Research Article

Milk Yield of Borgou Cows Improved with Lick Stones made in Benin

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Abstract | Feed is one of the main constraints affecting milk production and its economic return. The present study aimed to examine the efficiency of the supply of cows with feed supplements using locally available ingredients. Three lick stones were made and tested on 16 Borgou cows in the central part of Benin, West Africa. All test animals had similar initial milk yield, lactation number and body weight. They were divided into four groups of four animals and each group was randomly assigned to one type of dietary treatment. The experiment lasted 90 days. The cows were fed natural pasture, either supplemented or not supplemented with lick stones. Milking was performed twice a day. The cows were weighed weekly to evaluate the effect of supplementation and milking on their body weight. The intake from cows in the LS2 treatment group, which was fed stone rich in crude protein and molasses, was higher compared to the other groups during the dry season and higher than the intake of the treatment group fed with salt-poor stone during the experiment period. Cows in the LS2 treatment group produced much more milk during the dry season than the other treatment groups. Cows in the LS3 treatment group fed with stone low in salt produced much more milk from the fifth week to the end of the trial than the other treatment groups. Animals in the control group lost significant body weight. Thus, supplementation of lick stones based on local feedstuffs improved milk production, prevented body weight loss, and improved the economic return of Borgou cows in the dry season.

Keywords | Borgou cows, Dry season, Feed supplementation, Lick stone, Milk.

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INTRODUCTION

Using feed supplementation for ruminants improves productivity, increases profitability for breeders, and allows efficient and sustainable use of natural grasslands (Buza et al., 2014; Ormaechea et al., 2021). Unfortunately, in many countries around the world, fodder continues to be the only feed used, but it is not sufficient to fully meet the nutritional requirements of ruminants. The practice of food supplementation is uncommon on African farms due to the high price of feed supplements and the low use of indigenous feedstuffs (Faye & Alary, 2001; Montcho et al., 2018). In Benin, West Africa, its supply is lower than the demand due to the low quality and quantity of available feeds in the dry season. Moreover, with global population growth, many natural pastures that allowed ruminants to be raised easily have been destroyed to provide a suitable habitat for humans or cash crops (Faye & Alary, 2001). Even worse, the remaining small exploitable areas tend to have a low nutritional value, especially in the dry season (Babatounde et al., 2011; Makkar et al., 2007). In countries of the West African Economic and Monetary Union

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(WAEMU), the agricultural and industrial sectors generate more than 95 million tons of by-products, which is far more than these countries need (Food and Agriculture Organization [FAO], 2014). Their optimal recycling can both improve the performance of animals and reduce production costs. But the needed feedstuffs have to be processed and stored.

To solve this problem, pellets or meal (Houndonougbo et al., 2012), multi-nutritional blocks (Godoy Padilla et al., 2020; Montcho et al., 2016), and lick stone (Babatoundé et al., 2016; Ormaechea et al., 2021; Wahab et al., 2020) are potential supplements. Tons of lick stone have been imported at a relatively high price (about USD $1,200/T), which is difficult for farmers to afford. According to Marino et al. (2016) and Dollé & Gac, (2016), feeding management and the quality of nutritional supplements can help to reduce greenhouse gas emissions. This can be done by using local feedstuffs that can provide efficient feed supplements (Marino et al., 2016; Ormaechea et al., 2021).

In this context, the present research was carried out to identify suitable lick stones for Borgou cows from the end of dry season to the beginning of the first rains in the central part of Benin.

MATERIALS AND METHODS

Area of study

The research was carried out from March to May at Okpara breeding farm in Benin, located between 2°39' and 2°53' E and between 9°6' and 9°21' N, in the municipality of Tchaorou. The climate is continental Sudanian with a dry season from December to March and a rainy season from June to September. Between these two seasons, transition periods occur from April to May and from October to November. Consequently, the experiment took place at the end of the dry season and extended into a transition period that included the first rains. The average rainfall was 1,125 mm/year and the average temperature during the experiment was 40°C.

Manufacture of the lick stones

The ingredients were mixed in well-defined proportions (Table 1). They included: cement, charred bone meal, molasses, salt, cassava meal, oyster shell, urea, clay, rice bran and water (Table 1) (Yahya & Saadu, 2020). Some of the ingredients were ground before weighing. The order of introduction of the ingredients was very important in the process. The following order was used to produce good lick stones: molasses, urea, common salt, dicalcium phosphate, ochre, charred bone meal, oyster shell, binder (clay, cement, cassava meal), maize bran, and ferritic soil. Molasses, urea, salt, dicalcium phosphate were mixed by hand before add

Table 1: Formulation of the lick stone used

Ingredients	LS1	LS2	LS3
Oyster shell	15	12	15
Common salt	13	13	10
Maize bran		15	15
Urea	5	5	5
Molasses		5	3
Cement	20	20	20
Ochre		3	5
Clay		2	2
Ferritic soil	10	5	5
Cassava meal	20		
Charred bone meal	12	15	15
Dicalcium phosphate	5	5	5
Total (kg)	100	100	100

LS1: First treatment, LS2: Second treatment, LS3: Third treatment.

ing the other ingredients. Water was then added at the rate of 1 liter per 10 kg of mixture. The mixture was processed like dough for few minutes to create homogeneous paste. Then, we proceeded to mold the dough using a manual molder (15 x 20 cm) made in Benin. After demolding, the blocks were placed in a drying area, on a horizontal plane, and not exposed directly to the sun to avoid the fluidification of the molasses and urea (Allen, 1986; Yahya & Saadu, 2020).

Chemical composition of the lick stones

For each lick stone, the amounts of dry matter (DM), organic matter (OM), ash, crude protein (CP), fat, phosphorus (P), calcium (Ca), and magnesium (Mg) were determined (Table 2) according to Feldsine et al. (2002).

Experimental design and feeding

Sixteen five-year-old Borgou cows tending to the end of their milking period were grouped into four blocks of four animals and each group was assigned randomly to its dietary treatment. The average weight and the daily milk yield, respectively, at the beginning of the experiment were 195.75 ± 31.65 kg and 0.397 ± 0.09 liter/day for the control group (LS0); 223.75 ± 9.60 kg and 0.405 ± 0.16 liter/day for the group of Borgou cows fed the first lick stone (LS1); 218.25 ± 15.45 kg and 0.400 ± 0.15 liter/day for the group of Borgou cows fed the second lick stone (LS2); and 224.25 ± 36.11 kg and 0.386 ± 0.22 liter/day for the last group of Borgou cows fed the third lick stone (LS3). The distinctive feature of the first lick stone was that it did not have maize bran, molasses, and ochre (making its color different from the other stones, which were red). LS2 and LS3 did not have cassava meal, which was replaced by maize bran. LS2 was richer in molasses than the others but

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Table 2: Nutritional composition of the lick stones

Treatments	DM (%)	OM	Ash	CP	Fat	P (g/kg)	Ca (g/kg)	Mg (g/kg)
LS1	73.20	30.97	69.03	13.73	3.43	0.046	25.73	49.67
LS2	80.27	31.54	68.46	17.57	1.22	0.045	27.44	41.82
LS3	79.59	31.80	68.20	16.06	0.95	0.028	27.44	22.22
Cotton seed cake	86	92.68	7.00	19.20	33.43	-	-	-

LS1: First lick stone, LS2: Second lick stone, LS3: Third lick stone, DM: dry matter, OM: organic matter (% DM), Ash (% DM), CP: Crude protein (%DM) P: phosphorus, Ca: calcium, Mg: magnesium.

Table 3: Intake of lick stones (g)

Treatments	LS1	LS2	LS3	P
FId (g)	261.97 ± 64.33^{a}	401.00 ± 53.76^{b}	213.41 ± 36.44^{a}	0.000
FIr (g)	237.86 ± 83.01	243.44 ± 8.12	210.81 ± 19.58	0.676
FI (g)	249.91 ± 71.12^{ab}	322.22 ± 28.66^{b}	212.11 ± 24.90^{a}	0.049

LS1: First lick stone, LS2: Second lick stone, LS3: Third lick stone, FId: Feed intake during the dry season, FIr: Feed Intake during rainy season, FI: feed intake over the 90-day period.

Table 4: Feed conversion ratio (kg of lick stone and or feed /kg milk)

Treatments	LS0	LS1	LS2	LS3	p
FCRd	1.29 ± 0.17	1.58 ± 0.52	1.19 ± 0.34	1.43 ± 0.39	0.560
FCRr	0.87 ± 0.27	1.02 ± 0.29	1.03 ± 0.29	0.92 ± 0.29	0.840
FCR	1.08 ± 0.20	1.30 ± 0.41	1.11 ± 0.31	1.18 ± 0.34	0.790

LS0: control, LS1: First lick stone, LS2: Second lick stone, LS3: Third lick stone, FCRd: Feed conversion ration during dry season, FCRr: Feed conversion ratio during rainy season, FCR: feed conversion ratio over the 90-day period.

Table 5: Dairy operating account

Designation	LS0	LS1	LS2	LS3
Variable cost (CFA/cows)				
Cost of the utilization of lick stones	0	1934.625	2697.725	3256.805
Cost of the utilization of cottonseed cake	10800	10800	10800	10800
Health care cost	25030.250	25030.250	25030.250	25030.250
Fixed costs (CFA/cows)				
Depreciation of the equipment	100	100	100	100
Permanent labor costs	2812.500	2812.500	2812.500	2812.500
Gross proceeds (CFA/cows)				
Values of milk sold	55555.625	62548.250	67824.500	64292.500
Gross margin	19725.375	24783.375	29296.525	25205.450
Net margin	16812.875	21870.875	26384.025	22292.945
Benefit cost ratio	0.434	0.537	0.636	0.5308
Rate of return (%)	43.396	53.767	63.667	53.079

LS0: control, LS1: First lick stone, LS2: Second lick stone, LS3: Third lick stone.

had less oyster content; LS3 was richer in ochre than the others but had less common salt than the others and less molasses than LS2.

There was no significant difference (p 0.05) between the groups in terms of body weight and daily milk yield at the beginning of the experiment. Water was provided *ad libitum* to each animal. The animals were housed in individual stalls from 1800 to 1000 hours. They foddered in natural grassland essentially composed of *Panicum maximum C1* from 1000 to 1800 hours each day. Once they returned to their stalls, their feed was supplemented with cottonseed cake (for all the groups) and lick stone (according to the treatment). The feedstuffs used to make each lick stone are shown in Table 1, and their nutritional composition is shown in Table 2.

Data collection

After the two-week adaptation phase, each cow received lick stone in their respective feeder boxes every evening after returning from the pasture. The trial started in the third week and lasted 90 days. Milking was performed twice a day. Data collected included the quantity of milk yielded by each cow, the quantity of stone served, the quantity of stone intake, and the body weight of the cows and calves each week. These variables were used to evaluate the effect of the season and of stone supplementation on milk yield and the body weight of the cows.

Statistical analysis

The data were analyzed using the Student-Newman-Keuls (SNK) method in R software version 4.2.0 (R Core Team, 2022). The standard deviations of the means were calculated and added to them, and the differences were considered significant when the $p < 0.05$.

Lick stone intake

The lick stone intake allows us to know the average quantity of lick stone judged sufficient by the animals to fill their nutritional gap. It was measured in terms of the average daily amount of lick stone eaten by the cows under *ad libitum* feeding. The lick stone intake (LSI) was calculated by subtracting the quantity of the stone refused (LSr) from the amount of stone served (LSs). The standard deviations of the means were calculated and added to them.

LSI = LSs - LSr

Feed conversion ratio

The feed conversion ratio (FCR) was calculated as the amount of feed intake (FI, composed of cottonseed cake and lick stone) used to yield one liter of milk (MY=milk yield). It was evaluated weekly using the daily data collected.

FCR = FI/MY

RESULTS

Chemical composition of the lick stones

The chemical analysis as indicated in Table 2 showed that the stones had a sufficient nutritional content of organic matter, ash, crude protein, calcium, and magnesium. The LS3 was more deficient in phosphorus and fat compared to the others; LS1 had less crude protein than the others.

Lick stone intake

Table 3 presents the intake of lick stones by Borgou cows during the experiment. In the dry season (in March), the lick stone intake by cows in the LS1 group was lower than that of the other cows ($p < 0.05$). From the beginning to the end of the rainy period, the lick stone intake by all cows was similar across all treatment groups and lower than that of in the dry season. Therefore, Borgou cows in our study utilized more lick stones in the dry season (Table 3).

Feed conversion ratio

Table 4 presents the feed conversion ratio for the cows in each group. The cows had an approximately similar ability to convert dietary supplements (cottonseed cake and lick stone) to milk.

Milk yield

The average daily milk yield for each week during the experimental period is presented in Figure 1. The supplementation (cottonseed cake and/or lick stone) significantly increased the milk yield. From the dry season to the beginning of the first rains, the lick stone rich in protein and molasses (LS2) increased the milk yields more than the others. From the sixth week (when the first rains started) until the end of the 90-day period, the cows consuming lick stone poor in salt (LS3) had the highest milk yield, followed by the LS2 group. In total, animals in the control group produced 119.04 ± 22.48 L of milk over the 90 days while the LS1, LS2, and LS3 groups produced 134.03 ± 46.81 L, 143.82 ± 34.59 L, and 145.33 ± 32.00 L, respectively. Thus, supplementation with lick stone increased the milk yield.

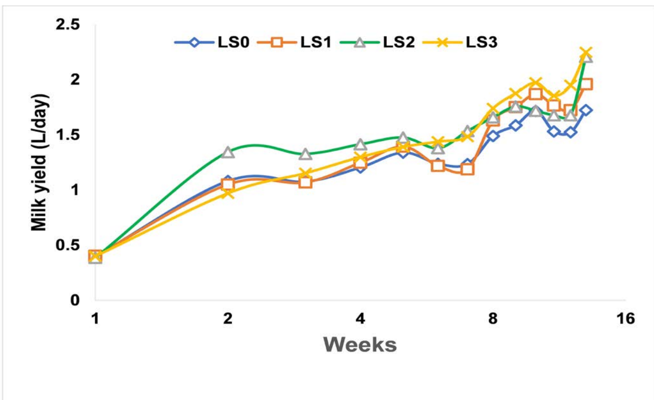

Figure 1: Average milk yield of Borgou cows from dry season to the start of the first rains

LS0: control, LS1: First lick stone, LS2: Second lick stone, LS3: Third lick stone.

Profitability

It is not profitable to have feed which can increase the milk production if it cannot allow breeders to have a good economic return. According with the Table 5 which presents the economic return relative to the use of the feed supplement with Borgou cows, it appears that cows supplemented with lick stone provided a better economic return compared to the control group.

DISCUSSION

This experiment showed that the chemical composition of lick stones, which included organic matter, crude protein, and minerals, met the requirements of the cows. Lick stones, therefore, have the potential to supply an important part of cows' nutritional requirements during the dry season. The amount of calcium (25.73 to 27.44g/kg) and magnesium (22.22 to 49.67 g/kg) in the lick stone mixtures was over 15g/kg and 6g/kg, respectively, the minimum requirement set by Noziere et al. (2018). This finding revealed that local feedstuffs can be used to make good lick stones for ruminants. But there is a need to explore more ingredients rich in phosphorus to fill this gap, since the soils in the study region are deficient in phosphorus. This could help to avoid a disproportionality between calcium and phosphorus, which can be a source of nutritional diseases (Karn, 2001; Magendie, 1828). The amounts of calcium and magnesium were higher than those in the studies by Gabriel et al. (2018) and Gadzama et al. (2016); this might be due to the large quantity of these elements in the material (including charred bones, oyster shells, clay, ochre and cement) used in this study.

The results revealed that Borgou cows benefited from feed supplementation, especially in dry the season and at the beginning of the first rains. This is due to the shortage of feed during the dry season, especially in central and northern Benin. The quantity of the lick stone intake was higher than the 38.1 g recorded by Asaolu et al. (2012). This might be explained by the binder (cement, cassava meal, clay), which was present in greater amounts. This might also be due to the composition of the stone which included, in addition to the minerals, crude protein and energy sources. The lick stone intake was approximately equal to the 340 g recorded by Rjiba-Ktita et al. (2019). To maintain the production level of the cows during the dry seasons, lick stones based on multi-nutrient requirements seem necessary.

As indicated by the similar conversion ratios, all the cows had approximately the same ability to convert their supplement to milk. This might be due to the fact that no special or hard-to-digest elements such as rice bran and hay were included in the feed supplements (Noziere et al., 2018; NRC, 2007). The fact that the animals were adapted to the type of lick stone might also explain this result. Also, the study took place in the dry season and the animals had access to only little feed with low nutritional quality. The feed conversion ratio was improved compared to those found by Jiwuba et al. (2018) and Idowu et al. (2013). This might be due to the breed of the cows and the season.

During the first six weeks (dry season), the LS2 treatment group receiving lick stone rich in protein and molasses yielded more milk. Supplementation with lick stone rich in protein and molasses is therefore necessary for Borgou cows during the dry season. Since the cows fed with the LS2 produced more milk during the first six weeks (dry season), this might suggest that, during the dry season, the little fodder available for Borgou cows is of low quality in some nutrients. However, the average daily milk yield during the dry season was lower than the amounts of 1.77 ± 0.84 L/d and 2.85 ± 0.26 L/d recorded by Senou et al. (2008) and Alkoiret & Bagri (2013), respectively, during the rainy season when fodder is readily available for the cows. In addition, these other studies used cows in their early lactation period, whereas the cows used in this trial were nearing the end of their lactation period. However, the milk yield recorded was better than the 1.25 ± 0.31 L/d reported by Adambi Boukari et al. (2018) for Borgou cows on the same farm that we used. This comparison reveals an interesting effect of multi-nutritional lick stone supplementation than the sources of minerals used by those authors. Benin can therefore use readily available materials to improve the performance of Borgou cows in milk production.

The economic analysis revealed that only the cows supplemented with lick stone enabled an acceptable rate of return which should be 50% to 100% as defined by CIMMYT, (1988). Therefore, supplementing the nutritional content provided to Borgou cows with lick stone based on local feedstuffs offers a great opportunity from the dry season until the beginning of the first rains in the central part of Benin. The improvement of economic return with the cows supplemented with lick stone based on local feedstuffs confirmed research by FAO (2014) which reported that the problems faced by Western African countries in animal feeding are more related to the management, process and storage of agricultural and industrial by-products than the lack of resources. The lick stones based on local feedstuffs could enable Benin to increase its milk production and economic return of the cow farms.

CONCLUSION

The feed supplementation provided in this study improved the milk production of Borgou cows, their body weight and the economic return during the dry season and the transition period. This study reveals that it is possible to produce efficient lick stones to supplement cows' nutrition using local ingredients available in Benin. This is an opportunity for Benin to increase its milk production through the application of readily available materials that are generally regarded as waste. Such a supplementation approach can also contribute to limiting conflicts between breeders and crop producers, particularly in the dry season.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

NOVELTY STATEMENT

Previous studies have focused on the effect of feed supplements on Borgou cows. Some have evaluated the nutritional composition of the lick stone used by the breeders in North Benin. However, the lick stone which is very important for the cows is still not available and those imported are mostly sold at a high price reducing the economic return of the cow's farms. This study has revealed that it's possible to manufacture efficient lick stones based on local feedstuffs at low prices. Those lick stones have significantly improved milk production, and economic return, and prevented the body weight of Borgou cows during the dry season.

AUTHORS' CONTRIBUTIONS

Faustin D. and Frédéric M. H. participated in study design and planning, Faustin D and Service G. D. collected data, carried out analysis and interpretation of the results, and drafted the first version. Venant P. H., Sedjro L. D., Gwladys M. A. and Edith G. participated in critical review of the manuscript; Séverin B., Soumanou S.T. and Christophe A.A.M. C., participated in study design and planning and reviewed the manuscript.

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Links Researchers