



A comparative evaluation of nutrients, minerals and phytochemical components in shoots of four edible bamboos of northern India

Kanchan Rawat^{1*}, Nirmala Chongtham¹, Madho Singh Bisht²

¹Department of Botany, Panjab University, Chandigarh, India

²Department of Environment Studies, North-Eastern Hill University, Shillong, Meghalaya, India

Abstract

Bamboo shoots are conventional delicacy to several South East Asian countries since time immemorial. Currently, they are getting recognition globally due to presence of several health and medicinal properties. The present study is undertaken to evaluate shoots of four bamboo species (*Bambusa balcooa* Roxb, *Dendrocalamus giganteus* Munro, *Dendrocalamus hamiltonii* Nees & Arn. Ex Munro, *Dendrocalamus membranaceus* Munro) for their nutritional, minerals and phytochemicals content. The parameters analysed were nutritional (protein, carbohydrate, starch, total free amino acids, fat, ash and moisture) minerals (potassium, phosphorus, magnesium, calcium, chlorine, sodium, sulphur, silicon, iron, zinc, manganese, copper and nickel) and phytochemicals (vitamins, total phenols, total phytosterols and dietary fibres). The results exhibited that while comparing nutritional and minerals parameters in four species, the highest content of protein, iron and manganese in *B. balcooa*; carbohydrate, sulphur, calcium in *D. giganteus* and amino acids, potassium, phosphorous and zinc in *D. membranaceus* were observed. Considering phytochemicals, the highest content of vitamin C, neutral detergent fibre and hemicellulose in *B. balcooa*; total phytosterols in *D. giganteus* and vitamin E and total phenols in *D. hamiltonii* were observed. Bamboo shoots has boundless prospects for its the utilization in food, nutrition and health security.

Keywords: bamboo shoots, edible bamboos, minerals, nutrients, phytochemicals

Introduction

Food and nutrition which is not only required for sustenance but also allied to longevity, overall health and well-being, are currently the major challenges of over growing population. To combat food and nutritional security which are the highlighted goals recognized by United Nation sustainable developments, several neglected and underutilized nutritious plants need to be placed in our food system^[1]. Bamboo, the fast growing, ubiquitous, is one such plant which is neglected, underutilized and underexploited predominantly in the field of nutrition and health. Bamboos belong to subfamily Bambusoideae, of grass family Poaceae and encompass 1480 species in 119 genera worldwide^[2]. Globally, the main bamboo species which are used for their edible shoots belongs to few genera i.e. *Bambusa*, *Dendrocalamus* and *Phyllostachys*^[3,4].

Bamboo shoot is the young, immature, tender, extending culm with long tapered apical part, which nurtures from the nodes of the underground rhizome of bamboo plants. Newly emerging shoots of bamboo plant are conventional delicacy to several rural communities and is now gaining popularity worldwide due to its health and medicinal properties^[5]. In diverse parts of the world, bamboo shoots are consumed in many forms such as blanched, boiled, steamed, stir fried, roasted, salted, pickled, fermented, canned and dried^[6]. Recently, scientific research on bamboos has demonstrated to have anticancerous, antidiabetic, antimicrobial, anti-inflammatory, antibiotic and antipyretic properties and also helps in lowering cholesterol and cardiovascular diseases^[7,8]. Besides several health properties of bamboos, scientific data on nutrient and phytochemical composition is scattered and limited to few bamboo species.

With this contextual, the study was conducted to examine various nutrients, minerals and phytochemical components of four bamboos species of northern region, India. Present research will be supportive in attaining awareness about nutrient and phytochemical composition of these species. Besides, objective of present work is to encourage and exploit these widely distributed bamboos with regard to food, nutritive and health benefits.

Material and Methods

Collection of Plant material

Fresh shoots of four edible bamboos species viz., *Bambusa balcooa* Roxb, *Dendrocalamus giganteus* Munro, *Dendrocalamus hamiltonii* Nees & Arn. Ex Munro, *Dendrocalamus membranaceus* Munro were collected from Forest Research Institute, Dehradun, Uttarakhand and P. N. Mehra botanical garden, Chandigarh, India during the period of July to September 2015-2017. The harvested shoots of selected species have average length of 20 to 35 cm. The hard outer sheaths were peeled off by knife and remaining edible portion was washed in distilled water and stored at 4 °C in the refrigerator for further investigation.

Analysis of Nutrients

Edible shoots of four bamboo species were evaluated for various nutrient components. Nutrients (protein, carbohydrate, starch, amino acids, fat, ash and moisture) were analysed by AOAC method^[9].

Analysis of Minerals

Mineral analysis was achieved by using a commercial WD-XRF (Wavelength Dispersive X-Ray Fluorescence) spectrometer S8 TIGER (Bruker, Germany). Examination of specific sample was carried out for 20 min. The instrument was controlled by software system (Quant Express). For calibration, the standard reference materials i.e. leaves of spinach (1570a) and tomato (1573a) were used.

Analysis of Phytochemical Components

Phytochemical components analysed in the current study were vitamin C and E, total phenols, total phytosterols and dietary fiber components.

Vitamin C content was analyzed by using ascorbic acid as standard [10]. 1 g shoot was crushed in 10 ml of metaphosphoric acid (5%) and acetic acid solution (10%). The extract was then filtered and centrifuged at 4000 r.p.m for 15 min. To final 1 ml of extract, 0.11 ml of bromine water (3%), 0.06 ml of thiourea (10%) and 0.5 ml of 2, 4-dinitrophenylhydrazine was added. The optical density of final mixture was taken at 521 nm.

Vitamin E content was analyzed by using tocopherol as standard [11]. 1 g sample was suspended in mixture of chloroform: methanol (2:1) and vortexed for 2 min. Chloroform and water were then added to this mixture and centrifuged at 2000 r.p.m for 10 min. The mixture was filtered and the lower layer was dissolved and desiccated at 80 °C. To final dehydrated extract, 2, 2- dipyridyl solution (0.2%), FeCl₃ (0.5%) and butanol was added. The optical density was measured at 520 nm.

Total phenols content was evaluated by using gallic acid as standard [12]. To 0.1 ml of sample extract, 5 ml of Folin-Ciocalteu reagent (10%) was poured. To this, 3.5 ml of 1M of sodium carbonate was added and mixed. The final mixture was then incubated for 1 hr at 40° C. The absorption was measured at 765 nm.

Total phytosterols content was analysed by taking cholesterol as standard [13]. 1 g dried sample sample was homogenised in acetone and ethanol (1:1). The supernatant thus obtained was centrifuged and evaporated. Final residue was mixed with acetic anhydride and sulphuric acid (30:1) solution. The sample mixture was then set aside in dark for 20 min. The absorbance was taken at 680 nm.

Dietary fiber comprises of Neutral detergent fiber (NDF), Acid detergent fiber (ADF), lignin, hemicellulose and cellulose and estimation were carried out by methodology of Goering and Van Soest [14]. For NDF, dried powdered sample was gelatinized with 0.01g of α -amylase kept in oven at 60 °C for 2 hrs. To this, 10 ml of neutral detergent

solution (pH 7), 0.2 ml of dekalin and 0.1g of sodium sulphate were added. Final precipitate was ignited in the muffle furnace at 500 °C for 3 hrs and the loss in weight measured as NDF. For ADF, dried sample was acid hydrolyzed in 1N sulphuric acid, cetyltrimethyl ammonium bromide and dekalin for 30 min. The precipitate was then dried in oven at 100°C for 8 hrs. The loss in weight after ignition measured the ADF content.

For lignin estimation, the NDF and ADF residues were immersed in 72% sulphuric acid for 2 hrs and then washed with hot water. The residue was then ignited at 100°C and lignin content was determined by loss in weight before and after ignition. Hemicellulose was calculated by difference in ADF and NDF values. Cellulose was calculated by the difference in ADF and lignin content.

Statistical Analysis

Data were subjected to one way (ANOVA) using PASW statistics software version 18.0. Statistically significant variation in content of nutrient and phytochemical components among four species was performed by using Duncan's multiple range tests at significance level of $p < 0.05$.

Results and Discussion

Nutrients

Nutrients analysed in the present study includes protein, carbohydrate, total free amino acids, starch, fat, moisture and ash. Nutritional composition in shoots of four edible bamboo species are presented in Table 1.

The protein content ranged from 3.37 to 3.70 g/100g f.w. with maximum content in shoots of *B. balcooa*. However, the content showed insignificant variation among the three species (*B. balcooa*, *D. giganteus* and *D. membranaceus*) with significantly ($p < 0.05$) lower values in *D. hamiltonii*. The range of protein in our study was observed to be higher than the earlier reported values in other common vegetables [15]. Carbohydrate and starch content ranged from 3.22 to 5.65 g/100g f.w. and 1.21 to 2.38 g/100g f.w. respectively with significantly ($p < 0.05$) highest content of both the parameters in shoots of *D. giganteus*. Starch provides energy mainly in the brain and nervous system by breaking down into glucose and thus a vital element of caloric intake. Total free amino acid content varied significantly ($p < 0.05$) among the analysed species with highest content in *D. membranaceus* (3.20 g/100g f.w.). Amino acids have important role in regulation of metabolic pathways and thus aids in treatment of several ailments [16].

Table 1: Nutritional composition of fresh edible shoots of four bamboo species

Nutrients	<i>Bambusa balcooa</i>	<i>Dendrocalamus giganteus</i>	<i>D. hamiltonii</i>	<i>D. membranaceus</i>
Protein	3.70 ± 0.09 ^a	3.64 ± 0.05 ^a	3.37 ± 0.03 ^b	3.65 ± 0.09 ^a
Carbohydrate	3.22 ± 0.13 ^c	5.65 ± 0.06 ^a	3.33 ± 0.04 ^{bc}	3.48 ± 0.03 ^b
Amino acids	2.13 ± 0.03 ^d	2.26 ± 0.04 ^c	2.33 ± 0.02 ^b	3.20 ± 0.02 ^a
Starch	1.21 ± 0.02 ^d	2.38 ± 0.04 ^a	1.74 ± 0.02 ^b	1.49 ± 0.04 ^c
Fat	0.47 ± 0.01 ^a	0.49 ± 0.02 ^a	0.42 ± 0.02 ^b	0.44 ± 0.02 ^{ab}
Ash	0.86 ± 0.02 ^b	1.03 ± 0.00 ^a	0.76 ± 0.02 ^c	1.00 ± 0.04 ^a
Moisture	90.68 ± 0.09 ^b	89.02 ± 0.03 ^c	91.33 ± 0.18 ^a	89.20 ± 0.13 ^{bc}

Values are presented in mean ± standard deviation (n=3). Values with different letters superscript in each row show significant ($p < 0.05$) differences among the species

Shoots showed low content (0.42-0.49 g/100g f.w.) of fat and the variation was insignificant ($p > 0.05$) among the

evaluated species except *D. hamiltonii*. Ash can quantify total inorganic minerals by oxidation and combustion of

total organic matter existing in food sample. Ash content varied from 0.76 to 1.03 g/100g f.w. which is in parallel to values reported previously in other bamboo species [17]. Moisture content was conspicuously high in all the species that ranged from 89.02-91.33% with maximum content in *D. hamiltonii*. Moisture is an analytic of dry matter of food which controls food quality, safety, stability and influences biochemical and physical properties [18].

Minerals

Analysis of mineral revealed presence of 8 macrominerals (K, P, Mg, S, Si, Na, Ca, Cl) in the shoots of all the species. Out of all macrominerals detected, substantially higher range of K (4230-6120 mg/100g d.w.) was observed in the shoots of all species. The highest K was observed in *D. membranaceus* and least in *B. balcooa* (Fig 1). Present range of K are in corroboration of earlier data reported in other bamboo species by some authors [19, 20]. The other macrominerals data is presented in Fig 2.

Besides macromineral K, the concentration range of other macrominerals were found in this sequence: Cl (590-1220 mg/100g d.w.) >P (540-620 mg/100g d.w.) >S (220-270 mg/100g d.w.) >Mg (190-210 mg/100g d.w.) >Ca (150-210 mg/100g d.w.) >Si (120-190 mg/100g d.w.) >Na (20-90 mg/100g d.w.). The range of P and Mg content assessed in previous reports are in corroboration to our findings [20, 21, 22]. Among four evaluated species, content of Ca and S was maximum in *D. giganteus*; P and Na in *D. membranaceus*; Mg and Cl in *B. balcooa*, Si in *D. hamiltonii*. In view of content of all macrominerals and their recommended dietary allowances (RDAs), bamboo shoots can be regarded as potential source of K, P, Mg, Si and S. Shoots can be have great prospective to be employed as a raw material in recent pharmaceuticals and fortification of food products that are lacking in specific micronutrients.

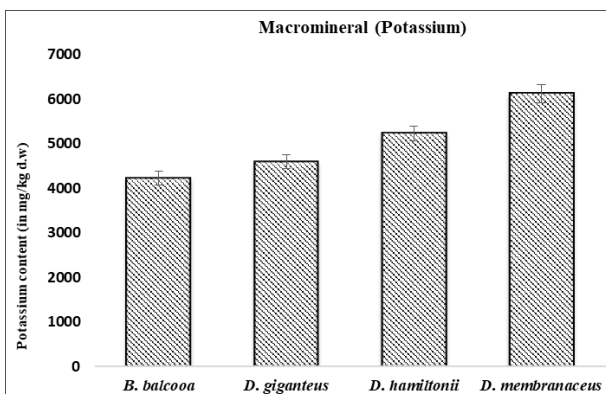


Fig 1: Macromineral (potassium) content in fresh shoots of four bamboo species

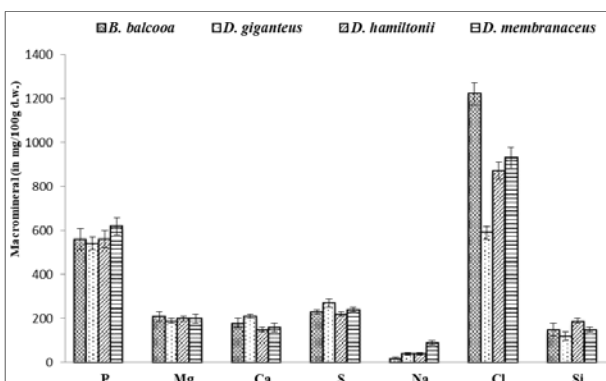


Fig 2: Macrominerals content in shoots of four bamboo species

Present study showed 5 microminerals (Fe, Zn, Mn, Cu and Ni) in the shoots (Fig 3). Fe and Zn content ranged from 6.8-8.2 mg/100g d.w. and 6.1-8.5 mg/100g d.w. respectively. Among four species, Fe and Zn content was maximum in *B. balcooa* and *D. membranaceus* respectively. The range of Fe and Zn falls in lower and higher range in previous studies in other bamboo species [19, 20, 21]. The difference in range of minerals might be due to variability in species, harvesting time, and topographical conditions. In present study, Cu, Mn and Ni content ranged from 2.2-5.1 mg/100g d.w., 1.2-2.5 mg/100g d.w. and 0.7-0.9 mg/100g d.w. respectively. Cu content was observed to be maximum in *D. giganteus*; Mn in *B. balcooa* and Ni values were highest and similar in *B. balcooa* and *D. membranaceus*. The data on microminerals of bamboo shoots are not much carried out in literature.

Among five micro-mineral which were evaluated in current findings, concentration of Fe and Zn were dominant in shoots. These two microminerals are deficient in the global populace [23] and hence vastly focused micronutrients in food fortification. Dominance of these minerals in bamboo shoots can attribute it to an effective intervention to improve micronutrients quality of commonly consumed food and moreover, to combat hidden hunger and malnutrition.

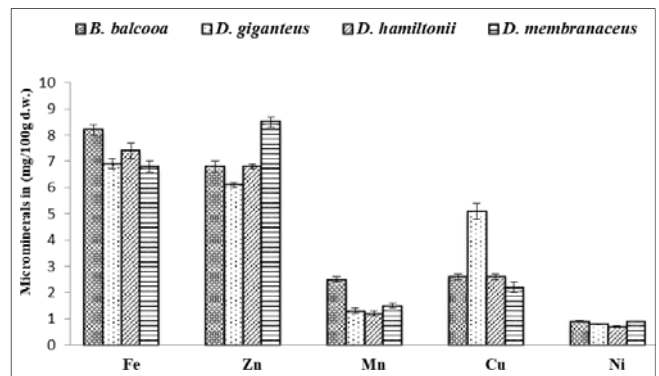


Fig 3: Microminerals content in fresh shoots of four bamboo species

Phytochemical components

Phytochemical components analysed were vitamin C, vitamin E, total phytosterols, total phenols and dietary fiber components (Table 2). In the present study, vitamin C content ranged from 1.83-2.63 mg/100g f.w. being significantly (p<0.05) highest in *B. balcooa* and lowest in *D. membranaceus*. The difference in vitamin C was insignificant between *D. giganteus* and *D. hamiltonii*. Similar range of vitamin C was reported in the shoots of other species in previous studies [24, 25]. Present findings revealed a range of vitamin E from 0.42 to 0.68 mg/100g f.w. being highest in *D. hamiltonii*. However, insignificant (p<0.05) difference in vitamin E content was observed between *D. hamiltonii* and *D. membranaceus*. Our study showed higher content of vitamin E compared to previously reported range (0.24-0.26 mg/100g) in other species [26]. Dietary polyphenols are plant derived secondary metabolites which are recently area of scientific attention as they have revealed several potential beneficial effects on human health [27, 28]. Total phenols in the shoots ranged from 362.36-678.56 mg/100g f.w. The content varied significantly (p<0.05) among the evaluated species with highest content in *D. hamiltonii* and least in *B. balcooa* (Table 2). Compared to our reports, the lower values of total phenols have been obtained in *D. hamiltonii* (88.23 mg) and *B.*

balcooa (101.65 mg) in previous findings [25]. Phytosterols are plant based bioactive molecules which cannot synthesize by humans. There is growing scientific indication that phytosterols are linked to numerous pharmacological properties, including ability to reduce cholesterol levels and

risk of several diseases [29, 30]. Total phytosterols content ranged from 127.24 to 196.14 mg/100g d.w. with significantly ($p < 0.05$) highest content in *D. giganteus*. Phytosterols content in our reports was found to be higher than the content previously recorded in other vegetables [31].

Table 2: Phytochemical components in the fresh edible shoots of four bamboo species

Phytochemicals	<i>Bambusa balcooa</i>	<i>Dendrocalamus giganteus</i>	<i>D. hamiltonii</i>	<i>D. membranaceus</i>
Vitamin C (mg/100g f.w)	2.63 ± 0.02 ^a	2.21 ± 0.02 ^b	2.48 ± 0.07 ^b	1.83 ± 0.04 ^c
Vitamin E (mg/100g f.w)	0.42 ± 0.02 ^c	0.56 ± 0.03 ^b	0.68 ± 0.03 ^a	0.65 ± 0.03 ^a
Total phenols (mg/100g f.w)	362.36 ± 4.80 ^d	616.50 ± 4.80 ^b	678.56 ± 2.34 ^a	471.73 ± 7.56 ^c
Total phytosterols (mg/100g d.w.)	127.24 ± 2.86 ^c	196.14 ± 3.23 ^a	131.73 ± 1.68 ^c	178.07 ± 2.35 ^b
NDF (g/100g f.w.)	6.07 ± 0.04 ^a	5.60 ± 0.02 ^b	4.78 ± 0.06 ^c	5.33 ± 0.12 ^{bc}
ADF (g/100g f.w.)	0.51 ± 0.02 ^d	0.83 ± 0.01 ^c	0.94 ± 0.02 ^b	1.93 ± 0.07 ^a
Lignin (g/100g f.w.)	0.30 ± 0.02 ^c	0.49 ± 0.04 ^a	0.38 ± 0.05 ^b	0.37 ± 0.03 ^b
Cellulose (g/100g f.w.)	0.21 ± 0.01 ^d	0.34 ± 0.02 ^c	0.56 ± 0.02 ^b	1.56 ± 0.06 ^a
Hemicellulose (g/100g f.w.)	5.56 ± 0.06 ^a	4.77 ± 0.14 ^b	3.84 ± 0.09 ^c	3.40 ± 0.04 ^d

Values are presented in mean ± standard deviation (n=3). Values with different letters superscript in each row show significant ($p < 0.05$) differences among the species

Dietary fiber has most recently been attaining recognition of health expert and nutritionists as research investigations have confirmed their significant role in several physiological functions [32]. Fiber characterizes total indigestible component of plant comprising of NDF, ADF, lignin, cellulose and hemicellulose (Table 2). In present findings, NDF content ranged from 4.78 to 6.07 g/100g f.w. with significantly ($p < 0.05$) highest in *B. balcooa* and least in *D. hamiltonii*. Our results are comparable to previous studies [33, 34, 35] while lower values have been reported in other prior findings [17]. The amount of ADF ranged from 0.51-1.93 g/100 g f.w. with significantly ($p < 0.05$) higher values in *D. membranaceus*. The amount of lignin varied from 0.30-0.49 g/100g f.w. with highest in *D. giganteus*. Cellulose ranged from 0.21 to 1.56 g/100g f.w. being highest in *D. membranaceus*. The amount of hemicellulose fraction in the shoots ranged from 3.40-5.56 g/100g f.w. being significantly ($p < 0.05$) highest in *B. balcooa*. The content of ADF, lignin, cellulose and hemicellulose content of *D. hamiltonii* and *B. balcooa* are in agreement to the previous reports [34, 35]. In past few years, fibre components which comprise of hemicellulose, cellulose, and lignin have proposed a huge potential mainly in food and nutraceutical industries, as they are allied to valuable nutrients and health promoting functions [36].

Conclusion

Shoots of all the five bamboo species analysed in this study have high nutritional significance and hold great prospects for its usage as a source of healthy food. Prevalence of essential minerals and amino acids in shoots make it a potential component to combat micronutrient deficiency among masses and for an effective intervention in foods deficient in micronutrients. Shoots are good source of dietary fiber and phytosterols which have several health promoting properties and thus opened new avenues of its usage as functional ingredients in foods and pharmaceutical industry. India, being a largest bamboo diversity country, has boundless prospects to exploit its huge and rich fastest growing bamboo resources for the utilization of its shoot for food, nutrition and health security which are highlighted objectives recognised by United Nation Sustainable developments.

Conflict of Interest

There is no conflict of interest.

Source of funding

Funding for research work was provided by University Grant Commission, India (grant no RFSMS, F.7-151/2007).

References

- Lau KQ, Sabran MR, Shafie SR. Utilization of Vegetable and Fruit By-products as Functional Ingredient and Food. *Frontiers in Nutrition*, 2021;8:261.
- Liese W, Köhl M. *Bamboo: The plant and its uses*. Tropical forestry. Springer, Basel, Switzerland, 2015.
- Midmore DJ, Walsh KB, Kleinhenz V, Milne JR, Leonardi J, Blackburn K. Culinary bamboo shoots in Australia: Preliminary research results. A report for the Rural Industries Research & Development Corporation. RIRDC Publication No 98/45 RIRDC Project No UCQ-4A, 1998.
- Collins RJ, Keilar S. The Australian bamboo shoots industry: a supply chain approach. A Report for Rural Industries Research and Development Corporation, Australia. *Community Medicine*, 2005;33:9-10.
- Wang Y, Chen J, Wang D, Ye F, He Y, Hu Z, Zhao G. A systematic review on the composition, storage, processing of bamboo shoots: Focusing the nutritional and functional benefits. *Journal of Functional Foods*, 2020;71:104015.
- Mera FAT, Xu C. Plantation management and bamboo resource economics in china/manejo de plantaciones y economía de los recursos de bambú en china. *Ciencia y Tecnología*, 2014;7(1):1-12.
- Behera P, Balaji S. Health Benefits of Fermented Bamboo Shoots: The Twenty-First Century Green Gold of Northeast India. *Applied Biochemistry and Biotechnology*, 2021, 1-13.
- Curci F, Cavalluzzi MM, Milani G, Clodoveo ML, Redovniković I, Cellamare S *et al.* *Phyllostachys Pubescens*: From Traditional to Functional Food. *Food Review International*, 2021: DOI: 10.1080/87559129.2021.1933020
- AOAC. Official methods of analysis. 17th ed. Association of Official Analytical Chemists, Gaithersburg, MD, USA, 2000.

10. Riemschneider R, Abedin MZ, Mocellin RP. Qualitats and stabilisierungsprufung hitzekonservierter Nahrungsmittelunter verwendung von Vit. C als kriterium. Mitt I. Alimenta,1976:15:171.
11. Baker H, Frank O, De Angelis B, Feingold S. Plasma tocopherol in man at various times after ingesting free or acetylated tocopherol. Nutrition Reports International,1980:21:531-536.
12. Singleton VL, Rossi JA. Colorimetry of total phenolics with phospho-molybdic- phosphotungstic acid reagents. American Journal of Enology and Viticulture,1965:16:144-153.
13. Srivastava RC. Bamboo: new raw materials for phytosterols. Current Science,1990:59:1333-1334.
14. Goering HK, Van Soest PJ. Forage fiber analyses (apparatus, reagents, procedures and some applications). Agriculture Handbook No. 379. USDA, Washington, DC, 1970, 1-20.
15. Naz S, Anjum MA, Naqvi SAH, Siddique B, Zulfiqar MA. Assessment of proximate, nutritional and mineral contents in some traditional vegetables consumed in Multan, Pakistan. Pakistan Journal of Agriculture Research,2018:31(4):375-381.
16. Wu G. Amino acids: Metabolism, functions, and nutrition. Amino acids,2009:37(1):1-17.
17. Giri SS, Janmejy L. Nutrient composition of three edible bamboo species of Manipur. Frontier Biology,1992:4:53-56.
18. Hamrouni-Sellami I, Rahali FZ, Rebey IB, Bourgou S, Limam F, Marzouk B. Total phenolics, flavonoids, and antioxidant activity of sage (*Salvia officinalis* L.) plants as affected by different drying methods. Food and Bioprocess Technology,2013:6:806-817.
19. Christian AL, Knott KK, Vance CK, Falcone JF, Bauer LL, Fahey GC *et al.* Nutrient and mineral composition during shoot growth in seven species of *Phyllostachys* and *Pseudosasa* bamboo consumed by giant panda. Journal of Animal Physiology and Animal Nutrition,2015:99(6):1172-1183.
20. Waikhom SD, Louis B, Sharma CK, Kumari P, Somkuwar BG, Singh MW *et al.* Grappling the high altitude for safe edible bamboo shoots with rich nutritional attributes and escaping cyanogenic toxicity. BioMed Research International,2013:289285:1-11.
21. Karanja PN, Kenji GM, Njoroge SM, Sila DN, Onyango CA, Koaze H *et al.* Variation of nutrients and functional properties within young shoots of a bamboo species (*Yushania alpina*) growing at Mt. Elgon Region in Western Kenya. Journal of Food and Nutrition Research,2016:3(10):675-680.
22. Awol A. Nutrient, mineral and bioactive constituent evaluation of bamboo shoots grown in Masha area, South-West of Ethiopia. American Scientific Research Journal for Engineering, Technology, and Sciences, 2015:7(1):15-25.
23. Gharibzahedi SMT, Jafari SM. The importance of minerals in human nutrition: Bioavailability, food fortification, processing effects and nanoencapsulation. Trends in Food Science and Technology,2017:62:119-132.
24. Nirmala C, David E, Sharma ML. Changes in nutrient components during ageing of emerging juvenile bamboo shoots. International Journal of Food Science and Nutrition,2007:58:345-352.
25. Badwaik LS, Gautam G, Deka SC. Influence of blanching on antioxidant, nutritional and physical properties of bamboo shoot. Journal of Agricultural Sciences,2015:10(3):140-150.
26. Kim HJ, Lee HO, Min DB. Effects and prooxidant mechanisms of oxidized α -tocopherol on the oxidative stability of soybean oil. Journal of Food Science, 2007:72:777-782.
27. Ganesan K, Xu B. A critical review on polyphenols and health benefits of black soybeans. Nutrients, 2017:9(5):455.
28. Mena P, Llorach R. New Frontiers on the Metabolism, Bioavailability and Health Effects of Phenolic Compounds, Molecules,2017:22(1):151.
29. Salehi B, Quispe C, Sharifi-Rad J, Cruz-Martins N, Nigam M, Mishra AP *et al.* Phytosterols: From preclinical evidence to potential clinical applications. Frontiers in Pharmacology,2021:11:18-19.
30. Plat J, Baumgartner S, Vanmierlo T, Lütjohann D, Calkins KL, Burrin DG. Plant-based sterols and stanols in health & disease: "Consequences of human development in a plant-based environment?" Progress in Lipid Research,2019:74:87-102.
31. Jun-Hua HAN, Yue-Xin YANG, Mei-Yuan FENG. Contents of phytosterols in vegetables and fruits commonly consumed in China. Biomedical and Environmental Sciences,2008:21(6):449-453.
32. Korczak K, Kamil A, Fleige L, Donovan SM, Slavin JL. Dietary fiber and digestive health in children. Nutrition Reviews,2017:75(4):241-259.
33. Nirmala C, Sharma ML, David E. A comparative study of nutrient components of freshly harvested, fermented and canned bamboo shoots of *Dendrocalamus giganteus* Munro. Bamboo Science and Culture: The Journal of the American Bamboo Society, 2008:21(1):33-39.
34. Nirmala C, Sheena H, David E. Bamboo shoots: A rich source of dietary fibres. In: Dietary fiber, fruit and vegetable consumption and health (Editors Klein F. and Moller G.). Nova Science Publishers, Inc., New York, 2010, 173-187.
35. Bajwa HK, Nirmala C, Kaul A, Bisht MS. Changes in organoleptic, physicochemical and nutritional qualities of shoots of an edible bamboo *Dendrocalamus hamiltonii* Nees and Arn. ex Munro during processing. Journal of Food Processing and Preservation, 2016:40(6):1309-1317.
36. Yang J, Wu L, Yang H, Pan Y. Using the Major Components (Cellulose, Hemicellulose, and Lignin) of *Phyllostachys praecox* Bamboo Shoot as Dietary Fiber. Frontiers in Bioengineering and Biotechnology, 2021:9:669136. doi: 10.3389/fbioe.2021.669136.
37. Kachhawa G, Charan SK, Choudhary R. Diversity and pollination probability of insect pollinators of *Tagetes Erecta* L. in the Chomu Tehsil, Rajasthan, India. International Journal of Entomology Research. 2020;5(6):106-10.