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Nutrient profiling of dominant sub-tropical edible bamboos of Terai region, India

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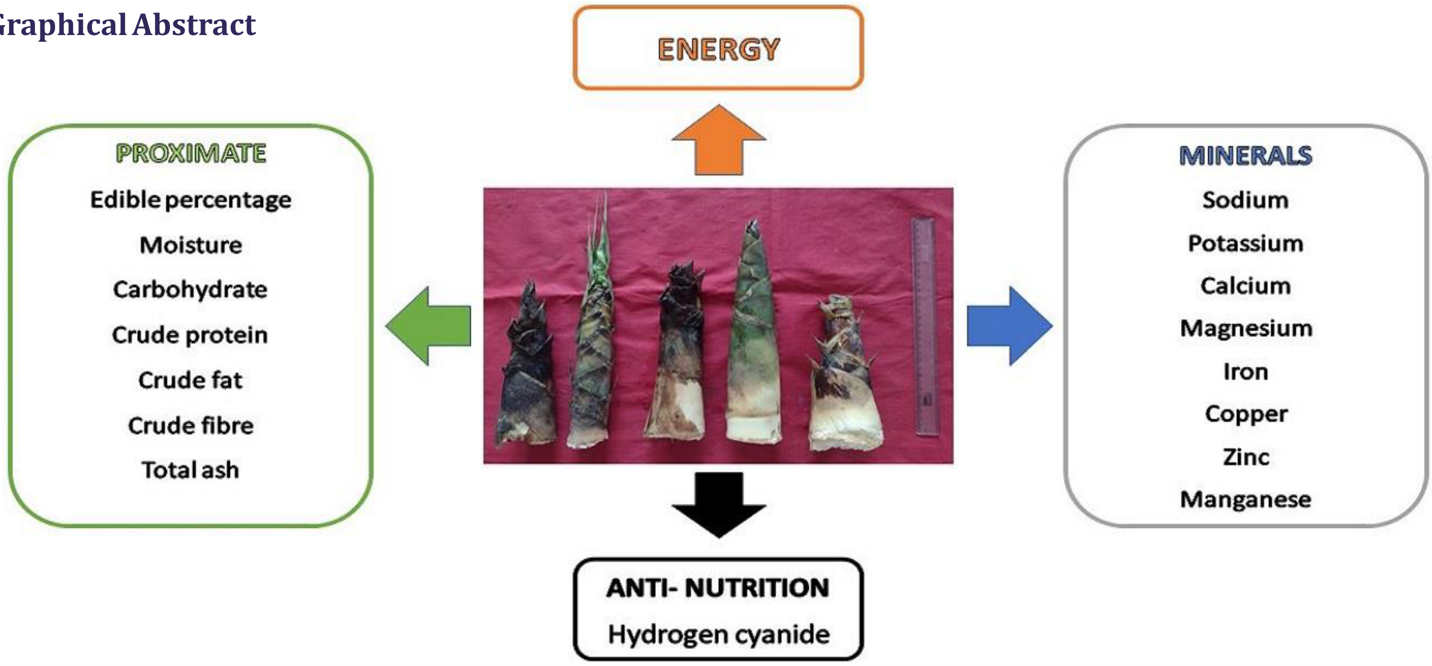
ABSTRACT

Nutrient profiling of five dominant edible bamboo shoots viz., three commercial bamboos (Bambusa balcooa, B. bambus, B. nutans), one ornamental bamboo (B.vulgaris var. striata) and one monopodial bamboo (Melocanna baccifera) were carried out in the Terai region of West Bengal, India. The fresh young bamboo shoots (preferably 7-10 days old) were collected and processed. The proximate and mineral composition was determined in the laboratory of the Department of Forestry, Uttar Banga Krishi Viswavidyalaya, Cooch Behar in 2021-22 to validate the food value using standard methods. In the present study, B. bamboos was found to be qualitatively superior with the highest carbohydrate (6.34 g/100 g fw), energy value (40.62 kcal/100 g fw), calcium (19.35 mg/100 g fw), iron (2.03 mg/100 g fw), copper (5.36 mg/100 g fw), and lowest fat content (0.56 g/100 g fw); whereas, B. nutans was quantitatively superior with maximum edible percent (43.17%), crude fibre (1.70 g/100 g fw), total ash content (0.18 g/100 g fw), sodium (2.06 mg/100 g fw), magnesium (5.65 mg/100 g fw), and manganese (1.29 mg/100 g fw). B. vulgaris var. striata was balanced with the highest crude protein (2.58 g/100g fw) and potassium (468.97 mg/100g fw). B. balcooa had the highest moisture percent (92.19%) and M. baccifera had highest zinc (1.10 mg/100g fw) and lowest hydrogen cyanide content (55.86 mg/Kg fw). However, further research on value addition and composite mixture is needed to ensure food security.

Keywords: *Alternate food, bamboo shoots, carbohydrate, crude fibre, hydrogen cyanide, micronutrients, nutrient profiling.*

Graphical Abstract



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Highlights

- Bamboo shoots are rich in carbohydrate, protein, crude fibre and minerals.
- Low-fat diet (56-68 g/ 100 g fw).
- Low caloric value (31.03- 40.62 kcal/100 g) and mineral rich.

- High potassium and low sodium content.
- In the presence of hydrogen cyanide (203.15 mg/ Kg), it is recommended to consume after boiling.

1. Introduction

In the present scenario over two million tonnes of edible bamboo shoots are consumed worldwide per year [1] as an alternative food, because of weather aberrations conventional food production is becoming restricted to some extent. Bamboo shoots are rich in both amino acids and antioxidants and other essential nutritive components with a pleasant aroma and delicious taste. Therefore, it is usually called 'the top-grade vegetable'[2] as well as 'rich man's delicacy'[3]. The shoots are low in fat content but contain a considerable amount of carbohydrates, potassium, pyridoxine, thiamine, riboflavin, niacin, ascorbic acid, phenolic acids, and dietary fibres such as hemicelluloses, cellulose, pectin and lignin [4,5]. It has a positive effect on human health, especially by reducing the incidence of cardiovascular diseases and several types of cancer [6].

Bamboo shoot products have been consumed by native people of the northeastern region of India as a routine traditional diet from time immemorial [7]. Bamboo shoots are consumed by the Kandha tribe of Odisha as *Kardi*[8], the Apatani tribes of Arunachal Pradesh consumed bamboo shoots after fermentation as Hikhu, Hiring, and Hithyi (sun-dried), whereas Adi and Galo tribes of Arunachal Pradesh were consumed fresh (Eting) or modified the shoots through fermentation (Ekung) and sun drying (Eyup). Similarly, the Meitei community of Manipur conserves the natural taste and flavor by avoiding washing bamboo shoots, and the Barman community of Tripura consumed it as Godhak with dry fish and banana pseudostem[9,10]. However, in Sikkim, it is consumed as *Tama*, a non-fermented bamboo shoot curry [11]. The Kani tribe of Kanyakumari uses the seeds of *Bambusa bamboo* to improve fertility[12]. Bamboo shoots are also consumed as a bamboo powder in biscuits, noodles and other snacks due to high dietary fibre. Apart from India, Bamboo is also consumed in Central and Southeast Asia, Brazil, Ethiopia, and other places around the globe as a potential vegetable.

Bambusa balcooa Roxb. (Family: Poaceae, subfamily: Bambusoideae, tribe: Bambuseae), widely known as boro bans or bheema bans, is a multipurpose bamboo with 12-23 m tall culms with 18-25cm circumference that grows well from semi-arid to humid tropics [13]. *B. bambos* Druce, an Indian thorny bamboo, is a tall (30-40 m), clump-forming bamboo, distributed from tropical to temperate regions, and is widely used in Indian folk medicine [14]. *B. nutans* Wall ex Munro, popularly known as Makla bans, is commonly used for construction purposes owing to its straight and long culms [15]. *B. vulgaris* var. *striata* Schrad., commonly known as the golden bamboo or yellow bamboo and popular for its recreational value [16]. *Melocanna baccifera* (Roxb.) Kruze, known as mulibans, is one of the most dwelling species for raw shoot extraction in Northeast India [17].

Undoubtedly, bamboo shoots have sufficient nutritional advantages, but they are always consumed as an underutilized food. Many researchers [18-21] evaluated the nutritional value of different bamboo species. However, the nutritional value of the dominant species in the Terai region is unexplored. Therefore, nutrient profiling of *B balcooa*, *B. bamboo*, *B. nutans, B. vulgaris* var. *striata* and *M. baccifera*.

The present study was conducted in the Terai region of West Bengal, which is mostly intensified with the cultivation of rice, wheat, jute, and potato. High rainfall, acidic soil, and a lack of cropping diversity threaten soil fertility and land-use patterns. This area also has geographic importance and acts as a gateway to northeast India, which is highly diverse in terms of bamboo resources. Although, a bamboo-based lifestyle is quite common in this area, in general people don't prefer bamboo as a vegetable due to its pungency and presence of phyto-toxin. Several researchers [16,19,22] conducted proximate analyses of different bamboo species, but the significance of anti-nutritional factors remained undefined. Similarly, there is also a research gap concerning the presence of essential microelements indifferent bamboo species [3, 23, 24]. Therefore, we experimented to determine the nutritional profiles of the dominant bamboo species in this region, including their proximates, micronutrients, and HCN.

2. Materials and methods

2.1. Study site

The study was conducted in the laboratory of the Department of Forestry, Uttar Banga Krishi Viswavidyalayaduring 2021-22. The samples of each bamboo species were collected from the Bambusetum of the Department of Forestry, UBKV, which lies in the plains of the terai region of West Bengal, at an altitude of 43m above mean sea level, with 26°24'14.2" N latitude and 89°23'35.0" E longitude. The area is dominated by a subtropical warm and humid climate with mean annual rainfall varying from 2500 to 3500 mm and a relative humidity of 64-98%.

2.2. Collection of plant sample

Strong and healthy shoots (7-10 days old) were selected from 10 different clumps of each species and harvested just above the neck of the rhizome around an inch above the ground before 30 cm height using a clean sharp knife. After harvesting, the dug-out portion was restored with soil and litter. The fresh weight of the harvested shoots was recorded and brought to the laboratory after wrapping in cling wrap film to prevent moisture loss for further analysis.

2.3. Preparation of plant sample

The shoots were washed thoroughly to remove soil, dirt, and sheath hairs. The inner tender creamy white portion was kept for analysis by removing the hard fibrous outer sheaths of the shoots. Shoot weight was recorded after removal of the outer sheath to estimate the edible percentage of shoots. Then the bamboo shoots were chopped and oven-dried. After drying, the shoots were ground, and the powder was stored in airtight containers for further analysis. An outline of the plant sample preparation and methodology is shown in Fig.1.

2.4. Nutritional analysis

The proximate of five different bamboo species (moisture content, crude protein, total fat, crude fiber, total ash, carbohydrate, energy value, hydrogen cyanide, and mineral elements such as sodium, potassium, calcium, magnesium, iron, copper, zinc, and manganese) were evaluated using standard methods according to AOAC [25] and all measurements were repeated five times and the average value was computed.

2.4.1. Moisture content

The moisture content of bamboo shoots was determined using the oven-drying method. 5 g of fresh sample was dried at 105°C for 6-8 hours in a hot-air oven until a constant weight was obtained. Moisture content was expressed as eq. 1 in below:

Moisture content (MC %)= $(W_f - W_d)/W_f \times 100$ (Eq. 1)

Where, W_f = fresh weight in grams and W_d = dry weight in gram

2.4.2. Crude protein

The crude protein content in the bamboo shoot samples was determined using the micro-Kjeldahl method. The sample was digested using KELPLUS KES 012 L E and distillate using KELPLUS ELITE-EX VA. After distillation, the sample was titrated against 0.025N HCl to determine its total nitrogen content. The crude protein is expressed as Eq. 2 in below:

Crude protein (g/100 g)= Total Nitrogen (%) × 6.25 (Eq. 2)

2.4.3. Total fat

The total fat content of the bamboo shoot samples was estimated using the petroleum ether extraction method with a Soxhlet apparatus. Two grams of the sample were placed in a thimble and loaded inside the apparatus. Petroleum ether was poured into the round-bottom flask from the top and boiled for approximately 80-90 minutes at 80 °C. After the completion of the processing time, the temperature was doubled to 15–20 min to recover petroleum ether. The thimble was removed and the ether was allowed to evaporate for 5 min, which was calculated as per the formula (Eq. 3) as given below:

Crude fat (g/100 g)= $(W_1 - W_2)/W \times 100$, (Eq. 3)

Where, W_1 = Weight of thimble + sample before fat removal (g); W_2 = Weight of thimble + sample after fat removal (g); W = Weight of the sample (g)

2.4.4. Crude fibre

The crude fiber content in the shoot samples was determined by alternate acid and alkali hydrolysis methods. A fat-free bamboo shoot sample (2 g) was then placed in a crucible.The sample was boiled in 200 ml 1.25% H_2SO_4 for 30 min, followed by 200 ml 1.25% NaOH for 30 min. The sample was then filtered with a muslin cloth and washed with 25ml of 1.25% sulphuric acid, followed by distilled water and alcohol. The residue was transferred to a crucible and dried in a hot-air oven at 100^0C. The dried sample was ashed in a muffle furnace at 550^0C for 4 h. The crude fiber content was calculated as follows:

Crude fibre (g/100 g) = $((W_2 - W_1) - (W_3 - W_1)) / W \times 100$ (Eq. 4)

Where, W_1= Weight of the crucible (g); W_2= Weight of the crucible with sample before ashing (g); W_3= Weight of the crucible with sample after ashing (g); W= Weight of the fat-free sample (g)

2.4.5. Total ash

The total ash content of the bamboo shoot samples was determined by charring in a muffle furnace for approximately 6 h at 550°C and was estimated as follows:

Total ash (g/100 g)= $(W_2 - W_1) / W \times 100$, (Eq. 5)

where W_1= Weight of the crucible (g), W_2= Weight of the crucible containing the sample after ashing (g), and W = Weight of the fat-free sample (g).

2.4.6. Carbohydrate

The carbohydrate content was determined by subtracting the total weight of the moisture, fat, ash, fibre, and protein contents from 100 [26].

2.4.7. Energy value

The energy value was determined by the sum of the values obtained through the multiplication of crude protein, carbohydrates, crude fat, and dietary fibre by factors of 4.00, 4.00, 9.00, and 2.00, respectively [27].

2.4.8. Mineral elements

A wet ashing method was used to access the mineral elements. Sodium and Potassium were estimated using flame photometry with monochromatic filters at 598nm and 548nm, respectively. Calcium and Magnesium were determined by titration against 0.01N EDTA [28]. The micronutrient viz. Zn, Fe, Mn, and Cu contents were determined after proper dilution using an atomic absorption spectrophotometre (ContrAA 700).

2.4.9. Hydrogen cyanide

Hydrogen cyanide-estimation was performed using the picrate paper technique, and the absorbance was measured at 510 nm using a UV-Vis spectrophotometre (Shimadzu UV-1800). The total cyanogen content was calculated using the following equation:

The total cyanogen content (mg/kg) = 396 × absorbance/weight of the sample(Eq. 6)

2.5. Statistical Analysis

The present investigation was performed using a completely randomized design.Statistical analysis for each parameter was performed with mean values using MS Excel-2019. One-way analysis of variance (ANOVA) was performed, and the best treatment was determined using DMRT multiple range test at $p < 0.05$ level of significance. All values were presented on a fresh weight (fw) basis.

3. Results and Discussion

3.1. Edible Percent

The edible percentage of bamboo shoots among all species significantly varied between 26.99- 43.17% (Table 1). It was found that *B. nutans* had a maximum extractable potential of43.17% was at par with *B. balcooa*(40.02%) and *M. baccifera* (33.43%); however, the lowest value was in *B. vulgaris* var. *striata* (26.99%) and *B.bambos*(31.14%) showed the harvesting of bamboo shoots was less profitable. The extractable edible biomass was below 50% of the total biomass production in all species, and the remaining part was dominated by the culm sheath, that is, protection against damage and predators. Moreover, bamboo shoots might be a good alternative food to *Musa paradisiaca* (67%), *Tamarindus indica* (60%), and*Citrullus lanatus* (52%)[29]. The edible portion of bamboo is based on species, size [30] and age of harvesting [23]. The days of harvesting offshoot might also be responsible for the variation in the edible percentage. Even if the growth was greater at a later stage, it was evident in the reduced nutrient content. Apart from this, all the selected species in the present study were hollow bamboos which showed a lower edible percentage compared to solid bamboos *viz*. *Dendrocalamus strictus* (74.27%) and *D. giganteus* (71.85%) [16].

3.2. Moisture content

The maximum moisture content (92.19%) was recorded in *B. balcooa* (Table 1), at par with *M. baccifera* (91.68%), followed by *B. nutans* (91.07%). In contrast, the minimum was recorded in *B. bambos* (89.81%), which was close to that of *B. vulgaris* var. *striata* (90.32%). The moisture content was varied between 88.98- 92.06% and 88.17-91.26%, respectively in different *Bambusa* spp [16, 22]. Similar results were recorded for *M. bambusoides* (91.22%), *B. balcooa* (90.78%), *B. tulda* (83.60 g/100 g), *D. asper* (93.15-94.27%), and *D. hamiltoni* (91.06%) [19-20, 31-33].

3.3. Crude protein

The crude protein profile of fresh shoots was recorded as *that of B. vulgaris* var. *striata* (2.58 g/100 g fw) >*B. bambos* (1.90 g/100 g fw), *B. nutans* (1.69 g/100 g fw), *M. baccifera* (1.39 g/100 g fw), and *B. balcooa*(1.08 g/100 g fw). Considering the average protein content, it may be suitable to fulfill the dietary allowance for protein (0.8g/Kg of body weight) recommended for adults [20]. This result agrees with the findings in *B. bambos* (1.88 g/100g fw), *B. tulda*(3.69 g/100g fw), *M. bambusoides* (3.29%), and *B. balcooa* (2.96%), respectively [18, 20, 31, 32].

3.4. Total fat

The total fat ranged from 0.56 g/100 g fw (*B. bambos*) to 0.68 g/100 g fw (*B. vulgaris* var. *striata*). The low fat content in bamboo shoots is considered ideal for healthy nutrition and cardiovascular disease [34]. Fatty acids are mainly palmitic, linoleic, and linolenic acid [35]. The fat content in bamboo shoots varied between 0.26% to 0.94% in different *Bambusa spp*[20]. The present study showed similar findings for *B. vulgaris* var. *striata* (0.10 g/100 g fw) [16], *and D. hamiltoni* (0.29%) [19], *B.tulda* (0.48 g/100g fw) [20], *B. balcooa* (0.28%) [32], and *B. nutans* (0.30%) [36].

3.5. Crude fibre

The maximum crude fibre content was observed in *B. nutans* (1.70g/100 g fw), followed by equal values (1.31 g/100 g fw) in both *B. balcooa* and *B. bambos*, whereas the lowest (1.03 g/100 g fw) was in *B. vulgaris* var. *striata* followed by *M. baccifera* (1.24 g/100 g fw). It has been proven that ingestion of dietary fibre of about 25–29 g day^{-1} could provide better health benefits, *viz*. protection against cardiovascular diseases, type 2 diabetes, and colorectal and breast cancer [37], by decreasing the serum and hepatic lipids [5] and faster transit time (*i.e.* time taken by the body to remove faecal waste). The results are well in line in *D. hamiltoni* (1.50 g/100 g) [19], *B. tulda* (3.97 g/100 g) [20] and *B. nutans* (0.76 g/100 g fw) [38], respectively.

3.6. Total ash

The total ash content of bamboo shoots ranged from 0.08g/100g fwin *B.bambos*to0.18g/100g fw in *B. nutans*. The study evaluated low ash content compared to bamboo grown in southernmost India *B. balcooa* (0.43%) and *B. bambos* (0.86%) [16]. However, Chongtham*et al*.[20] supported a study conducted in northern India in *B. tulda* (0.85 mg/100 g). Similar results were also recorded in *D. asper* (0.50 g/100gfw), *B. nutans* (0.90 g/100g fw) and *B. vulgaris* (0.80 g/100g fw), respectively [38]. This might be due to the high rainfall, poor soil fertility gradient of the Terai region, and other climatic attributes. The mineral rich in bamboo signifies that it is suitable for producing bamboo salt.

3.7. Carbohydrate

The carbohydrate of shoots varied from 4.65 g/100g fw(*B. nutans*) to 6.34 g/100g fw (*B. bambos*). The higher carbohydrates enhanced sweetness, which eventually attracted ants and other predators. However, the value is relatively low compared to other millets (60.9-72.0 g/100g), sorghum (72.6 g/100g) and Bajra (67.5 g/100g) [39]. This study is strongly supported by the findings in *B. nutans* [4, 11, 22], *B. balcooa* [32], *B. bambos* [40], *M. bambusoides* [31], *B. vulgaris* [38] and *B. tulda* [20], respectively (Table 2).

3.8. Energy value

The energy value of fresh bamboo shoots (Fig.2) was evaluated as *B. bambos* (40.62 Kcal/100g fw) >*B. vulgaris* var. *striata* (39.70 kcal/100 gfw) >*B. nutans (*34.87 kcal/100 gfw) >*M. baccifera* (33.08 kcal/100 gfw) >*B. balcooa* (31.03 kcal/100 gfw). It was found that all bamboo shoots had a very much low energy value diet as compared to regular staple diets like rice (345.79 Kcal/100g) and sorghum (351.43 Kcal/100g) [27]. The results of this study are in close agreement with those of Choudhury et al.[11]. The calorie requirements are 2400 kcal in rural areas and 2100 kcal in urban areas, as recommended by ICMR [41].

3.9. Mineral content

The mineral content of bamboo shoots is shown in Table 3. The sodium content in fresh bamboo shoots ranged from 1.46mg/100 g fw (*B. balcooa*) to 2.06 mg/100 g fw (*B. nutans*). The daily recommended dose to prevent chronic diseases is less than 2 g day^{-1} sodium (5 g day^{-1} salt) by WHO [42]. The potassium content was recorded for *B. vulgaris* var. *striata* (468.97 mg/100 g fw)>*B. nutans* (435.32 mg/100 g fw)>*B. bambos* (407.58 mg/100 g fw)>*M. baccifera* (331.71 mg/100 g fw)>*B. balcooa*(317.13 mg/100 g fw). The daily recommendation of K for adult is 2.0-5.5g day^{-1}[43]. Low sodium and high potassium levels have been identified as heart-friendly diets that maintain normal blood pressure [20]. The highest calcium content (19.35 mg/100g fw) of fresh bamboo shoots was evaluated in *B. bambos* at par with *B. balcooa* (19.27 mg/100g fw) followed by *M. baccifera, B. vulgaris* var. *striata* and *B. nutans* with 12.76, 12.60 and 10.12 mg/100g fw, respectively. The recommended dose of calcium for adults is 100 mg day^{-1} [44]. The magnesium of edible bamboo shoots ranged from 1.39 mg/100 g fw (*M. baccifera*) to 5.65 mg/100 g fw (*B. nutans*). The recommended dose of magnesium in adults is 232–439 mg day^{-1}[45]. The results showed well in line with the findings of other researchers [18-20, 46].

The iron content of fresh bamboo shoots was highest *B. bambos* (2.03 mg/100 g fw) followed by *M. baccifera* and *B. balcooa* with 1.78 and 1.71 mg/100 g fw respectively, whereas the lowest value was found in *B. vulgaris* var. *striata* (1.49mg/100 g fw), and *B. nutans* (1.58mg/100 g fw). However, it is sufficient to meet the daily requirements for pregnant women and children, that is, 1.65 and 1.05mg day^{-1} respectively[10]. The copper content of edible bamboo shoots was evaluated as follows: *B. bambos* (5.36 mg/100 g fw)>*B. vulgaris* var. *striata*(4.69 mg/100 g fw)>*M. baccifera*(4.46 mg/100 g fw)>*B. balcooa* (0.69 mg/100 g fw) >*B. nutans* (0.27 mg/100 g fw), respectively. Cu is essential for bone abnormalities, neutropenia, and anaemia [47]. The zinc of edible bamboo shoots was recorded *M. baccifera* (1.10 mg/100g fw), followed by *B. bambos* and *B. vulgaris* var. *striata* with 0.89 mg/100 g fw and 0.84 mg/100 g fw, respectively, whereas the lowest values were recorded in *B. balcooa*(0.50 mg/100 g fw) and *B. nutans* (0.58 mg/100 g fw). Zinc is effective against dwarfism and hypogonadism [48]. The recommended daily dose for zinc in adults is 10-12 mg day^{-1}[49]. The manganese of edible bamboo shoots ranged from 0.50 mg/100g fw(*B. vulgaris* var. *striata*) to *B. nutans* (1.29 mg/100g fw). The recommended dose of manganese is 3.0mg day^{-1} in adults [50]. The micronutrient values of fresh bamboo (Table 4) supported with similar studies [19-20, 46].

3.10. Hydrogen cyanide

An appraisal of Table 1, *B. balcooa* had the highest (203.15mg/Kg fw) hydrogen cyanide or cyanogenic glycoside content followed by *B. vulgaris* var. *striata* (166.52 mg/Kg fw) which was closed at par with *B. nutans* (165.10mg/Kg fw) whereas the lowest (55.86 mg/Kg fw) was recorded in *M. baccifera*. In a similar study, it was found that boiling the shoots of *D. strictus* for 25 min reduced it to 40 mg/kg from raw bamboo shoots (763 mg/kg)[51]. Cyanogenic glycoside production varies with age, plant parts, species, and environmental factors [52-53]. However, the toxicity of this compound can be readily reduced by simple traditional processing methods, such as blanching, soaking in cold water, and fermentation of fresh shoots before consumption [54]. Cyanogenic glycosides were present in the bamboo shoots as taxiphyllin; that convert to hydroxybenzaldehyde-cyanohydrin and glucose upon hydrolysis, which further decomposed into hydrogen cyanide and hydroxybenzaldehyde [55]. The acute lethal dose of HCN was 0.5-3.5 and 0.66-15 mg/kg body weight for human beings and animals, respectively [56].

4. Conclusion

Bamboo shoots are rich in carbohydrates, crude protein, crude fibre, potassium, iron, and calcium, indicating that bamboo is an ideal healthy diet. The present study revealed that the three species had superior food values among all bamboo species. *B. nutans* was qualitatively superior with the highest carbohydrate, calcium, iron, copper, energy value, and lowest fat content; *B. nutans* was quantitatively superior with maximum edible percent, crude fibre, total ash content, sodium, magnesium, manganese, and *B. vulgaris* var. *striata* was balanced with highest crude protein and potassium. *B. balcooa* had the highest moisture percent and *M. baccifera* had the highest zinc content. Applying the bamboo shoots as a souce of sugar, fibre and condiment in various items such as candy, chutney, church, crackers, nuggets, pickles, and other value-added products is essential for improving livelihoods and economic precision through standard processing technologies.

Conflict of Interest

The authors declare no conflict of interest.

Table 1. Proximate composition of five bamboo species of terai region

Species	Edible Percent (%)	Moisture content (%)	Carbohydrate (g/ 100g fw)	Crude protein (g/ 100g fw)	Total fat (g/ 100g fw)	Crude fibre (g/ 100g fw)	Total ash (g/ 100g fw)	Hydrogen cyanide (mg/Kgfw)
Bambusabalcooa	40.02[ab]	92.19[a]	4.65[b]	1.08[d]	0.61[ab]	1.31[b]	0.16[a]	203.15[a]
Bambusabambos	31.14[bc]	89.81[d]	6.34[a]	1.90[b]	0.56[b]	1.31[b]	0.08[b]	141.77[c]
Bambusa nutans	43.17[a]	91.07[bc]	4.71[b]	1.69[bc]	0.66[a]	1.70[a]	0.18[a]	165.10[b]
Bambusa vulgaris var. *striata*	26.99[c]	90.32[cd]	5.31[b]	2.58[a]	0.68[a]	1.03[c]	0.08[b]	166.52[b]
Melocannabaccifera	33.43[abc]	91.68[ab]	4.93[b]	1.39[cd]	0.58[b]	1.24[b]	0.14[ab]	55.86[d]
SEm±	3.48	0.25	0.32	0.15	0.02	0.06	0.02	6.27
CD (0.05)	10.48	0.75	1.01	0.47	0.07	0.20	0.06	18.51

Means with the same letters are not significantly different.

Table 2. Proximate composition of fresh bamboo shoots of different bamboo species

Species	Location	Edible Percent (%)	Moisture content (%)	Carbohydrate (g/ 100g fw)	Crude protein (g/ 100g fw)	Total fat (g/ 100g fw)	Crude fibre(g/ 100g fw)	Total ash (g/ 100g fw)	Hydrogen cyanide(g/ Kg fw)	Source
A.alpina	Ethiopia	-	92.67±0.42	-	2.3±0.12	0.41±0.04	0.9±0.07	1.0±0.12	2.36±0.02	[24]
B. balcooa	Kerala	51.62	88.98 ± 0.58	2.24 ± 0.14	0.89 ± 0.06	0.05 ± 0.01	4.06 ± 0.44	0.43 ± 0.05	-	[16]
B. bambos	Kerala	-	92.06 ± 0.24	1.93 ± 0.14	1.23 ± 0.08	0.07 ± 0.04	4.43 ± 1.00	0.86 ± 0.02	-	[16]
B. Blumeneana	Quirino	-	-	5.42	3.57	0.50	4.49	-	-	[3]
B. multiplex	Kerala	35.00	87.47 ± 0.49	0.80 ± 0.07	3.14 ± 0.18	Nil	4.28 ± 0.45	0.97 ± 0.08	-	[57]
B. nutans	Manipur	-	91.26±0.12	2.76±0.04	3.25± 0.004	0.31±0.02	9.89±0.08	0.82± 0.00	-	[22]
B. tulda	Manipur	-	88.17 ± 0.18	4.43 ± 0.02	2.88	0.40 ± 0.01	5.47 ± 0.12	0.89	-	[22]
B. polymorpha	Punjab	-	90.26	5.44	3.64	0.46	3.82	0.76	-	[20]
B. vulgaris var. striata	Java, Indonesia	-	91.75±0.13	3.56±0.13	2.65±0.12	0.96±0.004	-	1.08±0.12	327.44±14.45	[58]
D. asper	Jabalpur	-	-	3.36 ± 0.09	1.74 ± 0.10	-	-	-	-	[18]
D. giganteus	Kerala	71.85	89.74 ± 0.61	3.06 ± 0.16	1.26 ± 0.15	0.16 ± 0.01	3.07 ± 0.21	1.13 ± 0.05	-	[16]

D. hamiltoni	Palampur	33.33	91.06 ± 0.51	0.80 ± 0.07	3.50 ± 0.22	0.29 ± 0.72	1.50 ± 0.26	0.81 ± 0.07	-	[19]
D. sikkimensis	Manipur	-	91.24 ± 0.14	2.99 ± 0.02	1.88 ± 0.01	0.60 ± 0.01	5.20 ± 0.04	0.76	-	[22]
D. stocksii	Peninsular India	-	91.40	6.37	1.94	0.02	2.19	0.93	173.49	[59]
D. strictus	Pantnagar	-	90.74±0.52	3.95±0.21	2.39±0.10	0.33±0.06	1.48±0.14	1.11±0.04	795±21.33	[51]
G. atroviolacea	Manipur	69.72	88.05 ± 0.87	1.18 ± 0.11	0.97 ± 0.25	0.07 ± 0.02	5.41 ± 0.40	0.68 ±0.06	-	[16]
G.angustifolia	Peninsular India	-	90.80	4.87	2.39	0.04	2.55	1.33	-	[59]
M. baccifera	-	-	91.22	3.93	3.29	-	-	0.98	-	[11]
O.abyssinica	Ethiopia	-	92±0.26	-	2.12±0.11	0.38±0.3	0.69±0.03	0.88±0.09	248.6±8.50	[24]
P.pubescens	Palampur	29.10	92.06	1.11	3.70	0.39	1.29	0.90	-	[60]

A=Arundiaria, B=Bambusa, D=Dendrocalamus, G= Gigantochloa, M= Melocanna, O=Oxytenanthera, P=Phyllostachys

Table 3. Mineral composition (mg/100g fresh weight) of five bamboo species of terai region

Species	Na	K	Ca	Mg	Fe	Cu	Zn	Mn
Bambusabalcooa	1.46^{c}	317.13^{c}	19.27^{a}	3.13^{bc}	1.71^{b}	0.69^{c}	0.50^{c}	1.14^{ab}
Bambusabambos	1.87^{ab}	407.58^{ab}	19.35^{a}	4.41^{ab}	2.03^{a}	5.36^{a}	0.89^{b}	0.92^{bc}
Bambusa nutans	2.06^{a}	435.32^{a}	10.12^{b}	5.65^{a}	1.58^{bc}	0.27^{c}	0.58^{c}	1.29^{a}
Bambusa vulgaris var. *striata*	1.93^{ab}	468.97^{a}	12.60^{b}	4.20^{ab}	1.49^{c}	4.69^{b}	0.84^{b}	0.50^{d}
Melocannabaccifera	1.67^{bc}	331.71^{bc}	12.76^{b}	1.39^{c}	1.78^{b}	4.46^{b}	1.10^{a}	0.78^{cd}
SEm±	0.11	29.18	1.18	0.62	0.07	0.22	0.06	0.10
CD (0.05)	0.32	86.08	3.73	1.95	0.20	0.65	0.17	0.29

Means with the same letters are not significantly different.

Table 4. Mineral composition (mg/100g fresh weight) offresh bamboo shoots of different bamboo species

Species	Location	Na	K	Ca	Mg	Fe	Cu	Zn	Mn	Source
A.alpina	Ethiopia	6.83±0.36	122.07±5.17	27.85±4.86	-	6±0.58	-	0.63±0.08	-	[24]
B. bambos	Palampur	3.50	521.00	12.00	3.50	-	0.15	-	-	[60]
B. Blumeneana	Quirino	10.10	-	0.36	5.38	3.00	-	-	-	[3]
B. multiplex	Kerala	3.20±0.04	195±15	29.4±3.08	20±2.03	2.5±0.03	1.07±0.20	1.22±0.23	-	[57]
B. tulda	Punjab	12.96	408	4.06	8.68	3.19	0.44	0.72	0.70	[20]
D. asper	-	10.14	464	5.51	10.14	3.37	-	-	-	[21]
D. giganteus	Quirino	3.64	275	26.93	9.57	1.06	-	-	-	[3]
D. hamiltoni	Palampur	4.80 ± 0.06	533.00 ± 24	15.00 ± 2.08	3.90 ± 0.4	-	0.29 ± 0.72	-	-	[19]
D. strictus		40	490	150	150	-	-	-	-	[23]
D.stocksii	Peninsular India	12.57	270.33	5.03	-	2.81	0.42	0.65	0.88	[59]
G. angustifolia	Peninsular India	12.63	456.67	5.4	-	2.54	0.24	0.72	0.87	[59]
O.abyssinica	Ethiopia	6.44±0.16	372.58±15.17	15.9±1.16	-	6±0.40	-	0.70±0.03	-	[24]
P.pubescens	Palampur	4.00	459.00	13.00	3.40	-	0.19	-	-	[60]

A=Arundiaria, B=Bambusa, D=Dendrocalamus, G= Gigantochloa, M= Melocanna, O=Oxytenanthera, P=Phyllostachys

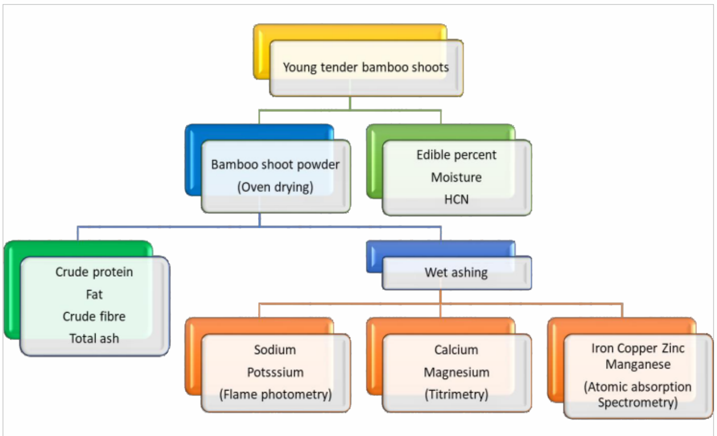

Fig. 1. Outline of the methodology followed for proximate and mineral analysis.

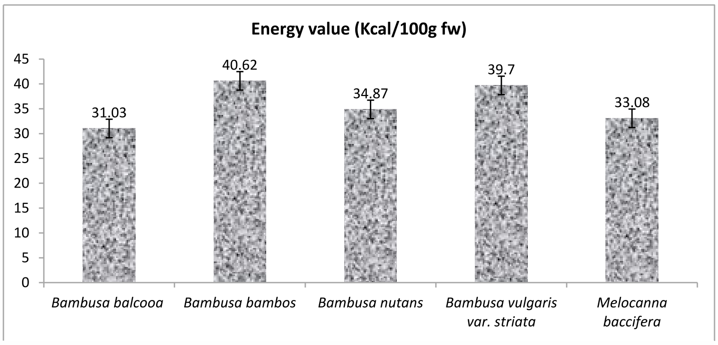

Fig.2. Energy value (Kcal/100g fresh weight) of five bamboo species of Terairegion

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