Bamboo Shoot Processing - Effects on Nutritional and Anti-Nutritional Quality from Assam, India.

ABSTRACT

The present investigation was designed to find out the nutritional potential of some local edible bamboo (*Bambusa* spp.) shoot species and the impact of different processing methods on it. Sliced bamboo shoot pieces were treated with soaking in water for 30 min, boiling in water for 10 min, boiling in 1% NaCl solution for 10 min, boiling in 5% NaCl solution for 10 min and steaming for 10 min. There were significant variations ($P < 0.05$) in ash, crude protein, total carbohydrate, minerals, ascorbic acid, phenol, flavonoid, and tannin contents. Boiling in 1% NaCl solution for 10 min was found best in retaining the nutrients with a significant ($P < 0.05$) reduction in cyanide content. Overall, bamboo shoots confer numerous health beneficial activities and have the potential to be used as bioactive.

Keywords: *Bamboo, Cyanide, Proximate, Minerals.*

1. INTRODUCTION

Bamboo is a giant and fast-growing woody grass of the subfamily *Bambusoideae* (Family *Poaceae*) and consists of approximately 1,250 species belonging to 75 genera. In terms of diversity of bamboo species, India is the third largest country in the world with about 125 species of bamboo belonging to 23 genera, China and Japan being the first and second with 300 and 237 species respectively [1]. Bamboo is one of the most economically important plants in the entire world with more than 1500 different uses - from construction materials to agricultural tools, from utensils and musical instrument to ornamental use etc.

The juvenile shoot of bamboo, commonly known as bamboo shoot is being consumed traditionally since time immemorial by the tribal communities worldwide, especially communities of South, South-East and East Asia in fresh, dried, shredded, canned, pickled or fermented and in the medicinal form [2]. Fermented bamboo shoot is a common consumption pattern of North East India such as *kharisa* (in vernacular) in Assam. Bamboo shoots are regarded as an ideal vegetable because of its high nutrient contents in terms of dietary fibre, vitamins, carbohydrates, proteins, minerals, secondary metabolites and antioxidants [3, 4, 5, 6, 7]. Due to its high fibre content and nutritional value, it is commonly used in many food products like breakfast cereals, sauces, fruit juices, shredded cheeses, frozen desserts, pastas, bakery and meat products [8].

Besides gastronomical practices, people have been using bamboo shoots traditionally to cure different diseases. Kalita and Dutta [9] have revealed that some ethnic tribes in Northeastern states of India, used bamboo shoots to treat cardiovascular ailments, control high blood pressure etc. Furthermore, South Asian countries were reported to utilize bamboo traditionally to relieve hypertension, sweating, and paralysis [10]. Overall, bamboo shoots confer numerous health beneficial activities such as improving appetite and digestion, curing cardiovascular disease and show antioxidant activity [11], controlling weight loss, anti-fatigue activity [12], antiallergic effects [13], anti-inflammatory [14] and anti-cancer [15] properties, antiviral activity [10]. Also, a regular consumer can indulge a youthful feeling, athletic energy, and longevity due to phytosterols present in the bamboo shoot [16].

Bamboo shoots are normally harvested when the shoot height is about 15-30 cm and generally 7-14 days after the emergence depending upon the species. The young shoots with overlapping sheaths are tightly clasped, which are removed to get the edible part. The freshly harvested bamboo shoot is soft, crispy, creamy yellow in color with a sweet taste that delivers a strong smell [17]. Shoots may contain as high as 90 per cent water at the time of harvest.

Not every species of bamboo shoot that can be found worldwide is edible. In India, economically important 18 bamboo species have been identified, out of which around 10 are edible [18]. The cyanogenic glycosides (taxiphyllin), a natural plant toxin is found in high amounts in bamboo shoots [19]. Different chemical constituents are responsible for the taste of bamboo shoots. While tannins increase the offensive taste of bamboo shoots, homogentisic acid provides pungent taste [20], and hydrogen cyanide (HCN) develops bitterness [17]. Due to high pungent smell and bitter acidic taste, many people avoid consuming bamboo shoots. There are reports that the cyanogenic glycosides of bamboo shoots cause acute cyanide poisoning, in animals including humans. But cyanogens can be removed or reduced before consumption by adequate processing, thereby reducing the potential health risk [21]. This work was conducted to provide the nutritional profile of some locally available and widely used edible bamboo shoot species of Assam with the effects of some processing treatments in reducing cyanide content and analyze their effects on nutrient contents.

2. MATERIALS AND METHODS

2.1 Materials and Reagents

Three locally available edible bamboo shoot species of Assam *i.e*., *Bambusa balcooa* Roxb. (in vernacular, *bhaluka*), *Bambusa tulda* Roxb. (in vernacular, *Jati*) and *Dendrocalamus hamiltonii* Gamble (in vernacular, *Kako*) belonging to family Poaceae were collected from Sivasagar district (Betbari) after attaining the height of 30 cm from the ground by each species separately. The shoots were cleaned by removing any dust and dirt after harvesting and wrapped with cling film (Oxywrap PVC cling film). The bamboo shoots were transported to the laboratory on the same day of the harvesting and kept in the refrigerator at 4°C for further analysis. The chemicals and reagents used in the current study were of the analytical grade.

2.2 Sample Preparation and Processing Treatments

The bamboo shoots were further cleaned by removing the outer covering sheaths and hard nodal portions while only the soft inner edible portions were taken for analysis. The cleaned shoots were cut into small pieces of equal size and subjected to five different treatments: (a) soaking in water for 30 minutes (T_1), (b) boiling in water for 10 minutes (T_2), (c) boiling in 1% NaCl for 10 minutes (T_3), (d) boiling in 5% NaCl for 10 minutes, (e) steaming for 10 minutes (T_5). Raw bamboo shoot without any treatment was taken as control (T_0).

2.3 Proximate Composition

Selected raw and processed bamboo shoots were analyzed for the proximate composition and mineral composition by following standard protocols described in the Association of Official Analytical Chemists [22].

2.4 Ascorbic Acid

Ascorbic acid was determined by volumetric method [22]. Here, sample extracts were prepared by homogenizing bamboo shoots with 4% oxalic acid and the supernatants were titrated against the 2,6-dichlorophenolindophenol dye until pink colour appeared. The standard ascorbic acid solution was diluted with 5 ml of 4% oxalic acid and titrated with dye solution till pink color persisted for 10 seconds to get the dye factor. The calculation was done by the following formula: Ascorbic acid = (Titre value × Dye factor × Volume made up × 100)/(Aliquot taken × Weight of the sample)

Dye Standardization

Five ml of standard ascorbic acid solution was diluted with 5 ml of 4% oxalic acid and titrated with dye solution till pink color persisted for 10 seconds. Dye factor (mg of ascorbic acid per ml of dye) was calculated as follows: Dye factor (D.F) = 5.0/ titre value

2.5 Total Phenol Content

Total phenolic content was estimated using Folin-Ciocalteu reagent [23]. In this method, sample (1 g) was extracted with 80% methanol (10 ml) and centrifuged at 10000 rpm (25°C). The residue was re-extracted for 5 times and centrifuged. The supernatant was used for the analysis of total phenol content. The supernatant was dried, and the pellet was dissolved in 5 ml of distilled water. Aliquots of the solution (between 0.2-2 ml) were then taken, and the total volume was increased to 3 ml using distilled water. Each test tube received 0.5 ml of Folin-Ciocalteu reagent and 2 ml of 20 percent sodium carbonate after three minutes. The combination was maintained at 100°C for one minute, and the sample's absorbance after cooling was measured at 650 nm (Chemito UV 2100 spectrophotometer). Catechol was used as the standard. The total phenol was calculated as catechol equivalent, expressed as mg phenol per 100 g of the sample.

2.6 Alkaloids

The total alkaloids content in the sample were estimated using the method of Daniel [24]. Two gram sample was taken and about 10 times water was added to it. The sample was boiled for 30 min and filtered in hot condition. Then 10% lead acetate solution was added and centrifuged to separate the precipitate. The supernatant was boiled and then cooled. An equal volume of chloroform was added and transferred to a separating funnel and shook it. Separating funnel was then left undisturbed for half an hour. The chloroform and aqueous layer were collected separately. The aqueous layer was again extracted with chloroform and pulled with previous chloroform extract. The chloroform was then evaporated, and the residue was then weighed. Alkaloid (%) = (Weight of residue × 100)/(Weight of the sample taken)

2.7 Flavonoid

Flavonoid content was determined by aluminium chloride colorimetric method [25]. Flavonoids were extracted with 80% ethanol in a ratio of 1:10 (w/v) and kept on a rotary shaker for 24 h. The extracts were filtered through Whatman No. 42 filter paper and the volume was adjusted with 80% ethanol. To 0.5 ml of extract, 1.5ml ethanol (95%), 0.1ml aluminium chloride (10%), 0.1ml potassium acetate (1M) and 2.8 ml of distilled water were added in order and incubated at room temperature for 30 min and then absorbance was measured at 415 nm in a UV-visible spectrophotometer (Varian Cary 50 Scan). Quercetin was taken as standard to make the calibration curve. The result was expressed as mg of quercetin equivalents (QE)/100g of dry weight.

2.8 Tannin

Tannin content was determined by the Folin Denis method [26]. For extraction, 0.5 g powder was boiled with 75 ml of distilled water for 30 min, and then centrifuged at 2000 rpm for 20 min. After centrifugation, the supernatant was collected in a volumetric flask and total volume was made to 100 ml with distilled water. A volumetric flask was filled with 1 ml of sample extract, 5 ml of Folin-Denis reagent, 10 ml of 35 percent sodium carbonate, and 100 ml by water in total. The solution was mixed well and after 30 minutes absorbance was read at 700 nm. The standard graph was prepared by using 0-100 µg tannic acid and expressed as tannic acid equivalent.

2.9 Cyanogens

The cyanogen content was determined by picrate paper method [27]. In a flat-bottomed glass bottle, 25 mg (z) grounded fresh bamboo shoot sample was placed and immediately 0.5 ml of 0.1M phosphate buffer (pH 6) was added to it followed by a yellow picrate paper attached to a plastic strip so that there is a gap between paper and the liquid of the bottle. Right away, the bottle was closed with the screw-capped lid. The blank was prepared by the same method without the addition of bamboo shoot sample. The bottle was kept in a dark place for 16 to 24 hours at room temperature. Finally, the orange-brown picrate paper was immersed in 5.0 ml of distilled water for 30 min with gentle shaking occasionally. Absorbance was measured at 510 nm. The total cyanogens content (ppm) = (396 × absorbance × 100)/z

2.10 Statistical Analysis

The experiment was performed by taking three replicates and the data obtained were subjected to statistical analysis using IBM SPSS Statistics version 25.0 for analysis and the results were statistically evaluated at significance level $P \leq 0.05$ by ANOVA.

3. RESULTS AND DISCUSSION

3.1 Processing Effect on Proximate Parameters

The proximate parameters of fresh and processed bamboo shoots are presented in Table 1. The moisture content in the fresh bamboo shoots under study ranged from 90.76 to 92.29%. Such a high moisture content makes bamboo shoots highly perishable. Karanja *et al*. [28] also described the moisture content in the young shoots of a bamboo species ranging between 92.2-92.4% which is in agreement with the present findings. The young shoots of bamboo are rich in protein [29]. The shoots of *B. tulda*, *B. balcooa* and *D. hamiltonii* had 16.42%, 14.44% and 13.56% of crude protein respectively. Slightly higher crude protein content (21.1% to 25.8% on a dry weight basis) was reported by Kumbhare and Bhargava [30]. Kalita *et al*. [31] reported protein percentage in *B. balcooa*, *B. bambos*, *D. hamiltonii* and *B. vulgaris* as 28.52%, 33.54%, 33.73% and 22.30% respectively. Such variation in protein content might be because of the genetic make-up of the species used, pH of soil, nutrition status of the soil, climate, rainfall, and the growth stage at which bamboo shoots were harvested. Crude protein content was found to decrease in all the treatments in the present study with maximum reduction in the treatment where bamboo shoots were boiled in 5% NaCl solution for 10 minutes. The nutrients like protein, reducing sugar, are significantly influenced by temperature and blanching time [32]. Blanching at 95°C markedly reduced the protein content of bamboo shoot in comparison to 75°C and 85°C as most of the labile protein gets denatured at high temperature [33]. The crude protein content might decrease because of boiling and soaking that might cause denaturation and solubilization of the nitrogenous substances [34].

The bamboo shoots can be considered an ideal vegetable due to low fat content, richness in minerals and dietary fibre [35]. The present study revealed that the fresh shoot of *B. tulda*, *B. balcooa* and *D. hamiltonii* had 1.48, 1.49 and 1.83% crude fat content respectively (Table 1). The crude fat content was almost in-line with those as reported by Bhatt *et al*. [36]. Badwaik *et al*. [32] observed that temperature and duration of blanching treatment significantly ($P < 0.05$) affected crude fat content. Blanching for 30 min resulted in the reduction of crude fat from 0.52 g/100g to 0.38, 0.28 and 0.19 g/100g at 75°C, 85°C and 95°C respectively. It was observed that blanching for 5-10 min retained more fat as compared to blanching for 20-30 minutes. In the present investigation, crude fat content was found reducing with each treatment with the highest reduction in all the samples steamed for 10 minutes. The reduction in fat might be due to oxidation and melting of fat at high temperature and longer duration, which may be lost with water during blanching [37].

The crude fibre content in *B. tulda*, *B. balcooa* and *D. hamiltonii* shoots was 5.28%, 5.57% and 4.09% respectively (Table 1). The almost similar crude fibre content of 6.90% was reported by Rajyalakshmi and Geervani [38]. Higher crude fibre content ranging from 23.1% to 35.5% in shoots of different bamboo species was reported by Bhatt *et al*. [36]. Variation in fibre content in bamboo shoots might arise from species difference as well as the growth stage and period of the harvest of bamboo shoots. Chongtham *et al*. [4] reported an approximately three-fold increase in dietary fibre in shoots after keeping for 10 days. Different treatments used in this study had no significant ($P < 0.05$) effect on the crude fibre content in the shoots of all the three bamboo species. Badwaik *et al*. [32] also reported that crude fibre content in bamboo shoots was almost unaffected against blanching temperatures and time.

Carbohydrate contents were recorded as 6.58%, 7.00% and 5.37% on dry weight basis in *B. tulda*, *B. balcooa* and *D. hamiltonii* shoots respectively (Table 1). Singhal *et al*. [39] reported the carbohydrate content in the raw bamboo shoots ranged from 2.0% to 9.94%. There was a significant ($P < 0.05$) increase in the total carbohydrate contents in all the three bamboo species upon boiling in water for 10 minutes which might be due to the hydrolysis of complex polysaccharides of bamboo shoots. Kumbhare and Bhargava [30] also observed an increase in carbohydrate contents ranging from 3.1% to 5.1% after boiling. However, a decrease in carbohydrate contents in bamboo shoots was found when boiled in 1% and 5% salt solution separately for 10 minutes. During wet processing in presence of salt, heating might help in leaching out of carbohydrates in water resulting in the decrease of total carbohydrate content [30]. Pandey and Ojha [35] reported similar observation when bamboo shoots were boiled in solution with different salt concentrations.

The ash content of a food is a measurement of the overall quantity of minerals present. Bamboo shoots are enriched with minerals like K, Na, Ca, Mg, P, and Fe. The present study revealed that shoots of *B. tulda* had 1.10%, *B. balcooa* had 1.54% and *D. hamiltonii* had 0.89% of ash content on a dry weight basis (Table 1). The result was found to be in-line with results reported earlier. Rawat *et al*. [40] found 1.03% ash in bamboo shoots. Badwaik *et al*. [32] reported ash content in the range of 0.82-0.90 g/100g of fresh shoots of *D. hamiltonii, B. balcooa* and *B. pallida*. However, there were reports of high ash content of 14.2-17.1% in bamboo shoots [6, 28]. Such variation in ash content in bamboo shoots could be due to the age of the shoots, samples used for analysis and genetic variations of the bamboo varieties. Ash content was decreased significantly ($P < 0.05$) with all the processing treatments with highest reduction of ash content in *B. tulda* with boiling the shoots in water for 10 min and boiling the shoots in 1% NaCl solution for 10 min. Reduction in ash content was found lowest in soaking the bamboo shoots in water for 30 minutes. The decrease in ash content upon boiling was reported by several workers [30, 4, 41] which might be due to the leaching out of minerals in water during the processing treatment [40].

3.2 Processing Effects on Mineral Contents

In the present study, minerals such as calcium, phosphorus, iron and potassium were found in the range of 4.83 to 6.70 mg, 572.0 to 654.0 mg, 9.34 to 10.94 mg and 645.33 to 890.33 mg/100g on dry weight basis respectively (Table 2). The three bamboo species varied significantly in their contents in these mineral elements. The treatments used did not have significant effect on calcium contents in bamboo shoots under study. However, treatments showed significant effects on phosphorus, iron and potassium contents in bamboo shoots. The contents of these mineral elements were found to decrease significantly ($P < 0.05$) with all the treatments in all the three species of bamboo shoots. The highest retention was found in samples soaked in water for 30 minutes and the lowest was found in boiling in water for 10 minutes. According to wet processing (soaking and boiling) and heat treatment was reported to be the major cause for the leaching out of mineral or ash content leading to the reduction in their contents [35].

3.3 Processing Effects on Ascorbic Acid and Secondary Metabolite Contents

Ascorbic acid contents in *B. tulda*, *B. balcooa* and *D. hamiltonii* shoots ranged between 2.47-3.31 mg/100g fresh sample (Table 3). These values were found lower than those reported earlier [35, 36]. All the treatments in the present study significantly reduced ($P < 0.05$) the ascorbic acid content in the shoots of all the bamboo species. Badwaik *et al.* [32] found that blanching temperature significantly reduced ($P < 0.05$) the ascorbic acid content of bamboo shoot. Blanching for short time (5-10 min) retained more ascorbic acid while at 20-30 min the losses were high. Zhang *et al*. [37] reported that ascorbic acid retention in boiled bamboo shoots was 47.37% while in steamed ones; it was 57.83%. Such variation might be due to the high solubility and heat labile character of ascorbic acid. Soaking and boiling, therefore, might cause leaching of ascorbic acid into water and destruction by oxidation during boiling [42, 43]. The reduction was lowest in the treatment soaking with water for 30 minutes.

There were significant variations ($P < 0.05$) in the total alkaloid, phenol and flavonoid contents of *B. tulda*, *B. balcooa* and *D. hamiltonii* shoots used in the study (Table 3). The alkaloid content varies with growing conditions, environmental factors, storage time and temperature, harvest season, age of shoot as well as part of shoot used [44]. No significant ($P < 0.05$) effect of the treatments was observed on the alkaloid content of bamboo shoots under study. The total phenol content varied between 493.64 and 506.62 mg Catechol Equivalent/100g on a dry weight basis. The phenolic content was found increasing in *B. tulda* and *D. hamiltonii* with steaming the bamboo shoots for 10 minutes. In other treatments, phenol content was found decreasing. Zhang *et al*. [37] reported after boiling total phenolic content was significantly reduced while total phenolic content increased by 3.98% after steaming. Badwaik *et al*. [32] also observed loss of phenolic content with an increase in temperature and duration of blanching. Heat treatment might inactivate polyphenol oxidases, thereby preventing decomposition of phenols [45]. Stewart *et al*. [46] also reported that dietary fibre bound polyphenol decomposed into free phenolic compounds due to heat treatment which made the detected phenolics value higher.

Flavonoid contents in bamboo shoots were found to be 370.00, 445.00 and 352.67 mg QE/100g in *B. tulda*, *B. balcooa* and *D. hamiltonii* respectively (Table 3). Kalita *et al*. [31] reported much higher flavonoid content in *B. balcooa*, *B. bambos*, *D. hamiltonii* and *B. vulgaris* as 5.19%, 7.22%, 5.32% and 4.17% respectively. The highest reduction in flavonoid content was found in *B. tulda* and *B. balcooa* shoots, boiled in 5% NaCl solution for 10 minutes. *D. hamiltonii* shoot was affected most by boiling in 1% NaCl solution. Flavonoid is water-soluble and can easily be reduced by heat treatment and this might be the probable cause for such reduction.

3.4 Processing Effects on Anti-Nutritional Contents

Tannin contents were found to be 204.20, 184.30 and 244.00 mg tannic acid equivalent/100g on a dry weight basis (Table 3) for *B. tulda*, *B. balcooa* and *D. hamiltonii* shoots respectively. Processing caused a reduction in the tannin contents in bamboo shoots. Tannin content was affected most by boiling bamboo shoots in 5% NaCl for 10 minutes. The minimum loss was recorded in soaking in water for 30 minutes. As tannin is water-soluble and heat-sensitive, during hot and wet processing loss was found maximum.

Bamboo shoots contain taxiphyllin, a cyanogenic glycosides which upon maceration gets hydrolyzed by intracellular enzyme ß-glycosidase to hydrogen cyanide (HCN). Cyanide can cause toxicity in humans, thus necessitating its removal from the shoots before human consumption. In the present study, cyanide contents in *B. tulda*, *B. balcooa* and *D. hamiltonii* were found to be 875.16, 866.91 and 1067.87 ppm respectively (Table 3). Mina *et al*. [47] reported distribution of cyanide in the succulent bamboo shoot of *B. tulda* as 354.45, 598.26 and 900.00 ppm in the base, middle and a tip portion. Cyanogen glycoside content is highest in the shoot tips of most of the edible bamboo shoots species [16]. High cyanogenic content in bamboo shoots can be mitigated by boiling in water for about 2 hours and by NaCl treatment. Anti-nutrient content can be reduced significantly by fermenting bamboo shoot slices [48]. In the present study, cyanide contents were reduced with each treatment and the maximum reduction (96-98%) was found with boiling the bamboo shoot at 5% NaCl for 10 minutes. Rana *et al*. [49] also treated bamboo shoots with NaCl and reported 95.4-98.1% reduction in cyanide content. The bamboo shoot's cell walls broke down during boiling, allowing the release of its cell content along with poisonous and antinutritional elements [50]. Jaiwunglok *et al*. [51] reported that sodium chloride might facilitate the leaching of taxiphyllin from bamboo shoot through exosmosis reaction. Therefore, optimized boiling of bamboo shoots may be an effective way to make them suitable for human consumption.

4. CONCLUSION

Bamboo shoots were found to differ in their nutritional and anti-nutritional contents. The processing methods were found effective in reducing the anti-nutrients, but also affected the nutrient contents. The highest reduction of cyanide was found in boiling in 5% NaCl for 10 minutes. Soaking in water for 30 minutes showed the highest retention of nutrients and cyanide content. Boiling in 1% NaCl for 10 minutes could be considered best with a significant reduction in cyanide content and better retention of the nutrients. Bamboo shoot is a highly nutritious food along with the medicinal value. Adapting pre-treatments and proper cooking methods, the toxic chemicals in bamboo shoots can easily be eliminated. Though nutritious, large scale use of bamboo shoots as food might affect the climate change as it helps in carbon sequestration.

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COMPETING INTEREST

The authors declared that they have no competing interest.

AUTHOR(S) CONTRIBUTION

IC- Methodology, Data compilation and writing initial draft; SR- Statistical Analysis & Editing; MDP-Methodology& Editing; AS- Methodology & Editing; SB – Concept and final editing.

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Table 1. Proximate Composition of Fresh and Processed Bamboo Shoots (g/100g on Dry Weight Basis).

Proximate analysis	Variety	Treatments						P <0.05	F value
		Control	Soaking in H_2O for 30 min.	Boiling in H_2O for 10 min.	Boiling in 1% NaCl for 10 min.	Boiling in 5% NaCl for 10 min.	Steaming for 10 min.		
Moisture	*Bambusatulda* (Jati)	90.76	90.79	91.90	90.41	90.06	89.27	0.235	1.594
	Dendrocalamus hamiltonii (Kako)	92.29	92.32	93.24	91.98	91.83	91.46	0.527	0.871
	Bambusabalcooa (bhaluka)	91.65	91.66	92.46	91.43	91.18	91.08	0.052	3.045
Crude protein	*Bambusatulda* (Jati)	16.42	16.49	14.66	14.65	14.66	14.63	0.001*	3802.266
	Dendrocalamus hamiltonii (Kako)	13.56	13.54	11.76	11.76	11.75	11.75	0.001*	1899.862
	Bambusabalcooa (bhaluka)	14.44	14.42	12.66	12.66	12.66	12.65	0.001*	1689.789
Crude Fat	*Bambusatulda* (Jati)	1.48	1.45	1.31	1.30	1.30	1.29	0.990	0.097
	Dendrocalamus hamiltonii (Kako)	1.83	1.80	1.75	1.75	1.74	1.78	0.999	0.033
	Bambusabalcooa (bhaluka)	1.49	1.48	1.39	1.38	1.37	1.36	0.716	0.578
Crude fibre	*Bambusatulda* (Jati)	5.28	5.17	5.07	5.00	4.97	5.07	0.597	0.756
	Dendrocalamus hamiltonii (Kako)	4.09	4.02	3.97	4.27	4.25	4.26	0.885	0.329
	Bambusabalcooa (bhaluka)	5.57	5.54	5.45	5.39	5.34	5.47	0.076	2.661
Total Carbohydrate	*Bambusatulda* (Jati)	6.58	6.52	8.39	6.12	6.01	6.17	0.001*	34.212
	Dendrocalamus hamiltonii (Kako)	5.37	5.07	7.63	4.82	4.66	4.72	0.001*	187.452
	Bambusabalcooa (bhaluka)	6.97	6.89	9.03	6.61	6.47	6.59	0.001*	144.225
Ash	*Bambusatulda* (Jati)	1.10	1.07	0.94	0.94	0.95	0.98	0.001*	12.130
	Dendrocalamus hamiltonii (Kako)	0.89	0.88	0.79	0.78	0.79	0.81	0.003*	6.656
	Bambusabalcooa (bhaluka)	1.54	1.52	1.43	1.44	1.44	1.47	0.001*	14.117

Note: Mean in the same row are significantly different (P<0.05)

*Significant

Table 2. Mineral Composition of Fresh and Processed Bamboo Shoots (mg/100g on Dry Weight Basis).

Mineral analysis	Variety	Treatments: Control	Soaking in H_2O for 30 min.	Boiling in H_2O for 10 min.	Boiling in 1% NaCl for 10 min.	Boiling in 5% NaCl for 10 min.	Steaming for 10 min.	P <0.05	F value
Potassium	*Bambusatulda* (Jati)	813.33	812.33	789.33	803.67	803.67	797.67	0.002*	7.050
	Dendrocalamus hamiltonii (Kako)	645.33	644.67	629.67	636.33	637.00	636.00	0.085	2.551
	Bambusabalcooa (bhaluka)	840.33	840.00	819.33	833.67	833.33	832.33	0.002*	7.031
Phosphorous	*Bambusatulda* (Jati)	654.00	608.00	420.00	422.00	422.00	590.00	0.001*	2242.70
	Dendrocalamus hamiltonii (Kako)	572.00	540.00	320.00	460.00	470.00	480.00	0.001*	1003.85
	Bambusabalcooa (bhaluka)	620.00	560.00	450.00	460.00	465.00	5.20	0.001*	626.221
Iron	*Bambusatulda* (Jati)	9.34	9.32	8.81	9.22	9.23	9.02	0.001*	207.614
	Dendrocalamus hamiltonii (Kako)	10.93	10.92	10.37	10.87	10.87	10.81	0.001*	481.160
	Bambusabalcooa (bhaluka)	9.07	8.99	8.59	8.99	9.00	8.95	0.001*	34.326
Calcium	*Bambusatulda* (Jati)	4.83	4.82	4.72	4.76	4.76	4.75	0.021*	4.083
	Dendrocalamus hamiltonii (Kako)	5.76	5.75	5.74	5.74	5.75	5.75	0.999	0.023
	Bambusabalcooa (bhaluka)	6.70	6.69	6.59	6.60	6.60	6.63	0.429	1.058

Note: Mean in the same row are significantly different (P<0.05)

*Significant

Table 3. Vitamin C Content, Secondary Metabolites, and Antinutritional Composition of Fresh and Processed Bamboo Shoots.

Biochemical parameters	Variety	Treatments						P <0.05	F value
		Control	Soaking in H_2O for 30 min.	Boiling in H_2O for 10 min.	Boiling in 1% NaCl for 10 min.	Boiling in 5% NaCl for 10 min.	Steaming for 10 min.		
Ascorbic acid (mg/100g fresh wt)	*Bambusatulda* (Jati)	2.60	2.45	1.83	1.86	1.86	1.92	0.001*	25.379
	Dendrocalamus hamiltonii (Kako)	2.47	2.38	1.82	1.88	1.88	1.93	0.001*	56.736
	Bambusabalcooa (bhaluka)	3.31	3.23	2.53	2.58	2.56	2.72	0.006*	5.580
Alkaloid (%) (on dry weight basis).	*Bambusatulda* (Jati)	20.38	20.37	19.58	19.55	19.17	19.60	0.663	0.655
	Dendrocalamus hamiltonii (Kako)	20.25	20.23	20.07	20.05	20.02	20.06	0.999	0.034
	Bambusabalcooa (bhaluka)	20.70	20.69	20.56	20.56	20.50	20.55	0.887	0.326
Phenol (mg Catechol Equivalent/100 g dry wt).	*Bambusatulda* (Jati)	493.64	493.27	399.34	400.45	400.30	493.83	0.001*	583.276
	Dendrocalamus hamiltonii (Kako)	506.62	506.35	470.90	470.55	470.41	507.06	0.001*	92.667
	Bambusabalcooa (bhaluka)	504.70	504.28	441.70	441.63	441.70	441.72	0.001*	133.724
Flavonoid contents (mg QE/100g dry wt).	*Bambusatulda* (Jati)	370.00	370.00	347.00	347.00	344.000	367.33	0.001*	103.162
	Dendrocalamus hamiltonii (Kako)	352.67	351.33	330.67	329.00	327.00	350.33	0.001*	208.605
	Bambusabalcooa (bhaluka)	445.00	444.67	413.67	413.33	313.33	442.00	0.001*	1381.944
Tannin (mg TAE/100g dry wt.)	*Bambusatulda* (Jati)	204.20	204.10	184.70	144.37	104.94	124.48	0.001*	16155.49
	Dendrocalamus hamiltonii (Kako)	204.20	204.10	184.40	184.40	124.77	164.51	0.001*	1854.33
	Bambusabalcooa (bhaluka)	184.30	184.23	144.70	144.37	104.94	124.48	0.001*	25338.47
Cyanide (ppm fresh wt)	*Bambusatulda* (Jati)	875.16	463.28	20.41	17.31	16.09	457.02	0.001*	7342.634
	Dendrocalamus hamiltonii (Kako)	1067.87	563.64	44.17	43.45	42.96	530.01	0.001*	759.946
	Bambusabalcooa (bhaluka)	866.91	468.89	27.51	25.27	25.17	461.36	0.001*	6082.855

Note: Mean in the same row are significantly different (P<0.05)

*Significant