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Comparison of the Physico-Chemical and Cost Analysis of Termite Mound Produced and Commercial Salt Licks.

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Abstract

The potentials of the Nigerian livestock industry to satisfy domestic demands and for export is being hampered by the importation of critical livestock inputs, especially salt blocks at huge foreign exchange costs. A preliminary study had demonstrated the potentials of salt lick produced with local ingredients as binding agent as a high level source of minerals. The present study compared the physico-chemical properties and cost analysis of commercial salt lick and salt licks produced using 50% termite mound as binding agent. The treatments were: T1 (commercial salt lick); T2 (termite mound, cement, bone meal and common salt); T3 (termite mound, cement, eggshell and common salt); and T4 (termite mound, cement, bone meal, eggshell and common salt) replicated three times as a completely randomized experiment conducted at the Ruminants' Unit, Teaching and Research Farm, Ekiti State University, Ado-Ekiti. The local ingredients were mixed with water in a cold process and each homogenous mixture was poured into 5 kg capacity aluminum container mound and pressed manually using hand to form blocks. The blocks were removed carefully and dried for one week under shade, and another week in the sun until they were hard. The results showed significant differences in the parameters measured. T1 showed good hardness throughout while T2, T3 and T4 were firm and compact like T1 at 2 weeks after de-moulding. The salt licks produced had significantly different nutrient contents from the commercial salt lick. The Ca, Mg, P and Cr contents were higher in the produced salt licks than the commercial salt lick and T2 had the highest Ca, P and Cr (98.02±0.23, 155.93±1.82 and 0.28±0.10 mg 100 ml^{-1} respectively) while T3 contained the highest Mg (0.77±0.10 mg 100 ml^{-1}). The Na content in T1 (15.53±0.06 mg 100 ml^{-1}) was significantly higher than in T2, T3, and T4 which had similar values. T2 was produced at ₦248.55 per block but this highest production cost was 12.4% of the cost of T1 block. Thus, mineral salt licks produced with termite mound are cheaper than commercial licks, affordable, nutritious and environment-friendly for ruminants.

Keywords: Commercial salt lick, termite mound, mineral salt licks, physico-chemical properties, cost analysis.

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Introduction

The combined effects of insecurity, rapid population growth and unpredictable weather changes are the direct causes of the crisis in food supply being experienced in several developing countries (Sasson, 2015). The resort to importation, to meet the supply deficit as an indicator of the food and nutrition insecurity, has turned Nigeria to one of the largest importers of food in the world, with the items of plant and animal origins obtained at exorbitant foreign exchange costs (Qpata, 2014). Thus, the agricultural sector, burdened by uninhibited importation of items for which Nigeria has comparative and competitive advantages and inadequate attention, suffers from poor growth.

The livestock industry is at the mercy of foreign traders as the critical inputs: veterinary drugs, vitamin mineral premixes, salt blocks and other raw materials must be imported. The ensuing exorbitant prices placed on the inputs are not affordable and beyond the financial capacity of the smallholder livestock owners in Nigeria. Thus, the potentials of the Nigerian livestock industry to develop at the level needed to satisfy domestic demands and earn foreign exchange within the sub-Saharan Africa would necessitate using locally available ingredients to improve livestock productivity (FAO, 2019).

An important supplement to livestock feeding is the use of salt licks (EDS, 2008). The salt licks are mineral salts that ruminants lick and can be found in the wild or through solidification process. They contain both macro- and micro- elements that are vital to animal health and better performance resulting in higher feed intake and greater milk production. The mineral imbalances in soils and forages have long been fingered as being responsible for the reproductive problems and low productivity of grazing ruminants in the tropics (Lopez-Alonzo, 2012). Ruminants need minerals especially sodium (Na), chlorine (Cl), potassium (K), calcium (Ca), sulphur (S), phosphorus (P), magnesium (Mg), iron (Fe), cobalt (Co) and manganese (Mn) to survive since they are needed for normal metabolic functions of the body and in the metabolism of rumen microorganisms to enhance digestibility of nutrients. The symptoms of mineral deficiencies may show up as rough, harsh coat, flaky skin, eating dirt, poor growth, recurring diseases, fence chewing, debarking trees, unhealthy skin, tooth decay etc. Thus, the adequate utilization of mineral licks in the diets of ruminant animals in tropical Africa would improve animal health and productivity (Kubkomawa, 2017). Salt licks produced through the solidification process are pressed blocks of ingredients intended for ruminants' health and nutrition. The local availability, nutritive value, cost, hardness, and existing facility for their use would influence block quality, availability, and adoption. The cost is of great concern in any animal production venture (Getu *et al.*, 2015) and readily available and cheaper ingredients would stimulate the utilization of locally produced salt licks in place of the commercial ones that are usually beyond the reach of the smallholder farmers in Nigeria.

The locally-sourced materials that can be useful in salt licks preparation abound in Nigeria. A gelling agent or binder is necessary for the solid block. Although nutritionists and extension agents have raised concern about the safety of cement as a gelling agent in salt blocks, many researches have not shown adverse effects at low levels (Kubkomewa, 2017). The termite mound or nest (termitarium) is made out of earth and mud, contains organic matter, Ca, Mg and water holding capacity which also make it an ideal ingredient in salt lick production (Khalid and Safdar 1982; Adegun, 2016). The deficiencies of P can be overcome by incorporating bone meal in salt licks (EDS, 2008). Common salt is cheap, available, and important but cannot satisfy all the mineral needs of ruminants. Egg shell is an agricultural waste material containing minerals that can be harnessed in salt lick preparation. A mixture of these locally-available and cheap ingredients rich in minerals using local methods of preparation may provide the ideal supplements to boost ruminants' productivity in Nigeria.

A preliminary investigation into the use of local binding agents in salt lick production in Nigeria revealed high contents of macro minerals in licks with termite mound as binding agent while the cement-bound salt licks were hard and firm at one week after de-moulding compared to other binding agents (Adegun, 2016). This study was undertaken to compare the physico-chemical properties and cost analysis of commercial salt lick to salt licks produced using termite mound and other local ingredients as binding agents.

Materials and Method

Experimental Site

The study was conducted at the Ruminants' Unit of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, South Western Nigeria. The area is latitude 7 37' 15'' N and longitude 5 13' 17'' E with elevation of 455m. It experiences a tropical climate with a temperature range of 17.78 – 32.22° C and a bimodal rainfall distribution between April and October with peaks in June and September and a break in August. The ambient temperature during the study ranged from 23 – 30 ° C with a mean of 26° C. The study lasted for 5 weeks (17th February to 25th March 2016)

Ingredients

Termite mound was sourced from the soil in the Teaching and Research Farm while cement and common salt were purchased from the market. Egg shell was gathered from restaurants and fast food shop within the university community, sun dried for 3 days and pounded with mortal. Bone was obtained from the abattoir at the Cattle Slaughtering Unit of the Teaching and Research Farm and burned until it became white. The termite mound was crushed and pounded in a mortar, then sieved through a 1 mm mesh. The crushed egg shells and bone meal were separately ground in a hammer mill to obtain fine ground products. Cement and table salt were purchased from the open market in Ado- Ekiti.

Experimental design

The experimental design was a completely randomized design with 4 treatments and 3 replicates. The treatments were:

1. Mineralized salt lick (commercial salt lick)
2. Termite mound, cement, bone meal and common salt
3. Termite mound, cement, eggshell and common salt
4. Termite mound, cement, bone meal, eggshell and common salt

Mineral Salt Lick Preparation

The cold process was used to produce the salt lick which required only aluminum container mould and water. Cement and termite mound were separately dissolved in water (40% w/w) to form a paste for treatments 2, 3 and 4. Cement constituted 3% of the total weight of the block in treatments 2-4. Termite mound was 50% and salt was 20% in treatments 2-4. In addition, bone meal, eggshell or mixture of bone meal and eggshell were 27% in treatment 2, 3 and 4, respectively. The ingredients were then mixed and stirred together accordingly to obtain a homogeneous mixture which was poured into the 5 kg capacity aluminum container mound and pressed manually using hand to form blocks. The surface of the mound was covered with polythene sheets to facilitate de-moulding and clearing of the surface. The blocks were removed carefully and dried for one week under shade, and another week in the sun until they were hard.

Physical Properties of the Salt Licks

Hardness and compactness of the blocks were tested after de-moulding, at one week and two weeks by 3 persons independently assessing the hardness on the scale: soft, medium and good. Hardness was determined by pressing with hand while compactness was by the ease of breakage by hand depicted by the scale: loose, slightly loose and firm. This would be considered during further studies

Chemical Analysis of the Salt Licks

Triplicate samples were obtained from moulded mineral salt licks and a commercial salt lick and analyzed for minerals and anti-nutritional factors. Mineral composition was determined by dry- ashing 1 g each of the samples at 550°C in a furnace and dissolving the ash in 10% HCl and filtered. The Na and K were determined by flame photometer while atomic absorption spectrometer (AAS) was used to determine the calcium, magnesium, phosphorus, zinc, chromium, selenium, manganese, iron, cobalt and lead A pH meter with combined glass electrode was used to determine the pH of the mineral salt licks.

Data Analysis.

All data obtained were analyzed using one-way ANOVA with Minitab 8.1 version package. The significant differences among the means were separated using the DMRT.

Results

Table 1 shows that there were significant differences in the parameters measured in the salt licks. T3 contained the highest calcium (98.02 ±0.23 mg 100 ml^{-1}) which did not differ from T4 but both differed significantly from T2. The P content was highest in T2 (155.93 ±1.82 mg 100 ml^{-1}) which differed significantly from the similar values in T3 and T4. The Mg content was highest in T4 (0.77±0.10 mg 100ml^{-1} which was significantly different from the similar values in T2 and T3. The Cr content was highest in T2 (0.28±0.10 mg 100 ml^{-1}) but was similar to the values in T3 and T4. For the nutrients, the commercial salt lick (T1) had significantly lower values being 13.0±0.10, 0.29±0.10, 2.35±0.10, and 0.13±0.10 mg 100 ml^{-1} for Ca, Mg, P and Cr respectively. The Na level in T1 (15.53±0.06 mg 100 ml^{-1}) was significantly higher than in T2, T3, and T4 with 8.49±0.11, 8.85±0.16 and 8.22±0.10 mg 100ml^{-1} respectively. The Mn and Fe contents were highest in T2 (0.23±0.0, 0.26±0.01 mg 100 ml^{-1} respectively) and differed from the similar values in T1, T3 and T4 while K, Zn, Cu, Se and Pb contents were not significantly different ($p>0.05$) among the treatment groups. T3 had the least pH (7.03) which was significantly ($P<0.05$) different from T1 and T4 with similar values while T2 had the highest value pH=9.94±0.03.

Table 1: Mineral and pH analysis of salt licks produced using cement and termite mound as binders compared with commercial salt lick (mg 100ml^{-1})

	TREATMENT			
Parameters	**1**	**2**	**3**	**4**
Zinc	0.01± 0.00	0.03±0.00	0.010±0.00	0.010±0.00
Copper	0.12±0.01	0.20±0.01	0.16±0.01	0.11±0.01
Chromium	0.13^{b}±0.10	0.28^{a}±0.00	0.25^{a}±0.01	0.23^{a}±0.01
Calcium	13.0^{c}±0.10	89.47^{b}±0.62	98.02^{a}±0.23	96.36^{a}±1.02
Magnesium	0.29^{c}±0.11	0.45^{b}±0.03	0.46^{b}±0.02	0.77^{a}±0.01
Iron	0.16^{b}±0.01	0.26^{a}±0.01	0.15^{b}±0.01	0.15^{b}±0.01
Manganese	0.12^{b}±0.01	0.23^{a}±0.0	0.13^{b}±0.01	0.13^{b}±0.01
Sodium	15.53^{a}±0.06	8.49^{b}±0.11	8.85^{b}±0.16	8.22^{b}±0.10
Potassium	1.55±0.04	1.59±0.01	1.58±0.01	1.59±0.01
Phosphorus	2.35^{c}±0.05	155.93^{a}±1.82	138.33^{b}±1.08	149.37^{a}±0.76
Selenium	0.003±0.0	0.003±0.0	0.003±0.0	0.003±0.0
Cobalt	0.12±0.01	0.08±0.0	0.13±0.01	0.13±0.01
Lead	0.04±0.01	0.02±0.00	0.02±0.01	0.02±0.00
pH	8.48^{b}±0.07	9.94^{a}±0.03	7.03^{c}±0.10	8.84^{b}±0.01

Means with different superscripts within the same row are significantly ($P < 0.05$) different.

Table 2 shows the degree of hardness of mineral salt licks produced using termite mound compared to the commercial salt lick at the de-moulding stage, one week and two weeks after production. The hardness of the control block was good all through. Soft consistency was observed at de-moulding stage of all the blocks in T2, T3 and T4 when pressed with the hand. At one week, T2, T3 and T4 had medium hardness while at 2 weeks after moulding, T2 and T3 showed good hardness while T4 still maintained medium hardness.

Table 2: Hardness of mineral salt licks produced using termite mound and commercial salt lick

	Treatment			
Time	**1**	**2**	**3**	**4**
De-moulding	Medium	Soft	Soft	Soft
One week	Good	Medium	Medium	Medium
2 weeks	Good	Good	Good	Medium

The compactness of mineral salt licks produced using termite mound compared to the commercial salt lick is shown in Table 3. The control block was firm in compactness. At de-moulding, all the mineral licks produced in T2, T3 and T4 were loose, at 1 week after production, T3 was firm, T2 and T4 had slightly loose compactness. However, at 2 weeks after de-moulding, T2, T3 and T4 were firm in compactness

Table 3: Compactness of mineral salt licks produced using termite mound as compared with commercial salt lick

	Treatment			
Drying time	**1**	**2**	**3**	**4**
De-moulding	Firm	Loose	Loose	Loose
One week	Firm	Slightly loose	Firm	Slightly Loose
2 weeks	Firm	Firm	Firm	Firm

Table 4 shows the production cost of the mineral licks based on cement and termite mound as binders compared to the purchase cost of commercial salt lick. The purchase cost of the commercial salt lick was the standard for comparing the costs of the ingredients used to produce the salt licks produced based on local binders (T2, T3 and T4). The costs incurred on equipment (₦1,500.00), labour (₦800.00) and the purchase of cement and common salt (₦2,014.00) were the same in T2, T3 and T4; ₦500.00 and ₦300.00 were spent on eggshell in T3 and T4 respectively while the bone meal cost ₦657.00 and ₦280.00 in T2 and T4 respectively. The cost of purchasing 5 kg of commercial salt lick (T1) was ₦2,000.00 compared to the cost of producing one block of T2 (₦248.55) which was the highest among the mineral salt licks. Thus, T1 was eight times (8) higher than the cost of producing T2 while T3 had the least cost of production at ₦240.70.

Table 4: Production costs (₦) of mineral salt licks using termite mound binder compared to purchase cost of commercial salt lick.

Feed Ingredients	Treatment			
	1	2	3	4
Cost /100 kg block				
Bone meal	-	657.00	-	280.00
Egg shell	-	-	500.00	300.00
Cement	-	800.00	800.00	800.00
Common salt	-	2,014.00	2,014.00	2,014.00
Termite mound	-	-	-	-
Equipment and labour	-	1,500.00	1,500.00	1,500.00
Total	40,000.00	4,971.00	4,814.00	4,894.00
Cost/5 kg block	2,000.00	248.55	240.70	244.70

Discussion

Data were collected on the physico-chemical properties and cost analysis of salt licks produced with termite mound as binder and commercial salt licks to demonstrate the potentials for supplementing minerals in diets that would stimulate the rumen for effective nutrient metabolism in ruminants. The salt blocks produced with local ingredients had comparable physical properties and significantly higher mineral contents than the commercial salt lick. The termite mounds display adhesive and cementing properties such that the salt licks produced in this study, using the materials as binder become strong (Enagbonma and Babalola, 2019). The improved hardness and compactness observed in the salt blocks containing eggshell than those with bone meal is another advantage of its cementing properties of the termite mound and a binding agent that can complement cement (Amarnath 2014; Gowsika *et al.*, 2014). The weekly increase in hardness and compactness of the salt licks is in agreement with studies by Mubi *et al.* (2013) who observed progressive increase in these parameters with time. Also, the addition of cement as a binding agent contributed to the hardness and compactness in this study as observed by Muhammed *et al.* (2016) that 4% cement had high strength in the production of multi-nutrient blocks. Good compactness enhances packaging, storage, transport, and ease of feeding because the mineral salts are released gradually during licking whereas soft block would lead to high intake which could cause imbalance or mineral toxicity. However, this disagrees with Krys *et al* (2009) who observed that dairy cows prefer a softer blocks which enable them to consume more salt lick at a shorter time.

The pH was influenced by the constituents of the mineral salt lick, being neutral (pH=7.03) where bone meal was omitted but increased to strongly alkaline and very strongly alkaline in relation to the proportion used in T4 and T2 respectively. The pH values of the mineral licks compare to 6.69 to 9.95 reported on geophagic soils visited by ungulates in the humid tropics (Matsubayashi *et al.*, 2006 and Onesmus *et al.*, 2015).

The highest minerals were Ca and P whose contents increased significantly in the salt licks in relation to the relative proportion of the constituents. The Ca content increased in proportion to the amount of egg shells in the salt licks which was more in T3 than T4. This is because Ca is the main constituent of egg shells (Schaafsma *et al.*, 2000). The P contents were highest where the salt lick contained bone meal (T2) and a mixture of bone meal and egg shells (T4) while Ca and Mg were significantly higher in salt licks that contained egg shell (T3 and T4). The higher P in the salt licks containing bone meal relates to the composition of bone meal in terms of P content (EDS, 2008). The high P in the locally-produced salt licks is useful to ruminants, because of the major roles in bone formation, phospholipid metabolism and the complex processes in nutrient oxidation

(Udoeye *et al.*, 2000). However, the ratio of Ca: P at 1:1.7, 1:1.4, 1, 1.55 in T2, T3 and T4 respectively is high and does not match with the ratio of Ca: P at 1.9:1 which provides for better apparent absorption in ruminants (Andrade *et al.*, 2002).

Thus, the higher contents of P, Ca and Mg in salt licks produced with the local materials and termite mound as binder than the commercial salt lick are associated with the mineral composition of the constituents apart from the significantly high accumulation of nutrients, especially Ca, P and Mg, in termite mounds (Danilo *et al.*, 2006; Sarcinellin *et al.*, 2009) which make them an eco-friendly means of producing agricultural inputs without compromising environmental safety. The constituent minerals in all the ingredients used in the production of the salt licks, such as Ca, Mg, P, K and Na can prevent ruminal acidosis, since these are alkalinizing agents, causing stability of pH in the rumen and increasing nutrient consumption and digestibility (Furtado *et al.*, 2018).

The higher Cr level in the locally produced salt lick (T2, T3 and T4) would confer better nutritional benefits to ruminants because of its involvement in glucose metabolism and the vital roles played in insulin signaling and stress alleviation (Amata, 2013). The lower Na content in the mineral salt licks than in the commercial salt lick would be more beneficial to animals' consumption as it has been observed that a negative correlation exists between high salt content in mineral lick and the appetite to consume it (Chladek and Zapletal, 2007; Cockwill *et al.*, 2000).

The local ingredients used in this study: cement, eggshell, termite mound, salt have good binding .

properties (Gowsika 2014; Mubi *et al.*, 2013; Furtado *et al.*, 2018). The binders are used to achieve properties such as mouldability, dimensional stability and adequate mechanical resistance (Furtado *et al.*, 2018). Thus, in addition to their enhanced nutrient contents, the mixture allows for longer period of storage because lime, kaolin and Portland cement avoids the action of deteriorative microorganisms, and the presence of bees and mosquitoes, reducing the loss due to the reuse of leftovers in the trough (Furtado *et al.*, 2018).

This study has shown that the cost of mineral salt lick produced locally using termite mound as binder is eight times (88%) cheaper than the commercial salt lick. This is an improvement on the findings of Kuleile and Molapo (2019) that farmers could save up to 36% of cost using farm formulated winter mineral lick. Getu *et al.* (2015) also reported that using the locally-available feed resources and binding agents as replacement for the costly agro-industrial materials in formulated blocks was cost effective without compromising animal daily performance.

Conclusion

This study has shown that locally-produced mineral salt licks using termite mound as binder is cheaper than commercial licks and would be affordable for adoption by the farmers, especially in a developing country such as Nigeria. The mineral salt licks or blocks produced locally have comparable physical qualities and contain more nutrients than the commercial salt licks which would make the use environment-friendly

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