Effects of blanching on nutrientdynamics in edible shoots of *Bambusa nutans*Wall ex Munro and *Bambusabalcooa*Roxb.

Abstract

The effect of hot water blanching on proximate and mineral constitution of two edible bamboo shoots viz., Bambusa nutans and B. balcooa, was investigated in the eastern Himalayan terai region of West Bengal, India. The proximate and mineral composition was determined at the laboratory of Department of Forestry, Uttar Banga Krishi Viswavidyalaya in 2021-22 by using standard methods. In the present study, hot water blanching at 100^0C for 20 minutes was significantly reduced the carbohydrate (4.11g/100g fw), total protein (1.19 g/100g fw), fat (0.28 g/100g fw), ash (0.09 g/100g fw), energy value (26.90Kcal/100g fw), HCN content (8.72mg/Kg) and minerals viz. potassium (233.10mg/100g fw), calcium (11.84mg/100g fw) and magnesium (3.19mg/100g fw) content whereas enhanced the moisture content (92.75 %), crude fibre (1.58 g/100g fw), iron (1.78mg/100g fw) and copper content (0.94mg/100g fw), respectively, in comparison to the raw bamboo shoots.It was also found that*B. nutans* was quantitatively superior with maximum edible percentage (43.17%),carbohydrate (4.50g/100g fw), total protein (1.51g/100g fw), fat content (0.48g/100g fw), crude fibre (1.74g/100g fw) and energy (31.80Kcal/100g fw) along with higher sodium (2.09mg/100g fw), potassium (339.37mg/100g fw), magnesium (4.85mg/100g fw), zinc (0.56mg/100g fw) and manganese (1.12mg/100g fw) while *B. balcooa* had higher moisture content (92.72%), HCN (104.15mg/Kg), calcium (16.05mg/100g fw), iron (1.77mg/100g fw) and copper content (1.13mg/100g fw).However, there is a need for further research towards value addition and composite mixture to ensure the nutritional security.

Key words: Blanching, edible shoots, hydrogen cyanide, minerals, nutrient dynamics

1. Introduction

Bamboo resource was very much diversified with 45 genera and 750 species in Tropical Asia, out of 90 genera and 1200 species around the world [1],however in India about 125 indigenous and 11 exotic bamboo species of 23 genera was found [2]and almost 99% of the total bamboo resource comes from natural forest in India [3]. However, only few bamboo species are edible. These bamboo shoots contain low calories and fat but fountain of like protein, crude fiber, vitamin and minerals [4]. It also showed anti-microbial and anti-oxidant properties due to presence of lignin, phyto-sterols and poly-phenolic compounds [5].Bamboo shoots are mostly consumed as raw, canned and fermented forms[6]. However, the nutritional status of these shoots is non-standardized based on seasonal and region-specific variation [7].

There are various food processing method like sun and oven drying [8], heat curing, freeze drying [9], vaccum drying [10] and microwave drying[11]. Apart from that, blanching, is an easy, cost effective and regular household bamboo processing method, is a process ofcooking where heatis applied to various vegetables to increase its shelf-life, prevent oxidation by elimination of intracellular air, stabilize enzymatic reactions, reduce microbial load and soften tissues for shorter cooking time and easier canning process[12] along with reduce the anti-nutrient components like hydrogen cyanide [13]. Hot water blanching is used to control microbial and fungal infestation and induced resistance against chilling injury at low storage temperature [14]. It also inhibits disease incidences, respiration, ethylene production and various enzymatic activities of bamboo shoots [5]storage at 20 ° C. There are several experiment was conducted by Oriow*et al.* [15], Viswanath *et al.*[16],Bigoniya *et al.*[17], Raveendran *et al.*[18]and Kong *et al.*[19]to determine the nutrient status of different raw bamboo shoots. But studies regarding the nutrient variability during processing of bamboo shoots of different specieswere remained in darkness. Based upon the local dominance of both the species, the present study was focused on investigation of change in nutritional composition (carbohydrate, total protein,fat, fibre, ash) along with Hydrogen cyanide and energy value of fresh bambooshoot during hot water blanching.

Comment [V1]: The objective research

2. Materials and Methods

The young tender bamboo samples were collected from thebamboo-setumunderDepartment of Forestry, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India which is geographically located in Eastern Himalayan agro-climatic region.The nutritional value was analyzed in the laboratory of during 2021-22. The experiment waslaid out with factorial Complete Randomized Design. The first factor was consisting of two levels i.e. *B. nutans* and *B. balcooa* and second factor was thetreatments with two levels viz. raw bamboo shoots and blanched bamboo shoots and each treatment was replicated five times and the mean value was computed for further analysis.

After harvesting the newly emerging 10-14 days old young tender shoots of *B. nutans* and *B. balcooa*, proximate analysis of bamboo shoot were determined by using standard methods according to AOAC [20] and all measurements were recorded. The edible percentage was calculated from the weight of edible tender portion after discarding the hard-fibrous portion to the total weight of shoot after harvesting [21].The moisture content of the bamboo shoots was determined by using oven drying method at 105°C for 6-8 hours in hot air oven till constant weight was obtained. The total protein in bamboo shoot samples were determined using micro Kjeldahl method,where the sample was digested ina digestion unit

(Kelplus KES 012L E) for three hour till it became colorless andafter cooling and it was transferred to the distillation unit (Kelplus ELITE- EX VA) andliberated ammonium gas was absorbed in 4% boric acid solution containing mixed indicatorand titrated against 0.025N H_2SO_4. The crude protein content will be calculated by multiplying percentage nitrogen by 6.25.The fat content of the bamboo shoot samples were estimated by soxhlet extraction method using petroleum ether at 80^0 C for about 80-90 min. The crude fibre content in shoot samples was determined by alternate acid and alkali hydrolysis methodwith 1.25% sulphuric acid and 1.25% sodium hydroxide solution. The total ash content of the bamboo shoot samples were determined by charring in the muffle furnace at 550°C for about 6 hours. The carbohydrate content was determined by subtracting the sum total of weight of the moisture, fat, ash, fibre and protein content from 100 [22].The mineral content were determined by followingthe standard procedures outlined by Jacobs [23].Sodium and Potassium were estimated by using the method of flame photometry at 598nm and 548nm monochromatic filter.Calcium and Magnesium content was determined by following EDTA titrimetry[24]. Micro-nutrientslikezinc, iron, manganese and copper were determined with proper dilution by using Atomic Absorption Spectrophotometer (model- ContrAA 700).Hydrogen cyanideestimation was done using the picrate paper technique[25] andthe absorbance was measured at 510 nm in a UV-Vis Spectrophotometer (Shimadzu UV-1800). The total cyanogen content was calculated by the following equation:Total cyanogen content (mg/ Kg) = 396 x absorbance / weight of the sample.The energy value was determined by sum of the values obtained through multiplication of carbohydrates, crude protein, crude fat and dietary fibre by 4.00, 4.00, 9.00 and 2 Kcal, respectively [26].The statistical analysis for each variable was carried out on mean values by using SPSS statistical tool by following procedure given by Gomez and Gomez [27].

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3. RESULTS AND DISCUSSION

3.1 Edible Percentage

The study (Figure 1)showed that *B. nutans*(43.17%) had maximum edible percentage than *B. balcooa*(40.02%). Edible biomass in both the species is below 50% of the total biomass production and the rest part is denoted by the culm sheath. The study was in line with Pandey [28], who reported that edible percent of a newly harvested shoot was typically 30%. The edible portion of bamboo depends upon the species, size [29] and harvesting age [21]. Raveendran *et al.*, [18]was found higheredible percentage in solid bamboos i.e. 71.85% and 74.27% in *Dendrocalamusgiganteus* and *D. strictus*, respectively.

3.2 Moisture content

Moisture content of raw bamboo shoots was recorded as 91.07 and 92.19% in *B. nutans* and *B. balcooa*, respectively (Table 1). However, after blanching the moisture content was significantly increased to 92.25% and 93.25%, respectively. Irrespective of the treatment, *B. balcooa*had higher moisture content (92.72%) than *B. nutans*(91.66%). Irrespective of species, blanched bamboo shootshad more moisture content (92.75%) than (91.63) raw bamboo shoots. The variation in moisture content may be due to factors like stage of maturity, time of harvesting, agro-climatic conditions and species variation. Apart from this, the thickness of protecting outer sheath also kept an important role to make the shoot more hydrated. The significant increase in the moisture content during blanching may be due to adsorption of moisture into the cell and inter cellular cavity during boiling. The study showed close agreement with Raveendran *et al*. [18], who observed 88.98 to 92.06% moisture content in different bamboo species.Sood*et al.*, [30] also reported that bamboo shoot may contain as much as 90% water at harvesting. Similarly, Premlata*et al.* [31] was found the moisture content was ranged in between 88.17- 91.26% in different *Bambusa spp.* similar results was recordedin *M. bambusoides* (91.22%) [32], *B. balcooa* (91.78%) [33], *D. asper* (93.15-94.27%) [34] and *D. hamiltoni* (91.06%) [35], respectively.

3.3 Total protein

Total protein of raw bamboo shoots was recorded as 1.69 and 1.08 g/100g fresh weight (fw) in *B. nutans* and *B. balcooa*, respectively, whereas, the value was significantly decreased to 1.32 and 1.06 g/100g fw, respectively, after blanching. Irrespective of treatment, *B. nutans* had higher protein content (1.51g/100g fw) than*B. balcooa*(1.07g/100g fw). Irrespective of species,blanchedbamboo shoots had lesser total protein (1.19g/100g fw) thanrawbamboo shoots (1.39g/100g fw). Higher temperature during blanching might be degenerate the essential amino acids and thereby decline the protein content. A decline in the protein content during blanching was also recorded by Kumbhare and Bhargava [36].Pandey and Ojha [13] also reported that *B. bambos* had protein content of 1.88 g/100g fw. This study is well in line with the findings in *B. balcooa* having protein content2.74% [32] and 2.96% [33], respectively. The variation in the protein content in different studies may be due to difference in species, agro-climatic region and parts of shoot take for analysis. Considering the average protein content it may be suitable to fulfil the daily dietary allowance for protein (0.8g/Kg of body weight) as recommended for adults [6].

3.4 Fat content

The fat content(Table 1)of raw bamboo shoots was recorded as 0.66 and 0.61g/100g fwin *B. nutans* and *B. balcooa*, respectively, however, after blanching the fat content was decreased to 0.33 and 0.27 g/100g fw, respectively. The study showed *B. nutans*had higher fat content (0.48g/100g fw) than *B. balcooa*(0.44g/100g fw), irrespective of treatment. Similarly, blanchedbamboo shoots (0.28g/100g fresh weight) had declined significantly in fat content as compared to raw bamboo shoots (0.63g/100g fw), irrespective of species. Chongtham*et al*. [6] estimated the fat content in bamboo shoots was varied between 0.26 to 0.94%. This study evidenced with similar findings in *B. vulgaris* var. *striata* (0.10 mg/100g fw) [18]; *D. hamiltoni*(0.29 %) [35] and (2.1%) [37]; *B. tulda*(0.48 mg/100g fw) [6]; *B. nutans* (0.30%) [38] and *B. balcooa* (0.28%) [33]. The low fat content made it ideal candidate for healthy nutrition and cardio- vascular disease [39] and dominated by palmitic acid, linoleic acid and linolenic acid [40].

3.5 Crude fibre

Fibre-rich diet reduces the bad cholesterols like low and very low density lipoproteins. The crude fibre of raw (1.70 and 1.31g/100g fw) and blanched bamboo shoots (1.78 and 1.38g/100g fw) was recordedin *B. nutans* and *B. balcooa*, respectively and it was observed that blanch bamboo shoots showed an increasing trend. Irrespective of treatment *B. nutans* had higher crude fibre (1.74g/100g fw) than *B. balcooa*(1.35g/100g fw) while,irrespective of species, blanched bamboo shoots (1.58g/100g fw) had a little more crude fibre than raw bamboo shoots (1.50g/100g fw) but no significant difference among the treatments. The results showed close agreement with the findlings of Sood*et al*. [35] in *D. hamiltoni*(1.50 g/100g), Chongtham*et al.* [6] in *B. tulda* (3.97 g/100g) and Kumbhare and Bhargava [36] in *B. nutans* (0.76 g/100g fw), respectively.Significantly higher crude fibre wasrecorded by Kong *et al.* [19] through boiling at 100^0C for 20 minutes. However, ingestion of dietary fibre about 25 - 29 g day^{-1} could provide better health benefit viz. protection against cardiovascular diseases, type-2 diabetes and colorectal and breast cancer by decreasing the serum and hepatic lipids and faster transit time i.e. time taken by body to remove faecal waste.

3.6 Total ash

A perusal of the data presented in the Table 1, the total ash of raw bamboo shoots had 0.18 and 0.16g/100g fw, whereas the total ash content was decreased to 0.06 and 0.11g/100g fwin *B. nutans* and *B. balcooa*, respectively after blanching. Irrespective of treatment total ash content (0.12g/100g fw) of *B. nutans*was significantly at par with (0.13g/100g fw) *B. balcooa*. Similarly, irrespective of species, total ash content in blanched bamboo shoots showed declining trend (0.09g/100g fw) as compared to raw bamboo shoots (0.17g/100g fresh weight).Similar findings was exhibited in *B. balcooa* (0.43%), *B. bambos* (0.86%), *B. tulda* (0.85mg/100g), *D. asper* (0.50g/100g), *B. nutans* (0.90 g/100g fw) and *B. vulgaris* (0.80 g/100g fw) [36],[6],[18], respectively. The difference in value may be due to the high rainfall, poor soil fertility gradient and regional climatic attribute.

3.7 Carbohydrate

The carbohydrate of raw bamboo shoots was 4.71 and 4.65g/100g fwin *B. nutan* and *B. balcooa*, respectively, whereas, it was 4.29 and 3.93g/100g fw, in blanched bamboo shoots accordingly. The carbohydrate in blanched bamboo shoots showed decreasing trend in comparison to raw bamboo shoot. Irrespective of treatment, *B. nutans*had significantly higher carbohydrate (4.50g/100g fw) than *B. balcooa*(4.29g/100g fw) and irrespective of species,blanched bamboo shoots (4.68g/100g fw) had lesser amount of carbohydrate as compared toraw bamboo shoots (4.11g/100g fw) because of hydrolysis of carbohydrate due to boiling [13]. The present study was supported by the findings of Tripathi [40] and Premlata*et al.* [31] in *B. nutans* (3.30% and 2.76 g/100g fw, respectively); Choudhury *et al.* [7] and Bora *et al.* [33] in *B. balcooa* (3.90% and 5.28%, respectively);Viswanath *et al*. [16] in *B. bambos*(5.83-6.83 g/100g fw); Bhat *et al.* [32] in *M. bambusoides*(3.93%)and Kumbhare and Bhargava [36] in *B. vulgaris* (3.40 g/100g fw), respectively. The higher level of carbohydrate enhanced the sweetness that eventually attracted ants and other predators. Bamboo shoots contained higher amount of carbohydrate than fat and protein like other vegetables.

3.8 Mineral content

The macro and micronutrients present in bamboo shoot was significantly affected by the effect of blanching represented in table 2and the difference in mineral content was influenced by variation in agro climatic zones, stage of maturity, genetic makeup, season, harvest methodology and post-harvest handling conditions.

Irrespective of treatment, sodium content (2.09mg/100g fw) in *B. nutans* was statistically at par with (1.78mg/100g fw) *B. balcooa* and irrespective of species, sodium content in the blanchedbamboo shoots (2.10 mg/100g fw) was at par with raw bamboo shoots (1.76 mg/100g fw). The increasing trend of blanching was evident by Pandey and Ojha [13] due to osmotic balance. Our finding is close agreement withSood*et al.* [35] in *D. hamiltonii* (4.80 mg/100g fw), Chongtham*et al.* [6] in *D. hamiltonii* (9.32 mg/100g fw) and in *B. tulda* (12.96 mg/100g fw) and Nirmala *et al.* [41] in *B. bambos* (3.60 mg/100g fw), *D. asper* (4.42 mg/100g fw). The daily recommended dose is less than 2 g day^{-1} sodium (5g day^{-1} salt) to prevent chronic diseases by World Health Organization [42].

Comment [V3]: Table 2

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Irrespective of treatments, significantly higher (339.37mg/100g fw)potassium content was observed in *B. nutans* as compared to (269.95mg/100g fw) *B. balcooa* whereas, irrespective of species, blanching evidenced significant reduction in potassium content (233.10mg/100g fw) with respect to raw bamboo shoots (376.22mg/100g fw). This study is well in line with the findings of Sood*et al.* [35] in *D. hamiltonii* (533.00 mg/100g fw), Chongtham*et al.* [6] in *D. hamiltonii* (408.00 mg/100g fw) and in *B. tulda* (416.00 mg/100g fw) and Nirmala *et al.* [41] in *B. bambos* (566.00 mg/100g fw), *D. asper* (460.00 mg/100g fw).The loss in potassium might be due to leaching of minerals in water [43]. The daily recommendation of K for adult is 2.0-5.5g day^{-1}[44]. Low sodium and high potassium identified bamboo as a heart friendly diet that maintain normal blood pressure [6].

*B. balcooa*had significantly higher calcium content (16.05mg/100g fw) as compared to (10.52mg/100g fw) *B. nutans*. Irrespective of species, calcium content in the blanched bamboo shoots (11.84mg/100g fw) was declined significantly from raw bamboo shoots (14.73mg/100g fw). It might be due to the leaching in water during the boiling [43]. The results are in consonance with the findings of Sood*et al*. [35] in *D. hamiltonii* (15.00 mg/100g fw), Chongtham*et al.* [6] in *D. hamiltonii* (4.06 mg/100g fw) and in *B. tulda* (3.00 mg/100g fw), Nirmala *et al*. [41] in *B. bambos* (0.30 mg/100g fw), *D. asper* (1.68 mg/100g fw) and Gopalan *et al*. [45] in *Bambusa spp.* (20 mg/100 gfw). The recommended dose of calcium for adults is 100mg day^{-1} [46].

The study showed significantly higher (4.85mg/100g fw)magnesium content in *B. nutans*as compared to*B. balcooa*(2.73mg/100g fw) whereas blanching bamboo shootshowed reduction in magnesium content (3.19mg/100g fw) with respect to rawbamboo shoots (4.39mg/100g fw). It may be due to the nutrient loss during blanching.The recommended dose of magnesium is 232 – 439 mg day^{-1} in adults [47]. Similarresults were obtained by Sood*et al*. [35] in *D. hamiltonii* (3.90 mg/100g fw), Chongtham*et al.* [6]in *D. hamiltonii* (8.68 mg/100g fw) and in *B. tulda* (6.09 mg/100g fresh weight), Pandey and Ojha [13] in *B. bambos*(0.17 g/100g) and Nirmala *et al.* [41] in *B. bambos* (5.20 mg/100g fw) and *D. asper* (8.20 mg/100g fw).

The study showed iron content was significantly higher (1.77mg/100g fw)in *B. balcooa*as compared to (1.65mg/100g fw) *B. nutans*. It was also found that, irrespective of species, blanchingcaused significant enhance in iron content (1.78mg/100g fresh weight) with respect to rawbamboo shoots (1.64mg/100g fw). It might be due to the release of iron from its chelating agents on the effect of higher temperature [48].However, it is quite enough to meet the daily requirement for women and children i.e. 1.65 and 1.05mg day^{-1}, respectively [37].

The values showed close agreement with Sonar *et al.* [49] in Hirring bamboo shoot (2.45mg/ g dry weight basis)and Nirmala *et al.* [41]in *B. bambos* (1.31 mg/100g fw) and*D. asper* (2.52 mg/100g fw).

Significantly higher copper content (1.13mg/100g fw) was observed in *B. balcooa* as compared to (0.29mg/100g fw) *B. nutans*and irrespective of species, blanchingcaused significantly increase in copper content (0.94mg/100g fw) with respect to rawbamboo shoots (0.48mg/100g fresh weight). It might be due to denaturation of copper containing enzymes like polyphenoloxidases[50]. The study showed close agreement with Sood*et al.* [35] in *D. hamiltonii* (0.29 mg/100g fw), Chongtham*et al.* [6] in *D. hamiltonii* (0.44 mg/100g fw) and in *B. tulda* (0.29 mg/100g fw), Sonar *et al*. [49] in Eup bamboo shoot (0.38 mg/g dry weight basis) and Nirmala *et al*. [41]in *B. bambos* (0.20 mg/100g fresh weight), *D. asper* (0.14 mg/100g fw).

The zinc content (0.56 mg/100g fresh weight) of *B. nutans* was statistically at par with (0.52 mg/100g fresh weight) *B. balcooa*. It was also found that, irrespective of species, blanching had no significant change in zinc content (0.54 mg/100g fw).The study showed close agreement with Chongtham*et al*. [6] in *D. hamiltonii* (0.72 mg/100g fw) and *B. tulda* (0.70 mg/100g fw), Sonar *et al*. [49] in Hechhe bamboo shoot (0.63 mg/g dry weight basis) and Nirmala *et al*. [41] in *B. bambos* (0.49 mg/100g fw) and *D. asper* (0.83 mg/100g fw). The daily recommended dose for zinc in adults was 10-12 mg day^{-1}[51].

The manganese content (1.12mg/100g fw) of *B. nutans*was significantly at par with (1.10mg/100g fw)*B. balcooa*. Similarly, blanching had no significant effect on manganese content (1.21mg/100g fw) with respect to raw bamboo shoots (1.01mg/100g fw).The recommended dose of manganese is 3.0 mg day^{-1} in adults [52]. The study is well in line with the studies of Chongtham*et al.* [6] in *D. hamiltonii* (0.70 mg/100g fw) and in *B. tulda* (0.16 mg/100g fw) and Nirmala *et al.* [41]in *B. bambos* (0.24 mg/100g fw) and *D. asper* (0.16 mg/100g fw).

3.9 Hydrogen cyanide

The hydrogen cyanide of raw bamboo shoots was recorded as 165.10 and 203.15 mg/Kg fresh weight in *B. nutans* and *B. balcooa*, respectively (Table 1). However, after blanching the cyanogenic glycoside was significantly decreased to 12.28 and 5.15 mg/Kg fw, respectively. The study showed *B. balcooa*had higher cyanogenic glycoside content (104.15mg/Kg fw) than*B. nutans* (88.69mg/Kg fw). It was also found that, irrespective of species, blanched (T_2) bamboo shoots (8.72mg/Kg fw) had significantly lower cyanogenic glycoside than raw bamboo shoots (184.13g/100g fresh weight). In similar study Pokhariya*et* *al*. [53]was found that boiling the shoots of *D. strictus* for 25 minute was reduced to 40 mg/Kg from the raw bamboo shoots (763 mg/Kg). The cyanogenic glycosides production was varied with age, parts of the plant, species as well as the environmental factors [54], [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].

3.10 Energy value

The present findings showed significantly higher (31.80Kcal/100g fw)energy value in *B. nutans* as compared to(28.07 Kcal/100g fw) *B. balcooa*. Blanchingcaused significant reduction in energy value (26.90 Kcal/100g fw) with respect to rawbamboo shoots (32.97 Kcal/100g fw) by the process of volatilization irrespective of species.In similar studies, energy value of bamboo shoots was 43 kcal/100g [45]. Bhat*et al.*[32] reported energy value as 14.6-16.9 MJ/Kg in different species of bamboo shoots from different regions of North Eastern Himalaya, India.The study also showed close agreement with Pokhariya*et al.* [53] in *D. strictus* (28 kcal/100g) and Oriwo*et al*. [15] in *D. asper* (17.46 KJ/g in dry weight basis). The calorie-need is 2400 kcal in rural areas and 2100 kcal in urban areas as recommended by Indian Council of Medical Research [57].

Conclusion

Comment [V4]: Weather the conclusion has answered the objective research?

In the present investigation, it was found that blanching was significantly reduced the carbohydrate, total protein, fat, ash, energy value, HCN content and minerals viz. potassium, calcium, and magnesium content.In other hand, blanching enhanced the moisture content, crude fibre,iron and copper content, respectively. Among the species, *B. nutans* had higher edible percentage, total protein, fat content, crude fibre and carbohydrate along with higher sodium, potassium, magnesium, zinc and manganese while *B. balcooa* had higher moisture content total ash content, calcium, iron and copper content. Overall, hot water blanching at 100^0c for 20minutes drastically reduced the phyto-toxin (hydrogen cyanide), so it was recommended against consuming raw ram bamboo shoots.

References

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1. FAO. World bamboo resources: A thematic study prepared in the framework of the Global Forest Resources Assessment. Non-wood forest products-18, Food and Agriculture Organization of the United Nations, Rome;2007.
2. ISFR. India State of Forest Report. Ministry of Environment and Forests, Government of India, Dehradun;2019.

3. Agnihotri RK, Nandi SK. *In vitro* shoot cut: A high frequency multiplication & rooting method in the bamboo *Dendrocalamushamiltoni*. Biotechnology.2009;8: 259-263.
4. Zheng H, Zhuang S, Sun B, Ji H, Li C, Zhou S. Estimation of biomass and carbon storage of moso bamboo (Phyllostachys pubescens Mazel ex Houz.) in southern China using a diameter–age bivariate distribution model. Forestry.2014; 87: 674–682.
5. Luo Z, Feng S, Pang J, Mao L, Shou H,Xie J. Effect of heat treatment on lignification of postharvest bamboo shoots (*Phyllostachys praecox f. prevernalis*). Food Chemistry.2012; 135(4): 2182-2187.
6. Chongtham N, Bisht MS,Haorongbam S. Nutritional properties of bamboo shoots: potential and prospects for utilization as health food. Comprehensive Reviews in Food Science and Food Safety. 2011; 10 (3): 153–168.
7. Choudhury D, SahuJK,SharmaGD. Value addition to bamboo shoots: a review. Journal of Food Science and Technology.2012; 49(4): 407-414.
8. Satya S, Bal LM, Singhal P, Naik SN. Bamboo shoot processing: food quality and safety aspect (a review). Trends in Food Science and Technology.2010;21:181–189.
9. Xu YY, Zhang M, Tu DY, Sun JC, Zhou LQ, Mujumdar AS. A two-stage convective air and vacuum freeze drying technique for bamboo shoots. International Journal of Food Science and Technology.2005;40: 589–595.
10. Cheng HP. Vacuum cooling combined with hydrocooling and vacuum drying on bamboo shoots. Applied Thermal Engineering.2006; 26: 2168–2175.
11. Bal LM, Kar A, Satya S, Naik SN. Drying kinetics and effective moisture diffusivity of bamboo shoot slices undergoing microwave drying. International Journal of Food Science and Technology.2010;45: 2321–2328.
12. Ruiz-Ojeda LM,Peñas FJ. Comparison study of conventional hot-water and microwave blanching on quality of green bean. Innovative Food Science and Emerging Technologies.2013;20: 191-197.
13. Pandey AK, Ojha V. Precooking processing of bamboo shoots for removal of anti-nutrients.Journal of Food Science and Technology.2014;51(1):43–50.
14. Lurie S. Postharvest heat treatments. Postharvest Biology and Technology.1998;14(3): 257–269.
15. OriwoV, WairaguN, OduorN, DuraiJ. Nutrient Content of Bamboo Shoots from Selected Species in Kenya.American Journal of Agriculture and Forestry.2022; 10(1): 14-20.

16. Viswanath S, Sreekumar VB, Sruthi S. *Bambusabalcooa*Roxb.: A multi-utility bamboo for domestication. KSCSTE-Kerala Forest Research Institute, Peechi, Kerala, India 2021;p.43.

17. Bigoniya P, Sohgaura AK, Shrivastava B. Antilithiatic effect of *C. dactylon*, *E. officinalis*, *K. pinnata* and *B. nutans* ethyl acetate fraction on glyoxylate-induced nephrolithiasis.Future Journal of Pharmaceutical Sciences.2021;7:79.

18. Raveendran U, Ganga KA, Viswanath S, Sreekumar VB,Jayaraj R. Nutritional Evaluation of different Bamboo species in Kerala as a Sustainable food Source. Journal of Non-Timber Forest Products.2020; 27(1): 22-26.

19. Kong CK, Tan YN, Chye FY, Sit NW. Nutritional composition and biological activities of the edible shoots of *Bambusa vulgaris* and *Gigantochloaligulata*. Food Bioscience.2020; 36: 100650

20. AOAC.Official methods of analysis, 16th ed., Association of Official Analytical Chemists, Washington, DC, USA.2017.

21. Pandey AK, Ojha V. Standardization of harvesting age of bamboo shoots with respect to nutritional and anti-nutritional components. Journal of Forestry Research.2013; 24(1): 83-90.

22. Onwuka GI. Food analysis and instrumentation, theory and practical. Edition Naphta Prints Lagos, Nigeria. 2005;p. 89-98.

23. Jacobs MB.The Chemical Analysis of Foods and Food Products (3rd edition). New Delhi, India: CBS Publishers and Distributors. 1999.

24. Saini RS, Sharma KD, Dhankar OP, Kaushik RA. Laboratory manual of analytic techniques in Horticulture. Agrobios (India). 2001; 135p.

25. Bradbury MG, Egan SV, Bradbury JH. Determination of all forms of cyanogens in cassava roots and cassava products using picrate paper kits. Journal of the Science of Food and Agriculture.1999;79: 593-601.

26. Wanjala WN, Mary O, Symon M. Optimization of Protein Content and Dietary Fibre in a Composite Flour Blend Containing Rice (*Oryza sativa*), Sorghum (*Sorghum bicolor* (L.) Moench) and Bamboo (*Yushaniaalpina*) Shoots. Food and Nutrition Sciences. 2020;11: 789-806.

27. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research, John Willey and Sons, Inc. New York. 1984; p.680.

28. Pandey S. Bamboo shoots for the 21st century. International Forest Reviews.2008;10:134-46.

29. Dabas D, Kumar K. Bamboo shoot processing in India. Advances in Food Technology and Nutritional Sciences– Open Journal. 2018; 4(1): 1-3.

30. Sood S, Walia S,Sood A. Quality Evaluation of Different Species of Edible Bamboo Shoots. ARC Journal of Nutrition and Growth.2017; 3(1):1-6

31. Premlata T, Saini N, Nirmala C, Bisht MS. Nutrient Components in Young Shoots of Edible Bamboos of Manipur, India (*In*:) Food and Pharmaceuticals10th World Bamboo Congress, Korea.Raja K, Sivasubramaniam K, Geetha R and Anandham R 2012. Evaluation of pot mixture for propagation of bamboo species (*Bambusa tulda*). Range Management & Agroforestry.2015;33 (2): 182-184.

32. Bhat BP, Singh K, Singh A. Nutritional values of some commercial edible bamboo species of North eastern Himalayan region. Indian Journal of Bamboo and Rattan. 2005;4(2):111-124.

33. Bora A, Sasikala S, Monis SA,Vinothini K. Evaluation of Biochemical and Nutritional composition of Tray Dried Bamboo Shoot (*Bambusa balcooa*) Powder (BSP)International Journal of Latest Technology in Engineering, Management & Applied Science.2015; 4(4):17-20.

34. Kong CK, Tan YN, Chye FY, Sit NW. Nutritional compositions, biological activities, and phytochemical contents of the edible bamboo shoot, *Dendrocalamus asper*, from Malaysia.International Food Research Journal. 2020;27(3): 546 – 556.

35. Sood S, Walia S, Gupta M,Sood A. Nutritional Characterization of Shoots and Other Edible Products of an Edible Bamboo- *Dendrocalamushamiltonii.*Current Research in Nutrition and Food Science.2013;1(2), 169-176.

36. Kumbhare, V, Bhargava, A. Effect of processing on nutritional value of central Indian bamboo shoots. Part 1. Journal of Food Science and Technology. 2007; 44(1): 29-31.

37. Bam Y,Malagi U. Effect of fermentation on nutrient composition of bamboo shoot. International Journal of Pure and Applied Bioscience. 2017;5(6): 1015-1023.

38. Kumar S, Bhardwaj DR, Mishra V, Rajpoot BS,Warpa P. Effect of Harvesting time and species on nutritional quality of edible bamboo shoots. The Pharma Innovation Journal. 2020; 9(9): 111-113.

39. Kozukue E,Kozukue N. Lipid content and fatty acid composition in bamboo shoots. Journal of Food Science.1981; 4:751-55.

40. Tripathi YC. Food and nutritional potential of bamboo. MFP News. 1998;8(1):10-11.

41. Nirmala C, David E,Sharma ML. Changes in nutrient components during ageing of emerging juvenile bamboo shoots. International Journal of Food Sciences and Nutrition. 2007;58(8): 612-618.
42. Anon. Guideline: Sodium intake for adults and children. World Health Organization (WHO), Geneva, Switzerland. 2012; p.46.
43. Gopalan C, Shastri RBV, Balasubramanian SC.Nutritive value of Indian foods. Hyderabad. India1994;156p.
44. Belitz HD, Grosch W. Food chemistry. 2nd ed. New York: Springer Verlag. 1999.
45. Gopalan C, Shastri RBV, Balasubramanian SC, Rao NBS, Deosthale YG, Pant KC. Nutritive value of Indian foods. Hyderabad. India, National Institute of Nutrition. Indian Council of Medical Research. 2004;74p.
46. Anon. Dietary Reference Intakes for Vitamin D and Calcium. Institute of Medicine, NW Washington DC, USA. 2011; p.4.
47. EFSA. Scientific Opinion on Dietary Reference Values for magnesium. EFSA Journal. 2015; 13(7):4186, p.63.
48. Lestienne I,Icard-Vernie`re C, Mouquet C,Picq C,Tre`che S. Effects of soaking whole cereal and legume seeds on iron, zinc and phytate contents. Food Chem. 2005; 89: 421-425.
49. Sonar NR, Vijayendra SVN, Prakash M, Saikia M, Tamang JP,Halami PM. Nutritional and functional profile of traditional fermented bamboo shoot based products from Arunachal Pradesh and Manipur states of India. International Food Research Journal.2015; 22(2): 788-797.
50. Kingsly ARP,Balasubramaniam VM, Rastogi NK. Influence of High-Pressure Blanching on Polyphenoloxidase Activity of Peach Fruits and its Drying Behavior. International Journal of Food Properties.2009; 12(3): 671-680.
51. ICMR. Dietary guidelines for Indians -a manual. National Institute of Nutrition, Indian Council for Medical Research, Hyderabad, India.2011; p.127.
52. EFSA. Scientific Opinion on Dietary Reference Values for manganese. EFSA Journal 2013; 11:44. DOI: 10.2903/j.efsa.2013.3419.
53. PokhariyaP, TangariyaP, SahooA, Awasthi P,Pandey A.Reducing hydrocyanic acid content, nutritional and sensory quality evaluation of edible bamboo shoot based food products. International Journal of Chemical Studies. 2018; 6(4): 1079-1084
54. Cooper-Driver GA, Swain T. Cyanogenic polymorphism in bracken in relation to herbivore predation. Nature.1976;260: 604.

55. Woodhead S, Bernays E. Change in release rates of cyanide in relation to patability of Sorghum to insects. Nature. 1977;270: 235- 236.

56. Sarma MP. Analysis of Cyanide Concentration in Five Selected Bamboo Shoots Consumed in North East India. Bioequivalance& BioavailabilityInternatonal Journal. 2018; 2(2): 000127.

57. Srivastava SK, Chand R. Tracking Transition in Calorie-Intake among Indian Households: Insights and Policy Implications Agricultural Economics Research Review. 2017; 30(1): 23-35.

TABLE 1. Effect of blanching on nutritional properties of *B. nutans* and *B. balcooa*

Species	Moisture content (%)	Total protein (g/100g fw)	Fat content (g/100g fw)	Crude fibre (g/100g fw)	Total ash (g/100g fw)	Carbohydrate (g/100g fw)	Hydrogen cyanide (mg/Kg)	Energy value (Kcal/100g fw)
S_1: *Bambusa nutans*	91.66	1.51	0.48	1.74	0.12	4.50	88.69	31.80
S_2: *Bambusa balcooa*	92.72	1.07	0.44	1.35	0.13	4.29	104.15	28.07
SEm±	0.19	0.03	0.01	0.03	0.00	0.19	4.84	0.73
C. D.(p=0.05)	0.56	0.09	0.03	0.10	NS	0.57	14.51	2.20
Treatment								
T_1: Raw	91.63	1.39	0.63	1.50	0.17	4.68	184.13	32.97
T_2: Blanched	92.75	1.19	0.28	1.58	0.09	4.11	8.72	26.90
SEm±	0.19	0.03	0.01	0.03	0.00	0.19	4.84	0.73
C. D.(p=0.05)	0.56	0.09	0.03	NS	0.01	NS	14.51	2.20
Interaction								
T_1S_1: Raw + *B. nutans*	91.07	1.69	0.66	1.70	0.18	4.71	165.10	34.91
T_2S_1: Blanched + *B. nutans*	92.25	1.32	0.30	1.78	0.06	4.29	12.28	28.70
T_1S_2: Raw + *B. balcooa*	92.19	1.08	0.61	1.31	0.16	4.65	203.15	31.03
T_2S_2: Blanched + *B. balcooa*	93.25	1.06	0.27	1.38	0.11	3.93	5.15	25.11
SEm±	0.27	0.04	0.01	0.05	0.01	0.27	6.84	1.04
C. D.(p=0.05)	NS	0.13	NS	NS	0.02	NS	20.52	NS

TABLE 2. Effect of blanching on mineral content (mg/100g fw) of *B. nutans* and *B. balcooa*

Species	Sodium	Potassium	Calcium	Magnesium	Iron	Copper	Zinc	Manganese
S_1: *Bambusa nutans*	2.09	339.37	10.52	4.85	1.65	0.29	0.56	1.12
S_2: *Bambusa balcooa*	1.78	269.95	16.05	2.73	1.77	1.13	0.52	1.10
SEm±	0.12	13.27	0.59	0.15	0.04	0.12	0.02	0.08
C. D.(p=0.05)	NS	39.77	1.76	0.46	0.12	0.35	NS	NS
Treatment								
T_1: Raw	1.76	376.22	14.73	4.39	1.64	0.48	0.54	1.21
T_2: Blanched	2.10	233.10	11.84	3.19	1.78	0.94	0.54	1.01
SEm±	0.12	13.27	0.59	0.15	0.04	0.12	0.02	0.08
C. D.(p=0.05)	NS	39.77	1.76	0.46	0.12	0.35	NS	NS
Interaction								
T_1S_1: Raw + *B. nutans*	2.06	435.32	10.18	5.65	1.58	0.27	0.58	1.29
T_2S_1: Blanched + *B. nutans*	2.11	243.42	10.85	4.05	1.73	0.30	0.55	0.95
T_1S_2: Raw + *B. balcooa*	1.46	317.13	19.27	3.13	1.71	0.69	0.50	1.14
T_2S_2: Blanched + *B. balcooa*	2.10	222.77	12.82	2.33	1.84	1.58	0.53	1.07
SEm±	0.17	18.76	0.83	0.22	0.06	0.17	0.03	0.11
C. D.(p=0.05)	NS	56.24	2.49	NS	NS	0.50	NS	NS

Figure 1. Edible percentage (%) of *B. nutans* and *B. balcooa*