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Leaf protein: New protein source for ruminants

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Abstract
There is a heavy competition between human beings and animals for the vegetable protein sources. That will increase the price of animal production and reduce the margin of profit. Therefore search for alternative protein sources are required. Leaf protein is the one of protein- rich component that will benefit the sustainable animal production by reducing the cost of production. There are many more plant leaves are useful for extraction of leaf protein like lucerne, cowpea, berseem, sweet potato, beri, neem leaves etc. Leaf protein can become a most useful alternative source of protein. To improve the feeding quality of leaf protein processing is required to reduce the level of different antinutritional factors present in plant leaves.

Keywords: feed, leaf protein, ruminants

Introduction
Leaf proteins are the proteins obtained from plant leaves. These are the cheapest and abundant source of available protein that has been evaluated for human or animal food source. This has recently led to renewed interest in LPC to reduce the use of human-edible vegetable protein sources in animal feed [38]. Protein concentrates from plant leaves obtained by extracting the leaf juice and coagulation of the protein. Leaf protein concentrates can be prepared by using many plants, like alfalfa, cereal fodder, beet tops etc. For the monogastric production, feeding cost ensures about 50–70% of the total costs. Protein rich feedstuffs contribute more expenditure than energy rich feedstuffs even though they included in small quantities as compared to cereals. Monogastric animal industries are faced with a major problem of limited protein sources; moreover, the competition for plant materials is expected to further increase feed prices [25].
Supplementing basal feeds that are deficient in major nutrients with either grain concentrate or forage legumes can improve the performance of sheep and goats. However, under smallholder farmer's condition supplementing poor quality feeds with grain concentrate is mostly unaffordable and expensive. One way of improving the utilization of poor quality feed is through supplementation with leaves of multipurpose tree species, which are affordable and easily accessible by farmers [29].
There is increased consumer demand for the livestock, poultry, and fish products in the human diet that threatens to push production toward the utilization of more and more conventional crops in animal feeds. Due to increase in the tightening grain crop supply and ensuring the increased development of animal husbandry through evaluation in protein feedstuff production have more challenges. Hence to know the different sources of leaf protein, this review is carried out.

Process of leaf protein extraction
Almost all plants synthesis proteins in the green part of the plant. Few forage crops produce leaf protein in more quantities i.e. about 5 tons per hectare and three to four times more than that of grain crops. From almost fifty years back, the basic technology for separating the leaf protein from the fibrous part of the leaf is known, but upto 1970s large-scale production technology was not developed. The main steps for the production of leaf protein concentrate (LPC) include grinding the plant and separating the juice by pressing. The protein is dissolved in the juice, after which it is coagulated, usually by heating, and then dried [41]. For large-scale production, required machinery is expensive, the minimum economical output being about 10 tons of leaf protein per hour - which means that about leaves from 5000 hectares of land are needed for the commercial production of LPC.

Now, smaller machinery has been designed for use at the village level.

During the production of leaf protein, it is necessary to keep in mind several principles in selecting the species for study. Protein extraction can be easily carried out from soft lush leaves than from those that are fibrous and dry. After addition of alkali or acid to leaves, it does not extract so well as those that give neutral extracts. Leaves that produce glutinous or slimy extracts are difficult to handle. It is necessary to use leaves that can be harvested mechanically from a perennial plant species; this probably not includes tree leaves, though coppiced trees have potentialities. Mixed weeds from untended ground are useless for leaf protein extraction. For the extraction of leaf protein from weeds, it is necessary that the ground is being manured to ensure an adequate yield of desirable species. Water weeds are growing luxuriantly, but about the extractability of the protein in them is somewhat unknown. Good yields of protein could be obtained from leaves that are by-products like beans (*Phaseolus* sp. and *Vicia faba*), jute (*Corchorus* sp.), peas (*Pisum sativum*), ramie (*Boehmeria nivea*), potato (*Solanum tuberosum*) and sugar beet (*Beta vulgaris*) [35].

Antinutritional factors in plant leaves

High concentrations of the antinutrients can severely affect the absorption of trace elements in food sources and hinder protein digestion. Boiling, sun drying, heating, simmering, blanching, soaking in single or in combination reduces the antinutritional factors like plant lectins, saponins, cyanide, oxalate, phytate, trypsin inhibitor, phytate, oxalate and mimosine etc. in leaves of plants and improve the digestibility and palatability of plant leaves for animals [45].

Lignin is another less digestible or non-digestible component commonly found in tree leaf forages. Lignin is a key structural material required for cell wall formation. A plant cell wall comprises an average of 23% lignin on a dry matter basis. Ruminants have the ability to utilize lignin as an energy source because rumen microbes can degrade lignin into monosaccharides. But, monogastric animals have simple digestive tract which is not able to synthesize enzymes that can utilize the lignin. Therefore, they cannot utilize lignin. Lignin content in tree leaves tends to increase with maturity. Shortening the cutting interval and harvesting young leaves during the early vegetative period are the main preventive measures to prevent accumulation of lignin in plants.

Table 1: Antinutritional factors present in different plant leaves.

Name of leaf forage	Antinutritional factor	Reference
Neem leaves	Tannins, phenolic compounds, azadirachtin and oxalates	[26]
Pigeon pea leaf meal	Saponins, tannins, alkaloids flavonoids, anthraquinones	[18]
Acacia Karro leaves	Phenolics and tannins	[31]
Air-dried *Moringa stenopetala* leaf	Tannin and phytate	[13]
Moringa oleifera	Alkaloids, Saponin Flavonoids, Tannin Oxalates, Phytate	[44]
Leucaena leucochepala leaf	Saponin	[42]
Cowpea leaves	Oxalates, phytates, and nitrates	[16]
Water hycinth leaves	Tannin and phytic acid.	[39]
Cassia obtusifolia Leaves	Tannin, phytic acid and polyphenol	[6]
Bamboo leaves	Flavonoids	[8]
Berseem leaves	Saponin, alkaloid	[42]
Khejari leaves	Tannins, alkaloid	[3]

Effect on growth and production

[12] Damor *et al*. (2017) concluded that feeding of dried moringa (Moringa oleifera) leaves replacing conventional concentrate mixture improved body weights and average daily body weight gain without affecting feed intake and overall health of Mehsana goat kids. *M. oleifera* leaf content 23.0% to 43.5% crude protein and 5.9% crude fibre on dry matter base which meet a criterion of good protein feed. Now, *Moringa* leaves have been widely used as substitutes for traditional protein feeds for monogastric animals (e.g., pig, rabbit, chicken), ruminants (e.g., cattle and sheep), and aquatic animals [47]. *Moringa oleifera* contains abundant nutrients, high protein with good biological value, and have good feeding effect. *M. oleifera* is a new protein feedstuff and has great potential in decreasing the feeding crisis [45].

Neem leaf can be used as a replacement to improved tree legumes (pigeon pea) and protein- rich conventional feeds (concentrate mixture). Supplementation of sole neem leaf by replacing concentrate mix and pigeon pea results in the reduction of feed cost and increase of net return. Likewise, NL and PP mixture at different levels can also replace the highly valued commercial concentrate feeds without affecting the growth and productive performance in goats [14]. Whereas, [34] Paengkoum (2010) have reported 50% of soya bean meal replacement could be possible with neam leaves in ruminant diets without hampering the feed intake, dry matter and fibre digestibility as well as body weight gain.

Improvement in the performance of ruminants after feeding neem leaves may be due to the effects of the bioactive compounds in the leaves on intestinal worms. This is proved by the available abundant literature shown the effect of neem leaves and extracts on intestinal worms [2] [37].

A. karroo leaf meal feeding in goats can help to improve animal performance by reducing the worm burden and increase in growth rate, meat quality and colour, carcass characteristics and health welfare of goats maintained under extensive systems of production. However, it is necessary to take care while incorporating *A. karroo* leaves into the feeding regime of goats to avoid untoward effects of antinutritional factors in *A. karro* leaves [21]. Whereas, [12] Damor *et al*. (2017) reported that inclusion of *Acacia karroo* leaves improved nutrient digestibility and growth rate of goats. Dry matter, crude protein and neutral detergent fibre digestibilities were optimized at different *Acacia karroo* leaf meal inclusion levels of 69.4%, 48.3% and 42.7%, respectively. *Acacia karroo* leaf meal has the potential as a protein feed could be supplied during the dry season when goats are reared on low-quality roughages.

Prosopis cineraria leaves are most important feeding resources in Rajasthan state of India, especially during the dry season. The leaves of *Prosopis cineraria* are more palatable and nutritious. [27] Meena *et al.* (2018) suggested that inclusion of concentrate feeds up to 60% in the Khejari leaves based diet resulted in decreased total feed intake, improved

plane of nutrition, average daily gain and feed conversion efficiency along with body confirmation.

[28] Melesse *et al.* (2015) found improved feed intake and weight gain in Aris-Bale goats after supplementation with Moringa stenopetala leaf to natural grass hay. This study further suggested that supplementation of low-quality feed resources such as natural grass hay with Moringa leaves is happen to be a good option in front of smallholder farmers for improving the productivity of local goats when conventional protein supplements are affordable.

[29] Melesse *et al.* (2020) reported that the supplementation of dried Sweet potato leaf (SPL) in sheep fed a basal diet of natural grass hay has resulted in improved intake, body weight gain, digestibility of nutrients and N retention. Thus, SPL can be used as a protein supplement to low-quality roughages under smallholder sheep production settings where conventional protein sources are beyond the reach of local farmers. Under the current experimental condition, as little as 150 g of daily SPL is sufficient for optimal response. It is recommended that SPL could be used as an alternative supplement in a natural pasture hay-based feeding for sheep in places where sweet potato is grown in abundance.

Inclusion of *Acacia karroo* leaves results in more nutrient digestibility and improved growth rate of goats. Dry matter, crude protein and neutral detergent fibre digestibilities were optimized at different *Acacia karroo* leaf meal inclusion levels of 69.4%, 48.3% and 42.7%, respectively. *Acacia karroo* leaf meal, therefore, has the potential of being utilized as a protein feed during the dry season when goats depend on low-quality roughages [11].

Prosopis cineraria leaves are most important feeding resources in Rajasthan state of India, especially during the dry season. The leaves of *Prosopis cineraria* are more palatable and nutritious.

[30] Mekuriaw *et al.* (2012) compared the intake, digestibility and live weight gain in Washera sheep after feeding the bamboo leaves in comparison with natural grass hay. They found low-land bamboo leaf hay contains high CP with greater digestibility, which improved average daily gain in body weight, feed conversion efficiency and they further concluded that bamboo leaf hay can be utilized as a basal diet for ruminants. Further, [9] Andriarimalala *et al.* (2019) stated that Bamboo leaves acts as potential forage for ruminants. Bamboo leaves have a good amount of nitrogen for ruminants and can be used with silage in a mixed ration, without a negative effect on the milk production. This allows cows to maintain their performance during the period of forage shortage.

The study demonstrated that different supplementation levels of *Moringa oleifera* in the diet achieved similar feed intake and milk production, but adding 6% of *Moringa oleifera* improved milk fat content, improved dairy product quality and potentially reduce methane emissions [15]. [48] Zhang *et al.* (2017) reported that addition of the moringa supplement into the diet of lactating multiparous cows improved milk production and health status and modified milk fatty acid profile positively. This suggests that moringa supplement could be used as a diet supplement for producing high quality and healthier milk. Whereas, [33] Nugroho *et al.* (2019) observed that supplementation with *Leucaena leucocephala* leaf at 10 and 20% of total forage DM increased milk composition in percentage of protein, fat and lactose. Moreover, the milk production only increases at *Leucaena leucocephala* leaf supplementation at 20%.

[24] Kholif *et al.* (2018) reported increased feed intake, digestibility, volatile fatty acids, acetate and propionate, serum total protein, albumin and glucose, Milk yield and energy corrected milk, and milk total solids, fat and energy content in milk in Nubian goats after replacement of Besrseem clover with *Moringa oleifera* at 75% level.

In the highlands of Madagascar, Bamboo leaves have nutritive value as forage for ruminants. Bamboo leaves acts as a good source of nitrogen for ruminants and may be along with silage in a mixed ration, without affecting the milk production. This allows cows to maintain their performance during the dry season, which is a period of forage shortage [9].

Beri leaves are comparatively more palatable than pipal leaves and used as a day to day fodder for small ruminants. Beri leaves have high CP (18.6%) but digestibility coefficient of only 36 [43]. [1] Abdu *et al.* (2012) assessed use of Indian Ber leaves in sheep diets as a replacement for cottonseed cake. Results from this study indicated that upto 10 to 20% (DM basis) level of Indian jujube could be added to the diets of growing sheep without a negative effect on the animal performance. Whereas, in grazing dairy goats, Indian Ber leaves used as a potential cottonseed cake replacer in a low-quality diet for 10 weeks and resulted in the improvement in the milk yield. The positive effect on milk yield could be due to low rumen degradability of ber leaves due to the presence of tannins and having relatively high bypass protein content [23].

Table 2: Chemical composition of different forage leaves

Forage leaves	DM	OM	Ash	CP	NDF	ADF	ADL	Reference
Neem leaves leaf meal	92.8	90.5	9.5	28.2	31.8	21.9	4.9	[14]
Pigeon pea leaf meal	94.4	92.5	7.5	16.7	54.0	39.7	13.7	[14]
Acacia karro leaves	97.1	92.1	7.9	12.7	38.0	32.5	--	[11]
Air-dried *Moringa stenopetala* leaf	94.4	88.0	-	29.5	17.8	16.5	-	[28]
Khejari leaves	45.09	--	--	17.89	48.11	40.41	--	[5]
Leucaena leucochepala leaf	96.2	--	9.92	20.26	50.05	19.98	15.52	[46]
Moringa oleifera	22.8		9.14	22.8	30.8	22.8	--	[40]
Cow-pea leaves	91.0	--	13.0	18.1	46.2	19.5	--	[22]
Water hycinth leaf protein	15.33	86.67	13.43	20.80	--	--	--	[20]
Bamboo leaves	45.0	--	11.5	14.15	68.8	42.3	--	[10]
Berseem leaves	23.8	85.58	15.4	29.80	43.91	27.5	-	[36]
Cassia obtusifolia Leaves	97.0	95.26	13.00	27.84	40.32	17.28	-	[4]
Sweet potato leaf	91.8	95.3	--	26.5	25.8	15.2	--	[29]
Ber leaves	48.9	--	9.8	13.3	35.8	25.5	--	[19]

Conclusion

By considering all the above facts about the nutritive value, antinutritional factors in leaf protein it is conferred that leaf protein may be used in ruminant ration as a alternate protein source after necessary treatment without affecting the performance of animals that results in the low cost of animal production.

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