






RESEARCH ARTICLE

## The effect of locally based and imported lick stones on the growth and economic productivity of African dwarf sheep during the dry season in Benin

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### ABSTRACT

**Objective:** This study aimed to make and compare the effects and economic viability of lick stones based on local feedstuffs and imported ones.

**Materials and Methods:** Two-lick stones (minerals and multi-nutritional) based on local feedstuffs were made. An imported lick stone (ILS) was purchased at a local market. Four dietary treatments (the three different lick stones and a control group) were established, with six dwarf sheep receiving each treatment. The experiment was carried out over 90 days. Growth and economic parameters were calculated and compared.

**Results:** The feed intake of sheep in the multi-nutritional lick stone group was better than that of the other groups. The feed conversion ratio was best for the lick stones made with local feedstuffs. The economic return (economic feed efficiency) was best for the mineral lick stone. For a unit of money invested in the feed supplements, the sheep fed with lick stone based on local feedstuffs have been allowed to gain 100.21 basic monetary unit of some West African countries more than the ones fed with imported feeds ( $p < 0.05$ ).

**Conclusion:** It is not desirable to use ILS because the economic and growth performance of sheep fed with the ILS was even lower than that of the non-supplemented sheep.

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### Introduction

Protein deficiencies are severe in parts of Africa and could compromise the future of many generations [1]. Over 16% of African children are underweight for their age, and 1 in 5 are stunted [1,2]. The World Health Organization [1] has set the minimum protein requirement for 90 kg males at 75 gm, but the average consumption is 63.3 gm in Africa overall and 57 gm in sub-Saharan Africa [1,3]. This situation can be attributed to the inadequate productivity of animals capable of producing the best protein quality; they represent just 21.26% of the protein supply in Africa, compared to 39.30% globally [3].

In some situations, the deficiency is because of war or the bad management of the local resources available [4,5]. In others, it is due to the swift evolution of the wilderness, human construction, or industrial activity that is reducing

crop farming and chasing animals away by taking the place of the former farms or natural pastures [6]. This change is also reducing the quality of fodder, which is the first efficient source of feed for ruminants [7]. In Benin, natural pastures are the major source of feed for ruminants [8]. For that reason, the problem of animal feeding is most strongly noticed in the dry season, during which natural pastures are not available and the quality of the tree leaves used as a supply becomes very bad, such that it cannot fulfill the animals' minimum nutritional requirements [8].

To prevent this situation, a great number of feed supplements, or the ingredients to make feed supplements, are imported, but at a high price that many breeders cannot afford [9]. That situation prevents a great part of the population from having access to animal products and leads to undernourishment, especially due to the lack of protein [1]. Meanwhile, many agricultural and industrial

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by-products that could be converted to feed supplements are thrown in the garbage. A report by the Food and Agriculture Organization [10] has revealed that the leading constraints on the feeding of livestock in western Africa are poor control of development techniques, difficulty in transferring existing technologies, and the lack of control or management of supplies, not the availability of ingredients [11].

To address this problem, Babatoundé et al. [12], Montcho et al. [13], and Dimon et al. [14] evaluated the nutritional value of some feed supplements manufactured using feedstuffs (local and imported) sold in the local market. However, the problem of high cost remains in these cases because some of the ingredients used by those authors were imported. This study aimed to find a viable way to address the problem of the high price of feed supplements, thereby increasing the economic return for breeders. In this study, we manufactured lick stones based on locally available feedstuffs and compared their effect, in terms of growth and economic return, with that of imported lick stones (ILS). We tested the lick stones on African dwarf sheep during the dry season in the southern part of Benin.

## Materials and Methods

### Study area

The trial took place on a farm in the subequatorial village of Hounbo in the Toffo district of southern Benin, which experiences two dry seasons and two rainy seasons. The annual rainfall is 1,100 mm during the rainy season and 800 mm during the dry season. The average temperature varies between 27°C and 31°C. The vegetation comprises herbaceous, shrubby savannah, and relict forests and plantations. Among those plantations, the oil palm (*Elaeis guineensis*), which covers a part of the natural pastures, is very common.

### Experimental design and animals

There was a 14-day adaptation period before the trial, which lasted 90 days. Twenty-four weaned dwarf sheep (12 males and 12 females) were weighed and assigned to four randomized groups of six animals each. The average weight of the animals at the beginning of the trial was  $9.43 \pm 2.41$  kg. There was no significant difference between the average weight of the sheep in each block. The control group (non-supplemented) was not supplemented. The three other groups received feed supplemented, respectively, with ILS used by breeders and purchased in a local market, multi-nutritional lick stone (MNS) based on local feedstuffs, and mineral lick stone (MIS) based on local feedstuffs.

### Feed and feeding

The animals grazed each day from 9:00 a.m. to 12:00 p.m. and from 16:00 to 18:00 p.m. on a natural pasture amidst palm oil plantations. Even when completely dry, the pasture comprised *Panicum maximum* C1, local *Panicum maximum*, *Tridax procunens*, etc. After returning from the pasture, the sheep were led to their stalls. The sheep receiving supplements had the lick stone available every time, *ad libitum*. Water was available to all the animals every time without restriction (*ad libitum*). The ingredients used to make the MNS were oyster shells, common salt, rice bran, urea, molasses, clay, ferritic soil, cassava flour, and charred bone meal. The ingredients were the same for the MIS except for the rice bran, molasses, and cassava flour, which were not used. The nutritional composition of the lick stones is shown in Table 1.

### Chemical analysis

The chemical composition of each feed determines its nutrient composition. To determine the chemical composition of the lick stones used, samples of each lick stone were submitted for chemical analysis. The amounts of dry matter (DM), organic matter (OM), crude protein (CP), ash, phosphorus (P), calcium (Ca), and magnesium (Mg) were determined according to the standard procedures of the AOAC [15].

### Data collection and statistical analysis

At the very beginning of the trial, the sheep were weighed, and their initial body weight was recorded. Each group's initial average body weight was compared using the student, Newman and Keuls (SNK) test in R software version 4.2.0 [16]. Once the trial began, each lick stone was weighed daily to determine the feed intake (FI). The sheep were weighed each week to determine their body weight gain (BWG). At the end of the trial, the recorded data enabled a calculation of the growth parameters, which were analyzed using the SNK test. The average values of each parameter according to the treatment are summarized in the tables. The SDs of the means were calculated and added to them, and the differences were considered significant at  $p < 0.05$ .

### Feed intake (FI)

Measuring FI allows us to measure the average amount of lick stone required by each animal to cover its daily nutritional requirement. To measure the FI, the amount of the feed supplement served daily was registered, and the amount remaining the next day was weighed. The FI represented the difference between the amount served and the remaining. In Table 2, the average FI values according to the treatment are shown, followed by the SD of the means and probabilities.

### Body weight gain (BWG)

This measure is important in animal production because the price of animals is set according to their body weight, which is the sum of their daily weight gain. It allows us to appreciate the evolution of the animal's body weight as they either consume or do not consume the lick stones. The average daily BWG was calculated by dividing the difference between the final body weight and the initial body weight by the number of days. The average values of each BWG and the SD of the means and probabilities are shown in Table 3.

### Feed conversion ratio (FCR)

The FCR allows us to measure the quantity of lick stone required to produce 1 kg of meat or to increase the body weight of the animal by 1 kg. In other words, it reveals the ability of the lick stones to increase the body weight of dwarf sheep. The FCR was calculated for each treatment by dividing the FI by the average weight gain. The average values for each FCR, followed by the SD of the means and probabilities, are shown in Table 4.

### Economic feed efficiency (EFE)

This measurement enables us to assess the financial gain from purchasing a unit of feed. It is very important because most breeders' main goal is not to breed for pleasure but to achieve a good economic return from their activity. It also allows us to appreciate the cost of each innovation relative to the existing practice. The EFE is calculated by dividing

the economic value of the BWG by the cost of the feed the animal has taken. The average values of EFE followed by the SD of the means, and the probabilities are recorded in Table 5.

## Results

### Chemical composition

Table 1 reveals that the ILS was more concentrated in minerals (other than phosphorus) and CP than the lick stone made with local feedstuffs. The lick stones made with local feedstuffs were more concentrated in OM and phosphorus than the imported ones. The ILS is specially made to fill the gap in minerals and CP, whereas those made with local feedstuffs seem more balanced in terms of nutritional composition.

### Feed intake

Table 2 allows us to appreciate the quantity of feed supplement required by each animal for its production. We can see that more of the MNS was consumed by the animals ( $p < 0.000$ ). The fact that this lick stone was less compact than the others may have contributed to that result.

### Body weight gain

Table 3 shows the change in body weight during the full trial period. It reveals that the MNS and the MIS, both based on local ingredients, allowed the sheep to gain 29.11% and 22.47% more body weight than the control group, respectively. The gain shown by the sheep in the ILS group was

Table 1. Chemical composition of the lick stones.

Treatments	DM (%)	% DM			P (gm/kg)	Ca (gm/kg)	Mg (gm/kg)
		OM	Ash	CP			
ILS	99.57	2.61	97.39	59.37	0.001	343.056	470.55
MNS	87.81	31.91	68.09	40.62	0.007	96.05	75.81
MIS	91.54	19.20	80.80	32.37	0.004	77.18	73.20

ILS: imported lick stone, MNS: multi-nutritional lick stone based on local feedstuffs, MIS: mineral lick stone based on local feedstuffs, DM: dry matter, OM: organic matter, CP: crude protein, P: phosphorus, Ca: calcium, Mg: magnesium.

Table 2. FI (gm/day).

Treatments	ILS	MIS	MNS	p-value
FI <sub>1</sub>	3.46 ± 0.60 <sup>a</sup>	5.01 ± 1.58 <sup>a</sup>	18.38 ± 6.49 <sup>b</sup>	0.000
FI <sub>2</sub>	6.65 ± 1.55 <sup>a</sup>	4.40 ± 0.72 <sup>a</sup>	20.18 ± 9.54 <sup>b</sup>	0.001
FI <sub>3</sub>	8.37 ± 0.70 <sup>b</sup>	4.53 ± 1.05 <sup>a</sup>	15.35 ± 2.33 <sup>c</sup>	0.000
FI	6.16 ± 0.55 <sup>a</sup>	4.65 ± 0.76 <sup>a</sup>	17.97 ± 5.76 <sup>b</sup>	0.000

<sup>abc</sup> Means with different superscripts in a row are significantly different according to the  $p$ -value, ILS: Imported lick stone, MNS: multi-nutritional lick stone based on local feedstuffs, MIS: mineral lick stone based on local feedstuffs, FI<sub>1</sub>: feed intake in the first month, FI<sub>2</sub>: feed intake in the second month, FI<sub>3</sub>: feed intake in the third month, FI: feed intake over the three months,  $p$ : probability.

12.94% less than that of the control group. Therefore, the sheep fed the lick stones based on local feedstuffs (MNS and MIS) gained 48.31% and 40.67% more body weight, respectively, than those fed an ILS.

#### Feed conversion ratio

Table 4 shows the quantity of feed supplement required by the sheep to produce 1 kg of body weight. The average quantity of lick stone required by the sheep to produce 1 kg of body weight ranged from a maximum of 361 gm to a minimum of 130 gm. The MIS based on the local ingredients allowed more body weight to be produced with less feed supplement.

#### Economic feed efficiency

Table 5 shows the money gained by investing one unit of money in the feed supplement. It revealed that lick stones used as a supplement could allow a gain of between 11.61 and 92.67 for every unit of money invested in the supplement. The EFE of the sheep-fed MNS has increased from 1 month to the next. The MIS based on local ingredients is more profitable than others.

#### Discussion

According to Khalil [17], for a well-balanced feed, calcium and phosphorus should be in the proportion of 1.7:1.0. Based on that ratio, the chemical analysis revealed that the

ILS has an imbalance between phosphorus and calcium. This can be a source of some diseases, such as gravel, if a source of phosphorus is not used to fill the gap while using this lick stone. The composition of the lick stone based on local feedstuffs in terms of OM, minerals, and CP had a good nutritional balance [18]. It thus has great potential to fill the sheep's mineral requirements. In a country such as Benin, where fodder is not available in the dry season, these lick stones could offer a great opportunity for breeders [19]. The composition of the lick stone in OM is under 63.9% DM, as revealed by Babatunde et al. [12], but their composition of CP and ash was better than that in the study by Babatunde et al. [12]. This might be due to the number of sources of OM used in each study. The composition of calcium and magnesium in the ILS was greater than that of the ones made with local feedstuffs, suggesting that the ILS are designed to be a source of those minerals. In areas where available fodder is deficient in calcium and magnesium, it is better to use those ILS if their price is acceptable. All the lick stones have a sufficient content of CP. As fodder in West Africa is mostly poor in CP, the lick stones in this study appear to offer a great opportunity for sheep farms [20].

The study found that the sheep were more receptive to eating the MNS during the dry season. This might be due to its composition, which includes feedstuffs such as rice bran, molasses, and cassava flour, which make it less compact than the other stones [19]. Those feedstuffs cause the

**Table 3.** BWG (gm/day).

Treatments	NS	ILS	MIS	MNS	p-value
ADG <sub>1</sub>	24.28 ± 12.28	19.64 ± 13.18	39.45 ± 15.03	23.92 ± 4.65	0.897
ADG <sub>2</sub>	55.35 ± 9.61	57.85 ± 9.82	82.50 ± 22.20	73.57 ± 22.95	0.075
ADG <sub>3</sub>	41.78 ± 10.97	33.21 ± 14.48	51.42 ± 16.09	59.28 ± 19.20	0.081
ADG	40.47 ± 6.34	35.23 ± 7.96	41.30 ± 25.36	52.26 ± 10.34	0.343
BWG (kg)	3.40 ± 0.53	2.96 ± 0.87	4.16 ± 1.90	4.39 ± 0.87	0.202

NS: non-supplemented (control), ILS: imported lick stone, MNS: multi-nutritional lick stone based on local feedstuffs, MIS: mineral lick stone based local feedstuffs; ADG<sub>1</sub>: average daily gain in the first month, ADG<sub>2</sub>: average daily gain in the second month, ADG<sub>3</sub>: average daily gain in the third month, ADG: average daily gain over the three months, BWG: body weight gain over the three months, p: probability.

**Table 4.** FCR (gm of feed/gm of BWG).

Treatments	ILS	MIS	MNS	p-value
FCR <sub>1</sub>	0.402 ± 0.11	0.921 ± 0.10	0.771 ± 0.26	0.653
FCR <sub>2</sub>	0.119 ± 0.04 <sup>a</sup>	0.055 ± 0.01 <sup>a</sup>	0.296 ± 0.02 <sup>b</sup>	0.001
FCR <sub>3</sub>	0.342 ± 0.27	0.090 ± 0.01	0.285 ± 0.11	0.087
FCR	0.183 ± 0.04 <sup>a</sup>	0.130 ± 0.03 <sup>a</sup>	0.361 ± 0.14 <sup>b</sup>	0.003

<sup>ab</sup> Means with different superscripts in a row are significantly different according to the p-value, ILS: imported lick stone, MNS: multi-nutritional lick stone based on local feedstuffs, MIS: mineral lick stone based on local feedstuffs, FCR<sub>1</sub>: feed conversion ratio in the first month, FCR<sub>2</sub>: feed conversion ratio in the second month, FCR<sub>3</sub>: feed conversion ratio in the third month, FCR: feed conversion ratio over the three months, p: probability.

**Table 5.** EFE (CFA gained/CFA invested in the lick stones).

Treatments	ILS	MIS	MNS	p-value
EFE <sub>1</sub>	12.32 ± 7.96 <sup>a</sup>	67.11 ± 35.47 <sup>b</sup>	13.02 ± 4.14 <sup>a</sup>	0.002
EFE <sub>2</sub>	18.44 ± 6.34 <sup>a</sup>	184.51 ± 41.67 <sup>b</sup>	27.03 ± 5.49 <sup>a</sup>	0.000
EFE <sub>3</sub>	8.13 ± 3.94 <sup>a</sup>	110.47 ± 12.77 <sup>c</sup>	35.70 ± 11.72 <sup>b</sup>	0.000
EFE	11.61 ± 3.42 <sup>a</sup>	111.82 ± 24.23 <sup>b</sup>	30.22 ± 16.10 <sup>a</sup>	0.000

<sup>abc</sup> Means with different superscripts in a row are significantly different according to the *p*-value, ILS: imported lick stone, MNS: multi-nutritional lick stone based on local feedstuffs, MIS: mineral lick stone based on local feedstuffs, EFE<sub>1</sub>: economic feed efficiency during the first month, EFE<sub>2</sub>: economic feed efficiency during the second month, EFE<sub>3</sub>: economic feed efficiency during the third month, EFE: economic feed efficiency over the three months, *p*: probability.

MNS to be abundant in many nutrients other than minerals. This finding is confirmed by their nutritional composition in terms of OM. Since our trial took place during the dry season, when the nutritional value of the fodder available was very low, the sheep consumed the MNS to fill their nutritional requirement gap [21]. When lick stones are less compact and contain more OM, sheep eat from them in greater amounts, as confirmed by the value of the lick stone intake (52.2 gm) found by Asaolu et al. [22]. Their lick stone contained 37% wheat offal and 33% moringa leaf powder. In the context of West Africa, it is better to provide dwarf sheep with an MNS than with an MIS during the dry season.

Dwarf sheep breeders want their sheep to attain a good body weight in a short time [23]. Therefore, the average BWG is the most important parameter as breeders evaluate the health of their flock [24]. The fact that the lick stones based on local feedstuffs allowed 48.31% (multi-nutritional) or 40.54% (mineral) more BWG than the ILS showed that it is not efficient or desirable to use the ILS. It is better to valorize local feedstuffs. Moreover, when one also considers that the MNS was ingested better (FI) and enabled the best BWG, it seems best to feed the dwarf sheep with multi-nutritional rather than MIS during the dry season [20]. That finding might also be justified by the fact that in the dry season, fodder is essentially unavailable, and the small amount the sheep can locate tends to have a low nutritional value and cannot meet their nutritional requirements [5]. That discovery is consistent with Koura et al. [8], who described the heavy use of tree leaves in some regions to compensate for the unavailability of fodder. The BWG recorded with the MNS was better than the 41.11 gm/day indicated by Montcho et al. [13], whereas the BWG of the sheep fed ILS was lower than the results found by Montcho et al. [13]. The lick stone based on local feedstuffs can be used to feed dwarf sheep in place of or a combination with a multi-nutritional block during the dry season in Benin. ILS didn't improve the health of sheep. Conversely, the local feedstuffs offer a great opportunity to improve the growth performance of sheep.

The results also show that to produce a unit of body weight in dwarf sheep during the dry season in southern

Benin, more of the MNS based on local feedstuffs is needed than the ILS or the MIS based on local feedstuffs. This might be due to some feedstuffs, such as rice bran, that can lessen digestibility and, thereby, the efficacy of the lick stone, as measured by feed conversion [18]. Therefore, the sheep need to consume a greater quantity of MNS to meet their nutritional requirements. This finding is confirmed by Noziere et al. [18] and NRC [25], who found that feedstuffs in the form of hay, such as rice bran, reduce the digestibility of the feed. All the feed conversion rates found in this study were better than the 11.49 found by Jiwuba et al. [26] because we measured only the feed conversion of the supplement (the lick stone) instead of the daily FCR measured by the prior authors. This approach is necessary because the lick stone cannot be used as the main feed for ruminants. Further study of the digestibility of the lick stones could help us understand their effects more fully. Also, a study of the effect of lick stones on the reproduction performance and general health of sheep is warranted.

The economic return on the cost of the feed is primarily what determines breeding profitability [27]. It is useless to have a very good feed if the economic return does not exceed the costs [28]. Calculating EFE allows us to evaluate each sheep group's profitability. In this study, the MIS based on local feedstuffs delivered the best economic return. The main reason this lick stone outperformed the MNS economically was the high price of the molasses and urea contained in the MNS. Buying molasses when it is available at a lower price and holding it in storage could improve the economic return of MNS. The lower feed conversion efficiency of the ILS, relative to that of the two lick stones made with local feedstuffs, demonstrates that it is a waste of money to buy an ILS when it is possible to manufacture one using available local feedstuffs [19]. This finding is confirmed by Wayu et al. [29] and Mengistu and Hassen [30], who revealed that incorporating local feedstuffs in feed supplements gives breeders a better economic return.

One limitation of this study is that it evaluated the apparent FCR of the lick stones. As noted above, additional studies could enhance our understanding of the impact of the lick stone on sheep growth. Also, we focused only on evaluating the sheep's growth performance and economic

return, not their general health. Finally, we examined only one ruminant species, namely African dwarf sheep; future studies could apply similar methodologies to other ruminants, such as African dwarf goats, which are also raised by breeders.

## Conclusion

This study has shown that it is possible to use local feedstuffs to make an efficient lick stone for African dwarf sheep during the dry season in Benin. The lick stones made with local feedstuffs enabled the best BWG and the best economic return, substantially superior to the ILS. Thus, it is a waste of money to continue importing lick stones when more profitable alternatives are readily available. Benin and other West African countries should encourage or set up local enterprises that will use local feedstuffs to produce an efficient lick stone for their sheep. Apart from the local feedstuffs used in this study, studies should be conducted to identify other prospective feeds that are largely considered waste but have important nutritional value.

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## List of abbreviations

AOAC, Association of Official Agricultural Chemists; BWG, Body weight gain; EFE, Economic feed efficiency; FCR; Feed conversion ratio; FI, Feed intake; ILS, Imported lick stone; MIS, Mineral lick stone based on local feedstuffs; MNS, Multi-nutritional lick stone based on local feedstuffs.

## Conflict of interest

The authors declare that they have no conflict of interest.

## Authors' contributions

FD and FMH participated in study design and planning. FD and EFA collected data, analyzed and interpreted the results, and drafted the first version. SB and CAAMC participated in the study design and planning and reviewed the manuscript.

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