

## **Commercial edible bamboo species of the North-Eastern Himalayan region, India. Part II: fermented, roasted and boiled bamboo shoots sales**

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**Abstract**—The sales of fermented, roasted and boiled bamboo shoots in the market places of Arunachal Pradesh, Manipur, Meghalaya, Nagaland and Sikkim, of the North-Eastern Himalayan (NEH) region, India have been reported. The results are based on the survey of 118 markets covering 1200 primary and secondary vendors from 51 districts of NEH region. The consumption of fermented, roasted and boiled shoots was estimated to be *ca.* 680 tonnes; the highest occurs in Arunachal Pradesh (481 tonnes/year) and the lowest in Nagaland (19.5 tonnes/year). The bamboo shoots are consumed in the form of fermented-slice, crushed-fermented moist, crushed-fermented dry, fermented whole shoot, roasted whole shoot and boiled whole shoot in different states of the region. Cost–return analysis for sales of these bamboo products revealed a net income of 23 million rupees per annum (US\$ 502 950) from the entire region with the highest (17.5 million rupees/year or US\$ 38 270) in Arunachal Pradesh and the lowest in Sikkim (0.47 million rupees/year or US\$ 10 280). Employment opportunities have also been worked out and *ca.* 1260 persons/year could earn their subsistence through selling of bamboo shoot products.

*Key words:* Bamboo shoots; North-East Himalaya (NEH) region; India; consumption; cost–return analysis.

### **INTRODUCTION**

Over 1500 bamboo species belonging to 75 genera occur worldwide in natural forests, semi-exploited stands and intensive plantations [1], of which India has contributed about 130 species belonging to 23 genera [2, 3]. As many as 78 bamboo species (both indigenous and exotic) belonging to 19 genera are being reported from the North-East region of India [4].

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The range of application of bamboo for mankind is remarkable, with an annual use of 12 kg bamboo biomass per capita in Asia [5, 6]. Besides the use of different bamboo parts as fuel, fodder, medicine, pulping material, construction and household as well as farms, the edible nature of tender shoots of some species enhanced the importance of bamboo in the global scenario. Data on worldwide production of bamboo products are extremely unreliable, as they do not appear in the major commodity databases. Worldwide, more than 2 million tonnes of bamboo shoots are consumed annually [7] with approximately 1.3 million tonnes produced in China [8]. In metropolitan Tokyo, more than 8000 tonnes of young shoots are consumed annually [9]. In India, bamboo shoots in fresh, fermented, roasted and pickle form are consumed, especially in the North-East region. Around 1000 tonnes of fresh bamboo shoots are reported to be obtained only through market places of three tribal states of this region, where an annual gross income of *ca.* US\$ 111 000 could be generated [10].

In spite of the consumption of fresh bamboo shoots in the North-East region, a considerable quantity of bamboo shoots is also consumed in the form of fermented products, roasted and pickles after processing through conventional methods. Almost all the ethnic groups of the region use bamboo shoot products in preparing major or minor food items. They are also applied in small quantities as food additives to improve delicacy of vegetarian or non-vegetarian dishes. Among the processed bamboo shoots, fermented products and pickles fetch higher income due to the ability of their long-term preservation with higher market price and their consumption throughout the year.

In part I of this series, entitled 'Commercial edible bamboo species of the North-Eastern Himalayan (NEH) region, India: Young shoot sales' [11], the main emphasis was on investigation and documentation the diversity of commercial edible bamboo species available in the NEH region, the annual consumption pattern of fresh tender shoots through market places and their cost–return analysis, including physical efforts made in merchandizing fresh bamboo shoots.

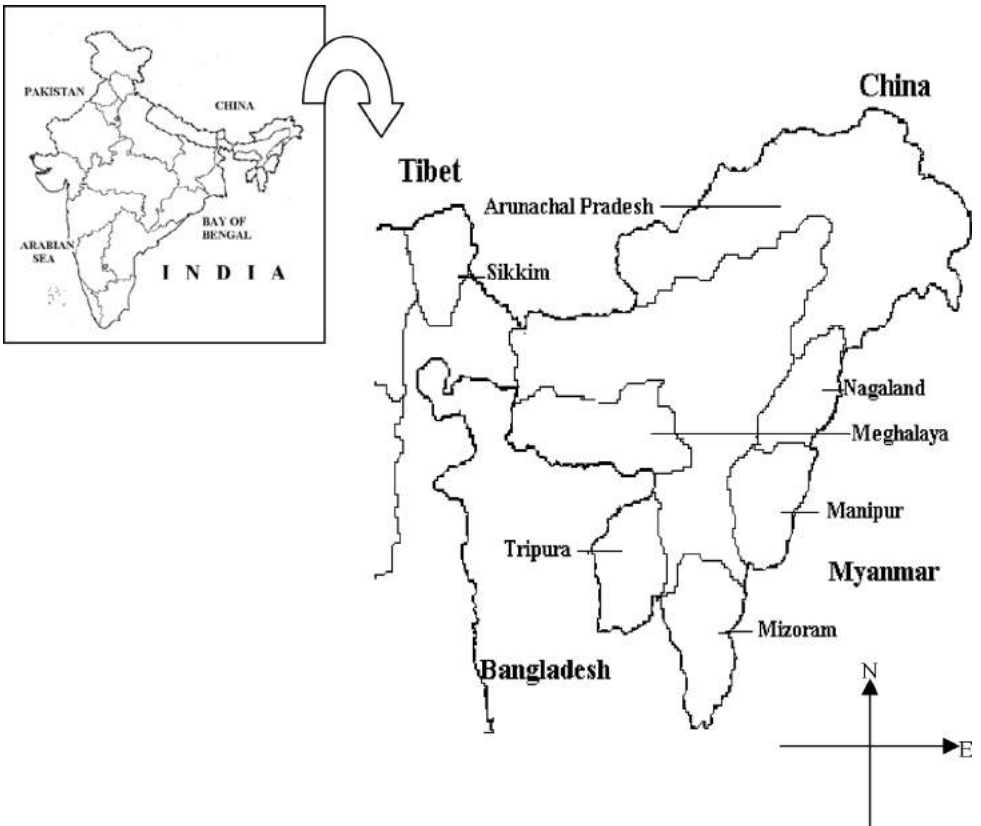
Most of the Governmental and Non-Governmental Organisations are giving full emphasis to utilize the available bamboo resources in the region through scientific implications for the sustainable development of the NEH region, and India as well. Although, no such efforts are being made on edible nature of bamboo shoots and their allied products with commercial importance in the NEH region or elsewhere in other parts of India.

In continuation to the previous study on edible bamboo species in the NEH region [11], the present study gives special emphasis to investigate and to document the annual consumption rate of processed bamboo shoot products through market places, their commercial values, the cost–return analysis, the indigenous technical knowledge (ITK) on bamboo shoot processing, etc. An attempt has also been made to understand the revenue generation through traditionally processed bamboo shoots and its potential to provide employment opportunities in the NEH region of India.

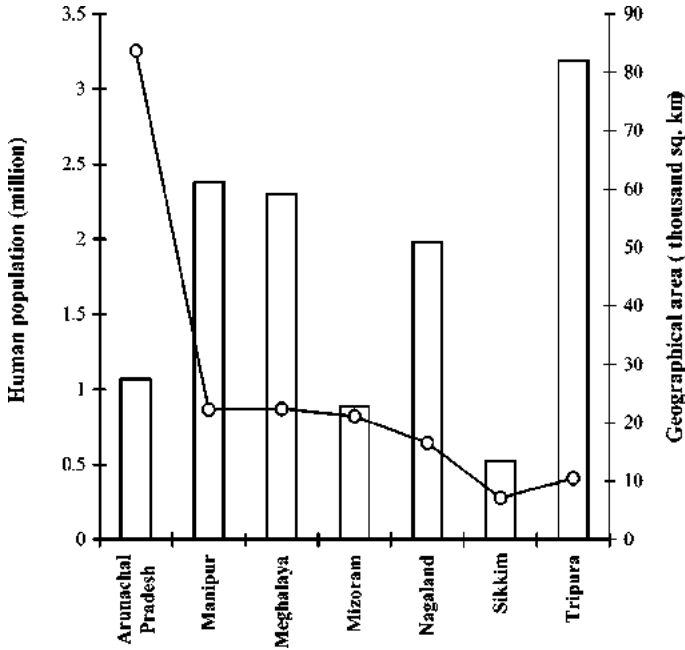
## STUDY SITE

The study was carried out in the North-Eastern Himalayan region (NEH) of India, covering 7 states, namely Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura (Fig. 1). The region lies between 21–30°N latitude and 85–98°E longitude, and occupies an area of 18.4 million ha. The region has a difficult terrain with hilly topography, characterized by steep slopes, gorges and plateaus with less than 15% valleys. The elevation ranges from 100 m to 5600 m above sea level (asl), tropical to alpine agro-climatic condition with *ca.* 100 to 6000 mm annual rainfall. This peculiar agro-climatic condition of the NEH region has supported very rich and diverse flora and fauna including bamboo species for which the region could account a position among the 25 hot spots of the world.

Based on the State of Forest Report [12] and Basic Statistics [13], the total land area and human population of the 7 states of the NEH region are shown in Fig. 2, in which the highest population density was reported in Tripura (304 persons/km<sup>2</sup>) and the lowest in Arunachal Pradesh (13 persons/km<sup>2</sup>). The range of total human population in the 7 states is very large and varies from 0.89 to 3.19 million. More



**Figure 1.** Location map of the study sites in the NEH region, India.



**Figure 2.** Total human population (□) and geographical area (○) of 7 states in the NEH region, India.

than 70% of the total population of the region belongs to the rural sectors and they exploit tender bamboo shoots from natural forests, plantation forests and home gardens for their income generation and livelihood.

## MATERIALS AND METHODS

A survey of fermented, roasted and boiled bamboo shoot products in market places of 7 selected states in the NEH region was carried out from March 2003 to March 2004 at four months interval. More than 40% of the available market places of the entire districts of the 7 states were randomly surveyed. Out of 297 market places a total of 118 market places belonging to 51 districts of the NEH region was surveyed. Vendors of bamboo shoot products were categorized as primary (those who process bamboo shoots for different products and sell) and secondary (those who purchase processed products at wholesale rate and sell in retail rates). Baseline information was gathered from 1200 primary and secondary vendors through suitable pre-prepared questionnaires. This information includes the number of primary and secondary vendors available in the market places, market days per week, quantity of fermented, roasted and boiled bamboo shoots sold per day, their availability period and costs (per kg), the number of persons involved including gender and age group, the physical efforts and financial investments made in merchandizing (fermented, roasted and boiled bamboo shoots), etc. Information on indigenous technical knowledge for the processing of bamboo shoots and recipes of different

tribal communities/ethnic groups were also accumulated from the nearby villages of the respective market places. All the data were statistically analysed and presented in this paper.

## RESULTS

### *Product preparations and description*

In addition to the bamboo shoot pickles, 5 more bamboo shoot products, such as fermented slice, crushed-fermented moist, crushed-fermented dry, fermented whole shoot and roasted whole shoot, were recorded from the NEH region of India. All the 5 fermented and roasted bamboo shoot products were sold in the market places of Arunachal Pradesh (Figs 3–5) and Nagaland (Fig. 6), and were consumed by almost all the ethnic groups and tribal communities in the two states, except Monpas (Tibetans) of West Kameng and Tawang districts of Arunachal Pradesh.

In Manipur fermented slice bamboo shoots and fermented whole shoots were observed in the market places, whereas only crushed-fermented (moist) was sold in Meghalaya. A unique boiled bamboo shoot product of two bamboo species was observed being sold in the market places of Sikkim. The consumption and commercialisation of processed bamboo shoots in Mizoram and Tripura were negligible. Only few ethnic groups in Mizoram consume fermented slice bamboo shoots, which in fact was met from their own processing and not through market places (Fig. 7).



**Figure 3.** Fermented whole shoot sold at Ganga market, Itanagar, Arunachal Pradesh.



**Figure 4.** Roasted and crushed-fermented moist bamboo shoots sold at Seppa, East Kameng District, Arunachal Pradesh.



**Figure 5.** Fermented crushed bamboo shoots sold at Pasighat, East Siang District, Arunachal Pradesh.



**Figure 6.** Sliced-bamboo shoots packed in polythene for fermentation process, Dimapur District, Nagaland.



**Figure 7.** Sliced-fermented bamboo shoot sold by secondary vendors at Khwairamband Bazar, Imphal West District, Manipur.

The principle of bamboo shoot fermentation in different states in the NEH region was similar although the indigenous technology for the processing of fermented bamboo shoot products is different among the 7 states, and even from one ethnic



group to another. Generalized conventional methods used for the processing of fermented, roasted and boiled bamboo shoot products employed in NEH region are highlighted below.

*Fermented-slice.* Freshly harvested bamboo shoots are cleaned and washed with water. They are thinly sliced and immediately packed with polythene sheets, and wrapped with cloth/synthetic sack. They are kept under pressure using heavy weights (boulders or concrete slabs etc.) for 3–6 months for fermentation. The fermented bamboo shoot slices can be preserved for several months after the completion of the fermentation process.

*Crushed-fermented moist.* Fresh bamboo shoots are simply crushed using wooden mortar and pestle after removing the hairy sheaths, and packed in polythene bags or filled into plastic/glass bottles. After 2–3 months fermentation in anaerobic condition, it becomes ready to consume.

*Crushed-fermented dry.* Fresh bamboo shoots are cleaned, washed and crushed into small pieces. They are allowed to get semi-fermented for 3–7 days in airtight pitcher or other containers, and then sun dried. After proper drying, they are packed in polythene bags and sold in the market places or are preserved in dry form for future use.

*Fermented whole shoot.* Freshly harvested bamboo shoots are cleaned and washed with water. They are fermented as usual in anaerobic condition using heavy weights, as in the case of fermented slice bamboo shoots. Generally, it requires more time for complete fermentation than the other fermented products.

*Roasted whole shoot.* Fresh bamboo shoots are fire roasted together with the culm sheath/swathe. After proper roasting, the culm sheath is removed carefully. It may be consumed as usual, or consumed along with rice, bread etc. In the market places, it is sold after wrapping with banana leaf, turmeric leaf, etc. It can be preserved only for 2–3 days.

*Boiled whole shoot.* Freshly harvested bamboo shoots are simply boiled in water in a large container until they are cooked properly. After draining off the water, they are ready for consumption. This bamboo shoot product is also sold as roasted whole shoot in the market places, wrapping with banana leaf, but it cannot be preserved for more than 2–3 days.

In addition to the above bamboo shoot products, fermented bamboo shoots squash, a by-product of bamboo shoot fermentation, was observed to be consumed on a commercial scale in Nagaland state. During the preparation of crushed fermented bamboo shoot products, bamboo shoot juices were decant and allowed to ferment in air tight containers for six to ten days till it becomes ready for consumption.





**Figure 8.** A customer purchasing bamboo shoot squash at Wokha market, Nagaland.

Liquid remnants of fermented-slice or crushed bamboo shoots after their complete fermentation were consumed as usual in little quantity as food additives. The annual consumption of bamboo shoot squash in Nagaland was recorded as *ca.* 71 630 litres per year (Fig. 8).

Table 1 gives the traditional dishes prepared from fermented, roasted and boiled bamboo shoot products in NEH region. The consumption pattern of different bamboo shoot products are different among the different ethnic groups, although, all the fermented products are consumed as food additives by applying in little quantity to increase the delicacy of different dishes.

In the Wokha district of Nagaland, consumption of the basal part of tender culm sheath after fermentation is also a unique bamboo shoot product of the region. It is known as Rhyuem by the Lotha tribe and especially used for the preparation of duck-meat curries. In Manipur, Soibum (slice fermented) and Soidon (whole shoot fermented) are the two highly esteemed fermented bamboo shoot products which are consumed as major dishes, as well as used as additives in vegetable and non-vegetable dishes. In Mizoram, Tripura and Sikkim, there were no fermented bamboo shoot products sold in the market places, whereas, in Sikkim, bamboo shoots in boiled form was observed to be sold on a commercial scale.

The period of availability of fermented, roasted and boiled bamboo shoot products in the market place of the NEH region and the quantity sold (per day and per year) are presented in Table 2. The six different processed bamboo shoot products sold

**Table 1.** Traditional dishes prepared from fermented, roasted and boiled bamboo shoot products in NEH region, India

State	Bamboo shoot products	Local name/dialect	Description of dishes
Arunachal Pradesh	Roasted bamboo shoots	Eva/Nyishing	This is a pre-cooked/fire roasted fresh bamboo shoot. It can be consumed as usual or is consumed by applying it in other vegetable/meat curries.
	Fermented	Slice, Hikhu/Apatani Crushed, Ekung/Nishies Crushed dry, Eup/Nishies Whole shoot, Hitak/Nishies	All the fermented products like crushed fermented, dry, sliced or whole shoot fermented are applied in small amounts to other curries (vegetable/non-vegetable) to increase their delicacy.
Manipur	Fermented	Slice, Soibum/Manipur	Slice fermented shoots are boiled/fried with potato, mixed with chilli, salt, <i>Haotonia cordata</i> , etc. It is also cooked along with fish/meat, etc.
Meghalaya	Fermented	Crushed, Syrwa/Khasi	Little quantity of crushed-fermented product is applied to pork/beef curry to increase the delicacy.
	Fermented	Whole shoot, Soidom/ Manipuri	Slice-fermented shoots are boiled with potato, arum stem and are mixed with chilli, coriander, seeds of <i>Euray/ferox</i> , salt and dry fish. Small pieces of fermented whole shoots are chopped and boiled/fried with potato, salt, chilli, or with fish/meat etc.
Nagaland	Fermented	Slice, Zusem/Ao Crushed, Zutsuk/Ao Crushed dry, Yisu/Ao Whole shoot, Sethu/Ao Squash, Zitzu/Ao	All type of fermented bamboo shoot products are applied in small quantities according to the taste preferred to all type of curries including boil curries, vegetable and non-vegetable dishes.
Sikkim	Boiled bamboo shoot	Whole shoot, Mesu/Nepali	It is pre-cooked/boiled bamboo shoots. It may be consumed as such along with bread/biscuits etc. and are applied generally to vegetables and non-vegetable curries.

in the market places can be categorized as fermented, roasted and boiled forms. Fermented products had the longest availability period with larger quantity sold in the market places than roasted and boiled forms. The availability of fermented slice and fermented whole shoot in Manipur state had longer period compared to that of Arunachal Pradesh and Nagaland. A comparatively large quantity of fermented slice compared with the other bamboo shoot products was sold in Manipur and Nagaland with *ca.* 105 and 6 tonnes/year, respectively. Crushed-fermented moist was observed in Arunachal Pradesh, Meghalaya and Nagaland, whereas crushed fermented dry was observed to be sold only in Arunachal Pradesh and Nagaland. Both crushed fermented moist and dry bamboo shoot products were sold in larger quantity in Arunachal Pradesh compared to other states in the NEH region. Fermented whole shoot was observed in Arunachal Pradesh, Manipur and Nagaland, whereas largest quantity was sold in Arunachal Pradesh with *ca.* 102 tonnes/year. Roasted bamboo shoot was recorded only in the market places of Arunachal Pradesh with an annual sale of *ca.* 52 tonnes, whereas *ca.* 27 tonnes of boiled bamboo shoots was observed to sell in Sikkim.

During the year 2003–2004, the total quantity of annual bamboo shoot products sold in the market places of the NEH region was recorded to be *ca.* 680 tonnes. Arunachal Pradesh has contributed highest with *ca.* 481 tonnes/year followed by Manipur, Meghalaya, Sikkim and Nagaland with *ca.* 114, 39, 27 and 19 tonnes/year, respectively.

Table 3 shows the cost–return analysis of fermented, roasted and boiled bamboo shoot products sold in the market places of NEH region. The retail price (per kg) of all the 5 bamboo shoot products sold in Arunachal Pradesh was higher than those sold in other states of the NEH region. Among the six bamboo shoot products, the cost of crushed-fermented dry bamboo shoot available in Arunachal Pradesh and Nagaland was comparatively high whereas, boiled shoots of large bamboo species in Sikkim state were sold at cheaper rate. The gross income per day as well as per annum from the bamboo shoot products (fermented, roasted and boiled) was highest in Arunachal Pradesh with *ca.* 195 000 Rs/day (US\$ 4264) and 32.61 million rupees per annum (US\$ 713 099). It was followed by Manipur, Meghalaya, Nagaland and Sikkim with *ca.* 5.2 (US\$ 113 711), 1.2 (US\$ 26 240), 0.8 (US\$ 17 494) and 0.6 million rupees (US\$ 13 120) per annum.

Financial investment and physical efforts made for merchandizing bamboo shoot products in the NEH region was also recorded to be highest in Arunachal Pradesh with *ca.* 15 million rupees per annum (US\$ 328 013), followed by Manipur, Meghalaya, Nagaland and Sikkim with *ca.* 1.4 (US\$ 30 614), 0.6 (US\$ 13 120), 0.3 (US\$ 6560) and 0.1 million (US\$ 2186) rupees per annum, respectively. The highest net income from bamboo shoot products after deduction of both financial investment and physical efforts was observed in Arunachal Pradesh with 17.5 million rupees per annum (US\$ 382 681) followed by Manipur, Meghalaya, Nagaland and Sikkim with *ca.* 3.8 (US\$ 83 093), 0.6 (US\$ 13 120), 0.6 (US\$ 13 120) and 0.5 million rupees (US\$ 10 933) per annum, respectively. The total gross income from the fermented,

**Table 2.** Fermented, roasted and boiled bamboo shoot products sold in the market places of the NEH region, India (mean  $\pm$  SD)

State	Bamboo shoot product	Availability of products in the market places (days/year)	Products sold (kg/day)	Products sold (tonnes/year)
Arunachal Pradesh	Fermented slice	180 $\pm$ 5	162 $\pm$ 20	29.2 $\pm$ 3.6
	Crushed-fermented moist	180 $\pm$ 5	1604 $\pm$ 105	288.7 $\pm$ 18.9
	Crushed-fermented dry	180 $\pm$ 5	53 $\pm$ 22	9.5 $\pm$ 1.0
	Fermented whole shoot	180 $\pm$ 3	567 $\pm$ 65	102.1 $\pm$ 11.7
	Roasted whole shoot	90 $\pm$ 6	576 $\pm$ 78	51.8 $\pm$ 7.0
	Total		2962 $\pm$ 290	481.3 $\pm$ 42.2
Manipur	Fermented slice	192 $\pm$ 19	548 $\pm$ 14	105.2 $\pm$ 2.7
	Fermented whole shoot	190 $\pm$ 3	48 $\pm$ 4	9.1 $\pm$ 0.8
	Total		596 $\pm$ 18	114.3 $\pm$ 3.5
Meghalaya	Crushed-fermented moist	70 $\pm$ 5	560 $\pm$ 80	39.2 $\pm$ 5.6
Nagaland	Fermented slice	78 $\pm$ 4	82 $\pm$ 23	6.4 $\pm$ 1.8
	Crushed-fermented dry (outer portion/culm sheath) <sup>a</sup>	90 $\pm$ 7	6 $\pm$ 2	0.5 $\pm$ 0.2
	Crushed-fermented dry (inner portion/rhizome) <sup>b</sup>	78 $\pm$ 11	4 $\pm$ 1	0.3 $\pm$ 0.1
	Crushed-fermented moist	67 $\pm$ 9	100 $\pm$ 13	6.7 $\pm$ 0.9
	Crushed-fermented dry (mixture of different bamboo species)	70 $\pm$ 5	20 $\pm$ 4	1.4 $\pm$ 0.3
	Fermented whole shoot	70 $\pm$ 5	46 $\pm$ 9	3.2 $\pm$ 0.6
	Total		258 $\pm$ 52	18.5 $\pm$ 3.9

**Table 2.**  
(Continued)

State	Bamboo shoot product	Availability of products in the market places (days/year)	Products sold (kg/day)	Products sold (tonnes/year)
Sikkim	Whole shoot boil of narrow bamboo species <sup>c</sup>	15 ± 8	246 ± 33	3.7 ± 0.5
	Whole shoot boil of large bamboo species <sup>d</sup>	48 ± 6	477 ± 52	22.9 ± 2.5
	Total		723 ± 85	26.6 ± 3.0
	Grand total		5099 ± 525	679.9 ± 58.2

<sup>a</sup> Basal part of tender culm sheath of fresh bamboo shoot in dried form.

<sup>b</sup> Crushed fermented tender rhizomes in dried form.

<sup>c</sup> Narrow bamboo species consist of *C. hookeriana*.

<sup>d</sup> Large bamboo species consist of *D. hamiltonii* and *D. giganteus*.

**Table 3.** Cost–return analysis of fermented, roasted and boiled bamboo shoot products in the NEH region, India (mean  $\pm$  SD)

States	Bamboo shoot product	Retail price (Rs/kg)	Gross income (Rs/day)	Gross income (million Rs/year)	Financial investment and wages for mandays (million Rs/year)	Net income (million Rs/year)
Arunachal Pradesh	Fermented slice	320 $\pm$ 30	51 840 $\pm$ 6400	9.33 $\pm$ 1.15	3.87 $\pm$ 0.29	5.46 $\pm$ 0.86
	Crushed-fermented moist	43 $\pm$ 10	68 972 $\pm$ 4515	12.41 $\pm$ 0.81	5.86 $\pm$ 0.66	6.55 $\pm$ 0.15
	Crushed-fermented dry	322 $\pm$ 50	17 066 $\pm$ 7084	3.07 $\pm$ 1.28	1.69 $\pm$ 0.58	1.38 $\pm$ 0.70
	Fermented whole shoot	52 $\pm$ 15	29 484 $\pm$ 3380	5.31 $\pm$ 0.61	2.76 $\pm$ 0.21	2.55 $\pm$ 0.40
	Roasted whole shoot	48 $\pm$ 5	27 648 $\pm$ 3744	2.49 $\pm$ 0.34	0.95 $\pm$ 0.05	1.54 $\pm$ 0.29
	Total		195 010 $\pm$ 25 123	32.61 $\pm$ 4.19	15.13 $\pm$ 1.79	17.48 $\pm$ 2.40
Manipur	Fermented-slice	45 $\pm$ 5	24 660 $\pm$ 630	4.73 $\pm$ 0.12	1.32 $\pm$ 0.03	3.41 $\pm$ 0.09
	Fermented whole shoot	50 $\pm$ 5	2400 $\pm$ 200	0.46 $\pm$ 0.04	0.08 $\pm$ 0.02	0.38 $\pm$ 0.02
	Total		27 060 $\pm$ 830	5.19 $\pm$ 0.16	1.40 $\pm$ 0.05	3.79 $\pm$ 0.11
Meghalaya	Crushed-fermented moist	30 $\pm$ 5	16 800 $\pm$ 2400	1.18 $\pm$ 0.17	0.59 $\pm$ 0.02	0.59 $\pm$ 0.15
	Fermented-slice	41 $\pm$ 3	3362 $\pm$ 943	0.26 $\pm$ 0.07	0.02 $\pm$ 0.01	0.24 $\pm$ 0.06
Nagaland	Crushed-fermented dry (outer portion/culm sheath) <sup>a</sup>	262 $\pm$ 12	1572 $\pm$ 524	0.14 $\pm$ 0.05	0.04 $\pm$ 0.02	0.10 $\pm$ 0.03
	Crushed-fermented dry (inner portion/rhizome) <sup>b</sup>	237 $\pm$ 11	948 $\pm$ 237	0.07 $\pm$ 0.02	0.03 $\pm$ 0.01	0.04 $\pm$ 0.01
	Crushed-fermented moist	19 $\pm$ 2	1900 $\pm$ 247	0.13 $\pm$ 0.02	0.05 $\pm$ 0.01	0.08 $\pm$ 0.01
	Crushed-fermented dry (mixture of dry bamboo species)	120 $\pm$ 12	2400 $\pm$ 480	0.17 $\pm$ 0.03	0.09 $\pm$ 0.01	0.08 $\pm$ 0.02
	Fermented whole shoot	19 $\pm$ 4	874 $\pm$ 171	0.06 $\pm$ 0.01	0.03 $\pm$ 0.02	0.03 $\pm$ 0.01
	Total		11 056 $\pm$ 2602	0.83 $\pm$ 0.20	0.26 $\pm$ 0.09	0.57 $\pm$ 0.14

**Table 3.**  
(Continued)

States	Bamboo shoot product	Retail price (Rs/kg)	Gross income (Rs/day)	Gross income (million Rs/year)	Financial investment and wages for mandays (million Rs/year)	Net income (million Rs/year)
Sikkim	Whole shoot boil of narrow bamboo species <sup>c</sup>	27 ± 6	6642 ± 891	0.18 ± 0.02	0.03 ± 0.00	0.15 ± 0.02
	Whole shoot boil of large bamboo species <sup>d</sup>	17 ± 2	8109 ± 884	0.39 ± 0.04	0.07 ± 0.02	0.32 ± 0.02
	Total		14751 ± 1775	0.57 ± 0.06	0.10 ± 0.02	0.47 ± 0.04
	Grand total (Rs.)		264 677 ± 32 730	40.38 ± 4.78	17.48 ± 1.97	22.90 ± 2.84
	Grand total (US\$) <sup>e</sup>		5788	883 010	382 244	500 766

<sup>a</sup> Basal part of tender culm sheath of fresh bamboo shoot in dried form.

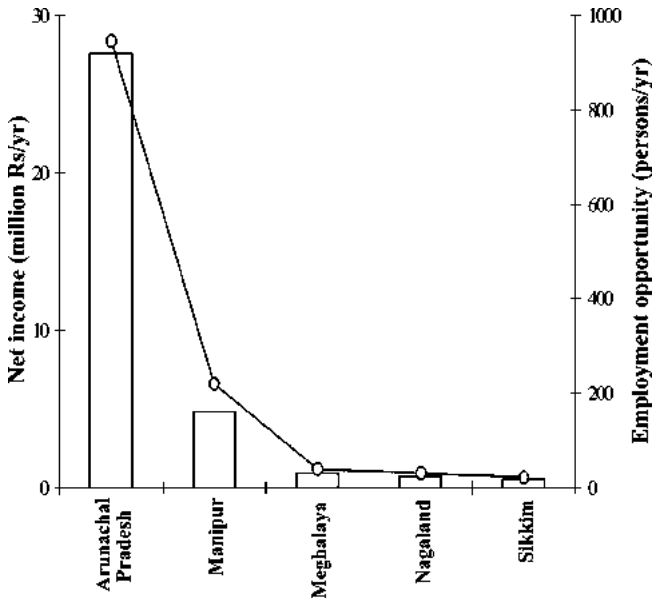
<sup>b</sup> Crushed fermented tender rhizomes in dried form.

<sup>c</sup> Narrow bamboo species consist of *C. hookeriana*.

<sup>d</sup> Large bamboo species consist of *D. hamiltonii* and *D. giganteus*.

<sup>e</sup> 1 US\$ = Rs. 45.73 in Indian currency (January 2004).





**Figure 9.** Net income [after deduction of financial investment ( $\square$ )] and employment opportunity ( $\circ$ ) in the NEH region, India.

roasted and boiled bamboo shoot products in NEH region, India was computed as *ca.* 40 million rupees per annum (US\$ 874 700), with a net income of *ca.* 23 million rupees per annum (US\$ 502 953), where a total of *ca.* 17 million rupee per annum (US\$ 371 748) financial investment and physical efforts as mandays were made for merchandizing them.

Figure 9 depicts the monetary return, annual income generated (after the deduction of financial investment made) from the merchandizing of bamboo shoot products and employment opportunity in the NEH region of India. During the study period, the highest income per manday was recorded in Arunachal Pradesh with Rs. 80 per day (US\$ 1.75) and lowest in Manipur with Rs. 60/day (US\$ 1.31), whereas in Meghalaya, Nagaland and Sikkim this was recorded to be Rs. 65 per day (US\$ 1.42). The net income (after deduction of financial investment) from selling of bamboo shoot products in Arunachal Pradesh could employ most persons (945 persons at Rs. 80 per day (US\$ 1.75) throughout the year), whereas in Sikkim state it could generate the least with 22 persons at Rs. 65 per day (US\$ 1.42). In Manipur, 220 persons could be engaged in merchandizing bamboo shoot products throughout the year at Rs. 60 per day (US\$ 1.31), whereas in Meghalaya and Nagaland it could generate employment for 40 and 31 persons, respectively, at Rs. 65 per day (US\$ 1.42). Thus, a total of 1258 persons could be engaged fully or partly for their livelihood through the merchandizing of fermented, roasted and boiled bamboo shoot products in 5 states of the NEH region of India.

## DISCUSSION

The present investigation could provide an idea on the available fermented, roasted and boiled bamboo shoot products consumed as well as sold in the market places of 5 states in the NEH region of India. The highest variety of bamboo shoot products observed in Nagaland and Arunachal Pradesh was due to the higher diversity of ethnic groups in these two states. Different ethnic groups have different indigenous technical knowledge for the processing of bamboo shoot products, although the principle remains same. Arunachal Pradesh has a moderate population with 1.09 million.

Largest sale of bamboo shoot products with highest commercial value in Arunachal Pradesh was due to the moderate population with rich bamboo resource in which *ca.* 80% of the total population belongs to the rural sector who access the resource. Another reason is the long term availability of fermented products with their high demand. Among the bamboo shoot products, the highest sale of crushed-fermented moist bamboo products observed in Arunachal Pradesh was due to its low cost with consumability by almost all tribal communities of the state, except the Monpa tribe. The shorter availability period of roasted whole shoot and whole shoot boil in the market places of the NEH region was due to the short bamboo shoot availability period in the forests/homegardens during the rainy season (May–July) and limited market days per week. The largest quantity of fermented-slice bamboo shoot in the NEH region, which was recorded in Manipur, was due to its longest availability period in the market places with higher sale.

In spite of the consumption of crushed fermented dry bamboo shoots by almost all the tribal communities in Arunachal Pradesh there was a lower sale which was due to a very high market price. As limited ethnic groups of Nagaland consume crushed fermented bamboo shoot products, there was a low sale of this product in few market places of particular localities of Nagaland. Almost all the ethnic groups of Manipur consume fermented slice bamboo shoots as major food item and as food additives in different dishes, whereas, fermented whole shoot was consumed by three communities. In addition, fermented slice bamboo shoots processed in Manipur are also exported to the neighbouring states of NEH region, like Arunachal Pradesh, Nagaland and Assam. Most of the fermented slice bamboo shoots sold in the market places of Arunachal Pradesh was dealt by secondary vendors who purchased and transported it from Manipur due to its better quality and delicacy, which resulted in a higher market price. In Meghalaya, only crushed fermented moist bamboo shoot was observed to be sold by the major three tribal communities, i.e., Khasi, Jaintia and Garo in less quantity compared to the other states of the NEH region, except Nagaland. It may be due to the higher availability of other food/vegetable crops with low price which can substitute costly bamboo shoot products.

The unique fermented dry basal portion of tender culm sheath recorded in Nagaland was restricted to the market places of Wokha, Mokokchung and Tuensang

districts. It was used by only 5 tribal communities of the three districts of the state in preparing particular dishes like duck meat, rabbit meat curries, etc.

In Nagaland, fermented bamboo shoot products are consumed in large quantities but not through the market places, rather they were processed in household level and preserved for their use throughout the year. In Sikkim, market price of boiled bamboo shoots of narrow bamboo species (*Chimonobambusa hookeriana*) was higher than that of large species (*Dendrocalamus hamiltonii* and *D. giganteus*) due to its more delicacy with sweet taste and its less availability in the natural forests as well as home gardens. A higher number of bamboo shoot products available in the market places of Arunachal Pradesh with larger quantity sold for longer periods, at higher market price, fetched higher annual gross income in this state. Though, the market price of few fermented bamboo shoot products sold in Nagaland was very high, but due to its negligible quantity sold in the market places with limited availability period throughout the year, annual gross income was low. Physical efforts as mandays required for merchandizing of all bamboo shoot products in all states of NEH region were more than that of financial investments made for purchasing fresh shoots, fuelwood cost, transportation charge and purchasing cost of processed bamboo shoot products in case of secondary vendors.

Higher net income generated from processed bamboo shoot products in Arunachal Pradesh was due to the higher gross income with comparatively less financial investment as well as physical efforts made for their commercialisation. Lowest net income generated from this resource in Sikkim was due to its lowest gross income resulted by low market price and availability for a very short period with higher financial investment and physical efforts made for commercialisation. Due to the large income generated from bamboo shoot products, Arunachal Pradesh alone could employ *ca.* 945 persons/year, whereas Manipur could employ *ca.* 220 persons throughout the year. Overall, fermented, roasted and boiled bamboo shoot products consumed through the market places in the 5 states of NEH region could support *ca.* 1258 persons throughout the year on a sustainable basis.

## CONCLUSIONS

Through this study, it can be understood that, in addition to the consumption of fresh bamboo shoots, there is a very high commercial value of fermented, roasted and boiled bamboo shoot products which can be used as a tool for the income generation and creating employment opportunities in the states of NEH region of India. Further, proper planning and implementation of small and large scale industries for bamboo shoot processing units in this region may reduce the unemployment problems and improve the socio-economic conditions of the region.

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