Meat Goats and Their Utilization of Browse Forage

[1]M.Tibezinda and L.O. Eik[2]

[1]Mbarara Zonal Agricultural Research and Development Institute.
P. O. Box 389, Mbarara, Uganda.

[2]Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, P.O. Box 5003, N-1432 Aas, Norway, Phone: + 4764948000, Fax: + 4764947960

Abstract

This review presents and discusses data related to meat goats and their performance when utilizing browse forages. Goats are capable of shifting feeding behaviour between grass and browse according to the availability of forage. Browse species are an important part of the diet for rangeland goats. They contain varying levels of crude protein; results from different studies indicate crude protein levels ranging from 6% in acacia leaves in Asia to 30% in Afzelia Africana in Nigeria and they show varying levels of intake and average daily gains for growing meat goats. Some browse species also contain tannin compounds, which may make protein and energy less available. Although Polyethylene glycol (PEG) has been shown to increase intake and digestibility of tannin rich browse, the increase may not justify its use because of the expense involved. Presence of tannin at certain levels may be useful in diets of kids for increasing microbial protein supply. Browses remain a useful protein source for rangeland meat goats and should therefore be utilized wisely to optimise performance.

Key words: Meat goats, browse, digestion, feed preferences, feeding behavior.

Introduction

The goat (*Capra Hircus*) is thought to have been the first animal to be domesticated for economic purposes. Evolutionary biology indicates that the goat was domesticated about 10,000 years ago and general consensus by scholars, backed by molecular genetic information, archaeology and anthropology show that the goat was first domesticated in the area referred to as the 'Fertile Crescent' on the eastern Mediterranean (Devendra, 2007). Meat goats constitute 95% of the world's goats (Thompson, 2006). They are quite capable of high productivity, comparative studies on grazing goats in Jamaica Malaysia demonstrated that economic returns form goat meat were higher than those from beef (Devendra and McLeroy, 1982). In the tropics, goats are mainly raised for meat. The principle mode of rearing being free grazing where growth rates are slow and the final weight achieved is often lower than would have been under improved feeding. While on the range, goats show particular preference for browsing against grazing. Some studies have shown that as much as 80% of the daily intake of grazing goats is from

*Corresponding author

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browse (Devendra and McLeroy, 1982). Hence in order to improve productivity of meat goats, it is useful to understand their performance on browse forage. This article reviews data related to meat goats in general and provides in depth discussion on their adaptation to feeding on browse forage and its effect on their growth performance.

Feeding behaviour of goats

Goats have often been referred to as browsers but in fact they are classified as intermediate feeders, (Hofmann, 1989) and have considerable versatility in feeding behaviour (Van Soest, 1996). They are active foragers, able to cover a wide area in search of scarce plant materials. Their small mouths and split upper lips enable them to pick small leaves, flowers, fruits and other plant parts, thus choosing only the most nutritious feed available. Unlike heavier, less agile ruminants, goats have the ability to utilize browse species that often have thorns and small leaves tucked among woody stems (Luginbuhl *et al.*, 1998). They also have an upright eating habit, enabling them to stand on their hind legs, or even climb trees in search of feed. Goats select grasses when the protein content and digestibility are high, but switch to browse when the overall nutritive value may be higher than for grasses (Hofmann, 1989; Van Soest, 1996; Luginbuhl *et al.*, 1998. The ability to choose feed from sources basing on nutritive value gives comparative advantage to goats in that they are able to select highly digestible parts and reject those materials which are low in quality (Luginbuhl *et al.*, 1998). When possible, goats in the tropics eat diets composed of tree leaves and shrubs (browse), which ensure a reliable and steady supply of food all year round, albeit of low to medium quality (Silanikove, 2000). Goats may take 80% of the total intake as browse but where such feed is not available; goats are quite capable of utilizing grasses and crop residues such as cereal straws and stover (Devendra and McLeroy, 1982). It is also common for goats to take about 60% browse and 40% grass in mixed plant populations (Pinkerton and Pinkerton, 1999a). A study on the morphometrics of mandible and teeth of mixed-breed goats on rangeland in a rural community of north east Mexico suggested that different dimensions in the oral apparatus of grazing goats led to divergent selection of range plants, without altering the quality of their diet. The morphological diversification of the oral jaw apparatus enabled crossbred goats to modulate diet selection in highly heterogeneous landscape (Mellado *et al.*, 2007). A similar study, conducted in the southwestern Argan forest of Morocco, confirmed that adaptation of feeding behaviour is an efficient tool for goats to adjust the quantity and quality of their ingesta to meet their requirements (El Aich *et al.*, 2007). In a *Pinus Nigra* Arnold subsp. *Nigra* (European black pine) reforested slope of the Pyrenees, a diurnal pattern of plant utilisation was observed and was characterised by a longer time devoted to browsing species early in the morning (Torrano and Valderrábano, 2005).

A study done in the Sahelian zone of Burkina Faso on the behaviour of cattle, sheep and goats on natural pasture and their preference for browse species revealed that goats browsed more than 20 species daily but the most preferred species were *Acacia Senegal, Balanites Aegyptiaca* and *Pterocarpus Lucens*. The mean height reached by goats when browsing was higher (1.65 m) than that of cattle (1.47 m) and sheep (0.87 m) (Sanon *et al.*, 2007). A comparative study between cattle and goats in oak forest stands of Northern Greece showed that cattle utilized the herbaceous vegetation only, whereas goats used a mixture of vegetation categories (Papachristou *et al.*, 2005). Given choice goats will often obtain more than 50% of their daily ration from browse. However, goats will perform well in grazing situations given that grazing management practices match their grazing behaviour (Luginbuhl *et al.*, 1996).

Digestion in goats

The goat is not able to digest the cell walls of plants as well as the cow because feed stays in their rumen for a shorter time period (Hofmann, 1989; Luginbuhl *et al.*, 1998). Similarly a study by Huston *et al.* (1986) found that in grazing animals, goats digested a smaller percentage of consumed material than either cows or sheep during three of four seasons even though diets were of similar in vitro digestibility. This difference was related to a faster turnover and shorter retention time in goats. On the other hand according to Silanikove (2000) the goat has superior digestion capacity which can be attributed to some physiological features that are common in ruminant intermediate feeders like large salivary gland, the large absorptive area of their rumen epithelium and the capacity to rapidly change the volume of the foregut in response to environmental changes. Goats like other intermediate feeders have a relatively larger salivary gland compared to grazers, these bigger glands supply more diluting liquid, which reduces retention time (Hofmann, 1989). Higher saliva production is a counter adaptation to overcome plants' chemical defenses by binding them (Hofmann, 1989). Provenza and Malechek (1984) observed that in goats with oesophageal fistulas browsing on blackbrush, 50% of the tannins had dissappeared already before swallowing.

Trees and shrubs, because of their highly lignified stems and bitter taste, which represent poor quality roughage sources for cattle, may be adequate in quality for goats. They may avoid eating the stems, don't mind the taste and benefit from the relatively high levels of protein and cell solubles in the leaves of these plants. On the other hand, straw, which is of poor quality due to high cell wall and low protein, can be used by cattle but will not provide even maintenance needs for goats. They must consume a more concentrated diet than cattle because their digestive tract size is smaller relative to their maintenance energy needs (Luginbuhl *et al.*, 1998).

Characteristics of meat goats

Growth rate and adaptability to production conditions are some of the most important traits in goats raised primarily for meat. The improved Boer goat an essentially meat breed, has a weaning weight averaging 29kg at 120 days and is able to survive without supplementary feeding during drought periods (Malan, 2000). It possesses distinctive qualities that enable it to excel as an efficient producer of red meat. It is early maturing, reaching a mean maximum weight of approximately 62 kg at 3.5 years of age on natural pasture under extensive grazing conditions (Erasmus, 2000). Boer goats are also useful in controlling brush encroachment in woodland and shrub land due to their active feeding habits in these environments (Aharon *et al.*, 2007). Under favourable nutritional conditions, meat goats may gain at a rate of more than 200 g per day from birth to 100 days of age (PSU, 2000). However, in the tropics it is hard to achieve the modest growth of 50g/day without feeding an energy and protein supplement (Peacock, 1996).

Nutrient requirements for meat goats

Grazing meat goats are not usually supplemented because the value added in term of meat may not justify the expenditure involved (Pinkerton and Pinkerton, 1999b). Practical recommendations for feeding growing kids are a feed containing 9-10% crude protein and 54-58% Total Digestible Nutrients (Pinkerton and Pinkerton, 2000). The best 'balanced' feed for kid growth is young grass, tree legume leaves or an oil seed cake (Peacock, 1996). Metabolizable energy requirements for growing meat goats were determined to be 23 KJ/g (0.023MJ/g) of average daily gain (ADG) (Luo *et al.*, 2004a) and that of metabolizable protein requirements were 0.4g/g of ADG (Luo *et al.*, 2004b). On the other hand because adequate dietary fibre is essential, dietary metabolizable energy density above 2.78 Mcal/kg (11.639MJ/Kg or 0.011639 MJ/g) is likely to depress intake and reduce growth rate in goats and kids (Lu *et al.*, 2005).

A study by Alonso-Diaz *et al.* (2008) showed that goats appeared able to discriminate foliage by its quality (the potentially digestible fraction) because dry matter intake and preference seemed to be regulated by several forage components that included cellulose, hemi cellulose, and polyphenolic compounds. Since goats are particularly adept at selecting the most nutritious plants (and within plants, the most nutritious portions), they may do reasonably well on grazing areas considered poor if, the amount of herbage is adequate. Like other animals, however, goats respond quite favourably to increased quality or quantity of feedstuffs. This is contrary to public perceptions that goats cannot economically turn low quality vegetative matter into meat and milk (Pinkerton and Pinkerton, 1999a).

Nutrient composition of forage browses

Browse refers to leaves and twigs from shrubs and trees available to ruminants as feed and in a broader sense flowers and fruits are also included. Browses often tend to show high protein levels (Tables 1, 3 and 4). However in reality, much of the actual protein digestibility is reduced by the presence of anti nutritional factors such as polyphenolic compounds like tannins (Peacock, 1996). This is the reason why goats often perform worse than might be predicted from a simple chemical analysis of their feed. In the humid tropics, the leaves from shrubs and trees may have a very high moisture content, which could depress intake (Peacock, 1996). Leguminous forbs and browses commonly contain more than 25% crude protein whereas perennial grasses seldom exceed 15%. The energy content of flowers, fruits, seeds and nuts of forbs and browses can exceed 3.5 mega-calories of digestible energy per kg of dry matter (Huston, 1984).

Ikhimioya *et al.* (2007) working in a Nigerian savannah zone, showed that shrub and tree foliages had higher crude protein and low cell wall contents with generally tolerable anti-nutritional factor levels compared tothe commonly available grasses (Tables 1 and 2). Similar findings were reported in Asia (Table 3).

Table 1. Proximate composition (g/100g DM, except for DM which is on fresh basis) of the studied shrub and tree foliages (Ikhimioya *et al.*, 2007).

Nutrient	Foliages							
	Afzelia africana	*Bambusa vulgaris*	*Chromolaena odorata*	*Mangifera indica*	*Newbouldia laevis*	Mean	SE	CV
Dry matter	30.50	50.82	26.80	43.33	42.24	38.74	4.41	25.48
Crude protein	29.85	22.38	24.31	15.13	15.57	21.45	2.78	28.94
Ash	6.66	10.61	3.89	7.26	2.49	6.18	1.41	51.09
Ether extract	7.95	7.20	8.32	10.38	13.59	9.49	1.15	27.17
Gross energy, Kcal/g	3.25	2.76	3.19	2.50	4.09	3.16	0.27	19.18

SE – standard error; CV – coefficient of variation

Table 2. Anti-nutritional factors concentration in the studied shrub and tree foliage (Ikhimioya *et al*., 2007)

Anti-nutrients	Foliages							
	Afzelia africana	*Bambusa vulgaris*	*Chromolaena odorata*	*Mangifera indica*	*Newbouldia laevis*	Mean	SE	cv
Haemagglutinnin, mg/g	17.13	15.28	9.72	12.04	20.84	15.00	1.94	28.94
Oxalate, %	1.06	1.61	1.89	0.77	1.27	1.32	0.20	33.49
Phytic acid, %	0.46	1.79	1.34	4.88	1.59	2.01	0.75	83.69
Saponin, %	4.40	1.92	0.50	3.12	2.34	2.46	0.65	58.72
Tannin, %	0.17	1.21	0.55	3.51	0.77	1.24	0.59	106.65
Trypsin Inhibitor, mg/g	12.50	9.87	22.37	19.74	17.09	16.31	2.29	31.43

SE – standard error; CV – coefficient of variation

Table 3: Proximate composition and digestibility of browse and tree leaves used by goats in Asia (Devendra, 2007)

	Ash	Crude protein	Crude fibre	Digestibility
Acacia	L	M	H	M
Banana	L	L	M	L
Erythrnia	L	H	H	H
Ficus	L	H	H	M
Hibiscus	L	L	M	L
Gliricidia	L	H	H	M
Jack fruit	M	H	H	M
Leucaena	L	H	H	M
Neem	L	M	M	L
Pigeon pea	M	H	H	M
Prosopsis	L	M	H	M
Sesbania	M	H	H	M

L- Low, M- Moderate, H- High
Ash (g/KgDM): L=<60, M=60-120, H=>120
Crude protein (g/KgDM): L=<60, M=60-110, H=>110
Crude fibre (g/KgDM): L=<60, M=60-120, H=>120
Digestibility (%DM): L=<40, M=40-60, H=>60

The legumes *Acacia Peninsularis; Cercidium Floridium, Mimosa Xantii, Pithecellobium Confine* and *Prosopis* and non-legumes *Bursera Microphylla* , *Cyrtocarpa Edulis, Lippia Palmeri, Opuntia Cholla,* and *Turnera Diffusa* were evaluated by Ramirez-Orduña *et al.*(2005) for their mineral content. From their study it was suggested that in order to sustain goat productivity, range goats grazing these shrub species must be supplemented with P, Cu and Zn throughout the year. Similarly Sprinkle *et al.* (2002) evaluated browse species in Arizona rangelands and found that they had less phosphorus, crude protein, and energy than forbs, but higher values than in grasses. They also reported that browse probably have higher concentrations of trace minerals than grasses, though not adequate to satisfy animal requirements year round.

A study on the potential utilisation of indigenous trees by cattle and goats in two semi-arid areas of Zimbabwe, Sibanda and Ndlovu (1992) observed that both leaves and pods had a high content of crude protein (7-28%) and low to medium content of neutral detergent fibre (11-64%) (Table 4). All the browse species had crude protein content that meets the minimum requirements for growing meat goats except for *Combretum Hereroense* leaves, *Kirkia Acuminata* leaves and *Piliostigma Thonningii* pods. Seeds of browse forages *Ziziphus Mucronata, Sclerocarya Birrea, Kirkia Acuminate* and *Rhus Lancea* were found to contain low crude protein values but that of *Lonchocarpus Capassa* seeds was found to be high 54.2% (Aganga and Mosase, 2001).

Table 4: Crude Protein and Neutral Detergent fibre contents (of the parts utilized by livestock) of browseable tree species (Sibanda and Ndlovu, 1992)

Species	Parts Used	Crude protein (%)	Neutral Detergent Fibre (%)
Acacia nilotica	Leaves	11.25	13.20
Acacia tortilis	Leaves	19.12	-
Afzelia quanzensis	Leaves	19.74	50.96
	Early leaves	18.46	44.16
Colophospermum	Mature leaves	15.42	47.58
mopane	Dry leaves	14.86	56.90
Combretum apiculatum	Leaves	21.50	18.34
Combretum hereroense	Leaves	8.51	19.27
Combretum imberbe	Leaves	13.0	28.20
Comimiphora africana	Leaves	17.64	-
Dischrostachys cinerea	Pods	28.54	45.93
Grewia bicolar	Leaves	21.12	60.71
Grewia flavescens	Leaves	11.45	32.40
Kirkia acuminata	Leaves	8.11	11.80
Lonchocarpus capassa	Early leaves	22.29	59.08
	Mature leaves	12.72	63.83
Piliostigma thonningii	Pods	7.87	55.37
Terminalia sericea	Leaves	9.15	20.23

Most tree leaves and twigs contain tannins, an anti nutritional factor for which proper precautions need to be taken in selecting the species of trees and their level of feeding to grazing animals (Agang and Tshwenyane, 2003). However the content of tannin-like substances varies among the browses that contain them. Tannin levels respond to disease, stress and attack by fungi (Van Soest, 1994). Goats are adapted to countering the effect of tannins through production of large quantities of saliva (Hofmann, 1989; Provenza and Malechek, 1984).

Feeding browse as basal or supplementary diets

Growth and dry matter intake vary for different breeds of growing goats and browse inclusion levels in the diets (Table 5). In a study to determine the effects of feeding browses on growth and meat quality of Korean black goats, feed intake, growth rates and feed conversion ratios were higher for bucks fed oak browse than those fed rice straw or pine browse (Choi *et al.*, 2006). However, goats fed on browses were generally leaner than those on rice straw and goats fed on pine browse yielded more tender and tasty meat than those fed rice straw or oak browse. In a study using oesophageal cannulated goats to determine seasonal changes in nutritive value of diets selected by range goats in a thorn scrubland of North México, the forage selected was adequate to meet their crude protein and energy requirements for maintenance throughout the year (Cerrillo *et al.*, 2006). Nevertheless, dry matter intake during autumn was insufficient to sustain an adequate nutritional condition during late pregnancy and early lactation and a supplementation program had to be considered. In order to improve productivity of browsing in these regions goats need to be supplemented, throughout the year, with Copper and Manganese (Cerrillo *et al.*, 2006).

Table 5: Intake and growth of goats feeding browse in different studies

Goat type	Browse species	DM Intake (g/day)	Growth ADG (g/day)	Author
Korean black goats (bucks)	Oak	197	45.3	Choi *et al.*, 2006
	Pine	124	28.1	
	Pine silage	74	30.0	
Beetle x Anglo Nubian x French alpine bucks (6 years)	Toona ciliate	740	-	Bakshi and Wadhwa, 2007
	Morus alba	1800	-	
	Luceana leucocephala	1640	-	
	Melia azedarach	1540	-	
Arbegelle growing males	Acacia etbaica (0.5%)	71.4*	5	Yayneshet *et al.*, 2008
	Acacia etbaica (1.0%)	84.6*	10.8	
	Acacia etbaica (1.5%)	72.6*	6.7	
	Dichrostachys cineria (0.5%)	84.6*	10	
	Dichrostachys cineria (1.0%)	83.8*	15.8	
	Dichrostachys cineria (1.5%)	94.3*	21.7	
Sahelian males 10-12 months	Acacia Senegal pods	648	56	Sanon *et al.*, 2008
	Pterocarpus lucens leaves	546	55	
	Pterocarpus lucens pods	472	24	
Kutchi weaner kids	Prosopsis cineraria with PEG	871	63.2	Raghavendra *et al.*, 2002
	Prosopsis cineraria without	691	52.4	
Tswana	Terminalia serecia	338	64	Aganga and Monyatsiwa, 1999
	Combretum apiculatum	330	77	
	Euclea schimperi	319	67	
Cross breeds	Cassia fistula	262	-	Salem *et al.*, 2006
	Cassia fistula with PEG	272	-	
	Schinus molle	259	-	
	Schinus molle with PEG	331	-	
	Chorisia speciosa	400	-	
	Chorisia speciosa with PEG	468	-	
	Eucalyptus camaldulensis	233	-	
	Eucalyptus camaldulensis PEG	244	-	
Small East African growing males	Acacia nilotica leaf meal	115.3	114	Rubanza *et al.*, 2007
	Acacia Polycantha leaf meal	125.9	42.9	
	Leuceana lucocephala leaf meal	124.1	157.1	
Omani males	Prosopsis juliflora pods 100g/kg	463	43	Maghoub *et al.*, 2005
	Prosopsis juliflora pods 200g/kg	500	76	
	Prosopsis juliflora pods 300g/kg	291	-21	

*Dry matter intake in g/Kg-75BW, respective diets were included as a percentage of body weight

Based on the chemical composition, digestibility of nutrients and efficiency of utilization of the nutrients, the tree leaves like *Morus Alba*, *Melai Azedarach* and *Leucaena Leucocepahala* were reported to be excellent unconventional feedstuff for small ruminants (Bakashi and Wadhwa, 2007). When lactating goats and sheep each suckling a young one were allotted three grazing treatments, it was shown that in the early dry season, Saltbush *(Atriplex Nummularia)*-grassland pastures can provide enough nutrients to does and kids for combined net weight gain, but not to ewes and lambs (König *et al.*, 1992). Supplementation of growing Abergelle goats grazing/browsing in the lowlands of Ethiopia with *Acacia Etbaica* or *Dichrostachys Cineria* fruits at 0.5%, 1.0% and 1.5% of body weight levels showed that dry matter intake of the goats without additional supplement was lower than any of the groups that received supplement (Yayneshet *et al.*, 2008). Growing Sahelian male goats fed *Acacia Senegal* pods, *Pterocarpus Lucens* leaves or *Pterocarpus Lucens* pods supplemented with millet bran and hay were found to have a higher dry matter intake on diets with *Acacia Senegal* pods and *Pterocarpus Lucens* leaves than the control diet, and there was a higher average daily gain for goats feeding on *Acacia Senegal* pods compared to the other three diets whose average daily gains were similar (Sanon *et al.*, 2008). Supplementation of male small East African growing goats feeding on a native pasture hay diet with *Acacia Nilotica*, *Acacia Polycantha* and *Leuceana Lucocephala* leaf meals resulted in higher total dry matter intake (Rubanza *et al.*, 2007). Similarly supplementation of *Calliandra Calothyrsus* and *Leuceana Leucocephala* on West African dwarf goats resulted in higher weight gains (Tekonkeng Pamo *et al.*, 2006). *Sericea Lespedoza* hay containing tannins did not reduce palatability of Boer x Spanish, Nubian and Spanish buck kids as total dry matter intake was comparable to or exceeded that of animals on alfalfa hay; however the average daily gain was higher for animals fed alfalfa hay (Turner *et al.*, 2005).

Effect of browse on rumen environment

Microbial protein synthesis provided with adequate salivary urea is a detoxification mechanism that provides extra protein to animals feeding on tannin containing diets (Van Soest, 1995). An investigation by Vaithiyanathan *et al.* (2007) to assess the effect of feeding graded levels of tannin containing *Prosopsis Cineraria* leaves in a complete feed mixture showed that *Proposis* tannin could be included at 23 and 45g/ kg dry matter in the ration of lambs and kids, respectively to have higher microbial protein supply. In a similar study, it was found that while the low levels of condensed tannins provided in *Desmodium* (1.0%) and *Calliandra* (2.3%) diets protected dietary protein from degradation in the rumen, there were no overall beneficial or detrimental effects of the tannins in the diets of sheep and goats (Perez-

Maldonado and Norton, 1996). When fresh tree leaves supplemented with a mineral mixture and common salt were offered to bucks (Beetle x Anglo Nubian x French alpine), all animals were found to be in positive nitrogen balance (Bakashi and Wadhwa, 2007). Pawelek *et al.* (2008) found that prairie acacia had the highest concentrations of condensed tannins of three Texas legumes studied and it showed the greatest potential for contributing rumen escape protein.

Goats are able to consume browses without them impacting significantly on the rumen environment. Gasmi-Boubaker *et al.* (2006) in a study to determine the effect of feed block supplementation on the rumenal ecosystem, on male goats grazing on Tunisian shrub land, reported that rumen pH and ammonia were optimum and that cellulotytic activity in the rumen of the non-supplemented goats was similar to that of the supplemented group. In another study, the blood metabolic profile of 2-3 year old non-lactating and non pregnant Mamaber goats consuming *Quercus Calliplirinos* (oak), *Pistacia Lentiscus* (Pisticia) and *Ceratonia Siliqua* (carob) leaves were examined. Levels were in normal range and not different from those of goats fed straw, it was suggested that goats may consume tannins up to 1.1-2.7 g per Kg body weight without suffering any ill effects (Silanikove *et al.*, 1996). But increasing levels of condensed tannins were shown to increase the amount of faecal nitrogen in castrate Boer-crosses on basal diet of hay when fed increasing levels of Black locust (*Robinia Pseudoacacia* L.) (Unruh Snyder *et al.*, 2007).

Polyethylene glycol (PEG) supplementation in browse diets for goats

PEG is a polymer that binds tannins irreversibly and may be used as an additive to increase the intake and digestibility of tannin-rich browse. In a study with four browse tree species (*Cassia fistula*; *Schinus Molle*; *Chorisia Speciosa*; and *Eucalyptus Camaldulensis*), PEG increased intake of dry matter in both sheep and goats. Goats consumed 3.9% more DM than sheep per kg $BW^{0.75}$, and their digestibility was about 8% higher (Salem *et al.*, 2006). However a subsequent study to assess the nutritional value of the same browse species showed that addition of PEG did not affect the overall nutritive ranking of these browse leaves (Salem *et al.*, 2007). A similar study in India revealed that feeding 5 g per day PEG-6000 alleviates negative effects of *Prosopis* tannin on protein digestion in kids and also improved voluntary intake of *Prosopis* foliage and their growth performance (Raghavendra *et al.*, 2002). Villalba *et al.* (2002) supplemented a tannin diet fed to lambs and kids with either PEG or macronutrients and found that both lambs and kids consumed more tannin food when given PEG than when supplemented with macronutrients. Animals supplemented with PEG ate much more of the tannin diet than the non-supplemented ones. In the United States, PEG supplementation of Boer x Spanish doelings grazing condensed tannin dominated pastures doubled their average daily gains compared to non-supplemented ones (Merkel *et al.*, 2003). It was concluded that PEG supplementation is a valuable tool in the management of meat goats on pastures containing tannins. Rubanza *et al.* (2005) also demonstrated that digestibility of four browse species (*Dischrostachys Cineria, Flagea Vilosa, Harrisonia Abyssinica* and *Piliostigma Thonningii*) was improved through addition of PEG. However, PEG supplementation of Tunisian goats browsing acacia positively influenced their ovulation rate, but but did not have an effect on the livewieght gain of the does or the growth of the kids (Lassoued *et al.*, 2006). According to Ben Salem *et al.* (2005) the increase in nitrogen value of kermes oak foliage due to PEG supplementation did not justfiy the use of PEG because it is a costly reagent.

Conclusion

Browse species are an important part of the diet for rangeland goats. They contain varying levels of crude protein; results from different studies indicate crude protein levels ranging from 6% in acacia leaves in Asia to 30% in *Afzelia Africana* in Nigeria and they show varying levels of intake and average daily gains for growing meat goats. Some browse species also contain tannin compounds which ultimately make protein and energy less available. Although PEG has been shown to increase intake and digestibility of tannin rich browse, the increase may not justify its use because of the expense involved. Presence of tannin at certain levels may be useful in diets of kids for increasing microbial protein supply. Browses remain a useful protein source for rangeland meat goats and should therefore be utilized wisely to optimise performance from meat goats.

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