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Monthly variations in nutritive value of *Leucaena leucocephala* (Lam) de Wit (leucaena) leaf fodder

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ABSTRACT

Leucaena leucocephala (Leguminosae) is valued as an excellent protein source for cattle fodder, consumed browsed or harvested mature or immature, green or dry. The present studies were carried out to evaluate monthly variations in nutritional and anti-nutritional factors present in the leaves of*L leucocephala*. The composite samples of its leaves were collected at monthly intervals from the month of August 2015 to January 2016. The findings revealed that the nutritional attributes of leaves varied markedly among different months of leaf collection. The dry matter (33.20 to 36.01%), crude fibre (14.11 to 18.44%), ether extract (3.40 to 6.04%), neutral detergent fibre (34.52 to 39.37%), acid detergent fibre (18.31 to 23.11%), total ash (6.68 to 8.23%), acid insoluble ash (0.81 to 1.42%) and calcium (0.82 to 1.18%) increased significantly with the maturity of leaves from August to January while crude protein (23.22 to 17.85%), nitrogen-free extract (52.59 to 49.45%), phosphorus (0.30 to 0.23%), tannin content (2.77 to 0.94%) and mimosine content (3.80 to 2.74%) decreased significantly with the maturity of leaves. There was significant monthly variations in the nutritive value of *L leucocephala* leaves with the maturity from August to January.

Keywords: *Leucaena leucocephala*; composite samples; monthly variations; mimosine

INTRODUCTION

The rearing of livestock is an integral part of hill agriculture and farming systems of majority of hill farmers. However a major constraint to animal production in Himalayas is the scarcity of animal feed and fodder resources. In Himachal Pradesh there is a deficit of 26.57 per cent green and 53.99 per cent dry fodder (Dev et al 2006). Fodder trees are an indispensable source of animal feed in the state mainly in the summer and winter seasons. However the present level of fodder tree production is meeting only partial needs of the animals. In general fodder tree leaves contain higher protein and calcium as compared to grasses and straw and a wide range of fodder trees have been utilized by the ruminants as the major source of feeding material.

The nutritive value of *Leucaena leucocephala* (Lam) de Wit (*leucaena*) is equal or superior to *Medicago sativa* (alfalfa) therefore former is often described as the 'alfalfa of the tropics'. All parts of *L leucocephala* are edible for the animals including leaves, young stems, flowers, young and mature pods and seeds. Its foliage (leaflets plus stems) contains both nutrients and roughage and makes the ruminant feed roughly comparable to alfalfa forage. It is a rich source of protein. During the 1970s and early 1980s *L leucocephala* was known as the 'miracle tree' because of its worldwide success as a long-lived and highly nutritious forage tree and various other uses. Besides forage it also provides firewood, timber, human food, green manure, shade and erosion control. It is estimated to cover 2-5 Mha worldwide (Brewbaker and Sorensson 1990).

Incorporation of tree legumes such as *L leucocephala* in silvi-pastoral systems represents an alternative in tropical ruminant production as it plays an important role in providing a forage rich in nutrients especially protein, vitamins and minerals. Consumption of this legume at high densities may be limited because of the excessive supply of fermentable nitrogen in the diet as well as occurrence of mimosine leading to a nutritional imbalance and a lower efficiency of microbial protein synthesis (Calsamiglia et al 2010).

The nutritional value of fodder differs according to species and season of growth. Therefore farmers prefer different species for different seasons to feed the animals. The traditional and experience-based choice of fodder species by farmers reflects their knowledge on nutritional values, cultivation easiness and seasonal variability of growth in local environment (Dhungana et al 2012).

L leucocephala leaves commonly called as subabul form the bulk of livestock feed in the sub-tropics and tropics. Its leaves contain mimosine and tannins hence before recommending it for livestock feeding it is important to analyze this species for different nutritional and anti-nutritional traits. Therefore the present studies were designed to assess the monthly variations in nutritive and anti-nutritive value of *L leucocephala* leaf fodder.

MATERIAL and METHODS

The present investigations were conducted in the Department of Silviculture and Agroforestry, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh during 2015-2016. The research farm from where samples had been taken is located at an elevation of 1250 m amsl in the mid-Himalayan zone. The area falls in the mid-hill zone of Himachal Pradesh (30°51′ N latitude and 76°11′ E longitude). Climatically the site lies in the sub-tropical belt but is slightly skewed towards the temperate climate and receives an annual rainfall of 110-115 cm.

Nutrient and anti-nutrient analysis of leaves

Sampling of the leaves was done from August 2015 to January 2016 at a monthly interval. In total 15 healthy and disease-free subabul trees were randomly selected in the vicinity of forest of Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh at the start of experiment. The leaves were collected from different positions of each tree in each month representing all parts uniformly. The collected leaves of 3 different trees were mixed to make the individual composite sample. In the similar pattern total 5 composite samples were made in each month and each composite sample was replicated thrice. The representative samples were packed in the paper bags and taken to laboratory for the estimation of dry matter content and further analysis of proximate principles and mineral contents. The fresh plant samples brought to the laboratory were immediately washed with water in order to make them free from dust or other adhering substances. After that all samples were air-dried to reduce chemical and biological changes in the samples, dried in the hot air oven at 60 ± 5°C till a constant weight was achieved to obtain moisture free samples and grounded in a Willey mill fitted with stainless steel blades so as to pass the samples through a 40-mesh sieve. After grinding these were mixed thoroughly and transferred to polyethylene bags, labelled clearly and stored till further analysis.

The dry matter (DM), crude protein (CP), crude fibre (CF), ether extracts (EE), total ash (TA), nitrogen-free extract (NFE) and mimosine were estimated following the procedure of Anon (2000), acid detergent fibre and neutral detergent fibre by the procedure of Van Soest et al (1991), total phenols by Folin–Ciocalteu method (Makkar 2000) and non-tannin phenols after binding the tannins with polyvinyl-polypyrrolidone. Total tannin phenols were calculated by difference between total phenols and non-tannin phenols. Statistical analysis of data was done by applying one-way analysis of variance (Snedecor and Cochran 1994) and the difference between the means was analysed by critical difference with a test of significance ($P < 0.05$) by using the statistical software OPSTAT to ascertain the monthly variations in the nutritive value.

RESULTS and DISCUSSION

The data on variation in nutrient and anti-nutrient contents of *L leucocephala* leaves are presented in Table 1. The dry matter content significantly increased from the month of August to January (from 33.20 to 36.01%) with advancing maturity of the leaves. The overall dry matter content was 34.45 per cent. Overall crude protein content varied from 23.22 to 17.85 per cent in the months of August to January with overall mean of 20.67 per cent. Crude protein content varied significantly in all the months of study and a decreasing trend from August to January (from 23.22 to 17.85%) was observed with the advancement of leaf maturity. The findings in the present studies are in agreement with those of

Table 1. Monthly variations in the nutritional value of *Leucaena leucocephala* leaves

Parameter (%)	Month						Overall mean	$CD_{0.05}$	SEm
	T_1 (Aug)	T_2 (Sept)	T_3 (Oct)	T_4 (Nov)	T_5 (Dec)	T_6 (Jan)			
DM	33.20[a]	33.74[ab]	34.00[ab]	34.42[b]	35.34[c]	36.01[c]	34.45	0.81	0.39
CP	23.22[f]	22.40[e]	21.12[d]	20.30[c]	19.13[b]	17.85[a]	20.67	0.69	0.33
EE	3.40 [a]	4.07[b]	4.95[c]	5.26[d]	5.55[e]	6.04[f]	4.88	0.31	0.15
CF	14.11[a]	15.55[b]	16.52[c]	17.28[d]	17.69[d]	18.44[e]	16.60	0.44	0.21
NDF	34.52[a]	35.59[b]	36.12[c]	37.07[d]	38.18[e]	39.37[f]	36.81	0.47	0.23
ADF	18.31[a]	19.14[b]	20.19[c]	21.11[d]	22.10[e]	23.11[f]	20.66	0.26	12.70
NFE	52.59[c]	51.23[b]	50.25[a]	49.64[a]	49.55[a]	49.45[a]	50.45	0.87	0.42
Total ash	6.68[a]	6.81[b]	7.12[c]	7.51[d]	8.07[e]	8.23[f]	7.40	0.04	0.02
AIA	0.81[a]	0.86[b]	0.92[c]	1.06[d]	1.24[e]	1.42[f]	1.05	0.01	0.01
Calcium	0.82[a]	0.90[b]	0.98[c]	1.09[d]	1.11[d]	1.18[e]	1.01	0.03	0.02
Phosphorus	0.30[e]	0.30[e]	0.28[d]	0.26[c]	0.25[b]	0.23[a]	0.27	0.01	0.00
Total tannin phenols	2.77[f]	2.54[e]	1.99[d]	1.71[c]	1.53[b]	0.94[a]	1.91	0.06	0.03
Mimosine	3.80[f]	3.68[e]	3.55[d]	3.29[c]	2.95[b]	2.74[a]	3.34	0.03	0.01

Means in a row with different alphabets differ significantly (P <0.05)

DM= Dry matter, CP= Crude protein, EE= Ether extract, CF= Crude fibre, ADF= Acid detergent fibre, NDF= Neutral detergent fibre, NFE= Nitrogen-free extract, OM= Organic matter, AIA= Acid insoluble ash

Kamalak et al (2005) and Onyeonagu et al (2013) who reported decline in crude protein content (N) with the maturity of leaves. The physiological basis of reduction of crude protein levels with the enhancement of season may be attributed to relatively rapid increase in dry matter which causes nitrogen initially present in high concentration to be diluted (Ralhan and Singh 1987, Verma and Mishra 1999, Singh and Todaria 2012) and partially leaching as well as back translocation of nitrogen from leaves to woody components during leaf senescence (Khosla et al 1992).

The ether extract of *L leucocephala* increased significantly from August to January (from 3.40 to 6.04%) with advancing maturity of the leaves. Ukanwoko and Ironkwe (2013) also reported increase in ether extract content with maturity of the leaves.

The crude fibre content, NDF and ADF in the leaves increased significantly from August to January (18.31 to 23.11%, 34.52 to 39.37% and 18.31 to 23.11% respectively) with the advancement of leaf maturity and similar findings were made by Kamalak et al (2005), Kokten et al (2012) and Ukanwoko and Ironkwe (2013) who reported an increase in crude fibre, NDF and ADF content of fodder tree leaves with maturity. The physiological basis for increment of crude fibre content with the advancement of months is attributed to increasing maturity of leaves. The leaves in general became more fibrous and lignified with the maturity. The crude fibre includes the NDF fraction (hemicelluloses, cellulose and lignin) and ADF fraction (cellulose and lignin). As the leaves mature there is an increase in the lignification of them. Since lignin is a component of the NDF and ADF fractions therefore an increase in the lignification increases the CF content of the leaves with maturity (Singh and Todaria 2012, Ukanwoko and Ironkwe 2013, Hashmi and Waqar 2014).

The nitrogen-free extract content ranged from 52.59 to 49.45 per cent in the months of August to January with an overall mean 50.45 per cent. The present results are in consonance with previous studies of Singh and Todaria (2012) who reported that the NFE content in the leaves of *Q semecarpifolia* decreased with the maturity from 52.01 (July) to 29.66 per cent (April).

Total ash and acid insoluble ash contents increased significantly from August to January (6.68 to 8.23% and 0.81 to 1.42% respectively) with increasing maturity of *L leucocephala* leaves. Similar findings in different tree leaves have been reported by Tambe et al (2012) who reported that the total ash was higher in winter season as compared to monsoon season. Kadam et al (2013) observed that the acid insoluble ash was highest in summer season followed by winter and monsoon in the leaves of *Sesbania* species (*Sesbani arostrata*, *S exaltata* and *S sesban*). The increase in ash content with the maturity may be due to accumulation of minerals.

Overall mean calcium content in the leaves of *L leucocephala* was 1.01 per cent and the value of calcium content ranged from 0.82 to 1.18 per cent from August to January. Verma and Mishra (1999) reported that the calcium content increased with the maturity of leaves of *Albizia stipulate* and *Ougeinia oojeinensis*. Singh and Todaria (2012) also reported that calcium content of *Q semecarpifolia* leaves increased with the maturity of leaves. The physiological basis of increase in calcium concentration is due to the immobile nature of calcium in the phloem which results in difficulty in its transportation to other parts of the tree through phloem and gradual accumulation in mature leaves (Guha and Mitchell 1966).

The overall mean of phosphorus content was 0.27 per cent and the value of content ranged from 0.30 to 0.23 per cent (August to January). It showed a decreasing trend with the advancement of maturity. Singh and Todaria (2012) also reported that phosphorus content of *Q semecarpifolia* leaves decreased with the maturity of leaves. The decrease in P concentration in the leaves with maturity has been attributed to the dilution effect of the rate of inflow of nutrient into the leaves that may be lower than the amount of dry matter produced at a particular growth stage (Ralhan and Singh 1987, Verma and Mishra 1999).

Total tannin phenols content varied significantly between the months of collection of leaves. The overall mean of total tannin phenols content was 1.91 per cent and it ranged from 0.94 to 2.77 per cent (August to January). Findings in the present study are in agreement with the previous studies of Devi et al(2013) and Zayed et al (2014) who also reported that *L leucocephala* leaves contained 2.34-4 per cent total tannins content and it decreased significantly with advancement of maturity. Makkar et al (1991) reported that there is decrease in total tannin phenols with increasing maturity of *Quercus incana* leaves. The condensation of tannins during winter season is an adaptive process of frost resistant mesophyll cells so as to avoid any injury during unfavourable temperate conditions (Salaj and Karmutak 1995) and to help the newly emerging leaves from attacks by herbivorous insects.

The overall mean of mimosine content was 3.34 per cent and its value ranged from 3.80 to 2.74 per cent (August to January). It exhibited a decreasing trend with the advancement of leaf maturity which varied significantly between different months of collection. Xuan et al (2006) reported that young leaves contain highest amount of mimosine (2.66% of dry weight) and the lowest amount was in xylem (0.11%). Foroughbakhch et al (2007) also studied the leaves of *Leucaena* species viz *L diversifolia*, *L shannoni*, *L pulverulenta* and *L leucocephala* and found mimosine content 1.23, 2.14, 2.91 and 3.02 (% DM) respectively.

CONCLUSION

The studies on the monthly variations in nutritive value of leaves of *L leucocephala* showed that in the proximate composition per cent dry matter and ether extract increased whereas crude protein and NFE content decreased with the maturity. The crude fibre, NDF and ADF increased with the maturity of leaves. In mineral composition total ash, acid insoluble ash and calcium increased whereas phosphorus decreased with the maturity from August to January. In the anti-nutritional factors tannins as well as mimosine contents decreased with the maturity of leaves from August to January. Total tannin phenols and mimosine contents were recorded below the toxic levels for animals. It is concluded that the total tannin phenols and mimosine contents were less in mature leaves therefore feeding of mature *L leucocephala* leaves during months of November to January should be preferred in the animal diet.

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