

Qualitative and Quantitative Mineral Element Variances in Shoots of two Edible Bamboo species after Processing and Storage Evaluated by Wavelength Dispersion X-ray Fluorescence Spectrometry

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ABSTRACT: Bamboo shoot, a neglected and less known traditional delicacy is gaining popularity for health promoting properties; generally consumed fresh but requires processing to remove acidity, improve palatability and for long term preservation, however processing affects the nutrient and phytochemical composition. In this study, fresh, processed (boiled, soaked and fermented) and six months stored shoots of *Bambusa balcooa* and *B. bambos* were analysed for macro and micromineral elements by using wavelength dispersion X-ray fluorescence spectrometry. Results depicted the presence of eight macrominerals (P, K, Ca, Mg, S, Cl, Na, Si) and five micromineral elements (Mn, Zn, Fe, Cu, Ni). Envisioning all treatments, boiling and six months storage reduced significantly ($p < 0.05$) nearly all macromineral elements while minimally the micromineral elements. Soaking was apropos relatively as it retained maximum content of K (64-87%), P (80-95%), Mg (83-86%) and increased Ca, Na and S while unaltering Zn and Cu content. With fermentation, micromineral elements were better retained or negligible change was observed.

KEYWORDS: Bamboo shoots, Macromineral, Micromineral, Processing, Storage.

I. INTRODUCTION

Hidden hunger is one of the most prevalent challenges of 21st century which is ascribed to inadequacy of vitamins and minerals that often remain less noticeable than macronutrient deficiencies such as protein and calories. Presently, around two billion people are lacking in one or more micronutrients which is more than double to 795 million undernourished people [1]. Minerals in the food are the naturally existing indispensable chemical elements which are critical for metabolism and normal functioning of muscles, heart, nerves, bones and bodily fluids and therefore crucial for maintaining human health and well-being [2,3]. Several edible wild, underutilized and neglected plants have high nutritional value and are reported to enrich health by providing micronutrients, vitamins and health promoting secondary metabolites [4,5]. Bamboo is one such neglected plant in terms of food though it is rich in nutrients and bioactive compounds. Since centuries, bamboo is used in ancient Chinese, Indian Ayurveda, Tibetan and various traditional system of medicine for a number of ailments [6,7]. Bamboo shoots, newly emerging edible buds of bamboo plant, are one such vegetable that is used as traditional delicacy and have grossed an ample cognizance globally due to occurrence of nutrients and various active phytochemicals which are proven to have functional activities and thus are associated with

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promotion of health and disease prevention [8,9]. Before consumption, edible shoots of most of the bamboo species in conventional food regime usually undergo one or more form of processing to remove the toxic cyanogenic glycosides to make them more palatable. Moreover, the young shoots have a very short shelf-life of 3-4 days due to which they need to be processed for long term preservation. Fresh shoots are the most delicious and nutritious and preferred by consumers, but they are also consumed in pickled, fermented, canned, roasted, boiled, salted forms and incorporated in numerous indigenous and contemporary dishes in different parts of the world. In the fresh form of bamboo shoots, analysis of macro and micromineral elements have been worked out in few species by some authors [10,11,12,13]; however, fragmented data is available only in boiled shoots [14,15] and there are no such reports of stored shoots. In the present study, an advanced technique, wavelength dispersion X-ray fluorescence spectrometry (WDXRF) has been used for detailed exploration and analysis regarding the impact of various processing techniques and storage on the elemental profile of shoots of two *Bambusa* species. The genus *Bambusa* Schreber is a member of family Poaceae comprising approximately 140 species worldwide [16] and 38 species in India [17], shows sympodial habit, are habitant of subtropical and tropical regions and native to Indian subcontinent [18].

WDXRF is gaining popularity in recent years as it gives prospect for analysing multiple elements together in a short time frame [19]. Moreover, XRF method is advantageous above conventional spectroscopic techniques by escaping intricate sample preparation, digestion and destruction [20,21]. In recent years, XRF has been used for analysing various food materials by several authors [19,22,23,24] but mineral composition in bamboo shoots has not been evaluated previously by this method. It is for the first time that WDXRF is being used to evaluate the mineral profile of fresh, processed and stored bamboo shoots.

II. MATERIAL AND METHOD

II.1. Material

Juvenile shoots of the two selected species viz. *Bambusa balcooa* Roxb. and *Bambusa bambos* Voss were collected from the populations maintained at P. N. Mehra Botanical Garden of Panjab University, Chandigarh (30.75° N, 76.76° E) and Institute of Himalayan and Bioresource Technology, Palampur, Himachal Pradesh (32.11° N, 76.53° E). Collection of shoots was done in the months of July and August for three consecutive years i.e. 2014-2016 and was harvested after 10-14 days of their emergence from the underground rhizome. In laboratory, harvested shoots were washed and outer culm sheaths were discarded along with the inedible tip and hard basal portion.

II.2. Processing Methods

Processing methods used in current analysis were boiling, soaking, fermentation, refrigerated storage in water and brine for six months.

II.2.1. Boiling and soaking

Shoot samples were cut into cubes and boiled for 20 minutes and soaked for 12 hours in water. The above duration of treatments were selected by considering our preliminary work [25] on bamboo shoots as these were best for nutrients and phytochemical retention and anti-nutrient depletion.

II.2.2. Fermentation

For fermentation, shoots were chopped into thin slices and then squeezed compactly in clean muslin cloth. These were then put into small jars and kept under pressure by putting weight above samples and left for 15-25 days at room temperature 25 ± 2 °C. Shoots were hand pressed at regular intervals for removal of exudates coming out from the shoots during the process. The particular aroma and softness of shoot tissue confirmed the completion of fermentation.

II.2.3. Refrigerated storage

Before storage, the shoots of both bamboo species were cut in large pieces and boiled for 20 minutes. After boiling, the shoots were cooled at room temperature before storage and then packaged in autoclaved glass bottles with pre-sterilized 5% (w/v) brine and water. The containers were then covered tightly and stored for six months in refrigerator at 4 °C.

II.3. WDXRF sample preparation

All the samples were kept in deep freezer at -20 °C for 24 hours, then the frozen samples were dried in Lyophilizer (LYOQUEST 55, Skadi, Europe) with 0.10 mbar vacuum pressure and -55 °C condenser temperature for 24 hrs.

Lyophilized samples were homogenized to fine powder with grinder to attain a particle size less than 50 μm . Then a pellet (34 x 4 mm diameter and thickness) was made by using hydraulic pressure (Insmart, Hyderabad) approximate 15 tons with a standing time of 10 seconds.

II.4. XRF analytical determination of mineral elements

A commercial Wavelength Dispersive X-Ray Fluorescence spectrometer (S8 TIGER, Bruker, Germany) has been used which was controlled by software (Quant Express). Equipment was characterized with a rhodium X-ray tube; eight primary beam filters and six analyzer crystals (LiF200, LiF220, PET, XS55, XSN, XSC). Scintillation counter and gas proportional counter were implied for heavy elements and lighter elements respectively. Maximum power and current directed were 4kW and 170mA respectively. All measurements were carried out for about 20 min in individual sample. The standard reference materials used for calibration were apple leaves (1515), spinach leaves (1570a), tomato leaves (1573a) and peach leaves (1547). After WDXRF analysis; the quantified macro and micromineral elements of bamboo shoots were presented in mg/100g dry weight. Data were subjected to one way analysis of variance (ANOVA) using PASW statistics software version 18.0. Statistical difference was determined by using Duncan's multiple range tests at significance level of $p < 0.05$.

III. RESULTS

The lyophilized samples of the edible shoots of two species of Bamboo viz. *B. balcooa* and *B. bambos* were analysed for mineral elements using wavelength dispersion X-ray fluorescence spectrometry. Various macro and micromineral elements were detected by using this technique. The X-ray fluorescence spectra for fresh shoots of *B. bambos* and *B. balcooa* depicting different peaks of these mineral elements are shown in Fig.1.

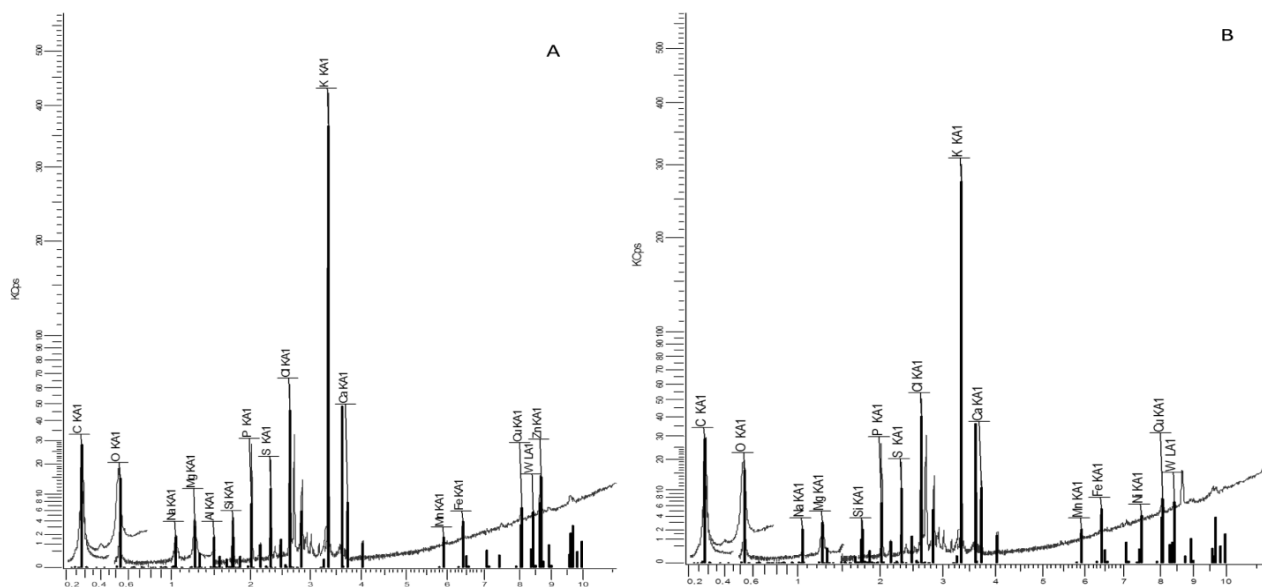


Fig.1. X-ray fluorescence spectra of fresh shoots of A) *B. bambos* and B) *B. balcooa*

III.1. Macromineral elements

The macromineral elements and their concentration detected in the fresh, processed and six months stored shoots of both the species are given in table 1 which were found in descending sequence i.e. potassium (K) > chlorine (Cl) > phosphorous (P) > sulphur (S) > magnesium (Mg) > calcium (Ca) > sodium (Na). Certain elements that showed higher variability after processing and storage are presented in Fig. 2 (*B. balcooa* and *B. bambos*) for P, Mg, Ca, S and Si.

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Potassium: In the fresh shoots, K content was higher in *B. bambos* (5980 mg/100g) as compared to *B. balcooa* (4230 mg/100g). With processing, minimum loss after soaking i.e. 36.28% in *B. bambos* and 12.53% in case of *B. balcooa* and maximum after boiling in *B. bambos* (53.67%) as compared to *B. balcooa* (34.75%) was observed. Upon fermentation, the content decreased by 43.64% in *B. bambos* and 16.28% in *B. balcooa*. With six months storage, reduction was more prominent in brine preserved i.e. 64.06% in *B. balcooa* and 78.76% in *B. bambos* as compared to water (49.88% in *B. balcooa* and 64.88% in *B. bambos*) preserved shoots.

Phosphorous: Phosphorous content in fresh shoots was more in *B. bambos* (750 mg/100g) than *B. balcooa* (560 mg/100g). The content reduced significantly ($p < 0.05$) with all processing treatments except soaking where no significant ($p > 0.05$) change was observed in case of *B. balcooa*. Boiling and fermentation reduced the amount statistically ($p < 0.05$) at higher rate by 51-53% in case of *B. bambos* and 21-35% in *B. balcooa*. With storage, phosphorous content was retained more in water as compared to brine preservation where it reduced by 44% in *B. balcooa* and 67% in *B. bambos*.

Magnesium: In the unprocessed shoots, no significant difference in magnesium content was observed in *B. balcooa* (210 mg/100g) and *B. bambos* (230 mg/100g). Mg content declined minimally by 14-17% after soaking; however, a decline by 38-43% was noticed in all other processing and storage treatments in both species and the variation in their content was non-significant.

Table 1. Macromineral elemental content (mg/100g dry weight) in fresh, processed and six months stored edible shoots of *B. balcooa* and *B. bambos*

Macromineral elements	Species	Fresh	Processing			Storage	
			Soaked	Boiled	Fermented	Water preserved	Brine Preserved
Potassium	<i>B. balcooa</i>	4230 ± 70 ^a	3700 ± 40 ^b	2760 ± 50 ^d	3520 ± 60 ^c	2120 ± 30 ^e	1520 ± 30 ^f
	<i>B. bambos</i>	5980 ± 80 ^a	3810 ± 50 ^b	2770 ± 50 ^d	3370 ± 60 ^c	2100 ± 30 ^e	1270 ± 40 ^f
Phosphorous	<i>B. balcooa</i>	560 ± 30 ^a	530 ± 10 ^a	440 ± 10 ^b	360 ± 20 ^c	530 ± 30 ^a	310 ± 20 ^d
	<i>B. bambos</i>	750 ± 30 ^a	590 ± 20 ^b	370 ± 10 ^c	350 ± 10 ^c	570 ± 20 ^b	250 ± 10 ^d
Magnesium	<i>B. balcooa</i>	210 ± 10 ^a	180 ± 20 ^b	120 ± 10 ^c	120 ± 10 ^c	120 ± 10 ^c	130 ± 20 ^c
	<i>B. bambos</i>	230 ± 10 ^a	190 ± 20 ^b	140 ± 10 ^c	130 ± 10 ^c	130 ± 10 ^c	140 ± 10 ^c
Calcium	<i>B. balcooa</i>	180 ± 30 ^b	240 ± 20 ^a	230 ± 10 ^a	160 ± 10 ^a	240 ± 10 ^a	210 ± 10 ^{ab}
	<i>B. bambos</i>	190 ± 30 ^b	210 ± 20 ^b	230 ± 10 ^b	180 ± 20 ^b	280 ± 10 ^a	260 ± 10 ^a
Sulphur	<i>B. balcooa</i>	230 ± 10 ^b	250 ± 10 ^a	210 ± 10 ^c	200 ± 10 ^c	260 ± 20 ^a	210 ± 20 ^c
	<i>B. bambos</i>	260 ± 10 ^b	290 ± 10 ^a	240 ± 10 ^c	250 ± 10 ^{bc}	280 ± 20 ^a	230 ± 20 ^c
Silicon	<i>B. balcooa</i>	150 ± 10 ^a	110 ± 00 ^{bc}	100 ± 00 ^c	120 ± 10 ^b	80 ± 10 ^d	70 ± 10 ^d
	<i>B. bambos</i>	130 ± 10 ^a	90 ± 00 ^b	80 ± 00 ^c	90 ± 00 ^b	70 ± 10 ^c	70 ± 10 ^c
Sodium	<i>B. balcooa</i>	20 ± 00 ^c	30 ± 00 ^b	20 ± 00 ^c	20 ± 00 ^c	40 ± 00 ^a	18450* ± 210
	<i>B. bambos</i>	20 ± 00 ^c	30 ± 00 ^b	20 ± 00 ^c	30 ± 00 ^b	40 ± 00 ^a	19230* ± 260
Chlorine	<i>B. balcooa</i>	1220 ± 40 ^a	900 ± 30 ^c	720 ± 30 ^d	810 ± 40 ^c	1100 ± 50 ^b	24240* ± 280
	<i>B. bambos</i>	1530 ± 40 ^a	1060 ± 30 ^d	1390 ± 30 ^b	1070 ± 40 ^d	1300 ± 40 ^c	24780* ± 310

Data are presented in mean values ± Standard deviation (n=3). Values with different letters superscript in each row indicates significant differences ($p < 0.05$) among processing and storage treatments for individual species.

* Shows exceptionally higher values of Sodium and Chlorine as NaCl was used as preservative

Calcium: In fresh shoots, calcium content was observed to be 190 mg/100g and 180 mg/100g in *B. bambos* and *B. balcooa* respectively. Ca content increased by 10-47% with all processing treatments except fermentation where it

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decreased by 5-11%. In both the species, significant increase ($p < 0.05$) in content by 33-47% after water storage and 16-33% after brine storage for six months was observed.

Sodium: Na content was 20 mg/100g in both the species. Na content in the bamboo shoots remained unchanged after boiling but showed 50% increase after soaking and fermentation in both the species. With water storage, two fold increase in content was observed whereas exceptionally higher content in brine preserved shoots, as table salt (NaCl) was added as preservative in this case.

Chlorine: In unprocessed shoots, Cl content was significantly higher in *B. bambos* (1530 mg/100g) than *B. balcooa* (1220 mg/100g). The content was significantly ($p < 0.05$) reduced with all processing treatments with maximum upto 41% after boiling in *B. balcooa* and 31% after soaking in *B. bambos*. With fermentation, decrease in chlorine content was almost at par i.e. upto 30-33% in the shoots of both the species.

Sulphur: Sulphur content was 260 mg/100g in *B. bambos* and 230 mg/100g in *B. balcooa* in fresh shoots and was increased significantly ($p < 0.05$) by 9-11% after soaking and 8-13% after storage of both shoots in water for six months. However, the content decreased slightly by 4-13% with boiling, fermentation and brine storage.

Silicon: *B. balcooa* contained higher (150 mg/100g) Si content than *B. bambos* (130 mg/100g) in unprocessed shoots but it reduced significantly ($p < 0.05$) at the rate of 33-38% after boiling in both the species. The content lowered by around 31% after soaking as well as fermentation in *B. bambos* shoots, whereas by 20-27% in *B. balcooa*. Storage in both brine and water retained similar ($p > 0.05$) amount of Si i.e. 53.84% in *B. bambos* and 46.66-53.33% in *B. balcooa*.

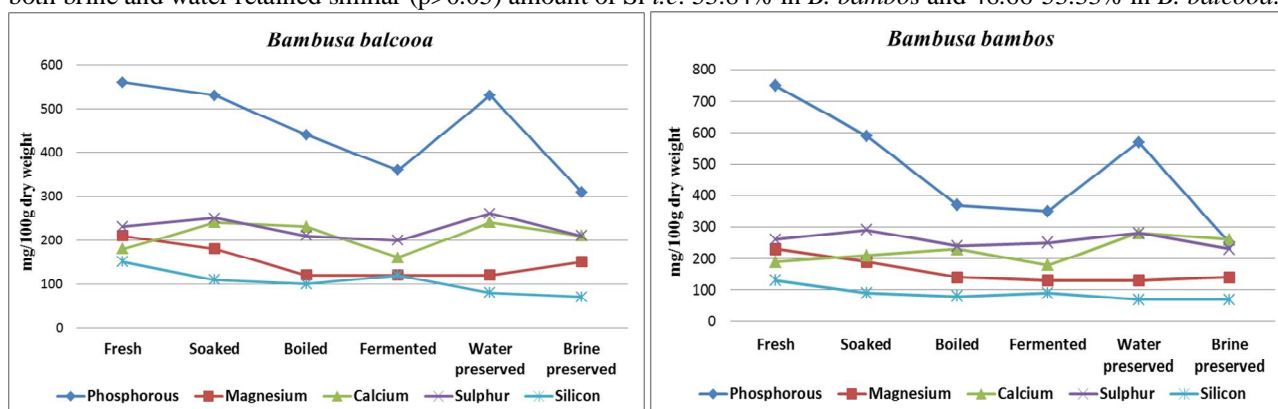


Fig. 2. Variation in five macromineral element's content after different processes and six months storage (water and brine preservation) in shoots of *B. balcooa* and *B. bambos*

III.2. Micromineral elements

The detected micromineral elements (Fe, Zn, Cu, Mn and Ni) and their quantity in the fresh shoots and variation after processing and six months storage in both the species are presented in table 2.

Iron: Both the species shared almost same content ($p > 0.05$) of iron (8.0-8.2 mg/100g) in fresh shoots, which displayed no variation upon fermentation as well as during storage in water and reduced at same rate with significant difference ($p < 0.05$) of 12% in both after soaking. However, upon boiling *B. balcooa* retained more amount of Fe (82.92%) than to *B. bambos* (73.75%). After six months storage in brine, commendable retention in Fe content upto 72.50-76.82% in both shoots was observed.

Zinc: *B. bambos* contained more Zn (10 mg/100g) in fresh shoots than *B. balcooa* (6.8 mg/100g) which remain stable after soaking in both the species. Boiling showed more loss of Zn i.e. 23% in *B. bambos* than 10% in *B. balcooa* from initial content. Besides, fermentation retained quite high content, about 94% (*B. bambos*) and 82% (*B. balcooa*). High Zn content was also maintained after water storage as 84% and 75% followed by brine storage as 81% and 63% in *B. bambos* and *B. balcooa* respectively.

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Table 2. Micromineral elemental content (mg/100g dry weight) in fresh, processed and six months stored edible shoots of *B. balcooa* and *B. bambos*

Micromineral elements	Species	Fresh	Processing			Storage	
			Soaked	Boiled	Fermented	Water preserved	Brine preserved
Iron	<i>B. balcooa</i>	8.2 ± 0.1 ^a	7.2 ± 0.1 ^b	6.8 ± 0.0 ^c	8.2 ± 0.2 ^a	8.1 ± 0.1 ^a	6.3 ± 0.1 ^d
	<i>B. bambos</i>	8.0 ± 0.1 ^a	7.0 ± 0.1 ^b	5.9 ± 0.0 ^c	8.0 ± 0.1 ^a	8.0 ± 0.1 ^a	5.8 ± 0.1 ^c
Zinc	<i>B. balcooa</i>	6.8 ± 0.2 ^a	6.6 ± 0.1 ^a	6.0 ± 0.0 ^b	5.6 ± 0.0 ^c	5.1 ± 0.1 ^d	4.3 ± 0.1 ^e
	<i>B. bambos</i>	10 ± 0.0 ^a	10 ± 0.0 ^a	7.7 ± 0.0 ^e	9.4 ± 0.1 ^b	8.4 ± 0.1 ^c	8.1 ± 0.1 ^d
Copper	<i>B. balcooa</i>	2.6 ± 0.1 ^a	2.8 ± 0.2 ^a	2.0 ± 0.0 ^c	2.6 ± 0.1 ^a	2.1 ± 0.1 ^c	2.3 ± 0.0 ^b
	<i>B. bambos</i>	2.5 ± 0.1 ^a	2.7 ± 0.1 ^a	1.7 ± 0.0 ^d	2.3 ± 0.0 ^b	1.9 ± 0.1 ^c	2.0 ± 0.0 ^c
Manganese	<i>B. balcooa</i>	2.5 ± 0.0 ^a	1.9 ± 0.0 ^b	1.4 ± 0.1 ^c	0.9 ± 0.0 ^d	0	0
	<i>B. bambos</i>	3.6 ± 0.0 ^a	2.8 ± 0.1 ^b	2.0 ± 0.0 ^c	1.9 ± 0.0 ^d	0	0
Nickel	<i>B. balcooa</i>	0.9 ± 0.0 ^a	0.5 ± 0.1 ^c	0.8 ± 0.0 ^b	0.8 ± 0.0 ^b	0.8 ± 0.0 ^b	0.8 ± 0.0 ^b
	<i>B. bambos</i>	0.7 ± 0.0 ^a	0.4 ± 0.1 ^c	0.6 ± 0.0 ^b	0.6 ± 0.0 ^b	0.6 ± 0.0 ^b	0.6 ± 0.0 ^b

Data are presented in mean values ± Standard deviation (n=3). Values with different letters superscript in each row indicates significant differences (p<0.05) among processing and storage treatments for individual species

Copper: Cu content in the fresh shoots of both the species was almost similar 2.5-2.6 mg/100g. After soaking, there was a slight increase in both the species which was insignificant whereas, after boiling a significant loss (p<0.05) of 23% and 32% was observed in *B. balcooa* and *B. bambos* respectively. Fermentation caused no difference on *B. balcooa* shoots but marginally depleted the Cu content (2.3 mg/100g) in *B. bambos* shoots. Upon storage for six months, Cu was prominently retained by 80-88% in *B. balcooa* and 76-80% in *B. bambos*.

Manganese: Mn content was estimated to be higher in fresh shoots of *B. bambos* (3.6 mg/100g) than *B. balcooa* (2.5 mg/100g). All processing treatments exerted noteworthy depletion (p<0.05) in Mn content but showed maximum retention after soaking (76-77%) followed by boiling (56%) in both the species. Fermentation in contrast to other elements caused high reduction in Mn, however preservation for six months excluded the element completely in both brine and water.

Nickel: Ni content was higher in fresh shoots of *B. balcooa* (0.9 mg/100g) than to *B. bambos* (0.7 mg/100g). It reduced slightly after boiling, fermentation and both storages (11-14%) but noticeably (p<0.05) after soaking (43-44%) in both species.

IV. DISCUSSION

With the steady rise in global population coupled with decreasing food production due to dependence on a few crops and neglect of many nutritionally rich edible plants, the world is not able to combat the greatest challenge: poverty, hunger and malnutrition which are the first three goals identified by UN for sustainable development [26]. Majority of food requirement is fulfilled with a handful of crops and new food strategies need to be developed for not only increasing production, but also improve access to more nutritious food [4]. The food basket needs to be diversified to include numerous neglected and underutilized plants which are generally nutrient rich. Bamboo is one such neglected plant whose shoots can be used for consumption considering its high nutrient content and presence of health enhancing bioactive compounds. It is the fastest growing plant and grows well in marginal lands without much care and could help in alleviating malnutrition especially prevalent in the rural communities. However, before consumption, the young shoots should be processed to remove toxicity, diminish postharvest losses and to enhance the shelf life, palatability and consumability of the bamboo shoots. These practices are known to affect interactions among biochemical elements which may be either positive or negative depending on the processing conditions as well as type of vegetable [27]. The

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bioavailability of minerals after processing and storage in bamboo shoots has remained unacquainted to the consumers. Current findings revealed high amount of macromineral elements viz. potassium, phosphorous; moderate incidence of calcium and magnesium with pioneer exploration of sulphur and silicon in the shoots of *B. balcooa* and *B. bambos*. With processing and storage treatments, concentration of most of the minerals declined while some get enriched or remain unaffected. Potassium, phosphorous and magnesium content in the bamboo shoots were reduced with all processing and storage treatments that may be attributed to percolating out of minerals into water, which were similar to the trend reported in other vegetables [28,29]. In former investigations, mineral content has been determined only after boiling in the shoots of few bamboo species with a reduction range upto 23-62% in K; 22-71% in P; 34-45% in Mg which corroborated the current observations [14,15,30]. The water based processes and storage augmented calcium, sodium and sulphur content in shoots which is possibly due to uptake and absorption of minerals by the tissues from the water [31], which requires further investigation. After boiling, elevation in calcium content in present findings was in agreement to the previous reports of Park and Jhon [15] in the shoots of *Sinoarundinaria nigra* and *Phyllostachys pubescens*. On the other hand, soaking reserved the maximum content of potassium, phosphorous and magnesium while elevating calcium, sodium and sulphur as compared to boiling and fermentation.

Remarkably higher content of potassium, phosphorus, silicon and sulphur was observed in fresh shoots that were fairly maintained in processed and stored shoots. These elements provide a great assistance in multiple functionalities and potential in the body's metabolism and homeostasis. K is a vital electrolyte for sustaining fluid equilibrium in cells and have defensive role against hypertension, kidney stones and osteoporosis [32]. Sulphur is anticancerous, lowers blood cholesterol and skin infirmities [33,34]. The presence of silicon in these two species is reported for the first time. This element is important as it is required for skeletal and connective tissue growth; is anticancerous, antidiabetic and antioxidant [35,36,]. Bamboo has the highest amount of silica content in the plant kingdom and is included in making several traditional medicinal products like "Tabasheer", "Sitopaladi Churna" and "Chaywanprash" and modern nutraceuticals [7]. Phosphorous participate in genetic material formation and energy management as well as for development of strong bone and teeth and tissue repair [32,37].

Among micromineral elements, copper, zinc and iron were least affected and remained more stable with processing and storage. Among treatments, boiling as well as long term storage minutely diluted the proportion of all micromineral elements. However, no remarkable alteration in copper and zinc after soaking; and iron and copper after fermentation was noticed, while manganese and nickel considerably abated with both processes. With heat processing, release of micromineral elements viz. copper, zinc and iron in bamboo shoots in present study is comparable to the three other bamboo genera (*Phyllostachys pubescens*, *Sinoarundinaria nigra* and *Oxytenanthera abyssinica*) as reported by Park and Jhon [15] and Hailu and Addis [30]. Although, there are no reports of impact of any processing on manganese and nickel content of bamboo shoots, a loss of 4-50% manganese has been observed in various other vegetables upon boiling due to its solubility in water [38]. Micromineral elements which were accessed in the present findings were iron, zinc, copper, manganese and nickel; among these elements, concentration of iron and zinc was dominant in both the studied species. These elements act as cofactor or catalyst for many enzymes which facilitate dynamic biochemical reactions in body, metabolise certain macromolecules, synthesize the modules of bone matrix and even interact with acquainted minerals antagonistically or synergistically thus affecting their activities [39,40]. Additionally, iron have pivotal role in haemoglobin synthesis and centre nervous system functioning [41]; Zn has antioxidant property and enhances the function of immune system, DNA replication, olfactory and taste senses [40,42]. Due to predominant deficiency of micromineral elements specifically iron and zinc in the world's population [37] these can be the targeted micronutrients in food fortification programs. Prevalence of these elements in the bamboo shoots can make it a prodigious processed produce for an effective intervention to improve the quality of staple food and furthermore to overcome their deficiencies.

V. CONCLUSION

Bamboo shoot, a conventional delicacy is now attaining an ample cognizance globally due to report of nutrients and various active phytochemicals based on research using advanced scientific techniques. Current findings revealed that the

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shoots are rich in macromineral elements viz. potassium, phosphorous with moderate amount of calcium, magnesium, sulphur and silicon. Among micromineral elements, concentration of iron and zinc was dominant with moderate content of copper, manganese and nickel. Potassium, phosphorous and magnesium content in the bamboo shoots was curtailed with all processing and storage treatments. Soaking is the best method of processing for bamboo shoots as it retained the maximum content of K, P, Mg, Cu and Zn and elevated the content of Ca, Na and S while fermentation sustained iron and copper. Commendable amount of macro as well as micromineral elements were available after six months storage where water retained more content than brine. Envisaging mineral abundance, shoots have great prospective to prevent mineral associated deficiency diseases and can be used as supplement in general diet and their formulation and supplementation in other foods which lack in one or more essential mineral as well as in pharmaceuticals. This can substantially improve its absorption and bioavailability which is an efficacious approach to combat hidden hunger among populations.

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