Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5562

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (6):** 1015-1023 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Effect of Fermentation on Nutrient Composition of Bamboo Shoot

Yombom Bam* and Usha Malagi

Department of Food Science and Nutrition, College of Rural Home Science

University of Agricultural Sciences, Dharwad-580005

*Corresponding Author E-mail: bamyombom@gmail.com

Received: 29.08.2017 | Revised: 26.09.2017 | Accepted: 1.10.2017

ABSTRACT

Bamboo shoot (BS) an ethnic food is one of the main gastronomy consumed by the tribes of Arunachal Pradesh. It is used in different form viz., raw, fermented, chutney, pickle and in various dishes and broths. However, the tribes prefer to eat in fermented form. Various products are made out of BS among the different tribes, as such Eiku (fermented BS) and Eip (sun dried fermented BS) of Galo tribe were taken for the present investigation to estimate the nutrient component of fermented BS. The traditionally consumed BS (fresh) was collected from the local area of Arunachal Pradesh. The fresh BS was fermented and estimated for nutrient composition. Significant decrease was observed in fat and ash content with the fermentation process. An increase in crude fiber (10.76 per cent) and protein (15.20 per cent) content was observed for Eip, where the protein content for fresh BS and Eiku was (12.52 and 9.14 per cent) and crude fiber was (7.38 and 5.63 per cent), respectively. The mineral content (Fe, Mn and Cu) showed significant difference among the fermented BS where the Fe content was found to be 4.50, 6.45 and 26.35 mg/100gm for Eiku, fresh and Eip, respectively. Hence it is concluded that fermentation processes can have direct effects on the nutritive qualities of BS. Higher nutrient content of BS makes it useful as health food, but its significance is not largely known by general public. Therefore BS can be popularized as food product and commercialized in large scale for capital needs and health security.

Key words: *Bamboo shoot (BS), Fresh BS, Eiku (Fermented BS), Eip (sun dried fermented BS), Ethnic, Gastronomy, Nutrient Content*

INTRODUCTION

Bamboos, tall arborescent grasses, belonging to the family Poaceae, are popularly known for their industrial uses. They are plants of inclusive concern because of their idiosyncratic life form, ecological importance, and the wide range of uses and values they have for humans. They are intermingled with the tradition and culture of rural and tribal populations and are an integral part of their cultural, social, and economic conditions[30] from times immemorial due to which they have been variously called as "The Cradle to Coffin Plant," "The Poor Man's Timber," "Friend of the People," "Green Gasoline," "The Plant with Thousand Faces," and "The Green Gold."

Cite this article: Bam, Y. and Malagi, U., Effect of Fermentation on Nutrient Composition of Bamboo Shoot, *Int. J. Pure App. Biosci.* **5(6):** 1015-1023 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5562

Copyright © Nov.-Dec., 2017; IJPAB

Bamboos can be used as food, for shelter making, also having medicinal properties, raw materials for construction, wood substitute, and used in paper and pulp for industry. They are also used for making furniture, handicrafts, containers, tool handles, poles, musical instruments, bows and arrows, boats, rafts and fishing poles. Though more popularly known for industrial usage, a lesser known fact of bamboos is the utilization of its juvenile shoots as food. Bamboo shoots (BS) are used in numerous Asian dishes and broths. It is being processed and consumed by the tribal's of north east India since time immemorial. Different varieties of BS are available in the northeast region. Bamboo shoots are generally 20-30 cm long, taper to one end, grow extraordinarily at about 121cm a day and weigh almost to a pound. The leaves covering the shoots are black, brown, yellow or purple, in some species and are covered with tiny hairs. Bamboo shoots look like coiled springs and have acerbic flavor. They are normally sheltered in specialized coverings called culm sheaths that are often multi-coloured, when young. The white meat, that is revealed, once the culm sheath is peeled off, it turns yellowish white when cooked, and is very sweet if it is cooked on the day of harvest, Choudury *et al*.[7]. It is one of the main gastronomy consumed by all the tribes of Arunachal Pradesh. Arunachal Pradesh is considered to be an abode of bio-cultural diversity in the world. The state is spread with an area of 83743 Sq Km and has a rich biodiversity. The tribes of the state have native culture, food habits and derived their nutrients from the wild plants available in the local forest, and among all the most commonly consumed is BS. It is available in the local forest of the villages and is also used as a source of income. The tribes consumed BS in different forms viz., raw, boil, fermented and pickle, etc., Fermentation, a chemical change produced through the breakdown of carbohydrates and proteins is a process used for centuries in order to make and preserve Bamboo shoots by the tribal's. It is prepared during mid april to early September when the young Bamboo shoots are available in plenty. Young tender Bamboo shoots (*Dendrocalamus hailtonii Nees. Et Arn.ex Munro, Bambusa balacoa* Roxb., *Dendrocalamus giganteus Munro, Phyllostachys assamica gamble ex brandis, Bambusa tulda* Roxb.,) are collected and outer leaves sheaths are removed. Almost all the tribes of Arunachal Pradesh consume BS with same process of fermentation though slight variation may be observed. Traditionally edible portions are chopped into very small pieces and stored in bamboo baskets laid into the pit lined with leaves, and then it is covered with leaves and sealed tightly. The fermentation is allowed for 1-3 months. Bamboo shoots are consumed mainly in two fermented form viz., fermented and fermented dry and are also eaten raw or cooked with meat, fish and vegetables. Various local terms are referred for fermented BS, viz., Eiku, Ikung, Hikhu for fermented BS and the sun dried fermented BS as Eip, Iyup, Hirring by different tribes of Arunachal Pradesh. BS is considered as one of the nutritious food among the tribes and also serves for many medicinal value, viz., vomiting, fever, infection. The fermented BS is also known locally as a folk remedy for the treatment of impotence, infertility, and menstrual pains. Hence, looking to the importance of BS in food, nutrition and livelihood the present study was taken up to determine the nutritional facts of fermented Bamboo shoots consumed by the tribes of Arunachal Pradesh.

MATERIALS AND METHODS

Study area: Papumpare district of Arunachal Pradesh was chosen as study area

Documentation: To collect information about the BS species which are used by the tribal and local people documentation was done by collecting their local names, usages and processing in different tribal and local languages. Also people residing the district from different region of northeast were documented.

Sample collection: The traditionally consumed Bamboo shoots (*Dendrocalamus*

hamiltonii) were collected from the local area of Papumpare district of Arunachal Pradesh. The sample was collected at one lot, stored in tight container and used for the study.

Processing:

The processing of fermentation of the bamboo shoot was done as par the traditional method opted by the Galo tribes of Arunachal Pradesh and as such Eiku (fermented BS) and Eip (sun dried fermented BS) were taken for the study.

Raw: The fresh BS was procured from local market and outer layer was removed and washed. The edible portions are chopped into very small pieces and are cooked (mostly boiled with salt and chilly).

Eiku: The chopped pieces of fresh BS were stored in bamboo baskets (filled with leaves to cover any leakage area) and then covered with local leaves (*toko*) and were allowed to ferment for 1-3 months. The basket was stored in dark place at room temperature (23-24ºC).

Eip: The fermented BS was further sun dried for 3-4 days.

Physical characteristics: Colour, aroma, texture and taste of the fresh and fermented BS were observed and recorded.

Nutritional quality:

The fresh BS and Eiku and Eip were further analyzed for moisture, Protein, fat, ash and crude fiber according to standard procedure. The mineral content (Mn, Cu, Zn and Fe) were determined using AAS.

Statistical analysis:

The data collected in triplicate values for all the quality parameters was statistically analyzed. The data was analyzed by using one way ANOVA using SPSS 16.0 to test significant difference in nutrient composition within the sample of the fresh and fermented BS (Eiku and Eip).

RESULTS AND DISCUSSION

While almost all the tribes and communities in Northest region of India relish fermented BS as one of the delicacy, fermentation process is almost similar with slight difference and it has got its own local names as shown in table 1. In India, shoots of *B. bambos*, *B. multiples*, *B. tulda*, *B. vulgaris*, *D. giganteus*, *D. hamiltonii*, *D. logispathus*, *D. strictus*, and *S. elegans* are used as vegetable and pickle products[34], Also Bhatt *et al*.[5] explored the occurrence of 11 edible bamboo species, namely *B. balcoa* Roxb, *B. nutans* Wall ex Munro, *B. tulda* Roxb, *D. giganteus* Munro, *D. hamiltonii* Nees, *D. hookerii* Munro, *D. longispathus* Kurz, *D. sikkimensis* Gamble, *M. baccifera* Roxb Kurz, *Phyllostachys bambusoides* Sieb and Zucc, and *Teinostachym wightii* Beddome, which were being sold in the markets of North East India by primary and secondary vendors in fresh, fermented, boiled, or roasted form. As such BS can be considered as one of the popular foods among the tribal which are being used in different forms viz., pickle, chutney, curry, etc. Variation in the physical characteristics viz., colour, aroma, texture and taste in the fresh and fermented BS were observed (Table 2). The fresh bamboo shoot got a creamish white colour which turned to yellowish white after fermentation and after being sun dried gives light or dark brown colour. The bamboo shoot gives an acrid flavor with acidic taste and is very juicy though variations were observed among the fresh and fermented BSGenerally, the results (Table 3) indicate that the BS is good sources of proteins, crude fiber. The moisture content of fresh BS was found to be 68.42 per cent which after fermentation increases to 82.56 per cent, this may be due to the sour acidic liquid produced during bamboo fermentation[15] and the moisture contents of the sun-dried Eiku decreased significantly ($P \leq 0.01$) with corresponding increase in the contents of dry matter. An increase in crude fiber (10.76 per cent) and protein (15.20 per cent) content was observed for fermented dry BS from fresh and wet fermented BS, where the protein and crude fiber content for fresh (12.52 and 7.38 per cent) and wet fermented was (9.14 and 5.63 per cent), respectively. This increase of protein and crude fiber in dry fermented BS may be due to the absence of moisture content as compare to fresh and Eiku where the compounds are discarded in liquid[1]. Similar report was found by other workers where the fiber content increases significantly after fermentation and canning[13] inspite of decrease in other content an increase in fiber content

was observed[7]. The fermentation process showed decrease in fat, 2.11 (fresh), 1.49 (wet fermented) and 0.46 per cent (dry fermented) respectively. There was also decrease in ash content (2.31 - 1.19 per cent). This decrease in fat content shows potential to be used as health food against various degenerative diseases.Various research studies suggest that Bamboo shoots are not only rich in macronutrients but also contain minerals that are required in trace amount by human body. The concentrations of minerals elements vary significantly ($P \leq 0.05$) with fermentation, with higher concentrations in the fresh, Ekung and Eiku, (Figure 1). Sun-drying had variable effects on the Fe content which was found to be 4.50, 6.45 and 26.35 mg/100gm for Ekung, fresh and Eip, respectively. The increase in iron content with fermentation period will be consistent with the period of maximum increase in the numbers of micro organism involved in fermentation. The iron content of fresh and Eiku was found to be less as compare to Eip which could be due to the fact reductions in moisture contents resulted in corresponding increases in dry matter contents due to concentration of soluble solids with relatively chemically stable products. Adewusi *et al*.[1] also found that substantial amount of solubilized iron may have been lost in the soak water used in the production of lafun and fufu. Similarly a higher value of iron (22mg/100g) was reported in processed and dried shoots[17]. Thus the result indicates that BS can be suggested as a good source of iron rich food especially for women and children who require 1.65 and 1.05 mg/day respectively. The Mn and Cu content were found to vary significantly among the BS while no significant difference was observed for Zn content. The Mn content range from 2.65 (fresh) to 4.84 mg/100gm (Eiku), while for Eip it was found to be 3.41 mg/100gm. An increase in Cu content was found 0.46 (fresh), 1.09 (Eiku) and 1.83 mg/100gm (Eip). The result for mineral analysis of the BS suggests adequate consumption can meet to the Recommended Daily Allowance (RDA) for minerals. Study by Shi and Yang[21], Nirmala and others[13] also resulted that the shoots have a good profile of minerals, consisting mainly of potassium (K), calcium (Ca), manganese, zinc, chromium, copper, iron (Fe), plus lower amounts of phosphorus (P), and selenium. Chaudhry *et al.*[7] also concluded that the Fe, Cu, Zn and Mn of fermented BS *D. giganteus* were found to be 2.22, 0.42, 0.54 and 0.34 per cent respectively. Heating is one of the most important methods developed to extend the shelf life of foods and increasing the availability of nutrients to consumers. Thermal processes such as sun drying increase storage life of foodstuffs and minimize food-borne diseases and also aimed primarily at increasing palatability of food. The increased iron contents and other mineral, viz., Mn and Cu content of Eiku from Ekung and fresh BS, respectively, could be attributed to the severity of thermal process during sun drying. Thus, BS as one of the staple food of the tribes of Arunachal Pradesh are nutritionally contribute substantially to protein, crude fiber and mineral intakes as evident in the following results. As such it can be substituted with other vegetables and can be served with daily food. BS has immense potential of being used as an important health food as they contain high proteins, amino acids, carbohydrates, many important minerals, and vitamins. Bamboo shoots are low in calories, high in dietary fiber, and rich in various nutrients[6]. The fermented food of northeast region shows good source of nutrition[19,22,29,32] some of fermented foods of north east region was compared to fermented BS (Eiku and Eip) of *Dendrocalamus hamiltonii* (Table 4). Apart from the fermented meat, milk, fish and soybean product the protein content of fermented BS showed higher values as compare to other fermented vegetables. The ash and fat content was found to be very low in fermented BS than the other fermented food products. Thus the result indicated fermented BS as one of the nutrient rich food of north east region. Also with its high protein and low fat content, it can be use as functional food. The reason for its easy processing and handling, BS can further be commercialized to various products and popularized to other region of the nation.

Table 1: Bamboo shoot* in different terms by different tribes of North East region

State	Tribes	Fresh	Fermented BS	Sun dried Fermented BS
Arunachal Pradesh	Adi	**Itiing**	Ikung	Iyup
Arunachal Pradesh	Apatani	**Byapoo**	Hikhu	Hirring , Hyi
Arunachal Pradesh	Galo	**Khule**	Eiku	Eip, Ephe
Arunachal Pradesh	Nyishi	**Eku**	Eku , Eitch	Eup
Arunachal Pradesh	Monpa	**Shonzha**	Shonzha	Khanze
Arunachal Pradesh	Nocte	**Mesi**	Mesi	Mesi
Arunachal Pradesh	Tagin		Ikung, , Ihpe	Ihyup
Arunachal Pradesh	Khamti	**Hankoo**	Noosom	Nooheu
Assam	Boro	**Bah-gaj**	Bagojali	Bagojali
Assam	Assamese	**Bahar gaj**	Khorisa	Hukan khorisa
Assam	Dimasa Kachari	**Miyah wathi**	Miyah wayung	Miyah wathi garain
Meghalaya	Garo	**Me'a**	Mea meseng	Mea meseng
Meghalaya	Khasi	**Lungsiej**	Lungsiej	Lungsiej
Meghalaya	Pnar	**Plung wa im**	Plung wa pdem	Plung wa thad
Manipur	Meitei	**Usoi**	Soibum	------
Manipur	Poumai	**Vouba**	Voubata	Voubatachi
Manipur	Tangkhul		Kahashon	
Manipur	Rongmei	**Thun**	Thun khai	Thun kang
Manipur	Liangmai	**Khasum**	Shumbom	Kashumki
Manipur	Kuki	**Guitui**	Tuibuong	Guitui gop
Manipur	Mao	**Kovoba**	Kovoba mata	Kovoba mataki
Nagaland	Lothas	**Evo**	Rhuchak	Rhujon
Nagaland	Rengma	**Ashoghen**	Athaghii	
Nagaland	Zeliang	**Kechü**	Kechü	Hechü keki be
Nagaland	Sema		Achepho	Athoki
Nagaland	Angami		Kese	
Nagaland	Ao	**Zü**	Ejak, Etsük	Esü
Nagaland	Chakesang	**Küsüh kurhu**	Küsüh	Küsüh Müche
Tripura	Kokbrok		Muyaa	
Tripura	Bengali	**Bash koroil**		
Sikkim	Sikkimese	**Mesu**	Mesu	Mesu
Sikkim	Lepcha	**Dhong**	Dhong	Dhong
Sikkim	Nepalee		Tamba	
Mizoram	Mizo		Mautuai	

***.** Bamboosa balcooa ; Bambuspolymorpha ; Melocanna bamboosoides ; Dendrocalamus Strictus ; Dendrocalamus hamiltonii ; Dendrocalamus giganteus ; Bamusa pallida

Table 2: Physical characteristic of bamboo shoots (*Dendrocalamus hamiltonii)* taken under

State	Colour	Aroma	Texture	Taste
Fresh	Creamish white	Mild acrid	Crunchy & juicy	Bland
Eiku	Yellowish white	Strongly acrid	Soft & juicy	Acidic taste
Eip	Light to dark brown	Moderately acrid	Crunchy	Acidic taste

Table 3: Nutrient composition (%) of fresh BS, Eiku and Eip (*Dendrocalamus hamiltonii)*

BS	Moisture	Protein	Fat	Ash	Crude fiber
Fresh	68.424	12.515	2.111	2.310	7.379
Eiku	82.56	9.140	1.495	1.342	5.632
Eip	7.990	15.203	0.460	1.1880	10.764
SeM±	4.403	0.759	0.166	0.298	0.991
CD	15.236**	2.626**	0.576**	1.032**	3.429**

******. Significant at the 0.01 level@ ; BS- Bamboo shoot

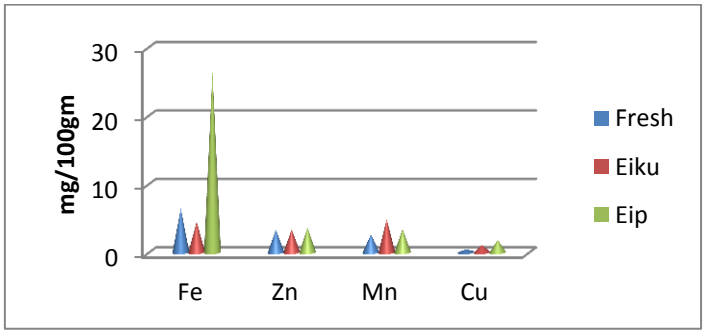

Fig. 1: Mineral content of fresh BS, Eiku and Eip (mg/100gm)

Table 4: Nutrient composition of fermented bamboo shoots of *Dendrocalamus hamiltonii* in comparison to other fermented foods of northeast region

Fermented foods	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Eiku	82.56	9.15	1.49	1.34
Eip	7.99	15.20	0.46	1.19
Seera (wheat)	10.5	17.2 (mg/g)		
Bhaturu (dough)	55.0	21.5 (mg/g)		
Gundruk (mustard & cauliflower)	15	38.7	2.1	22.2
Sinki (radish)	22.8	14.9	1.4	15.6
Goyang (magane-sang)	92.5	35.9	2.1	12.9
Inziangsang (mustard)	17.6	38.7	3.2	16.9
Khalpi (cucumber)	91.4	12.3	2.6	14.2
Hawaijar (soybean)	45.5	47.7	17.0	7.2
Philu (milk)	38.2	29	25.2	1.24
Hentak (fish)	36.30	33.38	13.60	11.43
Ngari (fish)	36.03	38.38	13.34	5.49
Kargyong (sausages, yak/beef/pork)	21.9	16.0	49.1	2.8
Kodo ko jaanr (alcoholic beverages of finger millet)	69.7	9.3	2.0	5.1

Tamang *et al*., 2012; Sharma et al., 2013; Thingom & chetry, 2011; Sarojnalini & Vishwanath., 1995

Plate 1. Freshly cultivated Bamboo Shoot

Plate 2. Fresh Bamboo shoot (after peeled off)

Plate 3. Wet Fermented Bamboo shoot

Plate 4. Dry Fermented Bamboo shoot

CONCLUSION

The BS (*Dendrocalamus hamiltonii)* locally available in Arunachal Pradesh has found to be rich in many aspects of nutrients. On account of its taste and food compatibility of the tribal communities, the BS has got special attention for its conservation and use. The shoot has been consumed in different forms viz., fresh, boil and fermented. Fermentation of BS has direct effects on the nutritive qualities of BS showing its potential to be used as health food. A significant increase in crude fiber and decrease in fat content of fermented dry BS showed its potential for therapeutic usage. When compared with other fermented foods of the northeast region, BS showed good nutrient quality. Thus, it can be further used as a functional and therapeutic food to combat various degenerative diseases.

Acknowledgement

This research could have not been successful without the support of UAS- Merit scholarship fund by University of Agricultural Sciences Dharwad.

REFERENCES

1. Adewusi, S.T.R., Ojumu, T.V., Falade, O.S. The effect of processing on total organic acids content and mineral availability of simulated cassava-vegetable diets. *Plant Foods for Human Nutrition*, **53:** 367–380 (1999).
2. Anonymous Official Methods of Analysis, 18th edition, Association of official Analytical Chemists, Washington, DC (1990).
3. Batra, L.R., Millner, P.D. Asian fermented foods and beverages, *Development of Indian Microbiology*, **17:** 117–128 (1976).
4. Bhardwaj, R., Singh, R.K., Wangchu, L., Sureja, A.K. Bamboo Shoot consumption: traditional wisdom and cultural invasion, In: Proceeding of national conference on Arunachal Pradesh: Tradition in transition, linking ecology, economics and ethics, NERIST, India (2005).
5. Bhatt, B.P., Singh, K., Singh, A. Nutritional values of some commercial edible bamboo species of the north Eastern Himalayan Region, India, *J Bamboo Rattan*, **4(2):** , 111–124 (2005).
6. Chongtham, N., Bisht, M.S., Haorongbam, S. Nutritional Properties of Bamboo shoots: Potential and Prospects for Utilization as a Health Food,

Comprehensive Reviews in Food Science and Food Safety, **10:** , 152-169 (2011).

7. Choudhury, D., Sahu, J.K., Sharma, G. D. Bamboo shoot based Fermented food products – a review. *Indian J Traditional Knowledge,* **11(2):** 242-249 (2010).
8. Choudhury, D., Sahu, J.K., Sharma, G.D. Bamboo shoot: Microbiology, Biochemistry and technology of Fermentation – a review, *J of Scientific & Industrial Research,* **11(2):** 242-249 (2012).
9. Das, A.J., Deka, S.C. Mini Review Fermented foods and beverages of the North-East India. *International Food Research J*, **19(2):** 377-392 (2012).
10. Giri, S.S., Janmejay, L.S. Effect of bamboo shoot fermentation and ageing on nutritional and sensory qualities of soibum, *J Food Sci and Technol*, **31(6):** 423-426 (2000).
11. Guala, G.F. A New Genus of Bamboos from the Cerrados of Brazil, *Bamboo Science and Culture: The J American Bamboo Society*, **17(1):** 1-3 (2003).
12. Kalita, T., Dutta, U. A comparative study on indigenous usage of bamboo shoot in health care practices in NE India. *The clarion,* **1(2):** 130-141 (2012).
13. Nirmala, C., David, E., Sharma, M.L. Changes in nutrient components during ageing of emerging juvenile Bamboo shoots, *Int J Food Sci and Nutr,* **58:** 345–52 (2007).
14. Nirmala, C., Sharma, M.L., David, E. A comparative study of nutrient components of freshly emerged, fermented and canned Bamboo shoots of *Dendrocalamus giganteus Munro*, *Bamboo Science and Culture* **21(1):** 41–47 (2008).
15. Nongdam, P. Traditional fermented bamboo shoot foods of North-East India and their characteristic natural microbial flora, 10th World Bamboo Congress, Korea (2015).
16. Nongdam, P., Tikendra, L. The Nutritional Facts of Bamboo Shoots and Their Usage as Important Traditional Foods of Northeast India, *International scholarly research notices* (2014).
17. Rajyalakshmi, P., Geervani, P. Nutritive value of the foods cultivated and consumed by the tribals of South India. *Plants food for human nutrition,* **46(1):** 53-61(1994).
18. RFRI. Bamboo as food and medicine, Report of Rain Forest Research Institute, Jorhat, India (2008).
19. Sarojnalini, C.H., Vishwanath, W. Nutritional characteristics of the two fermented fish products - hentak and ngari of manipur, *Journal of the Indian Fisheries Association* **25:** 75-81 (1995).
20. Sastry, C.B. A 2020 vision for bamboos in India: Opportunities and challenges. proceedings of international conference "improvement of bamboo productivity and marketing for sustainable livelihood, New delhi 15–17th april, 6–15 (2008).
21. Shi, Q.T. Yang K S, Study on relationship between nutrients in bamboo shoots and human health, In:Bamboo and its use, proceedings of the international symposium on industrial use of bamboo, Beijing, 7-11th December, 338-346 (1992).
22. Sharma, N., Handa, S., Gupta, A. A comprehensive study of different traditional fermented foods/beverages of himachal pradesh to evaluate their nutrition impact on health and rich biodiversity of fermenting microorganism a comprehensive study of different traditional fermented foods/beverages of himachal pradesh to evaluate their nutrition impact on health and rich biodiversity of fermenting microorganisms, *Int J research in applied, natural and social sciences*, **1(3):** 19-28 (2013).
23. Sharma, N., Singh, A. An insight into traditional foods of North-western area of Himachal Pradesh, *Indian J Traditional Knowledge*, **11(1):** 58-65 (2012).
24. Singhal, P., Bal, L.M. Satya S, Sudhakar P, & Naik S N, Bamboo Shoots: A Novel Source of Nutrition and Medicine, *Critical*

Reviews in Food Science and Nutrition, **53:** 517–534 (2013).

25. Tamang, J.P. Health benefits of fermented foods and beverages. CRC press, taylor & francise groupbocs raton, London, new York, 567-590 (2015).
26. Tamang, B., & Tamang, J.P. Traditional knowledge of biopreservation of perishable vegetable and bamboo shoots in Northeast India as food resources. *Indian Journal of Traditional Knowledge*, **8(1):** 89-95 (2009).
27. Tamang B, & Tamang J P, Microbiology and functionality of ethnic fermented bamboo shoots as food bioresources of Arunachal Pradesh in India, *In:Food Biotechnology*, (2009).
28. Tamang, B., Tamang, J.P. Lactic Acid Bacteria Isolated from Indigenous Fermented Bamboo Products of Arunachal Pradesh in India and Their Functionality, *Food Biotechnology*, **23(2):** 133-147 (2009).
29. Tamang, J.P., Tamang, N., Thapa, S., Dewan, S., Tamang, B., Yonzan, H., Rai, A.K., Chettri, R., Chakrabarty, J., Kharel, N. Microorganisms and Nutritional value of Ethnic fermented foods and alcoholic beverages of North East India, *Indian J Traditional Knowledge*, **11(1):** , 7-25 (2012).
30. Tewari, D.N. Bamboo as poverty alleviator, *Indian Forester*, **114:** 610–2 (1988).
31. Thakur, N., Savitri, Bhalla, T.C. Characterization of some traditional fermented foods and beverages of Himachal Pradesh, *Indian J Traditional Knowledge*, **3(3):** 325-335 (2004).
32. Thingom, P., Chetry, G.K.N. Nutritional Analysis of Fermented Soybean (Hawaijar), *Assam University Journal of Science & Technology*: *Biological and Environmental Sciences*, **7(1):** 96-100 (2011).
33. Tiwari, S.C Mahanta D, Ethnological observations on fermented foods products of certain tribes of Arunachal Pradesh, *Indian J Traditional Knowledge*, **6(1):** 106-110 (2007).
34. Vatsala, V.V.A. Bamboos in India, NISCAIR, New Delhi (2003).
35. Xuhe, C. Promotion of bamboo for poverty alleviation and economic development, *J Bamboo Rattan* **2(4):** 345–50 (2003).