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Uses of tree leaves as alternative feed resources for ruminant animals

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Abstract
Agriculture including the livestock as an integral component plays an important role in Indian economy. The total livestock population is 535.78 million in the country reflected an increase of 4.6% over livestock census 2012. Latest estimate on demand-supply gap in fodder availability shows a net deficit of 30.65% green fodder and 11.85% dry crop residues in year 2020 (IGFRI Vision, 2050) [23]. In hills, fodder trees, shrubs and grazing in the forests are the main sources for the livestock feed including use of agricultural residue (Singh and Sundriyal, 2009) [41]. Tree leaves are generally rich in proteins and minerals particularly calcium and phosphorus (Gaikwad *et al.*, 2017) [20]. Bakshi and Wadhwa, (2007) [7] reported that voluntary dry matter intake (kg/d) was significantly (P<0.05) higher by bucks fed leaves of *Morus alba*, than for all leaves. *Asparagus racemosus* roots and *Moringa oleifera* leaves can be supplemented in the diet of lactating cow to enhance the milk production of animal without any adverse effect on health of animal (Mishra,2008) [29]. Supplementation with *Leucaena leucocephala* and *Moringa oleifera* leaves during the dry season had a positive effect on the growth rate and reproductive performance of goats (Mataveia *et al.*, 2019) [27]. Feeding of *Terminalia arjuna* leaves fed group exhibited improved total gain in weight and growth rate in Surti goat kids (Patel *et al.*, 2017) [33]. On the basis of chemical composition, digestibility of nutrients and efficiency of utilization of nutrients, tree leaves proved to be excellent feedstuffs especially for small ruminants animals and provide potential feeding of livestock occur in long dry seasons, when there is insufficient plant biomass carried over from the wet season to support domestic livestock population.

Keywords: tree leaves, ruminants, production performance, nutrients utilization

Introduction

Agriculture including the livestock as an integral component plays an important role in Indian economy (DAHD&F, 2017-18) [15]. Livestock is considered a major source of income for the poor masses in developing countries including India, where it contributes, nearly 4.11 percent to total GDP & 25.6% of total Agriculture GDP. (DAHD&F, 2017-18; Delgado *et al*., 2020) [15, 16]. The total livestock population is 535.78 million in the country showing an increase of 4.6% over livestock census 2012. To meet the increasing global food demand, it is necessary both to increase the productivity and to use available resources more efficiently. Family farmers constitute approximately 60% of the global agricultural production (FAO 2016) [19]. Around 98% of farms in the world are family farms that are heavily dependent on natural resources for their subsistence (Bergeret et al. 2016) [12]. However, the scarcity of resources does not allow for increasing the agricultural production, leading to a vulnerability of the global population to food in security and hunger (FAO 2016). Livestock play an integral role in the livelihood of poor farmers by providing economic, social and food security. Taking 2010 as the base year, the world would need 73 percent more meat and 58 percent more milk in 2050, while these values for developing countries will be 109 percent and 116 percent, respectively (FAO, 2011) [18]. To meet this demand, huge quantity of feed resources will be required; challenging sustainability of the feed production systems.

Table 1: Demand and supply estimates of dry and green forages (million tonnes)

Year	Demand		Supply		Deficit		Deficit as%	
	Dry	Green	Dry	Green	Dry	Green	Dry	Green
2010	508.9	816.8	453.2	525.5	55.72	291.3	10.95	35.66
2020	530.5	851.3	467.6	590.4	62.85	260.9	11.85	30.65
2030	568.1	911.6	500.0	687.4	68.07	224.2	11.98	24.59
2040	594.9	954.8	524.4	761.7	70.57	193.0	11.86	20.22
2050	631.0	1012.7	547.7	826.0	83.27	186.6	13.20	18.43

IGFRI Vision, 2050

- The major constraint in the development of livestock sector is poor availability of nutrients through quality feed and fodder (Sarwar *et al*., 2002) [38]. There is a need of 13.5 and 110.3 million tons of crude protein (CP) and total digestible nutrient (TDN), respectively (Anonymous, 2006) [4] to fulfill the requirement of livestock therefore improvement in livestock demands the efficient use of available feed resources. Area under cultivated fodder in India is about 8.4 million hactare, which is static since last two-three decades & not adequate to meet the fodder demand (Ghosh *et al*., 2016) [21].
- The cost on feed and fodder production is further elevated due to climatic aberrations and water scarce conditions. These factors limit the fodder production and creates forage scarcity thus, force the animals to feed on wild shrubs and grasses, and this is recognized as one of the primary causes of lower productivity of milch animals in India. (Shankarnarayan, 1984; Patel, 2017) [39, 33].
- Several parts of the world including Africa, Ethiopia and India reveals that fodder trees and shrubs are valuable animal feed and play an important role in farming system due to their better adaptation to local environment and drought situation. (Narainet *et al*., 2004; Luseba *et al*., 2006; Tsegaye *et al*., 2007) [30, 26, 48].
- In India, several exotic and indigenous trees including fodder trees were introduced during 1950s, to the Central Arid Zone Research Institute (CAZRI), Jodhpur, Rajasthan. Feed and fodder availability among Asian countries is not sufficient to meet even dry matter requirement of growing ruminant population, there is need to explore new feed resources which do not compete with human feed chain (Raghuvansi *et al*., 2007) [34].

Tree Leaves as an Aletnative Feed Resources

- The leaves of tree fodders considered nutritious feed due to their high proteins, vitamins and minerals. (Baumer, 1992; Rana *et al*., 1999; Azim *et al*., 2011) [11, 37, 5]. Trees leaves play an important role in the nutrition of grazing animals in area where few or no alternatives are available (Meuret *et al*., 1990) [28]. Although, every part of tree is useful for feeding but leaves are considered most valuable due to their high crude protein. (Aganga *et al*., 2003; Hassene *et al*., 2010) [1, 22].
- In arid and semi arid zones, provide the largest part of the protein supply during the driest months. (Rai *et al*., 2007) [35]. Fodder tree is valuable in the hills especially during winter and summer months when very less availability of green forage in both quantity and quality. (Rana *et al*., 1999; Azim *et al*., 2011) [37, 5]. Leaves with low level of tannin show protection of protein from microbial degradation (Barry *et al*, 1986) [10].

Table 2: Important Fodder Trees

Sr No	Common / English Name	Scientific name	Commonly grown area's
1.	Subabool	*Leucaena leucocephala*	Sub humid, Semiarid
2.	Gliricidia	*Gliricidia sepium*	Humid, sub humid
3.	Ardu	*Alianthus excelsa*	Arid and semiarid regions
4.	Agasthi	*Sesbania grandiflora*	Arid and semiarid regions
5.	Shevri	*Sesbania sesban*	Arid and semiarid regions
6.	Khejri	*Prosopis cinereria*	Arid and semiarid regions
7.	Mahua	*Bassia latifolia - Flower*	Semi-arid
8.	Babul	*Acacia Nilotica*	Dry and moist tropics
9.	Neem	*Azadirachta indica*	Dry and moist tropics
10.	Kachnar	*Bauhinia variegata*	Sub tropics, moist and dry tropics
11.	Safed siris	*Albizia procera*	Wet tropical and subtropical
12.	Lallei	*Albizia amara*	Dry tropics
13.	Siris	*Albizia lebbeck*	Moist and dry tropics
14.	Shisham	*Dalbergia sissoo*	Moist tropics
15.	Mulbery	*Morus alba*	Moist tropics
16.	Bola	*Morus laevigata*	Subtropics
17.	Drum stick	*Moringa oleifera*	Moist tropics, sub humid Humid
18.	Kikkar	*Prosopis chilensis*	Dry tropics
19.	Ber	*Ziziphus mauritiana*	Dry and moist tropics

(NDDB, 2015) [32]

Fodder Tree in Uttrakhand State

- Uttrakhand is well endowed with forests, which constitute about 63.87% of the total geographic area; about 4.04% is estimated to be under permanent pastures and other grazing lands. (Nautiyal *et al*., 2018) [31]. In hills, fodder trees, shrubs and grazing in the forests are the main sources for the livestock feed including use of agricultural residue. (Singh and Sundriyal, 2009) [41]. In the mid-hill of Himalayas, about 30-50% of total animal feed mainly grass and tree fodder is from forests and grasslands. (Singh and Naik, 1987; Bajracharya, 1999) [6, 44]. Approximately, two-thirds to three-fourth of the fodder requirement are met from the forest in mid hills and 26-43% in the lower hill. (Singh, 1999)
- Interestingly, it has also been reported that dairy cattle are also dependent on forest resources particularly in the Himalayas (Tulachan *et al*., 2002) [49]. Several studies have been conducted on fodder resources in the Uttarakhand Himalaya by Jackson 1985 [24], Bhatt and Rawat 1993 [13], Singh 1985, 1989, 2002, 2005 [42, 43], Jodha and Shrestha 1990 [25], Singh and Bohra 2005 [43], Singh and Gaur 2005 [45], Bohra 2006 [14] and Singh *et al.* 2008 [46].
- *Grewia optiwa*, *Morus serrata*, *Bauhinia variegata*, *Quercus leucotrichophora*, *Quercus floribunda*, *Ilex dipyrena*, *Oogeinia oojeinensis*, *Behormeia rugulosa*, *Morus alba*, *Celitis australis* are common species which are used as fodder in Himalaya (Nautiyal *et.al*., 2018) [31].

Table 3: Chemical composition of tree leaves (Used as fodder in Himalaya)

S. No	Comoon name	Scientific name	CP (%)	TDN(%)
1.	Bhimal	*Grewia optiva*	18.84	77.2
2.	Himalayan Mulbarry	*Morus serrata*	15.63	68.9
3.	Kachnar	*Bauhinia variegata*	16.35	61.8
4.	Banj	*Quercus leucotrichophora*	11.56	68.7
5.	Mohru Oak	*Quercus floribunda*	10.37	68.7
6.	Himalayan Holi	*IIIex dipyrina*	11.86	65.8
7.	Sandan/Tilsa/ Kala plas	*Oogeinia oojeinensis*	10.68	69.4
8.	Daar	*Behormeia rugulosa*	11.66	60.6
9.	Sahtoot	*Morus alba*	16.32	66.5
10.	Karik/Hackberry	*Celtis australis*	15.26	62.4

(Singh *et al.*, 2007) [33]

Table 4: Bakshi & Wadhwa, 2007 [7] analysed chemical composition (% DM basis) of tree leaves.

Local name	Botanical name	OM	CP	NDF	ADF	Hemicellulose	Cellulose	ADL
Dhrake	*Melia azedarach*	90.3	19.3	35.0	22.5	12.5	13.5	6.5
Pilkan	*Ficus glomerata* var. *sublanceolata*	86.0	10.8	53.0	37.0	16.0	18.0	11.0
Tun	*Toona ciliate*	92.5	13.0	53.0	34.5	18.5	17.0	14.5
Tut	*Morus alba*	81.3	19.6	35.0	26.5	8.5	8.0	7.0
Gular	*Ficus glomerate*	80.0	11.8	60.0	45.5	14.5	20.0	13.0
Siris	*Albizzia lebbock*	92.3	18.3	58.0	34.0	24.0	21.0	13.0
Pipal	*Ficus religoosa*	84.5	12.5	48.0	38.0	10.0	19.0	9.0
Subabul	*Leucaena Leucocephala*	89.3	19.9	44.0	18.5	25.5	14.5	9.0
Neem	*Azadirachta indica*	93.3	15.9	51.0	30.5	20.5	20.0	14.0

Table 5: Sheikh *et al.,* 2011 [40] evaluated the chemical composition (% on DMB) of some Tree Leaves, Feeds and Fodders in Ladakh region.

Common name	DM	CP	EE	CF	NFE	NDF	ADF	ASH	A.I. A	Ca	P
Kiker leaves	88.45	15.53	6.30	18.03	55.14	41.04	34.87	5.00	1.20	3.41	0.15
Toot leaves	87.76	15.79	7.00	14.67	51.04	32.09	23.78	11.50	3.00	3.45	0.46
Prangs	91.33	12.47	6.50	12.00	62.53	42.65	31.00	6.50	2.00	2.20	0.04
Bathwa	88.76	10.29	6.50	6.67	64.54	37.87	41.43	12.00	2.00	2.50	0.18
Willow leaves	91.53	16.40	5.80	15.33	57.47	41.56	27.09	5.00	4.00	2.39	0.24
Poplar leaves	89.34	14.79	6.50	11.33	59.38	43.76	24.84	8.00	2.00	2.03	0.22
Apple leaves	88.67	14.22	6.00	18.00	54.28	49.76	57.87	7.50	3.00	2.87	0.45
Sarsing leaves	90.45	15.64	7.50	14.00	58.36	37.12	30.76	4.50	2.00	3.06	0.38
Seabuckthorn	93.87	15.95	8.50	14.67	52.38	38.09	31.00	8.50	3.00	2.36	0.12
Appricot leaves	87.54	14.31	6.00	13.00	54.19	44.87	39.43	12.50	3.00	2.51	0.21
Nayargal	92.87	13.13	3.16	21.32	50.05	65.09	32.23	12.34	2.30	0.86	0.13
Asmania	94.76	16.29	2.98	24.56	44.61	54.98	34.09	11.56	3.40	0.49	0.03
Gyapshan	91.45	11.48	3.14	20.19	49.27	56.98	32.08	15.92	1.67	0.87	0.15
Toma	93.98	19.21	3.98	27.21	38.37	37.09	25.09	11.23	2.34	0.62	0.06
Longma/Shangsho	92.44	27.35	2.56	19.39	41.56	54.76	23.98	9.14	1.00	0.88	0.12

Table 6: Chemical composition (%DMB) of fodder tree leaves of Scarcity Zone of Maharashtra.

Sr. No.	English Name	Scientific name	Per cent Structural Constituents.				
			DM	CF	NDF	ADF	Hemicelluloses
1.	Banyan	*Ficus bengalensis*	31.70	34.0	68.2	58.5	9.70
2.	Jamun	*Syzygium cumini*	33.22	28.5	66.2	62.7	3.50
3.	Guava	*Psidium guajava*	36.54	21.5	61.8	56.8	5.00
4.	Indian Bamboo	*Bambusa bambos*	56.60	24.0	77.4	52.9	24.50
5.	Drumstick	*Moringa oleifera*	18.88	19.0	36.0	26.9	9.10
6.	Peepal	*Ficus religiosa*	22.40	24.0	50.8	45.4	5.40
7.	Common sesban	*Sesbania sesban*	16.92	22.5	40.8	38.4	2.40
8.	Subabul	*Leucaena leucocephala*	28.74	16.0	56.2	40.8	15.40
9.	Tamarind	*Tamarindus indica*	32.68	24.0	57.6	42.2	15.40
10.	Gum Arabic	*Acacia nilotica subsp. Indica*	49.37	9.0	36.0	33.8	2.20
11.	Quick stick	*Gliricidia sepium*	20.55	16.5	48.2	44.5	3.70
12.	Saras	*Albizia lebbeck*	40.93	26.0	58.6	53.6	5.00
13.	Neem	*Azadirachta indica*	33.49	22.5	55.8	51.4	4.40
14.	Bel, Wood apple	*Aegle marmelos*	35.32	22.0	55.0	49.3	5.70
15.	Soft Fig	*Ficus mollis*	28.93	27.5	70.0	66.9	3.10

(Gaikwad *et al.,* 2017) [20].

Table 7: Mineral constituents (%DMB) of fodder tree leaves

Sr. No.	English Name	Scientific name	Ash (%)	Calcium (%)	Phosphorus (%)	Iron (µg/ g)	Zinc (µg/g
1.	Banyan	*Ficus bengalensis*	11.0	2.6	0.49	2458	73
2.	Jamun	*Syzygium cumini*	6.0	1.0	0.18	4773	85
3.	Guava	*Psidium guajava*	5.0	1.7	0.19	3745	05
4.	Indian Bamboo	*Bambusa bambos*	18.5	1.2	0.18	1618	04
5.	Drumstick	*Moringa oleifera*	1.5	2.6	0.26	5128	98
6.	Subabul	*Leucaena leucocephala*	10.5	1.9	0.30	2470	25
7.	Peepal	*Ficus religiosa*	11.0	4.5	0.24	5720	63
8.	Tamarind	*Tamarindus indica*	4.0	1.9	0.20	3418	80
9.	Common sesban	*Sesbania sesban*	10.0	1.4	0.27	2820	48
10.	Gum Arabic	*Acacia nilotica subsp. Indica*	3.5	1.4	0.21	3338	108
11.	Quickstick	*Gliricidia sepium*	8.0	1.5	0.23	2688	30
12.	Saras	*Albizia lebbeck*	8.0	4.5	0.21	1498	02
13.	Neem	*Azadirachta indica*	10.0	1.9	0.22	3348	02
14.	Bel, Wood apple	*Aegle marmelos*	9.5	3.0	0.21	4960	02
15.	Soft Fig	*Ficus mollis*	9.5	1.5	0.21	993	10

(Gaikwad *et al.*, 2017) [20].

Table 8: Anti-nutritional factors in tree leaves

Name	Scientific name	Anti-nutritional factors
Subabool	*Leucaena leucocephala*	Mimosine: 2-6% in leaves and pod 3-5% of DM, 4.45%Tannin (3.92% HT, 0.53% CT)
Siris	*Albiza lebbek*	5.92% tannin, saponin
Bamboo	*Bamboo spp*	2.0% tannin
Genthi	*Boehmeria rugulosa*	1.45% tannin
	Acacia catechu	1.54% tannin
Banj oak	*Quercus leucotrichophora*	9.7% tannin (5.8% CT, 3.9% HT)
Drumstick	*Moringa Oleifera*	Saponin

Table 9: Threshold level of tannin in animal

Species	%Tannin	Reference
Growing calves	4	(Barman and Rai, 2004) [9]
Lactating cows	3	(Dubey, 2007) [17]

Anti-nutritional Factors in Tree Leaves

The ANFs in shrub and tree forage may contain alkaloids, terpenoids, oxalate, indospecine, lignins. The terpenoids azadirachtin and limonin impart a bitter taste and the leaves of *Azadirachta indica* are therefore not relished by cattle. Oxalate in the leaves of *Acacia aneura* may limit the Ca availability and a negative correlation between digestibility and lignin content in tropical browse has been observed (Bamualin *et al.*, 1980) [8].

Most of the ANFs belong to a group of related compounds with similar mode of actions. There are about 8,000 polyphenols, 270 non-protein amino acids, 32 cyanogens, 10,000 alkaloids and several saponins which have been reported to occur in various plant species.

Detection: This can be approached either by evaluating animal performance or by chemical analysis. Certain ANFs can be detected through chemical analysis but it is not easy to look for all possible allelochemicals in a single plant.

Quantification: There is wide variation in the reported concentration of ANFs in the same plant species. This may be either real, because of the changes occurring due to environmental conditions, or may arise because of lack of standardization of methods between laboratories, as well as their destruction in assays.

Assessment of biological effects: It is often observed that sensitivity to ANFs varies between species of animals, different ages and physiological stages. Furthermore, the leaves of a particular tree or shrub may contain different group of ANFs and it becomes difficult to separate their biological effects.

Methods to Alleviate

Since ANFs have a major role in plant defence, selecting for low ANFs lines may have undesirable effects on the plant.

Alleviation by Rumen Microbial Activity

Ruminant animals have a symbiotic relationship with rumen microorganisms. The rumen environment (slightly acidic pH:E° = -0.35V; 10^{10} microbes/ml) provides many reductive and hydrolytic reactions which, in the majority of cases, decrease the biological activity of the allelochemicals before their absorption from the tract.

Rumen bacteria and fungi capable of degrading lignin have been isolated. Anaerobic degradation of flavonoid and hydrolysable tannins by mixed rumen microbes has also been demonstrated. Such rumen microbes are present in small numbers and their growth rate is slow. Anaerobic microbial degradation of condensed tannins has also been demonstrated.

Dietary oxalate can be degraded by rumen microbes into CO_2 and formic acid. Ruminants adapted to diets with high oxalate content can tolerate oxalate levels that are lethal to non-adapted animals. Moreover, it has been shown that the transfer of rumen fluid from animals in Hawai to Australian ruminants resulted in complete elimination of the toxic effects of mimosine and the bacteria involved in such effects have been identified (Allison *et al.*, 1990) [2].

Methods to reduce the deleterious effect of Anti-nutritional Factors

A number of methods have been tried to overcome the deleterious effects of different anti nutritional factor includes through making hay, silage with inoculants, using PEG: urea or biological treatment with fungi can be applied to either take off or minimized and decrease anti nutritional factors concentrations. It is well know that alkali treatment includes polyethylene glycol (PEG), which is a tannin binding agent, was shown to be a powerful tool for isolating the effects of tannin on various digestive functions. Addition of polyethylene glycol(PEG), which binds with tannin and other antinutritional factors is quite effective, success of its adoption depends on the cost: benefit ratio. Russell and Lolle suggest feed animals with 1% urea which not only provides extra N but also deactivates the leaf tannin.

Research Findings of Uses of Tree Leaves as Alternative Feed Resources for Ruminants

Table 10: DM intake and digestibility of nutrients in bucks: (Bakshi and Wadhwa (2007) [7].

Parameter	Tun (*T. Ciliate*)	Tut (*M.alba*)	Subabool (*L. Leucocephala*)	Neem (*M. Azedarach*)	Pooled SE
DMI (kg/d)	0.74	1.80	1.64	1.54	0.06
Digestibility (%)					
Dry matter	48.1	57.3	53.6	61.2	2.34
Organic matter	53.0	67.1	58.6	66.6	2.30
Crude protein	66.5	79.6	69.8	80.4	3.87
Cellulose	17.2	40.7	47.0	32.9	3.27
Nitrogen utilization in bucks (g/d)					
Intake	16.0	57.0	52.3	45.9	1.85
Fecal-N	4.9	11.61	15.81	9.0	0.64
Urine-N	14.9	24.1	25.8	27.1	0.82

Based on the availability of tree leaves of *Morus alba*, *Melia azedarach*, *Leucaena leucocephala* and *Toona ciliate* were selected for in vivo evaluation in goats (bucks). Bakshi and Wadhwa (2007) [7]. found that voluntary dry matter intake (as kg/d or as%LW) was significantly (*P*<0.05) higher by bucks fed leaves of *M. alba*, than for all leaves but *Leucaena* leaves. Bucks showed less interest in the leaves of *T. ciliate*, as indicated by the lowest dry matter intake (*P*<0.05), could be because of very high lignin content (14.5%).

The leaves of *M. alba*, *L. leucocephala* and *M. azedarach* were significantly (*P*<0.05) higher in DM digestibility as compared to the leaves of *Toona ciliate.* The digestibility of other nutrients followed similar trend among different species of tree leaves.

Table 11: Effect of feeding Shatavari and Saijan on Milk Production in Crossbred Lactating Cows

Periods	Groups		
	G1	G2	G3
0 Week	13.25	13.30	13.80
1st Week	12.77	14.07	12.77
2nd Week	13.19	13.41	13.50
3rd Week	13.25	13.94	13.60
4th Week	12.52	12.91	12.78
5th Week	11.00	11.43	11.65
6th Week	11.52	11.95	12.24
7th Week	11.28	11.99	11.83
8th Week	12.86	12.30	12.98
9th Week	12.46	13.05	12.89
10th Week	12.00	13.05	13.01
11th Week	11.41	12.95	12.84
12th Week	11.46	13.60	13.10
13th Week	10.32	12.99	13.10
Total (1-13 Weeks)	156.04	167.64	166.29
Average	12	12.89	12.79
Percent Increment	0	7.42	6.58

(Mishra, 2008) [29]

G1, (Control)- Green Fodder+ dry Fodder,70:30, conc.mix-500gms/litre of milk production

G2,(Shatavari root supplement)- G1+ 100g Shatavari (*Asparagus racemosus)* root powder with conc.mix.

G3, (Saijan leaves supplement)- G1+ 100g Saijan *(Moringa oleifera)* leaves powder mixed with concentrate mixture Mishra, 2008 [29] reported that overall average milk production (l/day) was 12.00, 12.89, 12.79 in G1, G2 and G3, respectively, which was non significantly different among themselves. Thus Shatavari (*Asparagus racemosu*) roots and Saijan (*Moringa oleifera*) leaves could be used as feed additive in ration of ruminant animals for milk production without any adverse effect on health of animals.

Table 12: Effects of *Moringa oleifera* Leaf Meal as Partially Replacement of Cotton Seed Cake in Diet of *Nili Ravi* Buffaloes

Ingredients proportion Kg DM/day	Treatment			
	MLM1	MLM2	MLM3	MLM4
MOLM	0.00	0.71	1.42	2.16
CSC	2.16	1.42	0.71	0.00
Maize Silage	**Ad-libitum**			
Wheat bran	2.94	2.94	2.94	2.94
Cane molasses	0.72	0.72	0.72	0.72
Mineral Mixture	0.180	0.180	0.180	0.180

Imran *et al.*,2016 have been conducted a feeding experiment to utilize *Moringa oleifera* as source of supplementation to ruminants but the use of *Moringa oleifera* leaf meal (MOLM) as an alternative of cotton seed cake as an ingredient of concentrate in *Nili-Ravi* buffaloes in the semi-arid zone.

Table 13: Digestibility of the nutrients

Apparent digestibility coefficient (%)	MLM1	MLM2	MLM3	MLM4
DM	70^a	72^a	73^a	70^a
OM	72^a	73^a	74^a	72^a
CP	74^a	76^a	79^a	81^b
NDF	69^a	72^a	74^a	80^b

Overall the apparent digestibility coefficients of dry matter (DM) organic matter (OM) and crude protein (CP) were non-significant (*P*>0.05) whereas digestibility of NDF was significantly increased (*P*<0.05) in treatment MLM4. When compared among treatments, the value of digestibility coefficient was high (*P*<0.05) in treatment MLM4 as compared to MLM1. Similar trend was also observed in case NDF among treatments.

Table 14: Milk production and composition:

Milk yield and constituent's Kg/day	MLM1	MLM2	MLM3	MLM4	Significance
Milk yield	10.8	11.4	11.8	11.9	(*P*<0.05)
4% FCM	12.42	12.93	13.57	13.32	(*P*<0.05)
Fat	0.54	0.55	0.59	0.57	(*P*>0.05)
Protein	0.36	0.38	0.41	0.42	(*P*<0.05)
Lactose	0.39	0.41	0.44	0.46	(*P*<0.05)
Milk composition%					
Fat	5.0	4.9	5.0	4.8	(*P*>0.05)
Protein	3.4	3.4	3.5	3.6	(*P*>0.05)
Lactose	3.7	3.6	3.8	3.9	(*P*>0.05)
Ash	0.8	0.80	0.81	0.82	(*P*>0.05)
Total Solids	12.9	12.7	13.11	13.12	(*P*>0.05)

(Imran *et al.*,2016)

Daily milk yield and 4% FCM has increased ($P<0.05$) in buffaloes fed treatment MLM3 and MLM4 as compared to other treatments (Table 5). While there was no significant ($P>0.05$) difference of percentage of fat, protein, lactose, ash, total solids and solid not fat observed among all treatments(Table,14) However, on the basis of total yield per buffalo in a day, an increasing ($P<0.05$) trend was observed in increase of milk protein and lactose contents. Moreover, a significant difference was observed in milk protein between treatment MLM1 and MLM4.

Table 15: Growth performance of surti goats (kid) fed with *Albizia lebbeck* and *Terminalia arjuna* tree leaves

Parameter	T1 (Control)	T2 (AL)	T3 (TA)	T4 (AL)	T5 (TA)
DMI g/d	400.7	383.9	395.0	397.9	400.9
Initial BW (kg)	8.65	8.52	8.89	9.05	8.76
Final BW (kg)	13.99	13.22	14.56	13.97	13.73
Total gain (kg)	5.34	4.69	5.68	4.92	4.97
Growth rate(g/d)	42.35	37.25	45.04	39.05	39.46

(Patel *et al.*, 2017) [33].

Surti goat kids were selected as experimental animals to evaluate the effects of replacing *Albizia lebbeck* (AL) and *Terminalia arjuna* (TA) leaves with conventional green fodder (jowar) on growth and blood biochemical parameters. Control (T1) animals were fed basal diet including 200 g green *jowar*, which was replaced with AL and TA tree leaves in T2 and T3; while each of 100 and 150 g of AL and TA leaves were fed to kids of treatment groups of T4 and T5, respectively.

Results revealed that the DM intake was alike between the treatments. Growth rate was found ($P<0.05$) higher in TA leaves fed (T3) group. Body weight of animals remained statistically comparable ($P>0.05$) among the treatments throughout the experiment, however, TA leaves fed group (T3) exhibited improved total gain in weight and growth rate. The AL leaves fed group (T2) performed poorer in terms of growth rate. The *Terminalia* leaves feeding have been found to be associated with better feed digestibility, which help animals to improve their performance (Table 15). On the other hand high content of tannins in *Albizia* leaves interfere with utilization of protein resulting into poorer growth of animals (Ramana *et al.*, 2000) [36].

Table 16: Nutritional potential of bamboo leaves for feeding dairy cattle

Ingredients	SIL0:BAM100	SIL25:BAM75	SIL50:BAM50	SIL75:BAM25	SIL100:BAM0
Maize (%)	85.00	81.00	77.00	75.00	72.00
Peanut cake (%)	12.00	16.00	20.00	22.00	25.00
Salt (%)	0.75	0.75	0.75	0.75	0.75
Shell powder (%)	2.00	2.00	2.00	2.00	2.00
M.M. & Salt(%)	0.25	0.25	0.25	0.25	0.25
Nutritive Value of Conc. feed					
DM (%)	89.20	89.30	89.50	89.70	90.00
CP (g/kg DM)	154.00	155.00	156.00	157.00	157.00
RBP (g/kg DM)	100.00	101.00	101.00	103.00	103.00

Andriarimalala *et al.*, (2019) [3] studied that Bamboo can produce a high quantity of biomass and could be an alternative way to increase the fodder supply for cattle and their optimal rate of bamboo as fodder is used for dairy cattle. Feeding experiments conducted with leaf samples from nine bamboo species were collected to determine their chemical composition and nutritive value. Bamboo leaves were mixed with maize silage in five proportions: SIL0:BAM100, SIL25:BAM75, SIL50:BAM50, SIL75:BAM25 and SIL100:BAM0. The contents of dry matter, total ash and crude protein in the bamboo leaves were, respectively, 44.5-64.6%, 6.68-18.5% and 7.71%.

Composition of Concentrate feed per treatment

In the feeding trial, the dry matter intake of bamboo leaves was 1.6-7.1 kg per day, with an average of 4.8 kg per day. The dry matter apparent digestibility of bamboo leaves was 37.4-56.4%. The SIL0:BAM100 treatment showed a significantly higher dry matter intake, while SIL75:BAM25 had the lowest one ($p<0.05$). The dry matter apparent digestibility in bamboo leaves was significantly higher for SIL50:BAM50, at 56.4% ($p<0.05$).

In contrast, the dry matter apparent digestibility was lower for SIL75:BAM25, at 37.4% ($p<0.05$). Concerning maize silage, the dry matter intake ranged from 2.1 kg per day to 8.5 kg per day, while the dry matter apparent digestibility ranged from 71.6% to 74.6%. SIL100:BAM0 had a significantly higher value for dry matter intake than the other treatments, while the intake of SIL25:BAM75 was lower, if compared to the other treatments ($p<0.05$). Although the dry matter digestibility of maize silage was numerically higher in SIL50:BAM50, when compared to the other treatments, the differences were not significant ($p>0.05$).

Table 17: Supplementation of *Moringa oleifera* and *Leucaena leucacephala* tree fodder on the production performance of indigenous goats

Trait	Control	LL50	LL75	LL100	MO40	MO60	MO80	SEM*	p-value
Initial Body Weight (Kg)									
Bucks	17.4	17.9	21.3	21.2	21.3	21.2	22.2	0.560	0.162
Does	16.3	14.9	14.2	14.3	14.3	14.3	14.9	0.491	0.956
Final Body Weight (Kg)									
Bucks	24.2^{b}	31.8^{ab}	35.8^{a}	34.9^{a}	31.3^{ab}	36.0^{a}	34.1^{a}	1.221	0.001
Does	21.3	22.5	25.4	24.2	21.6	24.9	22.6	0.594	0.461
ADG(g/day)									
Bucks	6.9^{b}	21.9^{ab}	30.2^{a}	28.6^{a}	21.4^{ab}	30.7^{a}	27.1^{a}	1.747	0.001
Does	10.0	15.1	21.9	19.4	14.2	20.7	14.9	1.521	0.437

(Mataveia *et al.*, 2019) [27]

(Mataveia *et al.*, 2019) [27] was conducted to assess the effect of supplementation with *Leucaena leucacephala* (LL), and *Moringa oleifera* (MO) tree leaves on growth and reproduction performance of indigenous goats in southern Mozambique. Fifty-six indigenous goats with an average age of 8 months and a body weight of 17.57 ± 3.97 kg were randomly divided into seven treatments groups of 4 castrated males and 4 females each. Treatment 0 served as the control group (Co), and these animals only grazed on natural pasture without any supplementation. In addition to the natural pasture, three groups received 50 g (LL50), 75 g (LL75) and 100 g (LL100) of *L. lecocephala* dried leaves, respectively while groups 4 to 6, received 40 g (MO40), 60 g (MO60) and 80 g (MO80) of *M. oleifera* dried leaf meal, respectively. *Leucaena leucocephala* contained 23.7% crude protein (CP) and 11.05 MJ/kg DM of metabolizable energy (ME), while *M. oleifera* leaves contained 28.8% CP and 7.61 MJ/kg DM of ME.

Results revealed that a tendency toward heavier weights when goats were supplemented with either *L. lecocephala or M. oleifera* compared to control goats. Between supplemented groups, goats fed 60 g *M. oleifera* and 75 g *L. lecocephala* leaf meals had heavier weights compared to goats fed other supplement levels, but there were no significant differences on weight gains resulting from both diets. Control goats always showed the lowest weight gain compared to supplemented goats, though no significant effects of diets on weight gains were observed during the rainy season. The goats in the control group didn't show compensatory growth during the rainy season as the weight gain level during the rainy season was not significantly different from the rest of the treatment.

Table 18: Reproductive Performance and Growth Performance of Kids

Diet	Birth rate (%)	Age at first Kidding (years)	Litter size	Twinning rate (%)	Survival rate (%)	Birth weight (kg)	Weaning weight (kg)
Co	0.75	2.30±0.10	1.00±0.00	0.0	50.0	1.60±0.70	7.05±0.05
LL50	100	2.15±0.10	0.75±0.50	0.0	75.0	2.23±0.13	9.30±0.15
LL75	100	2.17±0.08	1.75±0.50	75.0	28.6	2.09±0.16	10.15±0.35
LL100	100	2.13±0.09	1.00±0.00	0.0	75.0	2.00±0.08	9.37±0.35
MO40	100	2.10±0.12	1.00±0.00	0.0	100	2.33±0.15	8.65±0.88
MO60	100	2.24±0.09	1.25±0.50	25.0	80.0	2.14±0.14	9.13±0.43
MO80	100	2.10±0.14	1.25±0.50	25.0	60.0	2.12±0.20	9.53±0.64

(Mataveia *et al.*, 2019) [27]

The results of some reproductive traits of does and growth performance of newly born kids have presented in (Table 18). All does conceived during the experimental period, and the birth rate of supplemented goats (100%) was higher compared to control goats (75%). The twinning rate ranged from 25 to 75% in does supplemented with *L. lecocephala* or *M. oleifera* leaves. Live body weights at birth and weaning weight were not significantly ($p>0.05$) affected by the type of supplement. However, increasing levels of supplementary diets irrespective of source had a linear effect ($p<0.01$) on the weight of kids before weaning. Birth type and pre-weaning survival rate of the kids varied among supplementation levels. Goats fed higher level of supplement, except for LL100 group, had higher rates of twin births and lower pre-weaning survival rates of the kids compared to other levels of supplementation. The pre-weaning survival rate of the kids was higher in supplemented goats when compared to control goats, though 71.4% of the kids died from the LL75 groups.

Conclusion

- Potential value of tree leaves with their diversity; these feed resources are extremely useful for feeding of ruminant animals in terms of cost effectiveness, growth and production.
- On the basis of chemical composition, digestibility of nutrients and efficiency of utilization of nutrients, tree leaves proved to be excellent feedstuffs especially for small ruminants animals.
- Provide potential feeding of livestock occur in long dry seasons, when there is insufficient plant biomass carried

over from the wet season to support domestic livestock population.

- Tree fodder may supply the quality green fodder round the year due to their wide adaptation in a range of soils and climates. Besides, these are ideal for growing on wastelands, problem soils, undulating lands, farm boundaries, field bunds and swampy areas, and dry areas.

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