

REVIEW PAPER

Bamboo Shoots: Composition, Nutritional Value, Therapeutic Role and Product Development for Value Addition

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Abstract

Bamboo shoot is an important constituent of traditional cuisine of some parts of India, particularly in North-Eastern region and is highly valued for its nutritional and health benefits due to the presence of several bio-active compounds. Raw, canned, boiled, marinated, fermented, frozen, liquid and medicinal are the several forms in which bamboo shoots are processed. However, the consumption pattern of bamboo shoots is traditional, non-standardized, seasonal and region-specific with little value addition. Due to seasonal availability of bamboo shoot, processing for handling cytogenetic toxicity in raw shoot while keeping nutrients intact and enhancement of shelf life of the value added products assume great significance for business potential. There exists an urgent need to adopt the processing of bamboo shoot-based food products in an organized manner. The present article gives an overview of bamboo shoot-based food products, their quality attributes and the opportunities for value addition along with future prospects.

Keywords: Bamboo shoots, value addition, processing, products, nutrition, composition

Bamboo is a rapid growing fibrous plant available in abundance on the earth. It is a perennial, giant, woody grass and the fastest growing plants in the world. It belongs to the group angiosperms and the order monocotyledon and is classified under the grass family *Poaceae* (or *Gramineae*) under the subfamily *Bambusoideae* (Chapman, 1996). Bamboos are grown in tropical and subtropical (cosmopolitan) climate, with distribution covering wide areas of Asia, Africa, the Caribbean and Latin America. It being versatile, is a widely used bio-resource and is rightly considered as "Green Gold" (Choudhury *et al.* 2012, Dut, 2004). Over 1,200-1,500 species and about 60 to 70 genera of bamboo have been identified globally (Wang and Shen, 1987). Due to its diverse adjustability to a varied range of climates, cultivation

of bamboo shoots spread across different continents, from tropical jungles of Chile to the mountain slopes of the Himalayas.

Bamboo has a very long history with mankind. In India, annual turnover of the bamboo sector is estimated to be around ₹ 2500 crores and the size of bamboo industries is envisaged to grow to ₹ 26,000 crores by 2015 (Choudhury *et al.* 2012). About 2.5 billion people worldwide use bamboo and 1.0 billion people live in bamboo houses on the globe.

Apart from the diverse use that the various parts of the plant are put to, the tender shoot is consumed as a foodstuff during monsoons, when the fresh culms emerge out of the ground as shoot. The tender young offspring of bamboo which are generally harvested

after a growth period of two weeks are crisp and tender, and are widely used as a vegetable in Asian cooking (Fig. 1). Bamboo shoots or bamboo sprouts are young stems that are harvested when they reach a height of 30 cm. They are tender, soft, crispy, generally ivory yellow in colour. The sheaths which are covering the shoots are black, brown, yellow or purple. The underlying white part that is revealed, once the culm sheath is peeled off, turns yellowish when it is cooked.



Fig. 1: Bamboo shoot

Bamboo shoots are seasonal, perishable, short lived and unpreserved but are becoming one of the preferred food items among the people all over the world. Implying thereby a need to explore a well-organized bamboo shoot processing scheme making them available throughout the year. The edible bamboo shoots are of two types- winter and spring (Choudhury *et al.* 2012). Spring shoots are larger and tougher compared to winter shoots though are available in fresh and canned forms.

History of bamboos as a food

In earlier times, people were forced to find edible alternatives in the surroundings and from the forests when food was scarce and access to foodstuff was minimal, and bamboo shoot is one such 'food from the forest' that they soon began to relish. Hence,

began the use of bamboo shoot as food substance. The consumption of the harvested shoot of bamboo, as it emerges out of the ground, in various forms, has been more of a necessity rather than a delicacy, for the native rural population. There is a growing demand for processed and packaged bamboo shoots in the national and international markets. Bamboo shoots form a traditional and one of the most favourite food items in many countries like China, Japan, US, North East India, Thailand, Nepal, Bhutan, Korea, Australia, New Zealand, Malaysia and Indonesia (Choudhury, 2012).

Some of the edible varieties of bamboo available in different parts of India and other countries are listed in Table 1.

Table 1: Edible varieties of bamboo available in different parts of India and other Countries

North east (India)	<i>Dendrocalamus longispachus</i> , <i>D. Brandisii</i> , <i>Bambusa baluana</i> , <i>B. polymorpha</i> , <i>B. pallida</i> , <i>Melocanna baccifera</i>
South (India)	<i>Arundinaria aristata</i> , <i>A. Hirstuta</i> , <i>B. Arundinacea</i> , <i>B. glaucescens</i> , <i>B. Longispiculata</i> , <i>B. vulgaris</i> , <i>Cephalostachyum capitatum</i> , <i>C. fuchsianum</i> , <i>D. Hookeri</i> , <i>Oxytenanthera albociliata</i>
Central (India)	<i>D. strictus</i> , <i>B. Bambos</i>
Japan	<i>Bambusa oldhamii</i> , <i>Dendrocalamus asper</i> , <i>Phyllostachys edulis</i> , <i>P. bambusoides</i> , <i>P. pubescens</i> , <i>P. mitis</i>
China	<i>Bambusa oldhamii</i> , <i>Dendrocalamus asper</i> , <i>D. brandisii</i> , <i>D. latiflorus</i> , <i>Phyllostachys praecox</i> , <i>P. iridescens</i> , <i>P. nuda</i> , <i>Phyllostachys makinoi</i> , <i>P. pubescens</i> , <i>P. viridis</i> , <i>Pleioblastus amarus</i> , <i>Thyrsostachys siamensis</i>
Thailand	<i>Bambusa edulis</i> , <i>B. oldhamii</i> , <i>B. pallida</i> , <i>Dendrocalamus asper</i> , <i>D. latiflorus</i> , <i>Thyrsostachys siamensis</i>
Nepal	<i>Dendrocalamus giganteus</i> , <i>D. hamiltonii</i> , <i>D. hookeri</i> , <i>D. sikkimensis</i>
Taiwan	<i>Bambusa edulis</i> , <i>B. multiplex</i> , <i>B. oldhamii</i> , <i>B. pallida</i> , <i>Dendrocalamus asper</i> , <i>D. latiflorus</i> , <i>Phyllostachys makinoi</i> , <i>P. pubescens</i> and <i>Thyrsostachys siamensis</i>
United States	<i>Phyllostachys dulcis</i> , <i>P. edulis</i> , <i>P. bambusoides</i> , <i>P. pubescens</i> , <i>P. nuda</i> , <i>P. Viridis</i>

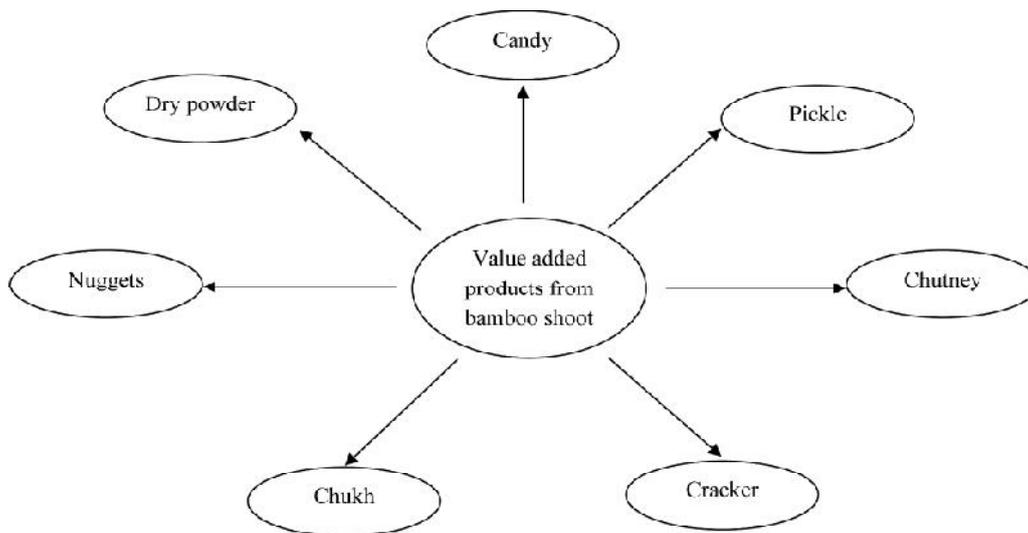


Fig. 2: Value added products from bamboo shoot

Source: Pandey *et al.* 2012; Nirmala *et al.* 2011.

VALUE ADDITION TO BAMBOO SHOOTS

Value addition to bamboo can be done by making different edible products which can lead to cultivation of bamboo shoots by the farmers and help in their income generation. The supple texture and rich aroma adds value to the bamboos. The shoots are used as food in various ways and forms such as fresh, dried, preserved, shredded or pickled (Fig. 2). Moreover, they are used as extender as they take on the flavour of the ingredients they are cooked with. Different types of preparations such as bamboo shoot curry, chutney, bamboo candy, pickle, fried shoots, pulav, kheema, manchurian, soup, bamboo canned juice, and bamboo beer are made from bamboo shoots.

Juice of bamboo vinegar, stored for about 50-60 days is used for flavouring vegetables. Canned bamboo shoots can be satisfactorily preserved and can be used frequently in various food items such as vegetables or pickle condiments (Sood, 2013). Bamboo shoot powder offers several advantages such as low moisture content, free-flowing, ease of handling and weighing, reduced storage space, ease of cleaning and sanitary aspects. It could be directly used into

various dry food items and preparing chutney and beverages.

PHYSICAL QUALITY CHARACTERISTICS OF BAMBOO SHOOTS

Bamboos mainly consist of the roots, culm and leaves. The culms are the most distinguishable part in a bamboo plant species. They are usually hollow and vary in sizes, diameters, colours and textures. Countless tiny black spots can be seen at the cross-section of the culm (hollow stem). These are the cellulose fibers which run along the length of the culm carrying nutrients between roots and leaves. The rest of stem is lighter coloured lignin. Individually, cellulose is stronger of the two components. Bamboo shoots are the young, edible bamboo plants that have just emerged from the ground. They are generally 20-30 cm long, tapering at one end. The shooting period of bamboo varies from species to species; their size and weight depending noticeably on location, depth and nutrition besides other factors.

Broadly, the temperate climate bamboos are runners, which shoot in the spring, while the tropical and sub-tropical are clumpers, which shoot in the late summer and fall (Choudhury *et al.* 2012). The physical properties of some edible bamboo shoot species and their HCN content are given in Table 2.

Table 2: Physical properties of some edible bamboo shoot species and their HCN content

Bamboo species	Distribution of HCN (mg/g of bamboo shoot) Region of the bamboo shoot			Physical properties of bamboo shoots (<i>D. hamiltonii</i>)	
	Tip	Middle	Base	Parameters Values	
<i>D. hamiltonii</i>	2.42	0.86	0.15	Length (cm)	26.50±0.04
<i>B. pallid</i>	0.27	0.17	0.13	Circumference (cm)	7.00±0.55
<i>B. tulda</i>	0.17	0.83	0.28	Weight of shoot (g)	300±1
<i>B. balcooa</i>	2.15	1.38	0.68	Peel (%)	66.67±0.04
<i>M. bambusoides</i>	1.81	0.68	0.35	Edible portion (%)	33.33±0.12
				Length (cm)	26.50±0.04

Source: Choudhary, *et al.* 2012; Haque and Bradbury, 2002; Sood *et al.* 2013.

CHEMICAL COMPOSITION OF BAMBOO SHOOTS

The main constituents of bamboo culms are cellulose, hemi-cellulose and lignin, which amount to over 90% of the total mass. The minor constituents of bamboo are resins, tannins, waxes and inorganic salts. It is considered a composite material because it consists of cellulose fibers imbedded in a lignin matrix. Sucrose is the most abundant sugar in bamboo shoot.

Bamboo shoots contain high proportion of linoleic acid. The major fat y acid in bamboo shoots is palmitic acid while glutamic acid and lysine are the most abundant amino acids in bamboo shoots (Sood *et al.* 2013; Soo-Jung and Sung-Ja, 1993). The chemical compositions of some of the bamboo based products are listed in Table 3.

Nutritional quality and health benefits of bamboo shoots

Bamboo shoots have low fat and calories yet it is rich in various other nutrients and edible fibers. Proximate analysis of bamboo shoot in fresh and dried form is given in Table 4. Nutritional facts of some of the commonly edible bamboo shoot species have been mentioned in Table 5 and 6. Bamboo shoots are good sources of potassium, vitamin E, vitamin C, vitamin B₆, thiamin, riboflavin, niacin, iron, phosphorous and dietary fibers like hemicelluloses celluloses, pectin lignin etc. It contains about 17 types of amino acids especially lysine and about ten types of minerals viz. Cr, Zn, Mn, Mg, Ni, Co, Cu are also found in bamboo shoots. A higher amount of selenium, commonly

Table 3: Chemical composition of bamboo shoot products

Para meters	Nuggets	Crackers	Parameters	Preserve	Candy	Chutney	Chukh
Moisture (%)	17.51±0.14	18.43±0.19	TSS	70±0.05	68±0.04	60±0.4	—
Protein (%)	2.92±0.22	2.35±0.06	Acidity (%) Citric acid	0.70±0.07	0.66±0.06	1.76±0.1	4.30±0.21
Fat (%)	3.64±0.08	7.88±0.11	Ascorbic acid (mg/100 gm)	8.51±0.21	8.09±0.33	1.04±0.12	17.00±3
Ash (%)	1.72±0.11	2.04±0.17	Total Sugars (%)	46.51±4	66.40±3	57.65±2	27.61±2
Fiber (%)	6.40±0.26	3.90±0.31	Reducing Sugars (%)	23.11±1.1	29.30±1.3	22.71±2	12.21±4
Total carbohydrate (%)	69.45±0.72	65.88±0.51	Non-Reducing Sugars (%)	22.23±2	35.24±2.2	27.92±2.8	14.63±1.7
			Percent Salt	—	—	—	17.11±1.9

Source: Sood *et al.* 2013; all values are in Mean±SD.

known as “Miracle life element,” is present in the bamboo shoots of some species than other vegetables.

Due to the high potassium content in bamboo shoots, they help in keeping the blood pressure under control. Germaclanium in shoots possess anti-ageing properties. The bioactive compounds such as phenols, phytosterols, and dietary fibers account for the health benefits accrued from bamboo shoots. The fermented succulent shoots of *B. Balcooa* and *D. strictus* are an improved source of phytosterol. It is also used to increase the appetite, decrease blood pressure and cholesterol. As a widely consumed vegetable, Bamboo shoot can be labelled as a heart protective vegetable and its component phytosterols may be suitable as nutraceuticals. Apart from boosting the body immunity, bamboo shoots have anti-inflammatory properties which decrease the risk of contracting various chronic diseases. Moreover, dietary fibres and phytosterols have a positive effect on the lipid profile and bowel function, and reduce total serum cholesterol and LDL cholesterol (Nirmala *et al.* 2014).

Toxic contents in bamboo shoots and its removal

Bamboo shoots however contain potentially toxic compounds called cyanogenic glycosides i.e. Taxiphyllin, which breakdown upon disruption of plant cells to form hydrogen cyanide Fig. 3 (Anonnyous, 2004).

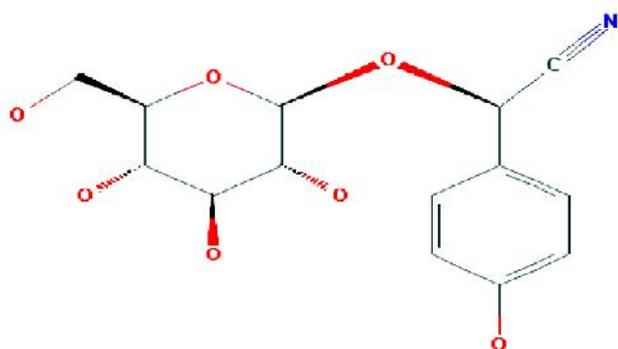


Fig. 3: Taxiphyllin

Bamboo plant produces cyanoglycosides and also a corresponding hydrolytic enzyme (beta-glycosidase), which is brought together when cell structure of the plant is disrupted by a predator, with subsequent breakdown to a sugar and acyanohydrin that rapidly decomposes to hydrogen cyanide and an aldehyde or a ketone (Moller and Seigler, 1999). Cyanogenic glycosides can produce both acute and chronic toxicity, but degrade readily in boiling 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 (Fig. 4) (Ferreira *et al.* 1995).

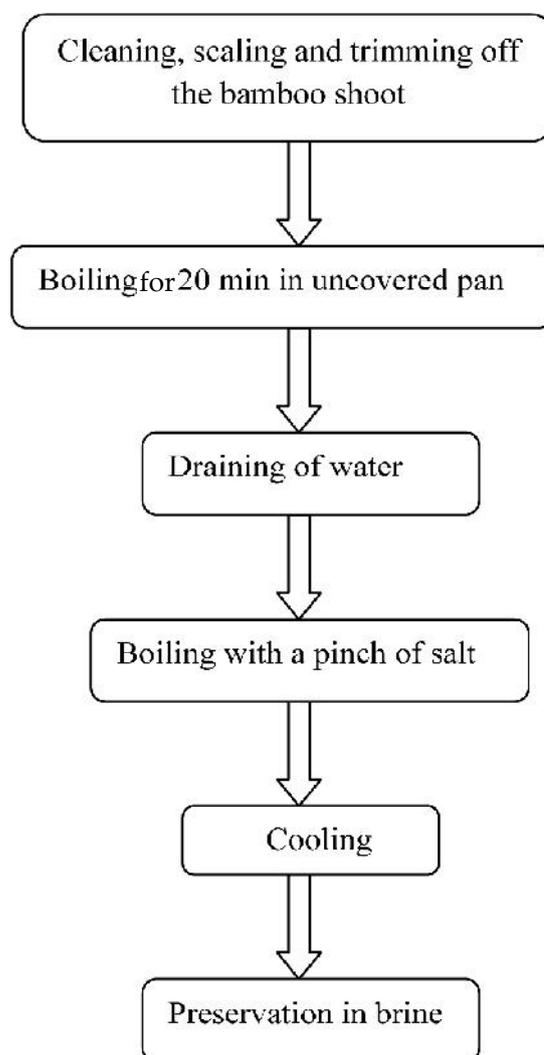
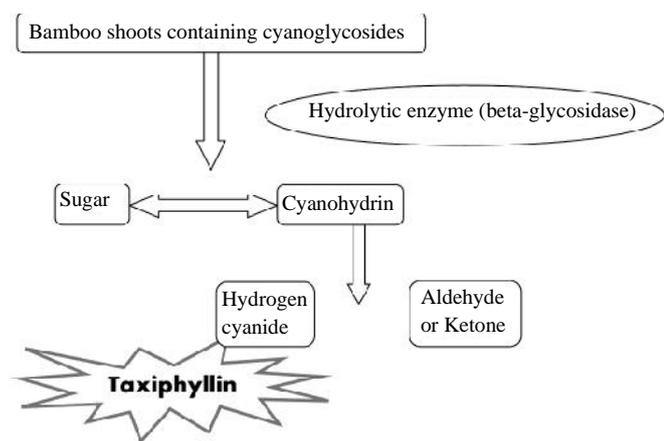


Fig. 4: Traditional method of removal of HCN (Source: Santosh Satya *et al.* 2010)

For humans, the acute lethal dose of HCN in mg kg⁻¹ body weight is 0.5-3.5 (Halstrom and Moiler, 1945). So, approximately 50-60 mg of free cyanide from bamboo shoot constitutes a lethal dose for an adult man (Fig. 5).



The acute lethal dose of HCN for humans in mgkg⁻¹ body weight is 0.5-3.5

Fig. 5: Hydrogen cyanide generation in bamboo shoot (Source: Moller & Seigler, 1999)

The symptoms of cyanide intoxication include rapid respiration, increase in blood pressure, dizziness, headache stomach pain convulsions. Cyanide content, naturally, is reported to decrease substantially following harvesting (Nirmala *et al.*, 2007). Some of the indigenous methods to lessen acidity/bit erness from fresh bamboo shoots include chopping of tender shoots into small pieces, partial drying of fresh shoots, boiling in water/salt water and draining or keeping shoots in hot water for 10-15 min or in water for a week at ambient temperature, steaming etc. Rana *et al.* (2012) found that boiling of bamboo shoot at optimum conditions (2.4% NaCl concentration, 1.25 cm thickness of bamboo shoot, 216 ml of NaCl solution and 23 min treatment time at 100°C) reduced HCN content to 11.3 mg/kg, well below the permissible limit (500 mg/kg). Nearly 70% of HCN removal has been achieved by boiling bamboo shoots for 20 min at 98°C and about 96% removal by boiling at this temperature for longer durations (Ferreira *et al.*, 1995).

Table 4: Proximate analysis of bamboo shoot in fresh and dried form

Parameter	Fresh shoot	Dried shoot
Water (g/100g fresh wt)	92.6	4.6
Protein (g/100g dry wt)	27.8	21.6
Starch (g/100g dry wt)	28.3	9.2
Fibre (g/100g dry wt)	5.2	5.0
Ascorbic acid (g/100g dry wt)	2.1	0.2

Source: Muchtadi and Adawiyah, 1996.

Table 5: Nutritional facts of *Bambusa tulda*

Minerals (mg/100gm)		Various Nutrients (g/100 g)	
Calcium	4.06	Amino acids	3.65
Iron	3.19	Proteins	3.69
Magnesium	8.68	Carbohydrates	6.92
Phosphorous	19.31	Starch	0.59
Potassium	408	Fat	0.48
Sodium	12.96	Vitamin C (mg/100 g)	1.42
Zinc	0.72	Vitamin E (mg/100 g)	0.61
Copper	0.44	Dietary fiber	3.97
Manganese	0.70	Ash	0.85
Selenium	0.4µg	Moisture	83.60

Source: Nirmala *et al.* 2011.

PROCESSING OF BAMBOO SHOOTS

A number of advanced methods for bamboo shoot processing and drying have been at emptied earlier (Li *et al.*, 2002, Madamba 2003, Xu *et al.*, 2005). Superheated steam drying of bamboo shoots eliminated boiling or blanching for reducing bit erness of shoots by decomposing Taxiphyllin and simultaneously preserving nutrients. Most of the bamboo shoot processing methods adopted are based on traditional knowledge. Different processing methods such as fermentation, roasting, boiling, blanching, canning, pickling etc. have been practiced as bamboo shoot are consumed in the form of fermented-slices, crushed-

Table 6: Nutrition facts of some of the commonly edible bamboo shoot species

Nutrients	<i>B. balcooa</i>	<i>B. polymorpha</i>	<i>M. bambusoides</i>	<i>D. strictus</i>	<i>D. hamiltonii</i>	<i>D. giganteus</i>	<i>B. pallida</i>
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
Hydrocyanic acid (%)	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

Source: Bhat *et al.* 2005a.

fermented moist, crushed-fermented dry, fermented whole shoot, roasted whole shoot and boiled whole shoot etc.

Fermented products based on traditional knowledge

Some popular ethnic fermented bamboo shoots in North-Eastern India are *Mesu* as a pickle and as a base in curries is a conventional dish in Sikkim, *Soidon*, *Soibum* and *Soijim* in Manipur, *Ekung*, *Eup* and *Hiring* in Arunachal Pradesh, *Lung-siej* or *Syrwain* Meghalaya (Singh *et al.* 2007, Tamang 2005). *Mesu* is an ethnic fermented bamboo tender shoot consumed by the Nepalis, Bhutias and Lepchas of Sikkim and the Darjeeling hills in India, eastern hills of Nepal and Bhutan (Panda and Padhy 2007). During preparation of *mesu*, tender shoots of bamboo (*Dendrocalamus sikkimensis*, *D. hamiltonii* and *Bambusa tulda*) are collected, their outer hard casings are removed and the inner portion is then, chopped into small pieces. The pieces are washed with water then, drained off and pressed tightly into a bamboo-made cylindrical vessel. This vessel is made air tight with a lid, placed in an upside-down position to drain out any liquid, and allowed to ferment under natural anaerobic conditions for 7–15 days. *Mesu* is eaten as a curry, pickle or soup. It is sold in the local markets during the months of July and September.

Soibum is prepared from succulent bamboo shoots of *B. balcooa*, *D. strictus* and *Melocanabaccifera*

(Sarangthem, 2003). It is whitish in color and with faint aroma and sour taste (Fu *et al.*, 2002). During preparation, the outer casings are removed from young bamboo shoots, the inner part is chopped, and these are washed and left in a covered earthen pot to ferment for 20 days. It can be prepared from the single species of bamboo or from intermixed material of more than one species. *Soibum* is a special delicacy and eaten as pickle and curry mixed with fermented fish. *Soidon* is a fermented product prepared from the tip of matured bamboo shoots. The tips are collected; outer casings are removed and cut into small pieces. Chopped pieces of bamboo shoot tips are merged in water in an earthen pot, covered and fermented for 3–7 days at room temperature. After fermentation, these pieces of bamboo shoots called *soidon* are taken out, and the acidic liquid portion called *soijim* is kept in a bottle, and stored at room temperature for a year or more. *Soidon* is consumed both as a curry and as pickle. It is also used as a condiment to supplement the sour-taste in curry (Tamang *et al.*, 2008).

In central India, the young shoots are grated and fermented to prepare *kardioramil*, a sour vegetable soup (Panda and Padhy, 2007). Kandha tribe of Kalahandi, Orissa consumes fresh sliced bamboo shoot named as *Kardi*. These pieces are dipped in water for a day for fermentation to wash off bitterness before cooking. It is also sometimes pounded in mortar and pestle, then sun dried, which is called

as *Handua* (Panda and Padhy, 2007). Ziro district of Arunachal Pradesh, Apatani tribes prepare varieties of fermented food products viz. *Hikhu*, *Hiring* and *Hithyi* from bamboo shoots. Adi tribes of East Siang, Arunachal Pradesh prepare bamboo shoots into three major forms: *Ekung* (fermented shoot), *Eyup* (dried shoots) and *Eting* (fresh shoot). Barman community of Tripura prepares traditional food called *Godhak*, from bamboo shoot by adding pseudo stem of banana, dry fishes, salt, chilli, onion and garlic (Sharma and Borthakur, 2008). *Tama*, a non-fermented bamboo shoot curry is very familiar among the people of Sikkim (Choudhary et al. 2012). Some of the bamboo based traditional fermented products are listed in the Table 7.

Dried bamboo shoots

The products are far off from standardization or globalization since there is scarcely any organized bamboo shoot processing and marketing industry. Different technologies may be suitable at different geographical locations depending on local socio-cultural conditions. Shelf-life of freshly harvested bamboo shoots is 9 and 23 days in water and brine, respectively (Nirmala et al., 2014). Water content of fresh bamboo shoots is 92.6/100 gm of fresh weight compared to 4.6/100 gm in dried bamboo shoots. The freshly harvested shoot is cream yellow in colour, has a strong smell and tastes sweet, if eaten on the day of harvest. During storage, a bit er 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. An important aspect during hot air drying of bamboo shoot is shrinkage of shoot parallel to its fibers (Chiangthong and Chayawat, 2009).

Table 7: Bamboo based traditional fermented products

<i>Mesu</i>	Sikkim
<i>Soidun, Soibum, Soijim</i>	Manipur
<i>Ekung, Eup, Hiring</i>	Arunachal Pradesh
<i>Lung Sieg, Syrwa</i>	Meghalaya

<i>Kardi, Handua</i>	Orissa
<i>Hikhu, Hiring, Hithyi</i>	Apatani tribes of Arunachal Pradesh
<i>Godhak</i>	Tripura
<i>Guleirebung, SayurIadeh</i>	Indonesia
<i>Naw-mai-dong, naw-mai-dong</i>	Thailand
<i>Used as vegetables in stir-fry dishes</i>	Vietnam
<i>Labong, GinataangLabong, DinengdengnaLabong</i>	Philippines
<i>Alu-tama, Tchang, Mesu</i>	Nepal and Bhutan
<i>Khorisa-tenga, Ushoi, Soibum, Soidon, Iromba, Ekung, Hiring, Kardi, Amil, Hendua</i>	India (NE states and Orissa)

Source: Choudhary, et al. 2012.

Preparation of sof drink and preserves using bamboo shoot

The sap of young stalks tapped during the rainy season is simply made into a sof drink in China (Yang et al. 2008).

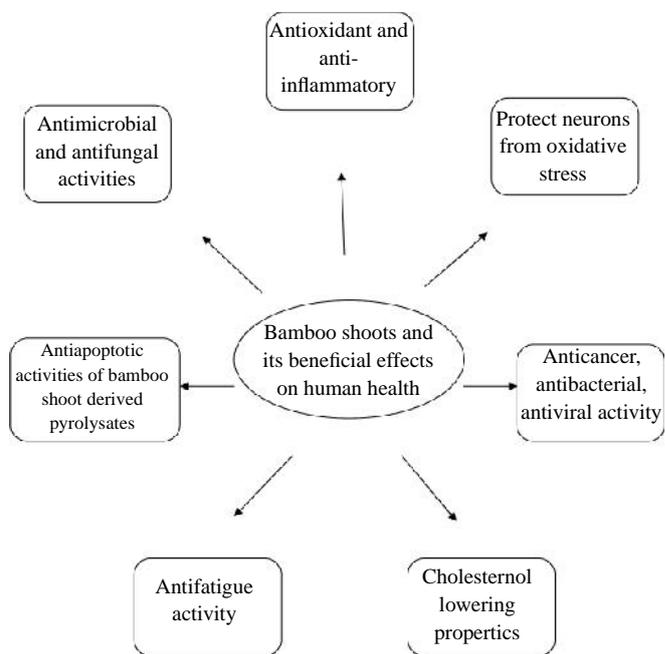


Fig. 6: Bamboo shoots and its beneficial effects on human Bamboo shoot preserve are meant for long term storage and involves sugar or honey as sweetening

agents. According to this method, the bamboo shoots were cut, washed and boiled in water for 30 min. The boiled soft bamboo shoots were then, steeped in prepared syrup of 40° Brix TSS for a day. Following day, the consistency was increased to 60° Brix by boiling and addition of more sugar. Repeated the process to raise the strength of syrup by 5° Brix on alternative days to 70° Brix. Once it reaches the desired concentration after 1 week, syrup was drained and filled in jar, covered with fresh syrup of 68° Brix (Sood *et al.* 2013).

Bamboo candy

Bamboo candy is a confectionery item made by boiling in concentrated sugar solution. Bamboo shoots were cut, washed and boiled in water for 30 min. The boiled soft bamboo shoots were steeped in prepared syrup of 40° Brix TSS for 1 day. Following day the consistency was increased to 60 Brix by boiling and addition of more sugar. Repeated the process to raise the strength of syrup by 5° Brix on alternative days to 75° Brix. Once it reaches the desired concentration after 1 week, syrup was drained and bamboo shoot pieces were washed with hot water and dried for 2 hrs, thereafter rolled in sugar powder and dried (Sood *et al.*, 2013).

Bamboo chutney

Bamboo chutney is a relish along with main course, made by blending the shoots into a homogenized pulp, concentrated by addition of spices etc. till it reaches desired consistency. The bamboo shoots were boiled in water for 30 min after which the boiled soft shoots were ground to make bamboo pulp. Bamboo pulp was mixed with sugar, spices and heated to obtain thick mass like consistency. After reaching the desired concentration, 2% glacial acetic acid was added as a preservative (Sood *et al.*, 2013).

Bamboo chukh

Bamboo chukh a speciality of Chamba district of Himachal Pradesh (Sood *et al.* 2013). It is prepared using red chilli and lemon juice. Bamboo shoots were mixed in oil and heated for 10 min. After that spices

such as red chilli powder, coriander powder, cumin seeds, black pepper were added and mixed properly with continuous heating. Lemon juice was added at the rate of 5% and boiled till mixture became thick in consistency. After reaching the end point, the product was filled into a jar and stored in cool and dry place.

Bamboo cracker (Papad)

A thin crispy wafer like snack product called crackers/papad may also be formulated from bamboo shoots (Tamang, 2005). One part of boiled shoots was mixed with one part of boiled potatoes, red chilli powder, black pepper powder, cumin seeds and salt to taste. Mixture was then, ground and dough was prepared. Equal sized balls were made from made from dough and rolled on a rolling board in circular movements to make round papads. Papads were then, dried in an oven at 45-50°C. Dried papads were stored in airtight containers.

Bamboo nuggets

Bamboo nuggets are made by mixing boiled bamboo shoots with pulse flour and condiments and then, dried it. Two parts of boiled bamboo shoots were mixed with one part of soaked pulse (Gram, green-gram, Soybean and black-gram), red chilli powder, turmeric powder and salt as per taste. The mixture was then ground to a coarse paste. Small equal size balls were then made from the paste dried in oven for 3 days at 45-50°C (Pandey *et al.*, 2012).

Bamboo shoot pickle

Pickling with salt also results in an organoleptically sound, shelf-stable product from bamboo shoots (Sood *et al.*, 2013). Pickles made from bamboo similar to fruits and vegetables preserved in brine or vinegar. To make spiced bamboo pickles, bamboo shoots were cut into small pieces boiled and dried in air for about 1 h. Chilli powder, turmeric powder and salt as per taste, roasted and ground fenugreek seeds, roasted and ground mustard seeds, black cumin seeds and asafoetida were mixed in a bowl, to which bamboo shoots were transferred. Mustard oil was heated till smoke comes, cooled and poured into the mixture.

APPLICATION OF BAMBOO FIBER IN THE FOOD INDUSTRY

Bamboo fibre improves dough yield and consistency due to water binding capacity. It helps in the decrease of product breakage or crumbling by controlling moisture loss in high and intermediate-moisture foods. Bamboo fiber can be used in non-caloric health nutrition bars. It can be used as viscosity and consistency improver, stabilizer. It has excellent water retention capacity, texture improvement and binding capacity (Nirmala *et al.*, 2011).

CHANGES DURING PROCESSING

During boiling, the polysaccharides get hydrolyzed into simpler sugars and gives sweet taste to the shoots. Whether as an accompanying vegetable or as main ingredient, bamboo shoots make an excellent combination with pickled condiments, stir fries, soups and beverages. In Australia and New Zealand, fresh bamboo shoots are sliced into strips, boiled in lightly salted water for 8-10 min before consumption. In Thailand and Vietnam, some shoots are finely grated and used in salads. In Japan, shoots are sometimes boiled whole for more than 2 h (Anonnyous, 2004).

THERAPEUTIC USES OF BAMBOO

The edible tender shoots have coiled spring like appearance and have an astringent flavour. Bamboo shoots have considerably high proportion of poly unsaturated fatty acids, indicating its potential as a source of great therapeutic value (Choudhury *et al.*, 2012). Similarly, bamboo shoots have a great medicinal value. Boiled bamboo shoots are used as appetizers and the decoction of shoots are used for cleaning wounds and maggot infected sores, ulcers, etc.

These are mixed with palm-jaggery, known to induce parturition and abortion. The sap of *B. vulgaris* is used for curing jaundice. Bamboo shoots are used in the preparation of steroidal drugs and they have antimicrobial qualities too. Antioxidation, anti-ageing, anti-fatigue, anti-microbial and prevention of cardio vascular diseases are a few of the major biological effects of phenolic compounds in bamboos

(Fig. 6). The antimicrobial property of crushed bamboo shoot sheath/bark prevents bacterial growth and is used as natural food preservative. The green shoots of *P. glauca* were roasted to produce fresh bamboo juice in treating infections (Choudhary *et al.* 2012).

FUTURE THRUST

Bamboo, a renewable and low cost resource can be utilized to prepare a number of products and has potential for setting up an industry. Increased research during the recent years has considerably contributed to improve processing technologies for broader uses. The integration of traditional processes after scientific validation would go a long way in developing a suitable system for storage and preservation of this perishable commodity for rural entrepreneurship. Also, processing techniques to take care of the food safety aspect would boost the export potential of this wonderful product. The potential of edible bamboos in supplementing nutrients in diet have even attracted attention of researchers. Interestingly, in spite of the fact that bamboo shoot has been an integral part of diet of tribal community, scientific validation of traditional processing methods in terms of food quality and safety has not been attempted and this demands adequate attention apart from scientific standardization of the processing technologies as well as product recipes for various bamboo shoot based food products.

In order to design appropriate machinery for processing of bamboo shoot such as slicing, striping, sizing and physical characteristics especially shear properties play very important role. Canning has been perceived to be effective in reducing rancidity and thus, preventing the growth of micro-organisms in bamboo shoots (Fu *et al.*, 2002). There is a need to develop processing technologies to preserve the bamboo shoots in consistent and imperishable forms to be used during the off-seasons.

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