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Nutritional, antioxidant and toxicity profile of different portions of bamboo shoot slice

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Abstract

The consumption of bamboo shoots has been integral component of traditional food of tribal communities of north-eastern India. Field visits were conducted in the East Siang district of Arunachal Pradesh inhabiting *Adi* tribe. After close observation, it was noticed that the communities use the tip and middle portions of the shoot. Hence the sample of bamboo shoot of *Bambusa vulgaris* species was collected from the *Adi* tribe for determining the toxicity, nutritional profile and antioxidant capacity of different portions of the bamboo shoot. The long conical shoot was divided into three portions viz. tip, middle and base. Physical hardness was kept as a parameter in deciding the type of portion. The samples of the three portions were analyzed for toxicity determination. The samples were then dried and further analyzed for nutritional composition, antioxidant capacity, toxicity and microstructure using standard methods. It was found that the tip portion has the maximum carbohydrate, protein, fat content, antioxidant potential and also the cyanogenic toxicity as compared to the middle and base portions. The fiber fraction was significantly lower in the tip portion. SEM results also showed a compact matrix of the tip portion as compared to the loose matrix in middle followed by the base. The results have validated the observations made during the field visit regarding consumption of the tip portion by the communities for various processes. It can be concluded that tip being the soft, tender, highly nutritious but the most toxic part is the most preferable and consumed portion of the shoots in the culinary of the north eastern communities. However, the base portion with high fiber content is equally valuable and precious as a food part and should not be discarded and consumed in other food preparations.

Keywords Bamboo shoot; Different Portions, Nutritional Profile, Antioxidant

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1. Introduction

Bamboo is not merely the poor man's timber but is also the rich man's delicacy. The food potential of bamboo shoots has been documented by various researchers (Nirmala et al, 2011; Singhal et al, 2013). Fresh, fermented and tender bamboo shoots are considered culinary treats and are consumed as vegetables, pickles, salads, and in various other forms in different. Bamboo shoots contain several nutritional components like protein, carbohydrates, fat, vitamins, minerals, enzymes, coenzymes, reducing and non-reducing sugars, lactic acid, and citric acid (fermented products), etc. The bamboo shoot is rich in fiber and low in fat; 100 g of edible portion of bamboo shoots contains 2.6 g of protein and 0.3 g of fat. No doubt that bamboo shoot is a nutritious vegetable but it also contains a natural toxin like many other foods like almonds, cassava, lima beans etc. The toxic compound becomes a matter of concern only if it has to be consumed. Taxiphyllin (4-hydroxy-(R)-mandelonitrile-b-D-glucopyranoside), a cynogenic glycoside is the potential toxic component present in various species of bamboo shoots like *Dendrocalamus latiflorus, D. giganteus, D. hamiltonii, Bambusa vulgaris* and *B. guadua* etc (Vetter, 2000)

Tender Bamboo shoot is obtained when the outer green sheath is removed. A long conical white tender mass comes out which is eaten in the south East-Asian countries as a delicacy. The long fresh shoot has nodes and internodes and can be divided into three sub parts-base, middle and the tip. Very few studies focus on the difference in the chemical composition and physical structure of the three portions. The cyanide (HCN) content varies in different parts of a plant and also between the same parts of different portions of the same species (Jones, 1998). For example, the top, middle, and base portion of bamboo shoots differ in their cyanogenic content. Few studies report difference in the toxic content of the three portions revealing that the tip portion has the maximum cyanide content. Therefore, the present study tries to find out variation in the chemical composition in terms of nutrition, antioxidant capacity and toxicity of three different parts of bamboo shoot.

2. Materials and methods

2.1. Sample preparation

Bamboo shoots of *B. vulgaris* species was procured from the field visits conducted in the *Adi* tribe at the East Siang district of Arunachal Pradesh. Outer sheath of the shoots was removed and the soft, white, young and tender portion was washed and air-dried. The long conical shoot was divided equally into three portions. Physical hardness was kept as a parameter in deciding the type of portion. The fresh samples were analyzed for toxicity determination which was done using

Picrate method (Haque and Bradbury, 2002) in triplicates. The samples were then dried in an hot air oven (Scientific Systems, India) at 50±2ºC and then kept in polypropylene zip pouches for further analyses.

2.2. Determination of nutritional composition

The moisture content of the shoots was determined by hot-air oven method (AOAC, 1990). Ash content was determined by dry ashing in muffle furnace at 600°C until grayish white ash was obtained (AOAC, 1990). Crude protein content was determined using a CHN elemental analyzer (Vario EL III, Elementar Analysen Systeme GmbH, Germany). The crude protein (%) was calculated using a conversion factor as N X 6.25 (Uthayakumaran et al., 2000). Fat content was determined using the soxhelet system where petroleum ether (B.P. 60°C- 80°C) is used as solvent (Sadasivam and Manickam, 1992). Crude fiber was determined by acid-base digestion with 1.25% H_2S0_4 (W/V) and 1.25% NaOH (W/V) solutions (AOAC, 1990). Total carbohydrates were calculated using the difference.

2.3. Antioxidant activity assays

2.3.1. Sample extraction

The powdered samples of bamboo shoot were homogenized in 80% methanol. The extract was centrifuged at 10000 rpm for 20 min at 4ºC. The residue was re-extracted under the same conditions. The supernatant was pooled together and the methanolic extract was used for antioxidant analysis (Koley et al., 2011).

2.3.2. Total phenolic content (TPC)

One-hundred microlitres of the methanolic extract was diluted to 3 mL with distilled water and 0.5 mL of Folin–Ciocalteau reagent was added. After 3 min, 2 mL of 20% of sodium carbonate was added and the contents were mixed thoroughly. The colour was developed and absorbance measured at 765 nm after 30 min using gallic acid as a standard. The results were expressed as mg gallic acid (GAE) /100 g of dry weight material (Koley et al., 2011).

2.3.3. Total Flavonoids

Total flavonoid content was determined by using a colorimetric method. Briefly, 0.25 mL of diluted onion extract was mixed with 1.25 mL of distilled water in a test tube, followed by the addition of 0.075 mL of 5% $NaNO_2$ solution. After 6 min, 0.15 mL of 10% $AlCl_3.6H_2O$ solution was added and allowed to stand for another 5 min before 0.5 mL 1 M NaOH was added. The

mixture was adjusted to 3 mL with distilled water and was thoroughly mixed. The absorbance was measured immediately against the blank at 510 nm using a UV vis spectrophotometer. The results are expressed as mean mg quercetin equivalents/100 g dry weight (Koley et al., 2011).

2.3.4. Ferric Reducing Antioxidant Power (FRAP)

FRAP assay was performed according to the procedure described by Kaur et al, 2009. The FRAP reagent included 300 mM acetate buffer (pH 3.6), 10 mM TPTZ in 40 mM HCl and 20 mM $FeCl_3$ in the ratio 10:1:1 (v:v:v). Three milliliters of the FRAP reagent was mixed with 100 µL of sample extract in a test tube and vortexed. Absorbance readings were recorded after 4 min of sample reagent mixing at a wavelength of 593 nm. Results of FRAP were expressed as µmol TE/g of dry weight material (Koley et al., 2011).

2.3.5. Free Radical Scavenging Activity

The free radical scavenging activity was determined using DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical. A methanolic solution (0.1 mL) of each sample extract was added to 3.9 mL of DPPH·(0.025 g/L) in methanol, and absorbance measured at 515 nm (Specord, Analytik, Jena) using methanol without DPPH· as the blank. The absorbance was measured until the reaction reached a plateau (steady state). The inhibition percentage (IP) of the DPPH· radical was calculated by the following formula: %inhibition = $100 \times (A_0 - A)/A_0$ where A_0 was the beginning absorbance at 515 nm and A was the final absorbance of the test sample at 515 nm (Koley et al., 2011).

2.4. Cyanogenic toxicity assay

Cyanogenic toxicity determination was done using the Picrate Kit obtained from Dr Howard Bradbury, Australia. The picrate method used is simple, convenient and quick (Haque & Bradbury, 2002). A small amount (25–50 mg) of sample was weighed to which 0.5 ml of 0.1 M phosphate buffer was added. A picrate paper {supplied in the picrate kit prepared by dipping filter paper in a solution of moist picric acid (0.5%w/v in 2.5% w/v sodium carbonate) and allowing the paper to dry in air and then cutting it to 1X10 cm size} was inserted and the vial immediately closed. After about 16-24 hrs at 30°C, the picrate paper was removed and immersed in 5.0 ml water for 30 min (Figure 3.1). The absorbance was measured at 510 nm and the total cyanide content (ppm) determined by the equation:

$$\text{Total cyanide content (ppm)} = \frac{396 \times \text{absorbance} \times 100}{z}$$

where z is the weight of sample in mg

2.5. Scanning Electron Microscopy

The structure of the dried bamboo shoot portion was examined using a scanning electron microscope (ZEISS EVO-50) coupled with an energy dispersive X-ray micro analytical system (OXFORD ISIS-300). Samples were fixed on steel supports and coated with gold using a JEOL metalizer (FFC-1100; Tokyo, Japan) at 1100–1200 V, 5 mA for 10 min and then observed in SEM (S3000N; Hitachi) at 20 kV.

2.6. Data analysis

Data is presented as mean ± standard deviation. The differences between treatments were analyzed using ANOVA. Significant differences between mean values were determined using Duncan's Multiple Range Test ($p<0.05$). All statistical analysis was performed using Microsoft Excel 2013.

3. Results and Discussion

The study aims to explore the difference in nutritional composition, antioxidant assays and toxicity in different portions of bamboo shoot slice.

3.1. Nutritional composition

The nutritional composition of different portions viz. base, middle and tip of bamboo shoot slices has been presented in Table 1. The moisture content was found to be similar for all the three portions. The crude fiber content was observed to be significantly ($p<0.05$) different in all the three portions, lowest being in the tip portion (2.0%) and highest being in the base portion (6.9%). The protein and carbohydrate content was found to be highest in tip portion followed by middle and base portions respectively. The fat and ash content was not significantly different. Similar results have been reported by another report which says that the nutrients were not evenly distributed in fresh bamboo shoots and there is a vertical distribution of nutrients from the tip to the basal (Wang et al, 2020). A study by Lin et al, 2018, the basal portion presented a lower protein level (19.5 g/100 g) than the middle and tip portions (27.8 g/100 g). Another study by Kozukue et al, 1983 revealed that, for the fresh shoots from *P. pubestens*, the levels of fructose (218 mg/100 g wb), glucose (216 mg/100 g wb) and sucrose (211 mg/100 g wb) were comparable in the tip quarter portion, while fructose (597 mg/100 g wb) and glucose (489 mg/100 g wb) were three times more than sucrose (151 mg/100 g wb) in the bottom quarter portion. In the same species the total fat sharply decreased from the tip (800 mg/100 g) to the basal (379 mg/100 g) (Kozukue & Kozukue, 1981).

Table 1. Proximate composition (g/100g on dw basis) of different portions of bamboo shoot slice.

Nutrients/Portion	Base	Middle	Tip
Moisture	11.80±0.81[a]	10.98±0.79[a]	9.98±0.87[a]
Ash	8.80±0.26[b]	11.12 ±0.12[a]	10.93 ±1.06[ab]
Protein	21.22 ± 0.82[c]	24.99 ± 1.15[b]	29.74 ± 0.54[a]
Fat	1.35 ± 0.06[a]	1.33 ± 0.05[a]	1.55 ± 0.08[a]
Crude fiber	6.98 ± 0.18[a]	5.97 ± 0.07[b]	1.20 ± 0.39[c]
Total carbohydrate	19.52 ± 2.40[c]	22.83 ± 2.43[b]	36.91 ± 0.11[a]

Results are means of triplicate ± standard deviation. Different alphabets in the same row denote significant differences ($p<0.05$).

3.2. Antioxidant capacity

The data regarding the total phenols and antioxidant capacity is presented in Table 2. The phenol content decreased significantly ($p<0.05$) from tip to base and ranged from 380.25 to 182.54 mg GAE/100g. Similar pattern was observed for flavanoid with a pattern of Tip>Middle>Base. The antioxidant assays also show that the tip portion exhibits the maximum antioxidant potential with free radical scavenging activity at 121.36 µmoTE/g and ferric reducing antioxidant power at 68.89 µmoTE/g. Many reports have proven that bamboo shoots have good antioxidant properties but no study focuses on the antioxidant capacity in different portions of the bamboo shoot slices.

Table 2. Antioxidant capacity of different portions of bamboo shoot slice

Antioxidant assays	Base	Middle	Tip
Total Phenolic content (mg GAE/100g)	182.54 ± 10.70[c]	366.99±23.67[b]	380.24±23.91[a]
Total Flavonoid content (mg CE/100g)	521.08±6.88[a]	948.10±71.53[b]	1243.27±68.87[e]
FRAP (µmoTE/g)	58.59±3.56[c]	90.65±0.83[a]	68.89±3.51[b]
DPPH (µmoTE/g)	72.12±0.75[b]	120.22±1.60[a]	121.36±7.92[a]

Results are means of triplicate ± standard deviation. Different alphabets in the same row denote significant differences ($p<0.05$).

3.3. Cyanogenic glycoside

The cyanogens content in the tip portion of the shoot slice was found to be 2310 ppm as compared to 1879 ppm in the base portion and 1735 ppm in the middle portion (Figure 1). The cyanogens content in the base and middle portion were not significantly different and the reason behind this

could be the difference in species, geographical conditions and climate. This kind of variation has been observed by other studies as well. The total cyanogen content varied from 300-2604 ppm (tip portion), 210-2243 ppm (middle portion) and 199-920 ppm (basal portion). Generally, the tip portion contains comparatively higher amount of cyanogenic content than the middle and base portion of the young edible shoot (Rawat et al, 2015). Another study has reported the toxicity level in different portions of different species of bamboo shoots. It was observed that out of the five species chosen, *D. hamiltonii* had the highest level in the tip portion followed by the middle and base portions (Choudhury et al, 2012). The reason for maximum toxicity in the tip portion attributes to the inbuilt self defence mechanism of the plants (Singhal et al, 2016).

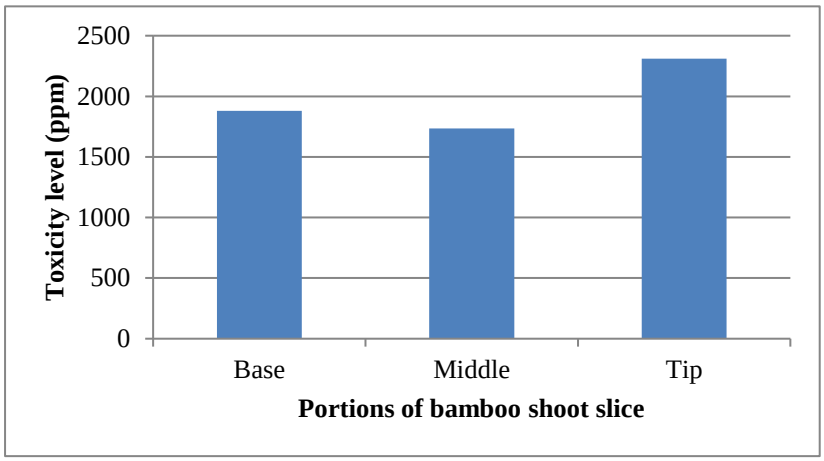

Figure 1. Toxicity level in different portions of bamboo shoot slice.

3.4. Scanning Electron Microscopy

The microstructure of the three portions was examined using a scanning electron microscope (SEM) and is presented as Figure 2. The results showed a compact matrix of the tip portion as compared to the loose matrix in middle followed by the base. The compact matrix indicates that all the nutrients are tightly packed in the matrix whereas loose matrix indicates the less amount and also that nutrients are more scattered.

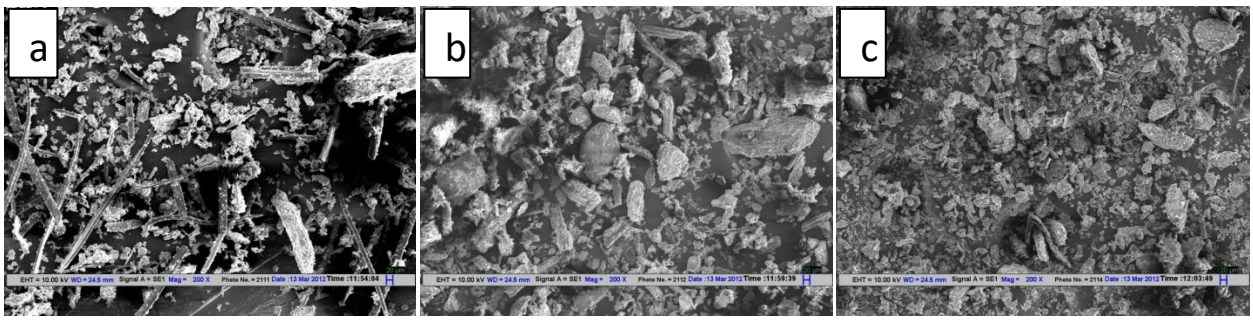

Figure 2. Microstructure of of different portions of bamboo shoot slice a: Base b: Middle and c: Tip

4. Discussion

The present study reveals that the tip portion of bamboo shoot is packed with nutrients like protein and carbohydrates. Reports suggests that the carbohydrate, protein and fat content decreased from the tip to bottom quarter portion (Kozukue et al, 1983, Kozukue & Kozukue, 1981 and Lin et al, 2018). Whereas the cyanogens content is present in the reverse manner from bottom to top being highest in the tip portion (Rawat et al, 2015, Choudhury et al, 2012). There are not many studies done in the past which focus on the different portions of the bamboo shoot as the vegetable does not have the same composition through its entire length. So, it is clear from the present and previous studies that the tip is more nutrient dense and thus can be utilized for making fermented dishes like pickle whereas the base portion containing more of fiber can be used in broths and vegetable curries. Many scientific reports have proven that bamboo shoots are good antioxidants but more research attempts are needed to determine the physicochemical characteristics of the different portions of bamboo shoot so as to promote the commercial usage of bamboo shoot in the food industry and also promote the micro enterprises for livelihood generation. Once it is clear from the research studies which portion of the shoot is the best in terms of nutrition and organoleptic characteristics more of the value-added products can be made utilizing that portion for commercial use.

5. Conclusion

Bamboo shoots no doubt form an important food source from the plant origin. Consumption of bamboo shoots in various forms is evident in the North-Eastern regions, and other parts of India. This is getting global popularity not just because of its nutritional profile, but also because of its important role in providing food security, combating malnutrition and micronutrient deficiencies. It can be concluded from the study that the nutrients are not evenly distributed in a fresh bamboo shoot slice and there is a vertical distribution of nutrients from the tip to the basal. Tip being the soft, tender, highly nutritious portion is the most preferable and consumed portion of the shoots in the culinary of the north eastern communities. Most of the important nutrients like protein and carbohydrates which are important in giving energy and maintain tissues are present in the tip portion. Tip has the highest toxicity as well when it comes to food safety and should therefore be processed before consumption. Base portion is rich in dietary fiber. However, the base portion with high fiber content is equally valuable and precious as a food part and should not be discarded and consumed in other food preparations. Hence it is important to include all the parts of bamboo shoot in the diet to get all the essential nutrients.

Conflict of Interest

The authors declare there is no conflict of interest

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