

# Bamboo shoots as a nutritive boon for Northeast India: an overview

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**Abstract** With about 136 species, India is one among the richest countries in bamboo resources that help mankind in more than 1500 diverse ways. Although the utilization of juvenile shoots of bamboo in tribal diet of Northeast India is a very old observable fact, its numerous health benefits and potentiality remains uncharted. Apart from being delicious, the bamboo shoots are also rich in minerals and nutrient components such as carbohydrates, proteins, fiber and are low in fat and sugar which could be helpful in mitigating the problem of malnutrition. Few studies also revealed the health benefits of bamboo shoots for the treatment of cancer and cardiovascular diseases, weight loss and to improve digestion. Over and above the nutritional values of different species of bamboo shoots, the increasing inclinations towards health awareness among the consumers have emphasized its utilization in modern diet as a health food for boosting the nutritional security. Thus, in the present review, the nutraceutical potentiality of bamboo shoots is explored alongside its various qualities.

**Keywords** Nutraceuticals · Bamboo shoot · Cardiovascular diseases · Nutritional values · Bioactive compounds

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## Introduction

Worldwide, human civilization is facing some of the major challenges including food, ecological and economical security, climate change, and energy. The emerging trends of health consciousness and growing awareness among the consumers have stimulated the field of ‘functional foods’ for adopting a nutritionally balanced diet (German et al. 2004; Chongtham et al. 2011). Around two billion people in the world do not have enough food for meeting their basic requirements and are therefore, deficient in one or more micronutrients (Kotecha 2008; Basumatary et al. 2015). Few factors such as unavailability of quality food commodity and steep increase in food prices also have shaken the foundation of the world communities may it be rural or urban. India has the highest number of underweight children, nearly double when compared to Sub-Saharan Africa (Srivastava et al. 2012). This type of ‘hungry’ situation might also lead to several problems involving a sense of insecurity among the people (Satya et al. 2012).

Problems related to environmental and groundwater pollution, declining soil fertility, very high input cost and stagnant productivity have altered the pattern of cropping. Due to such narrow food baskets in India, the local households have opted for the underutilized crops to fulfill their needs and bamboo is one among those crops (Devi 2013). The whole Northeast region of India is gifted with this nutritious, but less utilized, crop in abundance. This neglected commodity resource can help to meet up the rapidly increasing demand for nutraceuticals. Bamboos are gaining increased attention as a plant of ‘global interest’ due to their values and wide range of uses for humans (Bhatt et al. 2003; Goyal and Sen 2016).

In view of certain characteristics, bamboo, a group of tall, woody grasses belonging to the family Poaceae is well known

for its contribution mainly to the housing sector (Brahma et al. 2014a). But today, as a renewable, natural, low-or no-cost, widespread, versatile, easily accessed, productive, environment-enhancing resource, bamboo helps billions of people worldwide (Sastry 2008; Chongtham et al. 2011). The juvenile shoot used in tribal diet is a very age old phenomenon. It remained as one of the highly palatable dishes in delicacies (Benzhi et al. 2005). Usually, the edible part of the shoots is enclosed with culm sheath which needs to be removed so as to obtain the edible portion. In Northeast India, *Bambusa balcooa*, *Bambusa pallida* and *Melocanna baccifera* are mainly used for edible purposes. Presently, in the production of various bamboo-based products such as panels, flooring, pulp, daily-use articles, charcoal, etc., about 3000 companies in the world are engaged (Pandey et al. 2012). Because of its multifarious uses the bamboo, popular earlier as ‘poor man’s timber’ is now addressed with different names such as ‘the plant with thousand faces’, ‘friend of the people’, ‘green gold of forests’, etc. (Goyal and Brahma 2014).

From time immemorial, bamboo is recognized as a valuable and essential commodity. In Southeast Asia and China, the shoots of bamboo have a history of being used as a source of medicine and food as well (Bao 2006). Bamboo shoots are low in cholesterol and fat contents, but very high in dietary fiber and nutritional components. In case of cuisines, the matchless taste and acerbic flavor of bamboo shoots make it a rare of its kind (Pande and Pandey 2008). The utilization pattern of bamboo shoots in most of the countries indicates that it is consumed in raw canned, dried, boiled, fermented or medicinal. In Indian restaurants, there are about 11 popular intercontinental dishes prepared from the shoots of bamboo. Besides, they are also used as an extender as they take on the flavor of the ingredients they are cooked with. Few of the commonly found popular dishes include bamboo shoot halwa, chutney, pulao, curry, bhaji, keema, Manchurian, pickles (Wang and Ng 2003).

Despite the fact that bamboo shoots are rich in some nutrient components and medicinal properties, there is a lack of awareness among the human population (Shanmughavel 2004). Therefore, this review focuses on the nutritional value of bamboos and the prospects of its utilization as a dietary supplement.

## Bamboo shoots as a dietary supplement

The growing health consciousness globally has led to the increasing public demand for the bamboo shoots due to its therapeutic and nutritional values (Chauhan et al. 2016). Bamboo shoots are the young, immature and tender culms of the bamboo used for preparing various food items after being harvested. A systematic study on its nutritional significance is being worked out by several researchers (Nirmala et al. 2007; Park and Jhon 2009; Nirmala et al. 2014). Several nutritional components such as carbohydrates, proteins, fats, minerals, vitamins, reducing and non-reducing sugars, enzymes, co-enzymes, citric acid and lactic acid (fermented products). The nutritive value of bamboo shoots with other vegetables has been listed in Table 1. It is evident from Table 1 that the bamboo shoots are low in fat, ash, carbohydrate and protein when compared to other commonly consumed vegetables. Among the tabulated plant species *Hibiscus sabdariffa* had the highest carbohydrate and ash content. The fiber content of *Dendroclamus hamiltonii* was higher when compared to *Pleurotus ostreatus* (mushroom) but lower than *Houttuynia cordata*. Bamboo shoot is also rich in dietary fibers such as cellulose, lignin, hemicelluloses and pectin (Park and Jhon 2009). The juvenile shoots of *D. hamiltonii* have the highest protein content followed by *Bambusa bambos*. They are also found to be a good source of vitamin E ( $\alpha$  tocopherol), vitamin C (3.0–12.9%), B6 (0.01%), thiamin (0.05%), riboflavin (0.01%), and niacin (0.03%) along with vitamin A (20 IU), vitamin B1 (0.15 mg/100 g), and vitamin B3 (0.60 mg/100 g) (Nirmala et al. 2007; Choudhury et al. 2010).

The contents of free amino acid, protein and dietary fiber of the bamboo shoots are much higher as compared to all other vegetables. The shoot also has a good profile of over 10 types of mineral elements, i.e. chromium (Cr), zinc (Zn), manganese (Mn), magnesium (Mg), nickel (Ni), cobalt (Co), copper (Cu), lysine, germaclinium and other nutritious phytoconstituents (Choudhury et al. 2010; Satya et al. 2010). In the shoots of *Denrocalamus giganteus*, magnesium (Mg), a life supporting element that plays an indispensable role in body metabolism is found in higher content ranging from 5.38 to 140 mg/100 g (Bhatt et al. 2005). Being an excellent source of carbohydrates, proteins, vitamins and minerals, these shoots will help the rural

**Table 1** Comparison of proximate composition (g/100 g) of bamboo shoots with some common vegetables

Species	Carbohydrate	Protein	Fat	Ash	Fiber	References
Bamboo shoots	4.20–6.10	1.30–2.30	0.30–0.40	0.70–1.20	0.50–0.77	Shanmughavel (2004)
<i>Bambusa tulda</i>	6.92	3.69	0.48	0.85	3.97	Chongtham et al. (2011)
<i>Dendrocalamus hamiltonii</i>	3.44	2.93	0.37	0.91	6.14	Premlata et al. (2015)
<i>Pleurotus ostreatus</i>	43.40	37.63	2.47	10.17	4.20	Johnsy et al. (2011)
<i>Hibiscus sabdariffa</i>	43.51	15.18	1.83	35.00	–	Brahma et al. (2014b)
<i>Houttuynia cordata</i>	33.03	10.42	3.12	–	9.23	Saha et al. (2014)

poor to elude the ill effects of malnutrition (Satya et al. 2012). On the other hand, in some of the species, a higher amount of 'selenium (Se)' is present in shoots which is essential for fertility and normal growth. Selenium has close metabolic relationship with vitamin E for treating diseases and hence it is also known as 'miracle life element' (Chongtham et al. 2011; Thounaojam et al. 2015). Having an excellent antimicrobial quality with different flavones and glycosides makes the bamboo shoots a rising natural medicine (Park and Jhon 2009).

### Bamboo shoots as a nutraceutical

Studies depict that bamboo shoots are an excellent reservoir of nutrients bearing wide range of health profits and are therefore, identified as a natural medicine or nutraceutical for more than 2000 years in the traditional system of medicine. It has been used for treating paralysis, sweating and to relieve hypertension in South-Asian countries. Also, preventing and curing cardiovascular disease, cancers and peristalsis of the intestine are recorded. Modern research has revealed that presence of the anticarcinogenic constituents in shoots makes them a regular part of the diet. Neurons are being protected from oxidative stress with the help of bamboo derived pyrolysates possessing antimicrobial and antifungal activities (Akao et al. 2004). Due to the presence of lignins which are an important component of fiber, the shoots of the bamboo are reported to have anticancer, antiviral and antibacterial activity (Tamang et al. 2012). Bamboo is also labelled as a 'heart protective vegetable' because of its high content of potassium (K) which helps in maintaining normal blood pressure. It also prevents constipation and decreases body fat (Chongtham et al. 2011).

Commonly known as 'bamboo manna' in English are the silicious concentration found in shoots that are very hard to get, but are well known for its unique healing properties (Choudhury et al. 2010). In the Indo-Persian and Tibetan System of medicine, it is called 'tabashir' or 'tawashir', while in the traditional system of Indian medicine, it is called as 'banslochan' (Biswas 1994). Sap from inside the shoots of *Bambusa vulgaris* is also used for curing jaundice in Java (Choudhury et al. 2010). Therefore, Baskaran et al. (2014) insisted in vitro propagation of *B. vulgaris* from the mature clump. Intake of juice of pressed bamboo shoots that contains protease activity helps in triggering digestion of proteins. Besides, the shoots of few bamboo species such as *B. bambos* are used in treating thread worm, cough and diarrhea due to the presence of glucosides, betain, urease, cynogens, nuclease and choline (Choudhury et al. 2010). The decoction of bamboo shoots is used for cleaning maggot infected sores, wounds, ulcers

and cure jaundice as it induce abortion and parturition (Choudhury et al. 2010). As a result, being a good source of phytosterols, fiber and antimicrobial qualities, the bamboo shoots can qualify as nutraceuticals (Sarangthem and Singh 2003).

### Phytochemistry of bamboo shoots

The utilization of bamboo, a source of valuable nutraceutical, has been practiced in many tropical countries for thousands of years (Caragay 1992). At present, foods are not intended to only satisfy hunger and provide necessary nutrients for humans, but also to improve mental and physical well-being of human population and prevent diseases related to nutrition. Plant food contains bioactive compounds in abundance in addition to those traditionally considered nutrients and with the help of secondary metabolism; these physiologically active compounds are produced in small amounts known as "phytochemicals" (Rodriguez et al. 2006). At different concentrations, the phenolic compounds including their subcategory flavonoids are found in all the parts of the bamboo plant. Bamboo shoots, being a rich source of antioxidant compounds hold great promise for utilization as a health food (Miettinen and Gylling 1992). Commonly referred to as polyphenols, the phenolic compounds are secondary metabolites that inhibit the lipid peroxidation and have the potentiality to act as antioxidants in biological systems (Pereira et al. 2009). In the shoots of *Phyllostachys pubescence*, eight phenolic acids are present among which few were almost ubiquitous such as *p*-hydroxybenzoic acid (Park and Jhon 2010). Apart from possessing antimicrobial quality, experimental evidence shows that it also contains cardioprotective, antithrombotic and vasodilatory effects (Lehane and Saliba 2008).

Lignins are found in considerable amounts in the bamboo shoots and are one of the key ingredients in dietary fiber. Through supercritical carbon-dioxide extraction followed by subsequent hydrothermal treatment, many antimicrobials and antioxidants have been isolated from bamboo shoots. An antitumor agent has also been prepared from moso bamboo (*P. pubescences*) (Quitain et al. 2004). More than 200 different kinds of phytosterols have been reported in plants among which sitosterol is the most abundant. B-sitosterol, stigmasterol and campesterol are the predominant sterols in bamboo shoots (He and Lachance 1998). To facilitate dietary recommendations, the phytosterol content and composition in shoots were examined using ultra performance liquid chromatography with mass spectrometry. Regular intake of shoots will completely scavenge the free radicals producing

destructive carcinogens due to the presence of anticarcinogenic agents in it. An idiosyncratic antifungal protein, dendrocin, is also isolated from shoots (Wang and Ng 2003).

During extraction of bio-active compounds, prolonged exposure to oxygen and light may lead to the oxidation of phenolics. Thus, numbers of methods were developed for extraction of bio active compounds from the shoots. In both the leaves and shoots of *Bambusa textilis*, three potential bioactive compounds were detected through nuclear magnetic resonance spectra. They are identified as (*Z*)-*p*-coumaric acid (*E*)-*p* coumaric acid and apigenin-8- $\beta$ -D-(2''-O- $\alpha$ -L-rhamnosyl)-glucopyranoside (Satya et al. 2012). Using gas chromatography-mass spectroscopy method, in methanol-ethanolic extract of *Dendroclamus asper* leaves, about 20 organic compounds had been identified (Mulyono et al. 2012). The growth of total anaerobic bacteria and *Escherichia coli* is arrested/hindered by the caprylic acid because of its antimicrobial activity. Moreover, in most of the bamboo species, the phenolic acids namely vanillic acid, gallic acid and caffeic acid are documented (Sarangthem and Singh 2003).

## Future prospects

Advanced scientific investigations have exposed that in some diseases, diet may modulate various physiological functions that may play either detrimental or beneficial roles even though the role of diet is to provide sufficient nutrients to meet metabolic requirements (National Academy of Sciences 2001). Awareness of personal health deterioration is stimulating a legitimate need for adopting a diet that is nutritionally complete (Granato et al. 2010). Bamboo shoots, no doubt, capture a novel place in the continuum of the plant foods with both aesthetic and nutraceutical value by enhancing the eminence of life. Such type of functional foods that contain phytosterols are now available in the form of salad dressings, margarines, spreads and so forth adding essence to our diet.

In India, the shoot production of edible bamboo species is confined only to certain pockets of the country regardless of the rich genetic resources of bamboo. But in numerous Asian countries, the bamboo shoot-based industry is escalating rapidly mainly in Korea, China, the Philippines, Japan and Thailand where bamboo farming for edible shoot production is well established and for the growers, generating good earnings (Suresh et al. 2013). Being a fast-growing plant, bamboo, can be an important source of phytosterols and hence forward, the addition of plant sterols to foods could be an important public health policy for ensuring the food and nutritional security (Law 2000).

## Conclusion

The shoots of the bamboo not only remain as the poor man's meal but also have a great potential to become an urban man's favourite as an edible food. Universally, it has been an integral part of diet and lives of the tribal community. However, due to its special nutritional profile, it is incorporated in several other dishes all over the world. Since time immemorial, the bamboo shoots serve as sustainable food source and it may be in processed or fresh form. In case of bamboo shoot, food safety aspect can be taken care by suitable processing methods while keeping the nutrients intact. Craving for renewable biomass and the pressure of burgeoning human population all over the world has also posed the challenge of maintaining natural resources to meet the present and the future needs where this group of plants comes as a 'boon' in various forms. But appallingly, the community of researchers did show a little or no interest on this underutilized crop which has not only an enormous export potential but also is a priceless nutraceutical (Chongtham et al. 2011).

Amalgamation of both traditional and contemporary technologies may be an influential tool for producing reasonably priced food to poor farmers plus consumers. It does involve small savings and least attention for cultivating this soil conservative crop. With no disturbance to the bio-diversity, if the bamboos are popularized as food and commercial production is taken up on a large scale, it will contribute enormously to rural economies and boost up the export wages as discussed at National Bamboo Mission (Anitha 2012) and Odisha Economic Survey (Economic Survey 2015).

## Compliance with ethical standards

**Conflict of interest** The authors declare no conflict of interest.

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