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Effect of Harvesting time and species on nutritional quality of edible bamboo shoots

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Abstract
The study revealed that nutritional attributes of tender bamboo shoots varied markedly among different species of bamboo. The dry matter, crude protein, fat, carbohydrates and the P content in different bamboo species varied from 91.41 to 92.53 per cent, 7.69 to 8.54 per cent, 17.86 to 24.33 per cent, 0.30 to 0.47 per cent, 2.34 to 5.21 per cent and 32.59 to 39.59 mg/100g, respectively. The finding indicates that best nutritional traits were found in *D. hamiltonii* & *B. nutans*. Best time of harvest for the edible shoots is August when the tender shoots of bamboo are at the stage of best nutritional quality.

Keywords: Bamboo, nutritional quality, harvesting time, edible shoots

Introduction
Bamboos are considered as one of the most versatile multiutility forest tree grasses. Though distribution of bamboos is worldwide with over 1250 species, their presence is predominantly found in Southeast Asia (Scurlock *et al*., 2000, Bystriakova *et al*., 2003) [10, 3]. Bamboos, in addition to their multiple applications have another important usage as popular food. The presence of high content of protein, amino acids, minerals, fibre, carbohydrates and low fat makes the bamboo shoot one of the widely acclaimed nutrient rich food items. Also the presence of phytosterols in young shoots provides youthful feeling, athletic energy and longevity to regular consumers. Bamboos shoots are popular in Asiatic countries and form a major component of their traditional cuisines (Bao, 2006) [1]. Consumption of bamboo shoots as food in India is mainly confined to the Northeast states where they are taken either fresh at the time of harvesting season or dried, fermented or pickled forms during offseason (Nirmala *et al*., 2008) [7]. In North western Himalaya, Dendrocalamus hamiltonii,, Bambusa arundinacea, B. tulda and B. nutans, are the species which confined to low and mid hills. In the recent years the consumption of bamboo shoots and its edible products have increased steadily due to their recognization as an important source of natural antioxidants besides anticancer activities. The present study was conducted to identify the best bamboo species with high nutritional quality and best harvesting time of the the same.

Material and methods
In the present study was conducted at Depa, four different varieties of Bamboo shoots *viz. Dendrocalamus hamiltonii* (S1), *Bambusa tulda* (S2), *B. arundinacea* (S3) and *B. nutans* (S4) were used. Tender shoots were harvested in the months=August, September and October. After harvesting shoots were subjected to the nutritional analysis. Dry shoot samples of three replicates were ground and analysed for proximate principles (AOAC 1990) i. e. Dry matter (DM) and Crude protein (CP). Total carbohydrates content was estimated by Acid alkali digestion (ashing) as described by Sankaran (1966) and the AOAC (1980). Total ash content was estimated as per the procedure given by Association of Official Analytical Chemists (AOAC, 1980. Phosphorus content was determined by Vanado-molybdate-yellow colour method as described by Jackson, 1973 and was estimated using a flame photometer (Model 333183; Thermo Electron Corporation, US).

Statistical analysis
Observations recorded in the study were subjected to statistical analysis, wherever possible and feasible by adopting appropriate method as described by Gomez and Gomez (1984).

Results and Discussion

The effect of species, harvesting time and shoot length on the nutritional quality of bamboo was determined and results have been depicted in pertinent tables under the following subheads:

Dry matter content

Data reveals that dry matter content of different bamboo species varied significantly in all the bamboo species (Table 1). Maximum dry matter content (9.40%) was recorded in *B. arundinacea* (8.54%) which was found to be statistically higher than all other bamboo species. Minimum dry matter per cent was recorded in *D. hamiltonii* (7.95%). In the effect of month, maximum dry matter content (8.42%) was recorded in the month of October, which was found to be significantly higher than dry matter content of all the species as recorded in the month of August and September. Increase in dry matter content with with advancement of harvesting time may be attributed to the increasing maturity of shoots, possibly due to ageing (Pasha *et al*. 1994; Soest 1994) [8, 12]. Santis *et al*. (2004) also reported that nutritional value and dry matter composition of forage species is governed by changes in developmental morphology of plants. Dry matter content in the month of August and September remained statistically at par with one another. Study of ANOVA revealed that average effect of species and month of harvest exerts a significant influence on the dry matter content of bamboo shoots.

Total Carbohydrates

Total carbohydrate per cent was significantly influenced by the average effect of species and time of harvest (Table 1). In the interaction effect, two way interactions between bamboo species and time of harvest exercised significant influence on the carbohydrate content. Among all the species studied, mean maximum carbohydrate per cent (5.21%) was recorded in the *D. hamiltonii* species whereas mean minimum carbohydrate content (2.34%) was found in the *B. tulda* species. Considering the harvesting time, the maximum carbohydrate content (4.25%) was recorded in the shoots harvested in the month of August and minimum in those harvested in October. A decreasing trend could be seen in bamboo species in relation to the time of harvest in respect of total carbohydrate content. Maximum carbohydrate content was displayed by the *D. hamiltonii* shoot harvested in the month of August, which was found to be significantly higher than all other treatment combinations.

Fat per cent

Fat content (%) of the tender bamboo shoots was significantly influenced by the average effect of species and time of shoot collection (Table 1). The maximum fat content (0.46%) was displayed by *D. hamiltonii*, which was found to be significantly higher than all other species under investigation and followed the trend: *D. hamiltonii*> *B. arundinacea* > *B. tulda* > *B. nutans*. Among different harvesting months, maximum fat percent was recorded in the month of September (0.47%), which was found to be significantly higher than the month of August and October, respectively. Interaction effect of bamboo species and time of harvest significantly influenced the fat content of the tender bamboo shoot. Fat content in the bamboo shoots has been reported in the range of 0.26% to 0.94% (Nirmala *et al*. 2011) [5]. As bamboo shoots are very low in fat content, they can be very good for weight-conscious and dieting people.

Crude protein percent

Crude protein per cent of bamboo shoots was significantly influenced by average effect of species and harvesting time (Fig. 1). Among all the species, the mean maximum crude protein (24.33%) was demonstrated by *D. hamiltonii*, which was found to be significantly higher than all other bamboo species under investigation whereas, minimum crude protein content (17.86%) was demonstrated by *B. arundinacea* followed by *B. nutans* (19.98%) and *B. tulda* (22.14%), respectively. The mean maximum crude protein (23.18%) was recorded in the month of August followed by September (21.19%) and October (18.86%), respectively. The crude protein of shoots showed an inverse relationship with harvesting time. The maximum crude protein (26.29%) was displayed by *D. hamiltonii* in the month of August (26.29), which were found to be significantly higher than all the treatment combinations under consideration. Whereas, minimum crude protein content (16.05) was displayed by the *B.arundinacea* in the month of October. Protein is an indispensible requirement for the growth and maintenance of all biological organisms. Crude protein content of shoots decreased with the advancement in the harvesting time which may be attributed to a relatively rapid increase in dry matter content which results in dilution of nitrogen (Verma and Mishra 1999) [14]. In a study of 14 bamboo species, the protein content in the juvenile shoots ranged from 2.31 to 3.72 g/100 g fresh weight, the highest being in *D. hamiltonii* followed *by B. bambos*. Similar values have been also reported by other workers (Sundriyal and Sundriyal 2001; Bhatt and others 2005) [13, 2].

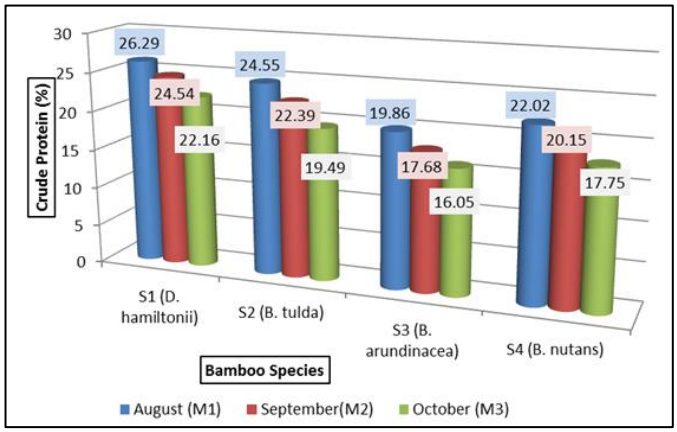

Fig 1: Crude protein (%) of tender bamboo shoots in relation to species and time of harvest

Phosphorus

Data presented in the Fig 2. show that phosphorus content was significantly influenced by the average effect of species, month and height. The maximum phosphorus content (35.59 mg/100g) was registered by *B. tulda*, followed by the bamboo species of *B. arundinacea*, *B. nutans* and *D. hamiltonii*, respectively in the descending order. The maximum phosphorus content was recorded when bamboo shoots were harvested in the month of September, which however remained statistically at par with that in month of October. Nirmala *et al*. 2011 [5] reported the phosphorus content in D. hamiltoni as 28.12 mg/ 100g which was lower than that recorded during our experiment. This may be attributed to different climatic conditions of the sample growing areas.

The nutritional value of edible shoots of different bamboo species has been worked out by several workers (Sharma and

others 2004; Xu and others 2005; Kumbhare and Bhargava 2007; Nirmala *et al*., 2007, 2008) [11, 15, 4, 6]. Changes in nutrient components were also observed during the aging and harvesting time of emerging juvenile shoots (Nirmala *et al*., 2007) [6]. A study conducted on 5 commercially important bamboos, *B. bambos, B. tulda, D. asper, D. giganteus, and D. hamiltonii*, showed that nutritional quality of the shoots depleted with aging (Nirmala *et al*. 2011) [5]. This also indicates that freshly emerging shoots are nutritionally superior to the older emerged shoots.

Table 1: Dry matter content, Total carbohydrates and Fat content of tender bamboo shoots in relation to species and time of harvest

Species (S)	Dry Matter content (%)				Total Carbohydrates (%)				Fat content (%)			
	Time of harvest (M)				Time of harvest (M)				Time of harvest (M)			
	August (M_1)	September (M_2)	October (M_3)	Grand Mean (S)	August (M_1)	September (M_2)	October (M_3)	Grand Mean (S)	August (M_1)	September (M_2)	October (M_3)	Grand Mean (S)
S_1 (*D. hamiltonii*)	7.94	7.91	8.01	7.95	5.37	5.22	5.03	5.21	0.42	0.62	0.35	0.46
S_2 (*B. tulda*)	7.46	7.46	8.15	7.69	2.40	2.27	2.35	2.34	0.34	0.50	0.25	0.36
S_3 (*B. arundinacea*)	8.29	7.93	9.40	8.54	5.08	5.10	4.84	5.01	0.43	0.40	0.37	0.40
S_4 (*B. nutans*)	8.45	8.42	8.11	8.33	4.13	4.03	4.10	4.09	0.30	0.34	0.26	0.30
Grand Mean (M)	8.04	7.93	8.42		4.25	4.16	4.08		0.37	0.47	0.31	
CD $_{(0.05)}$	S=0.11	M=0.10	SXM: 0.18		S=0.12	M=0.10	SXM: 0.21		S=0.08.	M= 0.06	SXM: 0.16	

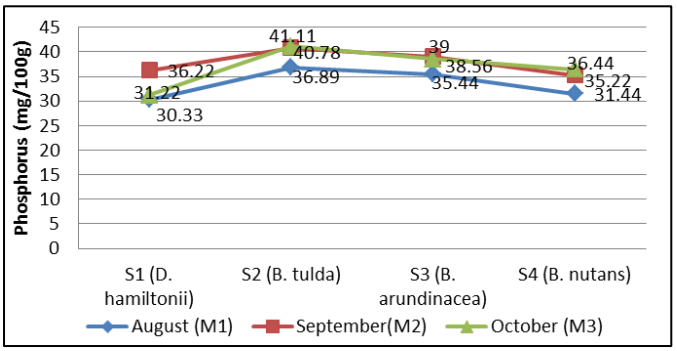

Fig 2: Phosphorus content (mg/100g) of tender bamboo shoots in relation to species and time of harvest

Conclusion

Bamboo shoots have immense potential of being used as important health food as they have high content of useful proteins, amino acids, carbohydrates, and many important minerals and vitamins and very low fat. Among different bamboo species studied, *D. hamiltonii* followed by *B. nutans* has been found to be the having the immense nutritional potential and can be successfully used as a food. Besides, harvesting bamboo shoots at tender and early stage is always useful in order to utilize the nutritional potential of bamboo shoots. The usefulness of bamboo shoots as health food is not largely known by general public due to ignorance of their high nutritional values. Therefore, there is a greater necessity to create awareness among the people about their nutritional health benefits so that they are widely accepted.

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