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Bamboo: Its prospects as food and medicine

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Abstract: The emerging young fresh succulent bamboo shoots of *Bambusa balcooa, B. tulda, Dendrocalamus halmiltonii, Melocanna bambusoides* and *Teinostachyum wightii* are edible. The young fresh bamboo shoots contain various ingredient of nutritional significance like carbohydrate, protein, ascorbic acid, flavonoids, tannins, and total phenols. Eight amino acids were also present. They contain high level of phytosterols which offers as precursors of steroidal drugs by pharmaceutical industries for commercial exploitation at low cost.

Keywords: Bamboo shoots, nutritive values, medicinal properties.

INTRODUCTION

Bamboo, the wonderful grass is nature's most valuable gifts to mankind. They are of economic and high cultural significance. The usage is supplemented to resource development like timber, fuel, industrial raw materials and as source of food. The emerging fresh young bamboo shoots are harvested and used as vegetables. They are used in numerous Asian dishes and are available in markets in various sliced forms, fresh, fermented and canned version (Tai, 1985; Fu *et al.*, 1987; Midmore, 1998). The content of edible fiber in bamboo shoot is high. They are also rich in mineral, have adequate amount of glucose, low in fat and is brittle, tender, delicious and nutritive (Yamaguchi and Kusama, 1976; Yamaguchi, 1983). Some of the common edible bamboo species found in Manipur, India are *Bambusa tulda , B. balcooa, Dendrocalamus hamiltonii, D. giganteus, D. strictus, Teinostachyum wightii, etc.* The fermented bamboo shoots are an important ingredient in cuisines across the Himalayas (Sarangthem and Singh, 2003; Tamang *et al.*, 2008). Pickle form may also be made from the pith of the young shoots (Tamang *et al.*, 1988). In Manipur, the fresh succulent bamboo shoots slices and the fermented shoot slices are highly prized vegetable items. Bamboo also contains many secondary metabolites which can be used as precursors of many pharmaceutical industries (Sarangthem and Singh, 2003). The present work is undertaken to assess the nutritive content of fresh and fermented

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succulent bamboo shoots and its medicinal properties so as to stimulate new uses of bamboo shoots in the existing markets.

MATERIALS AND METHODS

The emerging young fresh succulent bamboo shoots of *B. balcooa, B. tulda, D. halmiltonii* and *M. bambusoides* were collected during the growing season (May-July) from different districts of Manipur, India. The apical shoots (meristem) of *T. wightii* (nath) were harvested by shaking the bamboo plant and the young shoots toppled down to the ground, these were collected and the outer hard covering were removed and the inner delicate portions were used for the experiment.

Fermentation

Preservative methods of the fresh succulent bamboo shoots were done in large-scale in Manipur by traditional methods of fermentation process. The fermented bamboo shoot slices are locally called *soibum* and *soidon*. Bamboo shoots of many species like *B. tulda , B. balcooa, D. hamiltonii, M. bambusoides* were used for fermentation of *soibum* and *T. wightii* (Nath) is used for *soidon* fermentation.

Traditional method of fermentation

The *'soibum'* is prepared traditionally by storing thin slices of fresh succulent and soft bamboo shoots in certain containers/chambers for 2-3 months. The fermented chambers are either made of bamboo planks or roasted earthen pots. The inner surface of bamboo chambers are lined with banana leaves and a thin polythene sheets. The upper surface is sealed with polythene sheet and weights are then put on top for proper pressing. At the initial stage of fermentation the exudates is leached/drained out of the tilted side of the bamboo plank chamber. After fermentation is completed, which is indicated by the smell, colour and texure, soibum can be stored up to one year.

The *Soidon,* preparation is made from the fresh apical shoots (meristem) of *T. wightii* (Nath). The hard sheath covering the apical shoots of *T. wightii* were removed and the inner delicate portion is cut transverly into small pieces (1-2cm long) and kept in an earthen pots lined with polythene. To these cut pieces milky fermented exudate of the previously fermented *soidon* were added as inoculants for the fermentation process. These were then kept for 4-5 days or up to a week with intermittent stirring. The fermented samples (*soidon*) are then sold in the local market wrapped in fresh banana leaves.

Laboratory fermentation

Fermentation of the fresh bamboo shoot slices were also carried out in the laboratory

by a modified form of the traditional method of fermentation which involves inoculating thin slices of succulent bamboo shoots with the exudates obtained from already fermented slices of bamboo shoots (traditionally fermented) under aseptic condition using a Laminar flow. After inoculation, the samples were kept in an incubator at 30±2°C for a period of 60 days.

To assess the nutritional values of fresh and fermented samples of the succulent bamboo shoots, different parameters of biochemical analysis were conducted as follows:

Moisture content were determined using the ISTA methods (1996) as follows:

$$\text{Moisture content (\%)} = \frac{\text{original weight- oven dry weight}}{\text{Original weight}} \times 100$$

Biochemical analysis

Aminoacids by Thin Layer Chromatography (TLC)

Extractions of the fresh bamboo shoot samples of *B. tulda* and *D. hamiltonii* were made in 90 per cent ethanol, centrifuged and the supernatants were subjected to Thin Layer Chromatography (Stahl, 1969) using n-butanol, glacial acetic acid and distilled water in the ratio 4 : 1: 5 as the running solvent. The standard amino acids (amino acid kits having 24 amino acids) were dissolved in 5 ml distilled water each and subjected to TLC along with the screening samples as Co-chromatography. The purple coloured spots developed was calculated with reference to their Rf values and tallied with that of the standard amino acids.

Analysis of total carbohydrate

Total carbohydrate contents were determined by Anthrone method (Sadasivam and Manickam, 1992) using Anthrone in 20 per cent concentration H_2SO_4. The samples were prepared in 50 per cent ethanol. The samples and the standard glucose solutions were measured at wavelength 620 nm in a spectrophotometer.

Analysis of total soluble protein

Estimation of phosphate buffer soluble proteins were done in fresh samples by Lowry's *et al.* (1951) methods. Calculations were done from the standard curve prepared by using BSA (Bovine Serum Albumin) as the standard solution. The optical density was measured at 660 nm.

Analysis of total phenols

The dried powdered bamboo shoot samples were extracted in 10 ml of methanol by intermittent maceration up to 48 h, centrifuged and the supernatants were used for the

estimations of total phenols. Total phenolic contents were determined by folin-ciocalteu method with sodium carbonate solutions following Donald *et al.* (2001). The absorbance was measured at 765 nm using chlorogenic acid as the standard.

Total flavonoids content

The dried powdered bamboo shoot samples were extracted in 10 ml of methanol by intermittent maceration up to 48 h, centrifuged and the supernatants were used for the estimation of flavonoids. Flavonoids content were determined by Aluminium chloride method following Chang *et al.* (2002). The calibration curved was prepared by different concentrations of Quercetin in methanol. The absorbance was measured at 415 nm in a spectrophotometer.

Analysis of tannin contents

Tannin contents were determined by Folin-Denis method (Sadasivam and Manickam, 1992) which is based on the non-stoichiometric oxidation of the molecules containing a phenol hydroxyl group. Tannin like compounds reduced phosphotungstomolybdic acid in alkaline sodium carbonate solutions to produce highly blue coloured solutions. The intensity of which is proportional to the amount of tannin. The absorbance was measured at 700 nm using tannic acid as the standard compound.

Analysis of total phytosterol

The delicate bamboo shoot apex was sliced and oven dried at 60°C± 2°C for 12h. The dried samples of the delicate shoot apex were then crushed to powder form. The powder was used for determination of total phytosterols using Liebermann-Burchard reaction (Katayama *et al.*, 1974).

Extraction of phytosterols

To purify phytosterols, the dry fermented samples were taken and extracted in a 1litre clevenzer apparatus using benzene, petroleum ether and 2N ethanolic KOH(10:5:1) as the refluxing solvent (Sarangthem and Srivastava,1997). After selective solubilization of the crude phytosterols with acetonitrile, the crude phytosterols were then subjected to TLC (Stahl,1969).

Analysis of phytosterols

TLC was performed on silica gel-G plates (0.25mm thick, 20x20 cm) using solvent pairs hexane: ethyl acetate (3:1). Detecting reagent were acetic anhydride and sulphuric acid (30:1).

For obtaining crystallized form of the phytosterols isolated from fermented shoot

samples, preparative TLC was conducted. The phytosterols (tentatively identified as stigmasterol) resolved on TLC and confirmed with standard samples were scraped and eluted in chloroform for analysis.

The UV spectral analysis for the crystals obtained after preparative TLC (Stahl, 1969) as well as control authentic samples (Sigma Chemicals, USA) were measured from 225 to 400 nm on a Beckmann DU-64-spectrophotometer. Further analysis of IR, NMR and Mass spectral analysis were done at CDRI, Lucknow for confirmation of the compound in comparison with control authentic samples (Sigma Chemicals, USA).

RESULTS AND DISCUSSION

The results in Table 1 shows that fresh bamboo shoots of *B. tulda, B. balcooa, D. hamiltonii, M. bambusoides* and *T. wightii* contain 85.1 to 90.7 per cent of water content; 2.5 to 5.2 per cent of total carbohydrate; 2.0 to 3.2 per cent of buffer soluble protein ; 0.02 to 2.0 per cent of ascorbic acid and 0.01 to 0.05 per cent of tannins (Table 1). Similar findings were also reported by many workers (Kitagawa, 1971; Mizumoto *et al.*, 1975; Yamaguchi and Kusama, 1976; Kozukue *et al.*, 1982 and Yamaguchi, 1983). Bamboo shoots also contain 0.01 to 0.33 per cent of total phenols and 0.5 to 2.3 per cent of flavonoids (Table 1). The phenolic and flavonoids compounds have been reported to exert multiple biological effects including antioxidant, free radical scavenging, anti-inflammatory, anticarcinogenic and antiviral activities (Miller, 1996). Flavonoids are also known to be synthesized by plants in respond to microbial activities (Dixon *et al.*,1993).

Eight amino acids (lysine, glycine, threonine, proline, methionine, glutamic acid, tyrosine and Amino-n-butyric acid) were also detected by the TLC co-chromatography (Table 2). This agrees with that of aminoacid contents in bamboo shoots as reported by Kozukue *et al.*,1982.

Table 1. Biochemical analysis of different nutritive parameters of fresh bamboo shoot slices of different edible bamboo showing its constituent.

Name of the species	Moisture content (%)	Total carbo hydrate (%)	Total soluble protein (%)	Ascorbic acid (%)	Flavonoids (%)	Tannins (%)	Total phenols (%)
Bambusa tulda	87.5	5.2±0.8	2.9±1.2	0.07±0.8	1.2±0.06	0.02±0.1	0.33±0.01
B. balcooa	86.7	4.8±0.3	2.8±0.1	0.02±0.7	1.5±0.04	0.05±0.3	0.21±0.03
D. hamiltonii,	90.7	3.9±1.2	3.2±0.5	0.04±0.1	0.8±0.09	0.04±0.1	0.08±0.03
M. bambusoides	85.1						
(Shoots)		4.7±0.3	2.9±0.3	0.03±0.1	0.5±0.03	0.01±0.3	0.05±0.003
(Seeds)		8.8±0.1	2.3±0.1	2.0 ±0.1	2.3±0.05	-	0.01±0.003
T. wightii	87.5	2.5±0.3	2.0±0.1	0.03±0.3	1.1±0.06	0.05±0.1	0.03±0.06

*Standard error of the mean (n=3)

Table 2. Rf value of different spots on TLC plate separated with butanol, glacial acetate and water(4:1:5)solvent . The chromatogram was run at 28°C for 90min. and for development of spots the plate were sprayed with ninhydrin reagent followed by heating in oven at 80°C for 30min.

Mobile phase		Rf values		
		Standard samples	Test samples	
			Bambusa tulda	*Dendrocalamus hamiltonii*
Butanol: glacial acetic acid And H_2O	Lysine	0.12	0.11	0.12
	Glycine	0.22	0.21	0.22
	Threonine	0.25	0.25	0.25
	Proline	0.19	0.18	0.189
	Methionine	0.40	nil	0.39
	Glutamic acid	0.27	0.27	0.27
	Tyrosine	0.38	0.3.8	0.36
	Amino- n-butyric acid	0.33	0.31	nil

The level of total phytosterols in the succulent shoot samples of different species of bamboo ranges from 0.08 to 0.19 per cent dry wt. in fresh shoot slices with dry matter content of 9.3 to 15.7 (Table 3). The content of phytosterols in inflorescence and seed are 0.32 per cent dry wt. and 0.56 per centdry wt. respectively (Table 3). The level of phytosterols increases to four times or more in fermented bamboo slices. Fermentation increases the accumulation of certain by-products as a result of breaking down of the raw organic molecules (polymers) by the activity of microorganisms. The crude phytosterols extracted from the bamboo shoot slices when subjected to selective solubilization yielded different amount of phytosterols in various fractions (Table 4), which on further analysis by Co-chromatography with standard samples revealed

Table 3. Level of total phytosterols in the succulent shoot samples of different species of bamboo.

Species	Dry matter content (%)	Concentration of phytosterols (%dry wt.)	
		Fresh delicate shoot apex	Fermented shoot slices (3 months old)
B. tulda	15.7	0.18 ± 0.03	0.56± 0.01
B. balcooa	13.5	0.18 ± 0.08	0.65± 0.03
D. hamiltonii	9.3	0.19 ± 0.01	0.59± 0.05
M. bambusoides	12.7	0.14 ± 0.12	0.48± 0.08
M.bambusoides (Inflorescence)		0.32 ± 0.2	
M.bambusoides (seed)		10.56± 0.08	
T. wightii	10.3	0.08± 0.03	0.42± 0.08

*Standard error of the mean (n=3)

Table 4. Amount of solubilized fraction (crude phytosterols) obtained after solubilization of soft cake with acetonitrile.

Amount of dry sample (g)	Amount of soft cake (g)	Vol. of solubilizing solvent (ml)	Vol. of recovered solubilizing solvent (ml)	Amount of solubilized fractions (g)	Amt.of solubilized fractions (g)
100	14.6±0.48*	160	100	8.9	6.947±0.22

*Standard error of the mean (n=3)

Table 5. Rf value of different spots on TLC plate separated with Hexane and Ethylacetate solvent pairs. The chromatogram was run at28°C for 90min. and for development of spots the plate were sprayed with Liebermann- Burchard reagent followed by heating in oven at 80°C for 30min.

Solvent pair	Spots position	Rf value	Possible phytosterols Using standard samples on co-chromatography
Hexane: Ethylacetate (3:1)	1st(lower)	0.0428	Unidentified
	2nd	0.320	β-sitosterol
	3rd	0.732	Stigmasterol
	4th	0.814	campesterol

that the fractions were ^{2}–sitosterol, stigmasterol and campesterol (Table 5). This was further identified by analysis of its melting point, molecular wt. and mass spectral analysis at CDRI, Lucknow. The UV and IR spectral data of the compound showed similarity with those obtained with the authentic samples of ^{2}–sitosterol, stigmasterol and campesterol (Sigma Chemicals,USA).

Thus, bamboo shoots can be promoted as a nutritive food as well as a non-conventional source of phytosterols by the pharmaceutical industries to compete economically and commercially feasible with those obtained from other precursors. Further works on the effect of these phytosterols/hormones in the fertility of rats' reproduction during flowering of bamboos is in progress.

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