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Assessment and utilization of tree and shrub forages as livestock feed in Kenya: A review

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Abstract
The nutritive value of indigenous multipurpose trees and shrubs is reviewed. The ten local Kenyan MPTS contain appreciable crude protein (112-321 gkg^{-1} DM) total extractable phenolics (4.5- 52.3 gkg^{-1} DM), total extractable tannins (0.6–38.5 g/kg DM) and major and microelements. Although tannins may impair nutrient utilization, they contribute to bypass protein and ameliorate rumen methane production. The ranking of these tree forages reveals different scenarios depending on the criteria but preferred species are indicative of superiority of some of them. The highly ranked based on increasing nutritive value are: (*Maerua Angolensis*> *Zizyphus mucronata* > *Acacia Senegal*> *Acacia mellifera* >*Balanites aegyptiaca*) but palatability showed a different order: *A. tortilis*> *M. angolensis*> *B. aegyptiaca*> *Z. mucronata*> *Albizia coriaria* > and *Z. mucronata. M. angolensis* and *Z.mucronata* were comparable in intake (358 to 638 gDM/day) and rumen NH_3-N (9.3-13.7mg100ml^{-1}, and ADG (gd^{-1}) between 9.4 to 39.8 g/d. The nutrient digestibility, NH_3-N and ADGs improved with supplementation. It is concluded that *M. angolensis* and *Z. mucronata* can be supplemented alone to improve weight gains of ruminants.

Keywords: Animal performance, antinutritive factors, average daily gains, multipurpose tree forages, rumen degradation, methane amelioration, nutritive values, supplementation

Introduction

In the arid and semi-arid (ASALs) of Sub-Saharan Africa, availability of good quality feed resources all year round is a major constraint to animal production. Animals are offered natural pasture, crop residues or grown fodder such as Napier grass, but most of these feeds are low in digestible nutrients, and when fed alone do not supply adequate nutrients to meet the requirements of the animals [50]. The productivity of such animals in terms of meat, milk and other products is, therefore, sub-optimal.

Use of commercial concentrate supplements is one way of improving roughage utilization. However, for smallholder livestock farmers, these concentrates are considered to be too expensive or are not readily available. An alternative to these concentrates is to use on-farm supplements, and forages from multipurpose trees and shrubs (MPTS) [25]. The introduced MPTS species such as *Leucaena leucocephala* and *Gliricidia sepium* which are relatively new to the tropics are highly productive and used extensively in areas of high agricultural potential as livestock feed. Nevertheless, they are not adapted to the arid and semi-arid lands where the larger population of livestock is found [1, 25, 4, 25, 29]. The native species, like the Acacias, have adapted to the local conditions and are, therefore, better suited for forage production. Besides supplying animals with forages, the tree legumes enrich the soil through biological nitrogen fixation, prevent soil erosion, serve as windbreaks and act as sources of fuel wood and building material, among others.

The MPTS have a wide variation in nutritive value and antinutritive factors. It is, therefore, essential to screen these MPTS using digestibility techniques like the *in sacco* or nylon bag and *in vitro* methods. Some of the antinutritive factors like tannins which abound in tree species like the Acacias [113], may compromise the nutritive value of the forages [99]. The proanthocyanidins, generally termed tannins, precipitate protein by forming tannin-protein complexes [88, 87], thereby reducing the digestibility of protein and feed dry matter [33]. The tree forages contain condensed tannins that are very effective in forming tannin-protein complexes. Most studies on MPTS have been on the agronomic performance, identification, propagation and management [114]. To some extent the basic chemical composition (dry matter, ash, and nitrogen) and feeding value [100] have been reported. More work is needed in determining the nutritional role of MPTS in livestock production.

Nutrient Composition of Tree Forages

The nutrient content of forages differs widely among species. Differences may also arise as they grow on different soil types that are endowed with different soil minerals and the forage species have different capacities to manufacture and store the nutrient compounds. It has been shown that tree forages contain higher levels of nutrients than grasses especially in the dry season when the latter wither away. The trees are deep rooted, often tap into the ground water and nutrients and remain green throughout the year [3, 22, 64, 72, 73, 74, 78, 93, 103].

Tree forages contain high levels of crude protein (14.7-22.5%) and, therefore, are potential sources of protein supplements. These are higher when compared to grasses like Rhodes Grass (*Chloris gayana*) [74] and Maize (*Zea mays*) stover [72] that has been shown to contain 3.6-4.8% and 10% CP, respectively especially in the dry season [48]. Leguminous trees that grow easily with minimal agronomic inputs are increasingly becoming alternatives to commercial concentrates. The MPTS are well adapted to the local conditions like soil fertility status, drought regimes, and retain substantial biomass in the dry season apart from withstanding frequent harvesting management [72, 114] and can be harvested and as supplements later [93]. They are moderate to high in minerals that are required by rumen microbes for growth, metabolism and synthetic processes. Low concentration of sulphur and phosphorus in forages reduce fibre digestion [97] and minerals in consumed forages in ruminants is scanty and is a growing research area.

Table 1 presents some values for the proximate composition [7] of common tree forages browsed by ruminants in the ASALs of Kenya. The values not only vary greatly between and within species but also indicate the ability to supply the much-needed nutrients that may not be the case for grasses.

Table 1: Proximate composition of common tree forages used in ASALs of Kenya

Species	OM	CP	NDF	ADF	References
A. abyssinica	937	165	462	531	[7, 73, 108, 114]
A. amara	953	167	413	601	[73]; [108]
A. brevispica	927	187	329	460	[1, 4, 7];
A. coriaria	935	169	373	482	[6, 73]
A. elatior	878	162	355	503	[73, 108]
A. hockii	952	121	160	218	[73, 108]
A. mellifera	837	183	306	392	[73]; [103, 104],
A. nilotica	935	121	212	290	[73, 108]
A. senegal	904	249	266	423	[1[4, 16];
A. tortilis	924	117	335	443	[7, 73, 108]
Acacia tortilis pods	-	154	617	-	[103, 104]
B. aegyptiaca	867	137	266	349	[73, 108];
B. aegyptiaca	-	126	283	143	[79, 108]
B. micrantha	940	112	421	481	[73, 108]
Cordia sinensis	-	193	589	568	[103, 108]
Ficus spp	861	412	-	-	[64]
G. bicolor	919	196	362	528	[43, 73, 93, 103, 104]
Justicia exigua	-	204	436	427	[103, 104]
Lannea schweinfurthii	-	174	472	362	[103, 104]
M. angolensis	941	321	332	449	[73]; [78]
Rhus natalensis	-	161	612	308	[103, 104]
Salvadora Persica	-	151	313	239	[103, 104]
Z. mucronata	929	200	222	393	[73]

The Rumen Environment and Feed Utilisation

The rumen environment describes the conditions that affect the breakdown of food in the rumen. These include pH, ammonia level, and a mixture of rumen microflora, which in turn is affected by the former two. Establishing an efficient rumen microbial ecosystem that maximizes fibre digestion and microbial protein synthesis may increase forage utilization by ruminants. For this to occur, sources of readily available and fermentable nitrogen and energy are necessary [25, 44]. The rumen ammonia-nitrogen (NH_3-N) is important for efficient synthesis of microbial protein. At low ammonia levels (<5 mg/100 ml) in the rumen fluid, the rumen microflora requires more energy in terms of ATP to fix ammonia into amino acids. Supplementing with fermentable protein sources increases the ammonia levels in the rumen [23, 62]. The ammonia released by microbial breakdown of protein in the rumen is absorbed through the rumen epithelium and transported in the blood to the liver where it is converted to urea or used by the microbes to synthesize microbial protein and any excess is recycled through saliva and rumen epithelium [49, 59] an indication of the adequacy for microbial protein synthesis. The concentration of ammonia in the rumen fluid is influenced by availability of fermentable organic matter or energy and nitrogen, which leads to synchronization of these nutrients to create a higher efficiency of microbial protein synthesis [96]. Supplementing slow energy release grass forage, however, may lead to asynchronous supply of energy and nitrogen in the rumen [89] hence low efficiency of microbial protein synthesis.

The minimum rumen NH_3-N levels required for proper rumen function ranges from 5 to 8 mg/100 ml [92] although levels of 23.5 mg/100 ml may be necessary to maximize feed degradation [58, 59, 61]. The rumen NH_3-N range that allow for proper rumen microbial function is wide but the optimum levels for proper microbial function vary from 15-20 mg/100 ml [60]. The rumen pH normally is in the range between 6 and 7. A pH of 6.2 is the lower limit that allows cellulolysis to proceed properly [66]. Therefore, a combination of the right levels of rumen NH_3-N (5-20 mg/100 ml) and pH (6.2-7.0) would optimize feed utilization by animals. The rumen ammonia may be varied depending on the type of feed or supplement given to the animals, but this largely may not influence the methane emission form the animals [15] or from the manure of such animals. Other greenhouse gasses (NH_3, N_2O, and CH_4) emission from excreta were not affected as well.

Relative Palatability of Multipurpose Tree Forage

Multipurpose tree and shrub (MPTS) forage has a high potential value as livestock feed and protein supplement [48]. The genera *Acacia, Albizia, Leucaena, Gliricidia* and *Prosopis* are among the documented tree species that have forage value. The Acacias predominate in the tropics [102, 114] and should be exploited as a quality feed resource.

To assess the palatability ranking of these browses, direct feeding, observation of preference and measurement of intake in confinement is used [40] rather than the cafeteria method, which gives an observation on the selection only. [39, 40, 45] suggested that good palatability data could be obtained when sheep were adjusted for five days and the feeds provided randomly to control the associative effects developed by animals. It has been reported that the form in which the forage is offered, either wilted or dry did not affect the palatability ranking.

Effect of Tannins on Browse Utilization

Tree forages contain varying levels of phenolic compounds that may contribute to differences in feed utilization by animals. There is usually a reduced intake of feed [20] which then affects weight gains due to tannins though low levels of less than 3-6% [60] may be beneficial [9] and detrimental effects [101, 19] set in when this is exceeded. The reactions as well as effects on digestion of those tannins differ with plant species. It is expected that the higher the tannin content in the forage the lower the digestibility and/ or degradability of the material. However, [9] found that although Gliricidia contained more tannin than sesbania, the former showed higher rumen degradation.

[95, 111] demonstrated an increase in dry matter digestibility when gliricidia and leucaena were used as supplements for sheep. When Guinea grass was supplemented with gliricidia in goats, the digestibility of the grass was not affected by supplementation [9] though that of nitrogen increased. [74] found that gliricidia supplement to Rhodes grass hay for dairy goats increased the total dry matter intake, as found by [9] where gliricidia was offered as a supplement to guinea grass diets. [3] showed that supplementation of Rhodes grass hay with *Gliricidia sepium* or *Leucaena leucocephala* increased total dry matter intake, and stover intake at lower level of supplementation and this was in contrast to [107]. This is comparable with other studies [32, 82].

The tannins complex with protein, prevent excessive degradation of protein in the rumen and, therefore, increase the supply of undegradable dietary protein to the lower gut (McNeill *et al,* 1998). This is especially so when the levels of the condensed tannins are moderate, at levels of less than 3-6% [60, 64] and may actually reduce digestibility and increase nitrogen excretion in the feces [60]. The tannins can be ameliorated by adding polyethylene glycol (PEG) to neutralize their effects [43, 60, 12]; [112]. Although the protein complexing effect of condensed tannins reduces protein digestibility, it has the advantage of increasing bypass protein by protecting the protein from degradation in the rumen, which becomes available postruminally to the host animal [10, 56]. Some browsing animals that feed on browse high in tannins also tend to have high levels of proline in their saliva essentially to neutralize some of the condensed tannins.

Effects of tannins on rumen methane production

The levels of tannins in most tropical multipurpose trees and shrub (MPTS) browses range from 2.9% to 19.7% [26, 98]. These MPTS include species like *Leucaena leucocephala, Gliricidia sepium, Samanea saman, Mimosa caesalpiniaefolia, Styzolobium aterrimum, Acacia nilotica* and *Acacia mearnsii* [14] that have been shown to reduce rumen methane production. [110, 38] and [17] report on reduction of ruminal enteric methane from ruminants due to inclusion of tannin-rich browses due to the anti-methanogenic activities of tannins. Tropical browses are rich in the tannins that may affect the rumen fauna variably and as a result reduce the population and activity and thus reduce methane production by 3 to 61% [14]. Therefore, an inclusion of some of these MPTS in ruminant feeds will greatly contribute to reducing anthropogenic methane pollution and general global warming associated with ruminant feeding.

Rumen Degradation and *In-Vitro* Gas Production

The *in-situ* forage degradation technique is extensively used to evaluate forage quality, but there are inherent material loses due to leakage of fine particles through the pores in the bags. Therefore, pore size and particle size become important factors to consider in this technique. However, mathematical models have been developed to combine degradation and outflow rates that better predict protein degradation [76]. This works better for fibrous forages than for concentrate feeds.

Nitrogen deficient feedstuffs like cereal straws and stover form the bulk of basal diet for ruminants in the tropics in the dry season. Intake and digestibility of these feedstuffs is low and animals fed on such materials have reduced production performance. The gas production technique [63] simulates the rumen environment and is easily used to predict food digestibility. The rumen microflora requires nutrients for growth and proper function. Nitrogen is one critical nutrient, and 80mg N/L of rumen fluid is required for maximum gas production and carbohydrate degradation. The nitrogen availability affects only the rate and not the extent of degradation. The amount of gas and volatile fatty acids (VFA) produced is not affected by the source of rumen inoculum or the diet consumed by the donor animal if the rumen fluid is taken before feeding [36]. [31] has reviewed the potential of using the gas technique for feed evaluation and outlines the requirements and need to complement it with residue determination.

Effects of Tree Legume Browse on Animal Performance

Supplementing grass diets containing <7% crude protein with legume forages improves both feed intake and animal performance [65]. Consequently, there is need to exploit the abundant tree/shrub forage resources. The MPTS forage is a cheap source of nitrogen [3] and may lead to significantly higher body weight gains as well as more feed intake when supplemented [93] and may form more than 90% of the animals' diet [94]. Acacia pods and leaf litter may sustain sheep, goats and cattle in the dry season, which shows the importance of tree browse as feed for livestock to maximize live weight gains or prevent weight loss, especially when supplementation is provided at 1.0-1.5% of liveweight or 40-60% of DMI [70] and using poor quality grass diets [67], Stewart *et al,* 1996, [3, 41]. [3] concluded that levels of 20 - 30 % of tree legume supplementation could support milk production. The total DMI would increase if energy is also supplemented with the MPTs [74, 75]. Some of the highly taniferous species like *A. saligna* and *A. salicinia* may negatively affect the animal performance [101, 19].

Table 2 shows the feed intake, weight gain, rumen ammonia nitrogen and nutrient digestibility of Chloris gayana grass supplemented with Maerua angolensis and Zyziphus mucronata mixed browes.

Table 2: Dry matter feed intake, average daily gains, rumen ammonia nitrogen and apparent nutrient digestibility of Small East African goats fed *Chloris gayana* hay and supplemented with1:1 mixture of *Maerua angolensis* and *Zizyphus mucronata.* The treatments studied inclused the control diet that did not have the tree tree forage ad the treatments that had a mixture of M. angolensis and Z, mucrionata at different rates of 15, 20, 25 and 30%

Treatments	MZ0	MZ15	MZ20	MZ25	MZ30	
Supplement level, g kg^{-1} W$^{0.75}$	**0**	**15**	**20**	**25**	**30**	**SEM**
Dry matter feed intake, gd^{-1}						
Hay	406^{a}	422^{a}	468^{b}	421^{a}	426^{a}	6.3
1:1 M. angolensis: Z. mucronata	0.00^{a}	111^{b}	149^{c}	184^{d}	227^{e}	17.8
Total	406^{a}	533^{b}	617^{cd}	605^{c}	653^{d}	20.9
Total DM intake, % BW	3.1^{a}	3.9^{b}	4.3^{c}	4.3^{c}	4.7^{c}	0.1
Daily gain, gd^{-1}	-4.9^{a}	12.9^{b}	28.1^{c}	14.3^{b}	17.4^{b}	2.7
Rumen NH_3-N, mg/100ml	9.0^{a}	11.6^{b}	12.7^{c}	11.4^{b}	11.3^{b}	0.3
Rumen pH	6.9^{a}	7.0^{a}	6.9^{a}	6.9^{a}	7.0^{a}	0.02
Apparent digestibility, g/kg^{-1} DM:						
Dry matter	677^{a}	892^{b}	910^{b}	923^{b}	930^{b}	2.3
Crude protein	627^{a}	716^{b}	758^{bc}	793^{c}	767^{bc}	1.6
Organic matter	687^{a}	904^{b}	921^{b}	932^{b}	939^{b}	2.3
Acid detergent fiber	600^{a}	805^{b}	830^{b}	851^{b}	860^{b}	2.3
Neutral detergent fiber	506^{a}	847^{b}	875^{b}	892^{b}	902^{b}	3.6

[a, b, c] Means on the same row with different superscripts are different at P<0.05
SEM- Standard error of the mean
Source: [73].

The Animal Breed Factor and Feed Utilisation

The utilization of tree forages is low despite the high nutrient levels. Due to the high fibre content, their use may require addition of an energy source if they are to contribute fully to the nutritional needs of animals. Energy sources such as cassava peels, molasses or maize bran have been used. Animal breed differences have also been reported [35].

Forage utilization by different breeds of ruminant species may vary due to the animal genetic effects on the anatomy and physiology of the animals. This is due to selective breeding that has occurred over time, resulting in sheep flocks suited for local food and environmental conditions. Apart from the chemical and physical factors that influence food digestibility and utilization, animal constraints also play a significant role. The mean retention time of forage in the fore stomach of an animal is related to the reticulo-rumen capacity, level of intake and digestibility of the diet. Rumen size is an anatomical function and, thus a product of the animal's genetics. Rumen fractional clearance rates are generally higher in smaller animals and fast outflow rates have a particular influence on the rumen environment, degradability of fibre and microbial protein yield [68, 90]. This hypothesis has led to investigations into differences in the digestive physiology of *Bos indicus* and *Bos taurus* cattle, where the former are able to utilize poor quality forage more efficiently. Differences in fermentation rates in the two breeds are reported and that the more tropical, small-sized *B. indicus* zebu cows degraded fibre better than the more temperate, large-sized cattle [85, 84].

There is likelihood that over time the Small East African Goat breed, adapted to feeding in the marginal areas, has evolved a digestive system that enables it to survive on the poor feed resources. Grasses in these areas are hardy, with a high fibre and low nitrogen levels. Animals kept on such diets are expected to have digestive capacities that are capable of utilizing the grass and shrubs found in these dry lands. This study reports the performance of the local Small East African Goat offered Rhodes grass hay, a low-quality basal diet, supplemented with tree legume leaf forage [68, 102].

Factors Determining Feed Intake of Tree Browse

Voluntary feed intake is the weight of feed eaten by an animal or group of animals during a given period of time during which they have free access to food [28].

Consumption of food initiates several events important for eventual development of satiety. Absorbed nutrients, gut hormones and sensory nerves are believed to mediate feedback mechanisms. Since animal productivity is largely dependent on the intake of food, the stockman strives to increase the voluntary intake of farm animals. The importance of the quantity of food an animal takes in is emphasized by the fact that the more food an animal consumes each day, the higher is the level of ingested nutrient and, therefore, the greater will be the opportunity for increasing its daily production.

Ruminant intake is controlled by a combination of physical, chemical and psychological factors. Of the four mechanisms of feed regulation, that is glucostatic, chemostatic, thermostatic and lipostatic, the glucostatic mechanism looks the least likely to influence feed intake in ruminants [45]. This is because the absorption of glucose in the gastrointestinal tract of ruminants is either absent or very low as most of the sugars are fermented to volatile fatty acids. In the tropics, performance of ruminant livestock is largely limited by voluntary intake and digestibility of the basal feed, which mainly consists of low-quality roughages and crop residues [45, 82]. There are five main factors that determine feed intake of tree browses, including animal factors [34, 109], environmental factors [109], physical factors [83], chemical factors [8, 32, 52, 73, 74, 82, 91] and antinutritional factors in tree legume browse [2, 3, 6, 11, 12, 18, 19, 22, 47, 54, 57, 72, 86, 88, 101, 106, 113].

Antinutritional Factors in Tree Legume Browse

Treating forages with chemicals such as polyethylglycol (PEG) or polyvinyl pyrridone (PVP) reduces the tannin content of the feed and the corresponding anti-nutritive effect. In a study designed to investigate the effect of administering PEG on tannin-rich diets significant increases in DMI were noted when PEG was added to diets of *A. saligna* and those of quebracho powder (tannic acid) [20]. Spraying high-tannin containing *Lotus pedunculatus* with PEG reduced the total reactive tannin content from 63 to 7 g/kg DM. This resulted in an increase in the voluntary intake of digestible organic matter (DOM), digestible fibre (P<0.05), and digestive total N (P<0.01) [12]; [112] with the lower intakes associated with negative effects on rumen fermentation rather than palatability.

The inclusion of tree legume browse in grass and crop residue ruminant diets is expected to improve performance, be it growth, milk or wool production. However, the presence of ANFs may be an impediment to expected performance unless their effects are minimized or their inhibitive effects are countered by suitable nutrient supplementation. Negative effects on production due to the ANFs could be countered by the additional provision of urea. The synergistic effect of combining rumen supplements with by-pass nutrients leads to dramatic improvement in animal performance, especially for demanding functions such as milk production. The urea will be an additional supply of N directly to the animal. The presence of the ANFs, especially phenolic compounds in tree legumes may generally enhance their usefulness as supplements.

Geographic spread and abundance

[73] assessed fifteen indigenous Kenyan browse species including *Maerua angolensis, Acacia brevispica* (Wait-a-bit thorn), *Acacia mellifera* (Oiti, Maasai), *Acacia tortilis*, *Acacia hockii* (Enchapalani, Maasai), *Zizyphus mucronata* (Buffalo Thorn, Cape thorn), *Grewia bicolor* (Sitetet, Kipsigis), *Acacia elatior* (Olerai, Maasai), *Acacia nilotica* (Nile thorn) *Balanites aegyptiaca* (Desert date), *Acacia senegal* (Gum Arabic Acacia, Gum Arabic tree), *Acacia abyssinica* (Flat-top Acacia), *Bridelia micrantha* (Shikanganya, Luhya), *Albizia amara* (Bitter albizia), and *Albizia coriaria.*These are widespraed in the Kenyan ASALs and are favourable due to not only their moderate to high nutritive value and were used for animal performance experiments but alsothe species abundance, robustness and ability to withstand dry conditions [81] and versatile uses as well [48]; [114].

The true nutritional values of each species is rated on the crude protein content (112-321gkg^{-1} DM) of the species where [21] reported similar values ranging of 10.5 to 22.5% DM and these are high compared to pasture grasses (48-52gkg^{-1} DM). They contain relatively high macro and micro mineral content, especially calcium and iron [2, 29, 30, 48]. The species are considerably rich in most of the minerals: Ca, P, Mg, Fe, Mn, Cu, Mo Zn and Se and, therefore, can be good sources of these mineral [2, 42, 93]. The NDF content of 218 to 601gkg^{-1} DM and ADF of 160 to 462gkg^{-1} DM is good as the higher the ADF and lower NDF fractions in feeds, the higher the digestible organic matter and expected metabolisable energy value. However, there could be a negative correlation between palatability and NDF, ADF and lignin, and a positive correlation to NDF-N [27, 39, 70, 71]. The palatability could be influenced by the polyphenol or tannin contents [73] that may affect the organic matter digestibility [47, 54, 86].

The tannins levels have beneficial effects, mediated by protein-tannin complexation at rumen pH and the dissociation of the complex post-ruminally, enhancing availability of feed protein for production purposes [10] although this depends on the nature of tannins and its affinity towards macromolecules [53]. Tannins at low levels could help synchronize the release of various nutrients, which in turn might be responsible for increase in microbial efficiency by increasing supply of non-ammonia nitrogen in the lower intestine for production purposes, resulting in higher milk, meat and wool production [53].

The different palatability indices used in the palatability studies did not show significant differences in the final results. The procedure by [48] could be recommended because the palatability index is based on the DM intakes of both the test forage and the basal diet. This method is preferable because the quantity and quality of the basal diet can influence the intake of a supplement [76]. The number of days used did not also show any significant change, though [13] recommend a recording of the intakes after an adaptation period of at least one day, and observations for 5 to 12 days.

Supplementation has been defined as the addition on a daily basis of a proportion of a forage to a basal diet, with the supplementary forage obtained either by grazing, as cut forage or a by-product from another industry [24]. The leaves of *A. brevispica* leaves have been shown to be as good as Lucerne hay and *A. tortilis* pods when given to sheep offered a basal diet of poor-quality grass hay [37]. Supplementation of barley straw diet for wethers with *A. brevispica* leaves and urea greatly improved the value of the overall diet. This was observed in the resulting improved intakes, digestibilities and weight gains. The increase in the feed intakes may be due to the species' relatively higher N-content than grasses as demonstrated by [80, 105, 82]. However, higher nitrogen excretion may lower animal performance despite having the high N intake [69]. This can be improved by supplying additional energy to enhance nutrient [74, 75, 96].

Conclusions

The following conclusions can be drawn from this review:

1. The ranking of tree forages based on nutrient composition, particularly CP, minerals, *in-vitro* and *in-vivo* degradation and 48hr OMD reveals the best forages that are potential supplements for poor quality basal feeds.
2. Multipurpose tree fodders are palatable to goats, especially *A. tortilis, M. angolensis, B. aegyptiaca, Z. mucronata, A. coriaria, A. Senegal* and *A. abyssinaica* which have a palatability index range of 1.8-1.2 and *Z. mucronata* and *M. angolensis* are protein-rich (200gkg^{-1} DM and 321 gkg^{-1} DM) with positive diet intake, digestibility and average daily gains.

Implications

Leaf forages from the local MPTS can be used as protein supplements and mineral sources to ameliorate these nutrient deficiencies for ruminant livestock feeding on poor basal diets and the leaf forages can be harvested and stored to be fed with basal diets especially in the dry season of feed scarcity.

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