J Food Sci Technol (July–August 2012) 49(4):407–414
DOI 10.1007/s13197-011-0379-z

REVIEW ARTICLE

Value addition to bamboo shoots: a review

Debangana Choudhury · Jatindra K. Sahu · G. D. Sharma

Revised: 7 April 2011 / Accepted: 8 April 2011 / Published online: 21 April 2011

Abstract Bamboo shoot forms a traditional delicacy in many countries. Being low in fat content and high in potassium, carbohydrate, dietary fibres, Vitamins and active materials, bamboo shoots are consumed in raw, canned, boiled, marinated, fermented, frozen, liquid and medicinal forms. Although the fresh bamboo shoots of species like *Dendraocalamus giganteus* are healthier and nutritionally rich, the young shoots, after fortification, can be consumed by processing into a wide range of food products with longer shelf-life and better organoleptic qualities. However, the consumption pattern of bamboo shoots in most of the countries is traditional, non-standardized, seasonal and region-specific with little value addition. Therefore, there exists a great opportunity, especially for the organized food processing sectors to take up the processing of bamboo shoot-based food products in an organized manner. The present article gives an insight into the global scenario of bamboo shoot-based food products and their consumption pattern, the quality attributes, and the opportunities for value addition along with future prospects in view of international food safety, security and nutrition.

Keywords Bamboo shoot · Value addition · Shelf stability · Fermented foods · HCN

D. Choudhury · G. D. Sharma
Department of Life Science, School of Life Sciences,
Assam University,
Silchar 788 011, Assam, India

J. K. Sahu (✉)
Department of Biological Systems Engineering, Virginia
Polytechnic Institute and State University,
Blacksburg 24061 VA, USA
e-mail: jks@vt.edu

Introduction

Basically a grass, belonging to family Poaceae, bamboo is spread over 1,250 species under 75 genera in the world (Upreti and Sundriyal 2001). Out of these, about 136 species under 23 genera are available only in India (Sharma 1980). The versatile and evergreen plant is found almost everywhere in the world, but the frozen poles.

Bamboo shoots are the new culms that just emerge from the ground and constitute a range of traditional delicacies. The freshly harvested bamboo shoot is cream yellow in color. When a newly harvested bamboo shoot is peeled, it gives a strong smell and bitter taste (Sharma 1987). The bitter taste in bamboo shoots is due to the presence of cyanogenic glycoside taxiphyllin, which is toxic in nature. All species of bamboo shoots available in the world are not edible. Out of 136 species available in India, the most commonly edible bamboo species are *Bambus pallida*, *Bambusa tulda*, *Bambusa polymorpha*, *Bambusa balcooa*, *Dendrocalamus hamiltonii*, *Dendrocalamus giganteus* and *Melocanna bambusoides* (Sharma 1980). The edible genera of bamboo shoots available in USA are *Phyllostachys*, the important being *Phyllostachys dulcis*, *Phyllostachys edulis*, *Phyllostachys bambusoides*, *Phyllostachys pubescens*, *Phyllostachys nuda* and *Phyllostachys viridis* (Rubatzky and Yamaguchi 1997).

Global scenario of bamboo shoots

The edible bamboo shoots have a matchless taste and flavor. In many parts of the world, bamboo shoots form a part of the conventional cuisine and are consumed in various forms (Daphne 1996; Tamang et al. 1988; Caitlin and Miles 2000; Tamang 2005; Bal et al. 2008; Pande and Pandey 2008).

However, bamboo grows naturally or is cultivated in homesteads and farms, and is one of the underestimated natural resources in the international scenario.

In international markets, China earns 6,500 million Indian rupees every year from export of edible bamboo shoots, with import of USA at around 44,000 tonnes accounting for 14.5% of the total world import (Lobovikov 2003). Every year USA imports 30,000 tonnes of canned bamboo shoots from Taiwan, Thailand, India and China for domestic consumption as food items (Daphne 1996). *Dendrocalamus asper*, and *Dendrocalamus lactiferous* and *Bambusa oldhami* are the most important edible species in Thailand (Fu et al. 1798) and Taiwan (Tai 1985), respectively. The import of Australia is estimated about 8,000 tonnes per annum (Cahill 1999). Taiwan consumes about 80,000 tonnes of bamboo shoots annually constituting a value of 2,500 million Indian rupees, covering 30,000 ha of land of bamboo shoots under cultivation, producing total 380,000 tonnes of bamboo shoots per year (Tai 1985). In Japan, the present annual consumption of bamboo shoots is 3 kg per person, compared to 1.2 kg per person in 1950s (Yang et al. 2008). At present, over two million tonnes of edible bamboo shoots are consumed in the world in each year (Yang et al. 2008; Vaiphei 2005). Statistic shows that about 26.2, 435 and 426.8 tonnes of bamboo shoots are harvested annually in the north eastern states of India like Sikkim, Meghalaya and Mizoram, respectively, where about 20–30 million tonnes of bamboo shoots are utilized for production of canned bamboo shoots annually (Bhatt et al. 2003; 2005a; b).

India's size of domestic bamboo economy currently is estimated at 2,000 million Indian rupees. The market potential of bamboo in India is estimated at present at 450 million Indian rupees, which will increase to 26,000 million Indian rupees by 2015, thus enabling five million families of artisans and farmers, crossing the poverty line (Farooquee et al. 2007).

Bamboo shoots

Depending upon species, bamboo shoots are usually 20–30 cm long and taper to a point. A bamboo shoot at the time of harvest normally weighs more than 1 kg. However, their size and weight depend considerably upon the location, depth, pH and nutrition of the soil, irrigation and drainage conditions, climate, rainfall, temperature and soil type and fertility. Cold tolerance is a limiting factor in the growth of certain bamboo species (Dollo et al. 2009; Gangwar and Ramakrishnan 1987; Maikhuri 1996; Anderson and Ingram 1993; Kigomo 2007).

Various constituents like acids, proteins, carbohydrates, starch, fat, dietary fibre, vitamins and minerals have been systematically analyzed and reported by various authors (Lee and Takahashi 1966; Bradford 1976; Mecreddy et al. 1958; Goering and Van Soest 1970; Baker et al. 1980; Nirmala et al. 2008; Reiss 1993). Although bamboo shoots are found during the monsoons, there are normally two types of bamboo shoots available in a year; winter shoots and spring shoots depending on the seasons of a year. The spring shoots are normally larger, tougher and more superior compared to the winter shoots.

Quality attributes of bamboo shoots

Bamboo shoots are becoming one of the preferred food products in the world, but there is hardly any organized bamboo shoot processing and marketing industry to serve this exceeding need of the caterers and restaurants in considerable quantities. In the following sub-sections, an attempt has been made to compile the physical, chemical, nutritional, sensory, and anti-microbial qualities of bamboo shoots in order to understand the qualities of the products derived and/or to be derived from them.

Physical quality

The shooting period of a bamboo varies from species to species. In general, the temperate-climate-bamboos are runners, which shoot in the spring, while the tropical and sub-tropical species are clumpers, which shoot in the late summer and fall.

Bamboo shoots are tender, soft, crispy, generally ivory yellow in color. The sheaths covering the shoots are black, brown, yellow or purple. The white meat that is revealed, once the culm sheath is peeled off, turns yellowish when it is cooked. The edible tender shoots look like coiled springs and have an astringent flavor. The shoots of some species are known to contain cyanogenic glycosides, called taxiphyllin, [2-(b-D-glucopyranosyloxy)-2-(4-hydroxyphenyl) acetonitrile] which, therefore, develops acrid taste in bamboo shoot (Fu et al. 2002; Sarangthem and Singh 2003; Anonnymous 2004).

Chemical quality

Bamboo shoots are low in fat content, but contain considerable amount of carbohydrate, potassium and dietary fibres. Many nutritious and active materials such as Vitamins, amino acids and anti-oxidants such as flavones, phenols and steroids can be extracted from the bamboo shoots (Shimada 1972; Sarangthem and Singh 2003). Bamboo shoots can be processed into a wide variety of beverages, medicines, additives and health foods (Lobovikov 2003; Majumdar 2006). However, there is hardly any product that has created its way into the market. A shoot contains about

90% of water at the time of harvest. However, carbohydrate, fat and protein content were observed to decrease after canning and fermentation (Kumbhare and Bhargava 2007; Nirmala et al. 2008). Table 1 shows the chemical analysis of commonly edible raw bamboo shoots.

Nutritional quality

Bamboo shoot is a good source of potassium, Vitamin E (α-Tocopherol), Vitamin C, Vitamin B6, thiamin riboflavin, niacin, iron, phosphorus and dietary fibers like hemicelluloses, cellulose, pectin, lignin (Tripathi 1998; Park and John 2009). With 17 different types of amino acids, bamboo shoots contain about ten types of minerals like Cr, Zn, Mn, Mg, Ni, Co, Cu, etc. and lysine, one of the limited amino acids, which is helpful for growth and development of children is found in bamboo shoots (Shimada 1972; Reiss 1993; Fu et al. 2002; Bhatt et al. 2005a, b; Nirmala et al. 2007). Germaclinium in shoots has been reported to carry anti-aging properties (Sarangthem and Singh 2003). Ash of bamboo shoots has been reported in use in Ayurveda medicines in India (Puri 2003). Table 2 shows the detailed nutritive values of processed bamboo shoots.

Sensory quality

The bamboo shoots of some species, owing to the presence of cyanides, develop an acrid flavor (Midmore 1998; Sue 1995). The new shoots are free from acrid taste and are brilliant for human consumption. HCN is a crash product of cyanogenic glycosides which breakdown upon disruption of the plant cell. The quantity of cyanides in bamboo shoots, however, varies depending upon the species, for instance, the amount of cyanides is 894 mg/kg in *Dendrocalamus giganteus* (Ferreira et al. 1995). It has been reported that up to 0.16% of total cyanide is contained in the tip of the shoot, reducing to 0.01% in the base (Haque and Bradbury 2002). Table 3 shows the hydrogen cyanide (HCN) content (mg/g of bamboo shoot) of some of the commonly edible bamboo shoot species. Cyanogenic glycosides can produce both acute and chronic toxicity, but degrades readily by boiling in water. Nearly 70% of HCN is removed by boiling bamboo shoots for 20 min at 98 °C and about 96% is removed by boiling at this temperature for longer interval (Ferreira et al. 1995).

Bamboo shoot and value addition

There is a growing demand for processed and packaged bamboo shoots in the national and international markets. Shelf life of freshly harvested bamboo shoots is 9 and 23 days in water and brine, respectively (National Mission for Bamboo Applications, India 2009). During storage, a bitter taste develops in the bamboo shoots, if stored for a longer period of time, or exposed to sunlight. It has been reported that bamboo shoots, preserved in plastic bags have a risk of contamination by the materials present in the plastic bags (Chiangthong and Chayawat 2009).

Bamboo shoots containing carbohydrates, proteins and minerals can be expected as part of a healthy diet in fresh, canned and fermented forms. Whether as an accompanying vegetable or as main ingredient, bamboo shoots make a brilliant totaling to many pickled condiments, stir fries, soups and beverages. Bamboo shoots can be dried, marinated and sauteed, can be formed powders, nuggets and can be used as medicines. Moreover, production of bamboo being seasonal with high demand throughout the year, especially in China, Japan, USA, Canada, Thailand, Nepal, Bhutan, Australia and India, there is a need to develop process technologies to preserve the bamboo shoots in consistent and imperishable forms to be used during the off-seasons.

Table 1 Chemical compositions of some of the commonly edible bamboo shoot species (Bhatt et al. 2005a, b)

Nutrients	Bamboo species						
	B. balcooa	*B. polymorpha*	*M. bambusoides*	*D. strictus*	*D. hamiltonii*	*D. giganteus*	*B. pallida*
Water (%)	91.65	91.65	91.22	85.98	92.37	91.19	92.29
Minerals (%)	0.99	0.91	0.98	1.14	1.01	0.89	1.12
Phosphorus (mg/100 g)	30.99	15.06	14.28	58.13	27.76	12.57	32.27
Calcium (mg/100 g)	24.01	180.69	47.58	139.5	44.16	26.93	21.17
Iron (mg/100 g)	1.02	1.53	0.879	2.917	1.65	1.06	1.11
Hydrocyanicaacid (%)	0.071	0.032	0.056	0.13	0.070	0.044	0.106
Protein (%)	2.74	2.10	3.29	1.98	2.60	2.59	2.31
Niacin (mg/100 g)	1.40	2.60	6.70	2.10	2.60	6.40	1.40
Carbohydrate (%)	3.90	4.86	3.93	9.94	4.00	4.78	3.83

Table 2 Various constituents in processed bamboo shoots (Young 1954)

Constituents	Quantity per 100 g
Dietary fibers	1.5 g
Lignin	46 mg
Proteins	21.45 g
Essential amino acids	7.51 g
Non-essential amino acids	10.08 g
Cellulose	850 mg
Monosaccharide	307 mg
Polysaccharides	288 mg
Saturated fatty acids	50 mg
Monounsaturated fatty acids	0.7 mg
Polyunsaturated fatty acids	120 mg
Long chain fatty acids	181 mg
Sodium	268 mg
Potassium	224 mg
Calcium	17 mg
Iron	0.5 mg
Zinc	0.18 mg
Sodium Chloride	68 mg
Uric acid	25 mg

Fresh bamboo shoots as foods

People consume fresh bamboo shoots in various forms. Bamboo shoot can be eaten fresh after boiling. In Indonesia, bamboo shoots are eaten with thick coconut milk and spices, which are called *gulei rebung*; sometimes also mixed with other vegetables, called *sayur lade* (Bhatt et al. 2003). Sweet pickles, chutney and candies are prepared from the pith of the bamboo shoots in the region. The sap of young stalks tapped during the rainy season is simply made into a soft drink in China (Yang et al. 2008). In Manipur, the fresh bamboo shoots are taken with dry fish (Tamang and Tamang 2009). The edible bamboo species in Western Ghats of India are extensively used as snacks, fried food stuffs, and curries (Bhatt et al. 2003). *Tama*, a non-fermentated bamboo shoot curry is very familiar among the people of Sikkim (Tamang 2009). In Singapore, people consume bamboo shoots in form of canned or frozen (Pan 1995).

Dried bamboo shoots

Drying is the oldest and simplest food processing technology in the food industry. Extensive research work has been carried out on drying technology. However, very little work is reported on drying of bamboo shoots. Nevertheless, it has been reported that there is a 95.1% decrease in the moisture content of dried bamboo shoots (Satya et al. 2010). Water content of fresh bamboo shoots is 92.6/100 g of fresh weight compared to 4.6/100 g in dried bamboo shoots (Muchtadi and Adawiyah 1996). Cheng (2006) reported a multi-stage vacuum pressure reserving technique combined with hydrocooling could reduce the temperature of bamboo shoots efficiently. The author suggested that the process has the advantage of minimizing the energy consumed by the vacuum system. A comparative study of various methods for drying of bamboo shoot along with their advantages and disadvantages has been systematically reported by Majumdar (2006) and Satya et al. (2010). Bal et al. (2010) studied the effect of microwave power on drying kinetics of bamboo shoots. The authors suggested that increasing microwave output power, the effective moisture diffusivity values increased from 4.153×10^{-10} to 22.835×10^{-10} m^2s^{-1}.

It may be noted that in selecting or designing an appropriate drying technology, it is important to explore energy, environmental and cost issues. Different technologies may be appropriate at different geographical locations depending on local socio-cultural conditions. Quality attributes of end product using multi-stage drying technologies, such as solar-assisted heat pump drying, solar drying with thermal energy storage, microwave assisted vacuum drying, refractive drying and supper heated steam drying may be explored for drying bamboo shoots.

Canned bamboo shoots

High moisture content of bamboo shoots make them easily perishable giving space for the growth of undesirable micro-organisms like bacteria, molds and yeasts. Canning has been observed to be effective in abating rancidity and preventing the growth of micro-organisms in bamboo shoots (Fu et al. 2002). Canned bamboo shoots can be satisfactorily preserved and can be used

Table 3 Hydrogen cyanine (HCN) content of some of the commonly edible bamboo shoot species (mg/g of bamboo shoot)

Region of the shoot	Bamboo species				
	D. hamiltonii	*B. pallida*	*B. tulda*	*B. balcooa*	*M. bambusoides*
Tip	2.42	0.27	0.17	2.15	1.81
Middle portion	0.86	0.17	0.83	1.38	0.68
Base	0.15	0.13	0.28	0.62	0.35

frequently in various food items such as vegetables or pickle condiments.

Fermented food items

Traditionally, various fermented bamboo shoot products are consumed in the world. Ethnic people living in sub Himalayan regions, Nepal and Bhutan prepare and consume a variety of domesticated and wild bamboo shoots and their fermented products (Sharma 1989; Tamang and Tamang 2009; Tamang et al. 1988; Tamang 2000; Vaiphei 2005). A traditional fermented bamboo shoot product of the eastern hills of Nepal and Bhutan is *mesu* (Tamang and Sarkar 1996). Use of *mesu* as a pickle and as a base in curries is a conventional dish among the Nepalis, Bhutias and the Lepchas of the Darjeeling hills and Sikkim (Tamang 2005). Delicacies in Indian cuisines include *ushoi, soidon, soibum*, *soijim*, *iromba*, *ekung, eup*, *hiring lung-siej* and *syrwa* (Giri and Janmejay 1987; Tamang 2000, 2009; Mao and Odyuo 2007; Agrahar-Murungkar and Subbulaskhmi 2006; Jeyaram et al. 2009). *Ushoi*, a fresh bamboo shoot, is one of the popular food products among the Manipuris and *Apa Tanis* of Arunachal Pradesh. *Soibum,* a fermented bamboo shoot, is an exceptional delicacy of the Meities of Manipur, eaten as pickle and curry mixed with fermented fish. Similar fermented bamboo shoot product called *naw-mai-dong* or *nor-mai-dorng* is consumed in Thailand (Phithakpol et al. 1995). *Soidon* is another fermented bamboo shoot product in Manipur, prepared from the tip of matured bamboo shoots and consumed both as a curry and pickle. *Soijim* is another type of fermented bamboo shoot product developed by submerged fermentation in Manipur. *Iromba* is a fermented or boiled bamboo shoot taken with fish and other vegetables by *Khasi* tribes in Meghalaya (Agrahar-Murungkar and Subbulaskhmi 2006).

The sap of young stalks tapped during the rainy season is fermented to prepare *ulanzi* (a sweet wine), which is used by Chinese as a delicious liquor (Qing et al. 2008). In central India, the young shoots are grated and fermented to prepare *kardi* or *amil*, a sour vegetable soup. In the region, the bamboo shoots are fermented, dried, ground into powder and used as a garnish called *hendua*, which is commonly preferred liquor among the tribal people (Panda and Padhy 2007; Bal et al. 2009). In Nepal, bamboo shoots are fermented with turmeric and oil, and cooked with potatoes to prepare an item called *alu tama* (Tamang 2009).

Bamboo shoot based powder

Bamboo shoot, from its constituents, indicates that it contains considerable amount of carbohydrate and dietary fibers. During boiling, the polysaccharides get hydrolyzed into simple sugars and gives sweet taste to the shoots (Kumbhare and Bhargava 2007). The key advantages of using dried bamboo shoot powder is its low moisture content which may allow its direct use into various dry food items, and preparing chutney and beverages. Other advantages of using dried bamboo shoot based powder may include free-flowing, ease of handling and weighing, reduced storage space, ease of cleaning and sanitary aspects. In Japan, bamboo shoot-based powder is used as an essence in cookies and various other food items. Japanese use bamboo powder in standard bread flour and also recommends a 3–8% addition of the powder to any food products (Hua 1987). In China, bamboo juice produced by pressure-cooking, is used to make beverages and specific liquors, apart from medicines (Qing et al. 2008). With a characteristic bamboo aroma and beer flavor, bamboo juice beers show a good number of health benefits by lowering blood lipids and fighting heart ailments (Shi and Yang 1992; Satya et al. 2009b).

Medicines

Bamboo shoot has been in use in medicine, since time immemorial by the tribal people in various regions. With different flavones, glycosides, bamboo shoots have good anti-oxidant, anti-free-radical and anti-aging agents, and can be extracted to make capsules and tablets (Shi and Yang 1992; RFRI 2008). In the traditional system of Ayurveda, the silicious concretions found in the bamboo shoots is called *banslochan* and in the Indo-Persian and Tibettan system of medicine, it is called as *bamboo manna* and is known to be a good tonic for respiratory disorders. *Bambusa arundinacea* species is considered as the excellent source of *bamboo manna* (Puri 2003).

In China, bamboo shoots are used for treating infections. The juice of pressed bamboo shoots possesses protease activity that helps in digestion of protein. The boiled bamboo shoots are used as appetizers. Decoction of the shoots are used for cleaning wounds and maggot infected sores, ulcers etc. Bamboo shoots, mixed with palm-jaggery, are known to induce parturition or abortion (Shi and Yang 1992; Puri 2003). In Java, sap from inside the shoots of *Bambusa vulgaris* is used for curing jaundice (Burkill 1935).

Bamboo salt tablets used in Korea are known to help treat certain internal maladies. These are prepared by sealing salt in bamboo shoots using uncontaminated yellow clay and then baking them eight times in a specially designed furnace. This allows the salt to absorb highly therapeutic trace elements including Cu, Zn and Fe and also eliminates any impurities and heavy metals from the salt that can cause any damage to the body. It serves as a natural detoxifying agent with a strong anti-microbial property and

also provides energy and nutrients to the body (Liu 1992). Korea markets a delicious *bamboo sea salt*, which is used as an alternative to table salt in cooking (Cost 1988). Korea is even reported of marketing bamboo shoot-based cosmetics such as cleansing agent called *bamboo bath salts* (Cost 1988).

Future prospects

A thriving economy revolves around bamboo resource. Bamboo is well placed to address the food security through bamboo-based agro-forestry systems by maintaining the fertility of adjoining agricultural lands, and as a direct food source like edible bamboo shoots. Bamboo shoots hold the prospect of value added economic activities at industrial and society levels through cultivation, processing, packaging and commercialization. However, the preparation of various bamboo shoot-based food products is traditional, local, unorganized and based on the taste of the local people. There is no standardized process technology for preservation of the raw bamboo shoots into various food items in an organized manner. This calls for the development of appropriate technologies for preservation of bamboo shoots in various forms. In India, there is yet neither major approach for promotion of shoots nor is there well thought-out market or supply chain for the raw or processed bamboo shoots. Focus should be directed for following aspects for sustainable development of a bamboo shoot-based food industry.

- Identification and selection of most suitable edible species
- Recommendation of proper package of practice for bamboo cultivation
- Appropriate fermentation technology of edible bamboo shoots
- Groove management procedures (plantation, maintenance, and harvesting)
- Materials processing (grading, cleaning, and drying)
- Product manufacturing (equipment, foods, jigs, dyes, paints, varnishes)
- Marketing (customer identification, distribution, advertisements)

Conclusion

Bamboo is a plant species that incorporates several economic, ecological and social benefits in the day to day life of human beings. Therefore, organized cultivation for bamboo shoot may be encouraged. This requires the use of a different package of practice which normally holds better soil, water and light conditions, and more intensive management. Plantation of the most edible and adventurous species, preferably *Dendraocalamus giganteus*, *Dendrocalamus asper, Bambusa balcooa* and *Dendrocalamus hamiltonii* may be adopted. Standardized cultivation practices at various locations may be encouraged by government and non-government organizations, especially in tribal areas in order to harmonize the international food safety, security and nutrition.

Acknowledgement The authors are thankful to the University Grants Commission (UGC), New Delhi for providing financial support to carry out the research work.

References

Agrahar-Murungkar D, Subbulaskhmi G (2006) Preparation techniques and nutritive values of fermented foods from the Khasi tribes of Meghalaya. Ecol Food Nutr 45:27–38

Anderson JM, Ingram JSI (1993) Tropical soil biology and fertility: a handbook methods. CAB International, UK, p 218

Anonnymous (2004) Cyanogenic glycosides in cassava and bamboo shoots, a human health risk assessment. Technical report series no. 28. Food Standards in Australia and New Zealand

Baker H, Frank O, De Angelis B, Feingold S (1980) Plasma tocopherol in man at various times after ingesting free or acetylated tocopherol. Nutr Rep Int 21:531–536

Bal LM, Sahu JK, Prusty SR (2008) Opportunity of bamboo shoots for nutritional security and socio-economical prosperity of north eastern region of India. Proceedings of the conference on Agricultural Engineering inputs for the development of the NR region. Assam University, Silchar on 3rd December, 2008, pp. 108–114

Bal LM, Naik SN, Satya S (2009) Scientific validation of indigenous knowledge system for bamboo shoot processing and utilization. Proceedings of national seminar on bamboo plantation, management and its utilization. 17th–19th March, 2009, Jodhpur, India. pp. 70

Bal LM, Kar A, Satya S, Naik SN (2010) Drying kinetics and effective moisture diffusivity of bamboo shoot slices undergoing microwave drying. Int J Food Sci Technol 45(11):2321–2328

Bhatt BP, Singha LB, Singh K, Sachan MS (2003) Some commercial edible bamboo species of North East India: production, indigenous uses, cost-benefit and management strategies. J Am Bamboo Soc 17 (1):4–20

Bhatt BP, Singh K, Singh A (2005a) Nutritional values of some commercial edible bamboo species of the North Eastern Himalayan region, India. J Bamboo Rattan 4(2):111–124

Bhatt BP, Singha LB, Singh K, Sachan MS (2005b) Commercial edible bamboo species of the north eastern Himalayan region, India. Part II. Fermented, roasted and boiled bamboo shoots. J Bamboo Rattan 4(1):13–31

Bradford MM (1976) A rapid and sensitive method for the quantization of micrograms quantities of protein utilizing the principle of protein-dye binding. Anal Biochem 72:248–254

Burkill IH (1935) A dictionary of the economic products of the Malay Peninsula. Crown Agents for the Colonies, London, pp 129–130

Cahill A (1999) Field day to explore edible bamboo shoot market. News Release, Dept of Primary Industries Queensland

Caitlin B, Miles C (2000) Investigating bamboo as an alternative crop in the Maritime Pacific Northwest. Pacific Northwest Sustain. Agric. 12(2):4–6

Cheng HP (2006) Vacuum cooling combined with hydrocooling and vacuum drying on bamboo shoots. Appl Therm Eng 26 (17–18):2168–2175

Chiangthong K, Chayawat L (2009) Bamboo shoot stream processing from Tha Sao community, Dept. of Science and Technology, Kanchanaburi Rajabhat University, Thailand

Cost B (1988) Asian ingredients: a guide to the foodstuffs of China, Japan, Korea, Thailand and Vietnam. Harper Collins Publishers, USA

Daphne L (1996) Bamboo shoots: delicious to eat, easy to sell. Washington Tilth. Autumn. 7–9

Dollo M, Samal PK, Sundriyal RC, Kumar K (2009) Environmentally sustainable traditional natural resource management and conservation in Ziro Valley, Arunachal Himalaya, India. J Am Sci 5 (5):41–52

Farooquee NA, Dollo M, Kala CP (2007) Traditional Wisdom of Apatani Community in the management and sharing of natural resources in North Eastern India. In: Misra KK (ed) Traditional knowledge in contemporary societies: challenges and opportunities. Pratibha Prakashan, Delhi, pp 110–126

Ferreira VLP, Yotsuyanagi K, Carvalho CRL (1995) Elimination of cyanogenic compounds from bamboo shoots *Dendrocalamus giganteus Munro*. Trop Sci 35:342–346

Fu MY, Ma NX, Qui FG (1798) Bamboo production and scientific research in Thailand [Chinese]. J Bamboo Res 6(1):54–61

Fu S, Yoon Y, Bazemore R (2002) Aroma-active components in fermented bamboo shoots. J Agric Food Chem 50(3):549–554

Gangwar AK, Ramakrishnan PS (1987) Cropping and yield patterns under different land use systems of the *Khasis* at higher elevations of Meghalaya in North-Eastern India. Int J Ecol Environ Sci 13:73–86

Giri SS, Janmejay LS (1987) Microbiological and chemical contents of the fermented bamboo shoot *soibum*. Front Bot 1:89–100

Goering HK, Van Soest PJ (1970) Forage fiber analysis. Agric. Handbook No. 379, ARS, USDA, Washington, DC. pp. 20

Haque MR, Bradbury JH (2002) Total cyanide determination of plants and foods using the picrate and acid hydrolysis methods. Food Chem 77:107–114

Hua X (1987) Bamboo shoot cultivation and management in Japan. In: Symposium on bamboo professional commission of zhaihiang forestry society, pp. 16

Jeyaram K, Singh TA, Romi W, Devi AR, Singh WM, Dayanidhi H, Singh NR, Tamang JP (2009) Traditional fermented foods of Manipur. Indian J Tradit. Knowl. 8(1):115–121

Kigomo, B (2007). Guidelines for growing bamboo. KFRI Guideline Series: No 4, Kenya Forestry Research Institute, Nairobi, Kenya.

Kumbhare V, Bhargava A (2007) Effect of processing on nutritional value of central Indian bamboo shoots. Part −1. J Food Sci Technol 44(1):29–31

Lee Y, Takahashi T (1966) An improved colorimetric determination of amino acids with the use of ninhydrin. Anal Biochem 14:71–77

Liu MS (1992) Bamboo shoot. In: Hui YH (ed) Encyclopedia of food science and technology, vol 3. Willey, New York, pp 177–180

Lobovikov M (2003) Bamboo and rattan products and trade. J Bamboo Rattan 2(4):397–406

Maikhuri RK (1996) Eco-Energetic analysis of village ecosystem of different traditional societies of Northeast India. Energy 21 (12):1287–1297

Majumdar AS (2006) Some recent developments in drying technologies appropriate for postharvest processing. Int J Postharvest Technol Innov 1(1):76–92

Mao AA, Odyuo N (2007) Traditional fermented foods of the Naga tribes in the Northeastern India. Indian J Tradit. Knowl. 6(1):37–41

Mecreddy RM, Guggolz J, Silviera V, Owens HS (1958) Determination of starch and amylase in vegetables. Anal Chem 22:1156

Midmore D (1998) Culinary bamboo shoots. The new rural industries. In: Hyde KW (ed), Rural industries research and development corporation, pp. 188–196

Muchtadi TR, Adawiyah DR (1996) Bamboo shoot drying technology. In: Ganapathy PM, Janssen JA, Sastry CB (ed), Engineering and utilization (pp. 239–245). INBAR Technical report No. 8. Proceedings of the Vth international bamboo workshop and the IVth international bamboo congress, 12th–22nd June, 1995. Indonesia

National Mission on Bamboo Applications (2009) Bamboo shoot composition. NMBA, India

Nirmala C, David E, Sharma ML (2007) Changes in nutrient components during ageing of emerging juvenile bamboo shoots. Int J Food Sci Nutr 58(8):612–618

Nirmala C, Sharma ML, David E (2008) A comparative study of nutrient components of freshly harvested, fermented and canned bamboo shoots of *Dendrocalamus giganteus* Munro, bamboo science and culture. J Am Bamboo Soc 21(1):41–47

Pan C (1995) Market opportunities for fresh and processed Asian vegetables. Canberra, RIRDC Research Paper No. 95/14. pp 117

Panda T, Padhy RN (2007) Sustainable food habits of the hill dwelling *Kandha* tribe in Kalahandi district of Orissa. Indian J Tradit. Knowl. 6(1):103–105

Pande SK, Pandey S (2008) Bamboo shoots for the 21st century. Int For Rev 10(2):134–146

Park E, John D (2009) Effects of bamboo shoot consumption on lipid profiles and bowel function in healthy young women. Nutri 25 (7–8):723–728

Phithakpol B, Varanyanond W, Reungmaneepaitoon S, Wood H (1995) Traditional fermented foods of Thailand. ASEAN Food Handling Bureau, Kuala Lumpur

Puri HS (2003) Rasayana ayurvedic herbs for longevity and rejuvenation. Taylor and Francis, London, pp 71–73

Qing Y, Zhu BD, Zheng LW, Kai HH, Qi XS, Zhen HP (2008) Bamboo resources, utilization and ex-situ conservation in Xishuangbanna, south-eastern China. J Forest Res 19(1):79–83

Reiss C (1993) Measuring the amount of ascorbic acid in cabbage. In: Goldman CA, Hauta PL (ed). Tested studies for laboratory teaching. Vol. 7/8. Proceedings of the 7th and 8th Workshop/ Conference of the Association for Biology Laboratory Education (ABLE). pp. 85–96. Available online at: http://www.zooutoronto.ca/able. Accessed on 27th July, 2010

RFRI (2008) Bamboo as food and medicine. Report of Rain Forest Research Institute (RFRI). Jorhat, India. www.icfre.gov.in/new/rfri/Bamboo_%20food_%20medicine_221206.pdf. Accessed on 11th March, 2010.

Rubatzky VE, Yamaguchi M (1997) World vegetables: principles, production and nutritive values. Chapman and Hall, New York, pp 658–660

Sarangthem K, Singh TN (2003) Microbial bioconversion of metabolites from fermented succulent bamboo shoots into phytosterols. Curr Sci 84(12):1544–1547

Satya S, Singhal P, Prabhu VG, Bal LM, Sudhakar P (2009b) Exploring the nutraceutical potential and food safety aspect of bamboo shoot of some Indian species. VIII World Bamboo Conference, Bangkok, Thailand. 6: 78–88

Satya S, Bal LM, Singhal P, Naik SN (2010) Bamboo shoot processing: food quality and safety aspect (a review). Trends Food Sci Technol 21(4):181–189

Sharma, YML (1980). Bamboos in the Asia-Pacific region. In: Lessard G, Chouinard A (ed) Bamboo research in Asia. Proceedings of a workshop held in Singapore. International Development Research Centre, Ottawa, Canada. pp. 99–120

Sharma OP (1989) Dendrocalamus hamiltonii Munro, the Himalayan miracle bamboo. In: Trivedi ML, Gill BS, Saini SS (eds) Plant Science Research in India. Today and Tomorrow's Printers and Publishers, New Delhi, pp. 189–195

Sharma YML (1987) Inventory and resource of bamboos. In: Rao AN, Dhanarajan G, Sastry CB (eds) Recent research on bamboo. Proceedings of the International Bamboo Workshop, Hangzhou, China, 6th-14th October, 1985. Chinese Academy of Forestry, Beijing, China; International Development Research Centre, Ottawa, Canada. pp. 1–17.

Shi QT, Yang KS (1992) Study on relationship between nutrients in bamboo shoots and human health. In: Bamboo and its use. Proceedings of the international symposium on industrial use of bamboo (pp. 338–346), Beijing. 7th–11th, December, 1992. International Tropical Timber Organization and Chinese Academy

Shimada M (1972) Biochemical studies on bamboo lignin and methoxylation in hardwood and softwood lignin. Wood Research: Bulletin of the Wood Research Institute Kyoto University, 53:19–6

Sue T (1995) Bamboo shoots = good food. Temp. Bamboo Q. 2(1):1–2, and 8–11

Tai KY (1985) The management and utilization of shoot-producing bamboos in Taiwan [Chinese]. Q J Chin For 18(2):1–46

Tamang JP (2000) Traditional fermented foods and beverages of the Sikkim Himalayas in India: indigenous process and product characterization. Proceedings of the International Conference on Traditional Foods, 6th–8th March, 1997, CFTRI, Mysore, India. pp. 99–116

Tamang JP (2005) Food culture of Sikkim. In: Sikkim study series, Vol. IV. Gangtok, Dept of Information and Public Relations, Govt. of Sikkim, India

Tamang JP (2009) Himalayan fermented foods: microbiology, nutrition and ethnic value. CRC Press, Taylor and Francis Group, New York

Tamang JP, Sarkar PK (1996) Microbiology of *mesu*, traditional fermented bamboo shoot product. Int J Food Microbiol 29:49–58

Tamang B, Tamang JP (2009) Traditional knowledge of biopreservation of perishable vegetables and bamboo shoots in the Northeast India as food resources. India J Tradit. Knowl. 8(1):89–95

Tamang JP, Sarkar PK, Hesseltine CW (1988) Traditional fermented foods and beverages of Darjeeling and Sikkim-a review. J Sci Food Agric 44:375–385

Tripathi YC (1998) Food and nutrition potential of bamboo. MFP News 8(1):10–11

Upreti TC, Sundriyal RC (2001) Indigenous resources and community dependence: a case study from Arunachal Pradesh, India. Grassroots Voices - A J Resour Dev. 6(1–2):28–39

Vaiphei SL (2005) Bamboo's economic value to the northeast. ManipurOnline. www.manipuronline.com/Economy/January2006/bamboo18_1.htm. Accessed on 5th January, 2010.

Yang Q, Duan Z, Wang Z, He K, Sun Q, Peng Z (2008) Bamboo resources, utilization and ex-situ conservation in Xishuangbanna, South-eastern China. J Forest Resour 19(1):79–83

Young RA (1954) Flavor qualities of some edible oriential bamboos. Econ Bot 8:377–386