# A REVIEW OF THE NUTRITIVE VALUE OF DRY SEASON FEEDS FOR RUMINANTS IN SOUTHERN RAJASTHAN

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## 1. Introduction

### 1.1 General description of farming systems

Integrated crop-livestock farming systems are common in semi-arid western India. They have recently been described by Rangnekar (1997). Products in this region often include combinations of trees, cereal crops, leguminous pulses and oilseeds along with a mixture of ruminant livestock (mainly cows, buffalo and goats) and poultry. Most components have multiple purposes, for example crop residues have a role as animal feeds while ruminant livestock are important sources of manure and draught power as well as food. In tribal areas the combination generally used is trees, cereal-legume mixed cropping, cows and/or goats and poultry. The majority of landowners own livestock, but some half of the landless also own some animals. Large ruminants tend to be more important in the favoured areas (wetter, more wealthy), small ruminants in the more arid areas.

About 60% of Rajasthan is desert or semi-desert, the south east being hilly and rainfed. Livestock contribute about a quarter of the net domestic income overall but are relatively more important in the more arid areas. NW Rajasthan is dominated by pastoralists, central Rajasthan by mixed agriculture with a mixed population and S Rajasthan by tribal peoples. Central Rajasthan produces cereals (maize, wheat and pearl millet) and pulses together with cattle and goats. Lucerne is produced for fodder in winter (dry season) on some farms. The area is susceptible to droughts making crop production irregular. Milk production and production of livestock for sale have increased in recent years. Crop residues are collected and stored for dry season feeds. As well as cereal straws and stovers, residues from pulses and groundnuts are stored.

The region has a single wet (monsoon) season in which July and August are often the wettest months, but which does vary in timing and intensity from year to year (for example see Hocking et al., 1992). For 5 months a year, in average years, the total feed available has been estimated to be inadequate to maintain grazing livestock, hence animals lose weight. Nevertheless, grass pasture land tends to be underutilised during the season of abundance (Hocking et al., 1992).

## 1.2 Area of study

This study has concentrated on Bhilwara district, central Rajasthan and Udaipur districts in Rajasthan where rainfall is relatively low (Udaipur 800 mm/year), droughts can be severe and seasonal feed shortages are considered to be most acute.

## 1.3 Feeding systems for small ruminants

Small ruminants are extensively grazed throughout the year. Tree fodders form a major part of the diet for goats for 4 months per year (in the dry season) and are used for a further 4 months (Hocking and Kapila, 1992). They do not normally consume crop residues even in the dry season. On return home in the evening goats are given water and may be fed a fermented grain mash made from barley, wheat or maize. This is prepared in the morning by crushing the grain and mixing in water. In addition, does at kidding and lactating does may receive a separate ration of grain (200-250g/day) when this is considered necessary. The grain used may be home grown, purchased from neighbours or from the market. In Rampuriya village (Bhilwara), it was reported that farmers bought grain in March/April to last them for the rest of the year. In the dry season, mixtures of ground Ber (*Ziziphus mauritania*) leaves, ground nut leaves, Methi (*Fernum gricum*) seeds and cluster bean (*Cyamopsis tetragonaloba*) seeds are also provided for milking goats. Krishnamurty *et al* (1993) mention the feeding of loong/pale, which is dried leaves of *Prosopis cineraria* and *Ziziphus nummularia*. At kidding, usually in the September-December period, does may be given an additional supplement consisting of Jagari juice (product of local sugar processing) (Matthewman and Conroy, 1997).

In the dry seasons, goats derive their greatest nutrient intake from a variety of trees (loppings of leaves, small branches and pods), including *Acacia nilotica* (Babul), *A. leucophloea* (Arunjia) and *Prosopis cineraria* (Khejri), depending on the village and the trees available in and around the village. Differences were noted, in this respect, between villages. For example, in Ajmer district *Ziziphus nummularia* is particularly important (ISGP, 1993). If suitable trees are not available near to the village, goats may be taken up to 5 km daily. If they have to go greater distances, they may not return at night. Goat owning families may lease the lopping rights to trees on an individual family basis. If the rains are late in June, then this can be a further cause of having to go greater distances for grazing. Hence, in the dry season the herder lops branches and pods from desired trees, which is an additional duty attached to herding during the drier months. For large herds, two or more people may be required for herding and lopping (Matthewman and Conroy, 1997).

Herds may temporarily migrate to less arid regions, perhaps in neighbouring states, where green forage is more available. This reduces the demand for feed during the periods when shortages are most acute.

Matthewman and Conroy (1997) noted that there could be differences between villages on the tree species available and in how they are managed. The availability of tree fodder resources depends on whether trees are available on common grazing land, whether a farmer owns trees or not, whether trees are available in the village on other farmers' land, and whether trees (and the possibility to purchase lopping rights) are

available in nearby villages. The utilisation of particular feeds also depends on the availability of alternatives. For example, in some villages *A. nilotica* was lopped from February to April whilst in other villages it was utilised later, from April to May. In general farmers do not plant specific trees for fodder use, although trees are selectively cleared or left and managed which presumably has an influence on the availability of particular species.

## 2. Nutritive value of major dry season feed resources available for Goats in Bhilwara and Udaipur Districts

### 2.1 Plant species identified

Matthewman and Conroy (1997) named 29 plant species available for dry season goat feed in Bhilwara and a further 40 species available in Udaipur, that is a total of 69 species within the two regions, although there was some unintentional repetition of the same species within the lists from the two districts as several of the species were identified only by their local names, which could be different in the two districts. The list has been expanded to a total of 76 species as other species were identified during goat monitoring studies conducted by the project (although there may still be unintentional repeats). Other villages may have other species of importance, so the list is not comprehensive.

Several of these species are well known as fodders in other regions of the world. Some have been characterised at least to some extent in terms of their composition, main properties and for several animal feeding trial data have been reported. For some of the feeds there is no information in the literature, and due to their apparent very minor importance in the diet the project did not generate information on these. Information on the species identified by has been collected for various sources and is given in Table 1 below.

**Table 1 Fodders used in Bhilwara and Udaipur districts, Rajasthan**

| Scientific name | Where found | Local name | Other common names |
|---|---|---|---|
| *Acacia leucophloea* | Bhilwara and Udaipur | Arunjia (t:Ronjia), Orinja, Reunja, Safed Kikar | |
| *Acacia nilotica* | Bhilwara and Udaipur | Babul | gum arabic tree |
| *Acacia senegal* | Bhilwara | Kumta | |
| *Acacia tortilis* | Bhilwara | Israeli babool, | umbrella thorn |
| *Ailanthus excelsa* | Bhilwara | Ardu/Paba | |
| *Albizia lebbeck* | Bhilwara | Siris (t:Kalio), Sisis | |
| *Anogeissus latifolia* | Udaipur | Chanbor, Gum ghatti, dhaura, bakli | |
| *Anogeissus pendula* | Bhilwara | Dhokra | |
| *Anogeissus seracea* | Udaipur | Kakaiya | |
| *Arundinaria cannavieira* | Bhilwara | Bans | Bamboo |
| *Azadirachta indica* | Bhilwara | Neem | |

| | | | |
|---|---|---|---|
| *Balanites aegyptica* | Bhilwara | Hingota | Desert date |
| *Bauhinia racemosa* | Udaipur | Hetri | |
| *Boswellia serrata* | Udaipur | Shehtoot, Shetrit | |
| *Butea monosperma* | Bhilwara | Khakhra/Dhak, Dhat | |
| *Calotropus gigantea* | Bhilwara | Akadi | |
| *Capparis decidua* | Bhilwara | Khair, kair | |
| *Cassia fistula* | Udaipur | Goondi | |
| *Cenchrus ciliaris* | Udaipur | Pharangli, Anjan | blue buffalo grass, African foxtail, Rhodesian foxtail, buffel grass |
| *Ceropagia bulbosa* | Udaipur | Godala | |
| *Citrus medica* | Udaipur | Anni, Arni | |
| *Clerodendrum phlomidis* | Bhilwara | Aruni | |
| *Cordia dichotoma* | Udaipur | Umbia | |
| *Derris indica* | Udaipur | Negad | |
| *Dichrostachys cinerea* | Udaipur | Halar | Sicklebush, Christmas bush |
| *Emblica officinalis* | Udaipur | Pipal | |
| *Eucalyptus teriticornis* | Bhilwara | Neelgiri/Safeda | |
| *Fernum gricum* | Bhilwara | Methi | |
| *Ficus indica* | | Pimpal | |
| *Ficus religiosa* | Udaipur | Kronda, Peepul | bo tree |
| *Garunga pinnata* | Bhilwara and Udaipur | Lapna, Tamat | Dhaman grass |
| *Gmelina arborea* | Udaipur | Karmela | |
| *Gossypium sp.* | Bhilwara | Cotton pala | Cotton leaves |
| *Grewia hirsuta* | Udaipur | Athedi | |
| *Holorrena antidisentrica* | Udaipur | Kadwa/Kadwo | |
| *Lannea coromandelica* | Udaipur | Hawan | |
| *Leucaena leucocephala* | Bhilwara | Subabul | |
| *Madhuca indica* | Bhilwara | Mahua, Mowra, mowrah, Illipi, mee | |
| *Mangifera indica* | Udaipur | | Mango |
| *Medicago sativa* | Udaipur | Palak | Lucerne, alfalfa, purple medick, snail clover, Chilean clover |
| *Melia azedarach* | Udaipur | Mujal | Persian lilac |
| *Miliusa tomentosa* | Udaipur | Arandia | |
| *Morus alba* | Udaipur | Kalambi, | White Mulberry |
| *Opuntia* spp. | Bhilwara | Thor | Cactus |
| *Pithecolobium dulce* | Bhilwara | Jangal jalebi, | Manila tamarind |

| | | | |
|---|---|---|---|
| *Pongamia pinnata* | Udaipur | Dhawda, Karanja, | Indian oilseed. |
| *Prenna* spp | Udaipur | Amena | |
| *Prosopis cineraria* | Bhilwara | Khejri | |
| *Prosopis juliflora* | Bhilwara | English babul, vilayati babool | |
| *Ricinus communis* | Udaipur | Limboo | Castor |
| *Tamarindus indica* | Bhilwara | Imli (t:Amali), Tamarind | |
| *Trifolium alexandrium* | Bhilwara | Berseem, | Egyptian clover |
| *Vitex negundo* | Udaipur | Khirani/Khanni | |
| *Wrightia tintoria* | Udaipur | Kankar | |
| *Ziziphus mauritiana* | Bhilwara and Udaipur | Ber | |
| *Ziziphus nummularia* | Bhilwara | Bordi/Jharberi, bordi pala (dried leaves) | |
| *Ziziphus xylopyrus* | Udaipur | Andruk | |
| | Udaipur | Amala | |
| | Udaipur | Bel | |
| | Bhilwara | Champeli | |
| | Udaipur | Dhawra | |
| | Bhilwara | Hingoli | |
| | Udaipur | Hitazi | |
| | Udaipur | Kabiti | |
| | Udaipur | Kalbi | |
| | Bhilwara | Kamboi | |
| | Udaipur | Kanja, Kanaja | |
| | Bhilwara | Ker | |
| | Udaipur | Khalia | |
| | Udaipur | Khavani | |
| | Udaipur | Kimra | |
| | Udaipur | Limda | |
| | Udaipur | Tamata | |
| | Udaipur | Timdi | |
| | Udaipur | Vaibana | Creeper |
| | Bhilwara | Zadki | |

## 2.2 Laboratory methods used to evaluate feeds

The supply of nutrients to an animal depends on the composition of its diet and the extent to which nutrients consumed are available to the animal. Laboratory assays can be used to describe feeds in terms of their major chemical components while laboratory (*in vitro*) digestibility assays can give indicators of nutrient availability. The comments below are primarily intended for readers with little knowledge of ruminant nutrition. The comments are necessarily a simplification of complex processes. The quality of individual feeds must be viewed in the context of the diet as a whole and the farming system as a whole. Availability is also a key factor in determining how useful any particular feed is to the livestock keepers.

The feed composition is indicated by various chemical assays, most of which are widely used to describe the qualities of feeds. Ruminants require both protein and energy in order to survive, grow, produce milk and reproduce. Both types of nutrient are required in an appropriate balance for efficient use to be made of the feed. Crude protein content (CP) gives some indication of protein supply. A high CP content indicates a potentially highly nutritious feed. Ruminant feeds are often very fibrous, with high fibre contents being associated with low intake (i.e. animals don't eat much of it) and digestibility. The fibre fraction can be estimated by the crude fibre assay (CF) and/or more recently developed assays, acid detergent fibre (ADF) and neutral detergent fibre (NDF). Lignin is associated with completely indigestible material. Good quality feeds will generally have lower fibre and lignin contents. Ash indicates the mineral content. High ash contents indicate poor feeds usually, although animals require an adequate supply of minerals. Ether extract (EE) indicates the fat content. Fat is a very good energy source but is rarely found to any great extent in the fodders described here. The Nitrogen-free extract (NFE) is the material not accounted for by the other analyses and consists of components such as soluble sugars which are generally readily digestible and good energy sources. Tree fodders often contain phenolic compounds such as tannins. The actions of these compounds are complex and not fully understood, but they are generally associated with reductions in the nutritive value of tree fodders. The total phenols (TP) assay gives an indication of the overall content of phenolic compounds. High TP levels may be associated with poor quality feeds.

The in vitro techniques imitate aspects of the digestion processes in order to indicate the availability of nutrients to the animal which consumes them. Two techniques were used by this project, in vitro gas production and the Tilley and Terry in vitro dry matter digestibility (IVDMD) assay. The techniques are similar in that they measure the degradation/fermentation of feeds by rumen microbes followed by digestion by an acid pepsin solution, similar to the digestion of feeds in ruminants. The gas production method measures the rate of gas produced during fermentation (measured by rate constant b) as an indicator of rumen degradation rates as well as the end point of digestion (measured by the dry matter disappearance, DMD, during 96 h gas production and acid pepsin treatment) , while the IVDMD assay gives digestion after 48h incubation time with rumen microbes and acid pepsin treatment. Feeds which are extensively and rapidly digested are generally regarded by nutritionists as being of high quality. However, highly digestible feeds may not always be preferred by livestock keepers during periods of feed shortages as lower digestibility feeds may be better at filling their animals and satisfying their hunger (Thorne et al., 1999).

Some data from animal experiments are also reported. In sacco degradability is a technique which involves measuring the rate and extent of feed degradation in the rumens of live animals. The "a" fraction is degraded quickly, the "b" fraction degraded more slowly, with a rate constant of "c". It is possible to measure the degradation of dry matter and protein separately using this method. The data can be interpreted in broadly the same way as the in vitro data. For some feeds digestibility data from animal feeding trials is reported. This gives data on the extent of digestion during the complete digestion process in animals, usually sheep or cattle. Digestibility may be given as an overall figure for dry matter, or by the different chemical components of the feed. The Metabolisable Energy (ME, expressed in

MJ/kg dry matter of feed) is an estimate of the energy in the feed that can be utilised by the animal (that is excluding that lost in faeces, urine and methane). Again, high digestibility is an indicator of high nutritive value.

### 2.3 Species of fodder in alphabetical order (by scientific name where known)

Summaries of the more important components of goat diets are given in boxes. Where the scientific name for the fodder has not been identified the local name only is given.

***Acacia leucophloea***
**Arunjia, Ronjia, Orinja, Reunja, Safed Kikar**

| Summary |
| --- |
| Pods: good protein source, potential toxicity problems.<br>Leaves: moderate to poor energy and protein source. |

Important and **widespread** dry season fodder for goats in Rajasthan. Lopped November to March(M+C, 1997) and[k] pods available Feb - March. New leaves flush in May and are an important browse for goats when feed is in short supply.*
Consumed by all livestock[k].
Actively managed fodder tree in Rajasthan.[l]

Less productive than *Prosopis cineraria* and *Acacia nilotica* at 6.45±4.70 kg DM/tree of fresh loppings, indicative yield of leaves + pods 6.2 - 13.6 kg DM/tree[m].

Should be fed in limited quantities as plants can contain cyanogenic glycosides, particularly from leaves and immature pods.[e] Pods should be fed fresh as they become toxic after some hours, it is said by farmers. Also mature pods are avoided by farmers. Toxicity of fresh pods a problem with pods from some trees only, and can be caused by mature as well as immature pods. Toxicity of pods varies from year to year according to farmers.[m]

Composition (% dry basis):
Leaves CP 19.5 to 21.8 (15.3 also reported[m] and 16.9 in new leaves*), ADF 19.7 to 27.0; NDF 35.8; pods CP 18.4 to 21.8, ADF 21.6 to 22.8, lignin 8 to 9, Total Phenols 5 to 10.
In vitro characteristics*:
Fermentation: Pods rich in fermentable protein and carbohydrate. Mature leaves very poorly fermentable, but new leaves are much more highly fermentable.
pods: rate constant b 0.040 $h^{-1}$, DMD 57%
Mature leaves (sampled in March): rate constant b 0.029 $h^{-1}$, DMD 32%
New leaves (sampled in May): rate constant b 0.024 $h^{-1}$, DMD 47%, IVDMD 54%.
Mature leaves (sampled in July): rate constant b 0.026 $h^{-1}$, DMD 40%, IVDMD 44%.

***Acacia nilotica***
**Babul, gum arabic tree**

| Summary |
| --- |

Pods: good source of protein
Leaves: moderate energy and protein source

Medium-sized thorny evergreen with rough black trunk and straight sharp spikes. Grows in dry regions, but also endures floods. A browse tree with pods and leaves that are excellent fodder and are available when there is no grass. Pods also collected as a supplement for dairy cattle. Used in rotation with grass to improve the soil. The pods are reported to contain tannic acid and must be ground before feeding to cattle, as otherwise the seeds pass undigested with faeces.[j] Pods and leaves contain tannins. *A. nilotica* also contains catechin gallates.[e] Important and **widespread** source of dry season fodder for goats in Rajasthan. Loppings also fed to cattle in some districts. Pods in trees in March to April, lopped Feb to April.(M+C,1997). Pods are purchased by some farmers in March/April. Loppings important Sept to Oct. Regarded as good quality fodder, associated with early inducement of oestrus.[l]
Actively managed fodder tree in Rajasthan.[l]

Yield of fodder less than *Prosopis cineraria* but more than *A. leucophloea* at 15.20±9.33, indicative yield of leaves + pods 15.1 to 60 kg DM/tree[m].

*A. nilotica* composition (% dry basis)[e]*:
Leaves: CP average 13.7 (range 11.9 to 16.2), CF 21.4 (11.3 to 31.6), Ash 6.4 (5.5 to 7.3), EE 5.6 (2.0 to 12.6), NFE 52.9 (42.9 to 59.1), lignin 13, TP 9
Fruit: CP 12.0 (10.4 to 13.1), CF 17.0 (12.3 to 28.5), Ash 6.6 (4.7 to 13.8), EE 2.0 (0.8 to 3.0), NFE 62.3 (51.2 to 68.6), NDF 31.6, ADF 22.5
Pods: CP 9.7, Ash 6.5, NDF 29.8, ADF 22.8
Seeds: CP 21.1, Ash 6.9, NDF 39.8, ADF 29.3.
Digestibility pods = 61 - 66% but seeds can pass undigested through gut.[e]
Pods, digestibility (%) in sheep: CP 51.7, CF 21.2, EE 88.2, NFE 79.0, ME 2.40[j]

Fruit of medium nutritive value (for Acacia fruit) leading to growth rates of 16.1 g $day^{-1}$ g in sheep when supplementing maize stover)[g]

In vitro characteristics*:
Fermentation: Pods especially, but also leaves, rich in fermentable protein and carbohydrate.
pods: rate constant b 0.0153 $h^{-1}$, DMD 66%
leaves: rate constant b 0.0146 $h^{-1}$, DMD 60%, IVDMD 38%

**Kumta**
***Acacia senegal***

Small tree, 2 - 3m high, can grow under most adverse heat and drought conditions. Foliage browsed by goats and camels, cattle eat pods.[j] Low yield of leaves, but reasonably high yield of timber. CP leaves = 18.2 to 20.5%, fruit 19.6 to 22%, seeds 38.9 to 40.1%.[e] CP of 10.3% also reported.[m]
Not actively managed fodder tree in Rajasthan.[l]

Composition (% dry basis)[j]:

| | |
|---|---|
| dry leaves | CP 18.2, CF 11.2, Ash 8.4, EE 6.7, NFE 55.5 |
| pods | CP 22.0, CF 39.0, Ash 7.1, EE 1.0, NFE 30.9 |
| seeds | CP 40.1, CF 13.7, Ash 5.0, EE 5.8, NFE 35.4 |

In sacco degradability of leaves[j]

| | a % | b % | c ($h^{-1}$) |
|---|---|---|---|
| DM | 28 | 55 | 0.111 |
| N | 17 | 73 | 0.107 |

***Acacia tortilis***
**Israeli babool, umbrella thorn**

Tree up to 10 m high with dark grey bark and a flat crown. The leaves, 5 cm long, are usually hairy and have pairs of white thorns, both straight or one recurved, at their base. The flower heads are cream-coloured spherical. The pods, irregularly twisted, are 3-5 cm long and generally less than 1 cm broad. The leaves and fruits are often eaten by stock. Cases of poisoning are rarely reported.[j] Fast growing. Fruits and leaves of young trees used as feed, provides timber, fuelwood. Fruits contain soluble phenolics, tannins. Yield of leaves relatively modest (2.3 to 10 kg DM/tree reported[m]), low yield of timber.

Actively managed fodder tree in Rajasthan.[l] Preferred species in Rajasthan[d]

Fruits depress intake of roughage when used as supplement, but increased DM and CP intake overall. Some 46% of seeds have been found to pass gut undigested. CP pods vary with site and season, 10.4 to 17.8% reported.[f]
Fruit of relatively high nutritive value leading to higher growth rates than A nilotica fruit (32.3 g $day^{-1}$ g in sheep when supplementing maize stover)[g]

Composition (% dry basis)[j]:

| | |
|---|---|
| fresh leaves | CP 19.2, CF 11.6, Ash 8.7, EE 6.1, NFE 54.4 |
| pods | CP 17.3, CF 24.8, Ash 5.7, EE 3.1, NFE 49.1 |
| seeds | CP 37.8, CF 10.9, Ash 5.9, EE 6.0, NFE 39.7 |
| pod husks | CP 8.7, CF 34.3, Ash 6.2, EE 1.6, NFE 49.2 |

Contain cyanogenic glycosides. CP leaves 6.5 to 19.2%, fruit 12.3 to 17.8%, pods 7.8%, seeds 19.1 to 37.8%[e]

Nylon bag degradabilities[j]

| | a % | b % | c ($h^{-1}$) |
|---|---|---|---|
| pods, DM | 25 | 45 | 0.082 |
| pods, N | 48 | 41 | 0.074 |
| leaves, DM | 33 | 33 | 0.057 |

***Ailanthus excelsa***
**Ardu/Paba**

Lopped Oct to Feb, no pods (M+C, 1997). Indicative yield 11.9 to 82.2 kg DM/tree.[m] Actively managed fodder tree in Rajasthan.[l]

CP 19% (16.3%[m]), ADF 42%, ADF 48%. Regarded as a good fodder by farmers.[l] Total digestible nutrients (TDN) 63.8%[m]. Mature leaves highly palatable and nutritious, usually fed to sheep and goats.[n]

***Albizia lebbeck***
**Siris (t:Kalio), Sisis**

Preferred species in Gujarat and Rajasthan[d] Lopped in October (M+C, 1997).
Total digestible nutrients (TDN) 63.8%, CP 14.9 TO 26.5%[m]
Not actively managed fodder tree in Rajasthan.[l]

***Anogeissus latifolia***
**Chanbor, dhaura, Gum ghatti**

Deciduous tree found in drier areas. The leaves contain tannin but are nevertheless browsed by cattle. CP has very low digestibility (8%).
Composition (% dry basis)[j]: Leaves CP 7.5, CF 24.2, Ash 9.5, EE 3.6, NFE 55.2; digestibility % (sheep) CP 8, CF 32.0, EE 53.0, NFE 64.0, ME 1.73.
Nylon bag data (%), leaves, DM a = 23.7, b = 52.1, c = 0.114 per h
young twigs, DM a = 24, b = 36, c = 0.039 per h[j]

Nylon bag degradabilities[j]

| | a % | b % | c ($h^{-1}$) |
|---|---|---|---|
| leaves, DM | 23.7 | 52.1 | 0.114 |
| Young twigs, DM | 24 | 36 | 0.039 |

***Anogeissus pendula***
**Dhokra**

Available in Rajasthan in June, at period of greatest need and is also lopped during the monsoon season when fields under cultivation (M+C, 1997).

***Anogeissus seracea***
**Kakaiya**

No information found.

***Arundinaria cannavieira***
**Bans, Bamboo**

Tall shrub forming more or less extensive colonies in dry areas, often at high altitudes, where it is frequently an important source of forage.

Composition (% dry basis) leaves[j]* CP 9 - 15, CF 15, Ash 3, EE 2, NFE 48, lignin 7, TP 0.4.
Digestibility (%) leaves[j] in cattle CP 71, CF 54, EE 4, NFE 83, ME 2.23.

In vitro characteristics*:
Fermentation: extensively fermented.
leaves: rate constant b 0.029 $h^{-1}$, DMD 70%, IVDMD 58%

***Azadirachta indica***
**Neem**

Summary
Leaves: good energy source

Large evergreen tree with edible fruits and aromatic leaves found throughout southern Asia. A mature tree can produce 350 kg of leaves a year (6.6 to 57.9 kg DM/tree also reported[m]), which may be used for feeding cattle during famines. After the oil has been pressed from the seeds, the cake is used as fertilizer, but it can also be used as feed. Up to 10% neem cake may be included in concentrates for cattle and up to 5% for poultry. The oilcake has a very bitter taste.[j] Preferred species in Gujarat and Rajasthan[d] Used as anthelmintic for goats and is said to give healthy looking animals when fed. Leaves are lopped June to Oct and Jan to Feb, the small pods not considered important as animal feed (Matthewman and Conroy, 1997). The pods can be sold to traders for oil extraction (for medical use). Neem trees are often planted around houses and are not common on communal land.

Actively managed fodder tree in Rajasthan.[l]

Composition (% dry basis) [j]*: leaves CP 11.6 to 13.4, CF 14.7, NDF 26.5, Ash 9.1 to10.3, EE 3 to 6.2, NFE 55.5, lignin 9, TP 3.
neem cake CP 17.1, CF 28.2, Ash 15.4, EE 2.3, NFE 37.3.
Digestibility leaves (cattle), CP 52.0%, CF 23.0%, EE 58.0%, NFE 68.0%, ME 2.03[j]
In vitro characteristics*:
Fermentation: Leaves highly fermentable but apparently deficient in fermentable protein, possible source of by-pass protein.*
leaves: rate constant b 0.032 - 0.050 $h^{-1}$, DMD 62 - 67%, IVDMD 72.5%

***Balanites aegyptica***

**Hingota, Desert date**

| Summary |
| --- |
| Leaves: good energy source |

Small or medium-sized tree 3.5-5.5 m high with recurved spiny branches and fleshy succulent leaves. Found mostly on flat land with slightly impeded drainage. As it is drought resistant, it is common in the Sahel. Goats eat the leaves avidly and also pick up the datelike fruits when they fall to the ground. The young spines are soft, and cattle eat young branches when other browse is scarce. Low fibre, probably rich in soluble sugars.[j]

Not actively managed fodder tree in Rajasthan.[l]

Composition (% dry basis)[j]

| | |
| --- | --- |
| Leaves | CP 11.6, CF 13.6, Ash 12.7, EE 4.2, NFE 56.9. |
| Early vegetation | CP 27.5, CF 23.3, Ash 6.6, EE 1.5, NFE 41.1 |
| Fruit | CP 11.1, CF 10.2, Ash 8.1, EE 1.7, NFE 68.9.[j] |

***Bauhinia racemosa***
**Hetri**

No information found.

***Boswellia serrata***
**Shehtoot (h:Shetrit)**

Not actively managed fodder tree in Rajasthan[l]

No information found on composition or nutritive value.

***Butea monosperma***
**Khakhra/Dhak, Dhat**

Buffuloes fed leaves in dry season (M + C, 1997).
Fed to buffaloes only[k]
**Widespread** in some areas of Rajasthan e.g. Bhat[k]. Lopped Nov to Dec.
Actively managed fodder tree in Rajasthan.[l]

***Calotropus gigantea***
**Akadi**

No information found.

***Capparis decidua***
**Khair**

Not actively managed fodder tree in Rajasthan.[l] Young twigs used a fodder for cattle and goats. Fruits used for human consumption

***Cassia fistula***
**Goondi, amaltas, golden shower tree, pudding-pipe tree, purging cassia**

Medium sized tree with large compound leaflets 5 – 15 cm long and large clusters of bright yellow cascading blossoms. Pods up to 1 m long. Twigs commonly lopped for fodder.[j] Not eaten by cattle and not noted for fodder use in North West India.[n]

Composition (% dry basis):[j]
Fresh leaves: CP 18, CF 30, Ash 8, EE 8, NFE 37

***Cenchrus ciliaris***
**Pharangli,** Anjan, blue buffalo grass, African foxtail, Rhodesian foxtail, buffel grass

A very variable tufted tussock-forming perennial grass with stems up to 1.5 m high and a large, strong root system. Grows in areas with 400-500 mm of summer rainfall and a long dry season. Found on many types of soil, but prefers sandy soils and is sensitive to waterlogging. High protein content and digestibility. Palatable when young, but protein content and digestibility diminish quickly with age. Good pasture grass for dry areas. Once established, withstands close grazing and fire. Recovers quickly if phosphorus available. Easily established from seeds, and widely used for seeding denuded arid pasture lands. Grows well with *Stylosanthes humilis*.

Composition (% dry basis)[j]

| | CP | CF | Ash | EE | NFE |
|---|---|---|---|---|---|
| early vegetative | 9.8 | 38.4 | 9.8 | 5.4 | 36.6 |
| fresh mature | 7.3 | 41.9 | 8.8 | 4.8 | 37.2 |
| early bloom | 11.0 | 31.9 | 13.2 | 2.6 | 41.3 |
| hay, first cutting | 7.4 | 35.2 | 11.7 | 1.7 | 44.0 |

Digestibility (%)[j] , early bloom, sheep CP 76.2, CF 76.2, EE 85.0, NFE 72.9, ME 2.50
hay, sheep CP 54.0, CF 71.6, EE 47.0, NFE 67.5, ME 2.22

***Ceropagia bulbosa***
**Godala**

No information found.

***Citrus medica***
**Anni/Arni**

No information found.

***Clerodendrum phlomidis***

**Aruni**

A tree species. No information found.

***Cordia dichotoma***
**Umbia, lasora or gunda**

Leaves used as fodder for goats, leaves about 12 to 16% CP and 16 to 27% CF. Fruits have medicinal properties.[n]

***Derris indica***
**Negad**

Summary
Leaves: moderate to good energy source

Leaves used as fodder.

Composition (% dry basis)*: CP 10 to 13, NDF 35 to 41, ash 6, EE 3 to 5, lignin 11, TP 3.
In vitro characteristics*:
Fermentation: Medium to high fermentability; appeared to be very deficient in fermentable protein but may be a source of by-pass protein.
leaves: rate constant b 0.045 $h^{-1}$, DMD 58 - 64%, IVDMD 73%

***Dichrostachys cinerea***
**Halar,** Sicklebush, Christmas bush

Shrub up to 3 m high with grey bark and solitary thorns often bearing one or two leaves. Leaves bipinnate and finely pubescent, 2-8 cm long. Pendulous flower heads that are pink in the upper part and yellow in the lower part. Dark-brown pods, borne in clusters, twisted, each 5-8 cm long and 0.5-1 cm broad. Pods eaten by livestock. In bush country often causes serious problems in over-grazed areas and forms impenetrable thickets. Browsed during the dry season. Dried leaves (leaf litter) consumed on hills in summer in Udaipur district.

Composition (% dry basis)[j] Pods CP 16.6, CF 22.1, Ash 5.6, EE 5.4, NFE 50.3.[j]

***Emblica officinalis***
**Pipal, aonla, amla, Indian gooseberry**

Fruits used in a range of medicinal preparations. Foliage and fruits consumed by livestock.[n]

***Eucalyptus teriticornis***
**Neelgiri/Safeda**

Leaves are a source of essential oil (cineole) which had medicinal properties. Not noted as a fodder tree.[n]

***Fernum gricum***
**Methi**

Seeds use as dry season feed in Rajasthan. Leaves cut and fed in March in Bhilwara, Rajasthan (M + C, 1997)

***Ficus indica***
**Pimpal**

| Summary |
| --- |
| Leaves: good energy source |

Composition (% dry basis)*: CP 12, NDF 43, ash 14, EE 3, lignin 8, TP 1.
In vitro characteristics*:
Fermentation: rapidly and extensively fermented.
leaves: rate constant b 0.068 $h^{-1}$, DMD 69%, IVDMD 75%

***Ficus religiosa***
**Kronda, Peepul, bo tree**

Large glabrous tree with leathery, shining, broad-based, pointed leaves. Commonly grown as an avenue tree. The leaves and branches are extensively lopped for fodder.
Composition (% dry basis) [j]:

| | |
| --- | --- |
| Leaves | CP 9.0, CF 15.9, Ash 20, EE 2.7, NFE 52.4; |
| Leaves and twigs | CP11.7, CF 26.1, Ash 15.3, EE 2.9, NFE 44.0. |
| Digestibility (%)[j] | |
| Leaves (cattle) | CP 59.0, CF 22, EE 36, NFE 52, ME 1.42; |
| Browse (cattle) | CP 55.0, CF 19, EE 46, NFE 37, ME 1.15.[j] |

***Garuga pinnata***
**Tamat, Dhaman grass, Lapna**

| Summary |
| --- |
| Leaves: moderate energy and protein source |

Composition (% dry basis)*
Fresh leaves CP 9.7 to 9.9, ADF 28.8 to 32.6, lignin 7, TP 2
Dry leaves CP 7, NDF 31, Ash 17, EE 1, lignin 4 to 7, TP 1 to 4.
In vitro characteristics*:
Fermentation: Sufficient in fermentable protein.
Fresh leaves: rate constant b n/a (no fit to model), DMD 70%, IVDMD 68%
Dry leaves: rate constant b 0.029 – 0.035 $h^{-1}$, DMD 60%, IVDMD 62 to 64%

***Gmelina arborea***
**Karmela, shewan, gumbhar, Malay bush tree**

Utility timber and firewood crop (up to 30 m3/ha/annum). Potential fodder species but relatively low palatability.[j] Leaves used as cattle fodder and for silkworms, CP about 12%.[n]

***Gossypium sp.***
**Cotton pala**

Summary
Leaves: moderate energy source

Stems, branches and leaves of cotton plants can be ground, ensiled or hydrolysed with sodium hydroxide for feeding to beef cattle.[j] In Rajasthan cotton plants are browsed in the fields or the leaves knocked off, collected and stored as cotton pala.

Composition (% dry basis):
Cotton wood[i]: CP 5, CF 65, ash 8, EE 1, NFE 44
Dry leaves (cotton pala)*: CP 13, NDF 46, Ash 13, EE 3, lignin 14, TP 0.6.

In vitro characteristics*:
Fermentation: Deficient in fermentable protein.
Dry leaves (cotton pala): rate constant b 0.053 $h^{-1}$, DMD 52%

***Grewia hirsuta***
**Athedi**

No information found.

***Holorrena antidisentrica***
**Kadwa/Kadwo**

Summary
Leaves: Moderate energy source

Dried leaves (leaf litter) consumed in summer in hills in Udaipur district.

Composition (% dry basis)*
Fresh leaves CP 12, NDF 34, Ash 7, EE 1, lignin 10, TP 2
Dry leaves (leaf litter) CP 7 to 9, NDF 32 to 36, Ash 11 to 14, EE 2 to 5, lignin 9 to 12, TP 1 to 3

In vitro characteristics*:
Fermentation: Readily fermentable, but may be slightly deficient in fermentable protein.
Fresh leaves: rate constant b 0.048 $h^{-1}$, DMD 60%, IVDMD 84%
Dry leaves (leaf litter): rate constant b 0.046 – 0.048 $h^{-1}$, DMD 58 - 61%, IVDMD 66%

***Lannea coromandelica***
**Hawan**

No information found.

***Leucaena leucocephala***
**Subabul**

Well researched and established as a valued source of energy, protein and sulphur for rumen microbes. Used as fencelines, fuel wood and N enrichment of soil. Stimulates liveweight gains when fed as supplement to roughage. Contains mimosine and tannins. Certain rumen bacteria can degrade mimosine making it harmless and have been successfully introduced into Australia where such bacteria were not native.[g] Actively managed fodder tree in Rajasthan (in less arid districts only).[l]

CP leaves 19.7 to 26.6%[h]

Composition (% dry basis)[j]:

| | CP | CF | Ash | EE | NFE |
|---|---|---|---|---|---|
| fresh leaves | 21.0 | 18.1 | 8.4 | 6.5 | 46.0 |
| fresh twigs | 27.8 | 10.4 | 3.5 | 3.2 | 55.1 |
| fresh browse | 24.2 | 24.2 | 8.9 | 2.7 | 40.0 |
| pods | 21.7 | 25.6 | 5.8 | 1.4 | 45.5 |
| seeds | 35.8 | 11.4 | 4.4 | 7.5 | 40.9 |

Dry matter digestibility of leaves and stems, goats 53.9 to 56.4%, sheep 50 to 50.5%[i]
Digestibility of browse in cattle CP 65%, CF 35 %, EE 36%, NFE 74%, ME 2.13
Nylon bag dry matter degradabilities, crushed leaves a = 28.7%, b = 55.7%, c = 0.0209 $h^{-1}$. [j]

In vitro characteristics*:
Fermentation: Mixed leaves, pods, twigs: rate constant b 0.036 to 0.037 $h^{-1}$, DMD 40 to 43%

***Madhuca indica***
**Mahua, Mowra, mowrah, Illipi, mee**

Native to southern Asia and cultivated for the edible fat in their fleshy seeds. The oilcakes are rich in saponin and toxic, causing injury to the mucosa of the digestive tract and haemolysis of the blood. Detoxification by heat treatment has been attempted, but the treated cakes are very low in digestibility (digestibility in sheep of CP 11.9%, CF 54.4%, EE 83.8%, NFE 17.1%, ME 1.14).[j]
Composition (% dry basis)[j]: (oilcakes mechanically extracted)

| | |
|---|---|
| oilcake | CP 16.0, CF 3.1, Ash 5.7, EE 10.9, NFE 64.3 |
| oilcake, detoxified | CP 29.0, CF 12.6, Ash 10.5, EE 7.7, NFE 40.2 |

Flowers a good energy source CP 8.4, CF 82.8, Ash 7.8, EE 1.4, TDN 73.7%

***Mangifera indica***
**Mango**

Principally a fruit tree, but leaves can be used as livestock feed.

Composition (% dry basis)*
Fresh leaves CP 7, NDF 43, Ash 16, EE 4, lignin 10, TP 6

In vitro characteristics*:
Fermentation: Fresh leaves: rate constant b 0.042 $h^{-1}$, DMD 50%, IVDMD 65%

***Medicago sativa***
**Palak, Lucerne, alfalfa, purple medick, snail clover, Chilean clover**

Deep-rooted perennial herb with a thick trunk root, occurring in a wide range of varieties. From the root crown arise a number of stems carrying trifoliate leaves and purple flowers in clusters of ten to seventy. Demands sunshine and tolerates high temperatures as long as they are not combined with high air moisture. It is generally grown alone but can also be mixed with grasses or other legumes. It is used for green fodder, for hay or silage, and for pasture, although it does not tolerate close grazing well. It is extensively sown under irrigation. The leaves are highly nutritive and are often dried for 2.5-5% inclusion in animal feeds as a source of vitamin A and other nutrients. During gestation and lactation a minimum of 10% lucerne leaf meal is usually included in the diet of sows. Unfortunately, the leaves are easily lost in haymaking. Good hay can be machine threshed so that the stems can serve as roughage, and the leaves can be used in concentrate mixtures. Sun-cured leaves contain less vitamin A than artificially dried leaves but provide vitamin D instead. Where lucerne can easily be grown, it is regarded as a key forage for high-producing ruminants because of its richness in protein, palatability and high calcium and vitamin content. In many cases supplements are not required by animals feeding on lucerne. It should be harvested before full bloom; the nutritive value and digestibility are lower after bloom. It can be used as pasture also for pigs and poultry.
Extensive data on composition and digestibility available.

Composition (% dry basis):
CP 14 to 25, CF 19 to 31, Ash 8 to 17, EE 2.4 to 4.3, NFE 36.1 to 48.2.
Digestibility, sheep, CP 69 to 89%, CF 45 to 80%, EE 21 to 60%, NFE 61 to 81%, ME 2.01 to 2.68.
Nylon bag data (meal) a = 24.9 to 39.3%, b = 36.6 to 44%, c = 0.0352 - 0.0491 per h.[j]

***Melia azedarach***
**Mujal,** Persian lilac, Indian lilac, Chinaberry, pride of India, bead tree

Fast growing tree up to 10 m high that blooms with giant clusters of fragrant flowers. The slightly poisonous fruit are about the size of a cherry. The leaves are palatable to goats.[j] Preferred species in Rajasthan[d] Leaves lopped for fodder for goats and are nutritious, but used only as emergency fodder. Root used as anthelmintic. Leaves astringent and have medicinal properties.[n]

Composition (% dry basis):
Fresh leaves CP 12 to 22, CF 12 to 15, Ash 11 to 12, EE 6 to 9, NFE 47 to 55

Digestibility (%):
Leaves in cattle: CP 50, CF 51, EE 65, NFE 54, ME 1.93

***Miliusa tomentosa***
**Arandia**

No information found.

***Morus alba***
**Kalambi, White Mulberry**

Wide-spreading round-headed tree up to 15 m high with grey or greyish yellow branches bearing thin, rather small light-green leaves. The leaves are palatable to cattle. In North Africa the coppice shoots are harvested for animal fodder.
Composition (% dry basis):[j]
Leaves CP 15.0, CF 15.3, Ash 14.3, EE 7.4, NFE 48.0.
Stems CP 3.0, CF 53.9, Ash 2.5, EE 2.0, NFE 38.6
Aerial part CP 14.4, CF 28.5, Ash 5.3, EE 3.5, NFE 48.3.
Digestibility (%) leaves, cattle, CP 71, CF 54, EE 4, NFE 83, ME 2.23.[j]

***Opuntia* spp**. Prickly-pear cactus
**Thor, Cactus**

| Summary |
| --- |
| Good energy source |

One of the largest genera of cactus, comprising at least three hundred species which are highly variable in habit and size. The stems and branches have flat cylindrical or globular joints, usually very fleshy. Some species are almost spineless. The opuntias are commonly large and rampant. They are sometimes cultivated as hedge or for the edible fruits, but they are more commonly regarded as a weed in arid and semiarid areas.

The prickly pears are sometimes used as an emergency feed for animals during droughts, but the spines must first be destroyed by passing a flame over the surface of the plant. The spines are dry and burn easily, especially if they are abundant and close. If large quantities are used, the material can be chopped so that the spines are thoroughly broken up. If they can still cause harm, the broken spines should be

winnowed out. Other methods of making the spines harmless are soaking in water, steaming or washing with soda. Because of its high water content and high average salt content, prickly-pear cactus is laxative when fed in large quantities. The opuntias are fairly palatable and when fed in liberal amounts can replace drinking water; however, the nutritive value is not sufficient to maintain weight in animals receiving only cactus. Sheep in good condition are known to survive up to eight months on a diet consisting entirely of opuntia. Preferably the feed should be supplemented by other less succulent dry feeds, such as 1-2 kg of straw or dry grass and 0.5 kg of cottonseed daily. Prickly-pear cactus is sometimes combined with poor quality straw or hay in silage.
Composition (% dry basis)[j]
Various species, branches or aerial parts CP 4.0 to 9.6, CF 10.9 to 13.8, Ash 14.0 to 24.4, EE 1.3 to 4.1, NFE 49.8 to 62.9.
Indian cactus*: CP 5, NDF 31, ash 10, EE 6, lignin 7 TP 1.

Digestibility (%)[j]:
cattle, aerial parts CP 69.4, CF 62.3, EE 72.9, NFE 67.2, ME 2.23;
sheep, leaves CP 68.1, CF 53.2, EE 31.1, NFE 73.9, ME 1.91.

In vitro characteristics*:
Fermentation: Very highly fermentable compared to tree fodders, but low crude protein content.
Dried: rate constant b 0.064 $h^{-1}$, DMD 81%, IVDMD 61%

***Pithecellobium dulce***
**Jangal jalebi, Manila tamarind**

Large rapid-growing tree up to 18 m high with pinnate leaves and spiral-twisted reddish pods containing black seeds. Cultivated as hedge and as a shade tree. Used for lopping and browsing. The pods are very palatable.[j] Preferred species in Rajasthan[d] Lopped all year round, pods in April (M+C, 1997)
Regarded as a good fodder by farmers.[l]
Actively managed fodder tree in Rajasthan.[l]

Composition (% dry basis)[j]
fresh leaves CP 29.0, CF 17.5, Ash 5.6, EE 4.4, NFE 43.5
fresh leaves plus twigs CP 30.6, CF 23.1, Ash 5.0, EE 3.0, NFE 45.4

***Pongamia pinnata***
**Karanj, dhawda, pongam, Indian beach**

| Summary |
| --- |
| Moderate energy source |

Ripe pods available from December/January to May. Leaves fed to livestock, green pods fed to cattle in Maharashtra. Digestibility of leaves poor, CP about 18%. Young leaves not liked by cattle. Leaves used as insect repellent in grain stores and suppress nematode population in soil.[n]

Leaf litter consumed by goats in dry season (May).
Composition leaf litter (% dry matter):*
CP 10 to 11, NDF 25 to 31, Ash 16, EE 1 to 2, lignin 4 to 8, TP 2 to 4
Appeared to contain a toxic factor (not identified).
In vitro characteristics*:
Fermentation: Leaf litter: rate constant b 0.049 to 0.054 $h^{-1}$, DMD 61 to 63%, IVDMD 67 to 76%

***Prenna* spp**
**Amena**

No information found.

***Prosopis cineraria***
**Khejri**

Summary
Pods: good protein and energy source
Leaves: poor energy source

Well adapted to arid and semi-arid climates, wood useful, possible medicinal use. Fruits attractive to humans and livestock, but only when ripe, and considered by some to be more important than leaves. Valued famine food[c]. A preferred fodder in Rajasthan and Gujarat.[d] Important and **widespread** dry season fodder for goats. Actively managed fodder tree in Rajasthan.[l] Lopped October to January, pods available in March (M+C,1997) Tree lopped and branches left to dry for 10-14 days, the dried leaves beaten off with sticks and stored. Product known as Loong[m] Particularly common in Northern Rajasthan. Said to be of high fodder quality[l]. Said to be regarded as sacred objects by some villagers and they are not lopped by villagers with these beliefs (Agrawal, 1994).

High yield of fodder at 26.20±15.87 kg DM/tree for fresh loppings and 23.50±22.78 kg DM/tree for dried leaves. Indicative yield of leaves and pods (kg DM/tree) 17.2 - 67.1. [m]

CP 9 - 17%, sucrose 17 - 31%, estimates of digestibility vary widely. Leaves said by some to be well accepted, but unacceptable by others, low digestibility possibly due to tannins and lignification of leaves and twigs. Leaves collected in Feb - March for feeding later in year, average composition and range (% dry basis):
CP 15.9 (range 9.9 to 21.9), CF 19.6 (14.6 to 22.6), Ash 8.2 (6.2 to 10.1), EE 3.4 (2.7 to 4.3), NFE 54.4 (52.8 to 57.2), NDF 59.1 (41.0 to 64.%), ADF 40.6 (32.2 to 49.3).
Contain tannins and alkaloids. High tannin leaves can kill cattle. Young leaves said to be high in tannins and levels very variable. Not recommended as sole feed. Management and genetic range little investigated, but could be important.[c]

TDN % = 41.0 [m]

Composition (% dry basis):*
Leaves: CP 12, NDF 36, ash 8, EE 2, lignin 12

Pods: CP 16, NDF 33, ash 4, EE 2, lignin 4, TP 5

In vitro characteristics*:
Fermentation: Pods highly fermentable, but leaves particularly poorly fermented.
Leaves: rate constant b 0.042 $h^{-1}$, DMD 30%, IVDMD 45
Pods: rate constant b 0.051 $h^{-1}$, DMD 77%, IVDMD 90.

***Prosopis juliflora***
**English babul, vilayati babool, mesquito**

Summary
Pods: good protein and energy source
Leaves: not palatable, not used as feed

A tree up to 10 – 15 m high, grows in arid and semi-arid regions. Native to Peru, Chile and Argentina. Introduced to Rajasthan during the period of British rule, hence the name English babul. Leaves not palatable to cattle but pods used as a supplement for cattle, sheep, goats, horses, donkeys. Pods mostly available in dry season. Used in W. Gujurat where it is often boiled before use as feed. Safe to feed to 30 to 40% of diet. Pods: CP 17%, sugar 25%; seeds: 30 to 40% CP, 7 to 8% oil.[n] Pod harvest is an easy but costly manual operation. Pods can be stored in wood-lined or brick houses, or in layers of sand, and may be stored for several years but are very prone to insect attack. Pods used to feed cattle, horses, sheep, goats; only ripe pods should be fed and poisonings have been recorded from pods eaten after exposure to rain.[j]

Composition (% dry basis):*[j]
Pods: CP 12 to 14, NDF 38, CF 28, ash 4 to 5, EE 1 to 3, lignin 4, TP 2

Digestibility (%):[j]
Pod meal: CP 80, CF 71, EE 91, NFE 83

In vitro characteristics*:
Fermentation: Pods: rate constant b 0.034 $h^{-1}$, DMD 81%, IVDMD 75%

***Ricinus communis***
**Limboo, Castor**

Species with variable properties, commonly an annual herb in temperate climates and a perennial tree in tropical climates. Cultivated for its oilseeds and also for ornamental purposes as some varieties have beautifully coloured leaves.
Composition (% dry basis): [j]
Leaves CP 24.8, CF 10.3, Ash 12.4, EE 5.4, NFE 47.1.

***Tamarindus indica***
**Imli (t:Amali), Tamarind**

Medium-sized stately tree up to 12 m high with a dense rounded crown of feathery leaves. The pale-yellow flowers with dark-red buds are succeeded by pods 3 cm broad and l 5 cm long containing a dark-brown edible sour pulp. To make the seeds palatable to cattle, they should be ground and soaked in water for an hour before feeding.
Composition (% dry basis):[j]
Leaves (India) CP 13.4, CF 17.7, Ash 9.5, EE 7.0, NFE 52.4
seeds CP 18.3, CF 26.4, Ash 3.5, EE 7.4, NFE 44.4.
Nylon bag degradability leaves, DM a= 26%, b= 45%, c= 0.0473 $h^{-1}$.

***Trifolium alexandrium***
**Berseem, Egyptian clover**

A vigorous true clover resistant to alkaline soils, usually cultivated under irrigation for pasture, green fodder and silage. One of the most important legumes of the Near East and the Mediterranean. Very palatable. May be cut several times a season and produces heavy yields under favourable conditions. The succulent stems are, however, difficult to dry because of their high water content, and the leaves drop off very easily in the dry state. The highest yield of protein with a relatively low yield of fibre obtained by cutting the plant at a height of about 40 cm. Valued for its rapid growth in the cooler winter season in the subtropics and for its good recovery after cutting. Up to six cuttings can be taken from the Miscari variety under irrigation; one or two cuttings can be taken from the Fahl variety on dry land. The herbage quality is good, and cultivation improves the soil nitrogen status. Tolerant of soil alkalinity and salinity. Affects of cutting time on composition and digestibility has been studied.
Composition (% dry basis)[j] data exists for different times of cutting from different countries:
CP in range 12.4 to 26.7, CF 14.9 to 36.1, Ash 8.6 to 19.7, EE 1.4 to 4.4, NFE 32.8 to 41.0.
Digestibility (%) varies with cutting etc.[j]
CP 60 to 80, CF 47 to 72, EE 49 to 64, NFE 65 to 83, ME 1.99 to 2.46

In sacco degradation data

| | | a (%) | b (%) | c (per h) |
|---|---|---|---|---|
| 3 to 4 weeks | DM | 21.9 | 68.8 | 0.0723 |
| (early) | N | 5.7 | 90.3 | 0.0651 |
| 3 rd young | DM | 24.3 | 59.4 | 0.0696 |
| stage (late) | N | 38 | 58.5 | 0.0535 |

***Vitex negundo***
**Khirani/Khanni**

Summary
Leaves: good protein source, consumed selectively apparently due to toxic factors

Goats select green tips of new leaf growths, apparently to avoid toxic factors in more mature leaves.
Composition (% dry basis):*
New growth: CP 22, NDF 21, ash 7, EE 6, lignin 4, TP 4
All green leaves: CP 12, NDF 35, ash 8, EE 8, lignin 7, TP 2

In vitro characteristics*:
Fermentation: New growth is highly fermentable and has a high protein content.
New growth: rate constant b 0.054 $h^{-1}$, DMD 82%, IVDMD 83%
All green leaves: rate constant b 0.065 $h^{-1}$, DMD 73%, IVDMD 84%

***Wrightia tintoria***
**Kankar**

No information found.

***Ziziphus mauritiana***
**Ber**

Summary
Leaves: good energy source, moderate protein source

Ground leaves used in combinations with other feeds in dry season in Rajasthan. Entire shrub can be cut, leaves allowed to dry and beaten off with sticks. Dried product called pala (a generic term for dried leaves collected as livestock feed). Low yielding at 1.0 to 1.6 kg DM/tree.[m]
Actively managed fodder tree in Rajasthan.[l]

Composition (% dry basis):*
Leaves CP 13 - 15, NDF 33 – 42, ash 8 – 15, EE 2, lignin 6 to 9, TP 4 to 7.

In vitro characteristics*:
Fermentation: Highly and rapidly fermentable leaves which are deficient in fermentable protein.
leaves: rate constant b 0.015 – 0.041 $h^{-1}$, DMD 46 - 63%, IVDMD 63 to 64

***Ziziphus nummularia***
**Bordi/Jharberi, Pala**

Prickly shrub with sweet small round fruits. The small leaves are dark green and velvety above, pale and densely woolly beneath. A valuable fodder for camels and livestock, highly valued in desert-like areas. Browsed as fresh leaves by goats or stored for winter use by beating them off dried cut branches and gathering them into heaps.

**Widespread** in Bhat, Rajasthan. Lopped in Nov to Dec.[k], or Jan[l]
Actively managed fodder tree in Rajasthan.[l] Preferred species in Rajasthan and Gujarat[d] Said to be consumed by goats only in Bhat, Rajasthan[k] Said to be a good fodder by farmers[l]

Composition (% dry basis):[j]
Leaves CP 11.5, CF 33.8, Ash 6.2, EE 1.6, NFE 46.9.
Digestibility (%)of leaves in cattle CP 47.0, CF 54.0, EE 28.0, NFE 69.0, ME 2.10.

Composition (% dry basis):*
Fresh leaves: CP 19, NDF 29, ash 6, EE 2, lignin 6, TP 9
Dried leaves (pala): CP 12 to 13, NDF 33 to 34, ash 13 to 14, EE 1 to 3, lignin 8, TP 4 to 7.

Dry matter digestibility, goats 45.7%, sheep 41.1%.[l]
TDN 49.7 to 58.0%.[m]

In vitro characteristics*:
Fermentation: possible source of by-pass protein.
Fresh leaves: rate constant b 0.022 $h^{-1}$, DMD 64%, IVDMD 45%
Dried leaves (pala): rate constant b 0.024 – 0.030 $h^{-1}$, DMD 51%, IVDMD 56 to 61%

***Ziziphus xylopyrus***
**Andruk**

Composition (% dry basis):*
Leaves CP 11.4 to 12.9, ADF 18.9 to 23.2

**Feeds not identified by scientific name**

**Amala**

No information found.

**Bel**

No information found.

**Champeli**

No information found.

**Dhawra**

Dried leaves (leaf litter) consumed in summer on hills in Udaipur district.

No information found on composition or digestibility.

**Hingoli**

Identified during goat monitoring in Bhilwara.

No information found on composition or digestibility.

**Hitazi**

Composition (% dry basis):*
Fresh leaves: CP 9, NDF 55, ash 9, EE 3, lignin 14, TP 4.

In vitro characteristics*:
Fermentation: Fresh leaves: rate constant b 0.043 $h^{-1}$, DMD 38%, IVDMD 45%

**Kabiti**

No information found.

**Kalbi**

Composition (% dry basis):*
Fresh leaves: CP 14, NDF 35, ash 16, EE 4, lignin 5, TP 0.6

In vitro characteristics*:
Fermentation: Fresh leaves: rate constant b 0.069 $h^{-1}$, DMD 76%, IVDMD 80%

**Kamboi**

No information found.

**Kanja, Kanaja?**

Dried leaves (leaf litter) consumed in summer on hills in Udaipur district. No information found.

**Ker**

Identified during goat monitoring in Bhilwara. No information found.

**Khalia**

No information found.

**Khavani**

No information found.

**Kimra**

No information found.

**Limda**

No information found.

**Tamata**

No information found.

**Timdi**

No information found.

**Vaibana (Creeper)**

No information found.

**Zadki**

No information found.

A summary of the major nutritive value characteristics of the most important tree fodders is given in Table 2.

**Table 2 Summary of chief characteristics of nutritive value of most important fodders**

| Scientific name | Where found | Chief characteristics |
|---|---|---|
| *Acacia leucophloea* | Bhilwara, Udaipur | |
| Pods | | Good protein source, potential toxicity problems |
| leaves | | Moderate to poor energy and protein source |
| *Acacia nilotica* | Bhilwara, Udaipur | |
| Pods | | Good protein source |
| leaves | | Moderate energy and protein source |
| *Azadirachta indica*, leaves | Bhilwara | Good energy source |
| *Balanites aegyptica*, leaves | Bhilwara | Good energy source |
| *Derris indica*, leaves | Udaipur | Moderate to good energy source |
| *Ficus indica*, leaves | | Good energy source |
| *Garunga pinnata*, leaves | Bhilwara, Udaipur | Moderate energy and protein source |
| *Gossypium sp.,* leaves | Bhilwara | Moderate energy source |
| *Holorrena antidisentrica*, leaves | Udaipur | Moderate energy source |
| *Opuntia* spp. ? | Bhilwara | Good energy source |
| *Pongamia pinnata* | Udaipur | Moderate energy source |
| *Prosopis cineraria* | Bhilwara | |
| pods | | Good protein and energy source |
| leaves | | Poor energy source |
| *Prosopis juliflora*, pods only | Bhilwara | Good protein and energy source |
| *Vitex negundo*, leaves | Udaipur | Good protein source |
| *Ziziphus mauritiana*, leaves | Bhilwara | Good energy source, moderate protein source |

**Sources of information**

* = This project
c = Clinch et al. (1993)
d = Rangnekar et al. (1992) Recent advances in goat production p 413 - 419
e = Bennison and Paterson (1993)
f = Bitende (1994)
g = Devendra C (1995a)
h = Topps (1992)
i = Devendra (1995b)
j = FAO tropical feeds database, version 8 (1998)
k= Hocking et al (1992) Recent advances in goat production p 707 - 716
l = Hocking and Kapila (1992) Recent advances in goat production
m = ISGP, 1993.

n = Singh (1995)

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