Journal of Biodiversity, Bioprospecting and Development

Joselin et al., J Biodivers Biopros Dev 2014, 1:1
DOI: 10.4172/2376-0214.1000103

Research Article Open Access

Phytochemical and FT-IR Spectral Analysis of Certain Bamboo Species of South India

Joseph Joselin[1] , **Selvamony Jenitha**[1], **Thankappan Sarasabai Shynin Brintha**[1], **Solomon Jeeva**[1*] , **Selvamony Sukumaran**[2] **and Vethamony Sathia Geetha**[3]

[1]*Department of Botany, Scott Christian College (Autonomous), Nagercoil, Kanyakumari District, Tamilnadu, India*

[2]*Department of Botany, Nesamony Memorial Christian College, Marthandam, Kanyakumari District, Tamilnadu, India*

[3]*Department of Botany and Microbiology, AVVM Sri Pushpam College, Poondi – 613503, Thanjavur, Tamil Nadu, India*

[*]**Corresponding author:** Jeeva S, Assistant Professor, Department of Botany, Scott Christian College, Nagercoil, Kanyakumari-629 003, Tamilnadu, India, Tel: +91-9952202112; E-mail: solomonjeeva@gmail.com

Received date: Mar 07, 2014, **Accepted date:** Apr 14, 2014, **Publication date:** Apr 24, 2014

Abstract

Bamboo with its varied uses has historically been an integral part of livelihoods and lifestyles in India. The present study was carried out to characterize the bioactive constituents present in the leaf extracts of certain bamboo species using Fourier transform infrared spectroscopic analysis (FT-IR). The various solvent extracts of various bamboo leaves subjected to qualitative analysis showed the availability of phytoconstituents including alkaloids, phenolic compounds, flavonoids, saponins, glycosides, terpenoids, steroids, coumarins and phytosterols. Quinones were completely absent in all the five bamboo species. The FT-IR spectrum confirmed the presence of sulphides (S-S), phenols (C-O), aromatic compounds, thiols (S-H), aliphatic compounds (C-Cl) and amines (NH) in different bamboo species. The present investigation has also opened avenues for further research into the development of potent phytomedicines from different bamboo species.

Keywords: Bamboo; Bioactive constituents; FT-IR; Phytomedicine

Introduction

Bamboo is a fast-growing perennial evergreen arborescent plant belonging to the true grass family Poaceae, subfamily Bambusoideae. Bamboo is commonly known as "poor man's timber" since it is commonly used by the rural population of many countries [1]. Because of its global demand and diverse uses bamboo is also known as the "green gold of the forest" [2]. Their adaptability in a wide range of climatic conditions and regions make them the principal and most productive members of the grass family [3-5]. Bamboo can thrive in hot, humid rainforests and also cold hardy forests where temperatures fall to about -20°C. It can tolerate extreme precipitation ranging from 32 to 50 inches per year. Bamboo's unique rhizome structure is responsible for its high growth rate. Comprising of over 1,500 species included in 87 genera worldwide [6-9], bamboos are unevenly distributed in different parts of the humid tropical, sub-tropical and temperate regions. The main problem with bamboo is its flowering because of which its taxonomy has been fairly neglected. Taxonomists have taken various factors, such as their different parts, into consideration and classified them variously.

In India, bamboo is cultivated in about 8.96 million hectares of land, including forest land, homesteads and private plantations, which account for nearly half the total area under bamboo cultivation in Asia. India is the second largest producer of bamboo in the world next only to China and also has a very high diversity of bamboos with about 18 genera and 136 species [10-14]. The areas particularly rich in bamboo are the northeastern states, the Western Ghats, Chattisgarh, Madhya Pradesh and Andaman Nicobar Islands. The important genera are *Arundinaria, Bambusa, Cephalostachyum, Dendrocalamus, Dinochloa, Gigantochloa, Melocanna, Ochlandra, Oxytenanhthera, Phyllostachys, Pseudostachyum*, etc. [15,16]. Western Ghats is endowed with some important genera of bamboo, including different species, subspecies and varieties [17,18]. Bamboo is a multipurpose plant having about 1500 documented uses in the everyday life of millions of people of Southeast Asia, as it helps meet their basic needs in the form of medicine, food and fodder, even helps in preventing soil erosion [19-22]. Keeping the merits of bamboo in mind, the present study was designed to screen the biomolecules present in aqueous, petroleum ether, chloroform, ethanol and acetone leaf extracts of five different bamboo species found in the campus of Scott Christian College, Nagercoil, Tamilnadu, India and to determine their functional groups using Fourier transform infrared spectroscopic analysis (FT-IR).

Materials and Methods

The leaves of *Bambusa arundinacea* (Retz) Willd., *Bambusa heterostachya* (**Munro**) **Holttum**, *Bambusa ventricosa* McClure, *Bambusa vulgaris Schrad.* ex. J. C. Wendl. and *Dendrocalamus strictus* (Roxb.) Nees were collected from Scott Christian College campus, Tamilnadu, India and identified by using the *Flora of Scott Christian College Campus* [23]. The leaves were examined carefully and old, infected and fungus-damaged leaves were removed. Extracts were prepared from fresh leaves. 50 grams of leaves was collected and kept in conical flasks and 200 ml each of distilled water (for aqueous extract), petroleum ether, chloroform, ethanol and acetone was added separately, and these flasks were kept in a shaker at room temperature for 24 h. After incubation, the extracts filtered through Whatman No.1 filter paper were collected and stored in a refrigerator at 4°C. The extracts were concentrated using a vacuum evaporator and dried at 60°C. Preliminary phytochemical screening was performed using standard procedures [24].

Fourier Transform Infrared Spectroscopic Analysis (FT-IR)

The leaf sample was oven-dried at 60°C and ground into fine powder using a mortar and pestle. Two milligrams of the sample was mixed with 100 mg KBr (FT-IR grade) and then compressed to prepare a salt-disc (3 mm diameter). The disc was immediately kept in the sample holder and FT-IR spectra were recorded in the absorption range between 400 and 4000 cm^{-1}. All investigations were carried out with a Shimadzu FT-IR spectrometer.

Results

Preliminary phytochemical screening was done in aqueous, petroleum ether, chloroform, ethanol and acetone leaf extracts of *B. arundinacea, B. heterostachya, B. ventricosa, B. vulgaris* and *D. strictus.* Of the 25 extracts tested, phytosterols showed their presence in 18 extracts, proteins in 15 extracts, steroids in 14 extracts, and carbohydrates and terpenoids in 13 extracts each. Nine extracts were positive for phenolic compounds and alkaloids, seven for flavonoids and coumarins, and six for saponins and glycosides. Quinones were completely absent in all the bamboo leaf extracts (Table 1).

The FT-IR spectra were used to identify and detect the characteristic peaks and functional groups of the active components based on the peak value in the region of infrared radiation (Table 2; Figures 1-5). The leaf sample of *B. arundinacea* was subjected to FT-IR analysis and the functional groups of the components were separated based on their peak ratios. The results confirmed the presence of polysulphides (S-S stretch), disulphides (C-S stretch), monosubstitution (phenyl), aliphatic fluoro compounds (C-F stretch), aromatic phosphates (P-O-C stretch), aromatic amine (CN stretch), carbonate ion, open-chain amino groups (-C=N-), cyanide ion, thiols (S-H stretch), alkyne compounds, aliphatic cyanide/nitrite, methylene (C-H stretch) and polymeric (OH) stretch which showed major peaks at 468.67, 603.68/651.89, 750.26, 1112.85, 1193.85, 1323.08, 1400.22, 1647.1, 1998.12, 2065.62, 2115.77, 2266.2, 2921.96 and 3328.91 cm^{-1}, respectively (Figure 1; Table 2). The FT-IR analysis of *B. heterostachya* leaves demonstrated the presence of polysulphides (S-S stretch), aliphatic bromo compounds (C-Br stretch), amines (CN stretch), alcohols (C-O), phenols (C-O stretch), vinylidene (C-H bend) methyne (C-H bend), methyl C-H asym/sym. bend, aromatic nitro compounds, alkenyl (C=C stretch), aromatic combination bands, carbonyls, terminal alkyne, methylene C-H asym/sym stretch and aromatic primary amine NH stretch which showed major peaks at 470.6, 530.39, 1049.2, 1097.42, 1155.28, 1244.00, 1323.08, 1373.22/1423.37, 1517.87, 1647.1, 1728.1, 2050.19, 2131.19, 2921.96 and 3404.13 cm^{-1}, respectively (Figure 2; Table 2).

The more intense bands occurring at 1043.42, 1242.07, 1367.44, 1635.52, 1730.03, 2046.33, 2318.28/2489.93, 2734.87, 2914.24, 3280.69 and 3427.27 indicate the presence of cyclohexane ring vibration, aromatic ethers, gem-dimethyl or "iso" (doubles), secondary amine (NH bend), aldehyde, isothiocyanate (-NCS), thiols (S-H stretch), methoxy stretch (CH-O), methylene stretch (C-H), ammonium ion and aromatic primary amine in *B. ventricosa*, respectively (Figure 3; Table 2).

The functional group analysis of *B. vulgaris* showed the presence of polysulphides (S-S stretch), disulphides (C-S stretch), thioethers CH3-S- (C-S stretch), aliphatic chloro compounds (C-Cl), aliphatic fluoro compounds (C-F stretch), aromatic phosphates (P-O-C stretch), aromatic primary amine (CN), phenol or tertiary alcohol (OH bend), methylene (C-H bend), aromatic nitro compounds, alkenyl (C=C stretch), metal carbonyls, cyanide ion, aliphatic cyanide or nitrate, methylene (C-H stretch) and normal polymeric OH stretches at 466.74, 603.68, 653.82, 750.26, 1114.78, 1193.85, 1334.65, 1400.22, 1456.16, 1517.87, 1666.38, 2065.62, 2113.84, 2269.27, 2923.88/2962.46 and 3319.26 cm^{-1} respectively (Figure 4; Table 2).

Phytoconstituents	Solvents																	
	Aqueous					Petroleum ether					Chloroform					Ethanol		
	A	B	C	D	E	A	B	C	D	E	A	B	C	D	E	A	B	C
Alkaloids	-	-	++	+++	-	-	-	-	-	-	-	-	-	-	-	++	+	+++
Phenolic compounds	+	-	+	-	-	-	-	-	-	-	-	+	+++	++	-	-	-	+++
Flavonoids	+++	+++	-	++	++	-	-	-	+	-	-	-	-	+	-	-	-	-
Saponins	+++	-	+++	++	+++	-	-	-	-	+	-	-	-	-	-	++	-	-
Glycosides	-	-	+	-	-	-	-	-	-	++	-	+++	++	++	++	-	-	-
Terpenoids	+	+	+	+	+	-	-	-	+++	-	-	-	-	++	-	+	-	-
Steroids	-	-	++	++	+	-	+	-	+	-	-	-	-	++	+++	+	-	-
Coumarins	-	+++	-	+	-	-	+++	++	++	+	-	-	-	++	-	-	-	-
Quinones	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phytosterols	-	-	+++	-	+	+	++	++	++	++	++	+++	++	-	+++	+++	-	+
Protein	+	-	++	++	+	-	++	+	-	+	-	+	++	++	+++	++	-	+
Carbohydrates	+	-	-	++	+	-	-	-	-	-	++	+++	+++	+++	+++	+	-	-

Table 1: Preliminary phytochemical constituents from the leaf extracts of certain Bamboo species.

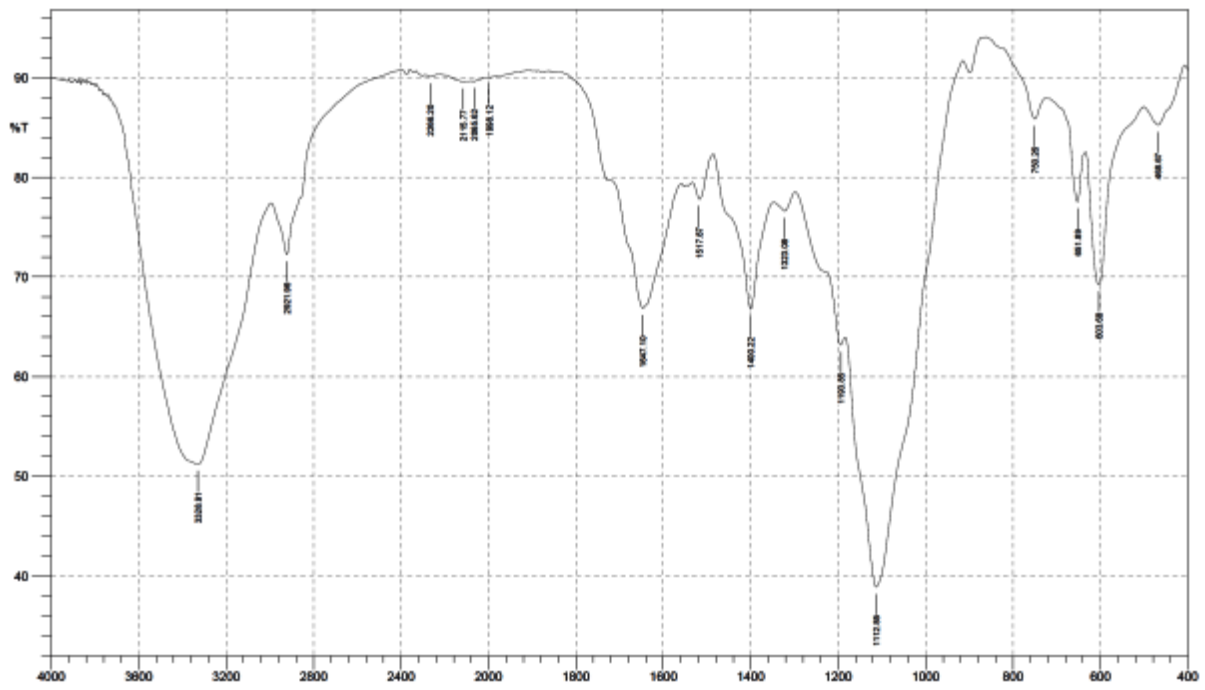

Figure 1: FT-IR spectrum of Bambusa arundinaceaa (Retz) Willd.

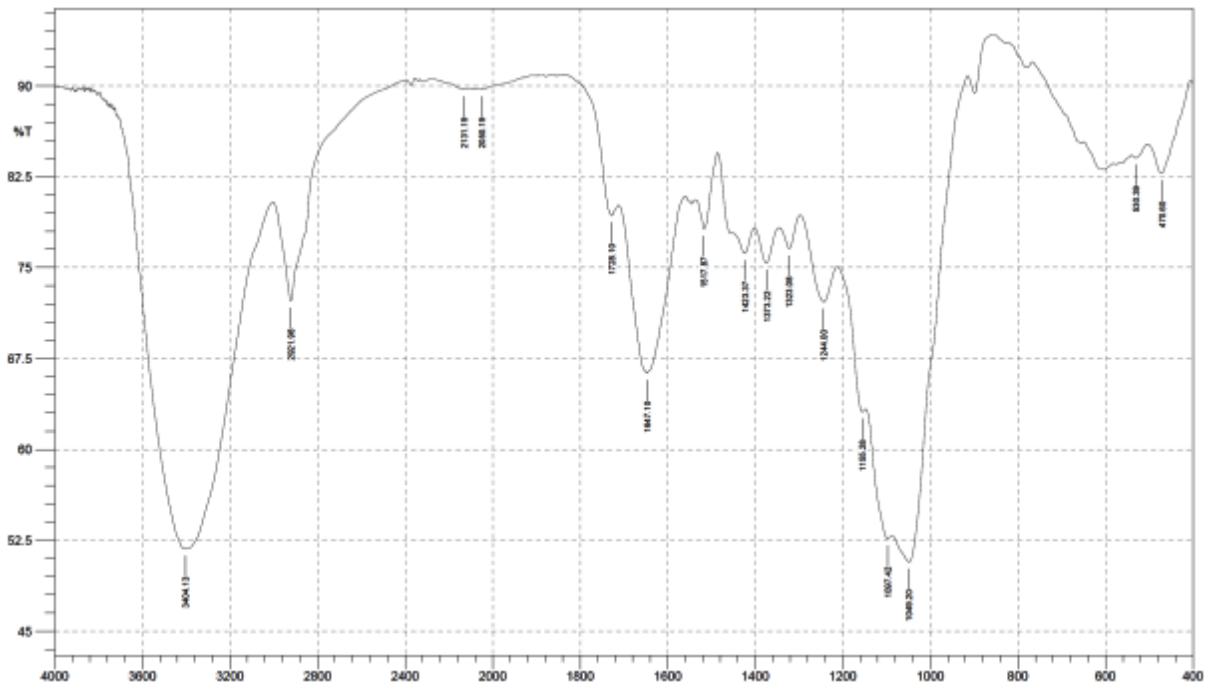

Figure 2: FT-IR spectrum of Bambusa heterostachya (**Munro**) **Holttum**. *Bambusa arundinacea* (A), *Bambusa heterostachya* (B), *Bambusa ventricosa* (C), *Bambusa vulgaris* (D), *Dendrocalamus strictus* (E).

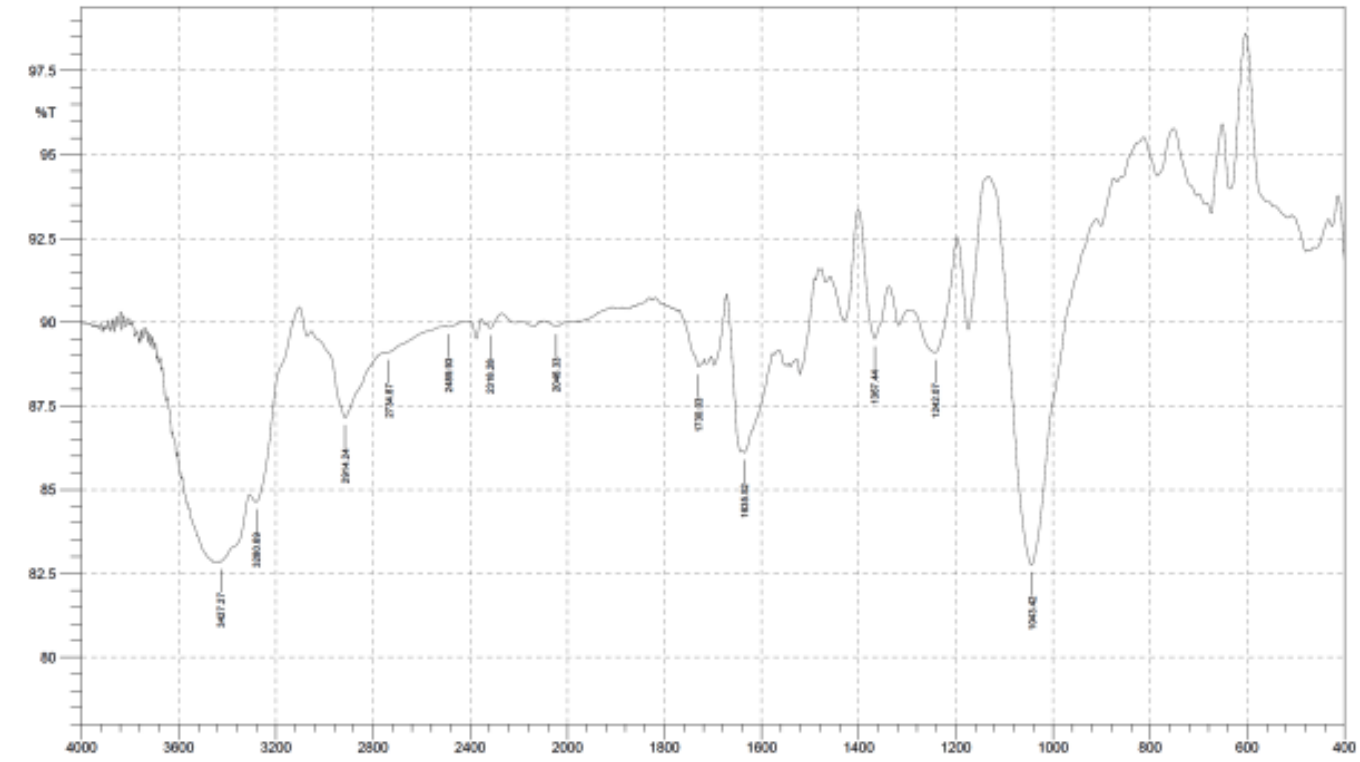

Figure 3: FT-IR spectrum of Bambusa ventricosa McClure.

Bambusa arundinacea		Bambusa heterostachya		Bambusa ventricosa		Bambusa vulgaris		Dendrocalamus strictus	
Peak values	**Functional groups**	**Peak values**	**Functional groups**	**Peak values**	**Functional groups**	**Peak values**	**Functional groups**	**Peak values**	**Functional groups**
468.67	Polysulfides (S-S stretch)	470.6	Polysurfides (S-S Stretch)	1043.42	Cyclohexane ring Vibration	466.74	Polysulfides (S-S stretch)	466.74	Poly Sulfides (S-S stretch)
603.68	Disulfides (C-S stretch)	530.39	Aliphatic bromo compounds C-Br stretch	1242.07	Aromatic ethers, aryl-o stretch	603.68	Disulfides (C-S stretch	601.75	Disulfides (C-S stretch)
651.89	Disulfides (C-S stretch)	1049.2	Primay amine, CN Stretch	1367.44	Gem-Dimethyl or "iso" (doubles)	653.82	Thioethers, CH3-S- (C-S stretch	651.89	OH Out-of-plane bend
750.26	Monosubstitution (Phenyl)	1097.42	Secondary alcohol, C-O stretch	1635.52	Secondary amine, NH bend	750.26	Aliphatic chlorocomponds, C-cl stretch	682.75	Aryl thioethers, ø-S (C-S stretch)
1112.85	Aliphatic fluoro compounds, C-F stretch	1155.28	Phenol, C-O stretch	1730.03	Aldehyde	1114.78	Aliphatic fluoro compounds, C-F stretch	786.9	Aliphatic chloro compounds, C-Cl stretch
1193.85	Aromatic Phosphates (P-O-C stretch)	1,244.00	Vinylidene C-H in-phane bend	2046.33	Isothiocyanate (-NCS)	1193.85	Aromatic phosphates (P-O-C stretch	1103.21	Organic Siloxane or Silicone (Si-O-C)
1323.08	Aromatic primary amine, CN stretch	1323.08	Methyne C-H bend	2318.28	Thiols (S-H Stretch)	1334.65	Aromatic Primary amine, CN stretch	1236.29	Skeletal C-C Vibrations

1400.22	Carbonate ion	1373.22	Methyl C-H asym./sym. Bend	2489.93	Thiols (S-H Stretch)	1400.22	Phenol or tertiary alcohol, OH bend	1328.86	Dialkyl / aryl sulfones
1647.1	Open-chain amino (-C=N-)	1423.37	Methyl C-H asym./sym. Bend	2734.87	Metoxy, -H Stretch (CH-O-)	1456.16	Methylene C-H bend	1400.22	Phenol or tertiary alcohol, OH bend
1998.12	Cyanide ion, thiocyanate ion, and related ions	1517.87	Aromatic nitro compounds	2914.24	Methylene C-H Asym./Syn. Stretch	1517.87	Aromatic nitro compounds	1450.37	Methylene C-H bend
2065.62	Thiols (S-H stretch)	1647.1	Alkenyl C=C stretch	3280.69	Ammonium ion	1666.38	Alkenyl C=C stretch	1517.87	Aromatic nitro compounds
2115.77	Terminal alkyne (mono substituted)	1728.1	Aromatic combination bands	3427.27	Aromatic Primary amine	2065.62	Transition metal carbonyls	1552.59	Carboxylate (carboxylic acid salt)
2266.2	Aliphatic cyanide / nitrite	2050.19	Transition metal carbonyls	-	-	2113.84	Cyanide ion, thiocyanate ion, and related ions	1649.02	Secondary amine, NH bend
2921.96	Methylene C-H asym./ sym. Stretch	2131.19	Terminal Alkyne	-	-	2269.27	Aliphatic cyanide / nitrite	1728.1	Aldehyde
3328.91	Normal "polymeric" OH stretch	2921.96	Methylene C-H asym./Sym stretch	-	-	2923.88	Methylene C-H asym./sym. Stretch	2005.83/ 2061.76	Isothiayanate (-NCS)
-	-	3404.13	Aromatic Primary amine, NH stretch	-	-	2962.46	Methylene C-H asym./sym. Stretch	2115.77	Terminal alkyne (monosubstituted)
-	-	-	-	-	-	3319.26	Normal "polymeric" OH stretch	2858.31	Methylene C-H asym./ sym. Stretch
-	-	-	-	-	-	-	-	2923.88	Methylene C-H asym./ sym. Stretch
-	-	-	-	-	-	-	-	3352.05	Aliphatic Secondary amine, NH stretch
		-						3377.12	Aromatic Primary amine, NH stretch
-	-		-	-	-	-	-	466.74	Poly Sulfides (S-S stretch)

Table 2: FTIR peak values and functional groups of certain bamboo species.

The leaf sample of *D. strictus* subjected to FT-IR spectroscopic analysis showed the availability of polysulphides (S-S stretch), disulphides (C-S stretch), OH out-of-plane bend, aryl thioethers ø-S (C-S stretch), aliphatic chloro compounds (C-Cl stretch), organic siloxane or silicone (Si-O-C), skeletal C-C vibrations, dialkyl / aryl sulfones, phenol or tertiary alcohol (OH bend), methylene (C-H bend), aromatic nitro compounds, carboxylate (carboxylic acid salt), secondary amine (NH bend), aldehyde, isothiayanate (-NCS), terminal alkyne (monosubstituted), methylene C-H asym./sym. stretch, aliphatic secondary amine (NH stretch), aromatic primary amine (NH stretch) which showed major peaks at 466.74, 601.75, 651.89, 682.75, 786.9, 1103.21, 1236.29, 1328.86, 1400.22, 1450.37, 1517.87, 1552.59, 1649.02, 1728.1, 2005.83/2061.76, 2115.77, 2858.31/2923.88, 3352.05 and 3377.12 cm^{-1} respectively (Figure 5; Table 2).

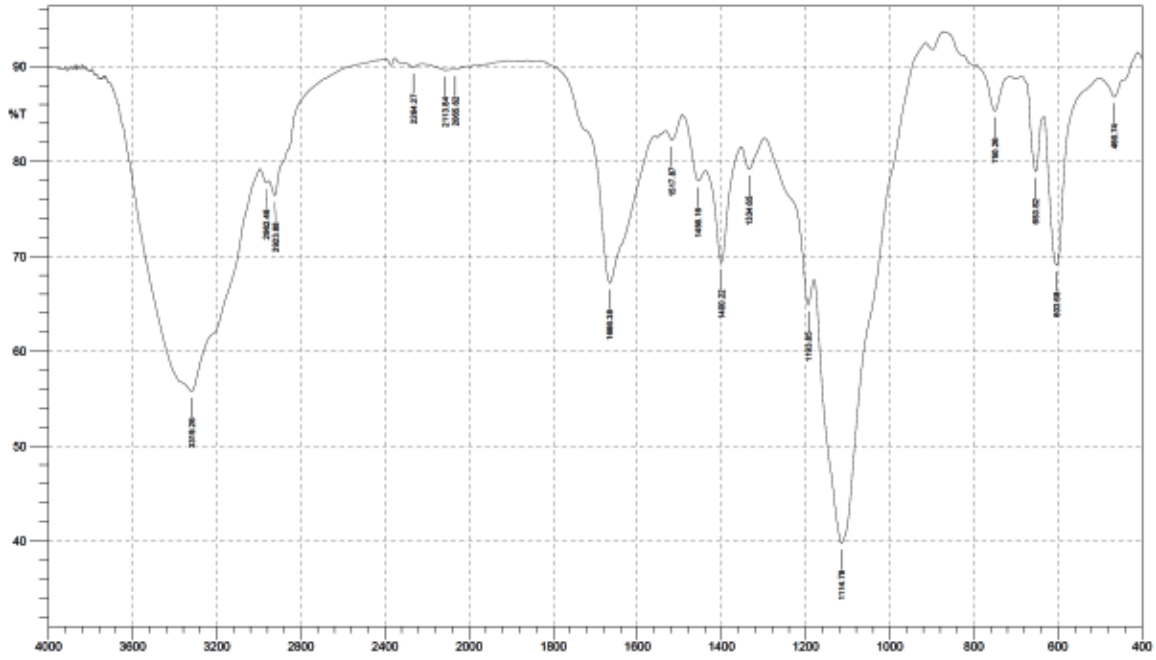

Figure 4: FT-IR spectrum of Bambusa vulgaris Schrad. ex J.C.Wendl.

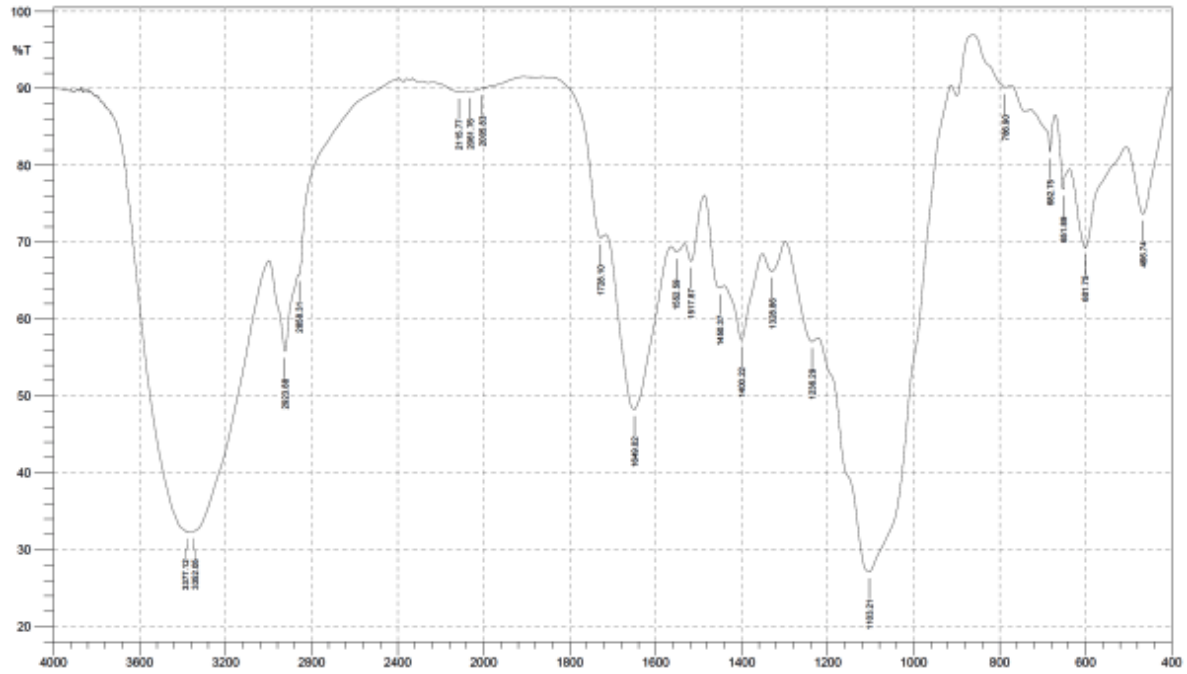

Figure 5: FT-IR spectrum of Dendrocalamus strictus (Roxb.) Nees.

Discussion

The wide range of uses that bamboo has only lately received more attention. Essential qualities along with dietary and therapeutic traits of different bamboo species have been systematically analyzed, compared and reported. Many essential minerals, vitamins, amino acids, flavones, phenolic compounds, polysaccharides, trace elements and steroids can be extracted from bamboo culms, shoots and leaves, all having anti-oxidant, anti-ageing, anti-bacterial and anti-viral properties [25,26]. These are valuable in healthcare and can form the bases for products as varied as beverages, medicines, pesticides or

other household items like toothpaste, soaps, etc. Polysaccharides in bamboo leaf contribute to various functions of the human body such as immunity regulation, anti-oxidation and tumour prevention [27].

There are several reports to show that bamboo leaves are an important source of bioactive molecules. The bamboo leaf contains 2% to 5% flavine and phenolic compound that have the power to remove active free radicals, stop sub-nitrification and abate blood fat [9]. Phenolic compounds were studied in the culms of five bamboo species (*Yushania chungii, Fargesia robusta, Fargesia denudata, Fargesia rufa* and *Fargesia scabrida*) collected in China by Sarita *et al.* [28], who found that the composition and concentrations of soluble phenolic compounds in the bamboo culms were affected by the species and age of the bamboo and the site of collection. The antioxidant and angiotension-converting enzyme inhibition activity of the extracts of two edible Korean bamboo species was studied by Park and John [29], who found that all the extracts had significant activity due to the presence of phenolic compounds. Qualitative analysis of the bamboo leaves in this study demonstrated the presence of phenolic compounds, which have antimicrobial and antifungal properties; for this reason bamboo leaves are used in ethnoveterinary practices for curing microbial infections of cattle [30].

Flavonoids and coumarins were found to be present in seven extracts. Generally, flavonoids have been referred to as 'nature's biological response modifiers' because of strong evidence of their inherent ability to modify the body's reaction to allergies, viruses and carcinogens. Flavine beverages and beer have been widely accepted particularly in East Asian countries like China, Korea and Japan mainly because of their value in health care. A new pyrone-coumarin, 7,8-dihydroxy-3-(3-hydroxy-4-oxo-4H-pyran-2-yl)-2H-chromen-2-one, along with two known coumarins, scopoletin and scopolin, was isolated from the 95% EtOH extract of the leaves of *Bambusa pervariabilis* McClure by Sun et al. [31]. In a related study Zhang et al. [32] isolated four flavone C-glycosides from bamboo leaves by macroporous resin column chromatography and preparative high-performance liquid chromatography. Kim et al. [33] isolated antioxidant compounds from the ethyl acetate-soluble fraction of black bamboo (*Phyllostachys nigra*) leaves through the activity profiles based on the online ABTS+ assay, and identified as isoorientin, orientin, vitexin, luteolin 6-C-(6-O-trans-caffeoylglucoside), vittariflavone, and tricin using NMR and HPLC-ESI/MS data and found good level of antioxidant activity. Bamboo extracts of the present investigation also indicated the presence of glycosides which in turn may pave way for their future use as antioxidant agents.

Studies conducted by Kweon et al. [34] in the butanol-soluble extract of leaves of *Phyllostachys edulis*, a bamboo, revealed significant antioxidant activity, as measured by it ability to scavenge the stable free radical, 1,1-diphenyl-2-picrylhydrazyl (DPPH) and the superoxide anion radical (O_2^-) in the xanthine/xanthine oxidase assay system. Antioxidant activity-directed fractionation of the extract led to the isolation and characterization of three structural isomeric chlorogenic acid derivatives: 3-O-(3′-methylcaffeoyl) quinic acid, 5-O-caffeoyl-4-methylquinic acid and 3-O-caffeoyl-1-methylquinic acid. All three compounds exhibited both superoxide scavenging activity and inhibitory effect on xanthine oxidase. The superoxide anion (O_2^-) scavenging activities were markedly stronger than those of ascorbic acid (IC50 = 56.0 μM), α-tocopherol (IC50 > 100 μM) and other test compounds; this may be explained by the fact that inhibitiory effects of these three compounds on xanthine oxidase contribute to their potent scavenging activity. α-Tocopherol exerted a significant inhibitory effect on superoxide generation in 12-O-tetradecanoylphorbol-13-acetate-induced human promyelocytic leukaemia HL-60 cells and 3-O-caffeoyl-1-methylquinic acid showed moderate activity. On the other hand, other compounds including 3-O-(3′-methylcaffeoyl) quinic acid, 5-O-caffeoyl-4-methylquinic acid chlorogenic acid and other antioxidants were weakly active in the suppression of superoxide generation.

FT-IR spectroscopy has demonstrated to be a reliable and sensitive method for finding out the biomolecular composition of plant samples. FT-IR analysis of hemicellulose from young bamboo shoots of *Phyllostachys pubescens* revealed that all polysaccharide fraction contained xylose, arabinose, glucose, galactose, ribose and uronic acid. Polysaccharides from young bamboo leaves mainly included arabinoxylans, arabinogalactans and non-cellulosic β-D-glucans having (1→3)- and (1→4)-glucosidic linkages [35]. In a related study, the carbonization of bamboo (*Phyllostachys sp.*) and subsequent analysis by FT-IR revealed the presence of hemicellulose, cellulose and lignin; the change in one of these substances to another was found to depend on temperature. The study revealed that at temperatures below 200°C, hemicellulose in bamboo was decomposed and a large nnumber of hydroxyl groups were dislocated from hemicellulose and cellulose, accompanied by the release of water; at 200–250°C, cellulose in bamboo was drastically decomposed whereas the net structure of lignin was stable, with the exception of the dislocation of methoxyl groups from lignin; at 250–400°C, the net structure of lignin collapsed, and above 400°C, more positions in aryl groups were substituted [36]. Sun et al. [37] determined the structure and thermal property of alkaline hemicelluloses from steam-exploded Phyllostachys pubescens by using FT-IR analysis. In a related study, phyllostadimers A and B, two bis-lignans in which the two lignan units are directly connected by a C–C bond, were isolated from stems of bamboo, *Phyllostachys edulis,* of these, compound phyllostadimer A significantly inhibited liposomal lipid peroxidation [38].

Plants have been a source of novel drugs as plant-derived medicines have made significant contributions towards human health [39,40,41]. Antimicrobial properties of plants are due to various chemical compounds including volatile oils, alkaloids, tannins and lipids present in the tissue [42,43]. Tanaka et al. [44] examined the antibacterial activity of *P. pubescens* (moso bamboo) shoot peel against *Staphylococcus aureus,* and suggested the possibility of deriving effective antibacterial compounds from bamboo shoot peel that are mostly discarded at present. The antibacterial activity is due to the active constituents, stigmasterol and dihydrobrassicasterol [45]. The leaf decoction of *D. strictus* is used as an abortifacient; the siliceous matter present in the leaves is used as a tonic and astringent by the Adi tribes of Arunachal Pradesh, India [46].

Apart from medicinal uses, young bamboo shoots are used as food [47,48]. Bamboo juice, bamboo based beverages, bamboo-flavoured rice, etc. are some novel products obtained from bamboos. Bamboo shoot is an ideal vegetable, being low in fat, high in edible fibre and rich in minerals. It helps in relieving congestion of the chest, enhances digestion, improves dieresis, and is often used for healing swollen tissues or oedema and abdominal disease in which watery fluid collects in cavities or body tissues, called ascites. The shoot also contains saccharine, which has been found to help resist little white mouse tumour and also has anti-ageing elements. Studies revealed that young shoots of *B. arundinacea* and *D. strictus* are highly nutritious, containing fibre, protein, carbohydrate, glucose, calcium, iron, phosphorus, vitamins, etc. [7,49]. Besides nutrients, bamboo shoots

also contain lethal concentrations of cyanogens that need to be removed before consumption. Choudhury et al. [50] also revealed that bamboo shoots contain the cyanogenic glycoside, taxiphyllin [2-(β-D-glucopyranosyloxy)-2-(4-hydroxyphenyl) acetonitrile] and are, therefore bitter and need to be leached or boiled before consumption. Incomplete cooking of bamboo shoots results in glycoside hydrolysis and higher release of HCN content [51].

Conclusion

The present qualitative phytochemical and FT-IR spectral study, along with previous studies on isolation of bioactive compounds and clinical trials, shows that extracts obtained from various species of bamboo, including the presently studied species can be used as potent bioactive agents. A more profound knowledge of the compounds present and their properties will allow application of the extracts in the food and pharmaceutical industry.

References

1. Rai PK (2009) Comparative assessment of soil properties after bamboo flowering and death in a tropical forest of Indo-Burma hot spot. Ambio 38: 118-120.
2. Keshari VP (2005)Bamboo: From poor man's timber to green gold. Hamro Kalpana Brikshya, 164: 10-4.
3. Qing Y, Zhu-biao D, Zheng-liang W, Kai-hong H, Qi-xiang S, et al. (2008) Bamboo resources, utilization and ex-situ conservation in Xishuangbanna, South-eastern China. Journal of Forestry Research 19 : 79-83.
4. Liu T (2011) Surveys of harvest technology of winter bamboo shoots. Journal of Forestry Research 22 : 487-490.
5. Komatsu YH, Batagin-Piotto D, Brondani GE, Goncalves AN, de Almeida M (2011) In vitro morphogenic response of leaf sheath of Phyllostachys bambusoides. Journal of Forestry Research 22 : 209-215.
6. Ohrnberger D (1999) The Bamboos of the World: Annotated Nomenclature and Literature of the Species and the Higher and Lower Taxa. Elsevier, Amsterdam, pp. 585.
7. Shanmughavel P (2004) Cultivation potential of culinary bamboos in Southern India. Natural Product Radiance 3 :237-239.
8. Li Z, Kobayashi M (2004) Plantation future of bamboo in China. Journal of Forestry Research 15 :233-242.
9. Ogunjinmi AA, Ijeomah HM, Aiyeloja AA (2009) Socio-economic importance of bamboo (Bambusa vulgaris) in Borgu local government area of Niger state, Nigeria. Journal of Sustainable Development in Africa 10 : 284-298.
10. Li Z, Denich M (2002) Elevational diversity of arrow bamboo (Fargesia spathacea) communities on Mount Shennongjia in Central China. Journal of Forestry Research, 13 :171-176.
11. Zhou B, Fu M, Xie J, Yang X, Li Z (2005) Ecological functions of bamboo forest: research and application. Journal of Forestry Research, 16 : 143-147.
12. Nath AJ, Das G, Das AK (2009) Traditional knowledge base in the management of village bamboos: a case study in Barak Valley, Assam, Northeast India. Indian Journal of Traditional Knowledge 8 : 163-168.
13. Yang X, Fu M, Xie J, Li Z (2009) Geographic variation and provenance selection for bamboo wood properties in Bambusa chungii. Journal of Forestry Research 20 : 261-267.
14. Gulabrao YA, Kaushal R, Tewari SK, Tomar JMS, Chaturvedi OP (2012) Seasonal effect on rooting behaviour of important bamboo species by culm cuttings. Journal of Forestry Research 23 :441-445.
15. Jeeva S, Kiruba S, Lalhruaitluanga H (2009) Flowering of Melocanna baccifera (Bambusaceae) in northeastern India. Current Science 96 : 1165-1166.
16. Pandey AK, Ojha V (2013) Standardization of harvesting age of bamboo shoots with respect to nutritional and anti-nutritional components. Journal of Forestry Research 24 :83-90.
17. Kiruba S, Jeeva S (2010) Flowering of Bamboos in Two Biodiversity Hotspots of India. The Indian Forester 136 : 137-140.
18. Jeeva S, Sheeja BD (2013) Flowering of Thorny Bamboo (Bambusa arundinacea) in the Agroforestry system of Kanyakumari-Tamilnadu, South India. The Indian Forester 139 : 568-568.
19. Shanmughavel P, Francis K, George M (1997) Plantation Bamboo. International Book Distributors. 191, Dehradun.
20. Kharlyngdoh E, Barik SK (2008) Diversity, distribution pattern and use of bamboos in Meghalaya. Journal of Bamboo and Rattan 7 : 73-90.
21. Islam MS, Bhuiyan MK, Hossain MM, Hossain MA (2011) Clonal propagation of Bambusa vulgaris by leafy branch cuttings. Journal of Forestry Research 22 : 387-392.
22. Upadhyaya K, Arunachalam A, Arunachalam K, Das AK (2012) Decomposition and nutrient release patterns of Phyllostachys bambusoides and Arundinaria racemosa, India. Journal of Forestry Research 23 : 245-252.
23. Brintha TSS (2012) Flora of Scott Christian College Campus, Thesis, Department of Botany, Scott Christian College (Autonomous), Nagercoil, Tamilnadu, India.
24. Harborne JB (1998) Phytochemical methods-A guide to modern techniques of plant analysis. Chapman and Hall, London.
25. Nimachow G, Rawat JS, Dai O (2010) Prospects of bamboo shoot processing in north-east India. Current Science 98 : 288-289.
26. Choudhury D, Sahu JK, Sharma GD (2011) Bamboo shoot based fermented food products: a review. Journal of Scientific and Industrial Research 70: 199-203.
27. Gao Y, Tian C, Zhao L (2012) Extraction, purification and antioxidant activity of polysaccharides from bamboo leaves. Journal of Forestry Research 23 : 139-143.
28. Sarita K, Ossipov V, Riitta J, Jia J, Danell K, et al. (2008) Phenolics from the culms of five bamboo species in the Tangjiahe and Wolong Giant Panda Reserves, Sichuan, China. Biochemical Systematics and Ecology 36 : 758-765.
29. Park E, John D (2010) The antioxidant, angiostensin converting enzyme inhibition activity, and phenolic compounds of bamboo shoot extracts. LWT – Food Science and Technology 43 : 655-659.
30. Kiruba S, Jeeva S, Das SSM (2006) Enumeration of ethnoveterinary plants of Cape Comorin, Tamilnadu. Indian Journal of Traditional Knowledge 5 : 576-578.
31. Sun J1, Yue YD, Tang F, Guo XF (2010) Coumarins from the leaves of Bambusa pervariabilis McClure. J Asian Nat Prod Res 12: 248-251.
32. Zhang Y, Jiao J, Liu C, Wu X, Zhang Y (2008) Isolation and purification of four flavone C-glycosides from antioxidant of bamboo leaves by macroporous resin column chromatography and preparative high-performance liquid chromatography. Food Chemistry 107 : 1326-1336.
33. Kim CY, Lee HJ, Jung SH, Lee EH, Cha KH, et al. (2009) Rapid identification of radical scavenging phenolic compounds from black bamboo leaves using high-performance liquid chromatography coupled to an online ABTS+-based assay. Journal of the Korean Society for Applied Biological Chemistry 52 : 613-619.
34. Kweon MH1, Hwang HJ, Sung HC (2001) Identification and antioxidant activity of novel chlorogenic acid derivatives from bamboo (Phyllostachys edulis). J Agric Food Chem 49: 4646-4655.
35. Peng H1, Zhou M, Yu Z, Zhang J, Ruan R, et al. (2013) Fractionation and characterization of hemicelluloses from young bamboo (Phyllostachys pubescens Mazel) leaves. Carbohydr Polym 95: 262-271.
36. Zuo S, Gao S, Yuan X, Xu B (2003) Carbonization mechanism of bamboo (phyllostachys) by means of Fourier Transform Infrared and elemental analysis. Journal of Forestry Research 14 : 75-79.
37. Sun SN1, Cao XF, Xu F, Sun RC, Jones GL, et al. (2014) Structure and thermal property of alkaline hemicelluloses from steam exploded Phyllostachys pubescens. Carbohydr Polym 101: 1191-1197.

38. Suga A1, Takaishi Y, Goto S, Munakata T, Yamauchi I, et al. (2003) Two lignan dimers from bamboo stems (Phyllostachys edulis). Phytochemistry 64: 991-996.
39. Florence AR, Joselin J, Jeeva S (2012) Intra-specific variation of bioactive principles in select members of the genus Clerodendrum L. Journal of Chemical and Pharmaceutical Research 4 : 4908-4914.
40. Joselin J, Brintha TSS, Florence AR, Jeeva S (2012) Phytochemical evaluation of Bignoniaceae flowers. Journal of Chemical and Pharmaceutical Research 5 : 106-111.
41. Sakthidevi G, Mohan VR, Jeeva S (2014) In vitro antioxidant activity of leaf extracts of Alangium salvifolium (L.f.) Wang (Alangiaceae). Bioscience Discovery 5 : 74-81.
42. Joselin J, Brintha TSS, Florence AR, Jeeva S (2012) Screening of select ornamental flowers of the family Apocynaceae for phytochemical constituents. Asian Pacific Journal of Tropical Disease 2: S260-S264.
43. Florence AR, Joselin J, Brintha TSS, Sukumaran S, Jeeva S (2014) Preliminary phytochemical studies of select members of the family Annonaceae for bioactive constituents. Bioscience Discovery 5 : 85-96.
44. Tanaka A, Kim HJ, Oda S, Shimizu K, Kondo R (2011) Antibacterial activity of moso bamboo shoot skin (Phyllostachys pubescens) against Staphylococcus aureus. Journal of Wood Science 57 : 542-544.
45. Tanaka A, Shimizu K, Kondo R (2013) Antibacterial compounds from shoot skins of moso bamboo (Phyllostachys pubescens). Journal of Wood Science 59 : 155-159.
46. Sharma TP, Borthakur SK (2008) Ethnobotanical observations on bamboos among Adi tribes of Arunachal Pradesh. Indian Journal of Traditional Knowledge 7 : 594-597.
47. Tamang B, Tamang JP, Jyoti P (2009) Traditional knowledge of biopreservation of perishable vegetable and bamboo shoots in northeast India as food resources. Indian Journal of Traditional Knowledge 8 : 89-95.
48. Nath AJ, Das AK (2011) Population status and regeneration of a tropical clumping bamboo Schizostachyum dullooa under two management regimes. Journal of Forestry Research 22 : 43-46.
49. Kiruba S, Jeeva S, Das SSM, Kannan D (2007) Bamboo seeds as a means to sustenance of the indigenous community. Indian Journal of Traditional Knowledge 6 : 199-203.
50. Choudhury B, Sahu JK, Sharma GD (2010) Biochemistry of bitterness in bamboo shoots. Assam University Journal of Science and Technology: Physical Sciences and Technology 6 : 105-111.
51. Pandey AK, Ojha V (2014) Precooking processing of bamboo shoots for removal of anti-nutrients. J Food Sci Technol 51: 43-50.