Cultivation prospects of edible bamboo shoots in South India

Book · January 2016

CITATION
1

READS
3,207

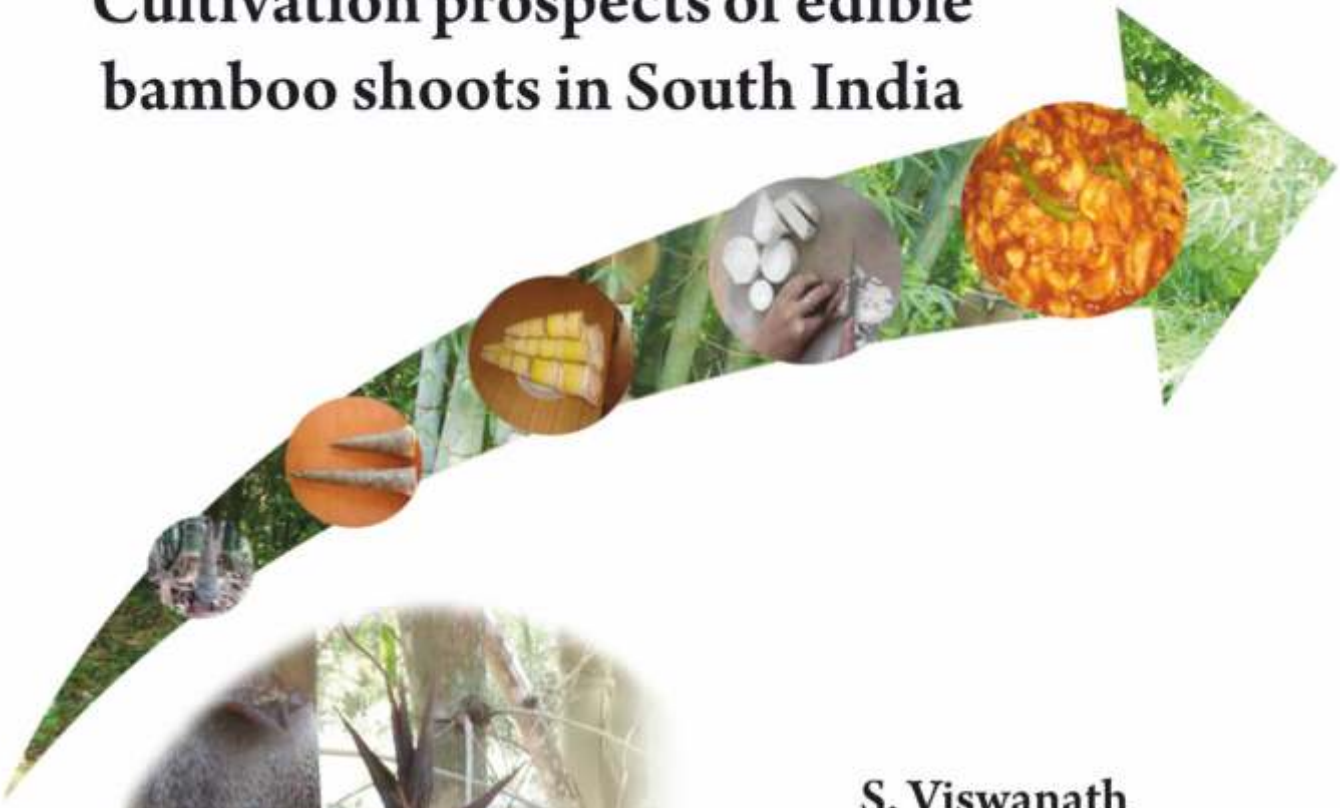
2 authors:

Syam Viswanath
Institute of Forest Genetics and Tree Breeding
146 PUBLICATIONS **1,055** CITATIONS
SEE PROFILE

Sowmya Chandramouli
Siri Sampada Farmlands Pvt. Ltd., Hyderabad, India
20 PUBLICATIONS **101** CITATIONS
SEE PROFILE

IWST Technical Bulletin No. 14

Cultivation prospects of edible bamboo shoots in South India



S. Viswanath
Sowmya Chandramouli

Institute of Wood Science & Technology
(Indian Council for Forestry Research & Education)

2016

A Publication of Institute of Wood Science & Technology, Bangalore

Photo Credits : Syam Vishwanath and Sowmya Chandramouli

सत्यमेव जयते

काष्ठ विज्ञान एंव प्रौद्योगिकी संस्थान
भारतीय वानिकी अनुसंधान एंव शिक्षा परिषद्
पर्यावरण, वन एंव जलवायु परिवर्तन मंत्रालय
पी.ओ. मल्लेश्वरम, बेंगलुरु – 560 003

INSTITUTE OF WOOD SCIENCE AND TECHNOLOGY
Indian Council of Forestry Research and Education
Ministry of Environment, Forest & Climate Change
P.O. Malleswaram, Bengaluru - 560 003.

PREFACE

Availability of information on edible Bamboo shoot cultivation and its exploitation in South India is very meager. In North East (NE) India, bamboo forms a major component of the dietary habit especially of indigenous communities. In Peninsular India, exploitation of bamboo shoots is largely limited to only two species *viz. Bambusa bambos* and *Dendrocalamus strictus* and confined to some coastal districts of Dakshin Kannada, Mangalore and Coorg in Karnataka and some parts of Kerala like Wayanad and Kasargod. There is also considerable difference in the processing of shoots and its utilization in NE India and Southern India. In NE, bamboo shoots are mostly eaten in the fermented form which is not preferred down south. Bamboo shoots are available in some form or other throughout the year in NE India and there is wide variety of species to choose from. Whereas, in Southern India, there is not much awareness on other edible bamboo species though many species are commercially cultivated for various other purposes. Out of 148 odd species recorded in India, National Mission on Bamboo Application (NMBA) has identified 15 commercially important edible bamboo species, of which there are 10 commercially cultivated species in Peninsular India *viz.*, *Bambusa bambos, B.balcooa, B.nutans, B.tulda, Dendrocalamus strictus, D.asper, D.brandisii, D.giganteus, Guadua angustifolia, Thyrsostachys oliveri* and in addition *D.stocksii,* a species endemic to Central Western Ghats. These commercially important species have been suitably detailed in this book.

India is the second largest producer of bamboo shoots after China. Yet not much importance has been given to its usage as food item. This may be due to lack of awareness about the edible characteristics of the shoots. From the perspective of human nutrition, bamboo shoots harvested can be of good nutraceutical /therapeutic value, containing good amount of fiber, carbohydrates, proteins and minerals such as potassium. The utilization of soft, tender young juvenile shoots as food has been gaining increased global attention as an alternative horticulture/plantation crop for the high nutritional value and health benefits.

This booklet is an attempt to focus some attention on commercial exploitation of bamboo shoots and put on record the work done on edible bamboo shoots and its utilization at IWST, Bangalore, including information on harvesting, processing of shoots, nutrient composition, economics of cultivation, problems and prospects in cultivating bamboo for edible shoot production. The effort taken by the authors in bringing this publication is appreciated and it is hoped that this information will be useful to farmers, entrepreneurs and various stakeholders who are planning to exploit bamboo shoots in one form or the other.

Surendra Kumar IFS
Director, IWST

CONTENTS

1. INTRODUCTION.....1

2. SPECIES IDEAL FOR PENINSULAR INDIA..... .2

3. HARVESTING AND PROCESSING.....6

4. PRECAUTIONS TO BE TAKEN WHILE HANDLING OF SHOOTS.....7

5. SIMPLE TECHNOLOGY DEVELOPED AT IWST FOR PROCESSING OF BAMBOO SHOOTS.....8

6. NUTRITIONAL COMPOSITION OF BAMBOO SHOOTS.....9

7. HEALTH BENEFITS OF BAMBOO SHOOTS.....10

8. ECONOMICS OF CULTIVATION OF EDIBLE SHOOTS.....10

9. PROBLEMS & PROSPECTS.....17

10. MYTHS Vs REALITY.....18

11. ACKNOWLEDGEMENTS 19

12. REFERENCES.....19

13. DISHES USING BAMBOO SHOOTS.....22

14. ANNEXURES.....23

1. INTRODUCTION

The most important trend in the food industry is the demand that all natural food ingredients be free of chemical additives and bamboo is one such plant that can be utilized for this purpose. Bamboos, tall arborescent grasses, belonging to the family *Poaceae*, subfamily Bambusoideae, tribe Bambuseae are known for industrial uses.Bamboo has been gaining increased global attention as an alternative horticulture/plantation crop with multiple uses and benefits, providing human beings with various resources. It is widely distributed, renewable resource, productive, versatile, low cost, easily accessed and environment-enhancing resource. Every part of the plant - leaves, shoots, culm sheath and culms are used either as food or used for medicine and health benefits. Bamboo is the fastest growing woody plant in the world with a unique rhizome-dependent system, highly dependent on local soil and climate conditions. Bamboo, due to its biological characteristic and growth habits, is not only an ideal economic investment but also has an enormous potential for alleviating many environmental problems facing the world today.

There are more than 1500 different documented uses of bamboo. Various bamboo-based products such as panels, flooring, pulp, charcoal, edible shoots, and other daily-use articles are being produced around the globe. The leaves have been used as fodder for livestock. It is also a very important food for the giant pandas in China, because they survive only on bamboos. Many bamboos are popularly used as ornamental plants in landscaping. In addition, due to their characteristic growth habits, particularly its rhizomes and fibrous roots that performs the function of cohesion, Bamboos have enormous potential for alleviating many environmental conditions such as soil erosion control, water conservation, land rehabilitation, and carbon sequestration.

In India, the total demand of various bamboo consuming sector is estimated to be 26.9 million tonnes. The estimated supply is only 13.48 million tonnes i.e. only half of the total demand. The major consumer of bamboo include pulp and paper industry, construction, cottage industry and handloom, food, fuel and medicine which jointly contribute to a value of annual trade of Rs. 2042 crore. Demand of bamboo for industrial use is met from state owned forests, while for non-industrial purposes it comes from private as well as state owned resources (Salam, 2013). Bamboo is an integral part of the tradition and culture of rural and tribal populations in North-east India. Throughout monsoon in Asia, bamboo culms are widely used for construction, fencing and handicrafts, while bamboo shoots are an important dietary supplement of high nutritional value and have large economic potential in the livelihood income enhancement of rural communities.

Despite the fact that India is the second largest producer of bamboo shoots after China, not much importance has been given to its usage as food item. This may be primarily due to lack of awareness about the edible characteristics of the shoots. Consumption of tender shoots is confined mainly to the Northeastern states and few parts of Southern peninsula like Coorg, South Canara in Karnataka and

Wayanad, in Kerala where they are part of the traditional cuisine. Bamboos, in addition to multifarious uses, have an additional culinary use. The utilization of soft, tender young juvenile shoots as food has been gaining increased global attention as an alternative horticulture/plantation crop for the high nutritional value and health benefits. Apart from the Asian countries such as China, Japan, Korea, Taiwan, Thailand and Philippines, where it is already established as an ethnic traditional food, bamboo shoot has become very popular in other countries (Plate 1). Bamboo shoots are available in most of the countries in dried, canned, boiled or fermented form. The utilization pattern is rather traditional, non-standardized, unorganized and region-specific with little value addition. Plausible technologies need to be developed in order to utilize this renewable natural resource and to make them available throughout the year.

This booklet is an attempt to collate the various aspects of bamboo shoots to provide insight and increase awareness on the utilization and nutritional potential.

2. SPECIES IDEAL FOR PENINSULAR INDIA

NMBA has identified 15 commercially important edible bamboo species, out of 148 bamboo species in India viz; *Bambusa balcooa, B.bambos, B. nutans, B. pallida, B. polymorpha, B. tulda, Dendrocalamus asper, D.brandisii, D. giganteus, D. hamiltonii, D.longispathus, D. strictus, D. asper, Melonconna baccifera,* and *Thyrsostachys oliveri* (NMBA, 2011). Both International Network on Bamboo and Rattan (INBAR), at global level and NMBA, at national level, have included few industrially important bamboo species, out of which, *Dendrocalamus asper* and *Guadua angustifolia* are also considered as key species, having multifarious utility value. The INBAR has selected five species which are most suited for the development of bamboo shoot industry in India (*Bambusa balcooa, Dendrocalamus giganteus, D.hamiltonii, D.strictus* and *Meloncanna baccifera*).

In Peninsular India, various bamboo species are being cultivated for commercial purposes by the state forest departments and private cultivators. The species commonly cultivated, *Bambusa bambos, B.balcooa, B.nutans, B.tulda, Dendrocalamus strictus, D.asper, D.brandisii, D.giganteus, Guadua angustifolia, Thyrsostachys oliveri* are listed among the species reported edible by NMBA and INBAR. Apart from these, in a study conducted by IWST, Bangalore, *D.stocksii*, a species endemic to Central Western Ghats was reported to be edible (Chandramouli *et al*., 2014).

CHARACTERISTICS OF COMMERCIALLY IMPORTANT EDIBLE BAMBOO SPECIES IN PENINSULAR INDIA (PLATE 2)

Sl. No.	Species	Habitat & Distribution	Other Uses besides edible shoots
1	*Bambusa balcooa*	Species native to India. Non-thorny. Occurs at altitudes of up to 600 m. Prefers heavy textured soil with good drainage. Grows to a height of 20-25 m with culm diameter 8-15cm having a thickness of 1.9-3cm and, internode length 20-45cm. A common homestead bamboo in North East India and West Bengal. Cultivated in Peninsular India. Life span of 90 years with gregarious flowering which is isolated and rarely sporadic	House construction, scaffolding, ladders, agarbatti, bioenergy
2	*Bambusa bambos*	Species native to India. Thorny densely packed culms with slightly swollen nodes. Occurs at altitudes of up to 1000m. Prefers rich and moist soil, thrives near perennial rivers. Alluvial or deep fine textured soils. Grows to a height of 25 m with culm diameter 15-18cm having a thickness of 1.5-2.5cm and, internode length 30-45cm. Found almost throughout India, and common in central and south India. Life span of 40-60 years with gregarious flowering which is occasionally sporadic	Raw material for pulp and paper, to make panel products and handicrafts, and for thatching and roofing
3	*Bambusa nutans*	Loosely clumped, straight and smooth culms. Grows best at altitudes of between 500-1500 m. Thrives on moist hill slopes and flat uplands, and well-drained sandy loam to clayey loam soils. Grows to a height of 20-25 m with culm diameter 5-10cm having a thickness of 0.3-2.5cm and, internode length 24-45cm. Commonly found and cultivated in the North East, Orissa, Bengal, Peninsular India. Life span of 35 years with gregarious/sporadic flowering	House construction, basketry, crafts
4	*Bambusa tulda*	Closely packed clumps. Prefers good rainfall areas with moist alluvial soil at an altitude around 0-1500 m. Grows to a height of 25 m with culm diameter 5-10cm having a thickness of 0.8-1.5cm and, internode length 40-70cm. Commonly found and cultivated in the North East, West Bengal and South India. Life span of 30-60 years with gregarious flowering	Basketry and weaving applications

Sl. No.	Species	Habitat & Distribution	Other Uses besides edible shoots
5	*Guadua angustifolia*	Native of South America Thorny and few branches above the middle of culm, Open clumped. Prefers High rainfall, humid tropics, loamy rich soil, riverine regions.Introduced in Kerala and Karnataka. Grows to a height of 20-25 m with culm diameter 10-15 cm having a thickness of 3-3.5 cm and, internode length 18-20 cm. Sporadic flowering	Construction, scaffolding
6	*Dendrocalamus asper*	Native to Indonesia. Non thorny, slightly closely packed culms with prominent nodes. Introduced in India. Occurs at altitudes of 1500 meters. Prefers well drained soil. Grows to a height of 20-30 m with culm diameter 8-20 cm having a thickness of 1.1-2cm and, internode length 20-45cm. Life span of 60-100 years with gregarious/sporadic flowering	Construction, handicrafts
7	*Dendrocalamus stocksii*	Endemic to Peninsular India. Small to medium sized bamboo species. Non thorny, Loosely packed culms. Occurs at altitudes of 800 meters. Found in banks of streams and valleys, prefers well drained and deep, loamy soil. Grows to a height of 15 m with culm diameter 2.5-4 cm having solid/partially solid culms with internode length 15-30 cm. Life span of 70 years. Only sporadic flowering seen. This species has a problem in viable seed setting.	Construction purposes, making furniture, ladders and agricultural implements
8	*Dendrocalamus strictus*	Native to India. Small to mid-sized bamboo species. Non thorny , Very Densely packed culms with prominent nodes. Occurs at altitudes of 1000 meters. Prefers Alluvial plains and can be found in dry, open deciduous forests. Grows to a height of 12-15 m with culm diameter 8-10 cm having a thickness of 2-3cm and, internode length 30-45cm. Commonly found throughout the country. Life span of 24-28 years with gregarious flowering	As building material and for making furniture, mats, basketry and implements

Sl. No.	Species	Habitat & Distribution	Other Uses besides edible shoots
9	*Dendrocalamus brandisii*	Closely packed clumps in altitude ranging from 0-1300 m in Calcarious rocks. Grows to a height of 25 m with culm diameter 13-20 cm having a thickness of 1.7-3cm and, internode length 30-60cm. Commonly found in Andamans, Kerala, Manipur, Nagaland, West Bengal and in homesteads in Karnataka. Life span of 40-45 years with gregarious and sporadic flowering	House construction, basketry, handicrafts
10	*Dendrocalamus giganteus*	Non-thorny, densely packed clumps. Humid tropical and subtropical regions. Prefers moist hill slopes and rich loamy soil in altitude ranging from 0-1200 m. Grows to a height of 35-40 m with culm diameter 20-30 cm having a thickness of 0.1-0.2 at top, 0.7-0.8 in middle and 2.5-3.5 cm at the bottom and, internode length 20-60cm. Commonly found in Bihar, North East Himalayas, North East, West Bengal and also cultivated in Peninsular India. Life span of 80-90 years with sporadic flowering	Construction, boat moats
11	*Thrysostachys oliveri*	Non-thorny closely packed clumps found growing in altitude ranging from 0-650m in deep soil with high relative humidity. Grows to a height of 15-20m with culm diameter 5 cm having a thickness of 1.1-2cm and, internode length 40-60 cm. Found growing in Tripura and West Bengal and cultivated in Kerala. Life span of 48-50 years with gregarious flowering	Baskets, window blinds, handicrafts

3. HARVESTING AND PROCESSING

Juvenile shoots in bamboos usually emerge with the beginning of the rainy season in June/July, during which the young edible shoots are harvested. The shoot is actually a culm that emerges from the ground in full diameter and contains nodes and inter nodes in a vertically miniaturized form and the young shoots are tightly clasped with overlapping sheaths that have to be removed to extract the edible part. Shoots are normally harvested 7-14 days after the emergence from the ground and when the shoot height is about 15-30 cm depending upon the species. The typical "shooting season" of a species rarely exceeds 2 months which may be extended by modifying the cultivation and management practices. The shoots are harvested from just above the neck of the rhizome around an inch above the ground before they reach 30cm in height, when they are two weeks old. Strong and healthy shoots are selected. Clean sharp knife is used to harvest the shoots. After extracting the shoot, the portion dug out is restored by heaping the area with soil and litter. The shoots are washed to remove the soil and sheath hairs. The outer sheaths of the shoots are removed. The inner tender creamy white portion is used for edible purposes. Only the tender portion is edible and the hard fibrous portion discarded (Plate 3).

The bitterness in the shoots and the long processing time have been major cause for lack of acceptance of bamboo shoots as a common vegetable. Bamboo shoots contain very high concentration of cyanogenic glucosides, which on endogenic hydrolysis, yield hydrocyanic acid lending a bitter taste to the bamboo shoots. Cooking largely destroys the enzymes responsible for the endogenic hydrolysis. Another constituent of bamboo shoot is homogentistic acid which is responsible for the disagreeable, pungent taste, characteristic of bamboo shoot (Ferreira *et al.* 1995). Cyanogenic glycosides which are phytotoxins, occur in at least 2000 plant species including cassava, almonds etc. of which a number of species are important food items in many parts of the world.

Being a perishable commodity, the shelf life of bamboo shoots is very less. The components of the shoots will change after harvest over a period of time and these changes are influenced by temperature, moisture, microorganisms and the means of storage. Mechanical damage/ harvest can induce high respiration and invasion of microbes, and hence cause rotting of bamboo shoots. The Hydrogen cyanide content causing bitterness is reported to decrease substantially following harvesting. Since storing shoots without processing for a long duration will result in loss of nutrients, processing is essential for preservation of shoots as well as before immediate consumption of fresh shoots. Indigenous methods of reducing bitterness from fresh shoots have been reported with some of them being traditionally practiced over centuries by ethnic groups. Different processing methods such as fermentation, soaking in water, roasting, boiling, blanching, canning, pickling etc. have been reported as bamboo shoot are consumed in the form of fermented-sliced, crushed-fermented moist, crushed-fermented dry, fermented whole shoot, roasted whole shoot and boiled whole shoot etc. In spite of the fact that, bamboo shoots have been an integral part of the diet of the tribal community, there is not much information on scientific validation of traditional processing methods in terms of food quality and

safety except for fermentation. Also, apart from the other traditional methods, new advanced technology like vacuum freeze drying (Xu *et al*., 2005); vacuum cooling (Cheng, 2006); superheated steam drying (Wongsakpairod, 2000) have been attempted to facilitate establishment of cost effective processing on a commercial scale.

Bamboo shoots need to be processed before consumption to remove bitterness. Communities which traditionally have been using shoots may have evolved their own local techniques for doing so. Processing of bamboo shoots after harvest varies from region to region depending on culture and tradition. In North-east India, processing is slightly different and shoots are generally allowed to ferment before consumption. Traditionally in rural areas of peninsular India, the shoots are processed by soaking in water for more than 24 hours before cooking. It is possible that some other processing methods like boiling, steaming, treatment with common salt can also reduce the HCN content in the bamboo shoots (Ferreira *et al.,* 1995; Bindu *et al.,* 2010; Sopade, 2010). Cooking of raw shoots is usually done to enhance increase its palatability. The actual nutrient value of the cooked bamboo shoots may differ from that of the fresh raw bamboo shoots. Various cooking methods may also have different degrees of impact on the nutrient composition and functional ingredients as well. Communities which traditionally have been using shoots may have evolved their own local techniques for doing so which are generally laborous and time consuming.

4. PRECAUTIONS TO BE TAKEN WHILE HANDLING SHOOTS

- The shoot should be harvested from the base using a sharp knife to get maximum edible portion causing minimal damage to the clump
- Only young shoots of around 15-30 cm height should be harvested. Size of shoots ideal for edible purposes varies with species and location. Very small shoots would contain very less edible portion and beyond a particular height, the fiber content in the inner portion increases exponentially rendering the shoots inedible.
- It is essential to retain a few shoots in the clump for sustenance of the clump. All the emerging shoots should not be harvested from a single clump
- The cut portion should be covered with soil and leaf litter to prevent microbial damage
- Immediately after harvest, the exposed portion of the shoot should be covered with a cling film wrap or a plastic cover and rubber band tightly to prevent discoloration and loss of moisture during transportation
- If in case the base of the shoot gets soiled while harvesting, the base should be cleaned with water before wrapping the base to prevent rotting of the shoot
- The shoots should not be harvested when it is raining since water may be accumulated in the sheaths in shoots of some species and may result in rotting and lesser shelf life

- Sheaths of the shoots should be retained if being stored for a couple of days before usage
- Even if the sheath is removed, the shoots should be tightly wrapped in cling film wrap or plastic cover to prevent the discoloration of the creamy white inner portion
- Before removal of sheaths, the shoot should be washed under running water to remove all the sheath hair which will enable easy handling
- The hard nodal portion and the high fibrous portions should be discarded as these portions are not palatable. This can be differentiated while cutting of the shoots. Only the tender portions that are easy to cut should be used
- The bitterness in the shoots varies with species and with location of growth. The time consumed for processing needs to be customized taking into consideration all these factors.

5. SIMPLE TECHNOLOGY DEVELOPED AT IWST FOR PROCESSING OF BAMBOO SHOOTS

A simple method of processing of bamboo shoots for utilizing it as a cooked vegetable has been deveoped at IWST, Bangalore. The tender portion is cut into small pieces and washed in water. The pieces are then cooked in a simple pressure cooker for 15 minutes and the supernatant water is discarded. The shoots can be directly boiled with water for 30-45 minutes. The water discarded and the shoots can be directly used for consumption. It is essential to modify the time duration according to the species being processed since the level of HCN content varies from species to species and also depends on the location of growth. It has been observed that the crunchy, crispy texture and creamish white colour of the shoots are retained after pressure cooking as well as boiling. Also the bitterness is completely removed thus making the shoots ideal for consumption as any other common vegetable.

Studies in IWST on impact of pressure cooking and boiling on nutritional composition of vegetables indicate minimal nutrient loss as compared to other methods of processing which are reported to remove bitterness from shoots (Table 1; Fig 1).

Table 1: Macronutrients (g/100 g fresh weight), and HCN content (ppm) in the freshly harvested, overnight soaked and pressure cooked shoots of *Dendrocalamus asper*

Species/ Processing method	Moisture	Ash	Fat	Protein	Carbohydrate	Crude fibre	HCN
Fresh shoots	0.92	0.93	0.020	1.66	7.63	1.57	1812.72
Overnight soaked shoots	0.93	0.93	0.019	1.64	6.92	1.56	968.35
Pressure cooked shoots	0.92	0.93	0.018	1.61	7.62	1.56	354.29

6. NUTRITIONAL COMPOSITION OF BAMBOO SHOOTS

Bamboo shoots are low in calories, high in dietary fiber, and rich in various nutrients. The main nutrients in bamboo shoots are protein, carbohydrates, amino acids, minerals, fat, sugar, and fiber. The shoots have a good composition of minerals, consisting mainly of potassium (K), calcium (Ca), manganese (Mn), zinc (Zn), chromium (Cr), copper (Cu), iron (Fe), and lower amounts of phosphorus (P), and selenium (Si). Juvenile shoots are a good source of thiamine, niacin, vitamin A, vitamin B6, and vitamin E and rich source of dietary fiber (Nirmala *et al*., 2011). However, bamboo shoots of many species also contain lethal concentration of cyanogenic glucosides, which on endogenic hydrolysis, yield hydrocyanic acid. It has been reported that the nutritional composition of bamboo shoots of species cultivated in Peninsular India are on par with those traditionally consumed in North-East India and elsewhere in the world. *D.*stocksii, a species endemic to Central Western Ghats, not considered edible in the region was found to nutritionally on par with other species which are commonly consumed (Chandramouli *et al*., 2014). From the perspective of human nutrition, bamboo shoots harvested can be of good nutraceutical /therapeutic value, containing good amount of fiber, carbohydrates, proteins and rich in minerals such as potassium. The Recommended dietary allowance (RDA) of an adult person per day for protein, dietary fibre and minerals (RDA, 2009) is more or less met from addition of bamboo shoots (Table 2) making it wholesome as compared to some of the the regularly consumed vegetables which are rich in one or other macronutrient. Hence, daily consumption of shoots can be expected to be beneficial to the human body in so many ways besides helping in balanced nutrition.

Table 2: Potential of bamboo shoots (100g Fresh weight (FW)) in meeting the Recommended Dietary Allowance (RDA) per day of an average Indian Adult.

Nutrient elements	Value range	RDA
Protein	1.66 - 3.45 g/100g FW	60 g
Carbohydrates	4.9 – 7.1 g/100g FW	300 g
Fat	0.01 – 0.07 g/100g FW	30 g
Fiber	1.57 – 3.7 g/100g FW	40 g
Vitamin C	1.00-4.48 mg/100 g FW	40 mg
Vitamin E	0.42-0.91 mg/100 g FW	10 mg
Calcium	4.07 – 6.37 mg/100g FW	600 mg
Copper	0.24 – 0.57 mg/100g FW	2 g
Sodium	9.23 – 15.04 mg/100g FW	2500 mg
Potassium	268.33 – 515.67 mg/100g FW	2500 mg
Iron	1.01 – 2.97 mg/100g FW	17 mg
Manganese	0.61 – 0.94 mg/100g FW	340 mg
Zinc	0.65 – 0.88 mg/100g FW	12 mg
Selenium	0.1 – 0.8 µg/100g FW	40 µg

7. HEALTH BENEFITS OF BAMBOO SHOOTS

The main nutrients in bamboo shoots are protein, carbohydrates, amino acids, minerals, fat, sugar, fiber, and inorganic salts. As a dietary fiber source, the shoots have beneficial effects on lipid profile and bowel function. An increase in dietary fiber from shoot consumption may also be useful in the management of hypertension and obesity through its effect on energy density of food and nutrient bioavailability. People prone to high blood pressure are often advised to increase K intake and decrease sodium consumption. Bamboo shoots fill that need completely. The shoots are also reported to have anticancer, antibacterial, and antiviral activity due to the presence of lignans, which is an important component of fiber. Its also claimed that eating bamboo shoots imparts a freshness to the skin and makes the skin fairer and smooth (Shi and Yang 1992). The survey conducted by Kalita and Dutta (2012) showed that some ethnic tribes of Northeast India used bamboo shoots to control high blood pressure and cardiovascular ailments. A comparitive analysis of two bamboo species with common vegetables shows that both the bamboo species are rich in proteins and also the protein content is much higher than the common vegetables. Apart from proteins and CHO, some species (*B.vulgaris, D.hamiltonii*) were found to have high concentration of vitamin C and vitamin E also. Shoots also contain fairly high amounts of minerals like iron, manganese and zinc as compared to some commonly used vegetables like *Brassica oleraceae* var. *Botrytis* (Cauliflower), *Solanum tuberosum* (Potato), *Abelmoschus esculantus* (Ladies finger) and *Solanum melongena* (Brinjal) (Fig 2). Selenium, another very important mineral known for antioxidant properties, is also present in bamboo shoots unlike in other vegetables (Nirmala *et al*., 2011). Bamboo shoots appear to provide complete nutrition and perhaps this could be the reason bamboo shoots are always there in the local cuisine of the people of various South-east Asian countries including north-East India

8. ECONOMICS OF CULTIVATION OF EDIBLE SHOOTS

India, has second largest diversity of bamboo species next to China 148 species in 29 genera. Around 90% of the species diversity is found in North-east India. Various native species from other parts of India and exotic species from outside India have been introduced in Peninsular India in the past few decades. Though many species of bamboo are being cultivated, there is not much emphasis on exploitation of these commercial plantations for edible shoots. This may be attributed to lack of awareness on the nutritional potential of edible shoots and the lack of information on the potential of bamboo as edible shoots. There are various bamboo species that are considered as multipurpose species, since mature culms from plantations raised for shoot production, can be used for other purposes like construction, furniture, handicrafts, agriculture implements etc. as well.

For commercial cultivation of edible bamboo shoots *D.asper* (sweet bamboo) (Plate 4) scores much above all other species in terms of taste, volume of extractible shoots and ease in management. Hence economics of cultivation has been worked out for this species only. *Dendrocalamus asper* Backer,

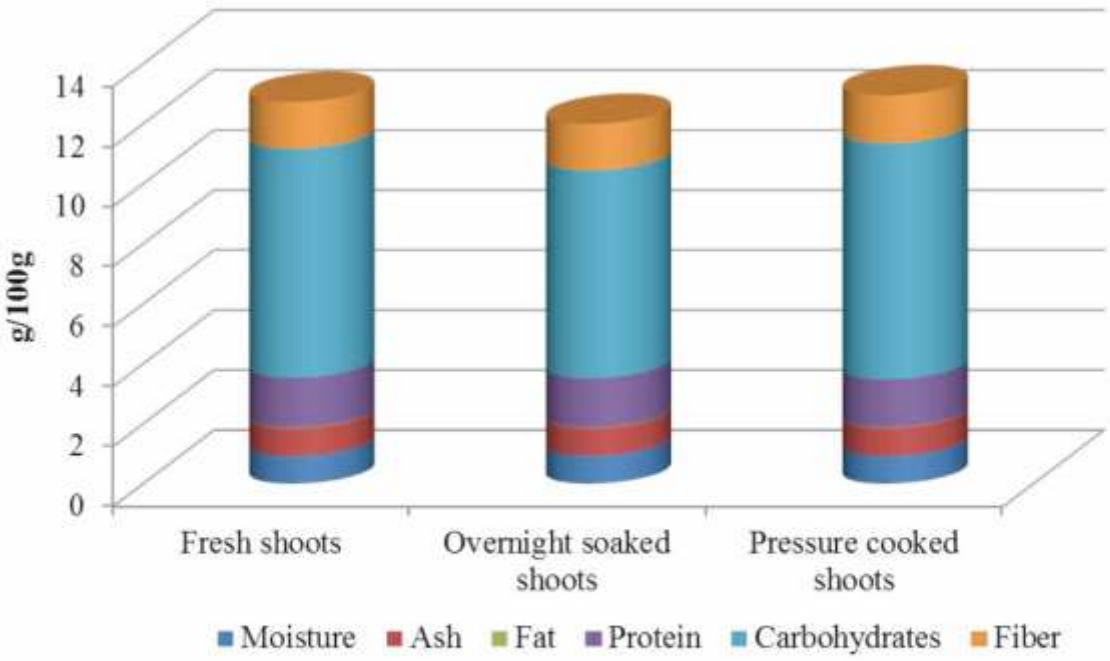


Fig. 1: Variation in macronutrient composition before and after processing in *D.asper*

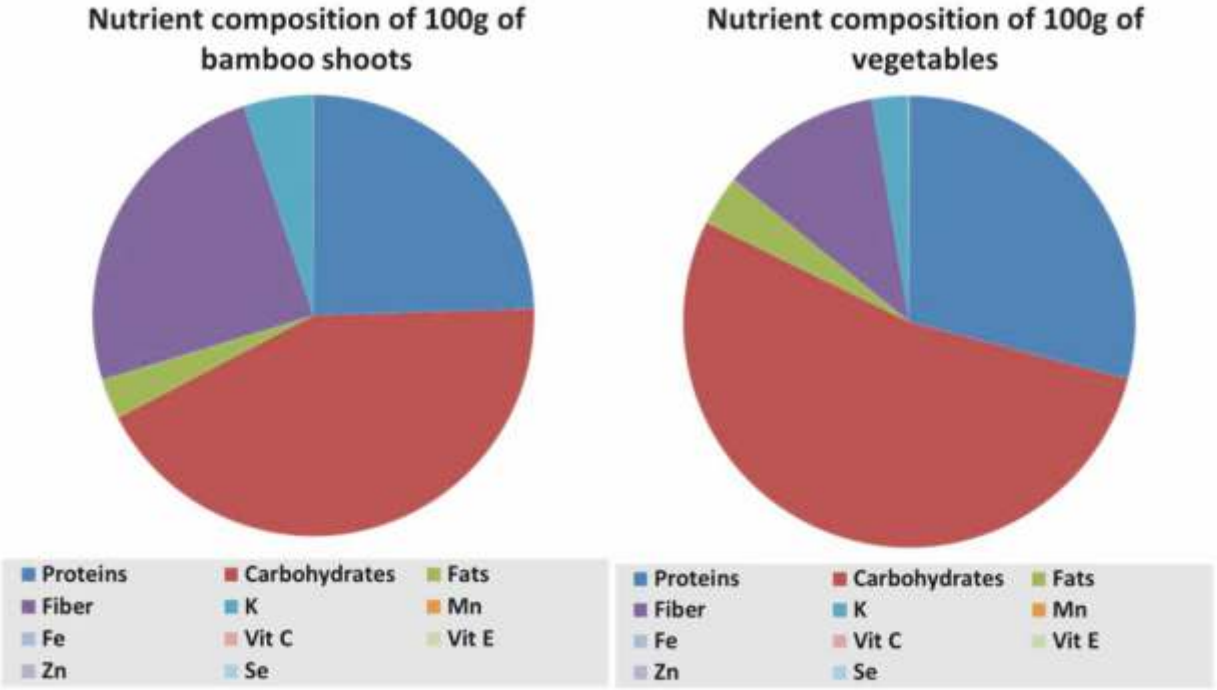


Fig 2: Comparison of nutritional composition of shoots and commonly consumed vegetables

PLATE 1: BAMBOO SHOOTS. A: Shoots commonly sold on roadside in Byrnihat, Assam, India; B: Shoots sold in the market during monsoon (June-September) in Bangalore, Karnataka, India; C: Bamboo shoots in market in China; D: Bamboo shoot processing unit in China; E&F: Various processed and packed products of Bamboo shoots in China (Photos C-F: Dr.B.N.Mohanty)

PLATE 2: COMMERCIALLY IMPORTANT EDIBLE BAMBOO SPECIES IN PENINSULAR INDIA

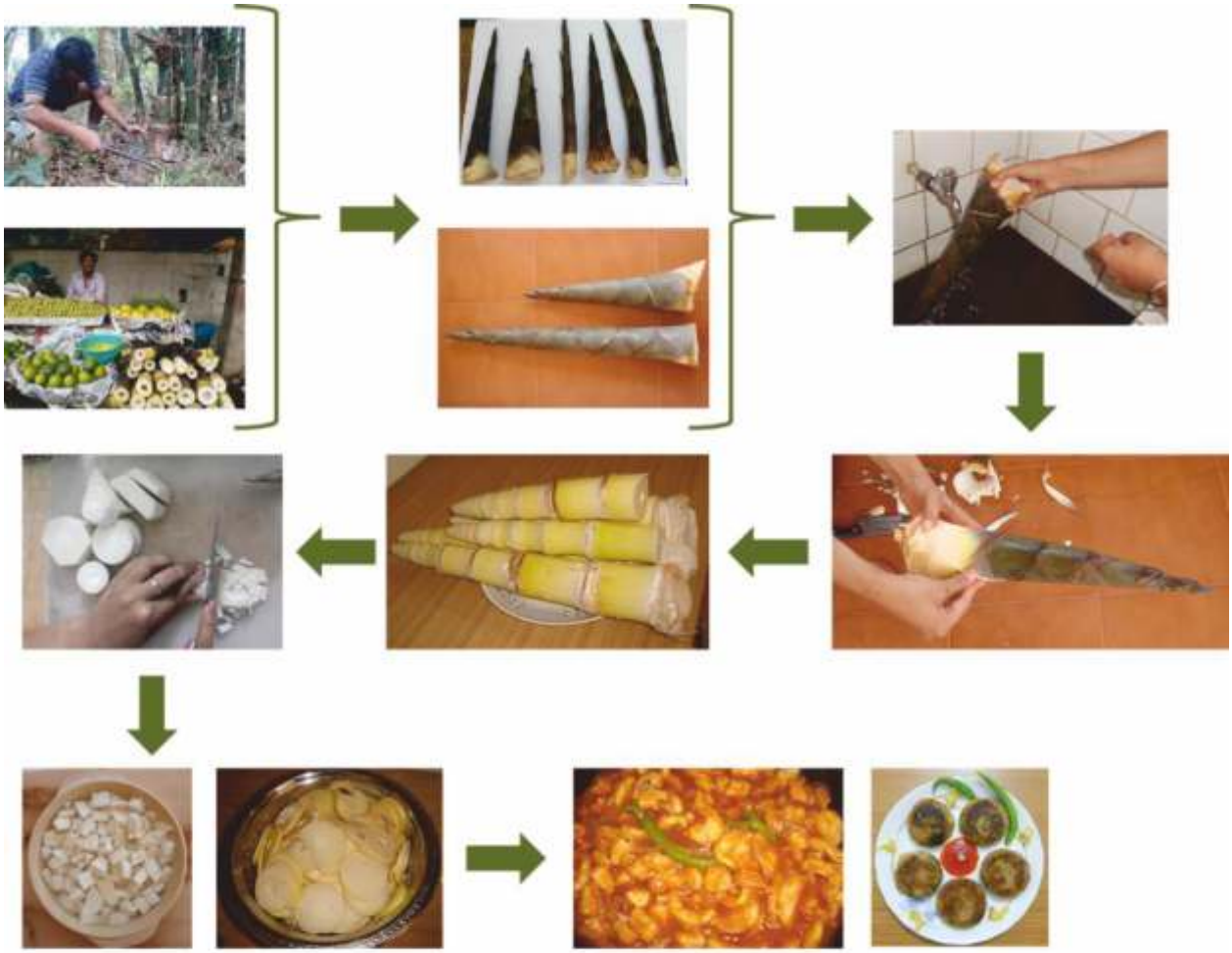


PLATE 3: PROCESSING OF JUVENILE SHOOTS

PLATE 4: D.ASPER PLANTATION IN TROPICAL HUMID CONDITIONS IN KARNATAKA

native of Indonesia, also known as sweet bamboo is one of bamboo species which is recognized world wide for its culinary value of the shoots.This exotic bamboo species, which was introduced in India around 15 years ago, has been well recognized for its multifarious uses. The species grows best in rich and heavy soils of humid regions from lowlands to 1500 m altitude. It also grows well in semiarid conditions under good mangement practices. Apart from being used as edible shoots, it is also used in making good quality furniture, musical instruments, containers, household utensils, handicrafts and in paper making. It is considered as structural timber due to its fairly good physical and mechanical properties. Hence, this species is being considered as an example to highlight the economical benefits of raising and maintaining a bamboo plantation for edible shoots. Field trials by IWST in Hosakote, Bangalore reveal that *Dendrocalamus asper* can be exploited for edible shoots throughout the year with supplementary irrigation and can be a profitable commercial venture.

In semi arid conditions, around 15 shoots were produced in a five year old clump with the average shoot diameter was around 23mm. In humid tropical conditions, *D. asper* clumps of same age produced around 25 shoots with an average shoot diameter of around 50mm. With appropriate irrigation, a species like *Dendrocalamus asper* can also be exploited even in semiarid conditions. The typical "shooting season" of this species rarely exceeds two months which may be extended by modifying the cultivation and management practices since it is an intensively managed process. The shoots have to be harvested within two weeks of emergence when they reach 30-40cm height. Continuous monitoring is essential as to harvest the shoots at the appropriate time to get the maximum volume of edible portion. After harvest, deterioration of shoot quality is rapid especially if the outer sheath is removed. Hence transportation of shoots from the harvesting site to the processing unit has to be well coordinated.

The profitability of *D.asper* cultivation for shoot production and culm production was assessed through a Benefit – Cost Analysis(BCA) following Friday *et al*. (2000) and Purushothaman (2005).The financial returns from plantations raised for shoots production were estimated three years after planting. It becomes imperative to judge the viability of bamboo plantations through appropriate financial analysis, taking the time value of money into account. *D.*asper has a life span of around 40 years and is expected to keep producing shoots at least for 40 years, hence the time period taken for analysis was kept at 40 years. The indicators used for financial analysis include Net Present Value (NPV), Benefit Cost (B/C) ratio, Internal rate of return (IRR) and Equivalent Annual Income (EAI) at three different discount rates. BCA takes into account all the major costs incurred including labour, site preparation, pitting, soil working, fertilization, cost of planting material, transport, irrigation, fencing, watch and ward, protection etc. In subsequent years, the input costs include the harvesting of emerging shoots/culms, infrastructure and labour for processing of shoots, annual marketing etc.

Costs and benefits were valued at farm gate or nearest market prices (Annexure 1 & 2) and discounted at 10 per cent, 12 per cent and 15 per cent based on prevailing interest rates. Apart from the costs incurred in the systems maintained for culm production, additional recurring costs incurred include compost,

soil working, irrigation, tending, cleaning, harvesting and processing of shoots and watch and ward and one-time cost for establishment of on-site infrastructure facility for processing of shoots. The fertilization is replaced by application of compost since the plantation is raised for edible shoots. To facilitate better emergence of shoots, soil working and saucer pit enlargement should be done twice every year throughout as compared to the plantations maintained for culm production. The observations on growth have indicated that *D. asper* has the potential to produce 25 – 30 emerging shoots in the fifth year in tropical humid conditions and around 14-16 shoots in semi-arid conditions. However, an average of 25 extractable shoots/ clump/ year in tropical humid conditions and 15 extractable shoots/ clump/ year in semi-arid conditions from fifth year onwards have been taken for financial analysis taking into account out of which 30 % of the shoots may have to be retained and allowed to grow to culm size for the future sustenance of the clump. Around 750 gm of edible portion from shoots in semi-arid conditions and around 2000gm of edible portion from shoots in tropical humid conditions can be extracted if the shoots are harvested at the right size after removal of the sheath and nodal portions. This can be processed and sold at a minimum rate of Rs.80/kg at farm gate prices.

Potential revenue of Rs. 14.4 lakh $year^{-1}$ can be expected from fifth year onwards from approximately 9000 juvenile shoots after accounting 10 % mortality of clumps in humid tropics and around Rs.3.24 lakh $year^{-1}$ can be expected from approximately 5400 juvenile shoots after accounting 10 % mortality of clumps in semiarid conditions. Over a 40 year period of the plantation at different discount rates like 10 %, 12 % and 15 %, the net present value (NPV) is 88.08, 69.72 and 50.98 lakhs in humid tropics (Table 3) and 5.81, 3.64 and 1.50 lakhs in semi-arid (Table 4) conditions. However, the benefit cost ratio is 6.24, 5.84 and 5.33 in humid tropics and 1.33, 1.24 and 1.12 in semi-arid conditions respectively for the same discount rates. The internal rate of return (IRR) at the same discount rates is 63%, 60% and 56% in humid tropics as compared to 8%, 6% and 3% in semi-arid conditions. Equivalent annual net income (EAI) of 9, 8.45 and 7.67 lakhs can be reasonably expected from the sale of young shoots over a 40 year period of plantation in humid tropics while the EAI in semi-arid conditions is as low as 0.59, 0.44 and 0.22 lakhs. The results revealed that cultivation of *D.asper* for shoot production is a highly profitable venture in humid tropics but may not be commercially viable in semi-arid conditions considering the financial indicators.

Table 3: Financial analysis of *Dendrocalamus asper* plantations for shoot production in tropical humid conditions at different discount rates (Rs in lakhs)

Discount rates	Net Present Worth (NPV)	Benefit cost Ratio (B/C)	Internal rate of Returns (IRR)	Equivalent annual Income (EAI)
10%	8808708.36	6.21	63.00%	900773.36
12%	6972005.16	5.84	60.00%	845729.50
15%	5098292.47	5.33	56.00%	767609.54

Table 4:Financial analysis of *Dendrocalamus asper* plantations for shoot production in semi-arid conditions at different discount rates (Rs in lakhs)

Discount rates	Net Present Worth (NPV)	Benefit cost Ratio (B/C)	Internal rate of Returns (IRR)	Equivalent annual Income (EAI)
10%	581895.82	1.33	8%	59504.33
12%	364060.03	1.24	6%	44161.80
15%	149980.65	1.12	3%	22581.40

9. PROBLEMS & PROSPECTS

For a commercial venture on edible shoots it is ideal that *D.asper* be used. But for meeting home nutrition needs any of the 15 bamboo species listed earlier can be used including native species like *D.strictus* and *B.bambos* in south India. The quantity of extratible edible portion may be low but in terms of nutritional properties it may be per on par with *D.asper* or even better. India, though it is the second largest resource of bamboo in the world, stands nowhere in the bamboo shoot export market in the international scenario. Rather, for its domestic consumption, India, imports shoots from countries like Bhutan and Thailand. Though shoots are found being sold in the open market in India, it is mostly restricted to North-East India. Except for in few regions, bamboo shoots are not so commonly found in the market alongside other vegetables in Peninsular India. The high returns from bamboo plantations has attracted people to raise plantation in abandoned agricultural lands and tea/coffee estates where availability of labour is a major constraint.

The typical "shooting season" of a species rarely exceeds two months which may be extended by modifying the cultivation and management practices. Clump management is very essential in plantations raised for shoot production since the ideal number of emerging shoots harvested will help in maintaining the clump for the next season. Thus, it aims to maximize the yield of one product, or alternatively to optimize yield of individual products to increase their combined monetary output. Since bamboo is a perennial, all culm management practices must also aim to sustain long-term

productivity of the stand. Being a biological material, bamboo is subjected to greater variability and complexity due to various growing conditions such as moisture, soil and competition. Many factors, such as culm height, topography and climate, affect the properties of bamboo to a great extent and thus its utilization. The production of shoots is far less than the area covered by bamboo in India would indicate, as bamboo is currently underexploited, being used primarily as a source of timber and fibre and not for its vegetable shoots.

Bamboo shoots are becoming a popular food item globally mainly due to its nutritive value and health enhancing properties. There is a growing demand for processed and packaged bamboo shoots in the national and international market as the shelf life of freshly harvested shoots is only 2-3 days. Edible bamboo shoots can be a better alternative to vegetables in terms of nutritional value and can also be a potential bioresource in addressing the food security needs of future. The essential requirement for successful exploitation of shoot production technology is the availability of bamboo bioresource and technical and entrepreneurial skills in managing shoot-producing bamboo plantation. Also the industrially important species if cultivated with appropriate inputs will aid in the exploitation of the shoots for other industrial purposes as well as a potential nutrient source**.**

10. MYTHS Vs REALITY

S.No.	Myth	Reality
1	Bamboo shoots are bitter so they are poisonous and not edible	Bamboo shoots are bitter due to the presence of cyanogenic glucosides which are also found in cassava, almonds etc and can be easily removed by processing making them edible
2	All bamboo shoots can be eaten	All bamboo species are not edible.
3	Eating bamboo shoots regularly causes too much body heat	Bamboo shoots are highly nutritious. As with any food rich in protein, carbohydrates and fiber bamboo shoots also increase the body temperature while getting digested. This is normal and not harmful. This can also be handled by balanced cooking
4	Only tribal people consume bamboo shoots	Bamboo shoots are considered as a functional food and ranked as one among the top five highly nutritious foods in the world.
5	Bamboo shoots require special training for processing and preparation	The processing of bamboo shoots is very simple and does not require any special training. It can be cooked like any other vegetable after processing.

6	Bamboo shoots require 2-3 days of processing	Newer processing methods of processing are available which enable processing of the shoots in as less as 15 minutes
7	Bamboo shoots can be found only in regions adjoining forest areas	Bamboo shoots are available during the rainy season along with other vegetables in the local markets
8	Bamboo shoots are a rare commodity hence very expensive	Bamboo shoots are not very expensive and are affordable by all.

ACKNOWLEDGEMENTS

The work was part of Ph.D work of Sowmya Chandramouli and also part of an ICFRE project on bamboo shoots utilization executed by the Principal investigator Dr. Syam Viswanath at IWST, Bangalore.. The encouragement and support of Shri. Surendra Kumar IFS, Director, IWST is gratefully acknowledged. The assistance and help rendered by various scientists and staff, Tree improvement and Genetics Division, IWST; especially by Mr.Sushanth Arade, JRF under the said ICFRE project is gratefully acknowledged. The encouragement and support provided by Dr.Nirmala Chongtham, Professor, Department of Botany, Panjab University, Chandigarh; Dr. Uday Kumar Nidoni, Food Processing and Engineering Department, University of Agriculture Science, Raichur and Mr.Ranganathan, PoinTech Pens, Attibele is also acknowledged. The support and encouragement rendered by Mr. M Srinivasa Rao IFS, Chief Conservator of Forests, IWST and Dr TS Rathore, Scientist G and Head, Tree Improvement and Genetics, IWST is also gratefully acknowledged. The author also acknowledge the reviewer Dr.B.N.Diwakara, Scientist, IWST for valuable comments and suggestions. Special thanks to Dr.Pankaj Aggarwal, Organizing Secretary, National Seminar on Bamboo reserve management and advances in utilization options, February 2016, IWST and for all encouragement and support for bring out this publication for release during the seminar. The support and co-operation at field level rendered by Mr.Kurien, MD and Mr.Phillip Jacob, General Manager, Devon Tea and coffee Estates Pvt Ltd, Koppa is gratefully acknowledged.

REFERENCES

Bindu, Rana., Pratima, Awasthi. and B. K. Kumbhare. 2010. Optimization of processing conditions for cyanide content reduction in fresh bamboo shoot during NaCl treatment by response surface methodology. *Journal of Food Science and Technology.*, **49** (1): 103 – 109.

Chandramouli. S., Viswanath, S. & Nidoni, U. 2014. Potential for exploitation of *Dendrocalamus stocksii* (Munro.) shoots: New report from Peninsular India. *Tropical Plant Research*.**1**(3): 89–91

Cheng, H.P.2006. Vacuum cooling combined with hydro cooling and vacuum drying on bamboo shoots. *Applied Thermal Engineering*., **26** (17–18): 2168–2175.

Ferreira, V.L.P., Yotsuyanagi, K. and Carvalho, C.R.L.1995. Elimination of cyanogenic compounds from bamboo shoots *D. giganteus* Munro. *Tropical Science.*, **35**:342 - 346.

Friday, J.B. Cabal, C. and Yanagida, J. 2000. Financial analysis for tree farming in Hawaii. .College of Tropical Agriculture and Human Resources publication. www.2.ctahr.hawaii.edu. 1-7.

Kalita,T. and U. Dutta. 2012. A comparative study on indigenous usage of bamboo shoot in the health care practices in NE India, *The Clarion*, 1(2): 130–141.

Nirmala, C., Sheena, H. and David, E. 2011.Bamboo shoots: a rich source of dietary fibres. In *Dietary fibres, fruit and vegetable consumption and health (ed.* Klein, F. and Moller, G.), Nova Science Publishers, USA, 2009, pp. 15–30.Nirmala, C., Bisht, M. S. and Sheena, H., Nutritional properties of Bamboo shoots: Potential and prospects for utilization as health food. *Comprehensive reviews in food science and food safety,* **10**: 153-169.

NMBA, The Bamboo Book FG 01 07/11. 2011.NMBA, TIFAC, DST, GoI, New Delhi, India.

Purushothaman, S. 2005. Land-use Strategies, Economic Options and Stakeholder Preferences: A Study of Tribal Communities in Forest Peripheries. SANDEE Working Paper No.13-05. 75 pp

RDA - Nutrient requirements and recommended dietary allowances for Indians, 2009.Draft of A report of the expert group of ICMR, National Institute of Nutrition, ICMR, Hyderabad.

Salam, K. 2013. Connecting the poor : Bamboo, Problems and prospect . South Asia Bamboo Foundation (SABF) retrieved 17 December 2013 from jeevika .org/bamboo/2g-article-for-nbda.docx

Shi, Q. T. and Yang, K. S. 1992. Study on relationship between nutrients in bamboo shoots and human health, Proceedings of the International Symposium on Industrial Use of Bamboo, International Tropical Timber Organization and Chinese Academy, Beijing, China: Bamboo and its Use.

Sopade, P.A. 2000. The fate of cyanogens during the cooking of cassava in mumu, a traditional oven in Papua NewGuinea. *International Journal of Food Science and Technology.,* **35**: 173-182.

Wongsakpairod, T. 2000. Bamboo shoot drying using superheated steam. MEng Thesis, King Mongkut's University of Technology, Thonburi, Bangkok, Thailand.

Xu S., Cao, W., Song, Y., Fang, L.2005. Analysis and evaluation of protein and amino acid nutritional components of different species of bamboo shoots. *Food Science*., **26**: 222–227.

DISHES USING BAMBOO SHOOTS

S.No.	Dish	Ingredients	Method of preparation
1	Bamboo shoot Manchurian	Processed Bamboo shoots 200g Corn flour 100g Oil for frying Ginger garlic paste 1 tsp Onion 1 small sliced Soy Sauce to taste Tomato Sauce to taste Salt to taste Spring onions Chopped for garnish	Coat the processed bamboo shoots with corn flour and deep fry them in oil till golden brown. In a pan, add oil, add ginger garlic paste, sliced onions and sauté till transparent. Add the fried shoots, soy sauce, tomato sauce and salt to taste and toss them till the sauce coats the shoots. Garnish with spring onions and serve hot.
2	Bamboo shoot cutlet	Processed bamboo shoots chopped 200g Chopped vegetables (Beans, Carrot any vegetable of choice) 100g Boiled potato 100g Onion 1 small chopped Green chili to taste Garam masala ½ tsp Corn flour 2 tbsp Bread crumbs to coat Oil	In a pan, heat little oil, add green chili, onions and sauté well. Add chopped vegetables and bamboo shoots and mix well intermittently until cooked. Add salt to taste, garam masala and mix well. Add mashed boiled potatoes and mix well. Allow it to cool. Make small flattened patties of the mixture. Dip the patties in a thin paste of corn flour and roll them in bread crumbs. Shallow fry the patties on a pan until golden brown. Serve hot.
3	Bamboo shoot Dal vada	Processed bamboo shoots chopped 200g Channa dal (Chick pea) 200g Curry leaves 10-15 Green chili to taste Onion 1 small chopped Hing (Asofoetida) one pinch Salt to taste Oil for frying	Soak the channa dal for 2 hours in water and coarsely grind them with curry leaves and green chili. To the mixture add chopped shoots, onion, hing, salt and mix well. Small balls of the mixture are made concave in shape and deep fry in oil. Serve hot.
4	Bamboo shoot coconut curry	Processed bamboo shoot cut as per requirement 200g Coconut 100g Green chili to taste Mustard seeds 1tsp Oil Salt to taste	In a pan, add little oil and splutter the mustard seeds. Add the cooked bamboo shoots and sauté. Grind coconut and green chili coarsely and add this to the shoots. Add salt and mix well. Can be served with rice or roti.

S.No.	Dish	Ingredients	Method of preparation
5	Bamboo shoot pickle	Bamboo shoots chopped/grated Salt to taste Red chili powder Oil Mustard	Bamboo shoots(chopped/grated) are mixed with salt and kept in an airtight container for a week. After a week, the salt is drained out and chili powder added and mixed. Oil as per requirement is heated, mustard spluttered and added to the shoots. The shoots are mixed well and stored in airtight container.
6	Bamboo shoot halwa	Grated processed bamboo shoots 200g Sugar 150g Khoya 100g Ghee Cashew nuts for garnish	Grated bamboo shoots and sugar are mixed together and allowed to cook in a pan. After the sugar melts completely and shoots get well cooked add khoya and mix well. Add ghee and mix. Allow the mixture to cook until ghee separates out of the mixture. Add cashew nuts fried in ghee for garnish.

ANNEXURE 1: COST OF DENDROCALAMUS ASPER CULTIVATION IN TROPICAL HUMID CONDITIONS

ESPACEMENT: 5X5 Wage rate (Rs./manday) : 250

NO.OF CLUMPS/HA.: 400 Casualty replacement (%): 10% SURVIVAL/HA.: 360

SL. NO.	PARTICULARS OF WORKS	UNIT	Qnty.	Cost	COST (Rs.) PER YEAR 0	1	2	3	4	5	TOTAL (Rs.)
1	Site preparation	MD	100	250	25000						25000
2	Alignment & staking	MD	3	250	750						750
3	Digging of pits (60 cm3) and refilling of pits after	Cum	86.4	50	4320						4320
	mixing FYM,Fertiliser and insecticide	Cum	8.64	50	432	432					864
	@ Rs.50/Cum				0						
4	Cost of FYM @5 Kg/pit	Rs./ton.	2	3000	6000						6000
5	Cost of compost@10kg/clump	Rs./kg	4000	8	0	0	0	0	32000	32000	64000
6	Cost of fertiliser @100	Rs./Kg	40	10	400	400					800
	Gm/plant for 2 years.				0						0
7	Cost of insecticides (2 Yrs.)	LS			0	200					200
8	Cost of plants including	Rs./Plant	400	15	6000	600					6600
	transport(400)		40								0
9	Planting & replanting	MD	10	250	2500						2500
		MD	1	250	250						250
10	Weeding (3,2)	7 MD per	21	250	5250	3500					8750
		weeding	14								0
11	Soil working,saucer pit	16 MD per	16	250	4000	8000	8000	8000	8000	8000	44000
	enlargement,heaping	working	32								0
	earth(1 working in 1st		32								0
	year & 2 workings		32								0
	thereafter)		32								0
12	Tending,cleaning , harvesting & processing of shoots per year	15 MD per month6 months per year	90	250	0	0			22500	22500	45000
13	Cost of equipment & on-site infrastructure facility								100000	0	100000
14	Irrigation(5 times a year)	RS./irrgn.	200		1000	1000	1000	1000			4000
15	Irrigation(4 times a year)		32000	0.08					2560	2560	5120
16	Fencing(CPT/Live hedge)	@ Rs./Rmt	400	10	4000	1000					5000
			100								
17	Watch and ward	250			91000	91000	91000	91000	91000	91000	546000
18	SUB TOTAL	Rs.			150902	106132	100000	100000	256060	156060	869154
19	CONTINGENCY 05 %	Rs.			7545.1	5306.6	5000	5000	12803	7803	43457.7
20	GRAND TOTAL	RS.			158447.1	111438.6	105000	105000	268863	163863	912611.7

NB : *Cost is indicative only and may have to be revised as per actual site condition. **Costs include rental value of land (@10%,12% and 15% respectively for 40 years

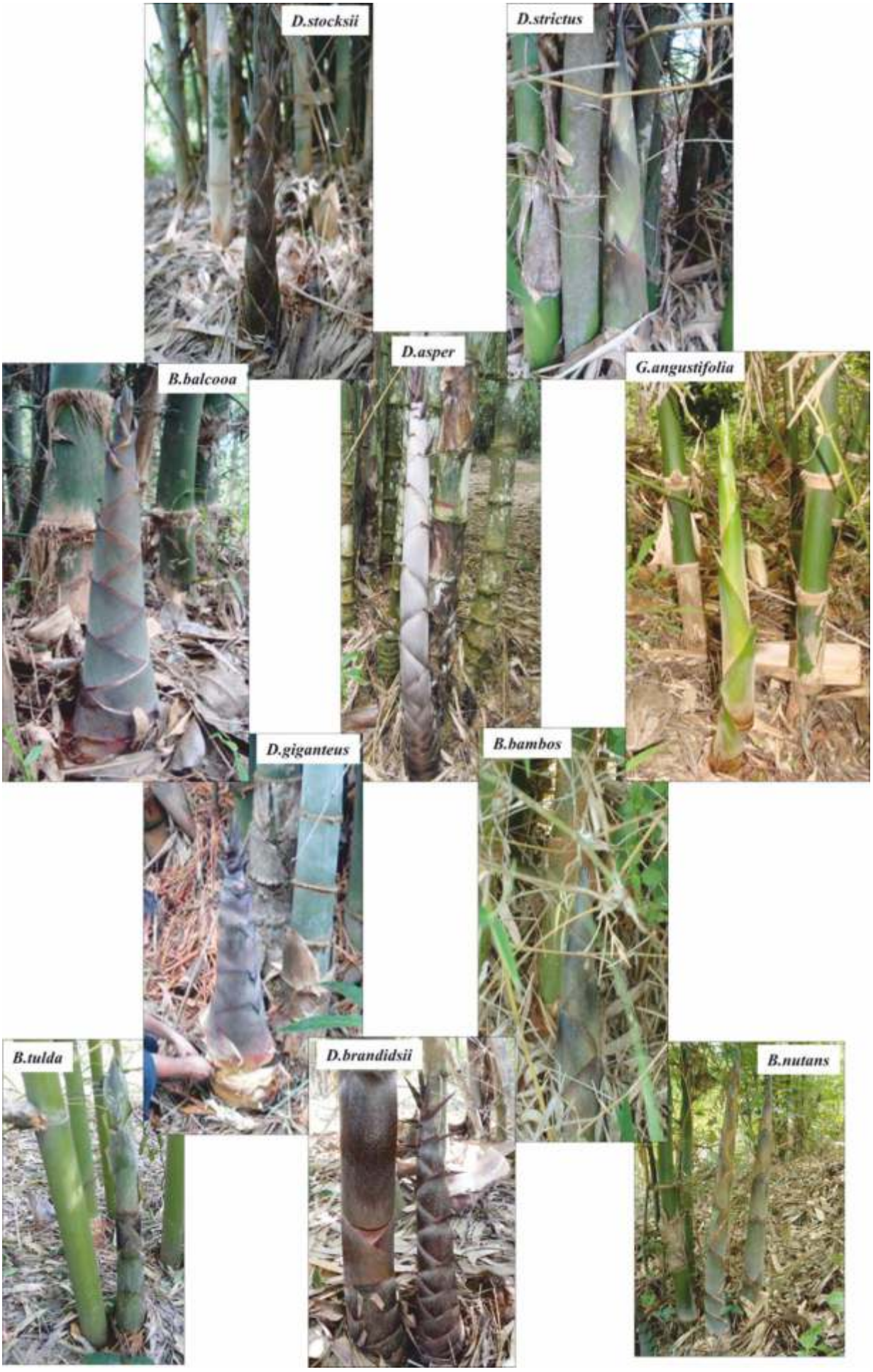
ANNEXURE 2: COST OF DENDROCALAMUS ASPER CULTIVATION IN SEMI-ARID CONDITIONS

ESPACEMENT: 5X5 Wage rate (Rs./manday) : 250

NO.OF CLUMPS/HA.: 400 Casualty replacement (%): 10% SURVIVAL/HA.:360

SL. NO.	PARTICULARS OF WORKS	UNIT	Qnty.	Cost	COST (Rs.) PER YEAR						TOTAL (Rs.)
					0	1	2	3	4	5	
1	Site preparation	MD	10	250	2500						**25000**
2	Alignment & staking	MD	3	250	750						**750**
3	Digging of pits (60 cm3)	Cum	86.4	50	4320						4320
	and refilling of pits after	Cum	8.64	50	432	432					864
	mixing FYM,Fertiliser and				0						
	insecticide @ Rs.50/Cum				0						
4	Cost of FYM @5 Kg/pit	Rs./ton.	2	3000	6000						6000
5	Cost of compost@10kg/clump	Rs./kg	4000	8	0	0	0	0	32000	32000	64000
6	Cost of fertiliser @100	Rs./Kg	40	10	400	400					800
	Gm/plant for 2 years.				0						0
7	Cost of insecticides (2 Yrs.)	LS			0	200					200
8	Cost of plants including	Rs./Plant	400	15	6000	600					6600
	transport(400)										0
9	Planting & replanting	MD	10	250	2500						2500
		MD	1	250	250						250
10	Weeding (3,2)	7 MD per	21	250	5250	3500					8750
		weeding	14								0
11	Soil working,saucer pan	16 MD per	16	250	4000	8000	8000	8000	8000	8000	44000
	enlargement,heaping	working	32								0
	earth(1 working in 1st		32								0
	year & 2 workings thereafter)		32								0
12	Tending,cleaning , harvesting & processing of shoots per year	10 MD per month 6 months per year	60	250	0	0			15000	15000	30000
13	Cost of equipment & on-site infrastructure facility								100000		100000
14	Irrigation(5 times a year)	RS./irrgn.	200		1000	1000	1000	1000			4000
15	Irrigation(4 times a year)		32000	0.08					2560	2560	5120
16	Fencing(CPT/Live hedge)	@ Rs./Rmt	400	10	4000	1000					5000
			100								
17	Watch and ward upto 4th yr	250			91000	91000	91000	91000	91000	91000	546000
18	SUB TOTAL	Rs.			128402	106132	100000	100000	248560	148560	854154
19	CONTINGENCY 05 %	Rs.			6420.1	5306.6	5000	5000	12428	7428	42707.7
20	GRAND TOTAL	RS.			134822.1	111438.6	105000	105000	509548	155988	896861.7

NB : *Cost is indicative only and may have to be revised as per actual site condition. **Costs include rental value of land (@10%,12% and 15% respectively for 40 years


D.stocksii
D.strictus
D.asper
B.balcooa
G.angustifolia
D.giganteus
B.bambos
B.tulda
D.brandidsii
B.nutans

Institute of Wood Science and Technology, Bangalore

Institute of Wood Science and Technology (IWST) is one of the institutes of Indian Council of Forestry Research & Education (ICFRE) with a long history of valuable research in the field of wood science. The Institute has a vision to attain excellence in forestry, in general and wood science in particular. IWST is mandated to conduct research on wood science and technology as a national objective and also focuses its research activities to important forestry research needs of the states of Karnataka and Goa. ICFRE has recognized IWST as centre for advanced studies in the area of Improved Utilization of Wood, Mangrove and Coastal Ecology and Research on Sandal. In addition to this, the Institute has an Advanced Woodworking Training Center (AWTC), a Woods Museum cum Interpretation Centre (WMIC) and a Library cum Documentation Centre. The institute is adhering to procedures of ISO 9001-2008 to achieve continual improvements in quality managements systems. The major research thrust areas are on better utilization of traditional as well as lesser known natural and plantation species, wood processing, engineered wood, timber protection, tree improvement techniques, better protection of natural and plantation areas, developing new bio-based materials and chemistry of forest products.

Institute of Wood Science and Technology

(Indian Council of Forestry Research and Education)

18th Cross, Malleshwaram, Bangalore – 560 003
Phone: +91-80-23341731, 22190100, Fax: +91-80-23340529
E-mail: dir_iwst@icfre.org; extension_iwst@icfre.org
Web: http:\\iwst.icfre.gov.in

Published by: Publication Cell on behalf of the Director, IWST, Bangalore