is through proper supplementation (Ndlovu & Buchanan, 1985). The supplements could be grains, oil seed cakes/meal, protein rich forage or microbial additives. The economics of this supplementation is also a point to be noted. The high cost of protein supplement makes it difficult and almost impossible for small scale holders in developing countries to adopt this technology. In this regard, multi nutrient blocks containing urea should be considered as supplements for their relatively low cost per unit nitrogen.

2.1.1 Supplementation with Fermentable Nitrogen

Priority should be given to overcoming nutrient limitations to fermentation of low quality forage in the rumen. The first constraint is ammonia-N which is usually deficient in low quality forages. To maximize rate of fermentation of fibre, the level of rumen ammonia should be above 150 ml/litre (Krebs & Leng, 1984). It is desirable that supplementation ensures an almost continuous supply of ammonia-N. Urea is commonly used as a source of fermentable N, which can be sprayed onto forages or be mixed with available energy supplements. The use of urea/molasses blocks is one convenient way to avoid excessive intake of urea (Leng & Preston, 1983). Ammoniation is one possible way to provide a continuous supply of N with an associated advantage of upgrading the carbohydrate component, which may result in an improvement in energy supply.

In Ghana, the use of anhydrous ammonia to process forage is unlikely to be widely accepted due to its high price and difficulties in transportation and handling. Urea is mainly used as nitrogenous fertilizer in agriculture and also relatively expensive unless its cost is subsidized by the government.

2.1.2 Supplementation with Protein Sources

When fermentable N is provided or forage is treated with ammonia, consideration should be given to the amino acids which are not degraded in the rumen but may be absorbed in the intestines.

They may serve to overcome specific amino acid deficiencies which are limiting production, or may be catabolized to improve the supplies of glucogenic substrates which are usually deficient in low quality forage based diets (Preston & Leng, 1984). Protein supplements used in developing countries are mainly oilseed cake or meal.

2.1.3 Supplementation with Highly Digestible Forage

It is known that small quantities of green forage can improve the utilization of low quality forage diets (Preston & Leng, 1984). Thus an introduction of forage supplements may be an alternative strategy for increasing the nutrient intake and improving productive performance of ruminants in developing countries. There is a wide range of forage supplements available, including leucaena, gliricidia, lablab etc. In specific locations farmers also offer animals the forages from many trees, crops and water weeds, such as banana, pigeon peas, sweet potato and water hyacinth. The supplementation level of forage would therefore depend on the types of forages used, its availability and cost relative to straw. The limitation is, however, that supplementary forages are usually in short supply in most areas and countries.

The rumen microbial system alters the nutrients finally made available to the animal converting fibrous carbohydrate, sugars and starches and soluble protein to microbial cells, short chain organic acids and waste products in the form of methane, carbon dioxide and heat. The critical issue for the animal is the ratio of protein (from microbial and dietary origin) to energy yielding substrates (the P/E ratio expressed as g protein/ MJ of energy from volatile fatty acids available for metabolism), since this determines efficiency and level of productivity (Preston & Leng, 1987). However, even when the rumen system is optimized by providing an array of essential nutrients for microbes, the P: E ratio is usually still inadequate to support optimum efficiency of utilization of the basal feed resource.

2.2 Optimizing Rumen Environment for Forage Diet Utilization

The feeding value of low quality forage, especially crop residues, is limited because they are low in nitrogen, are high in ligno-cellulosic compounds and, therefore, low in fermentable carbohydrates (Smith, 1992). Moreover, the poor quality of these residues, such as maize stover, is exacerbated by their post-harvest management (prolonged exposure to residual humidity and sun in late wet season in the field). Such residues generate a low level of ammonia (NH_3) in the rumen from degraded protein to ensure an efficient digestion process (Ørskov, 1995) and a subsequent microbial protein supply to the host animal. It has been suggested that protein and non-protein nitrogen (NPN) supplements may be used to correct the nitrogen deficiency of low quality roughages (Siebert & Hunter, 1982).

Strategies for the utilization of low quality forage should aim at establishing an efficient rumen ecosystem in order to maximize fibre digestion and optimize microbial protein synthesis. An efficient rumen ecosystem requires fermentable nitrogen, energy and minerals sufficient to support the rumen microbial population.

2.0 Materials and Methods

The experiment was conducted at the Livestock Section of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi.

It was undertaken to verify previous findings, to determine the best possible combination levels of the two binders (quicklime 7%and 8% and cement 5%and 4%).

3.1 Experimental Design

In a factorial arrangement of the treatments, two binders (quick lime and cement) at two levels were studied. The percentage compositions of ingredients in each formula are listed in Table 1. There were two treatments.

Table 1: Formulation of multi nutrient blocks using different types and levels of binders

Ingredients	Treatments	
	I	II
Quicklime	7	8
Cement	5	4
Urea	10	10
Salt	10	10
Oyster shell	17	17
Wheat bran	21	21
Soy bean meal	20	20
Bone meal	10	10
Total	100	100

Source: Author's construct

3.2 Preparation of Ingredients

Almost all the ingredients were used without processing. Lumps in the urea were broken to avoid intoxication. Lumps in the salt were also broken. All the ingredients were weighed separately according to the formulation and placed in different sacs.

3.3 Mixing of Ingredients

The mixing procedure was as follows:

- The cement was mixed with salt and minimum water sprinkled on the mix.
- The urea, quicklime, bone meal and oyster shell were also mixed together.
- The two mixes were compounded together.
- Finally the soy bean meal and wheat bran were added and mixed thoroughly. Minimum amount of water was used.

3.4 Moulding and Demoulding

The well mixed material was placed in wooden planks placed on a smooth concrete floor. The planks were of the measurement 15cm×15cm×10cm and 7.5cm×7.5cm×10cm. The material was pressed manually using a simple piece of wood. The wooden planks had slots sawn in it to allow easy assembling and disassembling. After pressing, the wooden planks were removed to expose the blocks that are formed.

3.5 Drying and Turning of blocks

Blocks were dried in the open air under shelter with good ventilation. Turning of the blocks was done to hasten and ensure even drying. Turning of blocks were done twice in a week. The shed under which the drying took placed was fenced to avoid destruction by animals. The drying was done for 28 days before the strength of the blocks were assessed using the point loading method and 7days for the Hassoun (1989) method.

3.6 Assessment of blocks

Hardness (H) and compactness (C) of blocks were measured by three persons independently seven days after manufacturing following the method of Hassoun (1989). Hardness was assessed by pressing with the thumb in the middle of the block. A block was characterized soft (S), medium (M) or good (G) when the thumb penetrated easily, very little or only with greater pressure, respectively.

The C was assessed by trying to break the block by hand. A block was characterized either null (N), medium (M) or good (G) when it was broken easily, with difficulty or with great effort, respectively. Again the compressive strength of the blocks was determined using point loading method at the Civil Engineering Department, KNUST-Kumasi.

3.7 Chemical Analysis

Samples of the two treatments were analyzed for dry matter (DM), moisture, ash and total nitrogen seven days after manufacturing of the multi nutrient blocks using the methods of AOAC (1980).

3.0 Results and Discussion

4.2 Chemical Composition of Blocks

Dry matter (DM) of the block consists of the organic and inorganic component of the multi nutrient mixture. The DM of a feed component consists of carbohydrate, protein, fats and oil, vitamins and minerals. From Table 2 the higher DM values indicate that when fed to animals, they will eat less to obtain their requirement. McDonald, Edwards & Greehalgh (1995) indicated that animals will eat less of a feed with high DM to obtain their requirement.

Moisture in the multi nutrient block might reduce the storage period of the blocks as it will encourage mould growth. However, it may also serve as a source of water to ruminants fed low moisture feed especially during the dry season. Moisture content of the blocks though not much might be due poor hydration in the drying area. This goes on to reiterate what was reported by Sansoucy, Aarts & Leng (1988) that if dried multi nutrient blocks are needed for feeding they should be fabricated at an earlier date.

Ash is the inorganic residue which is estimated after the sample is burnt at 600 ^{0}C. The ash may contain materials of organic origin such as sulphur and phosphorous from proteins, and some loss of volatile material of sodium, chlorine, potassium, sulphur and phosphorous will take place during ignition. From Table 2 total ash does not give any information about the amount and types of minerals present in the sample. But from the ingredients used especially bone meal, oyster shell and salt and their levels of inclusion we can deduce that the blocks are high in Ca, P and Na. Ash is not a true representative of the inorganic component in the multi nutrient mixture either quantitatively or qualitatively (McDonald et al ,1995).

The micro-kjeldahl technique was adopted to estimate the total nitrogen content in the multi nutrient mixture. Total nitrogen was calculated instead of crude protein because nitrogen is derived from other sources other than protein form living tissues such as soya bean meal amino acids but from non-protein nitrogen source (urea). This is to say that we cannot assume that the protein, N constitutes 16% of the total make up. From Table 2 total nitrogen does not reflect the ingredients used. These low values might be due to the method used in their extraction and processing and duration of storage of the ingredients. McDonald *et al*. (1995) reported that method of extraction and processing and duration of storage feed influence their crude protein level and hence their total nitrogen. According to McDonald *et al*. (1995) urea alone contains 484g/kg of nitrogen, therefore the low values observed might be due to the inert conditioner that keeps it flowing freely and this reduces it nitrogen.

Analyses made on the blocks showed that the composition of the finished blocks was related to that of the individual ingredients even though there is no greater difference between the two treatments. The chemical composition of a block determines its feeding value as a supplement.

Table 2: Chemical composition of the blocks

	Treatment I	Treatment II
Dry matter (%)	76.66	76.22
Moisture (%)	23.44	23.78
Ash (% DM)	36.02	34.73
Total Nitrogen (kg DM)	0.102	0.114

Source: Author's construct

4.3 Strength of the Blocks

Hardness and compactness of the blocks were tested seven days after fabrication using the method of Hassoun (1989). Hardness (H) and compactness (C) of blocks were measured by three persons independently. Most of the blocks were of medium (M) compactness and hardness. Results of the strength of the multi nutrient block from the point loading method are given in Tables 3 and 4. This assessment was done after 28 days of manufacture. From Tables 3 and 4 it is observed that the strength of the multi nutrient blocks are not consistent. This inconsistency might be due to the inability of the wood presser in giving a good press.

Table 3: Compressive strength (N) of the 3kg multi nutrient blocks

Treatment	Compressive strength(N) of blocks			Mean	Standard deviation
1	462	417.1	484.6	454.77	34.36
2	529.6	507.1	507.1	514.6	12.99

Source: Author's construct

According to Sansoucy *et al*. (1988) strength (hardness and compactness) of the blocks must be consistent. If they are too soft, there may be risks of toxicity resulting from the high intake of urea. If they are too hard, the intake is too low to have any effect on the animals. This shows that good compression is needed to obtain multi nutrient blocks of good strength despite the role binders play

Table 4: Compressive strength (N) of the 1kg multi nutrient blocks

Treatment	Compressive strength (N) of blocks			Mean	Standard deviation
1	304.6	270.1	259.6	278.1	23.54
2	304.6	304.6	282.1	297.1	12.99

Source: Author's construct

It is observed that Treatment II combination (8% quick lime and 4% cement) produced a higher strength than Treatment I combination (7% quick lime and 5% cement). This is similar to what was reported by Hadjipanayiotou, Verhaeghe, Kronfoleh, Labben, Shurbaji, Al-Wadi, Dassouki, Shakel & Amin (1993) that increasing the level of quick lime increases the strength of multi nutrient blocks. This indicate that quick lime can replace most cement as most animal welfare advocates are against the usage of cement in animal feed preparation.

The two combinations of binders gave blocks of good strength. This has the advantage of ensuring gradual release of urea to animals when fed such feed blocks, otherwise, urea toxicity will occur, as noted by Sansoucy *et al*. (1988).It must however be noted that binders are not the only determinants of the strength but other components like bran.

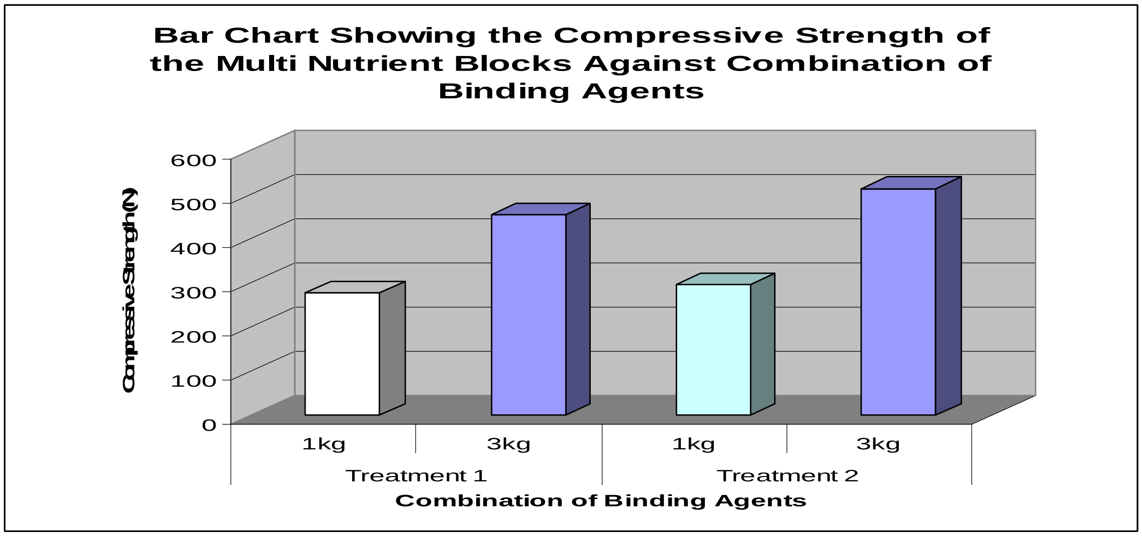

Figure 1: Bar chart showing the compressive strength of the multi nutrient blocks against combination of binding agents.

Source: Author's construct

4.4 Drying and storage of the Multi Nutrient Blocks

Figures 2 and 3 show the fabricated multi nutrient blocks being dried. In all 72 blocks of the 3kg and 46 blocks of the 1kg were manufactured. The drying was done under a shed with 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 even when stored after one month of manufacture. 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.

Figure 2: Blocks of Treatment I

Figure 3: Blocks of Treatment II

4.5 Premixing of Binder and Strength of Blocks

The blocks were of good strength. The consistency observed in the final blocks mixtures was due to the premixing of the cement in water before adding to mixture. This also tends to ensure an even spread of the cement in the feed mixture which facilitates and improves uniform hardening of blocks (Sansoucy *et al*., 1988). This also ensured that the ingredients were held together reasonably.

5.1 Conclusions

Multi nutrient block of good hardness and compactness could be obtained using the two combinations of binders for use for supplementary feeding of ruminants. Premixing of the cement in water before adding to mixture ensured that the ingredients are held together. Hardening of blocks increased with advancing storage period.

It was observed from the results that, without a good mould and compression, the strength of the multi nutrient blocks would not be consistent despite the type, amount and combination levels of binders. Quick lime can replace most cement as most animal welfare advocates are against the usage of cement in animal feed preparation. Quick lime can replace a great part of cement; the selection of the binder therefore, should depend upon price and availability.

The chemical composition of a multi nutrient block depends on the quantity and the kind of ingredients used in the fabrication. The use of wooden planks is capable of producing multi nutrient blocks of good shape and strength, so could be promoted for adoption at the smallholder farmer level.

5.2 Recommendations

Future manufacture of the blocks should have holes in it to facilitate easy hanging during its usage. Vitamins, pharmaceuticals and additives should be added to manipulate rumen fermentation in subsequent fabrications.

Experiment should be carried to use a wide variety of by-products and other locally available ingredients in the formulation of multi nutrient blocks, to promote their utilization in different localities. It is also recommended that, future experiment should be carried out on the effects of the multi nutrient blocks on the performance of ruminants.

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