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Feeding Values and Anti - Nutritive Factors of Forage Tree Legumes

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Abstract: Animal production in Botswana suffers from inadequate feed quantities and qualities, due mainly to semi-arid low rainfall which can barely support arable farming in most years. This problem is compounded by the competition between the livestock and human feed industries for the little available pulses and cereals. Consequently, tree fodders are available forage resources which grazing herbivores can utilize without competition from monogastric animals and man. Tree fodders can be utilized as supplements to low quality grasses and straws. Most tree leaves and twigs contain tannins, an antinutritional factor for which proper precautions need to be taken in selecting the species of trees and their level of feeding to grazing animals. Many plant components have the potential to precipitate adverse effects on the productivity of farm livestock. Plant anti-nutritive factors may be divided into a heat-labile group, comprising lectins, proteinase inhibitors and cyanogens, which are sensitive to standard processing temperatures and a heat-stable group including, among many others, antigenic proteins, condensed tannins, saponins, the non-protein amino acids and mimosine. These compounds are present in the foliage and/or seeds of virtually every plant that is used in practical feeding. Processing can be used to destroy some anti nutrient factors, also rumen digestion reduces the impart of anti-nutritive factors in some tree fodders for cattle, sheep and goats. This paper reviews feeding values of tree forages and some common anti nutritive factors present in the tree forages.

Key words: Tree fodders, tropical grass, forage trees, tannins

Introduction

Tree leaves and twigs form a natural part of the diet of many ruminant animals and have been used conventionally as sources of forages for livestock in Botswana and the rest of Africa. The parts of tree fodders commonly used as feed is referred to as browse which can be defined as the tender shoots, twigs and leaves of shrubs and woody plants and also fruits and pods. Tree fodders are important in providing nutrients to grazing ruminants in arid and semi-arid environments where inadequate feeds are a major constraint for livestock production. Tree fodders maintain higher protein and mineral contents during growth than do grasses, which decline rapidly in quality with progress to maturity.

Tree fodders are important sources of high quality feed for grazing ruminants and as supplements to improve the productivity of herbivores fed on low quality feeds. Tree fodders form part of the complex interactions between plants, animals and crops, the positive aspects of which help to balance a plant-animal-soil ecosystem and from which there is a sustainable source of feeds (Devendra, 1994).

Tree fodders have nutritional significance for free ranging herbivores in extensive, communal management system. These grazing ruminants and non-ruminants usually nibble on the young foliage of shrubs on the rangelands. The availability of a variety of these feeds and the selection process enables the herbivores especially the goats to extend as well as meet their feed preferences. Aganga (1999) stated that, there are several types of leguminous and non-leguminous trees used as forage by goats but the predominant genus in Botswana is *Acacias*. Traditional farmers in Botswana allow their goats, sheep and cattle to browse on tree forages in the rangelands and they also cut and feed these tree foliages as supplements based on experience and convenience.

Plants have co-evolved with predator population of bacteria, insects, fungi and grazing animals and have developed defense mechanisms which assist their survival. Leguminous trees and shrubs often have thorns, fibrous foliage and growth habits which protect the crown of the tree from defoliation. Many plants also produce chemicals which are not directly involved in the process of plant growth (secondary compounds), but act as deterrents to insects and fungal attack. These compounds also affect animals and the nutritive value of the forages. Mycotoxins (fungal metabolites) produced by saprophytic and endophytic fungi are also a potential source of toxins in forages (Norton, 1994).

The anti-nutritive factors (ANFs) may be defined as those substances generated in natural feed stuffs by the normal metabolism of species and by different mechanisms e.g inactivation of some nutrients, interference with the digestive process or metabolic utilization of feed which exert effects contrary to optimum nutrition. Being an ANF is not an intrinsic characteristic of a compound but depends upon the digestive process of the ingesting animal. Trypsin inhibitors, which are

Table 1: Intake and response of *T. swana* goats to *C. apiculatum, T. Serecia and E. Schimperi* as supplements

	Control (Buffel grass + Lucerne)	Treatment 1 (Buffel grass+ *C. apiculatum*)	Treatment 2 (Buffel grass+ *T.sereccia*)	Treatment 3 Buffel grass+ *E.schimperi*)	Significance
Initial weight (kg)	17.8±3.3	17.8±3.0	17.8±1.5	17.8±3.4	NS
Final weight (kg)	24.8±4	24.7±3.3	23.6±1.7	23.9±2.6	NS
Metabolic mass ($kg^{0.75}$)	9.9±1.2	9.9±1.1	9.7±0.5	9.7±1	NS
Body weight gain $kg^{(0.75)}$	7.0±0.7	6.9±1.4	5.8±0.4	6.1±1.6	NS
Average daily gain (g/day)	78±5	77±15	64±9	67±19	NS
Average daily dry matter Intake (g)	702.2±.7[c]	769.9±12.4[ab]	776.6±10[a]	752.5±15.8[b]	*
Average daily DM grass hay intake (g)	439.4±13.3	439.4±8.9	438.4±8.4	432.9±13.3	NS
Average Daily DM Browse intake (g)	262.8±9	330.5±5.5	338.3±3.5	319.6±5.2	NS
DM intake/body Weight (%)	3.3±0.6	3.7±0.5	3.8±0.2	3.6±0.5	NS
DM/gain (g/g) feed Conversion ration)	9.0±0.8	10.4±1.8	12±1.9	11.2±4.2	NS
DM browse or legume Intake/body wt (%)	1.3±0.2[b]	1.6±0.2[a]	1.6±0.1[a]	1.6±0.2[a]	*
DM intake/kgBW$^{0.75}$ (g)	71.0±10.5	78.6±8.2	80.2±3.8	77.3±7.8	NS
Average daily water Intake (ml)	1270±32[a]	1166±52.2[ab]	1150±103.2[b]	1184±100[ab]	*
Average daily waterIntake/kgBW$^{0.75}$ (ml)	129.9±15.0	118.8±10	119.1±14.8	123.0±21.2	NS

Values are mean ± standard error. *Means in the same row bearing different superscripts are significantly different ($p<0.05$). NS= No significant difference. +Source: Aganga and Monyatsiwa, 1999.

ANFs for monogastric animals, do not exert adverse effects in ruminants because they are degraded in the rumen (Kumar, 2003). The utility of the leaves, pods and edible twigs shrubs and trees as animal feed is limited by the presence of ANFs. The reason of ANFs in plants seems to be as a way of storing nutrient or as a means of defending their structure and reproductive elements (Harborne, 1989). In fact, plants contain thousand of compounds which, depending upon their situations, can have beneficial or deleterious effects on organisms consuming them. These compounds, with the exception of nutrients, are referred to as "allelochemicals" (Jurgens, 1997). ANFs may be regarded as a class of these compounds which are generally not lethal. They diminish animal productivity but may also cause toxicity during periods of scarcity or confinement when the feed rich in these substances is consumed by animals in large quantities. The ANFs which have been implicated in limiting the utilization of shrub and tree forages include non-protein amino acids, glycosides, phytohemagglutinins, polyphenolics, alkaloids, triter penes and oxalic acid.

Tree Fodders as Supplements to Low quality Forage: Leaves and twigs of tree fodders, have been used as supplements to a wide range of forages and agricultural by-products. Norton (1994) stated that they have been incorporated into concentrate rations as substitutes for more expensive processed protein sources.

Table 1 shows data on the growth, feed intake, feed conversion ratio, daily dry matter intake and daily water intake of the Tswana goats fed *Cenchrus ciliaris* as basal diet and *Combretum apiculatum, Terminalia serecia* or *Euclea schimperi* as supplements while lucerne was fed to the control group as supplements. The data reported by Aganga and Monyatsiwa (1999) shows that the treatment effects on average body weight gain were not significant, but the goats on lucerne as a supplement had a slightly higher average daily gain. Of the three tree fodders, the goats on *C. apiculatum* gained most with 77g/day, the lowest being *T. serecia* with 64/day. Although the protein content of each of the tree fodders fed is less than that in lucerne (Aganga and Monyatsiwa, 1999), the CP of the browse plants was more than 8%, below which it would be considered deficient (Norton, 1994). Protein is the limiting nutrient for grazing animal productivity, a deficiency being manifested in poor overall production by the animal, such as low live weight gain, poor reproduction rate and low forage hay intake owing to the inability to provide enough nitrogen for the microbes in the rumen to break down cellulose. Kaitho *et al.* (1998) evaluated 40 browse species in Ethiopia using *in vitro* digestibility and *in sacco* degradability techniques. They concluded that the *in vitro* method was accurate for estimating digestibility of ruminally undergradable nitrogen and hence its use would considerably reduce the need for delicate surgery and the elaborate procedures involving the mobile nylon bag technique. The study showed that some indigenous tree fodders constitute excellent forages which could be used as supplements to low quality grasses in feeding grazing ruminants.

Nutrient Composition of Some Tree Fodders: Aganga (1999) reviewed chemical composition of browses and she found that, considerable information is now available on the chemical composition of tree foliage commonly eaten by grazing ruminants in Botswana.

Aganga *et al.,* 1994 found that the protein content of browses is usually high compared with that of mature grasses. They reported the macro and micro mineral contents of the browse plants analyzed. The nutritive value of browse foliages depends on the voluntary intake of the feed consumed and the extent to which the quantity of dry matter eaten by the animal supplies dietary energy, proteins, minerals and vitamins. Much will depend therefore on the actual quantity of feed eaten by the animal on a daily basis (Devendra, 1994).

The chemical composition of tropical browse legumes has been reported variously, by several individuals. These include Le Houerou, 1980; Devendra, 1992; Aganga and Boudib, 1993; Skerman *et al.*, 1988; thus attention of the reader is drawn to these and other published data. The nutritional significance of some browse seeds was reported by Aganga *et al.*, 1999. The protein levels reported for the browse seeds compare favourably with values for grain legumes reported by Valentine and Bartsch (1987); Schlink and Burt (1993). Aganga *et al.* (1999) found that the seeds evaluated provide nutrients in excess of those required for the digestion and metabolism of the seeds and therefore can act as valuable supplement to correct nutritional deficiencies or imbalances in mature roughage.

Species with anti-nutritive factors: Mulga (*Acacia aneura*) is the most common Acacia species used for stock feeding in Australia. Many acacias have high concentrations of phenolic compounds in their leaves, the major compounds being lignin and tannins. The tannins may be further categorized into hyrolysable tannins (polyesters of gallic acid and hexahdroxyphenic acid derivatives) and condensed tannins (proanthocyanidins). The condensed tannins in mulga inhibit plant protein degradation in the rumen and decrease rumen availability of sulphur, which then depresses the digestibility of plant cell walls. It is also possible that these tannins inhibit microbial enzymes in the rumen and decrease the availability of plant proteins for digestion in the intestines (Norton, 1994a). Tannins may also be associated with poor acceptability of young mulga leaves, although volatile oil content is also highest in young leaf. There is recent evidence that some ruminal micro organisms are able to metabolize tannins, or able to remain active in a high tannin environment and may be used as inoculants to overcome the detrimental effects of tannins in ruminants (Norton, 1994a).

The seeds and pods of *Acacia georgina* contain fluoroacetic acid (FA), an organic acid found in a range of other plants(e.g *Dichapetalum, gastrolobium and Spondanthius)*. This compound inhibits the Kreb's cycle by formation of flourocitrate and is used as insecticides. Fluorine is a cumulative poison and its effects are often observed only after stock have been grazing plants containing these compounds for a significant time. *A. georgina* has low FA poisoning and is only a problem when the plant is the sole source of food during a drought (Norton,1994a).

Albizia chinensis contains significant levels of condensed tannins and proanthocyanidins while *A. lebbeck* contains no extractable tannins (Ahn *et al.*, 1989). Green leaf, fallen leaf and flowers of *A. lebbeck* have all been shown to be highly palatable and of high nutritive value for sheep (Lowry, 1989). A. chinensis is readily accepted (either fresh or dried) by young goats as a supplement to low quality straw and is eagerly browsed by does and their kids (Norton, 1994). A variety of secondary compounds have been isolated from Albizia species, some having biological activity. A range of sterols (taxerol, cycloartemol, lupeol, campesterol and sitosterol) have been found in the flowers of *A. lebbeck* (Asif *et al.,* 1986) and saponin (echinocystic acid) was reported in the roots extracts. Saponins are glycosides of steroid or triterpenoid compounds and by their detergent action, have been implicated in the formation of bloat in cattle grazing white clover pastures. The tendency of tannins to interact with proteins differed, such that those with higher molecular weight have more interactions with proteins making them less available. Robbins *et al.* (1991) observed that tannins formation of indigestible complexes with protein varies with animal species while Hagerman *et al.* (1992) found that quebracho tannin (commercial tannin), a condensed tannin, diminished protein digestibility in sheep while hydrolyzable tannin, did not affect protein digestibility. Barry and McNabb (1999) postulated that small amounts of condensed tannins [CT] (C.4% DM) in the diet prove advantageous by promoting by-pass protein based on comparison of tanniniferous plants that vary in CT content and often with the use of polyethylene glycol (PEG) to neutralise tannin action. Komolong *et al.* (1999) observed increased faecal nitrogen output and reduced apparent nitrogen digestibility in weaner sheep fed a basal diet of lucerne hay and dosed with quebracho tannin, while others (e.g. Mangan, 1988) reported improvements in animal production due to active CT, in Lotus forage.

Silanikove *et al.* (1999) reported the following biological effects of tannins in studies where its anti-nutritional effects were partially or completely neutralized by variable levels of PEG (polyethylene glycol) supplementation.

Effects on appetite: The negative effects of tannins on appetite can occur in the short-term (within 20 to 60 minutes) and the long-term (days and weeks). They noted that the astringency and aversive postingestive influences of tannins on the epithelium of oral cavity and foregut cause short-term influences on food intake. Long-term effects are related to reduction in the concentration of ammonia and volatile fatty acids (VFA) in rumen fluids, which in turn serves as metabolic cues for deficiency of nitrogen (ammonia), energy (VFA), or both.

Effects on digestion: Silanikove *et al.* (1999) reported that increasing content of tannins in foliage is associated with an increase of bound free material (mainly protein) and a decrease in the degradation rate of the degradable matter in the rumen, but not with an increase of the non-degradable fraction. Therefore, organic matter, protein and cell wall digestibility are inversely related to tannin concentrations.

Inducing digestive responses: If a significant amount of tannins reach the duodenum, they may induce a marked depressive effect on the intestinal activity of pancreatic enzymes and hamper amino acid absorption from the intestine. Condensed tannins depresses the rumen fluid and particulate content of the rumen, accelerate the passage of liquid from the abomasum and delay the passage of digesta in the intestine. Silanikove *et al.* (1999) concluded that the overall effect is a delay in the passage of fluid and particulate matter throughout the entire gastrointestinal tract. They hypothesized that these responses are largely the consequence of the interaction of tannins with digestive enzymes and the epithelium lining the digestive tract.

The value of leucaena leucocephala as a feed for stock has been documented though all parts of the plant contain the non-protein amino acid mimosine which is highly toxic to non-ruminants. (Norton, 1994a). Mimosine acts by interfering in cellular mitosis and the symptoms of toxicity are alopecia, reduced appetite, reduced weight gain and often death. It known that in areas where leucaena is indigenous (Central America) and Asia, ruminants consuming leucaena appear able to degrade the ruminal metabolite of mimosine to harmless end –products (Jones and Lowry, 1984). However, where leucaena has been introduced to ruminant populations without this adaptation, symptoms of toxicity such as alopecia, excessive salivation, lack of coordination of gait, enlarged thyroid glands (low serum thyroxine) and reduced fertility are often observed (Jones, 1979). Toxicity in ruminants is caused by 3-hydroxy-4 (1H)-pyridone (DHP), which is a potent goitrogen. The severity of toxicity is related to the level of leucaena consumed and diet containing less than 30% are generally considered safe for ruminants (Norton, 1994a) .

Two species of *Sesbania* are potentially useful forage sources- the slower growing tree *S. grandiflora* and the rapidly growing short-lived species *S. sesban. Sesbania grandiflora* leaves and pods are reported to be palatable non toxic for cattle. Some other reports suggest that the white flowering variety is non-toxic, while the purple flowering type is toxic (Hutagalung, 1981). Dried leaves of *S. grandiflora* have been fed (20% of diet) to milking cows and 15% of diet without detrimental effects. *Sesbania sesban* has also been successfully fed as a sole diet to goats (Singh *et al.*, 1980) and as a supplement to low quality forage for young sheep (Reed and Soller, 1987).

A major difference between the species is that *S. grandiflora* contains condensed tannin precursors (cyanidins) in leaves, whilst no tannin can be detected in *S. sesban*. However, both species contain compounds potentially toxic to non ruminants. The methyl ester of oleanolic acid has been isolated from the flowers of *S. grandiflora* and have shown to have haemolytic effects on sheep and human erythrocytes (Kalyanaguranathan *et al.,* 1985). In grazing studies with goats in Australia, goats showed a high preference for the bark of *S. sesban*, even when sufficient leaf was available, killing many trees. Non toxic effects were found in goats consuming this bark. It has been observed that the bark of *S. sesban* accessions may be either green or red and goats readily consumed green bark. It is not known whether goats have the same preference for the red bark variety or whether the colour is indicative of compounds detrimental to ruminants (Gutteridge and Shelton, 1994).

Description of anti-nutritional factors

Mimosine: Mimosine, a non protein amino acid structurally similar to tyrosine, occurs in a few species of mimosa and all species of closely allied genus leucaena. Concern has arisen because of the importance of *L. leucocephala*, in which the level of mimosine in the leaf is about 2-6% and varies with seasons and maturity (Kumar, 2003).

In non-ruminant animals mimosine causes poor growth, loss of hair and wool, swollen and raw coronets above the hooves, lameness, mouth and esophageal lesions, depressed serum thyroxine level and goiter (Kumar, 2003). Some of these systems may be due to mimosine and others to 3,4 dihydropyridine, a metabolite of mimosine in the rumen (Jones and Hegarty, 1984). Toxic signs like skin lesions also resemble Zn deficiency. Reduction in calving percentage due to leucana leucophala feeding has also been reported (Jones *et al.,* 1989).

A solution to the momosine problem could be the development of low mimosine cultivars. However, low mimosine types are found to be unproductive and have low vigour. The other approach is to feed Leucaena mixed with other feeds. Hiremath (1981) suggested that use of leucaena fodder may be restricted to 30% of the green forage in the case of cattle and buffalo and 50% for goats. The effect of leucaena and mimosine can be reduced by heat treatment (Tangendijaja *et al.*, 1990), by supplementation with amino acids or with metal ions such as Fe^{2+}, Al^{3+} and Zn^{+2} (Kumar, 2003).

Cyanogens: Cyanogens occur widely in plants and in diverse forms and they are glycosides of a sugar and cyanide containing aglycone. Table 2 provides a few examples of fodder trees and shrubs containing cyanogens. Cyanogens can be hydrolyzed by enzymes

Table 2: Anti-nutritional factors in the leaves of tree and shrubs documented as being in livestock feeding

Anti nutritional substances	Species
Non protein amino acids	
mimosine	*Leucaena leucocephala*
indospecine	*Indigofera spicta*
Glycosides	
a. Cyanogens	*Acacia giraffe*
	A. cunninghamii
	A. sieberiana
	Barteria fistulosa
	Manihot esculenta
b. Saponins	*Albizia stipulata*
	Bassia latifolia
	Sesbania sesban
Phytohemagglutinins	*Bauhinia purpurea*
	Ricinus communis
	Robinia pseudoacacia
Polyphenolic compounds	
a. Tannins	All vascular plants
b.Lignins	All vascular plants
Alkaloids	
N-methyl-B-phen	
ethyl amine	*Acacia berlandieri*
Sesbanine	*Sesbania vesicaria*
	S. punicea
Triterpenes	
Azadirachtin	*Azadirachta indica*
Limonin	*Azadirachta indica*
	Acacia aneura
Oxalate	*Acacia aneura*

Source: Kumar, 2003

to release HCN. However, the glycosides occur in vacuoles in plant cell and enzymes are found in the cytosol. Damage to the plant results in the enzymes and glycoside coming together and producing HCN. The hydrolytic reaction can take place in the rumen by microbial activity. Hence ruminants are more susceptible to HCN toxicity than non-ruminants. The HCN is absorbed and is rapidly detoxified in the liver by the enzyme rhodanese which converts HCN to thiocyanate (SCN). Excess cyanide ion inhibits the cytochrome oxidase. This stops ATP formation, tissues suffer energy deprivation and death follows rapidly.
The lethal dose of HCN for cattle and Sheep is 2.0-4.0 mg per Kg body weight. The lethal dose for cyanogens would be 10-20 times greater because the HCN comprise 5-10% of their molecular weight (Conn, 1979). For poisoning, forage containing this amount of cyanogens would have to be rapid. Rercorded accounts of livestock poisoning by cyanogens plants showed that such situations occur. Post-harvest wilting of cyanogenic leaves may reduce the risk of cyanide toxicity. Animals suffering from cyanide must be immediately treated by injecting a suitable dose of sodium nitrate and sodium thiosulphate. (Kumar, 2003).

Saponins: Saponins are divided into two groups: Steroidal saponins, which occur as glycosides in certain pastures plants and triterpenoid saponins, which occur in soybean and alfalfa. Saponins are glycosides containing a polycyclic aglcone molecule of either C_{27} steroid or C_{30} triterpenoid (collectively termed as sapogenins) attached to a carbohydrate. They are widely distributed in the plant kingdom. Table 2 includes some of the fodder trees in which they may have nutritional significance (Kumar, 2003).
Saponins are characterized by a bitter taste and foaming properties. Erythrocytes lyse in saponin solution and these compounds are toxic when injected intravenously. The anti-nutritional effects of saponins have been mainly studied using alfalfa saponins. Sharma *et al.* (1969) observed that 4-7 weeks of *ad lib* feeding of Albiza gave rise to toxic manifestation in sheep. Symptoms include listlessness, anorexia, weight loss and gastroenteritis. The adverse effects of saponins can be overcome by repeated washing with water which makes the feed more palatable by reducing the bitterness associated with saponins (Joshi *et al.,* 1989).

Pytohemaggutinins: Phytohemaggluttins, otherwise referred to as lectins, are proteins which agglutinate red blood cells and are capable of damaging the intestinal mucosa. They have been shown to occur in some important fodder trees. The highest concentrations of lectins are found in seeds but, in the leaves, their concentration is low due to translocation. The biological effects of lectins probably result from their affinity for sugars. They may bind to the carbohydrate moieties of cells of the intestinal wall and cause a non-specific interference with nutrient absorption (Liener, 1985). In fodder trees, the lectins of interest are robin and ricin (Kumar, 2003). In contrast to most other proteins, lectins resist digestive breakdown and substantial quantities of ingested lectins may be recovered intact from the faeces of animals fed diets containing one of a legume seeds (D'Mello, 2000).
Robin, a lectin from Robinia psedoacacia, has been reported to cause poisoning in all class of livestock. Due to ricin, de-oiled castor seed cake (CP 35%) is seldom used as a livestock feed. However, the mature leaves of R. communis have been found suitable for feeding to sheep (Behl *et al.,* 1986); hence precautions against bean contamination are necessary.

Tannins: Tannins are water soluble phenolic compounds with a molecular weight greater than 500 Daltons and with the ability to precipitate proteins from aqueous solution. They occur almost in all vascular

Table 3: Some examples of anti-nutritional effects of tannins in shrub and tree forages

Fodder tree/shrub	Predominant tannin	Animal	Nutritional effect
Acacia aneura	CT	Sheep	Reduction in N digestibility decreased wool yield and growth, decreased S absorption
A. Cyanophylla	CT	Sheep	Reduced feed intake, negative N digestibility, loss in weight
A. nilotica (pods)	CT	Sheep	Low growth rate, reduced N and NDF digestibility
A. sieberianab	HT	Sheep	Low growth rate, reduced N and NDF digestibility
Leucaena leucocephala	CT	Poultry	Poor N retention, low apparent metabolisable energy value
Albizia chinensis	CT	Goat	Reduced in sacco N digestibility
Manihot esculenta	CT	*In vitro*	Inhibits digestibility
Prosopis cineraria	CT	Sheep	Reduction in feed intake protein, digestibility decreased wool yield and growth, decreased iron absorption
Terminalia oblongata	HT	Sheep	Reduction in feed intake, toxicity but no effect upon digestibility
Ziziphus nummularia	CT	Sheep	Reduction in feed intake protein and DM digestibility, decreased wool yield and weight loss

Source: Kumar, 2003. CT: condensed tannins. HT: hydrolyzable tannins

plants. Hydrolyzable tannins and condensed tannins (proanthocyanidins) are two different groups of these compounds. Generally tree and shrub leaves contain both types of tannins. The two types differ in their nutritional and toxic effects. Condensed tannins (CTs) are widely distributed in leguminous forages and seeds. Goats can tolerate CTs better than cattle and sheep. Adverse effects may be seen in sheep when CTs in browse legumes such as Acacia species, comprise a significant part of their diets (D'Mello, 2002). The condensed tannins have a more profound digestibility reducing effect than hydrolyzable tannins, where the latter may cause varied toxic manifestation due to hydrolysis in rumen. Sheep ingesting 0.9 g hydrolyzable tannins kg/body weight showed signs of toxicity in 15 days. Animals like mule deer, rats and mice have been shown to secrete proline rich proteins in saliva which constitute the first line of defense against ingested tannins. Nevertheless, deleterious effects and episodes of toxicity suggest the inadequacy of defense against high quantities of dietary tannins (Kumar, 2003). Primary effects of CTs include impaired rumen function and depressed intake, wool growth and live-weight gain. However, at moderate levels (30 to 40 g/Kg legume dry matter), CTs may result in nutritional advantages in respect of increased bypass protein availability and bloat suppression in cattle. At higher levels (100 to 120 g CTs/Kg legume dry matter), reduced gastrointestinal parasitism in lambs has been reported (D'Mello, 2000). The anti-nutritional effects of the tannins present in tree leaves are summarized in Table 3. The mechanism of dietary effects of tannins may be understood by their ability to form complex with proteins. Tannins may form a less digestible complex with dietary proteins and may bind and inhibit the endogenous protein, such as digestive enzymes (Kumar and Singh, 1984). Tannin protein complex involve both hydrogen bonding and hydrophobic interactions; the precipitation of the protein tannin complex depends upon pH, ionic strength and molecular size of tannins. Both the protein precipitation and incorporation of tannin phenolic into the precipitate increase in molecular weight is very large (5000), the tannin become insoluble and loose their protein precipitating capacity. Hence the measurement of the phenolic profile in terms of total phenolics. In ruminants, dietary condensed tannins (2-3%) have been shown to impart beneficial effects because they reduce the wasteful protein degradation in the rumen by the formation of a protein-tannin complex (Barry, 1987). The complex appears to dissociate post-ruminally at a low pH where, presumably, the protein becomes available for digestion. Aganga and Mosase (2001) reported content (% DM) of condensed tannins as determined by the butanol-HCl method were 2.62, 3.09, 3.10, 4.26 and 5.07 for *Sclerocarya birrea, Zizyphus mucronata kirkia acuminata, Lonchocarpus capassa* and *Rhus lancea seeds* respectively. They reported that the tannins contents in the seeds were low and may be beneficial to ruminants due to their effect in reducing rumen degradation of forage proteins which can be outweighed by increasing protein availability in the small intestines.

Other anti–nutritional factors: Shrubs and tree forage may contain alkaloids, terpenoids. Oxalate, indospecine, lignins and certain other ANFs. Alkaloids such as N-methl-a-phenethylamine cause locomotor ataxia of the hind quarters in sheep. Sesbaine causes haemorrhagic diarrhoea. The terpenoids azadirachtin and lignin impart a bitter taste and the leaves of acacia aneura may limit the Ca availability and a negative correlation between digestibility and lignin content in tropical browse has been observed (Bamualin *et al.*, 1980).

Conclusion: The nutritional importance of tree fodders to grazing ruminants have been reviewed in this paper. It is evident that tree fodders have a distinct advantage over tropical grasses in terms of their superior nutritional value especially during the dry season. The review suggests that forage trees have considerable potential as supplements to low quality grasses and straws. Although many different, secondary compounds have been isolated from many of the potentially useful tree fodders, they still provide necessary nutrients to grazing ruminants. Therefore; there is a need for intensive research into developing methods of processing these forages to reduce the impact of ANFs on nutrient utilization by the animals.

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