EFFECTS OF NATURAL LICKS ON FEED INTAKE, NUTRIENT DIGESTIBILITY, MILK PRODUCTION AND QUALITY IN KENYA ALPINE DAIRY GOAT RATION

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ABSTRACT
Consumption of natural licks is common among domestic animals under natural circumstances, and as a substitute to commercial mineral licks among smallholder livestock keepers in Tharaka-Nithi County, Kenya, with a believe that animals obtain potential nutritional benefits. However, this has never been established through an experimental research using natural licks from the study area. Therefore, this study was aimed at determining feed intake, nutrient digestibility and milk production performance in dairy goats fed on natural licks. Four lactating Kenya Alpine Dairy Goats (KADG) in their second lactation stage and weighing 47.5 ± 3 kg were randomly assigned four treatment diets that consisted of three natural licks from Kang'au, Nagundu and Kabariange, and a standard commercial lick (control) in a 4 by 4 Latin square design. A basal diet of Boma Rhodes grass hay and a standard concentrate were fed to the animals, and feed intake, fecal output and milk yield were measured. One-way Analysis of Variance model was used for the lick intake, nutrient intake, and apparent digestibility and milk parameters. Correlation analysis was carried out to establish the relationship between natural lick sources and milk parameters. There was no significant difference on dry matter intake, nutrient intake, apparent digestibility and milk yield and quality (P>0.05) among goats consuming natural licks compared to commercial lick. However, there was a positive correlation (r) with a value of 0.70 between milk production and lick intake. Natural licks can be an alternative source of mineral supplementation where commercial mineral licks are not available.

Keywords: *Digestibility, Feed intake, Goat ration, Milk production, Natural lick*

INTRODUCTION
Consumption of natural licks (geophagy) has been studied widely in wildlife, and animals are expected to obtain essential minerals and be protected from the effects of plant secondary metabolites such as tannins, and digestive disorders which are associated with ingestion of lush pastures or greening plants (McDonald et al., 1995, Rice, 2010 and Blake et al., 2011). Studies have showed that animals travel long distances away from their natural habitats to consume the naturally occurring minerals (Hishashi, et al., 2006 and Ulli, 2010), and this demonstrates how useful the licks could be in animal's health. It is believed that natural licks are major sources of sodium for herbivores because tropical plants do not accumulate adequate levels for the animals to depend on them, due to poor aerosol deposition especially

in areas far from the ocean (Bravo et al., 2010 and Dudley et al., 2012). Sodium plays a significant role in pregnant and lactating animals especially on maintenance of acid base balance. However, studies have revealed presence of higher levels of other essential minerals in the licks thus refuting arguments that sodium is the only reason for geophagy (Ayotte, 2006, Houston, 2011 and Nderi et al., 2015). For example, Katherine et al. (2004) reported high levels of magnesium for wet and dry licks, which is thought to supplement diets when there are high concentrations of potassium in spring forage that reduces absorption of magnesium by ruminants, thus interfering with rumen fermentation. Livestock production in the tropics largely depends on climate-regulated feed supply whose nutritional value rises and falls according to the season (Hogan et al., 1996). During the dry season, animals are unable to derive nutrients from plants due to high fiber that leads to low microbial attack, low level of protein and minerals for use by rumen microorganisms and in animal tissues (Bakrie, 1996). However, poor animal performance is common even when forage supply is adequate. This is associated with mineral deficiencies caused by mineral imbalances and low concentrations in soils and associated forages, and this result into poor production performance in ruminants (McDowell, 1997, Tiffany et al., 2000 and Khan et al., 2003). It is universally known that animals require certain essential minerals for maintenance and production, but most livestock in the tropics hardly receive mineral supplements (Garg et al., 2009). Proper nutrition is however, the cornerstone for the health and productivity of all animals, and it is the basis of successful livestock production. Despite the fact that many studies on geophagy have been conducted, consumption of natural licks by livestock has received less attention even though some farmers feed animals on this earth material with an aim of enhancing productivity (Karbo, 2006 and Nderi et al., 2014).

Most studies focus on wildlife visitation and chemical characterization of natural licks but little is known on the association between geophagy and domestic ruminant's production performance. The influence of natural lick on livestock production is poorly understood probably due to the promotion of commercial mineral licks in livestock farming. However, studies by Sisay et al., 2007, showed that consumption of natural licks improved total weight gain in sheep, which indicates a positive performance in livestock production. Knowledge of production performance in an animal is important in order to plan on how to incorporate natural licks in the animal's diet, predict milk production response following consumption, and development of quality and effective feed rations. Natural licks can be an intervention measure to mitigate against mineral deficiencies in the diets and hence maintain healthy animals which translates into improving food security (Bishaw and Melaku, 2008). This is particularly important in Kenya where most livestock are owned by smallholder poor farmers who cannot afford the commercial mineral licks (Yinnesu and Nurfeta 2012). Traditionally, some communities in Tharaka Nithi County incorporate natural licks in livestock diets with believe that animals obtain potential benefits such as improved digestion and increased milk production (Nderi et al., 2014). This perception was explored by finding out the relationship between natural licks and feed intake, digestibility and milk production using Kenya Alpines Dairy Goats.

MATERIALS AND METHODS

The feeding experiment was carried out at Chuka University in Tharaka-Nithi County, Kenya between January and April 2015. Before data collection, research approval was sought from the National Commission for Science, Technology and Innovation (NACOSTI) and the permit obtained was presented to the Meru-South Sub County Education and Commissioner offices for clearance. Four lactating Kenya Alpine Dairy goats (KADG) in their second lactation and weighing 47.5±3 kg were used in the experiment. The animals were purchased from farmers self-help group in Matanya, Laikipia County. All animals were housed individually in 1.4 by 1.1 by 1.1 meter wooden pens. Prior to commencement of the experiment, the animals were kept for 14 days in order for them to acclimatize while observing their health status, drenched with Albendazole 2.5% and treated against external parasites using pour on preparation (Ectopor®) (Osuji et al. 1993 and Gaylean, 2010). The animals were then randomly assigned four treatment diets that consisted of three natural licks and a standard commercially prepared mineral mixture which served as a control.

Experimental Diet

The experimental diets consisted of three natural licks and a standard commercially prepared mineral mixture (control) (Table 1). The licks were selected based on the sum total of the quantities of three macro minerals, calcium, sodium and magnesium in each lick using the values obtained from the mineral characterization of the natural licks in the study area (Nderi et al., 2015). In preliminary stage of the experiment, natural licks from Kimenyi, Kieroo and Kang'au sites were selected because they had the highest content of the three macro minerals which were; 3.04%, 1.93% and 1.56% respectively. However, licks Kimenyi and Kieroo were not consumed by goats when offered but lick from Kang'au was accepted. This led to selection of two next best lick sites in the sum total of calcium, sodium and magnesium, and these were; Nagundu and Kabariange licks, whose concentrations were, 1.23% and 1.09% respectively. The selected licks were accepted by the animals. As a result, the treatment diets comprised of three natural licks from site Kang'au, Nagundu, Kabariange and commercial lick. The mineral contents for Kang'au, Nagundu, Kabariange and control were as follows; Calcium, 24545, 13762, 14512 and 69600mg/kg, respectively; sodium, 3227, 4150, 4290 and 39600 mg/kg respectively; magnesium 14063, 9584, 5891and 9900 mg/kg respectively. The natural licks were ground using a mortar and pestle sieved to pass through 2 mm screen, weighed using a weigh balance (Ohaus™), and offered to goat's *ad libitum* in wooden mineral troughs that were firmly fixed in the animal pens. The licks were topped up whenever the level went low to ensure adequate supply. The lick intake was estimated as the difference between the amount offered and refusal at the end of each experimental period.

Table 1: Mineral quantities (mg/kg) of mineral licks from sites with the highest mineral profile and commercial lick

Diet	Ca	Na	Mg
Kimenyi	44445	7961	26640
Kieroo	19812	4756	24427
Kang'au	24545	3227	14063
Nagundu	13762	4150	9584
Kabariange	14512	4290	5891
Commercial lick	69600	39600	9900

Basal Diet

The animals were fed on a basal diet that comprised of Boma Rhodes (*Chloris gayana)* hay and a standard concentrate (Table 2). Before feeding, the grass hay was cut into small pieces using a motorized shredder (Marina®). Two thirds of the daily basal diet were offered in the morning at 08:00 hours while the other one third was offered at 15:00 hours.

Table 2: Chemical composition of Boma Rhodes and concentrate

Parameters	Boma Rhodes	Concentrate
DM (%)	95.267	91.706
CP (%)	7.008	17.645
CF (%)	37.504	13.715
EE (%)	2.341	6.761
Ash (%)	11.391	9.958
NFE (%)	41.746	51.921
OM (%)	88.609	90.042
Ca (mg/kg)	5800	10300
Na(mg/kg)	7200	4700
Mg (mg/kg)	800	1100

Water was given in plastic buckets *ad libitum* during the entire experimental period. A fourteen-day adaptation period whereby the animals were fed the treatment and basal diets was followed by a 4-day data collection period during which the exact amounts of feed offered and refusal were recorded. The feed intake was estimated as the difference between the amount offered and refusals on daily basis. An allowance of 10% above previous day's diet intake was given to cater for increased feed intake (Irungu

et al., 2004). A 5% sample of feed offered and refusal was collected on daily basis and stored under refrigeration for analysis. The dry matter (DM), crude protein (CP), crude fiber (CF), Ether extract (EE), nitrogen free extract (NFE) and total ash were determined in accordance to the methods of (AOAC, 1995). The macro elements, calcium (Ca), sodium (Na) and magnesium (Mg) were determined using Atomic absorption spectrometry methods. Faeces were collected every morning from each goat for the last 4 days of each period, weighed, pooled and thoroughly mixed before sampling. A 5% aliquot of the total daily fecal output from each goat was transferred into a glass stoppered bottle containing a preservative of 25 milliliters of concentrated sulphuric acid to await analysis.

Determination of Milk Yield

The goats were milked once daily at 0800hrs, and milk volume recorded on the last 4 days of the experimental period. After the morning milking a 20 ml milk sample from each goat was taken and pooled into one composite sample which was put in glass bottles with rubber stoppers to prevent moisture loss and stored in freezer until chemical analysis.

Laboratory Analysis

Proximate analysis method was done for the basal diet *(Chloris gayana)* hay, concentrates and feces (moisture content, crude protein, crude fiber, ether extract, ash and nitrogen free extract) according to Gupta et al. (1988). The moisture contents were estimated by drying the samples in an Air Forced Draft Oven (Model: Gallenkamp) at 105 ^{o}C till a constant weight was reached (AOAC, 1995). The samples were then milled using Thomas Willey laboratory mill (Model: Thomas/Arthur H. Thomas co. Phila, PA, USA) for analysis. Crude protein content was determined using Micro Kjeldahl distillation apparatus (Model: Gerhardt Bonn-VAP001460). Crude fiber of the samples was determined in fat free samples by treating with (2.04 N) 1.25% sulfuric acid solution (H_2SO_4), and the left over material was subjected to further treatment with (1.78 N) 1.25% sodium hydroxide solution (NaOH). Ether extract content was determined using Analytical grade petroleum ether 40-60 ^{o}C (AR Loba chemie) as a solvent in Soxhlet fat extraction apparatus. Ash quantities were determined by direct incineration of samples in a Muffle Furnace (Model: Heraewl. wicheraeusGmbH.Hanan) at 600 °C for three hours. Nitrogen free extract (NFE) was calculated using the following equation: NFE% = 100 – (moisture contents% + crude protein% + crude fiber% + ether extract% + ash %). Concentrations of calcium, sodium and magnesium were determined in the samples by using atomic absorption spectrophotometer (PG990). The milk samples were analyzed for butter fat (BF), Protein, Solids-Not-Fat (SNF), Density, Lactose, Solids and Freezing point content using milk analyzer (Lactoscan®).

Data Analysis

Data were obtained by employing a 4 by 4 Latin square design using four experimental units in four periods. The feed intake was determined by difference. Further the data collected were subjected to statistical analysis using statistical analytical software (SAS®, Version 9.1). One way Analysis of Variance (ANOVA) model was used and the level of significance ($P<0.05$) for lick intake, nutrient intake, apparent digestibility and milk parameters determined as outlined by Kothari (2004). Correlation analysis was carried out in milk samples to establish the relationship between natural licks sources and milk parameters.

RESULTS AND DISCUSSION

Effects of Natural Lick on Dry Matter Intake and Digestible Nutrients Intake of the Basal Diet

Table 3 presents results from natural lick intake, feed dry matter intake and digestible nutrient intake of the basal diet in goats fed licks from different sources. The mean lick intake by goats were; 405.50, 33.75, 68.50 and 237.50 g/kg/goat/day, for Kang'au, Nagundu, Kabariange sites and commercial licks respectively. There was no significant difference on lick intake ($P>0.05$) among goats fed licks from different sources. However, the highest consumption was observed from Kang'au lick site and the lowest was on those fed on lick from Nagundu site. The dry matter intake were as follows; Kang'au (1.95), Nagundu (1.82), Kabariange (1.84) and commercial lick (1.89) kg/day, respectively.

Table 3: Intake of mineral lick (grams/animal/day) and nutrients of the basal diet (kg dry matter basis/day) fed to lactating goats

Lick source	Lick intake	Dry matter	Organic matter	Crude protein	Crude fiber	Ether extract	Nitrogen free extract	Ash	Conc: forage ratio
Kang'au	405.50	1.95	1.73	0.17	0.66	0.058	0.84	0.22	5.08
Nagundu	33.75	1.82	1.61	0.16	0.60	0.056	0.79	0.20	4.66
Kabariange	68.50	1.84	1.63	0.17	0.61	0.057	0.80	0.21	4.73
Commercial lick	237.50	1.89	1.68	0.17	0.63	0.056	0.81	0.21	4.88

P>0.05, Kang'au, Nagundu, Kabariange

Table 4: Effects of source of mineral lick on digestible nutrients intake (% of dry matter basis/day) of lactating goats

Lick source	Crude protein	Crude fiber	Ether extract	Nitrogen free extracts	Total digestible nutrients
Kang'au	4.96	10.83	1.22	14.96	31.97
Nagundu	3.60	9.83	1.48	14.19	29.10
Kabariange	4.97	12.98	1.62	18.64	38.21
Commercial lick	4.58	14.01	1.84	19.26	39.71

P>0.05, Kang'au, Nagundu, Kabariange

Table 5: Effects of Source of Mineral Lick on the Apparent Digestibility (% DM Basis)

Lick source	Dry matter	Organic matter	Crude protein	Crude fiber	Ether extract	Nitrogen free extract
Kang'au	31.09	37.82	54.59	30.88	34.87	35.01
Nagundu	28.36	34.16	39.17	25.74	48.76	34.18
Kabariange	37.82	43.27	54.84	37.45	50.21	43.09
Commercial lick	40.46	46.00	51.07	40.55	59.64	44.91

P>0.05, Kang'au, Nagundu, Kabariange

Table 6: Effects of Source of Natural Lick on Milk Yield (ml) and Quality in Lactating Goats

Lick source	Milk Volume (ml)	Milk quality (%)					
		Butter fat	Protein	Density	Solids	Lactose	Solid-Not-Fat
Kang'au	474	3.67	4.39	30.45	0.78	3.69	8.95
Nagundu	373	3.32	4.35	29.46	0.76	3.50	8.67
Kabariange	383	3.67	4.53	29.43	0.77	3.43	8.75
Commercial lick	377	3.63	4.44	29.88	0.77	3.64	8.79

P>0.05, Kang'au, Nagundu, Kabariange

These results also revealed that there was no significant difference on dry matter intake (P>0.05) among goats consuming different licks. Similarly, there was no significant difference on nutrients intake of the basal diet (P>0.05), and concentrate to forage ratio intake (P>0.05) in goats following consumption of licks from various sources. Results in Table 4, showed that there was no significant difference on digestible nutrients intake of the basal diet (CP, CF, EE, NFE, TDN) (P>0.05) due to consumption of natural licks from different sources and a commercial lick. Ingestion of natural licks has been reported in both domestic and wild animals, and it is associated with mineral supplementation, detoxification of plant secondary metabolites and alleviation of digestive disorders (Ayotte et al., 2006). This study shows that there were no significant differences on lick intake (P>0.05) among goats, which supports results of a previous study on sheep in Ethiopia (Sisay et al., 2007). Presence of essential macro minerals in the natural licks may explain the observed similarities on lick intake in comparison to the commercial lick, which suggests that a goat could consume natural lick to meet the body's mineral demand.

The natural lick from Kang'au tended to be consumed more than the rest, which implies that this lick could be more palatable for goats than other licks. Sodium was previously suggested to be the attractant

for animals to consume licks because it is easily lost through leaching in soil and due to inability of terrestrial plants to accumulate enough for the animals (Montenegro, 1998). In the present investigation, however, consumption of natural licks was similar to commercial lick despite the fact that sodium level was 9-12 times lower (Table 3). As indicated in Table 1, natural lick from Kang'au site also had higher level of magnesium than the commercial lick and Boma Rhodes (basal diet). This implies that there could be a physiological demand for magnesium in goats that made them to seek for natural licks as suggested by Heimer (1988). One of the possible physiological reasons could be the need for magnesium as an enzyme activator and for metabolism of carbohydrates and lipids (McDonald et al., 1995). Further examination of these results showed that there was no significant difference on dry matter intake and nutrient intake ($P>0.05$) among goats consuming licks from different sources. A consistent trend was found in digestible nutrient intake, whereby there was no significant difference ($P>0.05$). The mean dry matter intake by goats was found to be 3.95% (w/w), which exceeded the minimum expected daily dietary intake of 3% for lactating goats (NOP, 2010). This observation might have been due to low levels of minerals in the basal diet fed to goats which could have contributed to goats consuming more dry matter in order to satisfy their physiological needs (Worker, 2015). Further, the 350 grams of concentrate given might have not been sufficient to meet the goat's mineral demand.

Apparent Digestibility of the Basal Diet

The apparent nutrient digestibility coefficient values were not significantly different ($P>0.05$) across all the treatments (Table 5). This indicates that digestion of nutrients in the goat's rumen was similar after consuming licks from various sources. The presence of essential minerals in the natural licks as reported in Table 1, might have contributed in providing nutrition that was required for microbial fermentation (McDonald et al., 1995). Though the commercial lick is expected to be well balanced in minerals, it was not better than the natural lick in influencing digestibility. However, the dry matter and nutrient digestibility's were generally low and this could have been associated with high fiber content in the basal diet. This situation was attributed to harvesting grass when it had overgrown (BLGG, 2013). These results indicated that the effects of consuming licks were the same as consumption of a standard commercial lick.

Milk Yield and Quality

The milk production and quality from goats fed on licks from different sources is presented in Table 6. The mean milk production was 474, 373, 383 and 377 milliliters from goats fed on licks from Kang'au, Nagundu, Kabariange and commercial lick respectively. These results indicate that there was no significant difference on milk yield and quality (Butter fat, protein, milk density, solids, lactose, solid not fat ($P>0.05$) among goats fed on licks from different sources. Although there were no significant differences on milk yield and quality across all treatments, goats consuming lick from Kang'au site produced more milk. These results support the previous studies that consumption of natural licks could be associated with meeting the lactation demands of animals (Ayotte et al., 2006). The highest milk yield that was found in Kang'au lick might be related to the relatively higher dry matter intake that was associated with this lick (Table 3) which led to ingestion of more nutrients that was translated into milk production. According to McDonald et al. (1995), the more feed an animal consumes each day, the greater is the opportunity for increasing production.

These findings are supported by the correlation analysis (Table 7) which indicate a positive correlation of 0.75 between natural lick intake and milk production. Additionally, the three natural licks contained essential macro minerals which are known to have a significant influence in milk production. For example, the composition of milk is highly regulated and a deficiency of sodium in the diet tends to decrease milk production (Suttle, 2010). A lot of calcium is lost in milk of lactating animals and therefore a higher supplement is required in the diet (Singh, 1987). This indicates that the natural licks were competitive to the commercial lick in influencing milk production and maintaining quality. Therefore, natural licks could be a source of nutrition for high producing animals especially in the tropical areas where pastures and forages have inadequate minerals.

Table 7: Coefficient of Correlation between Lick Source, Lick Intake, Feed Intake, Milk Production and Quality

		Lick source	Lick intake	Dry matter intake	Organic matter digestibility	Dry matter digestibility	Milk production	Lactose
Lick source	Pearson's Correlation	1						
	Sig. (2-tailed)							
Lick intake	Pearson's Correlation	0.343	1					
	Sig. (2-tailed)	0.194						
Dry matter intake	Pearson's Correlation	0.109	0.462	1				
	Sig. (2-tailed)	0.688	0.071					
Organic matter digestibility	Pearson's Correlation	0.069	0.286	0.379	1			
	Sig. (2-tailed)	0.0800	0.282	0.148				
Dry matter digestibility	Pearson's Correlation	0.058	0.297	0.443	0.981	1		
	Sig. (2-tailed)	0.830	0.264	0.085	0.001			
Milk production	Pearson's Correlation	0.092	0.75	0.261	0.122	0.162	1	
	Sig. (2-tailed)	0.734	0.000	0.329	0.653	0.548		
Lactose	Pearson's Correlation	0.316	-0.269	-0.001	0.234	0.187	-0.557	1
	Sig. (2-tailed)	0.232	0.314	0.996	0.382	0.488	0.024	

CONCLUSION

The mean dry matter intake by goats consuming natural lick exceeds the minimum expected daily dietary intake. The dry matter and nutrient digestibility by goats consuming natural licks from Igambang'ombe are sites are generally low compared to the normal average. The milk yield and quality of dairy goats on consuming natural licks are comparable to the commercial licks. However, the natural lick from Kang'au site has more influence on milk production when compared to commercial licks. In general, natural licks can be an alternative source of minerals where commercial mineral licks are not available.

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