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SHORT COMMUNICATION

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Seasonal variation in nutrient composition in the leaves of two *Bauhinia* species

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Abstract

Trees happen to be a prominent source of nutritive fodders and provide sufficient nutrients to the cattle throughout the year. The leaves of two *Bauhinia* species, that is, *Bauhinia retusa* and *Bauhinia variegata*, were collected in different seasons from their natural growing habitats.The collected leaves were air-dried to make a fine powder, and the nutrient concentrations were estimated as per the standard processes. Significant variations were recorded in the nutritive values of both species in different seasons. The leaves of *B. retusa* revealed highest dry matter and total carbohydrate in the summer season, while the rainy season exhibited the highest value of ash per cent and crude protein.The ether extract and nitrogen-free extract per cent were higher in the winter season, and the maximum crude fibre and organic matter per cent were prominent in the spring season. In case of *B. variegata* leaves, the dry matter, nitrogen-free extract, ash and ether extract per cent were higher in the winter season. The highest crude fibre percent and total carbohydrate were found to be the maximum in the rainy season, and crude protein was higher in summer season. The results of the present study revealed that the both *Bauhinia* species are good sources of green fodder for cattle, especially in the rainy season in case of *B. retusa* and in the summer season for *B. variegata,* to correct the deficiency of protein in animals in the hill state of Uttarakhand, India.

Keys words

Bauhinia retusa, Bauhinia variegata, carbohydrate, crude protein, seasonal variation, tree fodder

Introduction

India is predominantly an agricultural country, which has the second largest cattle population in the world (F.A.O. 2021). Livestock or cattle constitutes an important component in the economy of any country. In India, the total livestock population consisting of cattle, buffalo, sheep, goat, pig, horses, ponies, mules, donkeys, camels, mithun and yak is 535.08 million, with cattle, buffaloes, sheep and goat making up the largest share (Anonymous 2021a). Compared to 2012, the total animal population of India increased by 4.6% (Anonymous 2021a) and contributed 5.1% and 17.1% of the total gross value added (GVA) and agriculture and allied industries, respectively (Anonymous 2021b). Clearly, the trend of increasing cattle population has an impact on the types of fodder resources needed to meet their dietary needs (PCI 2011).

Tree leaf fodder is almost as nutritious as that of leguminous fodder crops (Singh 1982). Tree foliage has

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high digestibility, good vitamin and mineral content and also enhances the microbial growth and digestion of cellulosic biomass in the rumen of livestock. In some foliage, the presence of antinutritional content likes tannins, phenolics, glycosides, alkaloids, triterpenes, oxalic acid and so on reduces their nutritional quality, which can be taken care of by proper alleviation method (Samtiya et al. 2020). India, being rich in diversity of foliage trees, has an enormous potential of using tree foliage as a basal feed or forage supplement (Rajan 2009). Potent feed for livestock (Papachristou and Nastis 1996; Saklani 1999; Singh et al. 2022) plays an important role in the nutrition of livestock in areas where few or no alternatives are available. The farmer-planted/maintained trees are suitable for fodder in the bunds of the agricultural field known as agroforestry systems (Khosla et al. 1992) because they can offer various products and have a big impact on rural economies (Sharma et al. 2017, 2022). As in many other regions of the world, farmers in the Garhwal Himalayan region of India also depend largely on tree fodder for sustaining their livestock (during winter and summer seasons) for almost half of the year (Singh et al. 2010; Singh and Todaria 2012; Singh et al. 2022). The dependency is very high (>70%) during the period beginning from October to February (Verma and Mishra 1999). Plant development and the accumulation of leaves can be negatively or positively impacted by seasonal change, which will either result in a scarcity or an abundance of feed that is readily available for cattle (Hassen et al. 2017). Owing to changing climatic conditions, farmers' preference for a particular tree species is also variable, according to the low, mid and high hill regions of Garhwal Himalaya.

Bauhinia belongs to the family Fabaceae and is distributed in the tropical and subtropical regions of Garhwal Himalaya (Troup 1921). *Bauhinia* species has a rich diversity of life forms ranging from trees and shrubs to climbers and is represented by about 15 species in India. *Bauhinia* species are used mainly as fodder during the lean period (when there is no other feeding material available), particularly the summer season. Farmers harvest the foliage of these trees to feed their cattle and buffaloes. Natural populations of *Bauhinia retusa* and *Bauhinia variegata* in Garhwal Himalaya are overexploited for different purposes, that is, fodder, firewood, medicine, small timber and bee forage (Bhatt and Varma 2004; Nagar et al. 2022). Very little scientific and systematic information is available on both agroforestry species with reference to change in nutrient composition with season. Keeping in view the above-mentioned fact, the present study was conducted to evaluate the variation in nutrient composition of two *Bauhinia* species, that is, *B. retusa* and *B. Variegata,* with seasons.

Material and methods

To assess the nutritive value, leaves of two *Bauhinia* species were harvested from Nagni area of Tehri Garhwal district, which lies between 30°20.205'N latitude and 78°25.024'E longitude with an altitude of 1280 m above sea level. Five trees were selected and more than half kilogram of composited samples of fresh leaves was collected from the upper, middle and lower portions of each tree from all four directions of both *Bauhinia* species. The leaves were collected quarterly in spring, summer, rainy and winter seasons in 2015 to record the seasonal variation in nutritive values. The collected samples were air-dried for 15 days, and the dried leaves were crushed in a mechanical grinder to obtain fine powder for further observations.

The dry matter content was measured using standard procedures through oven-dry methods. The crucibles were dried by placing them in an electric oven at 100°C and cooled in desiccators to record their weight. Ten grams of fresh leaf materials was taken in a crucible and again weighed. Further, the crucible containing the plant materials was placed in an electric oven for 24 h and then allowed to cool. Dry matter of leaf samples was calculated as follows:

$$\text{Dry matter (\%)} = \frac{\text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100$$

Ash content was analysed as per the procedure given by A.O.A.C (1995) and Sankaram (1966). The total ash content in percentage was calculated by the following formula:

$$\text{Total ash (\%)} = \frac{\text{Weight of ash}}{\text{Original weight of sample}} \times 100$$

Total nitrogen in the leaves was estimated by the Kjeldahl method. To record the crude protein in the fo-

liage, the nitrogen value was multiplied by 6.25. Crude fibre and ether extract (EE) were estimated as per the method used by Ranjhan and Krishna (1981). The nitrogen-free extract (NFE) was determined by subtracting the sum of crude protein, crude fibre, EE and total ash content from 100 as outlined by A.O.A.C (1995) and Sankaram (1966):

$$NFE = 100 - (\%CP + \%EE + \%CF + \%ASH)$$

Organic matter (OM) was determined by using the following formula given by A.O.A.C (1995) and Sankaram (1966):

$$OM = \%CP + \%EE + \%CF + \%NFE$$

Total carbohydrate (TC) was calculated by the formula given by A.O.A.C (1995) as follows:

$$TC = \%\ CF + \%\ NFE$$

Statistical analysis

Arcsine transformation was done for normality of data and then analysis of variance was calculated for different seasons with the help of online software ICAR Goa. Tukey test was used to evaluate significant ($p < 0.05$) variations in nutritive value between different seasons (Panse and Sukhatme, 1978).

Results

A significant variation was observed in the nutrient concentration of *B. retusa* leaves collected in different seasons. The dry matter in *B. retusa* leaves was found to be the maximum (60.21%) in summer season (May) and minimum (51.25%) in winter (November) season. Total ash per cent was found to be maximum (10.36%) in the rainy season (August) and minimum (7.83%) in the spring season (February). The highest and lowest (2.63% and 1.76%, respectively) EE were recorded in the rainy season (August) and spring season (February), respectively. The crude fibre (25.71%) was prominent in spring (February) and least (13.47%) in the rainy season (August). In case of crude protein (11.43%), the rainy season (August) showed high content, while the lowest content (9.72%) was noticed in the month of summer (May). NFE was highest (60.38%) in winter (November) and the minimum in spring. TC was noted to be maximum (81.25%) in summer (May) and minimum (73.77%) in the rainy season (Tab. 1).

A significant variation was recorded in the nutritive value of *B. variegata* leaves among different seasons. Dry matter was found to be maximum (58.10%) in the winter season (November) and minimum (48.67%) in the summer season (May). The total ash content was found to be maximum (8.06%) in the winter season (November) and lowest (7.53%) in the spring season (February). EE per cent was maximum (3.31%) in winter (November) and minimum (1.88%) in summer season (May). The crude protein was higher (12.06%)

Table 1. Seasonal variations in nutritive value of *Bauhinia retusa and Bauhinia variegata*

Species	Seasons/(month of harvesting)	Dry matter (%)	Total ash (%)	Ether extract (%)	Crude fibre (%)	Crude protein (%)	Nitrogen-free extract (%)	Organic matter (%)	Total carbohydrate (%)
B. retusa	Spring (February)	55.74	7.83	1.76	25.71	10.01	54.70	92.84	80.41
	Summer (May)	60.21	8.28	2.08	21.42	9.72	59.83	91.39	81.25
	Rainy (August)	54.64	10.36	2.44	13.47	11.43	60.30	89.69	73.77
	Winter (November)	51.25	8.49	2.63	17.81	10.69	60.38	91.51	78.19
B. variegata	Spring (February)	50.40	7.40	2.56	21.10	9.63	59.31	92.93	80.41
	Summer (May)	48.67	7.53	1.88	20.88	12.06	57.65	92.47	78.53
	Rainy (August)	57.82	7.62	2.67	23.03	8.92	57.71	92.38	80.80
	Winter (November)	58.10	8.06	3.31	19.42	9.78	59.43	91.61	78.85

Table 2. Analysis of variance for different nutrient concentrations of *Bauhinia* species influenced by the season

Species	Source of variation	df	Dry matter	Total ash	Ether extract	Crude fibre	Crude protein	Nitro-gen-free extract	Organic matter	Total carbohy-drate
Bauhinia retusa	seasons	3	41.01^{**}	3.74^{**}	4.29^{**}	82.37^{**}	41.52^{**}	22.65^{**}	4.15^{NS}	33.68^{**}
	replications	2	7.68^{NS}	0.04^{NS}	0.02^{NS}	0.26^{NS}	2.07^{NS}	0.25^{NS}	0.59^{NS}	2.06^{NS}
Bauhinia variegata	seasons	3	72.57^{**}	0.24^{*}	1.03^{**}	6.84^{**}	5.57^{**}	2.87^{*}	0.91^{NS}	3.80^{NS}
	replications	2	5.96^{NS}	0.08^{NS}	0.003^{NS}	0.08^{NS}	0.06^{NS}	1.73^{NS}	0.21^{NS}	4.51^{NS}

df = degree of freedom
**Significant at $p < 0.01$; *significant at $p < 0.05$; NS = non-ignificant

in the summer season (May) and minimum (8.92%) in the rainy season (August). Winter season exhibited the highest (59.43%) NFE,whereas the lowest content (57.65%) was found in the summer season. TCs were found to be maximum (80.8%) in the rainy season, while the lowest content (78.53%) was noticed in the summer season (Tab. 1).

Analysis of variance revealed a significant difference in seasons for different nutrient contents in both *Bauhinia* species (Tab. 2). Significant ($p < 0.01$) variation among seasons was estimated in all nutrient contents, except dry matter production and OM in *B. retusa*. While in *B. variegata*, the nutrient contents were significantly ($p < 0.1$, $p < 0.05$) affected by the seasons, except for OM and TCs (Tab. 2).

Discussion

Nutritive value of both *Bauhinia* species significantly ($p < 0.05$) varied among the seasons. Seasonal variations in nutrient concentrations of tree foliage were also reported by many researchers (Saklani 1999; Singh et al. 2010, 2022; Singh and Todaria 2012; Navale et al. 2022). Further, seasonal variation in leaf chemistry and nutritive values of fodder species is also well documented in different species (Mauffett and Oechel 1989; Subba et al. 1994, 1996; Pathak et al., 2005; Shah et al. 2019; Enri et al. 2020). Dry matter was found to be maximum during maturity in both *Bauhinia* species. Similar finding was found in *Celtis australis* by Singh et al. (2022). In the present study, crude protein was maximum in the summer season (May) and rainy season (August) in *B. retusa* and *B. variegata*, respectively. Similar findings were also recorded in *Quercus semicarpifolia* (Singh and Todaria 2012). Crude protein was found to be maximum in the wet season compared to the dry season in Haloxylon schmittianum, Anabasis articulata and Astragalus armatus (Mayouf and Arbouch 2015). Similarly, the rainy season showed higher levels of crude protein in browse species on savanna rangelands, compared to the dry season (Mudzengi et al. 2020). These results are in conformation with *B. variegata*, while in *B. retusa,* it was higher in the summer season. The higher crude protein in the summer season might be due to the leaf longevity of this species (more than 1 year) and the leaves of all age groups are present during this season. Seasonal variations for ash and crude protein of *Amrtocarpus lakoocha* foliage have also been recorded by Wood et al. (1995). Kamalak et al. (2005) reported that EE in *Gundelia tournefortii* increased with increasing maturity, which was in agreement with the present investigation, that is, EE was higher in mature leaves of *B. variegata,* while in *B. retusa,* EE decreased with increasing maturity of leaves. Interestingly, EE was higher in the winter season in both *Bauhinia* species. Higher EE in the winter season was also reported in *Quercus semecarpifolia* leaves (Singh and Todaria 2012).

Generally, as plant leaves mature, crude protein decreases and fibre increases, while digestibility and energy content decline. In the present study, the crude protein reduced with leaves' maturity, while the crude fibre content increased with maturity. For maintaining the normal metabolism in ruminant animals, a continuous supply of protein is required in all the seasons. Six to eight per cent crude protein is required for the efficient fermentation of plant tissue by the bacteria in ruminant animals' stomach (Van Soest 1982). Protein content in leaves may vary due to the retranslocation of leaf nitrogen into branches and partly due to a dilution

factor with expansion and fall of the leaves at maturity (Khosla et al. 1992). In *Bauhinia purpurea*, dry matter and crude protein contents were significantly variable with seasons (Shah et al. 2019). The results of the present study revealed that both species are good fodder trees and have >8% crude protein. So, the leaves of both *Bauhinia* species might be harvested as green fodder throughout the year to prevent deficiency of protein in animals. The green fodder is useful for improving the health of animals. To increase the cattle output, the leaves of fodder trees should be collected when they are at their most nutritious stage because seasonal variation affects the nutritious efficiency. Further, the plantation of both agroforestry crops should be emphasised for the fulfilment of green fodder, which might enhance the economic conditions of poor and marginal farmers in the Garhwal Himalayan region. Planting of trees on any degraded land is beneficial from an economic and ecological point of view.

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