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Full Length Research Paper

Supplementary feeding of lactating goats with processed and unprocessed *Acacia tortilis* pods and local grass in the dry season in northern Kenya

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Abstract

An on-farm feeding trial was conducted to determine the effect of feeding processed (milled *Acacia tortilis* pods and chopped grass hay) and unprocessed (whole *Acacia tortilis* pods and long grass) dry season supplementary feeds on milk yield of goats, growth response of suckling kids and their economic effects. Twenty multiparous Small East African goats from one pastoral herd weighing 28.3±0.7 kg live weight were randomly divided into five groups of four animals each and assigned to one of five treatment diets. The treatment diets comprised of chopped mixed grass hay (chopped MGH), long mixed standing grass (long MSG), milled *Acacia tortilis* (milled ATP), whole *Acacia tortilis* (whole ATP) and control (no supplement). The results showed that daily intakes of chopped grass (309.5 g), whole ATP (413.1 g) were higher than long standing grass (165.4 g) and milled ATP (186.4 g). Of the supplement diets, whole *Acacia tortilis* was the most consumed (87.7%) followed by milled ATP (67.3%), chopped grass (51%), while long grass (40.4%) was the least. In five prescribed incubation periods, milled ATP and whole ATP were degraded faster, followed by chopped grass hay, while long grass was the least degraded. Supplementation increased (P<0.05) milk production of goats between 6.3-45.3%. However, average daily gain (ADG) of suckling kids were similar (P>0.05) among the treatment groups. This study showed that processing by milling of *Acacia tortilis* pods improved digestibility, while chopping of grass hay increased intake. All supplementation provided net economic benefits, but processing only paid off for *Acacia* pods. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods can alleviate nutritional constraints in the dry season, increase milk yield and sustain the body condition of pastoral goats in the arid rangelands.

Key words: lactating goats, grass, Acacia tortilis pods, suckling kids.

INTRODUCTION

Sheep and goats are the most widespread livestock raised by pastoralists world-wide, with goats being able to penetrate more arid regions than sheep (Degen, 2006). In the arid and semi arid areas (ASALs) of Kenya, goats rank second to camels in terms of drought resilience, ability to survive in hot and dry environments, and produce high quality animal protein. In these areas, small ruminant producers mainly depend on Small East African (SEAG) and Galla goats for milk, meat and cash income. However, milk and meat production level per animal was reported to be below optimum (Harry, 1999). The low productivity is further exacerbated by kidding period which falls in the dry season, which is characterized by inadequate pasture production. Inadequate nutrition particularly during the dry season is a major constraint in pastoral livestock production. Diets during the dry season

Table 1. Animal groups, body weights and treatment diets

Treatment Group	Body weight (kg±SEM)	Treatment diet	No of animals	No. of weeks in feeding trial
Chopped MGH	28.2±1.8	Chopped mixed grass hay + grazing	4	9
Long MSG	29.0±1.5	Long mixed standing grass + grazing	4	9
Whole ATP	27.5±1.6	Whole *Acacia tortilis* pods + grazing	4	9
Milled ATP	28.4±1.2	Milled *Acacia tortilis* pods + grazing	4	9
Control	28.3±1.2	No supplement, only grazing	4	9

All the goats grazed daily for 8 hours in the communal pastures of Olturot area. SEM, Standard error means
Animal management and feeding

are fibrous, low in digestible protein, energy, minerals and vitamins do not meet goat nutrient requirements. Pastoral producer responses to inadequate nutrition include herd division, movement to dry season pastures, extended grazing hours and supplementation of milking herds. Nutritional supplementation particularly during the dry season is one alternative to rectify energy and protein deficiencies in local feeds (Lengarite *et al*., 2012).

As dry season feeding strategy, pastoralists in northern Kenya practice supplementary feeding of livestock by use of local forage resources. The most common supplementary feeds were local grasses, leave of browse plants and *Acacia* pods. These forages are traditionally stored in open shades, tree branches and living huts, which affect their quality and shelf life (Lengarite and Mbuvi, 2003). Leaves of browse trees and grass forages drastically decline in quality due to heat and smoke produced in the living hut. Stored whole *Acacia* pods are known to have a short life span due to infestation by insect pests and moulds (Keya, 2001). Pods of leguminous plants such as *A. tortilis* are valuable source of protein with moderate to high dry matter degradability and rich in macro and micro-minerals (Ngwa *et al*., 2000). However, substantial undigested proportions of ingested seeds of *Acacia* species are lost through faeces and mouth during the process of rumination. The undigested seeds represent loss of nutrients which is important during periods of feed scarcity (Shamayo and Uden, 1998). Processing of *Acacia* pods by milling reduces nutrient loss, incidence of pests that target the seeds of whole pods, increases the rate of passage and protein digestibility.

Grasses are the second most preferred forages by goats after browse. The productivity of grass in the rangelands is strongly influenced by precipitation. The changing climatic patterns, which results in excess and decline of rainfall in some years calls for baling of grass in favorable periods for feeding animals during the dry season. In periods of feed shortages chopping of grass will minimize refusals and wastage.

In the arid rangelands of northern Kenya, lack of suitable feed processing and storage technologies are to blame for lack of supplementary feeds for feeding goats, damage of limited feeds by pests, reduction in shelf life and feed quality. The objectives of this study were to determine the quality of processed, unprocessed *Acacia tortilis* pods and local grass, assess the growth of kids, milk yield of lactating goats and economic effect of supplementing with processed and unprocessed *Acacia tortilis* pods and local grass.

Materials and Methods

Study site

The study was conducted at Olturot village in Loiyangalani District, Marsabit County of northern Kenya. The site is located 50 km East of Lake Turkana at the foot slopes of Mt.Kulal. It lies at an altitude of 600 m above seas level, between latitudes ($2^0$46.5'N) and Longitudes ($37^0$14.5'E).

The annual rainfall and temperatures ranged between 160-330 mm and 23^0C-39^0C, respectively. It has stratified sandy to sandy loam soils, strongly calcareous, slightly sodic with moderate soil fertility and high availability of phosphorus (Lusigi, 1984). The vegetation types are wooded bushland and shrubland dominated by the tree layer of *Acacia tortilis, Acacia reficiens, Acacia mellifera* and ground layer of *Duosperma eremophilium, Indigofera spinosa, Salsola dendroides* and grass species.

Animals and Experimental design

Twenty lactating SEA goats managed by a pastoral producer with an average body weight of 28.3±0.7 kg, at the same stage of lactation and 3^{rd} and 4^{th} parities were used for the study. The animals were randomly divided into five groups of four animals each balancing for weight and parity and allocated to one of the five dietary treatments. (Table 1). The treatment diets were chopped mixed grass hay (chopped MGH), long mixed standing grass (long MSG), milled *Acacia tortilis* (milled ATP), whole *Acacia tortilis* (whole ATP) and control (no supplement).

At the onset of the experiment the goats were ear tagged, dewormed using 10% albendazole, the does and their suckling kids at birth were weighed and thereafter on a weekly basis. Weighing of does and kids was done in the morning before grazing and suckling respectively using a mobile scale. The differences in weekly body weights were used to determine growth rates (ADG) of kids. In the first month of life the kids were allowed to stay at night with the mothers and only separated during the day of milk measurement. In the second month the suckling kids were introduced to browse feed through cut and carry. Milk yield of the does was initially recorded at the end of first week post- partum and thereafter once a week. During milking the kids were allowed to suckle one teat to stimulate milk let down. One teat was hand stripped in the morning and the other in the evening and total daily and weekly yields were computed. The animals were allowed seven days for conditioning to the feeding protocol and offered supplements daily in the morning between 07:00- 08:00 hours and then released for grazing. The animals grazed for 8 hours in communal pastures and had free access to water in the village water pan. Feed supplements were initially offered at 2.5% of body weight (BW) and adjusted to actual amounts consumed. Feed offered and refusals were measured using an electronic balance, and recorded daily. Does on *Acacia tortilis* diets were individually fed using mobile plastic troughs, while those on grass based diets were feed using polythene sheets spread on the ground. The daily feed consumed was computed from the differences between feed offered and left over. The on-farm feeding trial conducted between August and October 2013, lasted for 9 weeks. At the end of the study period the body condition of animals were assessed using the visual scoring technique commonly used by pastoralists. The body condition scores (BCS) which relate with the quantity of subcutaneous fat cover of animals were categorized as very poor (1), poor (2), fair (3), good (4) and very good (5).

Feed processing and storage

Ripe pods of *Acacia tortilis* were collected (January-February 2013) in the communal grazing land and sorted to remove foreign materials and damaged pods. Some of the pods were packaged in polythene bags, while others were milled using a portable manual grinder. A coarse meal consisting of seeds and husks was prepared by adjusting the screen size of the grinder. The bags containing milled and whole pods were stored in a cool and dry storage shed. Local grasses, mainly *Bracharia leersiodes*, *Dactyloctenium aegyptium, Tetrapogon cenchriformis, Cenchrus ciliaris* and *Aristida mutabilis* were harvested and baled. Dry standing grass produced in previous seasons was collected and stored in a separate storage shed with hay grass.

Chemical composition and* in sacco *analysis of diets

Duplicate samples of chopped grass hay, long grass, milled and whole *Acacia tortilis* pods were submitted for chemical and dry matter degradability determination by *in sacco* technique. To account for undigested seeds (Shayo and Ude'n, 1998), 24% of the seeds were removed from pods and the remaining empty pods and whole pods were ground together. Chopped grass hay, long grass, milled and whole *Acacia tortilis* pods (24% of seed removed) were analyzed for dry matter (DM), ash, crude protein (CP), crude fibre (CF) and ether extract (EE) using the methods described in AOAC (1995). The cell wall polysaccharides of neutral detergent fibre, acid detergent fibre and acid detergent lignin (NDF, ADF, and ADL) were determined according to Van Soest *et al* (1991). The samples for mineral determination were digested according to AOAC (1998). The concentration of Ca, Mg, Fe, Zn, and Mn were analyzed by use of an atomic absorption spectrophotometer while K and Na were determined by use of flame photometer and P concentration was analyzed calorimetrically using spectrophotometer.
The *in sacco* (ruminal) dry matter degradability (DMD) of chopped grass, long grass, milled and whole (intact seeds and husks) *Acacia tortilis* diets were measured using the nylon bag technique described by Ørskov *et al* (1980). Duplicate samples in nylon bags containing 5 g of feed were incubated in the rumen of cattle bull for 24, 32, 48, 72 and 96 hours before removal at a prescribed time. Dry matter degradability was calculated using the formula described by Jansen *et al.* (2007).

Economic analysis

The cost per unit (kg) of 1 bale of mixed dry standing grass weighing 3.4 kg, a bale of mixed hay grass of 3.1 kg, one bag of whole *Acacia tortilis* pods (10.1 kg) and

Table 2. Mean intake (g d^{-1}) of supplement diets by lactating small east African goats (SEAG) expressed as percentage of body weights (BW) and percentage consumption by hour

Treatment Group	Intake (g d^{-1})	SEM	DMI, % of BW	SEM	% Consumed in one hour
Chopped MGH	309.5	37.2	1.12	0.15	51.0
Long MSG	165.4	18.5	0.58	0.08	40.4
Whole ATP	413.1	13.5	1.52	0.06	87.7
Milled ATP	186.4	6.3	0.66	0.03	67.3

MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods; DMI, Dry matter intake; SEM, Standard error means

ground *Acacia tortilis* pods (10 kg) were KES 58.8, 64.5, 39.6 and 70, respectively. These costs include processing, packaging and labour for chopping grass hay. As the feeds were collected in the communal land, the buying prices of long standing grass (180 KES/bale), mixed grass hay (150 KES/ bale), whole *Acacia tortilis* pods (300 KES/bag) were paid in terms of labour. The labour charges for baling, chopping 3 kg hay and grinding 10 kg *Acacia tortilis* pods using a manual grinding machine were 20, 30 and 200 KES, respectively. Whole and ground *Acacia tortilis* pods were packed in recycled 50 kg polythene bags. Packaging of 112 kg of whole pods utilized 11 bags while milled pods (50.7 kg) were stored in one bag. The total feeding costs was computed from the total feed intake of consumed diets. The market value of milk (KES 100/ litre) was used to derive the gross returns from milk. A simple benefit cost analysis was calculated using the total feed costs and gross returns from milk.

Data analysis

Data on diet intake, milk yield, growth rates of kids, body condition scores, chemical composition, DMD and cost benefit analysis of diets were entered in Microsoft excel. Descriptive statistics were generated for the cost and benefit analysis. The chemical composition, *in sacco* DMD of diets, milk and growth rate data were subjected to one way analysis of variance using the GenStat program (2010). When treatment was significant means were separated using the least significant difference procedure ($LSD_{0.05}$).

RESULTS AND DISCUSSION

Dietary intake

The mean body weights of goats and daily intake of treatment diets expressed as percent of body weights are presented in Table 2. The daily intakes of chopped grass (309.5 g), whole ATP (413.1 g) were higher than long standing grass (165.4 g) and milled ATP (186.4 g). The intake of chopped MGH, long MSG, whole ATP and milled ATP correspond with 1.12, 0.58, 1.52 and 0.66% of body weight dry matter intake of goats, respectively (Table 2). Of the supplement diets, whole *Acacia tortilis* was the most consumed (87.7%) followed by milled ATP (67.3%) and chopped grass (51%). Whole pods contributed over half (1.52%) of total dry matter intake (DMI) of lactating goats (2.8% BW) (NRC, 2007). Thus, supplementation using whole *Acacia tortilis* pods may decrease intake of the basal forage diet (Bii *et al*. 2010). The concomitant reduction in forage intake limits energy intake and animal performance. The lower intake of ground *Acacia tortilis* pods (seeds and husks) can be attributed to the meal form and slight dustiness of the diet supplement. During processing the seeds produced coarse particles, while empty pods formed fine particles. In the case of grass, the higher intake of chopped MGH was due to short length and good quality grass, while the low consumption of long MSG (40.4%) can be ascribed to the long length, high fibre and low CP contents. In this study, it was observed that [1]spreading the grass diets allowed selectivity thereby enhancing intake.

The result of high intake of chopped grass was supported by the findings of Castillo *et al*. (1982) who found that buffaloes consumed more chopped rice straw than long straw and Omokanye *et al*. (2001), who stated that chopping of browse species enhanced intake by 60%. In contrasts, animals offered long lengths of food which are not chopped had lower intake (Castle *et al*., 1979; Deswysen *et al*., 1978).

Chemical composition of treatments diets

Table 3 shows the chemical components of chopped grass hay, long standing grass, milled and whole *Acacia tortilis* pods. With the exception of ether extract, the DM, ash, CF, CP, NDF, ADF and ADL contents varied (P<0.05) among the diets. As expected, the DM content

[1]Grass diets during feeding were spread out on polythene paper sheets. In this way goats were able to select preferred feed components and thereby enhancing diet intake.

Table 3. Chemical composition (DM basis) of dietary supplements consumed by goats in Olturot area of northern Kenya

	Ingredient					
Chemical component	**Chopped MGH**	**Long MSG**	**Whole ATP**	**Milled ATP**	**SEM**	**P-value**
DM (%)	89.7[a]	93.4[b]	87.9[a]	88.8[a]	0.510	0.006
Ash (%)	10.4[a]	9.2[b]	5.9[ab]	5.7[ab]	0.196	<0.001
EE (%)	2.5[a]	1.5[a]	1.6[a]	1.6[a]	0.217	0.09
CF (%)	35.5[a]	43.1[b]	22.2[ab]	18.3[ac]	0.942	<0.001
CP (%)	7.4[a]	3.6[b]	12.2[ab]	12.5[ab]	0.149	<0.001
NDF (%)	62.7[a]	65.4[a]	35.8[b]	33.0[b]	1.165	<0.001
ADF (%)	31.1[a]	41.7[b]	19.8[ab]	18.8[ab]	0.658	<0.001
ADL (%)	3.8[a]	5.1[b]	4.3[a]	4.3[a]	0.169	0.025
Ca (g/kg)	4.0[a]	3.8[a]	3.4[a]	3.4[a]	0.132	0.074
P (g/kg)	3.3[a]	1.2[b]	3.4[a]	3.8[a]	0.168	<0.001
Mg (g/kg)	4.5[a]	2.0[b]	2.3[b]	2.8[ab]	0.158	<0.001
K (g/kg)	31.7[a]	13.9[b]	26.5[ab]	24.9[ac]	0.255	<0.001
Na (g/kg)	3.6[a]	0.9[b]	0.5[b]	0.4[b]	0.158	<0.001
Fe (mg/kg)	198[a]	158[b]	154[b]	143.5[ab]	1.032	<0.001
Zn (mg/kg)	20.7[a]	12.3[b]	16[ab]	18.7[ac]	0.25	<0.001
Mn (mg/kg)	87[a]	80[b]	19[ab]	25.5[ac]	0.577	<0.001

[abc]Means along the same row followed by different superscript differ (P<0.05); MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods, DM, Dry matter; EE, Ether extract; CP, Crude protein; NDF,Neutral detergent fibre; ADF, Acid detergent fibre; ADL, Acid detergent lignin; SEM, Standard error means

was higher (P<0.05) in long standing grass, while it was lower and similar (P>0.05) in chopped grass hay, milled and whole *Acacia tortilis* pods (Table 3). The high DM content of long standing grass can be attributed to the stage of maturity and exposure to sunlight. The concentrations of ash was highest in chopped grass hay (10.2%) followed by standing grass (9.2%) and least was milled (5.7%) and whole *Acacia tortilis* pods (5.9%). The CF contents ranged between 35.5-43.1% in grassed based diets and 18.3-22.2% in *Acacia tortilis* based supplements. Of the diets, milled *Acacia tortilis* pods was the lowest in CF content, while long grass contained the highest level. The cell wall polysaccharides (NDF and ADF) of milled and whole *Acacia tortilis* pods were similar (P>0.05), but differed (P<0.05) with chopped grass hay and long standing grass. Except for long grass with high lignin content, the levels were similar in other diet supplements (Table 3). The variation in CF, NDF and ADL contents among the diets could be related to plant species and stage of maturity. Mckell (1980) reported that mature pasture plants in the tropics have high CF contents that ranged between 30 to 40%. The CP content of chopped grass hay (7.4%) was slightly above the critical level of 7% necessary for optimum rumen function. Mero and Uden (1998), Aganga and Autlwetse (2000) reported lower CP contents of 5.1 and 4.88% in *Cenchrus ciliaris* grass, respectively. Mixed grass species appear to be richer in CP content than single grass species. Milled and whole *Acacia tortilis* pods with CP contents ranging from 12.2-12.5% were adequate to meet the minimum (12%) recommended requirement for lactating does (NRC, 2007). However, Bii *et al*. (2010) and Abdulrazak *et al*. (1999) reported higher contents of CP, but comparable concentrations of NDF, ADF and ADL in *Acacia tortilis* pods.

In the case of macro (P, Mg, K, Na) and micro (Fe, Zn, Mn) minerals the contents were variable (P<0.05), while Ca was similar (P>0.05) among the supplements. Compared to long standing grass, chopped grass hay, milled and whole *Acacia tortilis* pods were higher (P<0.05) in P, Mg and K contents. Of the diets, chopped grass hay was the richest in macro (Mg, K and Na) and micro (Fe, Zn and Mn) minerals. The high Na content in chopped grass hay may be attributed to *Dactyloctenium aegyptium*, which is a salty grass species. Milled *Acacia tortilis* pod diet was higher (P<0.05) in micro-minerals, while whole *Acacia tortilis* pod supplement was rich in K. The higher concentration of micro-minerals in milled pods may be related to accumulation of these minerals in the seeds, which were more in the processed pods than whole pods (24% of seeds removed). The low mineral concentrations in long grass can be attributed to loss of leaves, seeds and translocation of minerals to the root system with plant maturity.

In sacco dry matter degradability of supplementary feeds

The dry matter degradability (DMD, %) of the diets consumed by goats are shown in Table 4. In the five

Table 4. In sacco dry matter degradability (DMD %) of dietary supplements fed by goats in Olturot area of northern Kenya

	Ingredient					
Incubation hours (h)	**Chopped MGH**	**Long MSG**	**Whole ATP**	**Milled ATP**	**SEM**	**P-value**
24	43.6[a]	30.0[b]	42.7[a]	44.5[a]	1.106	0.02
32	45.8[a]	33.7[b]	43.3[ab]	51.9[ac]	0.589	<0.001
48	48.6[a]	34.52[b]	55.3[ab]	53.7[ab]	1.037	<0.001
72	59.4[a]	51.0[b]	70.0[ab]	67.4[ab]	1.803	0.006
96	59.9[a]	55.9[b]	69.3[ab]	68.1[ab]	0.744	<0.001

[abc]Means in the same row followed by different superscript differ (P<0.05); MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods

Table 5. Milk yield and body condition score of supplemented and none supplemented lactating small east African goats at Olturot area of northern Kenya

Treatment Group	**Body condition score**	**SEM**	**Milk yield (g d^{-1})**	**SEM**	**% increase in milk yield**
Long MSG	2.5	0.3	255.2[a]	12.6	6.3
Chopped MGH	3.0	0.4	307.8[ab]	15.0	28.3
Whole ATP	3.8	0.3	300.5[ab]	16.5	25.2
Milled ATP	3.5	0.3	348.6[b]	17.8	45.3
Control, No supplement	2.1	0.1	240.0[a]	14.0	

[ab]Means along the same column with different superscript are different (P <0.05) , $LSD_{0.05}$ =39.9
MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods; Body condition scores; very poor (1), poor (2), fair (3), good (4), very good (5)

prescribed incubation periods, the diets showed marked differences (P<0.05) in dry matter degradability. The extent of degradation which improved with incubation period may be attributed to longer resident time of feed components in the rumen. This was in agreement with the report by Ondiek *et al.* (2010) who showed that degradation of *Acacia* browse leaves improved with incubation period (24-48 hrs). Milled ATP and whole ATP were degraded faster, followed by chopped grass hay, while long grass was the least degraded. Except at 32 h, where the DMD of milled pods was the highest, the extent of dry matter disappearance of milled pods was similar (P>0.05) to whole ATP (Table 4). However, the level of degradation was lower than the average reported by Shayo (1992) in empty *Acacia tortilis* pod (60.4%) and seeds (58.5%).

The higher dry matter degradability of milled pods (32 h) may be attributed to the low crude fiber content and reduced particle size. Feeds with small particle size pass through the retriculo-omasal orifice faster thereby stimulating intake and animal performance. Milled ATP and whole pods provide a rich source of nitrogen (N) for microbial growth and dry matter disappearance. The dry matter degradation of chopped grass which was higher than (P<0.05) long grass may be related to low lignin, rich mineral and CP contents (Table 3). The in sacco results compare favorably with that of Cenchrus ciliaris hay (Shayo, 1992). In contrast, the low crude protein and high lignin contents of long grass depress rumen microbial digestion and dry matter degradability. The rate of degradation of the plant components in the rumen can indicate the relative importance of the plant in the diet (Lebopa et al., 2011).

Milk yield of lactating goats

The milk production and body condition score of does are presented in Table 5. Diet treatment influenced significantly (P<0.05) the milk yield of goats. Supplementation increased milk production in the range of 6.3-45.3%. The daily milk yield was highest in goats receiving milled ATP followed by chopped grass, after whole ATP, and long MSG and finally control with no supplement (Table 5). The results are in agreement with previous studies in northern Kenya than indicated that milk yield of SEAG was a function of nutrient status than stage of lactation. Thus, supplementation modified the nutrition status and therefore milk production of goats. Similar findings was reported by Pamo *et al*. (2006) who observed increase in milk production in West African dwarf goats receiving browse leave supplements. The higher milk yield of goats supplemented with milled ATP was related to increased degradability and rate of

Table 6. Body weights and average daily weight gain (g d^{-1}) of kids suckling supplemented and control does

Parameter	Group						
	Long MSG	Chopped MGH	Whole ATP	Milled ATP	Control	SEM	P-value
Initial weight(kg)	2.9	3.0	2.6	2.8	2.7	0.190	0.634
Weight gain (kg)	4.9	5.4	5.5	5.9	5.3	0.345	0.350
Final weight (kg)	7.8	8.4	8.1	8.7	8.0	0.297	0.295
ADG (g)	71.7	79.8	82.0	86.8	77.6	5.07	0.350

MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods

Table 7. The value of milk produced and costs of the feed consumed by different groups of goats

Group	Benefit		Costs		Benefit/cost ratio
	Total milk produced (litres)	Total value of milk (KES)	Total feed consumed (kg)	Total value of feed (KES)	
Long MSG	69.4	6,941.4	44.9	2,645.3	2.6
Chopped MGH	83.7	8,372.2	84.2	5,429.9	1.5
Whole ATP	81.7	8,173.6	112.4	4,449.6	1.8
Milled ATP	94.8	9,481.9	50.7	3549.1	2.7
SEM	5.2	520	15.7	597	0.3

Costs (buying, processing and packaging)/kg (KES); long standing grass (58.8), chopped mixed grass hay (64.8), whole pods (39.6), milled pods (70); value of milk/litre (KES 100); KES 90 = 1$ USA. MGH, Mixed grass hay; MSG, Mixed standing grass; ATP, Acacia tortilis pods

passage of the ground ATP at 32 hrs (Table 4). Alteration of the physical form of *Acacia* seeds increased protein utilization and the dry matter digestibility (Aganga *et al*. 1998). Milled *Acacia* pods with seeds provided a supplement of similar value to maize bran (Gohl, 1981). The increased milk yield with processing of roughage are consistent with the report by Church and Kellems (1998) who showed that milled ration with roughages increased milk yield of lactating dairy cows. Conversely, as expected whole *Acacia tortilis* pods were bulky, limiting intake of forage and milk production of goats. The mean daily yield was in agreement with the value of 264 g d^{-1} reported by Mbui (1992) and 385 g d^{-1} by Ruvuna *et al.* (1984) for Small East African goats. Cooper *et al*. (1992) also reported a similar yield (270± 99 g d^{-1}) for SEAG supplemented with 250 g of maize bran and 259± 99 g/day (uniformizar) for control group.

Body condition assessment of lactating goats

The mean body condition score of goats are shown in Table 5. The body condition score of goats ranged between poor (2.1) to fair (3.8). The animals receiving good quality supplements of *Acacia tortilis* pods and mixed hay grass had fair body condition, while those offered long standing grass or not supplemented showed poor body status (Table 5). To meet the energy requirement during peak lactation, animals on poor quality diets mobilize their body reserves and thereby leading to poor body condition. Conversely, improving the nutrition status of goats during lactation by using good quality supplements can sustain the body condition of animals.

Daily weight gain of suckling kids

The average daily weight gains (ADG) of suckling kids are given in Table 6. ADG of kids were similar (P>0.05) among the treatment groups. It appears that at early and mid lactation, the milk output of supplemented and none supplemented SEAG does was sufficient to support the observed kid growth rates (Table 6). The findings concur with the report by Nga'mbi *et al*. (2008) who found that kid growth rate was not correlated with milk yield during the first two months after birth. Traditionally, kids in early lactation were allowed to stay with their mothers during the night and only separated during the day. The kids of dams producing low milk may be suckling more frequently and therefore consuming equivalent amount of milk suckled by kids of supplemented does. Feeding of kids with browse leaves in the second month may contribute to improve the growth rate of suckling kids. The moderate growth rates observed can be attributed to young age of kids (2-9 weeks) and adequate consumption of milk in early lactation. The mean ADG obtained were within the range of 59-83.9 g d^{-1} reported by Harry (1999) for SEAG kids between the ages of 0-16 weeks and Nga'mbi *et al*. (2008) in Angora goat kids at eight weeks.

Cost benefit analysis of the diet supplements

The costs and benefits of different supplementary feeds are shown in Table 7. The total cost of feed was highest for chopped grass hay and whole *Acacia tortilis* pods and least for long standing grass and milled *Acacia tortilis* pods (Table 7). Processing of *Acacia tortilis* pods increased feed density leading to the reduction of feed consumed, while chopping of grass hay increased consumption. The total value of milk (KES 100 per litre) was higher for *Acacia tortilis* pods base supplements followed by mixed hay grass and the least was dry standing grass. The benefit-cost ratio reveals the net impact of feed intake, nutrition, cost, and milk yield. For example, the total amount of milled pods consumed (50.7 kg) was markedly lower than whole pods (112.4 kg), plus there are additional costs of milling *Acacia tortilis* pods (KES 30 per kg). However, when accounting for increased milk yield, the benefit-cost ratio for milled pods, was 50% greater than for whole pods; therefore, milling provided a net benefit. The benefit: cost ratio was highest for milled *Acacia tortilis* pods (2.7) and long dry grass (2.6) and least for whole *acacia tortilis* pods (1.8) and chopped mixed grass (1.5). Thus, milling of whole *acacia tortilis* pods was a net benefit while processing of grass hay was not.

Conclusions

This study has confirmed that processing by milling of *Acacia tortilis pods* improved digestibility, while chopping of grass hay (mixed) increased intake. Milled *Acacia tortilis* pod with low CF content was better utilized than whole pods. Inclusion in the diet of good quality supplements such as mixed grass hay, milled and whole *Acacia tortilis* pods increased milk yield of goats. However, at early ages, supplementation had no benefit on kid growth. Thus, processing of feed supplements such as *Acacia tortilis* pods which are locally available would enhance the productivity of goats during the dry season in northern Kenya. In summary, all supplementation provided more benefit than costs, whether processed or not. Processing pods increased benefits, while processing hay cost more than it was worth in increased milk yields. Further studies are warranted to assess the benefit of feeding a combination of processed feeds to lactating goats and on-station experiment to validate the findings.

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References

AOAC (1995). Official Methods of Analysis, 15th ed. Association of Official Agricultural Chemists, Washington, DC.
AOAC (1998). Official Methods of Analysis of the Association of Official Analytical Chemistry.16th Edition, Volume I. Maryland.
Aganga AA, Tsopito CM, Adogla-Bessa T (1998). Feed potential of Acacia species to ruminants in Botswana. Arch.Zootec.47: 659:668.
Aganga AA, MN Autlwetse (2000). Utilization of sorghum forage, millet forage, veldt grass and buffel grass by Tswana sheep and goats when fed lablab purpureus L. as protein supplement. Asian-Australian journal of Animal science, Volume 13, No.8, pp. 1127-1132.
Abdulrazak SA, EA Orden, T Ichinohe, T Fujihara (2000). Chemical composition, phenolic concentrations and In vitro gas production characreristics of selected Acacia fuits and leaves. Asian-Australian journal of Animal science, Volume 13, No.7, pp. 935-940.
Bii JC, Abdulrazak SA, Mukisira EA, Shakala EK (2010). Performance of the East African Zebu weaner cattle supplemented with *Acacia tortilis* pods. In: Proceedings of 12th KARI biennial conference, Nairobi, Kenya.
Church DC, Kellens RO (eds). (1998). Feed preparation and processing. In: Livestock feeds and feeding 4th Edition. New Jersey, USA p.206.
Castillo LS, DB Roxas, MA Chavez, VG Momongan, SK Ranjhan (1982). The effect concentrate supplement and of chopping and soaking rice straw on its voluntary intake of carabaos. In: The utilization of fibrous agricultural residues as animal feeds. Melbourne, Victoria, Australia. pp.74-80.
Castle ME, Retter WC, Watson JN (1979). Silage and milk production: comparisons between three silages of different chop lengths. Grass Forage Science, 34, 293–301.
Degen AA (2006). Sheep and goat milk in pastoral societies

Small ruminant Research 7-19.
Deswysen A, Vanbelle M, Focant M (1978). The effect of silage chop length on the voluntary intake and rumination behaviour of sheep. Br. Grassland Soc. 33, 107–115.
GenStat software 12th edition, Release 12.1 (2010). www.vsni.co.uk/
Gohl B (1981). Tropical feeds. Feed information summaries and nutritive values. Food and Agricultural Organization of the United Nations, p.529.
Harry I (1999). Effect of seasonality on productivity of pastoral goat herds in northern Kenya PhD dissertation, Berlin University, Germany.
Jansen DAWAM, van Langevelde F, de Boer WF, Kirkman KP (2007). Optimisation or satiation, testing diet selection rules in goats. Small Ruminant Research, 73:160-168.
Keya GA (2001). Coping with drought: overview of adaptive strategies against livestock losses by nomads of northern Kenya. In proceeding of APSK 2001, Njoro, Kenya.
Lengarite MI, Mbugua PN, Gachuiri CK, Kabuage LW (2012). Mineral status of sheep and goats grazing in the arid rangelands of northern Kenya. Pakistan Journal of nutrition, pp.383-390.
Lengarite MI, Mbuvi M (2003). Feedback workshop on improved young stock management technologies. KARI / EU, report, Marsabit-Kenya.
Lebopa CK, Boomker EA, Chimonyo M, Mokoboki HK (2011). *In sacco* dry matter and crude protein degradation of woody plant species in Tswana and Boer goats. Life Science Journal, 2011:8.
Lusigi WJ (1984). IPAL- Integrated project in arid lands. Resource management assessment, A-6. UNESCO, Nairobi, Kenya.
Mbui MK (1992). The production performance of Rendille Small East African goats and Somali Galla goat under Arid conditions of northern Kenya. In: National arid lands Annual report 1992. p.31.
Minson DJ (1990). Forage in ruminant nutrition. Academic press Inc., London, UK.
Mckell CM (1980). Multiple uses of fodder trees and shrubs, a world-wide perspective. In: Le Houerou, H.N (ed), Browse in Africa current state of knowledge. Ilca, Addis Ababa, Ethiopia pp.141-150.
Mero RN, P Uden (1998). Promising tropical grasses and legumes as feed resources in Central Tanzania: Effect of supplementing Cenchrus ciliaris hay with leaves from four legumes on intake and digestibility by growing Mpwapwa bulls. Animal feed science technology 70, pp. 111-122.
Ndikumana J, Stuth J, Kamidi R, Ossiya S, Marambii R, P Hamlett (2000). Coping mechanisms and their efficacy in disaster-prone systems of the greater horn of Africa. Effect of the 1995-97 drought and the 1997-98 El Nino rains and the responses of pastoralists and livestock.
Ngwa AT, Nsahlai IV, Bonsi MLK (2000). The potential of legume pods as supplements to low quality roughages. *Short paper and poster abstracts: 38th Congress of the South African Society of Animal Science* © South African Society of Animal Science. South African Journal of Animal Science 2000, 30 (Supplement 1).
Nga'mbi JW, L Khitsane, D Norris, CA Mbajiorgu (2008). Effects of soybean meal supplementation on pre- and post-partum productivity of Angora goats in communal rangelands of Molimo-Nthuse in Lesotho. Livestock Research for rural Development 20 (1).
NRC (2007). Nutrient Requirements of Small Ruminants: Sheep, Goats, Cervids and New World Camelids. The National Academies Press. Washington, DC.
NRC (1981). National Research Council. Nutrient Requirement of goats: Angora, Dairy and Meat goats in Temperate and Tropical countries, National Academic Press, Washington, D.C.
Omokanye AT, Balogun RO, Onifade OS, Afolayan RA. Olayemi ME (2001). Assessment of preference and intake of browse species by Yankasa sheep at Shika. Niger. Small Rumin. Res. 42, 203–210.
Ondiek JO, Abdulrazak SA, EN Njoka (2010). Chemical and mineral composition, in-vitro gas production, in-sacco degradation of selected indigenous Kenyan browses. Livestock Research for Rural Development 22(2) 2010.
Ørskov ER, Hovel FDD, Mould F (1980). The use of the nylon bag technique for the evaluation of feedstuffs. *Tropical Animal Production* ; 5:195-213.
Pamo ET, FA Fonteh, F Tendonkeng, JR, Kana, B Boukila, PJ Djaga, G Fomewang (2006). Influence of supplementary feeding with multipurpose leguminous tree leaves on kid growth and milk production in the West African dwarf goat. Small ruminant Research 63, pp. 142-149.
Ruvuna F, Cartwright TC, Smith GM, Bradford YM, Berger C, Ahuya C, Muia J (1983). Preliminary results of performance of different breeds of goats at Ol magogo. In: Proceedings of the 2nd Small ruminant CRSP workshop, February 22, 1983, Naivasha, Kenya.
Shayo CM, Uden P (1998). Recovery of seeds of four African browse shrubs ingested by cattle, sheep, goats and the effect of ingestion, hot water and acid treatment on the viability of the seeds.Tropical Grasslands, Volume 32, 195-200.
Shayo CM (1992). Introduction of dairy cattle production systems in soil conservation areas. In: Proceedings of workshop on future of livestock industries in East and Southern Africa, Harare, Zimbabwe, ILCA, Addis Ababa, p.227.
Van Soest PJ, Robertson JD, Lewis BA (1991). Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci, 74: 3583-3597.