



ISSN (E): 2277- 7695

ISSN (P): 2349-8242

NAAS Rating: 5.03

TPI 2020; 9(2): 456-459

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www.thepharmajournal.com

Received: 10-12-2019

Accepted: 12-01-2020

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Quality attributes of four species of bamboo shoot harvested at different stages

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Abstract

Bamboos are grown mainly in the deciduous and tropical evergreen areas of Asia, Africa, Caribbean and Latin America. They are one of the most important resources on the earth and regarded one of the best food items among the people all over the world. Bamboos are characterized by woody and mostly hollow culms. Presence of high amount of dietary fibre, amino acids, proteins, carbohydrates, vitamins, minerals and low fat content in bamboo shoots have made it attractive to many people for consumption. Assessment of the physical status of four edible bamboo shoots (with and without sheath) harvested at different stages was performed. It was observed that the edible portion decreased with ageing while the shoot weight, tip and base diameter, and peel percentage were increased.

Keywords: Bamboo shoots, harvesting, physical status

Introduction

Bamboos belonging to the sub-family *Bambusoideae* of *Poaceae*, is one of the fastest growing plants. They have the ability to survive in a varied climatic and soil conditions. It is capable of growing from organically poor to mineral rich soil and moisture to drought to flooding which makes it effective for reclaiming degraded lands. Due to its diverse adjustability to a varied range of climates, cultivation of bamboos spreads across different continents, from tropical jungles of Chile to the mountain slopes of the Himalayas. It grows mainly in the mixed deciduous and tropical evergreen areas of Asia, Africa, the Caribbean and Latin America (Singhal *et al.*, 2013) [16]. China is reported to have the most abundant bamboo resources worldwide and the richest bamboo culture which is followed by India. The total area of forests covered by bamboo is 22.0 million ha, which accounts for about 1 per cent of the total global forest area (Liu *et al.*, 2018) [9]. In India, bamboos cover an area of 15.69 million hectare which is 22.15 per cent of the total forest cover in the country. More than 50 per cent of the total bamboo species recorded in India is found in North-eastern states like Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Sikkim along with the state of West Bengal (North Bengal, Himalaya). In North West India, Himachal Pradesh is the only state that has plenty of naturally growing bamboo occupying 540 km² area which is 4.8 per cent of total forest cover and contributes about 0.34 per cent to the country (FSI, 2017) [7].

Bamboos are shrubs with a tree-like habit. Their culms are erect and sometimes climbing. They are characterized by woody and mostly hollow culms (Meher *et al.*, 2012) [11]. Bamboos are addressed in different names by people from different countries because of their highly multipurpose properties. The Chinese called bamboos as “Friends of the people,” Vietnamese as “My brother,” and Indians as “Green Gold” (Nongdam and Tikendra, 2014) [13]. *Bambusa* and *Dendrocalamus* are found under tropical conditions in which *Dendrocalamus strictus* is predominant in dry deciduous forests while *Bambusa bamboos* flourishes best in moist deciduous forests. Even though, a good number of bamboo species produce shoots suitable for human consumption, however the commercially most important species belong to a few genera like *Phyllostachys*, *Bambusa* and *Dendrocalamus* (Kleinhenz *et al.*, 2000) [8].

Bamboo shoots are tender, soft, crispy and generally ivory yellow in colour. The sheaths covering the shoots are black, brown, yellow or purple (Choudhury *et al.* 2012) [2]. Bamboo shoots usually emerge at the onset of monsoon and are harvested after attaining 20-30 cm height. If the shoots are not harvested soon after they emerge from the ground, they grow into a tall bamboo plant within three to four months, turn tougher, acrid or bitter (Sue, 1995 and Singhal *et al.*, 2013) [16]. Exposure of shoots to light causes bitterness due to the presence of cyanogenic glycoside taxiphyllin, which is toxic in nature (Choudhury *et al.*, 2010) [4].

Every part of the bamboo plant - leaves, shoots, culm sheath and culms are used either as food or for medicine and health benefits (Nirmala and Bisht, 2015) ^[12]. Young shoots of both running and clump-forming bamboos can be used as food, and the extract of bamboo leaves could be used as food additives (Pandey and Ojha, 2014) ^[14]. Bamboo shoots are a popular food in Asia and the nutritional value is as good as those of many commercial vegetables. The shoots are traditionally consumed as fresh vegetables during their season of availability. They are also preserved as salted, fermented, dried products in North-eastern regions of India and salted and pickled products in the Western Ghats, Karnataka and Himachal Pradesh.

Materials and Methods

Four bamboo species viz. *Dendrocalamus strictus*, *Dendrocalamus hamiltonii*, *Phyllostachys reticulata* and *Bambusa nutans* were used in the study. The bamboo shoots of *Dendrocalamus strictus*, *Dendrocalamus hamiltonii* and *Bambusa nutans* species were procured from Anu, Giripul, Karganu, Lakothi, and Nauni villages of District Solan, in Himachal Pradesh, India while *Phyllostachys reticulata* shoots were procured from University Experimental Farm, Nauni, Solan. The bamboo shoots of these species were harvested at 30, 40, 50 and 60 cm height and brought to the Fruit Processing Laboratory, Department of Food Science and Technology, UHF, Nauni, Solan (HP) for conducting various physical and chemical characteristics.

Physical and chemical characteristics of bamboo shoots

The bamboo shoots of different species harvested at 30, 40, 50 and 60 cm height were assessed for various physical and chemical characteristics. The species were coded and the analyzed detail is presented in Table 1.

The weight of randomly selected bamboo shoots (with and without sheath) was taken on an electronic weighing scale (Goldface, GFTT-II) and expressed as gram per unit. The length of ten randomly selected shoots (with and without sheath) was measured with the help of a non-stretchable thread which was correspondingly equated in centimetres with the help of standard scale. Vernier calliper (Mitutoyo Absolute Digimatic Caliper) was used for measuring the diameter of the base and tip portion of bamboo shoots (with and without sheath) and expressed in cm. The edible portion (%) was calculated by dividing the weight of the edible portion by bamboo shoot weight and multiplied by 100. Peel (%) was calculated by dividing the weight of the peel by weight of the whole shoot and multiplied by 100. The colour of the bamboo shoot (with and without sheath) was determined by using colour chart of Royal Horticultural Society Colour Chart (RHC).

Statistical analysis

Data on chemical and functional characteristics of bamboo shoot powder and pasta was analysed by Completely Randomized Design (CRD) suggested by Cochran and Cox (1967) ^[5]. While Randomised Complete Block Design (RBD) as described by Mahony (1985) ^[10] was used to analyze the data pertaining to sensory evaluation.

Results and Discussion

Physical characteristics of bamboo shoot with sheath

The results obtained for physical characteristics of bamboo shoot (with sheath) are presented in Table 1. The data revealed a significant increase in physical parameters such as weight and diameter of shoots of all the species for 30 to 60

cm of height. The shoot weight of *Dendrocalamus strictus* (S₁), *Dendrocalamus hamiltonii* (S₂), *Phyllostachys reticulata* (S₃) and *Bambusa nutans* (S₄) increased from 0.603 to 0.767 kg, 0.964 to 1.292 kg, 0.137 to 0.168 kg and 0.735 to 0.906 kg, respectively at 30 to 60 cm height. It was concluded that the highest shoot weight was noted in S₂ at 60 cm height while the lowest in S₃ at 30 cm height. The increase in tip diameter with aging was found to be non-significant in all the species. A non-significant increase was also observed in basal diameter in S₃ and S₄ while a significant increase was detected in S₁ and S₂ from 5.54 cm at 30 cm height to 5.62 cm at 60 cm height and 8.43 cm at 30 cm height to 8.52 cm at 60 cm height, respectively. The data clearly showed that the aging has a significant effect on weight and diameter in all the species. These results for basal diameters are slightly lower than the findings of Dhiman *et al.* (2017) ^[6] in *D. strictus* and *D. hamiltonii*. The colour of shoot as examined by using Royal Horticulture Cards, London in shoots at different heights matched Yellow-green, Greyed-orange, Greyed-red and Brown group. The colour range reported by Choudhury *et al.* (2011) ^[3] was light-green to blackish-green. Dhiman *et al.* (2017) ^[6] observed a yellowish green, blackish green and light green in *D. strictus*, *D. hamiltonii* and *B. nutans*, respectively.

Physical characteristics of bamboo shoot without sheath

The data regarding physical characteristics of bamboo shoot (without sheath) are presented in Table 2. The results showed non-significant increase in shoot weight of S₁, S₃ and S₄ whereas in S₂ it was found to be significant during aging. The shoot at 30 cm length of S₁ increased from 21.20 at 30 cm height to 51.30 cm at 60 cm height, S₂ from 25.38 cm at 30 cm height to 54.40 cm at 60 cm height, S₃ from 18.95 cm at 30 cm height to 48.85 cm at 60 cm height and S₄ from 22.90 cm in 30 cm height to 53.25 cm in 60 cm height. These findings are in compliance with the result of Bhatt *et al.* (2004) ^[1] and higher than the values given by Sood *et al.* (2013) ^[17]. Tip and base diameter in all the species showed a non-significant increase. The recovery of edible portion in S₁ was 57.71, 53.65, 50.00 and 47.46 per cent at 30, 40, 50 and 60 cm height, respectively. Edible portion recovered from S₂ was 52.07 at 30 cm height, 51.81 at 40 cm height, 47.68 at 50 cm height and 46.75 per cent at 60 cm height. S₃ recorded 66.42, 64.58, 63.82 and 60.12 per cent edible portion, respectively at 30, 40, 50 and 60 cm height. The edible portion recovered from S₄ was 51.43 (30 cm height), 48.61 (40 cm height), 45.58 (50 cm height) and 43.16 cm (60 cm height). Edible portion of 59.28 per cent at 15 to 30 cm shoot height of *D. strictus* was reported by Pandey and Ojha (2013) ^[15] and 33.33 per cent at 26.50 cm shoot height of *D. hamiltonii* by Sood *et al.* (2013) ^[17]. Shoots of *D. strictus* (40.92 cm height), *D. hamiltonii* (43.19 cm height) and *B. nutans* (44.10 cm height) possessed edible portion of 33.28, 30.05 and 30.10 per cent, respectively as reported by Dhiman *et al.* (2017) ^[6]. The increase in peel portion was from 42.29 at 30 cm height to 52.54 per cent at 60 cm height, 47.93 cm at 30 cm height to 53.25 per cent at 60 cm, 33.58 at 30 cm height to 39.88 per cent at 60 cm height and 48.57 at 30 cm height to 56.84 per cent at 60 cm height in S₁, S₂, S₃ and S₄. It can be concluded that the peel percentage was highest at 60 cm shoot height of S₂ and lowest at 30 cm shoot of S₃ the lowest. Sood *et al.* (2013) ^[17] recorded 66.67 peel per cent in shoot of *D. hamiltonii* at 26.50 cm height. The colour of shoot as examined by using Royal Horticulture Cards, London matched Yellow group in S₁, Yellow-orange group in S₂ and S₃, and Green group in S₄.

Table 1: Physical characteristics of bamboo shoot (with sheath)

Parameters	<i>Dendrocalamus strictus</i> (S ₁)				<i>Dendrocalamus hamiltonii</i> (S ₂)				<i>Phyllostachys reticulata</i> (S ₃)				<i>Bambusa nutans</i> (S ₄)			
	30 (cm)	40 (cm)	50 (cm)	60 (cm)	30 (cm)	40 (cm)	50 (cm)	60 (cm)	30 (cm)	40 (cm)	50 (cm)	60 (cm)	30 (cm)	40 (cm)	50 (cm)	60 (cm)
Shoot weight (kg)	0.603	0.658	0.712	0.767	0.964	1.023	1.187	1.292	0.137	0.144	0.152	0.168	0.735	0.792	0.849	0.906
Tip diameter (cm)	0.55	0.57	0.58	0.61	0.83	0.85	0.86	0.88	0.13	0.15	0.15	0.16	0.79	0.81	0.82	0.83
Base diameter (cm)	5.54	5.55	5.59	5.62	8.43	8.45	8.49	8.52	2.04	2.05	2.08	2.09	7.82	7.83	7.85	7.85
Visual colour *	Yellow-green 147B	Yellow-green 147A	Yellow-green 146B	Yellow-green 148A	Greyed-orange 177A	Greyed-orange 166A	Greyed-orange 177A	Greyed-orange 176A	Greyed-red 182A	Greyed-red 182A	Greyed-red 182B	Greyed-red 182B	Brown group 200B	Brown group 200B	Brown group 200C	Brown group 200C

* Royal Horticulture Chart

Table 2: Physical characteristics of bamboo shoot (without sheath)

Parameters	<i>Dendrocalamus strictus</i> (S ₁)				<i>Dendrocalamus hamiltonii</i> (S ₂)				<i>Phyllostachys reticulata</i> (S ₃)				<i>Bambusa nutans</i> (S ₄)			
	30 (cm)	40 (cm)	50 (cm)	60 (cm)	30 (cm)	40 (cm)	50 (cm)	60 (cm)	30 (cm)	40 (cm)	50 (cm)	60 (cm)	30 (cm)	40 (cm)	50 (cm)	60 (cm)
Shoot weight (kg)	0.348	0.353	0.356	0.364	0.502	0.530	0.566	0.604	0.091	0.093	0.097	0.101	0.378	0.385	0.387	0.391
Shoot length (cm)	21.20	27.70	30.80	51.30	25.38	33.10	42.53	54.40	18.95	22.15	27.80	48.85	22.90	31.85	38.95	53.25
Tip diameter (cm)	0.12	0.14	0.15	0.18	0.20	0.21	0.23	0.26	0.09	0.09	0.10	0.10	0.19	0.22	0.22	0.24
Base diameter (cm)	4.23	4.25	4.25	4.27	7.37	7.38	7.40	7.41	1.95	1.96	1.96	1.98	6.56	6.58	6.59	6.61
Edible portion (%)	57.71	53.65	50.00	47.46	52.07	51.81	47.68	46.75	66.42	64.58	63.82	60.12	51.43	48.61	45.58	43.16
Peel (%)	42.29	46.35	50.00	52.54	47.93	48.19	52.32	53.25	33.58	35.42	36.18	39.88	48.57	51.39	54.42	56.84
Visual colour *	Yellow group 10C	Yellow group 10B	Yellow group 10D	Yellow group 10A	Yellow-orange 16D	Yellow-orange 18B	Yellow-orange 18C	Yellow-orange 19B	Yellow-orange 16C	Yellow-orange 16D	Yellow-orange 17D	Yellow-orange 18D	Green group 142B	Green group 142C	Green group 142D	Green group 143D

* Royal Horticulture Char

Conclusion

Bamboo shoots have a good profile of minerals consisting mainly of potassium, phosphorous, magnesium, calcium, iron, copper and zinc plus lower amounts of selenium. Fresh shoots are also a good source of vitamins and amino acids. Therefore, due to its high nutritional value, the utilization of bamboo shoots as a food commodity is fast gaining popularity. The physical attributes of the shoots varies among species and also depends on the age of shoots and the harvesting time. The present study was focused on the detailed physical status of four edible bamboo species which are promising species as they are delicious, higher in nutrients and have higher yield.

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