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# Tree fodder : An alternate source of quality fodder in Himachal Pradesh

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***Abstract***

Though India possesses huge livestock population, the productivity is low mainly due to malnutrition. The utilization of tree foliage as an alternative or supplementary feed to the available grass fodder is one of the useful method to solve the scarcity of quality feed for the livestock. Tree foliages are increasingly considered as potential protein and energy supplements to increase productivity by ruminants. The foliages have high digestibility, good vitamin and mineral content and they enhance the microbial growth and digestion of cellulosic biomass in the rumen of livestock. In some foliages, presence of anti-nutritional compounds like tannins, phenolics, glycosides, alkaloids, triterpenes, oxalic acids *etc*. reduce their nutrient quality, which can be taken care of by proper alleviation methods. India being rich in diversity of foliage trees has an enormous potential of using tree foliage as a basal feed or forage supplement.

**Key words :** Anti-nutrients, Dairy, Fodder trees, Foliage, Nutritional composition.

## Introduction

Animals have crucial role to play in human food production, either directly or indirectly. In developing countries, ruminants are primarily kept as a source of draft power, as an accessible source of funds, for milk production and often as an indicator of wealth and standing for the farmers. Seventy percent of the 1.7 billion poor householders in the developing countries own livestock which is crucial source of food, income and social capital (Smith, 2001). The main reason for low production of livestock products in the country is malnutrition. Although various genetic improvement programmes have evolved new breeds of livestock with high potential but unavailability of adequate feed and quality fodder resources limits the expression of their full potential. Recent nutritional research has demonstrated the possibility of a large increase in animal production that can be achieved by alterations to the feed base (Leng, 1997). The production could be increased up to five fold by providing critical catalytic nutrients in the diet. In a developing country like India human population and livestock compete for food on some scarce land area. Further there is fodder scarcity of in lean periods of the year. Therefore, trees and shrubs are the appropriate source to meet the nutritional requirement of animals. This calls for better utilization of already known unconventional feed resources. Trees and shrubs also plays a vital role in the control of soil erosion, nitrogen fixing, bringing economic benefits to farmers and bridging the wide gap between supply and demand for animal feeds (Atta-Krah *et al.*, 1986; Brewbaker, 1986). Intensification, in the context of ruminant production systems, means a broadening of the feed resource base to compensate not only for the shrinking of rangeland and natural grasslands but also for the low quality and seasonal nature of this major feed resource. A new generation of farming systems in the tropics where multipurpose trees play a critical role in the sustainability of the system, by supplying protein for livestock, firewood, and sinks for carbon dioxide and controlling erosion has been adopted in the past years (Preston and Murgueitio, 1992; Moog 1992, Rosales and Gill, 1997). The choice of alternate feed resource should not be restrictive but must fit within the existing farming systems, and be adapted to the economic realities of the farmer. Farmers' preferences for certain fodder species were based on feeding values (palatability and ability to fatten), tree growth characteristics (fast regrowth, ease of propagation and establishment) and tree management issues. For farmers it is important that the trees are tolerant of frequent cutting and the cut herbage is easy to handle. Also animals do not like to eat the same fodder all the time but prefer to consume mixtures of several species. Farmers also prefer to plant fodder trees that can also serve as fence or border markers or can hold soil in very steep portions of their fields.

### *Fodder trees in current scenario*

A major constraint to animal production in developing countries is the scarcity and fluctuating quantity and quality of the year-round feed supply. These countries experience serious shortages in animal feeds of the conventional type. The grains are required almost exclusively for human consumption. By the year 2020, world population is expected to reach 8 billion and most of the population growth will occur in developing countries. With increasing demand for livestock products as a result of rapid growth in the world economies and shrinking land area, future hopes of feeding the millions and safeguarding their food security will depend on the better utilization of unconventional feed resources which do not compete with human food. Many small-scale farmers in hills keep livestock, particularly cattle, goats and sheep for milk, meat, leather or wool, ploughing of fields and manure to fertilize crops. Feeds, like grass and leaves, contain a water and a non-water part, the latter being called 'dry matter' contains energy (carbohydrates), 'protein' and other substances (like minerals). Even when a cow, goat or sheep is not producing milk, it needs energy to breathe, walk and maintain all kinds of body processes. The basic need of feed, which is necessary just to maintain a stable condition of the body, is called 'maintenance requirements'. Fodder trees and shrubs are important as a source of energy and protein to keep the animals' healthy, improve there are growth rates and even increase milk and wool production. On an average, fodder trees and shrubs are richer in protein and lower in fibre and ash than tropical grasses (Smith, 1992). The feed value of forage is a function of its nutrient content and digestibility, its palatability (which determines its consumption level) and the associative effects of other feeds. Interplay of these factors determines the effective utilization or feed value of the material. The right fodder trees and shrubs are the ones, which produce feed during the droughts or accumulate feed that can be used after a disaster such as fire.

Trees and shrubs have long been considered as important sources of nutrition for grazing animals especially in areas with a pronounced dry season. The wealth of potential tree fodder is enormous and they are an effective insurance against seasonal feed shortages, supplementing the quantity and quality of pasture compounds (Lefroy *et al.*, 1992). Fodder trees, which are one of the benefits of agroforestry, are less affected by seasonal dry conditions because of their more extensive root systems and longer life spans (Abel *et al.*, 1997). The legume forages and tree forages in pastures have been generally accepted to improve ruminant productivity in both temperate and tropical pastures (Milford, 1967; Ulyatt, 1980). The animal productivity is always greater for legume-based pastures than from pure grass pastures. A most important attribute of legumes is that their digestibility declines more slowly with maturity and environmental temperature than that of grasses (Mannetje, 1984; Thompson, 1977; Walker, 1987).

Torres (1983) defined browse as the "shoots or sprouts, especially tender twigs and stems of woody plants with their leaves. However, the term can be broadened to include the flowers, fruits or pods, which can be more valuable than foliage, especially if the species as deciduous" (Torres, 1989).

Tree forages form an integral part of ruminant feeds in the high altitudes of the Himachal Pradesh, Jammu and Kashmir and Uttranchal states of India. Trees provide an alternate source of quality fodder in hilly areas and is comparable with leguminous fodder crops in nutritive value. The forage value of any feed depends on the combination of its palatability, nutrition value and digestibility (Lefroy *et al.*, 1992). Most feed types are not sufficiently digestible or nutritious to meet all of an animal's needs in isolation. During the dry season crop straw and dry grass is usually fed to animals, which has poor digestibility, as dry grass is rich in fibre (cellulose and lignin) and poor in sugar, proteins, minerals and vitamin content; Aganga *et al.*, 1994).

### *Fodder trees are important as*

**Cheap protein source:** Tree foliage is being increasingly recognized for supplying crude proteins (Leng, 1997). Crude protein content of dry, mature tropical grasses often falls below the minimum 6% required for maintenance, while most fodder trees remain green with higher protein contents. For growth and milk production, protein is a major requirement in the daily feeding ration. However, livestock is often fed on low quality roughage or grasses, which contain low amount of proteins, sugar and high amount of fibre (cellulose and lignin). Therefore it is recommended to supplement the basic diet, with concentrates, which contain enough protein. Fodder tree leaves contain high quantities of protein ranging from 10-30% of the 'dry matter' (DM) and minerals with high levels of digestibility (Paterson *et al.*, 1998). Fodder tree leaves can thus replace concentrates to a great extent without any adverse effect. However, the availability and quality of tree leaves depends on the season while concentrates might be available year round.

***Dry season supplement :*** During the dry periods, trees and shrubs remain green for a longer period than greases because of their deeper rooting system, which can tap water beyond the reach of grass roots. So, when the availability of grass decreases as it dries up and its protein content declines, the fodder trees are still green and can provide the required energy and proteins. Thus, it reduces the drought risk and continues supply of feed to the animals. It has been recommended that, when used as supplements, the optimum dietary level of fodder trees and shrubs should be about 30 to 50 % of the ration on dry matter basis, or 0.9–1.5 kg per 100kg body weight (Devendra, 1988).

***Multipurpose uses :*** Many fodder tree species protects soil erosion, improve soil fertility by providing green mulch or by fixing nitrogen. They also provide construction material, firewood, shelter and shade (Brewbaker, 1986; Topps, 1992; Sibanda, 1993).

## *Chemical composition of tree fodders of Himachal Pradesh*

Fodder, the mainstay for livestock rearing is cultivated only on 4% of the total cultivable land in India and this figure has remained more or less static for the last three decades. Tree forages form an integral part of ruminant feeds in high altitudes of Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh. Recognition of the potential of tree foliage to produce considerable amounts of high protein biomass has led to the development of animal farming systems that integrate the use of tree foliages with local bulky feed resources. In order to determine the suitability of trees/shrubs as components of ruminant fibrous diets, knowledge is required for

- Capacity and ability of the tree to regenerate foliage when grazed or harvested
- Feeding behavior of animals when confronted with tree forages
- Voluntary intake of tree foliage under different environmental conditions.
- Adaptation of trees to the local conditions and their potential to become weeds
- Growth pattern of trees/shrubs in relation to crops or pasture.
- Nutritive value of the foliage and its change with harvesting, grazing or cultivation.

The optimal utilization of browse tree fodder for livestock feeding is limited by available scanty data on their nutritional value including conventional chemical composition, minerals and presence of feed anti-nutrient factors (ANFs) such as polyphenolics (i.e., phenolics and tannins) due to their effects on lowered feed digestibility and nutrient availability in ruminants (Rubanza *et al.*, 2006). The high variability in the nutrient content of fodder trees and shrubs often encountered in the literature could be attributed to within species variability due to factors such as plant age, plant part, harvesting regime, season and location. These factors should be considered when chemically evaluating fodder trees. Chemical composition of 30 species of tree leaves fed to livestock in the hilly areas of Kangra district were studied in three seasons *viz*., summer, rains and winter by Sharma *et al*. (1966a). In the pooled data the crude protein content ranged from 9.13 to 22.08% in the dry matter of the leaves and the corresponding ranges of Ca and P contents were 0.50 - 6.31 mg/100g and 0.12 - 0.27 mg/100g respectively. The differences in the composition of the various tree leaves were highly significant and so were the seasonal differences. The generally high crude protein and phosphorus and a low content of crude fibre in tree leaves during summers were indicative of their higher nutritive value during the period.

The crude protein digestibility or the DCP contents in biul (*Grewia oppositifolia*) and magar (*Bambusa arundinacea*) leaves compared quite favourably with those present in leguminous fodders like berseem or cowpea (Sharma *et al.,* 1966b). Sharma et al. (1969) reported that digestibility of crude protein in *Celtis australis* (Khirak) tree leaves collected around Palampur lowered down to 43% in October from 63% in May. In *Robinia pseudoacacia,* the content of Ca, CF and total ash increased with leaf maturation while there was decrease in CP, EE, P and tannins content (Negi *et al.,* 1979).

Pal *et al*. (1979) studied the chemical composition of fodder trees of Himachal Pradesh during the months of April, August and December. The average percentage composition of the dry matter of the different species varied in respect of CP from 10.29% in *Ficus benghalensis* to 20.99% in *Albizzia stipulata,* CF from 14.38% in *Morus alba* to 33.74% in *A. stipulata*, NFE from 35.41% in *Bambusa nutans* to 60.41% in *Eugenia jambolana*, total ash from 7.40% in *Bauhinia variegata* to 17.41% in *Cordia dichotoma,* insoluble ash from 0.35% in *E. jambolana* to 8.05% in *B. nutans*, Calcium from 0.76 mg/100g in *Dendrocalamus hamiltonii* to 4.79 mg/100g in *Aegle marmelos* and Phosphorus from 0.11 mg/100g in *E. jambolana* and *Quercus incana* to 0.25 mg/100g in *C. dichotoma*. The differences between the three periods of study were also significant in respect of CP, EE, CF, NFE, Ca, P and insoluble ash. CP and P were significantly higher in the spring/ summer season (April) than during rain (August) or winter (December) while the ether extract followed the reverse trend.

Scoring of fodder trees on the basis of most desirable traits *viz*., CP and aggregate of undesirable traits *viz*., tannin and CF considered in reverse order gave highest arbitrary overall value of 63.5 to *Grewia optiva,* followed by *Morus alba* (61.5) and the least value was observed for *Quercus incana* (9).

Similarly Khatta and Katoch (1983) estimated CP, CF, EE, total ash, NFE, Ca and P of different fodder tree leaves (Table 1). The results showed that the CP and CF levels were comparatively higher and NFE levels lower in the samples collected from high rainfall zone (Palampur) than those from hot and humid shivalik zone (Jawalamukhi) and this variation was attributed to differences in agro-climatic conditions. The overall proximate composition of the samples collected from the former area were in agreement with that reported by Sharma *et al*. (1966a) except some variation in the CP content of siras (*Albizzia lebbek)* and Khirak (*Celtis australis*). Scoring of fodder trees done on the basis of CP, EE (useful nutrient moieties) and CF levels (having depressing effect on the digestibility of nutrients due to lignin contents) and their comparative palatabilities revealed that toot (*Morus alba*), biul (*Grewia oppositifolia*) and magar (*Bambusa arundinacea*) were found to be best for both the locations whereas Oee (*Albezia lebbek*) got lowest score. Although Pal *et al*. (1979) have graded dheon (*Artocarpus lakoocha*) superior to magar but Khatta and Katoch (1983) justified that magar is not only nutritionally superior but is ecologically better adaptable, quick growing and has more advantageous foliage and also serves as raw material for supporting small scale industries for the local artisans.

Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were lower and reverse was the case for cell contents in the samples from the first zone as compared to those of second zone (Table 1).

Except siras, tuni and dheon, the entire fodder tree leaves were sufficiently rich in Zinc (Zn) *viz*., less than 5 mg/ 100g except toot (Table 1).

Negi (1986) observed that *Bauhinia variegata* excelled other fodder trees in comprehensive nutrient value and collated well with cultivated green leguminous fodder. Similarly Khosla *et al*. (1992) in a study of six important fodder species of high hill zone of Himachal Pradesh found much higher leaf proteins (32%) in young leaves of *Grewia optiva, Celtis australis* and *Robinia pseudoacacia. R. pseudoacacia* maintained highest leaf protein content at all stages of development although decline was observed with the increase in age of leaves. However, protein content remained constant throughout the growing season in *Quercus leucotrichophora*.

The leaf fodder of mulberry (Morus alba) is reported to be of good quality and can be profitably utilized as a supplement to poor quality roughages. On dry matter basis, the leaves contained 15.0 - 27.6 % crude protein (CP), 2.3 - 8.0 % ether extract (EE), 9.1 - 15.3 % crude fibre (CF), 48.0 - 49.7 % nitrogen free extract (NFE), 63.3 % total carbohydrates, 14.3 - 22.9 % ash, 2.42 - 4.71 % Ca, 0.23 - 0.97 % P, 0.196 % S, 1.66 - 3.25 % K, 350 - 840 ppm Fe (Jayal and Kehar, 1962; Singh *et al*., 1984; Singh *et al.,* 1989; Makkar *et al*., 1989). The cell wall constituents were: neutral detergent fibre (NDF) 33 - 46 %, acid detergent fibre (ADF) 28 - 35 %, hemicellulose 5 - 10 %, cellulose 19 - 25 %, and lignin approximately 11 % (Lohan *et al*., 1979; Makkar *et al*., 1989). The content of total phenols was very low (1.8 % as tannic acid equivalent), and tannins by the protein precipitation capacity method were not detectable (Makkar *et al*., 1989; Makkar and Becker,1998). Prolamin has been separated from alcoholic (alkaline) extracts of mulberry leaves and it forms the principal protein of the leaves. The nitrogen (N) distribution in a preparation containing 12.6% N was as follows: HCl-insoluble N 0.50, humin N 0.45, amide N 0.96, diamino acid N (arginine N 0.89, histidine N 0.49, lysine N 0.35, cystine N 0.01) 1.74, and monoamino acid N 7.89%. Protein preparations from young mulberry leaves form an excellent supplement to protein-deficient diets.

Non-protein nitrogen accounts for approximately 22% of the total N in young leaves and approximately 14% in mature leaves. The amino acids identified in the free form are: phenylalanine, leucine, valine, tyrosine, proline, alanine, glutamic acid, glycine, serine, arginine, aspartic acid, cystine, threonine, pipecolic acid and 5-hydroxy pipecolic acid. The mulberry leaves are thus rich in Crude protein, ether extract and ascorbic acid (200-300mg/100g, 90% of which is present in the reduced form) and low in CF. They also contain carotene, vitamin B1, folic acid and vitamin D. The presence of glutathione in leaves has been reported. Copper, zinc, boron and manganese occur in traces. Phytate phosphorus accounts for 18% of total phosphorus. Sulphur is required together with nitrogen for microbial protein synthesis in the rumen. Concentrations of sulphur greater than 1.5 g/kg dry matter or nitrogen : sulphur ratios less than 15:1 are considered adequate. Both these requirements are met in mulberry

**Table 1: Chemical composition, cell wall and cell constituents of tree fodder species (on dry matter basis)**

| Sl. No. | Name of tree fodder species | Locality | CP (%) | CF (%) | EE (%) | Ash (%) | NFE (%) | NDF (%) | Cell content (100-NDF) (%) | ADF (%) | Hemicellulose (NDF/ADF) (%) | Ca (mg/ 100g) | P (mg/ 100g) | Cu (mg/ 100g) | Zn (mg/ 100g) | Observed Palatability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Siris | P | 17.59 | 33.10 | 3.88 | 8.83 | 36.62 | 52.68 | 47.32 | 33.80 | 18.88 | 2.65 | 0.11 | 0.54 | 1.04 | Average |
| | (*Albizzia lebbek*) | J | 15.59 | 26.15 | 9.38 | 9.38 | 43.96 | 54.50 | 46.40 | 46.28 | 18.22 | 2.27 | 0.13 | 0.96 | 1.44 | |
| 2 | Tuni | P | 14.84 | 12.03 | 12.50 | 11.99 | 48.65 | 37.46 | 62.54 | 20.03 | 17.43 | 2.50 | 0.13 | 0.81 | * | Poor |
| | (*Cedrela toona*) | J | 12.68 | 14.03 | 7.42 | 11.86 | 54.01 | 47.49 | 52.41 | 29.11 | 18.48 | 2.12 | 0.33 | 1.22 | 4.51 | |
| 3 | Kachnar (*Bauhinia variegata*) | P | 15.25 | 24.36 | 3.42 | 6.72 | 50.25 | 59.81 | 40.19 | 46.59 | 13.22 | 2.13 | 0.27 | 2.80 | 3.50 | Average |
| 4 | Biul | P | 18.32 | 20.95 | 3.39 | 10.63 | 46.71 | 45.56 | 54.44 | 29.67 | 15.89 | 2.41 | 0.28 | 1.69 | 2.06 | Good |
| | (*Grewia oppositifolia*) | J | 17.30 | 17.97 | 4.04 | 11.95 | 48.74 | 47.14 | 52.86 | 32.36 | 14.78 | 3.00 | 0.19 | 1.42 | 2.66 | |
| 5 | Khirak (*Celtis australis*) | P | 18.08 | 18.0 | 2.19 | 16.43 | 45.20 | 37.21 | 62.79 | 27.12 | 10.09 | 3.16 | 0.26 | 1.68 | 2.63 | Good |
| 6 | Oee (*Albizzia stipulata*) | P | 10.35 | 32.75 | 3.86 | 7.71 | 45.33 | 68.37 | 31.63 | 33.29 | 35.08 | 1.12 | 0.23 | 1.24 | 5.17 | Average |
| 7 | Magar | P | 18.02 | 29.25 | 5.05 | 11.54 | 36.14 | 70.05 | 29.94 | 30.06 | 39.99 | 0.65 | 0.22 | 1.46 | 2.87 | Good |
| | (*Bambusa arundinacea*) | J | 16.76 | 27.29 | 4.18 | 13.84 | 37.30 | 72.11 | 17.89 | 35.12 | 36.99 | 0.43 | 0.26 | 2.05 | 3.00 | |
| 8 | Toot | P | 26.40 | 11.63 | 5.06 | 16.28 | 40.63 | 41.20 | 58.80 | 23.77 | 17.43 | 2.38 | 0.35 | 2.08 | 4.83 | Good |
| | (*Morus alba*) | J | 18.24 | 10.28 | 6.21 | 13.84 | 51.43 | 43.16 | 59.84 | 26.68 | 16.48 | 3.91 | 0.48 | 1.14 | 5.08 | |
| 9 | Beri (*Zizyphus nummularia*) | P | 14.99 | 16.48 | 2.20 | 10.70 | 55.63 | 70.90 | 29.10 | 59.63 | 11.27 | 0.48 | 0.32 | 1.32 | 3.50 | Good |
| 10 | Dheon (*Arrtocarpus lakoocha*) | P | 14.45 | 21.10 | 2.40 | 12.13 | 49.92 | 54.48 | 45.52 | 38.72 | 15.76 | 1.11 | 0.31 | 0.96 | 4.48 | Average |
| 11 | Robina (*Robinia pseudoacacia*) | P | 17.55 | 18.02 | 4.28 | 4.09 | 43.94 | 51.68 | 48.32 | 34.20 | 17.48 | 1.46 | 0.21 | 1.96 | * | Good |

P- high rainfall mountainous zone (Palampur), J- hot and humid Shivalik zone (Jawalamukhi), * no valid value is available leaves. Similarly, the levels of potassium and iron in mulberry leaves are also higher than their recommended levels (Fe 30 - 50 ppm, K 0.5 - 1.0 %) in diets (McDowell, 1997). High Ca content in mulberry leaves (2.4 -4.7 %) than the required level in diet (0.19 - 0.82 %;) could be useful for high yielding ruminants during early stages of lactation. Calcium is closely associated with phosphorus metabolism. The leaves are also useful as cattle fodder; they are nutritious and palatable, and are stated to improve milk yield when fed to dairy animals. The feeding value of mulberry leaves is rated high by the livestock owners. Feeding experiments have shown that up to 6 kg of leaves per day can be fed to cows without adversely affecting the health of animals or the yield and butter content of milk.

Mulberry is also an ideal tree species for economic management of unutilized wasteland (under rain fed conditions) for the following reasons:

- It is tap rooted with minimum superficial roots.
- It has good coppicing power and is tolerant to lopping and pruning. Pruning and training of mulberry enhances the size and quality of leaves.
- It has easy generation capacity through seeds and vegetative means.
- It is a multipurpose tree which yields fodder, fiber, fruit, wood *etc*.
- The leaves are highly palatable and nutritious for livestock, and these are used extensively for silk production
- Many varieties of mulberry can grow in varied agro-climatic conditions in both temperate and tropical areas.

***Detrimental factors of tree fodders***

Trees and shrubs also have several disadvantages as sources of feed.

***Digestibility :*** Although Protein content is higher, they often have lower energy value than herbaceous plants due to the lower digestibility of protein and reducing the production of metabolizable energy (D'mello, 1992). The foliage also generally has higher fibre and lignin contents than grasses, and often has higher levels of tannins and other astringent compounds (Lefroy *et al.,* 1992). Tannins in tree fodders form the most common detrimental factors that P- high rainfall mountainous zone (Palampur), J- hot and humid Shivalik zone (Jawalamukhi), * no valid value is available reduces the utilization of proteins not only from tree fodder but also from other feed ingredients. Tannins adversely affect the digestibility of dry matter and utilization of nutrients (Negi, 1986). Digestibility of tree foliage ranges from 40-60% (Oldemeyer *et a*l., 1977; Wilson, 1977). In general, fodder trees and shrubs not only degrade fairly well and rapidly in the rumen, supplying soluble carbohydrates and fermentable nitrogen to the rumen but also are well digested postruminally, often at a higher level than tropical grasses, and should therefore improve the intake and digestibility of the latter (Smith and Van Houtert, 1987).

***Toxicity* :** The harmful effects of feeding a particular fodder may not be clinically apparent for a long time but intensive latent internal damage may be caused (Negi, 1986). The anti-nutritional factors (ANFs) may be defined as those substances generated in natural feedstuffs by the normal metabolism of species and by different mechanisms (e.g., inactivation of some nutrients, diminution of 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 ANFs for monogastric animals do not exert adverse effect in ruminants because they are degraded in the rumen (Kumar, 2003). ANFs that have been implicated in limiting the utilization of shrub and tree forages include non-protein amino acids, glycosides, phytohemagglutinins, polyphenolics, alkaloids, triterpenes and oxalic acids (Table 2) (Makkar, 1993; Aganga and Tshwenyane, 2003; Kumar, 2003). For example, *Leucaena leucocephala*, an increasingly popular fodder species, contains tannins and a non-nutritive toxic amino acid mimosine (2-6%) which varied with season and maturity (Kumar, 2003). If fed indiscriminately, this species can lead to shedding of hair coat of animals, excessive salivation, loss of appetite, low weight gains, enlarged thyroid glands and death of newborn animals (Aganga and Tshwenyane, 2003).

***Methods for anti-nutrient management***

The simplest approach is dilution *i.e.,* feeding allelochemicals containing leaves in mixtures with other feeds, will reduce the risk of toxicity but simultaneous nutritional benefits may not accrue. Moreover the required degree of dilution is difficult to recommend because of uncertain quantification (Kumar, 2003).

Several studies indicate that tannin rich leaves in combination with concentrate rations could be fed to animals without any adverse effect (Raghavan, 1990). This happens because animals consume proteins in excess of their requirement from the concentrates and therefore, the anti-nutritional effects of tannins were masked.

The utility of management practices involving lopping/ harvesting of tree leaves at times when the concentration of ANF's are lowest (Vaithiyanathan and Singh, 1989) is limited because pattern of changes in concentration of various allelochemicals may not be same. It has been noted that, as leaves mature, both the ANF and nutrient contents decrease (Singh, 1982).

**Table 2 : Anti-nutritional factors in the leaves of tree and shrubs used in livestock feeding.**

| | Anti-nutritional substances | Species |
|---|---|---|
| 1. | Non protein amino acids | |
| | (A) Mimosine | Leucaena leucocephala |
| | (B) Indospecine | Indigofera spicta |
| 2. | Glycosides | |
| | (A) Cyanogens | Acacia giraffae |
| | | A. cunninghamii |
| | | A. sieberiana |
| | | Bambusa bambos |
| | | Barteria fistulosa |
| | | Manihot esculenta |
| | (B) Saponins | *Albizia stipulata* |
| | | Bassia latifolia |
| | | Sesbania sesban |
| 3. | Phytohemagglutinins | *Bauhinia purpurea* |
| | Ricin | *Ricinus communis* |
| | Robin | *Robinia pseudoacacia* |
| 4. | Polyphenolic compounds | |
| | (A) Tannins | All vascular plants |
| | (B) Lignins | All vascular plants |
| 5. | Alkaloids | |
| | (A) N-methyl- B- phenyl ethylamine | *Acacia berlandieri* |
| | (B) Sesbanine | *Sesbania vesicaria* |
| | | S. drummondii |
| | | S. punicea |
| *6.* | Triterpenes | |
| | (A) Azadirachtin | *Azadirachta indica* |
| | (B)Limonin | *Azadirachta indica* |
| *7.* | Oxalate | *Acacia aneura* |

Another approach of supplementation *e.g.* polyethylene glycol 4000 with tannin-rich leaves, may be suitable during acute shortage to avoid livestock losses (Pritchard *et al.*, 1988). These cannot be used routinely because of prohibitive costs. However, metal in and urea supplementation could be recommended to farmers after thoroughly accessing their alleviating effects against highest possible reported concentrations of allelochemicals.

Many ANFs are heat labile. Hence simple heating or autoclaving has been found useful in removing the effects of allelochemicals. This practice can be used by feed industry but not by farmers.

## Conclusion

A major constraint to animal production in developing countries is the scarcity of year round availability of quantity and quality feeds. India is endowed with rich diversity of trees and shrubs which can serve as useful feed resource. Fodder trees are also suitable for agroforestry and are less affected by seasonal dry conditions because of their more extensive root systems and longer life spans that make them one of the best replacements to the seasonal fodders during off-seasons. In addition to their new sprouts and leaves, fodder trees provide the flowers, fruits or pods, which are sometimes more nutritious than the foliage. Although tree fodders have some detrimental factors like low digestibility and anti-nutrient compounds, application of proper management techniques can diminish their effect to the feeding animals. Therefore, growing foliage trees with proper technologies will greatly help the poor farmers to provide quality feed to their cattle particularly during the off-seasons when the commonly used green fodders are not available. Promoting fodder tree planting in degraded grazing lands is like hitting two birds with one stone. On the one hand, it helps meet livestock raisers' needs for fodder, and on the other hand, trees help alleviate degradation. Successful adoption of using tree fodders by the farmers involves working hand in hand with farmers in analyzing their problems, identifying possible solutions, and testing these together. In addition to involving the farmers in research activities, it is useful to conduct complementary activities such as training seminars. These should not only focus on the technical aspects of growing and managing the trees but also on enhancing farmers' appreciation of sustainable resource management. Research efforts should be directed towards the following areas:

a. Agronomic evaluation including seed production and storage techniques for promising local species.
b. Nutritional characterization of these species under appropriate practical feeding systems.
c. Year-round feed utilization systems that will maximally exploit improved biomass yields resulting from a better understanding of agronomic features that could attracts the farmers.

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