Bamboo Resource of Himachal Pradesh (India) and Potential of Shoots in Socio-economic Development of the State

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Abstract

Himachal Pradesh is a hilly state of northern part of India with 55673 km^2geographical area. Of the total geographical area 26.37% is covered with forests, out of which bamboo cover an area of 3%. Eight species of bamboos are found under five genera. Bamboos are used for construction, scaffolding, furniture, crafting *etc*. by people of the region. Some species have edible shoots also, out of which *Bambusa nutans, Dendrocalamus hamiltonii* and *D. strictus* have highly nutritious shoots and are good source of nutrient and bioactive compounds. However, consumption of young shoots is not so popular as they are not available in the market and are eaten by people who grow bamboos in their homesteads. Moreover, people are not aware of the nutritional value of the young shoots. So the earning of income from the shoots is almost negligible. Addition of the shoots in diet shall enable the people to consume a healthy food item and also make it possible for income generation from the sale of shoots with the growing demand of shoots both in national and international markets and shall potentially boost the socioeconomic development of the state and its people.

Introduction

Himachal Pradesh described by the ancients as 'Abode of the Gods' is a hilly and mountainous state; located in Northern part of India. It extends from latitude 30º 22´ to 33º 12´ North and longitude 75º 45´ to 79º 04´ east and is surrounded by the states of Jammu and Kashmir in North, Punjab in west and southwest, Haryana and Utter Pradesh in south and Tibet in east (Figure 1).The state is part of the Himalayan range with altitude ranging from 350 to 7000 meters amsl (above mean sea level), annual rainfall between 350 mm to 3800 mm and temperature range of -25 ºC to 42 ºC. It can be divided in three zones topographically; 1) Outer Himalayas or The Shivaliks, with altitude ranges between 350 meters to 1500 meters amsl and annual rainfall of 1500 to 1800 mm. 2) Inner Himalayas or Mid mountains, where altitude ranges from 1500 to 4500 meters amsl and 3) Greater Himalayas or Alpine

zone, with altitude above 4500 meters amsl, rainfall is scanty here and the region remains cut off from other areas during the months of October to march due to heavy snowfall and very odd geographical conditions (HPDR2014).Due to utmost variation in elevation, the climate varies considerably from semi-tropical to semi-arctic depending on the altitude and due to the diverse climate the state is rich with a rich diversity of flora.

Forests play an important role in life of the people of the region as they provide raw material for industries, fodder for livestock, herbs and drugs which is an important source of income for people. Around 70 % of the inhabitants get employment through agriculture and it provides over 30% of the state's domestic products. But steep and hilly lands, operational land-holdings, climatic hazards, limited irrigation and restricted cultivation area is hampering agriculture (HPDR 2014). Bamboos, unlike most other agricultural crops, can grow well on steep hillsides, road embankments, on the banks of ponds and streams; without the application of any fertilizer or pesticides and are quite resistant to diseases, insects and climatic injuries (Ben-zhi et al. 2005; Nirmala et al. 2011). Bamboo is a multipurpose grass, being used from ancient time for construction, crafting, agricultural tools, utensils, musical instruments, medicines *etc*. Cultivation of bamboo has a great potential for the state for usage in industry and as food, is a latest substitute for light timber, contributing in making unique furniture, new generation building material and many other items, thus producing innumerable jobs along with potentially restoring ecology by facilitating carbon sequestration, water conservation, land rehabilitation, soil regeneration and preventing habitat destruction.

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Figure1. Map showing Himachal Pradesh and its districts.

Bamboo resource of Himachal Pradesh

India has bamboo cover of 13.96 million hectare. In Himachal Pradesh, bamboo forest covers 508 km^2 area which is 3 % of total forest area of the state (FSI 2011). Bamboo plantation has increased from 1950 onwards; bamboo planted till 2008-09 was 8930 hectare area, in 2009-10 it was 1242 ha and in 2010-11 it was around 754 ha; total raised area of bamboo plantation till 2011 is 10926 ha. Working plan wise area allotted in different regions of state as Nalagarh (3808 ha), Kunihar (1634 ha), Dehra (342 ha), Nurpur (335 ha), Nahan and Paonta Sahib (979 ha). Bamboo produce during 2012-13 is 508 ha which has contributed to state forest revenue to an estimated amount of 738 thousand INR or US$ 11.77 thousand (FDHP 2013).

A total of eight species of bamboo has been reported from the state under five genera *viz. Bambusa nutans, Dendrocalamus hamiltonii, D. parishii, D. strictus, Drepanastachyum falcatum, Phyllostachys aurea, P. Bambusoides* and *Thamnocalamus spathiflorus* (Richa et al. 2012) Among these, three species *B. nutans, D. hamiltonii* and *D. strictus* are widely distributed and commonly used (Table 1) and further work was conducted on these species.

Table 1.Morphological features and uses of three common bamboo species of Himachal Pradesh.

Species	Morphological Features	Shoots	Uses
Bambusa nutans	Moderate sized bamboo with culm height of 6 – 15 m and diameter 5-10 cm, 25 – 45 cm long internodes, bear white hairy ring below the nodes and is thick walled.	Edible shoots are moderate sized; 20-25 cm in height and basal circumference 25-30. Yellowish green at apex when young. Sheaths greenish with purple tinge at base; ligulate; two fringed auricles covered with brown black hair at adaxial surface.	Used as poles, making ladders, scaffolding, house construction, manufacturing paper, pulping, handicraft and furniture. **Leaves** used as fodder and boiled extract used in chicken pox, small pox and other skin diseases. **Root** paste cure ringworms. **Shoot** is edible and its paste applied on dog bites.
Dendrocalamus hamiltonii	Large bamboo with pachymorph rhizome and thin walled culm; 15 – 25 m tall with girth of 10-15 cm, have drooping tops.	Shoot moderate sized with 23-28 cm height and basal circumference 19-23 cm. Sheaths yellowish green, covered with stiff brown	**Culm** used in house construction, making of baskets, mats, containers. **Leaves** used as fodder for cattle **Shoots** are edible, used in

	There is one dominant branch among many others, arising from mid-culm nodes. Large, conical culm sheath without auricles.	hair, sides incurved; ligule entire; sheaths overlapping in beautiful pattern.	pickling.
D. strictus	Deciduous, densely clumped, thick walled with culm 8-16 m high, 2.5-8 cm girth, 30-45 cm internodes with swollen nodes. Culms curved; branching on lower nodes; culm sheath long, hairy, toothed, small auricles with triangular blade.	Small sized shoots with height 20-24 cm and basal circumference 12-14 cm. Sheaths green at apex yellowish brown at base, golden brown hair at the back; ligule toothed; auricles small and hairy.	**Culm** used for construction, agricultural tools, musical instruments, furniture, roofing, crafting and many other items like bow arrows, mats, hand fans etc. **Leaves** used as fodder, their decoction and silica are used in traditional medicine. **Shoots** edible, also consumed in fermented form, extract used as eardrops. Also used in paper manufacturing.

Source: Seethalakshmi and Kumar 1998; Richa et al. 2012.

Potential of shoots

Juvenile shoots of edible bamboos have remained one of the highly palatable dishes in delicacies for centuries. Due to their exotic taste, flavour and medicinal value, bamboo shoots have found an important place in the food of the people of South-East Asian countries and North-Eastern region of India particularly. Shoots are consumed as vegetables, pickles, salads and in many other forms in different countries, and are used fresh, dried, shredded, roasted, fermented and canned forms in culinary items (Choudhury et al. 2012; Singhal et al. 2013; Pandey and Ojha 2014). Bamboo shoots are not only delicious but are also rich in nutrients and rank among the 5 most popular healthcare foods in the world (Nirmala et al. 2011). They are particularly rich in proteins, carbohydrates, minerals, vitamins and are low in fats and calories. Bamboo shoots also contain bioactive compounds like dietary fibres, phenols and phytosterols, which are linked to health promoting benefits by modern researchers (Fujimura et al. 2005; Choudhury et al. 2010; Gupta et al. 2010; Nirmala et al. 2014) and provide health benefits beyond the basic nutritional value of the product (Biesalski et al. 2009). They possess antioxidant, anticancer, antibacterial, anti-inflammatory, antifungal activities and promote the

bowl function of the stomach and the intestine, help digestion and prevent cardiovascular diseases (Mattile and Hellstorm 2007; Galeotti et al. 2008; Oboh and Ademosun 2010).

Out of the eight species found in Himachal Pradesh, shoots of three species are popular *viz.Bambusa nutans, Dendrocalamus hamiltonii* and *Dendrocalamus strictus* and biochemical analysis was conducted on these species to determine their commercial viability (Figure 2) (Table 2).

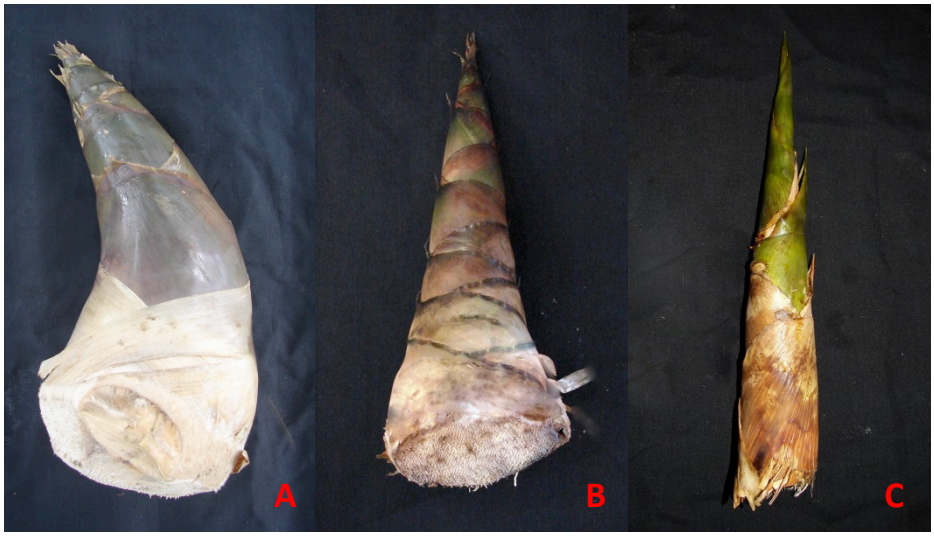

Figure 2.Harvested shoots of A) *Bambusa nutans* B) *Dendrocalamus hamiltonii* C) *D. strictus*

Table 2. Macronutrients, micronutrients and antinutrients present in freshly harvested juvenile bamboo shoots of three edible species of Himachal Pradesh

Parameter \ Species	***Bambusa nutans***	***Dendrocalamus hamiltonii***	***Dendrocalamus strictus***
Carbohydrates (g/100g)	2.76 ± 0.10	5.49 ± 0.07	6.17 ±0.02
Starch (g/100g)	1.37 ± 0.07	0.46 ± 0.03	0.31 ± 0.04
Proteins (g/100g)	3.25 ± 0.06	3.71 ±0.12	2.60 ± 0.06
Amino acids (g/100g)	2.21 ± 0.02	3.18 ± 0.04	3.07 ± 0.02
Fats (g/100g)	0.39 ± 0.01	0.40 ± 0.02	0.32 ± 0.04
Vitamin C (mg/100g)	1.19 ± 0.10	2.45 ± 0.07	2.43 ± 0.10
Vitamin E (mg/100g)	0.47 ± 0.05	0.70 ± 0.02	0.58 ± 0.02
Ash (g/100g)	0.82 ± 0.00	0.86 ± 0.20	0.71 ± 0.09
Moisture (%age)	91.26 ± 0.07	92.51 ± 0.51	90.10 ± 0.93

Dietary fiber (g/100g)	**NDF**	2.28 ± 0.01	3.90 ± 0.03	2.25 ± 0.00
	ADF	1.24 ± 0.05	3.23 ± 0.02	1.38 ± 0.02
	Lignin	0.43 ± 0.01	2.17 ± 0.01	0.64 ± 0.02
	Hemi-cellulose	1.03 ± 0.99	0.67 ± 0.00	0.84 ± 0.98
	Cellulose	0.71 ± 0.04	1.06 ± 0.00	0.93 ± 0.99
Cyanogenic glycosides	**(mg/kg)**	1673.50 ± 77.27	733.08 ± 25.23	1717.85 ± 68.42

Carbohydrates

Carbohydrates are broadly defined as polyhydroxy aldehydes or ketones and their derivatives; are considered as the staple foodstuff for most of the organisms. In human diet it is recommended that there should be 50 – 60 % carbohydrates intake daily, especially in developing countries people are majorly dependent on carbohydrates to fulfil their food requirements. Bamboo shoots as like other vegetables generally contain higher amount of carbohydrates than fats and proteins. Among carbohydrates, starch is the most important reserve food material in plants.

Carbohydrate and starch content of fresh bamboo shoots were estimated by methods of Whistler (1971) and Mecreddy et al. (1958) respectively with modifications. Highest carbohydrate content was found in shoots of *D. strictus* (6.17g/100g fresh weight) followed by *D. hamiltonii* (5.49g/100g fresh weight) then *B. nutans* (2.76g/100g fresh weight). Starch content in shoots is in lesser amounts as compare to total carbohydrates in *D. hamiltonii* (0.46g/100g fresh weight) and *D. strictus* (0.31g/100 g fresh weight) but in better quantities in shoots of *B. nutans* (1.37g/100 g fresh weight).

Proteins

Proteins are most abundant organic molecules in cell, structural components of tissues, play important role; as enzymes, in transport of molecules and during the deficiency of carbohydrates and fats, dietary proteins brake down to provide energy. Fresh bamboo shoots provide quite good amount of proteins than many other seasonal vegetables like members of brassicaseae family, potato, brinjal, cucumber, pumpkin, ladies finger etc.

In our experiment, we have quantitatively estimated the protein content in fresh shoots by using Bradford Assay (Bradford 1976) with some modifications. Among the three species; *D. hamiltonii* contain maximum protein content (3.71g/ 100g) followed by *B. nutans* (3.25g/100g) and then *D. strictus* (2.60g/100g).

Amino acids

Amino acids present in two forms in cells; either present freely in cytoplasm or as constituents of proteins. Many amino acids are present in plants and animals but only 20 are popular which majorly constitute proteins. Bamboo shoots contain 17 types of amino acids, 8 of which are essential for the human body (Qiu 1992).

Free amino acid content was estimated in fresh shoots by using the method of Lee and Takahashi (1966) with modifications. Among the three species the amount of amino acids was found to be almost equal in shoots of *D. hamiltonii* (3.18g/100g) and *D. strictus* (3.07g/100g) whereas shoots of *B. nutans* contain lesser amount (2.21g/100g) as compare to other two.

Fats

Although fats are most abundant of all lipids; Bamboo shoots are acknowledged for low fat containing food. So, bamboo shoots are beneficial for health, as they are helpful in preventing the physiological barriers caused by eating fat rich foods. Crude fat in bamboo shoots has been estimated by using Soxhlet method given by AOAC (1990). Fat content was found to be lowest in *D. strictus* shoots (0.32g/100g fresh weight) whereas shoots of *B. nutans* and *D. hamiltonii* contain almost equal fat content as 0.39g/100g and 0.40g/100g respectively, but higher than *D. strictus* shoots.

Vitamins

Vitamins are organic compounds which are not synthesized by organisms in sufficient quantities thus are obtained from diets. They may not provide nutritional benefits but are important in treating certain health problems in humans. Bamboo shoots contain very good quantity of vitamin C or ascorbic acid; which is a colourless, crystalline and water soluble vitamin. It gives a sour taste and usually lost under oxidising conditions. Content of vitamin C was determined by using method of Reiss (1993). Fresh shoots of *D. hamiltonii* (2.45mg/100g fresh weight) and *D. strictus* (2.43mg/100g) contain almost equal vitamin C content whereas it is lesser in *B. nutans* (1.19mg/100g). But these shoots contain more amount of this vitamin than many other common vegetables.

Bamboo shoots also contain vitamin E, which is a heat resistant vitamin (up to 200 ^{0}C), thus can be retained after cooking of food. It is an antioxidant; prevents the production of reactive oxygen species. Among the chosen species *D. hamiltonii* (0.70mg/100g fresh weight) contain highest amount of

vitamin E which is followed by *D. strictus* (0.58mg/100g) then *B. nutans* (0.47mg/100g). Vitamin E content was estimated by using Baker and Frank method given by Baker et al. (1980).

Ash

When the organic matter in a food material is completely oxidized or ignited, then the remaining inorganic residue is referred to ash content, and it represents the total mineral content of that food. Bamboo shoots contain good amount of ash content, consequently good amount of minerals too. We have estimated ash content in fresh bamboo shoots by using the dry-ashing method of Harbers (1994). There is little difference in amount of ash among three species, however highest ash content was found in *D. hamiltonii* (0.86g/100g) followed by *B. nutans* (0.82g/100g) and then *D. strictus* (0.71g/100g).

Moisture content

Bamboo shoots contain large amount of moisture in almost all species, about or more than 90 %. But some species of bamboos contain lesser moisture content like 54 % in *Bambusa arundinacea*, 77 % in *B. vulgaris* and 79% in *Chimonobambusa hookeriana* (Bhargava et al. 1996; Bhatt et al. 2005).

In the present study, the moisture content in fresh shoots has been calculated by using oven drying method. Moisture content among the chosen species is quite high with *Dendrocalamus hamiltonii* containing the highest content of 92.51%, followed by *Bambusa nutans* with 91.26 % and *D. strictus* with 90.10 % moisture.

Dietary fibres

Bamboo shoots contain high levels of dietary fibre, which play significant role in lowering cholesterol levels and associated with a number of health benefits like preventing cardiovascular diseases, hypertension, diabetes, obesity, cancer and certain gastrointestinal disorders (Lattimer and Haub 2010; Brennan et al. 2012). They also provide some properties to foods such as increase water and oil holding capacity, emulsification and/or gel formation (Nirmala et al. 2011).The fibre content in bamboo shoots can be classified as nutrient detergent fibre (NDF) and acid detergent fibre (ADF); the former one determines the indigestible component of the plant consisting of hemicelluloses, cellulose and lignin; the latter one represents cellulose and lignin primarily. We used the method of Goering and Van Soest (1970) for determining the NDF, ADF, Lignin, Hemicellulose and cellulose content in fresh bamboo shoots.

NDF, ADF and Lignin content was found highest in *D. hamiltonii* as 3.90g/100g, 3.23g/100g and 2.17g/100g respectively. *B. nutans* (2.25g/100g) and *D. strictus* (2.28g/100g) have almost equal amounts of NDF. ADF and Lignin content is slightly more in *D. strictus* (1.38g/100g, 0.64g/100g) than *B. nutans* (1.24g/100g, 0.43g/100g) but yet close. There was observed an opposite pattern in case of Hemicellulose content as it was found maximum in shoots of *B. nutans* (1.03g/100g) followed by *D. strictus* (0.84g/100g)then *D. hamiltonii* (0.67g/100g). Cellulose content was found maximum in *D. hamiltonii* (1.06g/100g) followed by *D. strictus* (0.93g/100g) then *B. nutans* (0.71g/100g).

Cyanogenic glycosides

Along with being a reservoir of macro and micronutrients raw bamboo shoots also contain the antinutrient - cyanogenic glycoside; which imparts a bitter taste to some shoots. Cyanogenic glycoside is a phytotoxin which is non-poisonous by itself (Nahrstedt 1993). But when the plant tissue is damaged or macerated, this compound comes in contact with intracellular enzyme ß-glycosidase, which hydrolyses it into hydrogen cyanide, glucose and ketone or benzaldehyde (Harborne 1993). HCN inhibit oxygen consumption by binding to mitochondrial cytochrome oxidase which play important role in cellular respiration (Cooper and Brown 2008). This compound possibly provides chemical defence to plant against herbivores, pests and other pathogens (Jones 1998). Consumption of cyanogenic glycosides upto a level of 500 ppm causes no health hazards (FAO 2005). Cyanogenic glycoside found in bamboo shoots is taxiphyllin (Schwarzmaier 1977). The cyanogenic glycosides in fresh shoots were determined by using picrate method of Haque and Bradbury (2002). Among the shoots of these three species *D. strictus* contains highest amount of cyanogenic glycosides (1717.85mg/100g) followed by *B. nutans* (1673.5mg/100g) then *D. hamiltonii* (733.08mg/100g). Toxicity of this compound can be easily reduced by simple traditional processing methods like boiling, soaking and fermentation of fresh shoots before consumption or cooking.

Bamboo shoot market

The international market potential of bamboo has an estimated value of $ 10 billion (Borah et al. 2006) in which contribution of bamboo shoots is about $ 1.2 billion (Anon 2003). Demand of preserved bamboo shoots is growing worldwide and annual consumption of bamboo shoots reached upto 2 million tonnes throughout the world (NMBA 2009). Total export value of bamboo shoots in 2010 has increased to US$ 214 million. China being the largest bamboo producer; is also largest shoot exporter while exporting 250000 tonnes shoots worth approximately US$ 195 million, which was almost 75% of total global bamboo shoot export in 2009, following which Thailand is the second largest by exporting about 6% of global shoot export. Besides these, domestic markets for production of bamboo shoots also exist in Bangladesh, India, Indonesia, Malaysia, Philippines, Sri Lanka and

Vietnam. Top importers of preserved bamboo shoots in 2010 were Japan (US$ 136 million), USA (US$ 36 million) and EU (US$ 30 million appx.) (INBAR2011).

The market potential of bamboos in India is estimated at US$ 7.19 million which is estimated to increase upto US$ 416 million in 2015 (Farooque et al. 2007). Potential of domestic bamboo shoot industry in country is around US$ 0.8 million; where maximum production of shoots occurs in North-Eastern region (Nongdam and Tikendra 2014). Total bamboo cover in North-East India is 24110 km^2 and shoot harvest is 5685 tonnes annually which have an estimated value of INR 26.96 million or US$ 0.43 million (Bisht et al. 2012). Small bamboo shoot processing units though established in North–eastern region as in Aizawl (Mizoram), Jorhat (Assam) and Dimapur (Nagaland) are not functional enough to cater even to the domestic market. Due to this, despite India being the second largest resource of bamboos after China, still imports shoots from China, Thailand and Bhutan. Local price of fresh shoots ranges from INR 15-20/ kg during peak growing season and imported canned shoots are available at INR 50 – 65/ 450g pack. In Himachal Pradesh, bamboo produce during 2012-2013 is 508 ha. which has contributed to state forest revenue to an estimated amount of INR 7,38,000 or US$ 11.77 thousand (FDHP 2013). In the state, people consume bamboo shoots mostly in pickle form, that also in few areas. Researchers from the region have prepared contemporary food items such as candies, nuggets, crackers *etc*. from edible shoots (Sood et al. 2013). Food items such as bread, cookies, cakes, chapatti, paranthas, paneer *etc*. have also been prepared with bamboo shoot paste (Bisht et al. 2012).Though plantation of bamboo has been initiated in the state but still, may be due to low consumption, lack of awareness about quality of bamboo shoots, market opportunities has not emerged over the years as there is no significant cultivation of bamboo for shoots nor proper organised markets or supply chains evolved in the state yet. For bamboo shoots to be commercialized, proper processing units need to be developed as the young shoots have a very short shelf life of 3-4 days

Bamboo shoot production has the potential to accumulate remarkable economic profits and can consequently bring social welfare due to higher earnings. As demand of shoots is growing worldwide, due to popularity of South Asian cuisines, development of proper processing and packaging of shoots is essential which gives an opportunity for starting commercial level processing units. Government can provide endowments for establishment of bamboo plantation with edible shoot species, low interest loans to shoot processors and training programmes to cultivators to promote bamboo shoot market/industry in the state. Organizations like National Mission on Bamboo Application (NMBA)/North East Centre for Technology Application & Reach (NECTAR) which is tasked to create the basis to enlarge the bamboo sector in many thrust areas; National Bank for Agriculture and Rural Development (NABARD) Promote sustainable and equitable agriculture and rural prosperity through effective credit support, related services, institution development and other innovative

initiatives; Forest Department, can support such states for propagation and cultivation of edible species. Under the Scheme for Cold Chain, Value Addition and Preservation Infrastructure, Ministry of Food Processing Industry (MoFPI) has approved ten cold chain projects during 2011-2013, which are in different stages of implementation and also Mega Food Park project in different areas of state. Bamboo shoots can also be introduced as a valuable food through these projects. Further, the local food processing units like Himalyan Food Processors in Kangra district, dealing with frozen food can also be involved in this task. Being agriculture based state, income generated by export of processed shoots will strengthen farmers economically and they will be able to invest funds in other activities for their social development also. Bamboo shoot production will surely have impact on livelihood of local people and establishment of processing units will also provide long term as well as seasonal employment to farmers and other workers.

Conclusion

Around 70% inhabitants of the Himachal Pradesh are dependent on agriculture for their livelihood, which are often hampered due to topology and climatic conditions of the region. Bamboo is a hardy plant and can grow well in marginal situations; it is naturally occurring in the state and the region has favourable condition for cultivation of the plant also. People are using the culms and leaves of bamboos for many purposes; domestically and commercially. In some areas people also use bamboo shoots for edible purposes, mostly in pickle form. Modern food items from shoots have also been prepared but have yet to reach the market. Most people in the regions are unaware of nutritional properties and health benefits of bamboo shoots. Bamboo shoots are considered as one of the five most nutritious foods of the world. If people here add shoots in their diet, they will be provided with basic nutrition as well as many other health benefits and can also fight the upcoming times of food insecurity, which will lead them to a better social life. Fresh shoots and their value added products can be used as a potential market product which will improve the economic status of the people of state. They can also be exported commercially as bamboo shoots are becoming popular worldwide for its delicacy as well as potential functional food. As shoots are seasonally available only, methods for their processing and preservation can be developed so that they can be provided during off seasons in proper packaging and shoots can be sold at industrial level which will also provide employment to many people of the state and will further boost up the socioeconomic development of state.

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