Feed Intake and Feed Conversion Efficiency (FCE) of Growing SEAG Fed on Mature Green Pods of *Acacia brevispica*, *A. mellifera* and *A. tortilis* Processed Differently as Supplements

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Abstract

Kenya has about 52 speciesof acacia which possess tannins. Little effort has been made to process the acacia species pods to add value to their nutritional potential. It is in this aspect that the study intended to assess the Feed Intake (FI) and Feed Conversion Efficiency (FCE) of growing Small East Africa Goats fed on mature green pods of Acacia brevispica, mellifera and tortilis processed differently as supplements in Emining ward within Mogotio Sub- County in Baringo County, Kenya A total of 20 bucks 4-5 months old weighing 12kg±1.05 were purchased. They were blocked according to their live weights and randomly allocated to five treatments in a Randomized Complete Block design. Deworming was done prior to data collection. The five treatments were; T1 (fresh mature green pods of Acacia sp. Untreated, T2 (green Acacia sp. pods - shade dried for 48 hours), T3 (green pods of Acacia sp sun dried for 48 hours), T4 (green pods of Acacia sp. soaked in wood ash mixed with water for 48 hours, and T5 (negative control-basal diet of Rhodes grass Hay-Chloris gayana mixed with wheat brand (3:1)). All the bucks in all the treatments were fed on the same basal diet of 400grams. FI was recorded daily and Average Weight Gain taken fortnightly for a period of three months. Data obtained was fed to Stratigraphic Centurion XVII and subjected to Analysis of Variance. A. tortilis pods processed differently was taken in large amounts when processed in alkaline (416.50±6.50 gm, ($p<0.05$). Initial weight of the SEAG did not differ prior to feeding ($p>0.05$). For control, Shade dried, Sun dried and Alkali treatment, A. tortilis ponds resulted to the highest weight ($p<0.05$). Bucks fed on Acacia tortilis- alkali-treated-pods resulted in best Average Daily Gain ($p<0.05$). Highest FCE was recorded in Acacia tortilis treated in alkali $p<0.05$) which had the lowest FCR. In conclusion based on the results of the current study, Acacia tortilis showed the overall best performance in most of parameters tested. To reduce the harmful effects of tannins in tanniniferous forages, the alkali technique of tannin reduction in acacia species pods should be used.

Key Words: Acacia species, nutritive value, tannin, processing effects, goats

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Introduction

Livestock sector is an important global player with enormous economic, social and environmental impact contributing to over 40% of global agricultural Gross Domestic Product as well as employing over 1.3 billion people (Steinfeld et al., 2006 & Alders et al.,2021). The livestock population in Kenya consisting of both indigenous and exotic is estimated at 60 million units (Mutai, 2022). This sector depends majorly on rangeland where a diversity of food plants for livestock is naturally found. These food plants consist of herbaceous plants, woody and non woody plants. The mixed grasses and browse vegetation commonly found in the field is low in nutritional value and hardly support fast growth rate and early maturity and off take that meets the pastoralists' various socio – economic requirements (Oba, 2012).

In the ASAL areas, the small ruminant keepers usually depend on the Galla goat breed or the Small East Africa Goat (SEAG) for meat, milk and capital income, but the production per animal is very low (Fanzo, 2014). In northern Kenya, there are over three million pastoralists who often experience severe drought, and in the past one hundred years have experienced twenty-eight major droughts four which took place in the last ten years. The pastoralists depend solely or mostly on livestock. Droughts usually result in high livestock mortality rate rendering these pastoralists among the most vulnerable communities in Kenya (Omoyo, Wakhungu & Oteng'i, 2015). Usually, at the onset of the dry season, the quality of feed worsens quickly, quantity reduces due to increased grazing pressure. The average crude protein percentage during dry season grazing is less than 3%. In the Arid and Semi-Arid Lands of Kenya, pastoralists rarely supplement their goats with the conventional commercial feeds due to their high cost occasioned by the human–animal nutritional conflict (Muteng'e,2021).

Kenya is divided into seven Agro-Ecological Zones each of which has its unique physiognomic characteristics such as the moisture availability zones and temperature zone. There are over 1,342 acacia species distributed throughout the world with Kenya having 52 species widely distributed across the varied agro-ecological zones (Mutai, 2022). For the woody food plants, a large diversity of acacia amongst them Acacia brevispica, A.mellifera and A.tortilis contributes to pool utilized by livestock. Most acacia sp. possesses Anti Nutritional Factors (ANFs) called tannins which protects them from excessive herbivory. Tannins binds to dietary proteins to form indigestible tannin-protein complexes and also inhibit ruminal microbial digestion by forming tannin- protein complexes with bacterial enzymes (Paul et al., 2020).

Digestibility can be defined as the amount of ingested feed that does not appear in faeces and is therefore assumed to have been digested, absorbed and utilized by the animal. Digestibility is an important parameter for quality of forages and various methods have been developed to measure in-vitro digestibility (Navarro Ortiz & Roa, 2020). The production of gas in digestibility experiments has proven to be accurate in estimating the ruminant's performance when fed on certain forages. This technique has been found to be very effective when determining the nutritive value of tanniniferous forages (Dong, Li & Diao, 2019). It is also versatile and best mimics the in-vivo technique and assists in understanding certain critical mechanistic issues confounding the effects of tannins in some plants in animal nutrition (Ronaldo, 2016).

In the rumen, plant material comes in contact with numerous microbial colonies which starts the degradation of forage cell walls into the end products of carbohydrates digestion- the simple sugars. They are utilized by ruminal microbes to make their own proteins for growth and development. They do these through fermentation of the sugars to yield volatile fatty acids (VFAs)-acetate, propionate and butyrate, and the release of gases like –ammonia, methane, hydrogen sulfide, and carbon dioxide (Leahy et al., 2022). The VFAs also known as short-chain fatty acids (SCFAs) are products produced through microbial degradation of carbohydrates in the gastro-intestinal tract (GIT), and from the endogenous substrates like mucus, and there are no animal digestive enzymes which degrade cellulose or other complex carbohydrates (Raza, Bashir & Tabassum, 2019).

Little effort has been made in Kenya to process the acacia species pods to add value to their nutritional potential by reducing the anti-nutritional factors (tannins). Most fodder forages possess lectins e.g. robin and ricin found in Robinia pseudo-acacia and have been implicated in causing clinical signs of malaise, posterior paralysis, and anorexia in cattle (Kamo et al., 2012). It is in this aspect that the study assessed the Feed intake and feed conversion efficiency (FCE) of the growing SEAG fed on mature green pods of Acacia brevispica, A. mellifera and A. tortilis processed differently as supplements.

Methodology

The Study Site

The study was carried out in Emining ward within Mogotio Sub-County in Baringo County, Kenya. Selection of the study was based on the fact that it falls within transitional zone IV which forms part of Kenya's ASAL regions and is the habitat of most of the acacia species. This area is among the locations where SEAG are kept and form the live line of the pastoral community. The experimental site was located at latitude 00 15' 00'' N and Longitude 360 00' 00'E. The study site and its environs were visited and the three acacia species under study, that is, Acacia brevispica, A. mellifera and A. tortilis, were positively identified with the help of the Government Kenya Forest Service (KFS) officers and the Range Management staff in the area (Mutai, 2022).

Sourcing Study Animals

A total of 20 bucks 4-5 months old weighing 12kg± 1.05 and of the Small East Africa Goat (SEAG) breed were purchased from goat keepers in Emining Ward in Mogotio Sub-County.

Study Animal Management

The bucks were blocked according to their live weights (lwt) and body conditions score (BC) and randomly allocated to five treatments (the 5th treatment was a negative control), in a Randomized Complete Block Design (RCBD). They were dewormed with a broad spectrum anthelminthic - albendazole 2.5% according to individual animal live weight and allowed 7 days feed acclimatization period before data collection was done. There were five treatments each allocated with 4 bucks (replicates) and fed on: T1 (fresh mature green pods of Acacia sp. untreated (positive-control), T2 (fresh mature green Acacia sp. pods - shade dried for 48hours), T3 (fresh mature green pods of Acacia sp pods - sun dried for 48 hours), T4 (fresh mature green pods of Acacia sp. soaked in wood ash mixed with water for 48 hours, (prepared by burning each Acacia sp. pods and sieving to give a fine clean soluble powder (alkali treatment 3% W/W) sol. And T5 (negative control-basal diet of ground Rhode's grass Hay-Chloris gayana mixed with wheat brand at a ratio of 3:1). All the bucks in all the treatments were fed on the same basal diet of 400grams (as supplement) to meet their nutritional requirements (Tufarelli & Laudadio, 2011).

All the bucks were given water and mineral salts adlibidum. The mature green acacia species pods used as supplements were harvested daily by picking the pods from the fruited acacia species and subjected to the five treatments then fed approximately 400 g (supplement) per buck per day in individual troughs and the refusals was collected and weighed in the next morning using a digital weigh scale before the next feed supplement was offered. Each Acacia sp. feeding trial experiment lasted for 3 months. Growth rate was monitored by weighing the bucks fortnightly using a digital weigh scale by hanging the well secured bucks on the scale. The data recorded was analyzed to give the average fortnight growth rate and the final weight gained (kg).

Feed Intake of the Small East Africa Goat (SEAG)

Feed intake was obtained from daily measurements using a digital weigh scale in kilograms of mature green pods of the acacia species given to each buck as per acacia species treatment and deducting from the next day's refusals in kilograms for a period of 3 months for each acacia species. All goats were fed with half (0.4 kilogram) of acacia ponds with respect to treatment. The data obtained was used to indicate average daily gain (ADG) (gm) and was calculated by dividing the average cumulative weight gained (gm) for each buck in each acacia species treatment for the period of three months by the cumulative average daily feed intake (kg) for each buck for the period of 3 months as a supplement.

Feed Conversion Efficiency (FCE) of the Small East Africa Goat (SEAG)

Feed Conversion Efficiency (FCE) was calculated based on data collected for the period of 3 months on feed intake for each group of bucks and for each treatment as per the Acacia species. This was calculated by dividing the total average weight gained by bucks per treatment in (gm) by the total average feed consumed in (kg) by the bucks per treatment per each of the Acacia species.

Calculation of FCE:

$$FCE = \frac{Total\ weight\ gained\ (kg)}{Total\ amount\ of\ feed\ taken\ (kg)}$$

Data Analysis

Data obtained from feeding trials on feed conversion efficiency (FCE) was fed to Stratigraphic Centurion XVII and subjected to Analysis of Variance (ANOVA). Significant differences in means were separated using Fishers least significant differences (LSD).

Results

Mean Daily Acacia Pods (Supplement) Feed Intake (g)

Averages mean daily feed (supplements) intake for the entire period was assessed. Between the acacia species, all supplements processed in alkaline were ingested in large amounts with a significant difference with other treatments ($p<0.05$). *A. tortilis* pods processed differently as supplements were taken in large amounts when processed in alkaline (416.50 ± 6.50), sun dried (305.25 ± 15.19), shade dried (259.96 ± 4.23) and control 1 (194.42±6.17) compared with the others ($F_{0.05}$ (2, 15) =11.04, p=0.0012). For *A. mellifera* pods high amount ingested were processed in alkaline (371.71 ± 8.71) and sun dried (276.42 ± 8.13) ($F_{0.05}$ (2, 15) = 4.09, p=0.0302) while for *A. brevispica* pods processed in alkaline (397.46 ± 3.46), sun dried (281.29 ± 11.77) and shade dried (250.92 ± 8.66) were taken in high amounts compared with the others ($F_{0.05}$ (2, 15) =11.04, p=0.0012) (Figure 1).

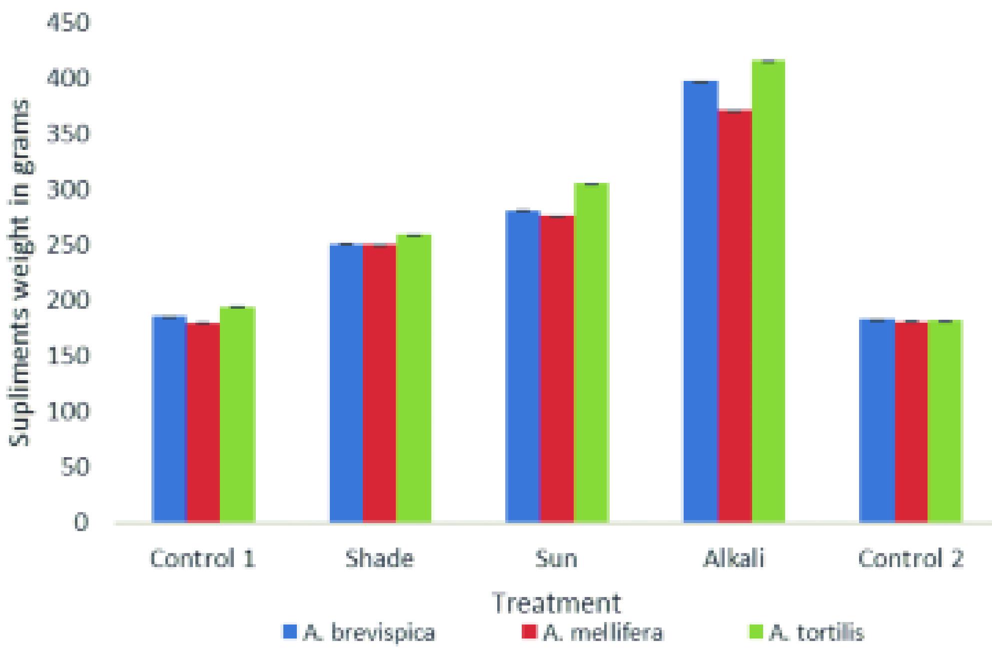


Figure 1: Mean Daily Feed (Supplement) Intake

Average Feed Taken for the Entire Period

Average feed intake in grams was computed for three months between the treatments. For control 1, more of *A. tortilis* supplement (17497.53 ± 55.56) was taken in as compared with *A. brevispica* (16781.22 ± 54.42) and A. mellifera (16211.25 ± 26.65) with a significant difference ($F_{0.05}$ (2, 15) = 11.06, p = 0.0011). There was no significant difference between *A. brevispica* and A. mellifera supplements taken in (p>0.05). In shade dried, A. tortilis supplement (25396.22 ± 38.06) was taken in high level as compared to others with a significant difference ($F_{0.05}$ (2, 15) = 4.43, p = 0.0008) with no significant difference between amount taken in *A. brevispica* and *A. mellifera*. Similarly, in sun dried treated *A. tortilis* were taken in in larger amounts as compared with the others with a significant difference ($F_{0.05}$ (2, 15) = 11.76, p = 0.0008). Within treatments, there was a significant difference between control (16781.22 ± 54.42) and shade dried (23596.22 ± 38.06), sun dried (25777.53 ± 28.13) alkaline treated (35771.22 ±

37.12) treated *A. brevispica* as well as between Alkali and all other treatments Similar trend was followed in different treatments of *A. mellifera* and *A. tortilis* as illustrated in Table 1.

Table 1
Average Feed Taken for the Entire Period in Grams

	A. brevispica	*A. mellifera*	*A. tortilis*	F-ratio	p-value
Control 1	16781.22 ± 54.42a*	16211.25± 26.65a*	17497.53 ± 55.56b*	11.06	0.0011
Shade dried	23596.22 ± 38.06a**	22582.53 ± 77.95a**	25396.22 ± 38.06b**	4.43	0.0008
Sun Dried	25777.53 ± 28.13a**	25316.28 ± 15.94a**	27472.50 ± 136.70b**	11.76	0.0008
Alkali	35771.22 ± 37.12a***	34353.72 ± 33.37a***	36585.00 ± 38.50b***	12.78	0.0006

Means followed by different letters in the same row are significantly different. Means followed with the same number of asterisk (*) in the same column are insignificantly different ($p<0.05$).

Initial and final mean body weight (kg)

Initial weight of the SEAG did not differ prior to feeding with supplements ($p>0.05$). There was a great variation in final weights after feeding with supplements treated differently. For control, Shade dried, Sun dried and Alkali treatment, *A. tortilis* ponds resulted to the highest weight of 14.20 ± 0.36 kg significantly different from the others acacia species ($F_{0.05}$ (2, 15) = 6.28, p=0.0196). There was a significant difference in treatment within a species as illustrated in Table 2.

Table 2
Initial and Final Mean Body Weight (kg

	Treatment	*A.brevispica*	*A.mellifera*	*A.tortilis*	F-ratio	p-value
Initial Weight (kg)	Control 1	12.63 ± 0.48a	12.38 ± 0.95a	12.58 ± 0.53a	0.15	0.8658
	Shade Dried	12.05 ± 0.50a	12.30 ± 1.29a	12.63 ± 0.85a	0.38	0.6963
	Sun Dried	12.31 ± 0.48a	12.23 ± 0.48a	12.75 ± 0.65a	1.10	0.3746
	Alkali	12.63 ± 1.29a	12.63 ± 0.48a	12.10 ± 0.74a	0.35	0.7141
	Control 2	12.00 ± 1.29a	12.14 ± 0.74a	12.10 ± 0.74a	0.02	0.9778
Final Weight (kg)	Control 1	13.64 ± 0.71a	13.47 ± 1.30b	13.59 ± 0.36a*	6.28	0.0196
	Shade Dried	13.07 ± 0.61a	13.41 ± 0.47b	13.78 ± 0.72c*	9.21	0.0066
	Sun Dried	13.47 ± 0.47a	13.27 ± 0.48a	14.01 ± 0.22b	9.06	0.007
	Alkali	13.81 ± 0.47a*	13.72 ± 0.47a*	14.07 ± 0.34b*	9.22	0.0066
	Control 2	13.00 ± 1.30a*	13.15 ± 0.74a	13.18 ± 0.74a	0.93	0.429

Means followed by different letters in the same row are significantly different. Means followed with the same number of asterisk (*) in the same column are insignificantly different ($p<0.05$).

Average Daily Gain (ADG) in g

Average daily gain (ADG) (g/d) of the goats fed with differently processed mature green pods of *Acacia sp*. was assessed. Bucks fed on *Acacia tortilis*- alkali-treated-pods resulted in best Average Daily Gain (ADG) of 15.03 KG ±2.01 gm followed by on A. *brevispica* (14.13±1.94) with a significant difference with that of *A. mellifera* ($p<0.05$). Control 1, shade dried and control 2 treatments resulted in insignificant average daily gain among and within all Acacia species tested as illustrated in Figure 2.

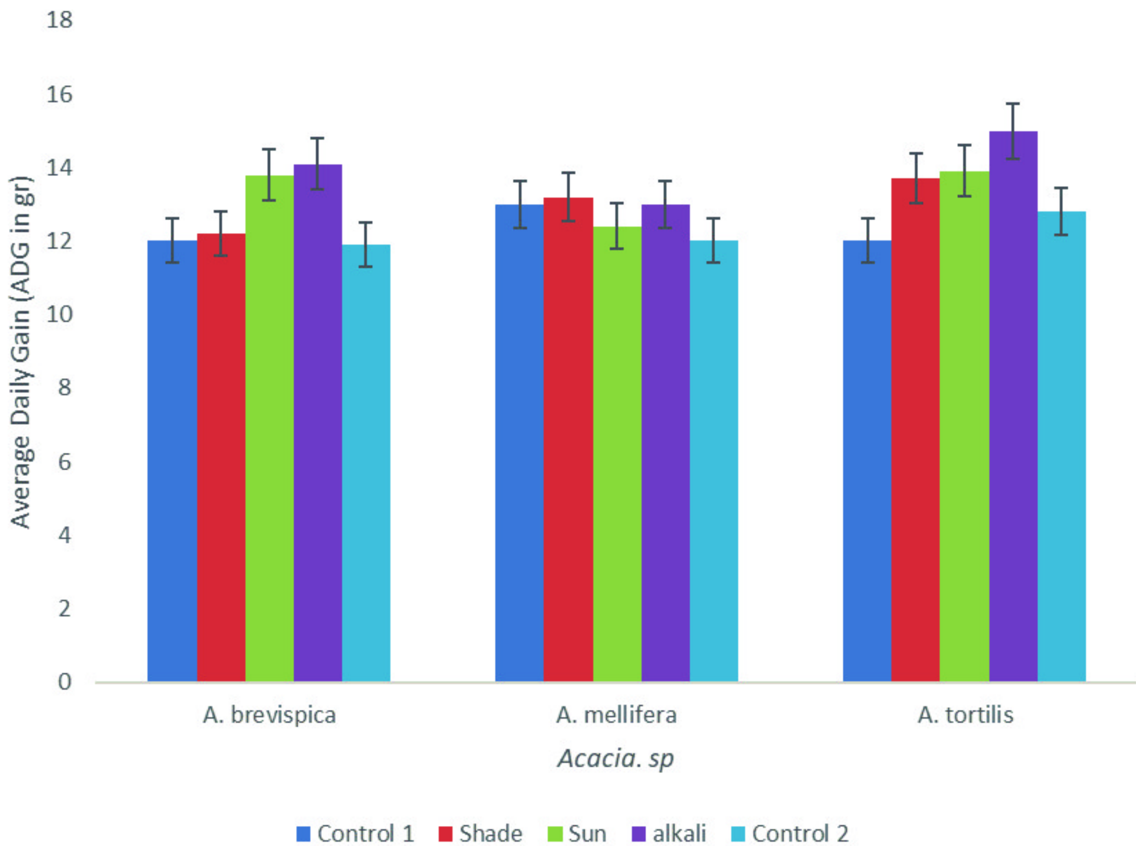
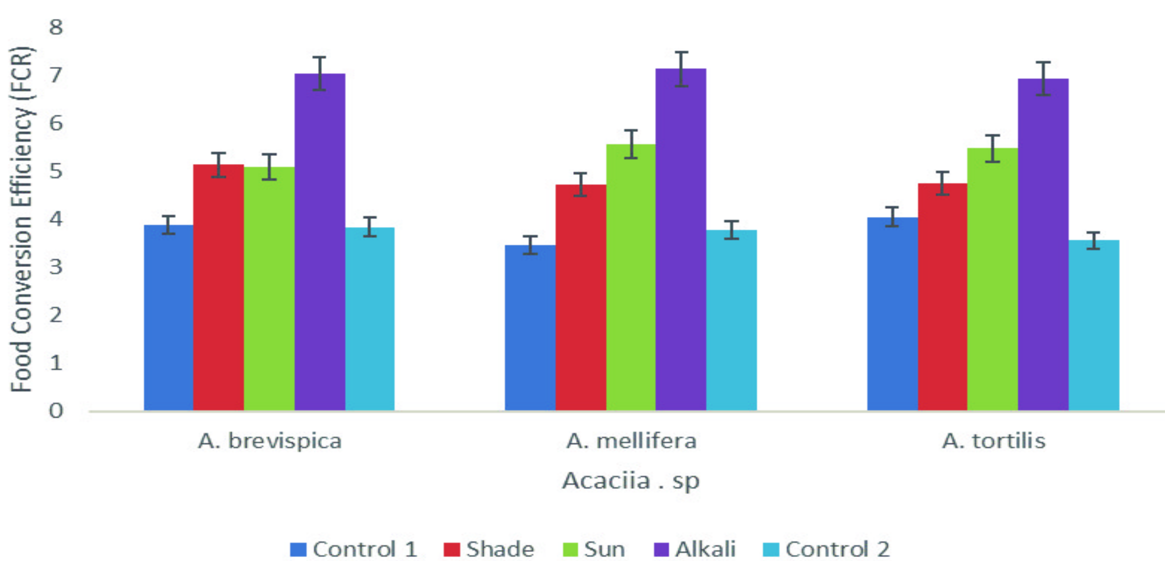


Figure 2: Average Daily Gain (ADG) in g of the Goats Fed with Differently Processed Mature Green Pods of Acacia sp.

Feed Conversion Efficiency (FCE)

There was a significant difference in food conversion ration within the acacia species pods treated differently. High feed conversion efficiency was recorded in *Acacia tortilis* treated in alkali as compared to other treatments as illustrated in Figure 3.



Discussion

Tannin production and protein precipitation differs with plant species, parts of the plant, different time on the same species and different environments. Studies have demonstrated that the availability of protein in *Acacia sp*. to ruminal microbes is interfered with by tannins hence affecting dry matter intake (DM). The carbon-nutrient hypothesis posits that the formation of tannins is due to the hunting of the primary metabolites like carbon –skeletons, during unfavourable periods like when there are poor nutrient levels and growth is hampered. It has also been observed that some tannin depicts characteristics of both hydrolysable tannin (HT) (Patra & Saxena, 2011). Condensed tannins can be either cis or Trans based on the orientation of the functional group located on the C-3 and C-4 positions relative to Benzene ring, and this affects their capacity to form complexes with proteins, carbohydrates, lipids and minerals depending on the pH of the rumen environment (Piluzza, Sulas & Bullitta, 2014).

Averages mean daily feed (supplements) intake for the entire period was assessed. Between the acacia species, all supplements processed in alkaline were ingested in large amounts with a significant difference with others treatments. *A. tortilis* pods processed differently as supplements were taken in large amounts when processed in alkaline compared with the others. This is attributed to low levels of tannin as compared to *A. mellifera* and *Acacia. brevispica* pods. Condensed tannins are often present in leguminous tropical forages more so those found in arid zones and acidic soils. The levels of the polyphenolic compounds in the pods (pulp and seeds) of A. mellifera and *Acacia. brevispica* have lower palatability and nutritive value. *Acacia mellifera* leaves have more total extractable tannins at 25% and 5% condensed tannins (CT), (>60g/kg digestible matter) and these phenolics have the tendency to lower the species palatability and nutritive value (Mlambo and Mapiye 2015). According to Katanga (2015), the raised contents of condensed tannins cause reduced forage degradability, low growth rate and palatability.

The findings are in line with those of Uguru et al. (2014) and Mlambo and Mapiye (2015) on tannins levels of *Acacia mellifera*. The findings are in line with those of Kremp et al. (2012) who posited that phenolic compound levels in leguminous plants differently affects animals fed on such plants as protein supplements and there is need to pinpoint the particular compounds that causes lowered palatability intake and digestibility. It has been reported that the section of diet, protective responses of animals and the interactions of fed diet components and the rumen microbes' digestive enzymes, significantly influence the degree of nutritional effects of tannins.

Treatment or processing method also influences palatability of the species pods. This is attributed to the fact that environmental effects like temperature and nutrient stress affects tannin levels and certain plants reacts to browsing by ruminants through quick rise in condensed tannin levels (Tadele, 2015). This is in agreement with the findings in this current study where feed intake and fed conversion efficiency varied significantly ($p \leq 0.05$). Low feed conversion ratio was recorded in *Acacia tortilis* treated in alkali resulting in the highest feed conversion efficiency (FCE). Research has established that treatment of tanniniferous forages with alkalis reduces their total extractable tannins and phenols and /or condensed tannins levels significantly. The reduction is achieved through conversion of tannins to quinones which have no capacity to form complexes with proteins and increases crude protein content and NDF digestibility (MacAdam & Villalba, 2015).

The presence of tannins in feeds reduces the nutritional value by binding with proteins rendering proteins unavailable for microbial degradation (Mlambo & Mapiye, 2015). However, this largely depends on the type of tannins and it is perceived that hydrolysable tannins (HT) are more hazardous than condensed tannins (CT) and it is said that (CT) have less harm when less than 5% of the dry matter in the feed, and that there is a negative correlation between (CT) levels in forages (>50GCT/kg DM) and their palatability, voluntary feed intake, digestibility and N retention in ruminants. Also, goats and sheep fed on diets of *Calliandra callothyrsus* and *Desmodium intortum* and legumes possessing 9.5g/kg and

22.5g/kg of condensed tannins respectively resulted in over 21% more Nitrogen reaching the abomasum when compared to the ones fed on tannin-free diet which directly affects food conversion efficiency (Herremans *et al.,* 2020).

Duvaux-Ponter (2017) reported that goats fed high levels of tannins resulted in clinical manifestation of lethal poisoning like abortion, ruminal atony, and hyper glycaemia. Condensed dietary tannin concentrations of less than about 100g/kg DM in the diet may improve ruminant performance, and that dietary tannins concentration of 20-45 g/kg DM in the diet increased Nitrogen efficiency resulting in increased daily weight gain in lambs feed on temperate fresh forages e.g.; *Lotus cornicalatus*, (Sujkowska-Rybkowska et al., 2020). Other studies have demonstrated that the optimal balance between positive and negative effects of condensed tannins was observed in sheep when the dietary concentration was 3-4%, and it has been proposed that tannin –rich legumes should be used to enhance by-pass protein and boost ruminant performance (Crawford et al., 2020). Many alternative hypotheses regarding the "bypass protein" which elucidates the impact of *proanthocyanidines* on protein degradation and utilization by the ruminants are in agreement with other studies on legume forages (Addisu, 2016). Livestock which eats diets having (>5% w/v tannin) level normally develop negative nitrogen balance, reduced feed digestibility and animal performance.

The findings concur with those of Lawa et al. (2017) who found a conversion efficiency of 6.37kg of feed to 1 kg of meat in Awassi male ramp lambs subjected to a feed containing 40% Acacia leaves resulted in a feed conversion efficiency (FCE) of 6 body weight gain. However, these results were comparable to the ones recorded in another finding of Kaushish (2019), where a concentrate ration was used resulting in a FCE of 6.55. This finding agrees with those of this study where the food conversion efficiency (FCE) for the best performing tannins reducing method (alkali) was 7.00.

Conclusion

Feed intake and Feed Conversion Efficiency were highest in goats supplemented with alkali- processed mature green pods of *Acacia tortilis,* with a food conversion efficiency of 7:1, comparable to that of conventional feed supplements. Bucks fed on *Acacia tortilis* alkali-treated-pods resulted in best average final weight of 15.03±2.01 Based on the results of the current study, *Acacia tortilis* showed the overall best performance in the majority of the criteria examined. The ripe green pods of *Acacia tortilis* have the necessary nutritional content as a supplement for ruminants, particularly in the arid and semi-arid lands (ASALs)

Recommendation

Pastoralists in Kenya's Arid and Semi-Arid (ASAL) zones ought to grow *Acacia tortilis* under commercial establishment. To lessen the harmful effects of tannins in tanniniferous forages, the alkali technique of tannin reduction in acacia species pods should be used.

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