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Supplementary Conventional Mineral Licks and the Productivity of Ruminant Animals in Tropical Africa: A Review

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Abstract: *The objective of the paper was to review the use of supplementary conventional mineral licks in improving the productivity of ruminant animals in tropical Africa. Conventional mineral licks have been extensively used by livestock farmers for years in many developing and developed countries especially, mixtures of liquid molasses and urea, which provides fermentable nitrogen and are good sources of minerals. However, small scale farmers have rarely benefitted from these supplements, usually because of difficulties of handling these in small quantities. Molasses in the liquid form is difficult to transport (requiring expensive tanker trucks), to store (requiring tanks), to handle (as it is highly viscous) and to distribute to animals (as troughs or other receptacles are needed).Minerals are needed for the proper development and maintenance of bones, muscles, circulatory systems and even the nervous systems. Salt is made up of sodium and chloride, but it's also an ideal carrier for a variety of essential trace minerals like calcium, magnesium, phosphorus and selenium. Sodium helps in controlling the blood's pH levels, and chloride helps in digestion and keeps the blood acid levels balanced. Proper use of conventional mineral licks in the diets of ruminant animals in tropical Africa would improve animal health and productivity.*

Keywords: *Conventional mineral licks, Ruminant Diets, Tropical Africa.*

INTRODUCTION

During the harsh and long dry season, important components of forages such as protein, energy and vitamins are, often, not available to the grazing livestock, which in turn reduces the intake of different minerals in the animals (McDowell, 2003). During those harsh and long dry season periods, diets of ruminant animals which are based on fibrous feeds, mainly matured pastures and crop residues for example, cowpea husk, groundnut hums, rice straw, maize and sorghum stovers are highly lignified and imbalanced as they are deficient in protein, minerals and vitamins, with low intake and digestibility. The principles of improving the use of these poor quality roughages by ruminants is through supplementation to satisfy the requirements of the rumen microorganisms to ensure efficient fermentation of fibre and increased production of microbial protein relative to volatile fatty acids (Preston, & Leng, 1984).All livestock need minerals especially sodium chloride, potassium, calcium etc. as shown in table 1 to survive since they form part of the blood, sweat and tears. The objective of the paper was to review the use of supplementary conventional mineral licks in improving the productivity of ruminant animals in tropical Africa.

PRODUCTION OF MINERAL BLOCKS

The goal of producing mineral blocks is to provide the small farmer with supplements for his ruminants which will improve the efficiency of use of the basal diet at an acceptable cost. The concept of using molasses-urea block to provide nutrients for livestock started 25 years ago in Australia and other countries (Beames, 1963). However, improvement in knowledge now indicates their strategic place in feeding strategies aimed at improving livestock production by the small farmer (Leng & Preston, 1983).

The solidification of molasses is a way of solving the difficulties encountered in the distribution and feeding of molasses while allowing for the incorporation of various other ingredients. Attempts have been made in many countries to manufacture solid blocks with high molasses content, but their development has not been very successful. However, recent work in India has revived interest in such blocks. Trials are now under way, with technical assistance from FAO, in several countries such as Burkina Faso, Bhutan, Egypt, India, Iran, Mali, Mauritius, Pakistan, the Philippines, Senegal and Sudan. More than 30 other countries have shown their interest in this technology.

The blocks can be made from a variety of components depending on their availability locally, nutritive value, price, existing facilities for their use and their influence on the quality of blocks. Molasses provides fermentable substrate and various minerals and trace elements with low amounts of phosphorus. Because of its pleasant taste and smell, it makes the block very attractive and palatable to animals. Urea, which provides fermentable nitrogen, is the major component of the block. Campling *et al*. (1962) have shown that, its continuous supply to cattle may increase the intake of straw by about 40 percent and its digestibility by 8 units or 20 percent. The intake of urea must be limited to avoid toxicity problems but sufficient to maintain ammonia levels in the rumen consistently above 200 mg N/1 for growth of microorganisms and high rates of degradation of fibre. Blocks are an excellent way of controlling intake and allow continual access.

Rice bran has multiple purposes in the blocks. It provides some key nutrients including fat, protein and phosphorus; it acts as an absorbent for the moisture contained in molasses and gives structure to the block. It may be replaced by other fibrous materials such as dry and fine grasses or groundnut hulls which are finely ground, but some loss of nutritive value occurs. Minerals may be added where appropriate. Common salt is generally added because this is often deficient in the diet and it is inexpensive. Calcium is supplied by molasses and by the gelling agent, calcium oxide or cement. Although, phosphorus is deficient, there is no evidence that its addition is beneficial where animals are at below maintenance when grazing on dry mature pastures or fed low-quality forage (Cohen, 1980; Van Niekerk & Jacobs, 1984). Mineral requirements are reduced at maintenance or survival levels. Deficiencies will generally become a problem only when production is increased, particularly when a by-pass protein supplement is given and in that case phosphorus should be included in the supplement.

A gelling agent or binder is necessary in order to solidify the blocks. Although, the mechanism of gelling is unknown, various products have been tried successfully, for example magnesium oxide, bentonite, calcium oxide, calcium hydroxide and cement. The use of cement has raised some questions, from various nutritionists and extension workers, about possible negative effects on animals. In fact, research on the use of cement or its by-product, cement kiln dust, as a mineral supplement in Canada (Bush *et al*., 1985), Italy (Galvano *et al*., 1982), USSR (Karadzhyan & Evoyan, 1984) and USA have not shown such adverse effects at levels of 1 to 3 percent of the total diet dry matter. Nevertheless, USDA has restricted the use of cement kiln dust since it could cause a deposit of heavy metals in animal tissue.

Various chemicals or drugs for the control of parasites or for manipulation of rumen fermentation such as anti-protozoal agents and ionophores can be added to the molasses blocks which can be an excellent carrier for these products. Earlier work by Van Houtert, and Leng (1986) has shown that the addition of small amounts of rumen-insoluble calcium salts of long chain fatty acids could further increase the efficiency of the use of fibrous residues.

PRODUCTION OF MOLASSES-UREA BLOCKS

Hot Technique

This technique was the first one recommended in Australia using molasses (60 percent) and urea (10 percent) which were cooked with magnesium oxide (5 percent), calcium carbonate (4 percent) and bentonite (1 percent) at a temperature of 100–120°C for about 10 minutes. The content was brought to a temperature of about 70°C and then cottonseed meal (20 percent) was added while stirring. The mixture was left to cool slowly, which enhanced solidification (George, 1981). It was allowed to settle after some hours and the cooking was done in a double-jacketed rotating boiler with circulating water and steam.

Warm Technique

The procedure involves heating molasses (55 percent) to the temperature of about 40° – 50°C and urea without water (7.5 percent) dissolved in the molasses (Choo, 1985). The gelling agents are usually calcium oxide (10 percent), common salt (5 percent) and bran (22.5 percent). The inconvenience of these processes, particularly the "hot" one, is the necessity for providing energy for heating. However, if it is possible to use the hot molasses as it leaves the sugar factory or if an excess of steam is available, the cost of energy may be acceptable. The advantages are the reduction of time for setting and the final product is not hygroscopic.

Cold Technique

It has been noted that, in tropical conditions, it was not necessary to heat the molasses in order to obtain a good block when 10 percent of calcium oxide is used as a gelling agent (Barker, 1984). This observation is of primary importance when blocks are manufactured in a unit separate from the sugar factory, as was the case in Senegal. The cold technique has been described in detail (Sansoucy, 1986). A horizontal paddle mixer with double axes is used to mix in the following order of introduction: molasses (50 percent), urea (10 percent), salt (5 percent), calcium oxide (10 percent) and bran (25 percent). The mixture is then poured into moulds (plastic mason's pails or a frame made of four boards 2.5 m × 0.2 m). After about 15 hours, blocks may be removed from the mould and they may be transported by truck after 2 days.

Calcium oxide may be replaced by cement, but when cement is used, it is important to mix it previously with about 40 percent of its weight in water, and common salt should be included in the block. This ensures its binding action, as the water in molasses does not seem to be available for the cement. The quality of the cement is of primary importance and should necessarily be ensured. Mixing the salt with cement, also, accelerates hardening.

The disadvantage of the cold technique is that, it needs some time to set and the final product is somewhat hygroscopic. The advantages are the saving in energy and the simplicity and ease of production. Independent of the process, the hardness of the block is affected by the nature and proportion of the various ingredients. High levels of molasses and urea tend to decrease solidification. The concentration of gelling agents and bran is highly important in the hardness of the final product. For example, if the urea percentage is as high as 20 percent, molasses should be reduced to 40–45 percent and the gelling agent needs to be increased. Quick lime produces harder blocks than cement.

FEEDING MOLASSES-UREA BLOCKS TO RUMINANTS

Factors Affecting the Intake of Blocks

High levels of urea reduces intake of the block as well as of straw, urea being unpalatable, the hardness of the block affects its rate of intake. If it is soft, it may be rapidly consumed with the risk of toxicity. On the other hand if it is too hard its intake may be highly limited. The level of inanition or imbalance in minerals which lead to pica may result in excessive consumption in a short time, also, leading to urea poisoning. This has been noticed, in at least one case, in Senegal. Precautions should be taken to avoid this problem of over-consumption in drought prone countries, particularly towards the end of the dry season when feed is scarce. The block should be introduced progressively and it should be clear that, the block, as it is presently formulated, cannot constitute the only feed therefore, a minimum of roughage is necessary (George, 1986a & 1986b).

Where there is a bulk of dry feed, the risk of toxicity from over-consumption is not apparent (Leng, & Preston, 1983). In India, several thousand buffaloes in village herds have been fed blocks containing 15 percent urea without problems (George, 1986a & 1986b) and there is some indication that, buffaloes learn to regulate their intake. Finally, the intake of block obviously varies with the type of animals.

Effects of Blocks on Intake of Basal Diets

Feeding blocks usually results in a stimulation of intake of the basal diet. With a basal diet of straw without any supplementary concentrate, the increase of straw consumption due to molasses urea blocks is between 25 and 30 percent. When some high protein concentrate is, also, given with the basal diet, the increase of straw consumption is less and varies between 5 and 10 percent (Leng & Preston, 1983).

Effects of Intake of Blocks on Digestibility

The digestibility of straw dry matter in dacron bags measured after 24 hours in the rumen of lambs (Sudana, & Leng, 1986) increased from 42.7 to 44.2 percent when 100 g of molasses urea block was consumed, and to 48.8 percent by an additional supply of 150 g cottonseed meal. Ammonia concentration in the rumen of lambs receiving molasses urea blocks increases to levels which are much higher than those generally recommended for optimal microbial development (60 to 100 mg NH3/1 of rumen fluid). This concentration increases with the urea content of the block when a by-pass protein is added. Krebs and Leng (1984) showed that, the digestibility of straw in sheep increased even up to 250 mg NH3 - N/1. The total volatile fatty acids in rumen fluid are increased when lambs consume the blocks with or without additional by-pass protein. There is a small but significant shift towards a higher propionate and butyrate production and a lower acetate production.

Effects of Blocks on Ruminant Growth

Dry mature pasture or straw given alone are unbalanced in nutrients to provide for an active and efficient rumen and efficient utilization of the nutrients absorbed. Feed intake and the nutrients absorbed from such diets are insufficient to ensure even maintenance requirements and therefore, animals lose weight if they do not receive any nitrogen and mineral supplement. Molasses-urea blocks added to such an unbalanced diet allow for maintenance requirements because they ensure an efficient fermentative digestion. When some by-pass protein is added, for example cottonseed meal and groundnut cake, there is a synergistic effect which further improves considerably the average daily gain of ruminants and they become much more efficient in using the available nutrients. In addition, total nutrients are often increased because feed intake is increased (Preston, & Leng, 1986). Compared to urea supplied by spraying on straw, urea from blocks gives superior results. It is assumed that, part of the response may be due to the small amount of supplementary energy supplied by the molasses but, also, by a stimulatory effect of other ingredients in the blocks on the rumen ecosystem (Preston, & Leng, 1986).

Effects of Blocks on Milk Production

The use of multi-nutrient blocks has allowed for a substantial reduction in concentrate in the diet of buffalo cows fed on rice straw. The fat-corrected milk yield was not diminished by replacing part of the concentrate with block. But the amount of straw in the diet and thus the profit per animal per day were greatly increased. Considerable commercial experience has now been acquired in the use of blocks for supplementing dairy buffaloes fed rice straw under village conditions in India (George, 1986b). Reducing the amount of concentrate given to buffalo cows from 5 to 3.5 or 4 to 2.5 kg/day, and distributing blocks, did not reduce milk production but increased fat percentage by about 10 percent and reduced the cost of feeding. In other observations, the addition of blocks to the diet increased milk production by about 10 to 25 percent and fat content of milk by 13 to 40 percent. In one village where the initial production level was lower the increase was even greater.

SALT LICKS

Salt licks (or mineral licks) are often found as natural occurrences in the wild, where mineral deposits form in clay, that livestock and wild animals can lick to obtain mineral nutrients. Whilst sodium (Na) is the mineral most commonly required to supplement animals' nutritional intakes, natural mineral lick sites often contain calcium (Ca), iron (Fe), magnesium (Mg), phosphorus (P), potassium (K) and zinc (Zn) among others (Kreulen, 1985). It is possible to produce artificial mineral licks for livestock using locally available materials (red mud, egg shells and salt) to improve their nutritional intake. The production of salt licks include: 1 kilogram of red mud taken at the back of the homestead; Dry under the sun for a couple of days and pound into a powder; Roast 10 egg shells, pound into a powder and add it to the red mud; Mix with around 1 kilogram of regular salt; Add ½ a kilogram of flour to bind the mixture; Finally pour some water as required until the mixture holds together and can be shaped into blocks. Shape them into donut shapes (making sure a hole is formed in the middle of the block); Leave to dry for a week in the shade, then another week in the sun until hard; Use the hole in the middle to string up the block in animal-shed. The mineral licks are produced in different shapes, colours and packages as can be seen in Figures Ia, b, c, d, e, f, g, h, i and j.

FigureIa. *Cow Licking Conventional Mineral Block Hanged in a Shade*

FigureIb. *Calves Licking Conventional Mineral Block on the Pasture.*

FigureIc. *Horse Licking a Conventional Mineral Block Hanged in the Shade*

FigureId. *A Heifer Licking a Conventional Mineral Block Placed on the Stubble*

Livestock will naturally lick the mineral blocks when inclined, taking in iron from the red earth, calcium and phosphorus from egg shells, and iodine, sodium and chlorine from the salt. These are all essential minerals necessary for the good health of cows and should result in the production of a good quantity of milk that is high in fat. Ensure that animal can reach the block at a stretch, as shown in Figures Ia, b, c, d, e, f, g, h, i and j.

FigureIe. *Brown Conventional Mineral Blocks*

FigureIf. *White Conventional Mineral Blocks*

FigureIg. *Well Packaged Milk Coloured Conventional Mineral Blocks*

FigureIh. *Well Packaged Brown Conventional Mineral Blocks*

FigureIi. *Mineral Licks Packaged in Different Bags*

FigureIj. *Mineral Licks in Different Bags and Sizes*

Table1. *Mineral Requirements and Maximum Tolerant Concentrations in % or ppm of Diet Dry Matter of Cattle*

			Requirement		
			Cows		
Mineral	**Unit**	**Growing and Finishing Cattle**	**Gestating**	**Early Lactation**	**Maximum Tolerable Concentration**
Chlorine	%	-	-	-	-
Chromium	Ppm	-	-	-	1,000
Cobalt	Ppm	0.10	0.10	0.10	10
Copper	Ppm	10.00	10.00	10.00	100
Iodine	Ppm	0.50	0.50	0.50	50
Iron	Ppm	50.00	50.00	50.00	1,000
Magnesium	%	0.10	0.12	0.20	0.40
Manganese	Ppm	20.00	40.00	40.00	1,000
Molybdenum	Ppm	-	-	-	5
Nickel	Ppm	-	-	-	50
Potassium	%	0.60	0.60	0.70	3
Selenium	Ppm	0.10	0.10	0.10	2
Sodium	%	0.60-0.80	0.60-0.80	0.10	-
Sulfur	%	0.15	0.15	0.15	0.40
Zink	Ppm	30.00	30.00	30.00	500
Aluminum	Ppm	-	-	-	1,000
Arsenic	Ppm	-	-	-	50 -100
Bromine	Ppm	-	-	-	200
Cadmium	Ppm	-	-	-	0.5
Fluorine	Ppm	-	-	-	40 – 100
Lead	Ppm	-	-	-	30
Mercury	Ppm	-	-	-	2
Strontium	Ppm	-	-	-	2,000

Sources: *Adopted from Tables1- 5 in Nutrient Requirements of Beef Cattle, National Research Council, 1996.Also, in Table 1 in National Research Council, 1980. Mineral Tolerant Limit of Domestic Animals, Washington, D.C.: National Academy of Sciences.*

WOOD ASHES

A lye is a liquid metal hydroxide obtained by leaching wood ashes (containing largely potassium carbonate or potash), or a strong alkali which is highly soluble in water producing caustic basic solutions (Puto, 2015). Though the term lye refers to any member of a broad range of metal hydroxides, it is also commonly an alternative name for sodium hydroxide (NaOH) or, historically, potassium hydroxide (KOH).

Today, lye is commercially manufactured using a membrane cell chloralkali process. It is one of the highest-volume industrial chemicals with worldwide annual production of 45 million tons. It is supplied in various forms such as flakes, pellets, microbeads, coarse powder or solution.

Lye is used to cure many types of food including the traditional Nordic lutefisk, olives (making them less bitter), canned mandarin oranges, hominy, lye rolls, century eggs, and pretzels. It is, also, used as a tenderizer in the crust of baked Cantonese moon cakes, in "zongzi" (glutinous rice dumplings wrapped in bamboo leaves), in chewy Southern Chinese noodles popular in Hong Kong and Southern China, and in Japanese ramen noodles. It is, also, used in kutsinta, a type of rice cake from the Philippines (Puto, 2015).

In the United States, food-grade lye must meet the requirements outlined in the Food Chemicals Codex (FCC) (Ayres, 2010), as prescribed by the U.S. Food and Drug Administration (FDA). Lower grades of lye which are unsuitable for use in food preparation are commonly used as drain de-cloggers and oven cleaners (Thacker & Kastner, 2004).

Soap Making

Lye in the form of both sodium hydroxide and potassium hydroxide is used in making soap. Sodium hydroxide is often used to make solid soap, while potassium hydroxide is used to make liquid soap (Saqib *et al.*, 2009). Potassium hydroxide soaps are softer and more easily dissolved in water than sodium hydroxide soaps. Sodium hydroxide and potassium hydroxide are not interchangeable in either the proportions required or the properties produced in making soaps. There are two methods of making soaps using lye which are:

The cold process method- This is often involves mixing of the lye with water, and then base oils, butters and fragrances added. The gradual chemical reaction between the lye and the fats eventually produces a solid soap (Wilson, 2014).

Lye is added to water, cooled for a few minutes and then oils and butters are added. The lye is then cooked over a period of time (1-2 hours), typically in a slow cooker, and then placed into a mold. This method is called hot process method and is much quicker than the cold process, as it takes several weeks to complete (Ayres, 2010).

Household Uses

Lye is, also, valued for its cleaning effects. Sodium hydroxide is commonly the major constituent in commercial and industrial oven cleaners and clogged drain openers, due to its grease-dissolving abilities. Lye decomposes greases via alkaline ester hydrolysis, yielding water-soluble residues that are easily removed by rinsing.

Sodium or potassium hydroxide can be used to digest tissues of animal carcasses or dead human bodies. Often referred to as alkaline hydrolysis, the process involves placing the carcass or body into a sealed chamber, adding a mixture of lye and water and the application of heat to accelerate the process. After several hours the chamber will contain a liquid with coffee-like appearance (Roach, 2004; Booth, 2009; McDaniel, 1997) and the only solid that remains are very fragile bone hulls of mostly calcium phosphate, which can be mechanically crushed to a fine powder with very little force. Sodium hydroxide is frequently used in the process of decomposing road kill dumped in landfills by animal disposal contractors (Booth, 2009). Due to its low cost and availability, it has been used to dispose of corpses by criminals. Italian serial killer Leonarda Cianciulli used this chemical to turn dead bodies into soap. In Mexico, a man who worked for drug cartels admitted to having disposed of more than 300 bodies with it.

A 3–10% solution of potassium hydroxide (KOH) gives a color change in some species of mushrooms. In Agaricus, some species such as A. xanthodermus turn yellow with KOH, many have no reaction, and A. subrutilescens turns green (Roach, 2004).

When handling lye, there should be personal protective equipment including safety glasses, chemical-resistant gloves, and adequate ventilation are required for the safe handling of lye. When in proximity to lye that is dissolving in an open container of water, the use of a vapor-resistant face mask is recommended. Adding lye to water too quickly can cause the solution to boil (McDaniel, 1997).

Solid lye is deliquescent and has a strong affinity for air moisture. Solid lye will deliquesce or dissolve when exposed to open air, absorbing a relatively large amount of water vapour. Accordingly, lye is stored in air-tight plastic containers. Glass is not a good material to be used for storage as lye is mildly corrosive to it. Similar to the case of other corrosives, the containers should be labeled to indicate the potential danger of the contents and stored away from children, pets, heat, and moisture (Roach, 2004; Booth, 2009; McDaniel, 1997).

The majority of safety concerns with lye are, also, common with most corrosives, such as their potentially destructive effects on living tissues; for example skin, flesh, and the cornea. Solutions containing lye can cause chemical burns, permanent injuries, scarring and blindness immediately upon contact. Lye may be harmful or even fatal if swallowed; ingestion can cause esophageal stricture. Moreover, the solution of dry solid lye is highly exothermic; the resulting heat may cause additional burns or ignite flammables (Booth, 2009; McDaniel, 1997). The reaction between sodium hydroxide and a few metals is, also, hazardous. Aluminum reacts with lye to produce hydrogen gas. Since hydrogen is flammable, mixing a large quantity of a lye such as sodium hydroxide with aluminum in a closed container is dangerous, especially, when the system is at high temperature, which speeds up the reaction. In addition to aluminum, lye may also react with magnesium, zinc, tin, chromium, brass or bronze producing hydrogen gas (Roach, 2004).

CONCLUSION AND RECOMMENDATIONS

High producing animals such as lactating cows need minerals to make milk which contains good sodium and chloride. Lack of enough sodium chloride in ruminant diets would result in loss of appetite and weight. Livestock craving for sodium chloride would start eating odd materials like dirt, rocks, urine, polythene bags and wood to satisfy their instinctive taste for salt. Lack of minerals can initiate a number of debilitating diseases and even death. For lactating dams and nursing calves, calcium from salt is critical for building strong bones and teeth, milk production, a regular heartbeat, blood clotting, muscle movement and nervous system function. Lactating cows without enough calcium are disposed to milk fever, and calves without proper calcium are susceptible to rickets. With milk fever, a milk-producing cow may first show signs of not being able to stand. Rather than a fever, a cow with "milk fever" has a lowered body temperature. For a lactating cow, it usually begins because her body uses more calcium to make milk than the body has. Prevention is the best cure, and many vets routinely prescribe a calcium salt in gel form for newly lactating cows. Rickets is a bone disease indicated by softened bones in the earlier stages and abnormal growth and impaired movement in later stages. It's totally preventable with proper nutrition for the calves and the dam.

Magnesium deficiency may cause grass tetany, an often fatal disease for dairy cows which can strike without any warning signs. This disease is preventable if cows have access to salt containing vital traces of magnesium. Cows lacking selenium have an increased number of calves dying at birth, or shortly thereafter, of white muscle disease. Symptoms are lameness, a failure to stand or simply heart failure. It's called "white muscle" disease because the muscles look white rather than red. While many humans have to carefully limit salt intake, farmers need to carefully supply minerals daily to their livestock for optimum productivity. Farmers are therefore encouraged to adopt the used of conventional mineral licks to improve livestock productivity in tropical Africa.

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