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A review on traditional fermented bamboo shoot and the rich culinary heritage of North East India

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Abstract

Traditional fermented foods play a significant role in the diet and cultural heritage of the communities in North East India. This region is known for its rich biodiversity, including a diverse range of bamboo species, which are widely utilized in food preparations. The fermentation process helps to preserve the bamboo shoots and also enhances their flavor. These foods are typically eaten as part of a meal, or they can be used as ingredients in other dishes. Among the popular fermented bamboo shoot products of Northeast India includes, *Soibum*, *Soijin* of Manipur, *Hirring*, *Ekung* and *Eup* of Arunachal Pradesh, *Rep* of Mizoram, *Kardi* or *amil* of Assam and *Lung-Siej* of Meghalaya. Some of the famous local dishes include, *Soibum eromba* of Manipur, *Rawtui-bai* of Mizoram, *Mia-gudhog* of Tripura. There are different types of fermented bamboo shoots in north-east India, each with its own unique flavor and texture. They are a good source of protein, fiber, vitamins, and minerals. They are also low in calories and fat. Moreover, bamboo shoots are known to possess a wide range of bioactive compounds such as phenolics, flavonoids, and dietary fibers, which are further modified during fermentation, leading to the formation of potential health-promoting metabolites. Additionally, fermentation enhances the bioavailability of certain nutrients and reduces the levels of anti-nutritional factors, thereby improving the overall nutritional quality of the products. The consumption of traditional bamboo shoot fermented foods has been associated with various health benefits, including improved gut health, antioxidant activity, and antimicrobial properties. The traditional bamboo shoots fermented foods of North East India represent a valuable and distinctive aspect of the region's culinary heritage. This review highlights their production methods, nutritional composition, potential health benefits and microbial diversity of this unique food culture.

Keywords Bamboo Shoots; Northeast India; Fermentation; Processing; Nutrition

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1. Introduction

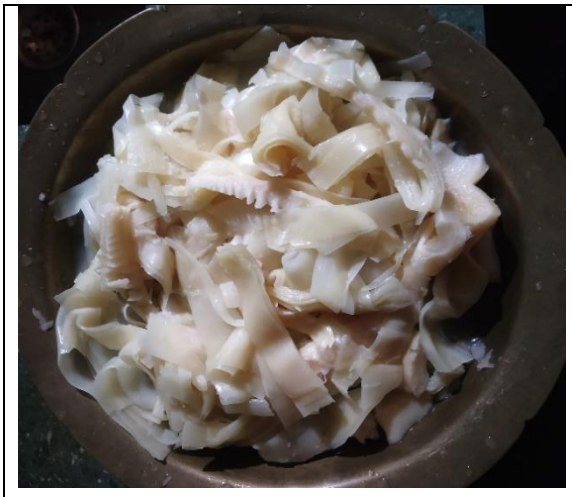
Fermented foods have held profound importance throughout human history since ancient times. Beyond the preservation of perishable ingredients in the absence of modern refrigeration, fermentation unlocked a treasure trove of flavors, textures, and nutritional benefits. Traditional fermented bamboo shoots hold a cherished place in the culinary heritage of Asia and, in particular, the enchanting northeast region of India (Acharya et al., 2023). The old age practice of fermenting bamboo shoots is an art that transcends generations, infusing a unique and unforgettable flavor into the cuisine of this culturally diverse and ecologically rich region. As an integral component of local diets, fermented bamboo shoots not only contribute to the distinctive taste of dishes but also offer a glimpse into the deep-rooted traditions and sustainable food practices that have sustained communities for centuries. Fermented bamboo shoots in Northeast India are more than just a culinary ingredient; they are a cultural cornerstone deeply rooted in the traditions and daily life of the region's diverse indigenous communities. This ancient practice of fermenting bamboo shoots reflects the resourcefulness of the people in this ecologically rich region, as bamboo is abundantly available. The preparation and consumption of fermented bamboo shoots are intricately linked to various cultural aspects, from rituals and festivals to communal gatherings and daily meals (Chongtham and Bisht, 2020). These bamboo shoots, often transformed into flavorful condiments or used as key ingredients in traditional dishes, offer a pungent and unique taste that embodies the spirit of northeast India's culinary diversity. Whether in the fiery stews of Nagaland, the tangy chutneys of Assam, or the aromatic curries of Manipur, fermented bamboo shoots remain a culinary thread connecting the region's cultural mosaic, preserving ancient flavors, and reinforcing a sense of shared identity among its people.

Northeast India boasts a rich tapestry of traditional fermented bamboo shoot preparations, each offering a unique culinary experience and cultural significance (Table 1). Fermented bamboo shoots are very common in the North-East region particularly in Manipur, Tripura, Arunachal Pradesh, Nagaland and Meghalaya (Meetei, 2020). Manipur's *Eromba* incorporates fermented bamboo shoots with fermented fish into a savory, creating a harmonious blend of flavors. In Nagaland, *Bastanga* is a fiery and tangy delicacy that packs a punch, often accompanying Naga meals. The Khasi people of Meghalaya savor *Lung-seij*, pungent chutney prepared from fermented bamboo shoots, *tungtap* and assorted spices. Assam's *Khorisa* is a delightful and versatile fermented bamboo shoot condiment used to add depth to various dishes. In Arunachal Pradesh, *Hirin, Hikhu, Hiyi* is a popular fermented bamboo shoot preparation for long-term

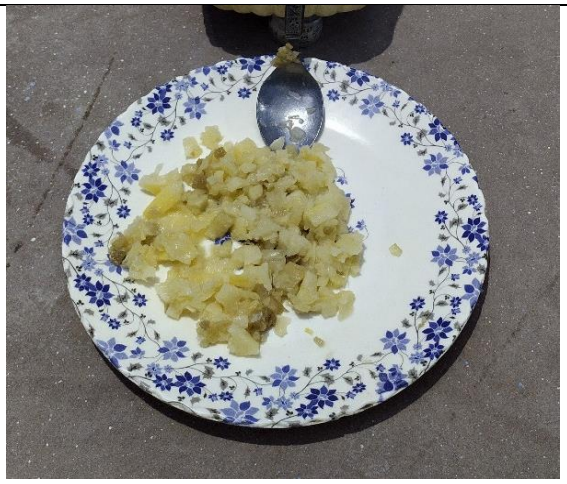
storage and *Pika pila* is one of the dishes prepared with fermented bamboo shoots (Fig 1.). These diverse culinary traditions, utilizing fermented bamboo shoots, not only contribute to the distinctive flavors of northeast Indian cuisine but also reflect the deep-rooted cultural diversity and resourcefulness of the region's indigenous communities.

Table 1. Traditional Fermented Bamboo Cuisines of North East Region of India

State	Cuisine	Preparations
Arunachal Pradesh	***Perok-Ikung***	Ikung (fermented) bamboo shoots prepared with fried or boiled chicken and spices
	Yekdin-Ikung	Fermented bamboo shoots fried or boiled with pork by adding other spices
	Engo-Ikung	Fermented bamboo shoots boiled with fish and combination of various spices
	Pika Pila	Fermented bamboo shoot prepared with pork
Assam	***Khorisa Maas***	It is a fish curry with grated fermented bamboo shoots.
Manipur	***Usoi-Ooti***	Sliced bamboo shoots *(Bambusa nutans)* and dried pea soaked in water overnight then boiled with a pinch of sodium bicarbonate
	Usoi-kangsu	Overnight water-soaked bamboo slices boiled with potato and mixed with fried fermented fish and dried chilies
	Soijin-eromba	Fermented bamboo shoots boiled with potato and mixed with fermented fish and dried chilies.
	Ngakra-Soijin Thongba	Fermented bamboo shoot (*Soijin*) and cat fish cooked with oil and spices.
Mizoram	***Arsa Buhchiar***	Fermented bamboo shoots are cooked with pork and spices to create a flavourful aromatic curry.
Meghalaya	***Lung-seij***	Khasi people of Meghalaya savor pungent chutney prepared from fermented bamboo shoots, *tungtap* (fermented fish) and assorted spices
Nagaland	***Bastanga***	A fiery and tangy delicacy of fermented bamboo shoot that packs a punch, often accompanying Naga meals
Sikkim	***Tama Curry***	It is a fermented bamboo shoot curry which is a staple dish of Sikkimese consumed with steamed rice.
Tripura	***Moiya Koshak-Shidal***	Fermented bamboo shoots with fermented fish (*shidal*)
	Chakkhoi	Fermented bamboo shoots mixed with other vegetables

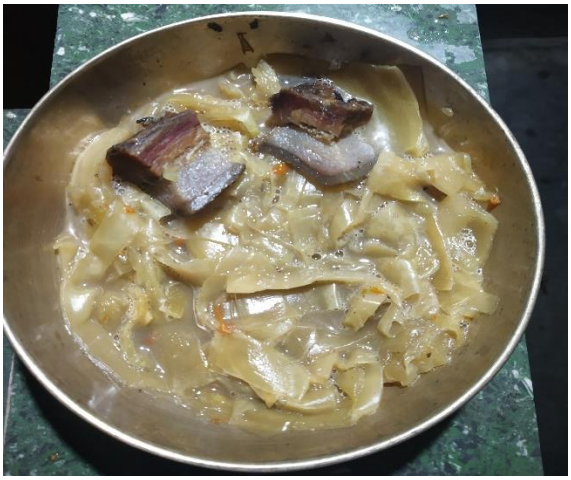


Hirin (fermented shoot)



Hikhu (fermented shoot)

Hiyi (dried shoot)



Pika Pila (Dish with bamboo and pork)

Fig. 1. Different processed bamboo shoot and bamboo shoot dish of Arunachal Pradesh

2. Fermentation of bamboo shoots in North East India

Bamboo shoot is a seasonable vegetable having a very short shelf life of 3-4 days at ambient temperature. It is available only during the monsoon season in India and in other South-East Asian countries. The post-harvest shelf life of bamboo shoot is limited and they have to be consumed or processed immediately after harvest. The firmness of the shoot increased rapidly after harvest due to tissue lignification and the quality of the shoot deteriorated as they are exposed to microbial spoilage, undergo browning with various enzymatic and non-enzymatic activities (Luo et al., 2008). Mechanical damage can induce high respiration and invasion of microbes and cause rotting of bamboo shoots. Matsui et al. (2004) reported for the change in

the texture properties of shoots during storage due to phenylalanine ammonia-lyase activity. Retention of moisture is essential for the bamboo shoot to keep it fresh, however, without proper processing and preservation external factor such as temperature, humidity, microbial exposure, and storage condition will affect the shelf life of shoots (Anonymous, 2009). The purpose of processing and preservation is to maintain the natural, color, smell, taste and to reduce the deterioration of bamboo shoot. Processing of bamboo shoot before consumption is also important due to the content of anti-nutrients particularly taxiphyllin. Several traditional and modern ways of processing and preservation of bamboo shoot are practiced including boiling, soaking, fermentation, sun drying, roasting, canning, pickling and more.

Fermented bamboo shoot is one of the important ingredients in the cuisines of northeast people. The fundamental concept of bamboo shoot fermentation is consistent across all northeast states, with minor variations in processing techniques influenced by specific regional and ethnic practices. Bamboo shoots can undergo fermentation as whole, slices, or through methods involving crushing and either moist or dry fermentation (Babita et al., 2023). Bamboo species used for fermentation include *Bambusa balcooa, B. tulda, B. pallia, B. vulgaris, D. hamiltonii, D. giganteus, D. sikkimensis, T. wightii,* and *M. bambusoides* (Jeyaram et al., 2009). Young shoots of *D. hamiltonii, D. sikkimensis,* and *Bambusa tulda* are used for the preparation of a non-salted fermented product *Mesu* consumed traditionally by the people of West Bengal and Sikkim of India (Tamang and Sarkar, 1996). The edible portion of the shoots is chopped and filled tightly in bamboo stem covered with leaves and allowed to ferment for 7-15 days at an ambient temperature of 20-25^{0}C. *Mesu* has a self-life of a week which is pickled for long term used in preparing curry by frying with meat. The *Adi* and *Galo* tribes of Arunachal Pradesh process shoots of *Dendrocalamus hamiltonii, D. hookeri, D. giganteus, D. longispathus, Bambusa balcooa, B. pallida* and *Melocanna baccifera* through fermentation and sun drying for the preparation of products such as *kupe, eepe, eeku* and *eep* (Bhardwaj et al., 2005; Roy et al., 2017). *Kupe* is prepared from the soft and tender edible portion of the shoots which is allowed to ferment either as a whole or sliced in an air-tight bamboo basket wrapped with leaves of locally available herbs preferably *Phrynium* sp. Heavy weight is put on top of the basket to remove excess exudates from the basket. Fermentation was carried out for 15- 30 days before consumption and the dried *Kupe* is used as *eepe*. Similarly, *soibum, soidon* and *soijin* are processed bamboo shoot products of the *Meitei* community of Manipur. Shoots of *Dendrocalamus hamiltonii, D. sikkimensis, and D. giganteus, Melocana bambusoides, Bambusa tulda, B. vulgaris, B. balcooa* and *B. pallida* are commonly used for the preparation of indigenous fermented product *Soibum* (Jeyaram et al., 2009). Processing of shoots for

soibum is of two types, *Noney*, and *Kwatha* in which tender shoots are fermented in different ways. In *Noney* type thin slice of the edible shoots are pressed tightly in a bamboo basket chamber wrapped with banana leaves perforated at the bottom to remove the acidic fermented juice and kept for about 6-12 months. In case of *Andro* type, sliced shoots are filled in an earthen pot with repeated filling when the previous volume reduced due to fermentation and the exudates are not drain out until 6-12 months. In Assam, India tender shoots are processed for the preparation of fermented product *Tuaithur* in which sliced shoots are tightly pressed in a cylindrical vessel made of bamboo where exudates are removed continuously 2-3 days and allow fermenting for 6-7 days in the natural condition with the addition of a little amount of water (Tamang et al., 2012). Fermentation and sun-drying of shoots are commonly followed traditional processing technique for several products such as *Poka khorisa, Khorisa, Khorisa tenga, Miya mikhri, Miya mecheng, Jim tenga, Tuaithur, Tuairoi,* of Assam, *Hirring, Hitch, Hitak, Iku, Heecha, Hikku, Ekung, Kupe, Eeku, Eup, Hi, Nogom, Ipe, Hithyi, Eepe, Eep* of Arunachal Pradesh, *Soibum, Soidon, Soijin* of Manipur, *Lung-seij, Pdam* of Meghalaya, *Rawtuai rep* of Mizoram, *Bastanga, Rhujuk* of Nagaland, *Kardi, Handua* of Odisha, and *Moiya koshak, Midukeye, Mellye amiley, Moiya pangsung* of Tripura (Panda and Padhy, 2007; Singh et al., 2007; Jeyaram et al., 2009; Tamang and Tamang, 2009; Tamang et al., 2009; Narzary et al., 2016; Bisht et al., 2015; Swain, 2015; Uchoi et al., 2015, Roy et al., 2017; Jamir and Deb, 2018) (Table. 2).

Table 2. Traditional fermented processed bamboo shoot product of North East India (Meetei, 2020).

State	Tribes	Products	Method	References
Assam	Assamese, Garo, Rabha	*Poka khorisa, Khorisa tenga*	Shoots of *B. balcooa* and *D hamiltonii* mixed with dried *Garcinia pedunculata* and dried chilies, packed in pre-smoked earthen pot tied with banana leaves and allowed to ferment for 4-12 days	Swain (2015)
	Dimasa	*Miya mikhri*	Sliced shoots wrapped in banana leaves and allowed to ferment in an earthen pot for 4-5 days	Swain (2015)
	Garo, Rabha	*Miya mecheng, Jim tenga*	Shoots are cut into small pieces and allowed to ferment for 5-6 days in a jar or container with very little amount of water sprinkled	Narzary et al. (2016)
	Hrangkhol, Baite, Hmar	*Tuaithur*	Sliced shoots are allowed to ferment in an airtight bamboo basket, decanted continuously for 2-3 days	Tamang et al. (2012)

			so that very little water is left and allowed to ferment for 6-7 days	
Arunachal Pradesh	Apatani, Nishi	*Hirring Hitch, Hitak, Iku, Heccha, Hikku*	Sliced shoots flattened by crushing and fermented in a bamboo basket wrapped tightly with leaves for 1-3 months	Tamang (2009, 2012)
	Adi, Apatani, Nishi	*Ekung, Iku, Hikku*	Chopped shoots fermented in a bamboo basket covered with banana leaves laid into a pit near river stream for 6-8 days with heavy weight on top to remove excess water and fermented for 1-3 months	Tamang (2009, 2012)
	Galo	*Kupe*	Sliced shoots pressed in an airtight bamboo basket wrapped with locally available leaves of *Phrynium sp*, removed excess liquid and placed near river stream or within the pit for 15-30 days	Bhardwaj et al. (2005); Roy et al. (2017)
		Eeku	Hard internode portion of young shoots are sliced and fermented in an airtight container for 15-30 days	Roy et al. (2017)
Manipur	Meitei	*Soibum,*	Sliced shoots are allowed to ferment in an airtight bamboo basket with the removal of exudates from a hole in the bottom of the container	Jeyaram et al. (2009)
		Soijin, Soidon	Sliced shoots are allowed to ferment in an earthen pot	Jeyaram et al. (2009)
Meghalaya	Khasi	*Lung-seij*	Sliced shoots are fermented in a bamboo basket	Tamang and Tamang (2009)
		Pdam	Tender shoots are fermented inside a plastic or a glass bottles dipped in water	Bisht et al. (2015)
Nagaland	Lotha Naga	*Bastanga, Rhujuk*	Sliced shoots slightly pounded, pressed tightly in a bamboo basket for 2-3 weeks with a hole at the bottom to remove exudates	Jamir and Deb (2018)
Sikkim	Gorkha	*Mesu*	Sliced shoots of *D. hamiltonii*, *B. tulda* and *D. sikkimensis* are pressed airtight in a bamboo vessel covered with bamboo leaves or wild plants for 7-15 days	Tamang et al. (2012)
Tripura	Chakma, Debbarma, Uchoi,	*Moiya koshak, Midukeye*	Shoots of *M. baccifera* and *M. bambusoides* are wrapped in banana leaves tied with bamboo strip and allowed to ferment for 2-3 days placing in a raised platform undisturbed	Uchoi et al. (2015)
	Chakma	*Mellye amiley*	Shoots are soaked in water for two days in the earthen pot before fermentation	Uchoi et al. (2015)
	Uchoi	*Moiya pangsung*	Whole shoots are fermented in a water-filled container for two nights	Uchoi et al. (2015)

3. Nutritional profile of fermented bamboo Shoots

Fermentation is a popular technique that enhances the appeal of bamboo shoots by refining their flavor and texture. Several scientists have investigated the nutritional profile of fermented bamboo shoots (Nirmala et al., 2008; Santosh et al., 2019). The nutritional profile of fermented bamboo shoots presents a well-rounded composition that encompasses several health-promoting attributes. Numerous studies conducted by various investigators have confirmed that traditional fermented bamboo shoot products are a valuable source of protein, carbohydrates, fibres, folic acid, ascorbic acid and minerals while containing low levels of fat. Chongtham and Sharma (2008) found lower protein content (2.57%) in fermented *D. giganteus* shoots compared to fresh ones (3.11%). Similarly, Badwaik et al. (2015) reported decreased protein content (2.56%) in *B. balcooa* shoots after fermentation versus fresh shoots (3.78%). Some studies also highlight fermented shoots as excellent sources of digestible proteins due to increased soluble protein content compared to fresh shoots. Devi and Singh (1986) also demonstrated increased soluble protein content in fermented shoots, reaching 7.8% and 8.1% on the third and fifth days of fermentation respectively. Amino acids are essential macronutrients in diets, serving as prerequisites not just for protein synthesis but also as precursors for the production of secondary metabolites involved in regulating signaling pathways and metabolism within the body. Chongtham and Bisht (2020) found that fermentation increased amino acid content in certain bamboo species, including *B. balcooa, D. hamiltonii* and *D. latiflorus*. In the case of *D. giganteus* shoots, the amino acid content decreased in fermented shoots (2.005 g/100g f.w.) compared to fresh juvenile shoots (3.863 g/100 g f.w.) (Chongtham and Sharma, 2008). This initial increase was due to microbial protein breakdown, while the later decrease resulted from microbes using amino acids for their own growth and multiplication (Lestari and Simamora, 2017). The content of carbohydrates and starch in fermented bamboo shoots of *B. balcooa, B. tulda* and *D. giganteus* decrease as compared to fresh shoots (Singhal et al., 2021; Badwaik et al., 2014; Nirmala et al., 2008). Fermented shoots are considered as excellent nutraceutical food options with low fat content. Singhal et al. (2021) reported a 90.2% reduction in fat content in fermented *B. vulgaris* shoots compared to fresh ones. Chonghtam and Bisht (2020) found that in certain bamboo species like *B. bambos*, *B. nutans*, *D. giganteus*, *D. hamiltonii* and *D. latiflorus*, fat content increased in fermented shoots compared to fresh shoots while it decreased in *B. balcooa*, *B. tulda*, *D. membranaceus, D. sikkimensis* and *P. mannii*. Consumption of essential vitamins is necessary for maintaining good health and proper body development. A decreasing pattern in vitamin C

content during fermentation in *D. giganteus* (1.09%) as compared to juvenile shoots (3.28%) was observed according to Nirmala et al. (2008). Similarly, Giri and Janmejay (2000) found a complete loss of vitamin C during the fermentation of *B. tulda* shoots. This decline may be linked to the breakdown of tocopherol isomers, primarily α and γ tocopherols which are lipid soluble vitamins with antioxidant properties (Satya et al., 2010).

Mineral elements play an important role in human metabolism. Nirmala et al. (2008) reported a decrease in both macro and micro elements in fermented *D. giganteus* Munro shoots compared to freshly harvested ones. Fermented *D. giganteus* shoots showed minor changes in trace elements but zinc content decreased significantly (Chongtham and Sharma, 2008). Bajwa et al. (2019) reported increased in sodium and magnesium levels and a notable decrease in potassium, phosphorous, chlorine and copper content after fermentation. Calcium and phosphorous decreased by 43.2% and 30.6% in fermented *B. vugaris* shoots compared to fresh shoots (Singhal et al., 2021). Fermentation also led to changes in other minerals like magnesium, sulphur, sodium, calcium, and iron possibly due to microbial breakdown of carbohydrates and proteins (Chongtham et al., 2021). Chongtham and Bisht (2020) found the highest iron levels in fermented shoots, suggesting improved iron availability due to the breakdown of complexes with dietary fibers, phytates and polyphenols during fermentation.

4. Bioactive compounds of fermented bamboo Shoots

Phenols, phytosterols and dietary fiber are key secondary metabolites found in bamboo shoots. These bioactive compounds make bamboo shoots valuable for functional foods and steroidal drugs. Phenolic compounds, especially flavonoids provide bamboo shoots with antioxidant properties. Fresh bamboo shoots are rich in phenolic compounds and their fermentation increases phenolic content due to microbial activity breaking glycosidic bonds releasing various bioactive compounds (Chongtham and Bisht, 2020). Badwaik et al. (2014) found comparable findings in *B.balcooa* with a significant rise in total phenol content from 97.5 mg/100g in fresh shoots to 255 mg/100g in fermented shoots. The major phenolic compounds detected in shoots include ferulic acid, p-coumaric acid, caffeic acid, protocatechuic acid, p-hydroxybenzoic acid, catechin, syringic acid, and chlorogenic acid (Bajwa et al., 2020). Phytosterols, which resembles cholesterol in structure are abundant in both fresh and fermented bamboo shoots. It has been reported that phytosterols have potential antihyperlipidemic and anticarcinogenic properties. The primary sterols in fermented bamboo shoots are β-sitosterol, campesterol, and stigmasterol (Sarangthem and Srivastava, 1997). In *D. giganteus* shoots, the

phytosterol content increases from 0.39% to 2.80% after fermentation (Srivastava, 1990). Sarangthem and Singh (2013) also noted an increase in total phytosterol content in *B. balcooa*, *D. strictus* and *D. hamiltonii* due to fermentation.

Fresh bamboo shoots are rich sources of dietary fibers including NDF, ADF, hemicellulose, cellulose and lignin. Dietary fiber in bamboo shoots contributes to lower blood pressure and reduced risk of coronary heart disease. Fermented bamboo shoots like *Hecche* are also high in dietary fiber containing 20% fiber content (Babita et al., 2023). Regular consumption of bamboo shoots can enhance the lipid profile and promote healthy bowel movements in young women. In fermented *D. giganteus* shoots, various dietary fiber components like NDF, ADF, lignin, hemicellulose and cellulose increased compared to fresh shoots (Chongtham et al., 2011). Chongtham and Sharma, (2008) found that fermentation led to higher NDF (4.18 g/100g), lignin (1.39 g/100g), hemicellulose (0.90 g/100g) and cellulose (1.88 g/100g) content in *D. giganteus* shoots when compared to fresh counterparts. The abundant fiber in bamboo shoots helps lower blood fat and cholesterol levels, making them a popular choice among individuals with modern lifestyle related health issues.

5. Effect of processing on fermented bamboo Shoots

Nirmala et al. (2008) studied the nutritional changes in fermented shoots which observed the depletion of nutrients from fresh to fermented shoots in terms of amino acids, proteins, carbohydrates, starch, fat, vitamin and minerals. However, increase in dietary fiber, phenolic and phytosterol content was observed in fermentation of *Bambusa balcooa, B. tulda, Dendrocalamus giganteus* and *D. hamiltonii* (Nirmala et al., 2014). Phytosterol content of bamboo shoot increased after fermentation due to anaerobic digestion and organic matter degradation by the microorganism (Sarangthem and Singh, 2003b). With ageing, nutritional value of fresh bamboo shoots decreased except in dietary fiber. Removal of anti-nutrients particularly taxiphyllin is very important before consumption of bamboo shoot. Among different processing method, fermentation is the best traditional practice. Preservation of bamboo shoot in plastic bags are also commonly practiced, however, the risk of contamination from the plastic materials are reported (Chiangthong and Chayawat, 2009). Bajwa et al. (2015) investigated the organoleptic, physicochemical and nutritional changes of *Dendrocalamus hamiltonii* during boiling, fermentation and brine treatment which shows maximum removal of cyanogenic glucoside in boiling. Saini et al. (2017) studied the effect of boiling, soaking, fermentation, water preserved and brine preserved in the mineral retention of *Bambusa balcooa*

and *B. bambos* using wavelength dispersion X-ray fluorescence spectrometry. The study revealed decreased in the potassium, phosphorus, magnesium, calcium, silicon, sodium and chlorine in all the processed form except increase in sodium and chlorine content in water preserved and brine preserved shoots. Thounaojam et al. (2017) studied *Dendrocalamus latiflorus* shoots for nutritional and phytochemical changes in soaked, boiled, salted and fermented shoots. The study indicated decrease in protein, carbohydrate, starch, ash, fiber, and vitamin C after processing whereas increase in dietary fiber was observed in salted and fermented shoots. Total phenolic content increased in fermented shoots and the phytosterol content increased in salted and fermented shoots. A rich content of macro elements including potassium, phosphorus, calcium, sulphur, magnesium, silicon, sodium and micro-elements zinc, iron, manganese, bromine, copper, nickel was also recorded. Several processing methods have been investigated in which the nutritional value of fresh shoots is decreased after processing; however, increase in dietary fiber and bioactive compounds are reported which is of pharmaceutical importance (Nirmala et al., 2008; Rawat et al., 2016).

6. Health Benefits of Fermented Bamboo Shoots

Bamboo shoots have been a part of traditional medicinal system of Asian countries. Various research investigations reported the high amount of bioactive compounds that provide health benefits like anti-cancer, anti-oxidant, anti-aging, cardio-protective, weight loss, probiotics (Behera and Balaji, 2021). The processes of fermentation further improve health-promoting components such as biologically active peptides, polysaccharides, phenolic compounds due associated microflora that provide various technological and pharmacological properties such as acidifying capacity, antimicrobial activities, degradation of phytic acid and oligosaccharides, bile-salt tolerance and enzymatic activities (Thakur et al., 2016). Behera and Balaji (2021) reported the cholesterol lowering and immune system strengthening the role of *Suansun*, a traditional fermented bamboo shoot product of China. Health benefits of fermented shoots include their role as probiotics, antioxidant and anti-microbial agents. Fermentation results in the increased bioactive compounds, hence further improves antioxidant capacity indicating their health benefit. The methanolic extracts of different fermented bamboo shoot samples including *Hirring, Soibum, Soidon, Hecche, Ekung* and *Eup* exhibited significant free radical scavenging activity ranging between 70.84 and 95.37% (Sonar et al., 2014). Similar results were reported, thirty days fermented shoot extract of *B. vulgaris* showed higher free radical scavenging activity as compared to fresh shoots (Singhal et al., 2021). Singh et al.

(2011) also reported the antioxidant potential of *Soibum*, a traditional fermented bamboo shoot of Manipur.

Probiotics are microbial preparations that enhances the host's health and well-being as improves the functioning of digestive and immune system of humans. The potential of fermented shoots as functional foods, and medicines enhanced due to presence of microbes like LAB, species like *Lactiplantibacillus plantarum* and *Lactobacillus brevis*. Various lactic acid bacteria present in fermented bamboo shoots showed probiotic as well as antagonistic properties against the selected pathogenic bacteria (Tamang and Tamang, 2009). Mir et al. (2018) reported the presence of *L. plantarum* in most fermented bamboo shoots that provide them probiotic effects along with cholesterol-lowering feature. *L. plantarum* along with *L. brevis* also reported to exhibit high hydrophobicity, which helps in adherence of bacterial culture to epithelial cell layer of the digestive tract for good colonization (He et al., 2014). Do et al. (2020) identified a novel exopolysaccharide (EPS) generated from fermented bamboo shoot-isolated *Limosilactobacillus fermentum*.

Fermented bamboo shoots have shown a great potential in food and pharmaceutical industry at owing to their antimicrobial activity. Angeline et al. (2021) showed that 10 mg/ml concentration of acetone extract of fermented *D. hamiltonii* shoots have antimicrobial activity against *Staphylococcus aureus, Escherichia coli* and *Pseudomonas aeruginosa*, respectively while methanol extract at same concentration showed zone of inhibition only for *P. aeruginosa.* Antifungal and antimicrobial properties of *L. plantarum* in *Ekung* and *Soibum* revealed as it produced maximum zone of inhibition against *Listeria monocytogenes* (Behera et al., 2018). Hata et al. (2009) showed that *Enterococcus faecalis* strain isolated from fermented bamboo shoot produces bacteriocin that inhibit the growth of pathogenic bacteria. Likewise, Alemu et al. (2006) reported *E. faecalis* isolated from fermented shoots as one of the dominant LABs that displayed desirable bacteriocin activity by inhibiting of food spoilage microorganism including *Leuconostoc mesenteroides* and *Latilactobacillus sakei*. Similarly, *Lactobacillus* isolated from *Khorisa* (fermented bamboo shoot) had shown anti-bacterial activity against *S. aureu*s (Badwaik et al., 2014). In another sudy, Badwaik et al., (2015) used *Lactiplantibacillus fermentum, L. plantarum, Bacillus amyloliquefaciens, Trypanosoma brucei,* and *Lactobacillus brevis* in fermentation that improves the palatability of shoots, owing to volatile flavour substances, organic acids and bacteriocins production. *Lactobacilli* isolated from bamboo shoot pickles fermented at 15°C showed antibacterial activity against *E. coli* and *S. aureus* (Hartayanie et al. (2016). Pickled bamboo shoot products can be a beneficial source of XOSs-

fermenting (xylooligosaccharides-fermenting) that displayed antimicrobial activity against foodborne pathogens (Kanpiengjai et al., 2022).

Conclusion

Fermented foods in northeast India are a testament to the region's cultural diversity and resilience. These foods not only provide sustenance but also offer a window into the intricate web of traditions, knowledge, and natural resources that have sustained the people of this region for millennia. As the world becomes more interested in sustainable and probiotic-rich foods, the unique fermented delicacies of northeast India may gain wider recognition for their cultural and nutritional value. Fermented food products offer a wide range of benefits that extend beyond their delicious flavors. They play a pivotal role in our diets, offering improved nutrition, food safety, and sustainability.

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Conflict of Interest

The authors declare there is no conflict of interest

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