Traditional fermented bamboo shoot foods of North-East India and their characteristic natural microbial flora

Potshangbam Nongdam
Department of Biotechnology
Manipur University, Canchipur, Imphal-795003

Abstract

The people of North-East India consume fermented bamboo shoot as one of the important traditional food items. Bamboo shoots form an indispensable part of different ethnic cuisines of the region. Some fermented shoot products preferred among the locals are *soibum, soidon, soijim, bastangapani, mesu, eup, ekhung* and *hirring*. The production of fermented bamboo shoots involves the natural fermentation process with various lactic acid bacteria playing dominant role in imparting flavour, taste and aroma to the product. *Lactobacillus plantarum, L. brevis, L. casei, L. fermentum, L. curvatus, Leuconostoc mesenteroides, L. fallax* and *Tetragenococcus halophilus* are predominantly found in fermented shoots. The fermented bamboo shoots contribute immensely to the food needs of the region as they constitute an integral part of daily diets of many low income families. Preserving the indigenous knowledge of fermented shoot production is essential in the present time of food insecurity and there is also high possibility of many healthy traditional foods being displaced by emerging western foods having glamorous appeal. The article explores the different traditional methods of fermented bamboo shoot production in North-East India. It also emphasizes on the functional and technological attributes of natural microbial flora of different fermented bamboo shoot products which make them one of the most sought after traditional foods with immense health benefits.

Key words

Bamboos, fermented bamboo shoots, Lactic acid bacteria

Introduction

Bamboos with over 1500 species have worldwide distribution and are considered as one of the most economically important plants with more than 1000 uses (Lewington 1990). They are extensively used as raw materials in paper and handicraft industries, in house construction, furniture making, water pipes, storage vessels and other important household items. Apart from their wide range of applications, they have another important usage in utilising their young, tender shoots as popular nutrient rich health foods. This is because of high content of proteins, carbohydrates, vitamins, minerals, fibres, phytosterols, phenols and very less fats (Nirmala et al. 2007). Bamboo shoots may be consumed either fresh during harvesting time or in fermented form throughout the seasons. The consumption of fermented bamboo shoots is confined to Asian countries but in India it is found mostly in the North-Eastern states. *Soibum, soidon, soijim, bastangapani*, *mesu, eup, ekung* etc. are popular fermented bamboo shoot foods of North-East India whose preparation generally use traditional methods of natural fermentation process.The fermented bamboo shoot preparation is a tradition in the region and constitutes an integral part of daily diets of majority population providing essential proteins, minerals, vitamins, carbohydrates and other nutrients. As traditional fermentation procedures make tremendous contribution to the local food needs, there is necessity to safeguard the less expensive, simple, indigenous knowledge of fermented shoot preparation before losing it to advancing world of scientific technologies. There is an immediate danger

that the introduction of western foods with attractive and highly glamorous image will displace those important traditional foods (FAO 1998). The various traditional methods of fermented bamboo shoot production should be studied in detail to determine the nutritional and anti-nutrient content of the final food product. All the available nutrient items present in any food item are essential to be scientifically analysed and displayed on the product (FAO 1998). Host of microbes mainly lactic acid bacteria are involved in bamboo shoot fermentation resulting not only in enhancement of flavour, taste and aroma but also detoxification of anti-nutrients present in bamboo shoots. Mixed lactic microflora like *Lactobacillus plantarum, L.brevis, L. casei, L. fermentum, L. curvatus* and *Tetragenococcus halophilus* are involved in bamboo shoot fermentation. Jeyram et al.(2010) considered fermented bamboo shoots as unique ecological niche wherein a plethora of microorganisms can naturally coexists. The present article highlights the different traditional methods of fermented bamboo shoot production in North-East India and their microbial populations contributing desirable functional and technological attributes.

Fermented bamboo shoots of North-East India

The North-East India comprising of eight states viz., Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Arunachal Pradesh and Tripura is home to different ethnic communities with diverse cultural and religious beliefs. The major communities residing in this region include *Ahom, Bodo, Karbi, Rabha, Bengali* (Assam); *Monpa, Memba, Nishi, Aka, Adi, Apatani* (Arunachal Pradesh); *Meetei, Naga, Kuki, Meetei Pangal, Nepali* (Manipur)*; Khasi, Garo, Jaintia, Gorkha* (Meghalaya);*Angami, Sema, Lotha, Konyak, Ao, Phom, Chakhesang* (Nagaland); *Gorkha, Nepali, Lepcha, Bhutia, Tibetan (*Sikkim)*; Reang, Noatia, Halam, Chakma, Lushai, Bengali* (Tripura) and *Hrangkhol, Lushai, Pawi, Lakher* (Mizoram).The region covering an area of around 18.4 million hectares is considered as a treasure house of bamboos contributing more than 66% of bamboo species of India (Sarmah et al. 2000). People consume fermented bamboo shoots in different forms and indigenous names are assigned to different fermented products based on ethnic communities consuming it, nature of products and their mode of preparation (Table1). Some important traditional fermented shoot popularly consumed are *soibum, soidon, soijim, bastangapani, ekhung, hirring, bastangapani, eup* and *mesu*. The tender shoots of *Bambusa nutans, Bambusa pallida, Bambusa polymorpha, Bambusa balcooa, Bambusa tulda, Bambusa nana, Bambusa arundinacea, Dendrocalamus hamiltonii, Dendrocalamus giganteus, Melocanna bambusoides, Chimonobambusa hookeriana, Teinostachyum wightii* are commonly used for production of fermented bamboo shoots. Traditional fermented bamboo shoot products normally taken by different indigenous people of North-East India are listed in Table1.

Table 1. Traditional fermented bamboo shoot based foods of North-East India

Fermented bamboo shoot	Nature of product	Uses	Community	NE States of India
Mesu	Solid, acidic, sour taste	Use as pickle	*Gorkha*	Sikkim
Soibum	Wet, solid, sour taste	Use in the preparation of special local dish called *Iromba* or cooked with fish and meat	*Meetei*	Manipur

Soidon	Wet, solid, sour taste	Use in making of *Iromba* or consumed as vegetable with fish or meat	*Meetei*	Manipur
Soijim	Liquid, acidic, sour taste	Use as condiment and flavouring agent	*Meetei*	Manipur
Bastangapani	Liquid, acidic, sour taste	Use as condiment and flavouring agent	*Nagas*	Nagaland
Ekhung	Solid, sour and acidic	Use in the preparation of local dishes, curry or soups	*Adi tribe*	Arunachal Pradesh
Iku	Solid, Sour, acidic	Preparation of traditional curry and soup	*Apatani tribe*	Arunachal Pradesh
Hiklu	Sour, acidic	Preparation of traditional dishes	*Apatani tribe*	Arunachal Pradesh
Hirring	Solid, Sour, acidic taste	Preparation of local dishes	*Nishi tribe*	Arunachal Pradesh
Eup	Solid, sour, acidic	Preparation of ethnic dishes	*Nishi*	Arunachal Pradesh
Tuaithar	Wet, solid and sour taste	Use as pickle or in the making of traditional curry	*Baite, Hmar*	Mizoram, Manipur
Tuairoi	Dried, solid and sour	Use in making traditional curry	*Hrankhol, Baite*	Mizoram , Manipur
Miyamikhri	Wet, sour , acidic	Used in the preparation of traditional curry	*Dimasa*	Assam

Soibum

It is one of the most popular fermented foods of Manipur normally sold in almost all local vegetable markets. Tender shoots of *Dendrocalamus hamiltonii, Dendrocalamus giganteus, Bambusa tulda*, *Bambusa balcooa* and *Bambusa pallida* are used to make *soibum*. *Iromba* which is a special delicacy of *Meetei* community is made from *soibum*. It can be classified into four different forms based on different approaches of *soibum* production by communities of different localities (Fig.1). The production of fermented bamboo shoots normally practised in *Kwatha* region of Manipur state involves the use of colocasia leaves or polythene sheets which lined the traditionally designed chamber packed with thinly sliced bamboo shoots. The compactly filled chamber is made airtight by adequately pressing the bamboo shoots while adding and covering of the upper surface. Perforations are provided at the bottom of chamber to facilitate draining of acidic juice released during the fermentation. The whole process of *soibum* production takes around 5-8 months after which the seal is opened to remove the fermented product.

The fermented *soibum* produced in *Kakching* region of Manipur state is highly popular among locals because of their unique aroma and taste. The preparation of *soibum* involves two stages of fermentation process. The collected tender shoots are chopped into fine slices after proper washing in clean tap water and incubated in a big plastic container with water for 7-8 days (Figs. 2a, b & c). The partially fermented bamboo shoots are packed tightly in plastic bags which are kept for another 10-15 days in inverted position (Fig. 2d). The second stage requires the use of specially designed basket of 4-5 feet long, 3-4 feet wide and 4-5 feet high made of bamboo canes. The layer of the basket is completely lined with polythene sheets with perforations at bottom layer and the partially fermented shoots from the plastic bags are loaded into the bamboo basket. The bamboo shoots are packed tightly into the basket by pressing the bamboo shoots while adding, after which the top of basket is covered completely by plastic sheet (Figs. 2e & f). Heavy stones and bricks are placed on the top of plastic cover to provide enough weight for tight packing of bamboo shoots in the chamber (Fig. 2g). Liquid drain out from the perforated bottom layer of

the chamber after 3-4 days of incubation and plastic cover may be removed after 3-4 months when there is reduction in liquid exudation.The fermented shoot product "*soibum*" obtained after completion of fermentation process can be used for domestic consumption or for sale at market (Figs.2h & i). The quality of the bamboo shoots improves considerably when fermentation continues for longer period. The longer the time of incubation, the better is the quality of the fermented bamboo shoot products (Giri and Janmejay 2000). Fermented bamboo shoots preserved in closed chamber for 5-6 years are considered to have the best quality and fetch much higher price as compared to fermented bamboo shoot products preserved for only 6 months to 1 year.

A simpler method practised in *Bishenpur,* another popular place for *soibum* production in Manipur, is the use of a large plastic container which may be lined with a layer of plastic sheets or can be used directly without the use of plastic sheet (Nongdam 2013). The finely chopped fresh bamboo shoots are incubated for 15-20 days in an open plastic tub containing water in aerobic condition (Figs. 3a & b). The bamboo shoots after fermentation are packed in plastic bags tightly and kept turned upside for adequate draining of liquid. The liquid remnants in plastic tub may be repeatedly used as starter culture for next round of *soibum* production as it shortens the fermentation process by 6-7 days. The plastic bags containing the fermented bamboo shoots can be kept for 2-3 months or even longer after which they can be consumed. *Andro* community of Manipur use big earthen pots without bottom perforations which are compactly filled up with chopped pieces of bamboo shoots collected during July and August (Figure 3c). The liquid produced during fermentation is taken out and the decreasing volume is filled up by adding the bamboo shoots externally as the fermentation process continues. *Soibum* is finally formed after 5-6 months of incubation and the quality of fermented products improves with increased duration of incubation. The production of *soibum* in *Andro* is basically for domestic consumption as *soibum* is not produced in large scale unlike in *Kwaktha, Kakching* and *Bishenpur* areas.

Soibum production by tribal people residing in hill districts dig pits to put bamboo basket inside it. The leaves of colocasia plant are placed into the basket to make a layer before the finely shredded bamboo shoots are added. Though plastic sheets can be used instead of colocacia leaves, perforations are made at the bottom layer to drain liquid properly during fermentation. The bamboo basket is filled with shoot pieces and placed inside the pit after closing tightly to avoid aeration. The bamboo shoots are incubated for around 9- 10 days after which the fermented bamboo shoot can be taken out for consumption. The taste, texture and aroma of fermented bamboo shoot increase sharply when incubation time increases to 7-9 months. The fermented *soibum* can be dried under the sun or on top of fire for use in the off season.

Soidon

The *Meetei* community of Manipur consume *soidon/soijin* prepared either from young tender stems of *Teinostachyum wightii* locally known as *naat* or from soft apical shoot portion of *D. hamiltonii, D. giganteus* and *B. tulda.* The stems are collected and hard sheaths are removed to expose the tender apical portion. The shoot tips are submerged in plastic tub containing water after proper cleaning. Sour liquid obtained from the previous batch is added along with leaves of *Garcinia pedunculata* Roxb. before the container is closed and allowed to incubate for about 9-10 days. The addition of liquid exudate and *G. pedunculata* leaves promotes fermentation and adds unique flavour to fermented bamboo shoot product "*soidon*". The incubation period can be increased to about 1 to 1 ½ years to improve aroma, taste and quality of *soidon*. The *naat* based *soidon* is more popular and accepted as fermented food than *soidon* prepared from apical portion of *D. hamiltonii,* and *D. giganteus* due to its better taste and food quality (Fig.3d). The *soidon* is commonly sold in local markets by womenfolk and is either used to prepare popular traditional chattani called "*iromba*" or cooked with fish or other vegetable items (Fig. 3e).

Mesu

The fermented bamboo shoot product is prepared from young tender edible shoots of *Dendrocalamus hamiltonii* and *Bambusa tulda*. The bamboo shoots are chopped into fine pieces after proper cleaning in the clean tap water and packed tightly by pressing them into a green hollow bamboo stem. The chamber is closed tightly with layers of bamboo or leaves of wild plants and allows fermenting under anaerobic conditions for 10-15 days. The whole unit is turned upside down to facilitate the draining of liquid during the fermentation process. The bamboo vessel is opened and the fermented product is taken out as consumed as bamboo pickle. This fermented bamboo shoot pickle is highly popular among locals of Sikkim and Darjeeling and used as pickle.

Fermented bamboo liquid

The sour acidic liquid called "*soijim*" produced during bamboo fermentation can be used as condiment mostly by tribal people of Manipur in the preparation of local curries. In Nagaland, in addition to normal intake of bamboo shoots as a highly popular food, the liquid portion can also be extracted from fermented shoots. This fermented bamboo liquid is locally called *banstangapani* and forms an indispensable part of daily cuisine of Nagas (Nongdam and Tikendra 2014). Liquid portion collected is packed in plastic bottles and sold in local markets (Fig. 3f). Few drops of it are usually added during the preparation of local curries by different Naga tribes of the state. It represents an important cooking ingredient as condiments by imparting a special taste highly relished by locals. In Arunachal Pradesh, the juice drained from fermented bamboo shoots is called *eku* which is popularly used as flavouring agent in cooking meat, fish and vegetables.

Ekung

This is one of the popular traditional bamboo based foods widely consumed in Arunachal Pradesh. Young shoots of *D. hamiltonii*; *Bambusa balcooa* and *B. tulda* are collected and chopped into small pieces after outer sheaths are removed. A pit is dug and bamboo basket containing the sliced bamboo shoots is placed inside the pit. The basket is closed tightly and the pit is covered completely with layers of leaves. Heavy stones and bricks are placed on the leaf surface to provide enough weight so that the liquid exudates released during the fermentation is drained off completely. The fermentation continues for 2-3 months after which the bamboo basket can be opened to take out the fermented shoot product. *Ekung* is consumed raw or cooked with meat, fish or vegetables by *Nyishing* tribe of Arunachal Pradesh.

Eup

The tender bamboo shoots collected from forest areas are shredded into fine pieces after proper washing in clean tap water. The bamboo shoot pieces are packed in bamboo basket. The container with the bamboo shoots is tightly closed and laid into pit dug for the purpose. The pit is covered with leaves and heavy weights are placed on the leaf cover for proper draining of water during fermentation. The whole container is incubated for 2- 3 hours after which the seal can be opened to bring out the fermented shoots. The shoots after removing from the container are again chopped into small pieces and allow to sun dry for another 7-10 days. *Eup* is cooked along with fish, meat and other fresh vegetables to make highly delicious local curries. The product is available in local market throughout the years because they can be preserved for long period by sun drying.

Microbiology of fermented bamboo shoots

The production of traditional fermented bamboo shoot products like *soibum, soidon, soijim, mesu* etc. involves natural process of fermentation by lactic acid bacteria. LAB (Lactic Acid Bacteria) belongs to group of gram positive, non-spore forming acid tolerant, non-motile cocci or rod which produces lactic acid as major end product through carbohydrate fermentation. The microbes involved in the fermentation determine the characteristic of the fermented bamboo shoot (Vogel et al. 2011). Bacterial fermentation of bamboo shoots results in the development of flavor, aroma and characteristic sour taste of the fermented products. Table 2 shows the microbial flora of different fermented bamboo shoots products consumed in different parts of the globe. Tamang and Tamang (2009) studied 44 samples of *ekung, eup* and *hirring* for their functional and technological properties. LABS which were predominantly found in the fermented shoots include *Lactobacillus plantarum, L. brevis, L. casei, L. fermentum, Lactococcus lactis* and *Tetragenococcus halophilus*. The 66 LAB strains isolated from *ekung* and *eup* were identified as *L. plantarum* with the ability of growing in pH 3.9, 6.5 % NaCl at 10% and 15^{o}C. *L. plantarum* showed highest percentage of phytic acid degradation which is an antinutritive factor present in fermented bamboo shoots.

Table 2. Microbial content of some popular traditional fermented bamboo shoot products

Fermented shoot product	Microorganism present	Country	References
Mesu	*Lactobacillus plantarum, Enterococcus faecium, Lactococcus lactis*	India, Nepal	Tamang and Sarkar, 1994; Das and Deka, 2012
Soibum	*Lactobacillus brevis, L. plantarum, Leuconostoc mesenteroides, L. fallax*	India	Sonar and Halami, 2014; Das and Deka, 2012; Tamang et al., 2008
Soidon	*Lactobacillus brevis, L. lactis, L.curvatus, Leuconostoc fallax*		Sonar and Halami, 2014; Das and Deka, 2012; Tamang et al., 2008
Soijim	*Lactobacillus brevis, Leuconostoc lactis, L. fallax, L. mesenteroides*	India	Tamang et al., 2008
Ekung	*Lactobacillus plantarum, L.brevis, L. casei, L. fermentum, Tetragenococcus halophiles*	India	Das and Deka, 2012; Tamang and Tamang., 2009
Heccha	*Lactobacillus plantarum, Leuconostoc sp.*	India	Sonar and Halami, 2014
Eup	*Lactobacillus brevis, L. plantarum, L. xylosus, L. casei, L. fermentum, Leuconostoc mesenteroides, L. fallax*	India	Sonar and Halami, 2014; Tamang et al., 2012; Tamang et al., 2008
Hirring	*Lactobacillus brevis, L. plantarum, L.curvatus, L. lactis*	India	Sonar and Halami, 2014; Das and Deka, 2012; Tamang et al., 2008
Lung-seij	*Lactobacillus brevis, L.curvatus, Leuconostoc mesenteroides, L. fallax, L. lactis, L. citreus*	India	Tamang et al., 2008

Tuaithur	*Lactobacillus brevis, L.curvatus, L.plantarum, Bacillus circulans, B. firmus, B. sphaericus, B. subtilis*	India	Tamang et al., 2012
Soidonmahi	*Bacillus subtilis, B. cereus, B. pumilus, Lactobacillus brevis, L. plantarum, Enterococcus faecium*	India	Jeyram et al., 2010
Tabah bam shoot pickel	*Lactobacillus plantarum, L. brevis*	Indonesia	Darmayanti et al., 2014
Naw-maidong	*Lactobacillus buchneri L.plantarum, L.brevis, L. fermentum*	Thailand	Tanasupawat and Komagata, 1995
Jiang-sun	*Lactobacillus plantarum, Lactococcus lactis, Enterococcus faecium*	Taiwan	Chen et al., 2010

Phytic acid forms an insoluble complex with calcium, zinc, iron and copper interfering their absorption in diets. Sonar and Halami (2014) also reported phytic acid degradation by *L. brevis* in *soidon* and *hirring*. However *L. plantarum, L. fermentum* and *Lactobacillus sp.* isolated from *soidon* did not produce any activities of phytic degradation. Tamang and Sarkar (1996) while investigating the traditional fermented bamboo shoot product called *mesu* of Sikkim and Darjeeling states of India observed the presence of *L. plantarum, L brevis* and *P. pentosaceus*. While *P. pentosaceus* dominated the early stage of fermentation of first 2 days while in later stage of fermentation on 4th day, the load of *L.brevis* reached its highest peak. In the last phase of fermentation, the high acid tolerant *L.plantarum* population was predominantly found as the counts of *P. pentosaceus* and *L. brevis* were dramatically reduced. Similarly, Chen et al. (2010) also reported replacement of various LAB present in *jiang-sun* - a traditional fermented bamboo shoot food of Taiwan by *L.plantarum* after 1 day of fermentation. The 42 cultures isolated from the fermented product were characterized phenotypically and classified into three different groups through the analysis of RFLP markers and sequencing of 16S ribosomal DNA. The result of the study suggested *L. plantarum* as the main LAB present during the fermentation process of *jang-sun*. Darmayanta et al.(2014) also identified *L. plantarum* as dominant LAB in fermented bamboo pickle of Bali, Indonesia through PCR analysis. The LAB load was observed highest on the 4th day of fermentation though the HCN concentration decreases as the fermentation progressed. LAB inhabiting fermented bamboo shoots have the ability to acidify substrate. This ability of LAB in lowering the pH of the substrate is important for effective preservation of food (Brown and Booth, 1991). Tamang and Tamang (2009) found *L. plantarum* from *ekung* as having the lowest acidification values of pH 3.9 among all the bacterial strains tested. Sonar and Halami (2014) also identified strains of *L.plantarum* isolated from *soidon*, *hecche* and *hirring* producing highest acidification (less than 4 pH values) while the lowest (pH 5.78) was observed for *Lactobacilli sp*. of *soidon*. The absence of other pathogenic bacteria in fermented bamboo shoot products might be due to high acidic nature of the foods. The production of lactic acid by LAB inhabiting the fermented food reduce the pH to such level that the pathogenic bacteria if present in the food are either inhibited or killed thus making their survival very difficult (Halzaptel et al.1995). Tamang and Tamang (2009) reported majority of strains of LAB obtained from *ekhung, eup* and *hirring* to be highly tolerant to bile salt. Sonar and Halami (2014) also observed strains of *L. fermentum, L. plantarum*, *L brevis* isolated from *soibum* showing tolerance to 0.5% concentration of bile salt. Tolerance to bile salt is considered an important colonization factor for being a probiotic bacterium (du Toit et al. 1998). The probiotic bacteria should be able to survive while passing through the human gut which is characterized by acidic gastric juices and bile salts (Swain et al. 2014). Another important

property of probiotic bacteria is the ability to proliferate and colonize the digestive tract by adhering to the epithelial surfaces. LAB isolated from *soibum* such as *L. plantarum and L.brevis* exhibited high degree of hydrophobicity (Sonar and Halami 2014). High hydrophobicity is the indication capability of bacterial culture to adhere into the epithelial cell layer of digestive tract for efficient colonization (Holzapfel et al. 2002). Nostro et al. (2004) classified bacterial cultures as hydrophobic if they exhibit percent hydrophobicity greater than 70%. Tamang and Tamang (2009) could not find any LAB strains from *ekung, eup* and *hirring* showing percent hydrophobicity greater than 70% thereby indicating their inability to adhere to the gut epithelial cell surfaces. Jeyram et al. (2010) investigated microbial content of *soidonmahi* a liquid starter for *soidon*- a non-salted acid fermented bamboo shoot food of Manipur. The microbial population distribution of *soidonmahi* was studied by employing amplified ribosomal DNA restriction analysis (ARDRA), 16 rDNA sequencing and randomly amplified DNA and found out to be dominated by *Bacillus cereus* (35.7%), *B. subtilis* (29.3%), *B. pumilus* (2.6%), *Lactobacillus brevis* (9.6%), *L. plantarum* (5.1%) and *Pseudomonas fluorescens* (4.6%). Presence of high load of *B. cereus* in majority of starter cultures studied cause concerned about the biosafety of the *soibum* consumption. Alemu et al.(2006) identified *Enterococcus faecalis* as one of the dominant LABs present in the fermented bamboo shoot item of Thailand on the basis of analysis of physiological and biochemical properties along with16SrRNA sequence study. The *E. faecalis* isolated displayed desirable bacteriocin activity by inhibiting wide range of bacteria including *Leuconostoc mesenteroides* and *Lactobacillus sakei* and other gram positive food spoilage pathogenic bacteria. Rattanachaikunsopon and Phumkhachorn (2000) however reported LAB strains isolated from fermented bamboo shootsof Thailand did not show any bacteriocin activities against *Leuconostoc mesenteroides*.

Conclusion

Fermented bamboo shoots are consumed mainly in North-Eastern part of India where they form an important constituent of many acclaimed ethnic cuisines. The production of fermented bamboo foods is generally traditional and meant largely for local markets in spite of the region being the largest producer of bamboos in the country. Improvement of crude traditional methods by employing modern scientific technologies is the need of hour to upgrade the quality and production of bamboo shoots at commercial scale while keeping intact their unique natural flavour, taste and aroma. There have been limited studies on the technological and functional attributes of different microbial flora present in various ethnic fermented bamboo foods. Extensive investigation on microbial biodiversity is required to understand the safety aspect of the food as there are reports of toxic pathogens in some fermented bamboo shoot products. Improvisation of fermented shoot production with advance scientific inputs combined with detailed studies on microbial biodiversity for their characteristic functional and technological properties will help in accelerating the production of safe fermented bamboo shoots in larger scale.

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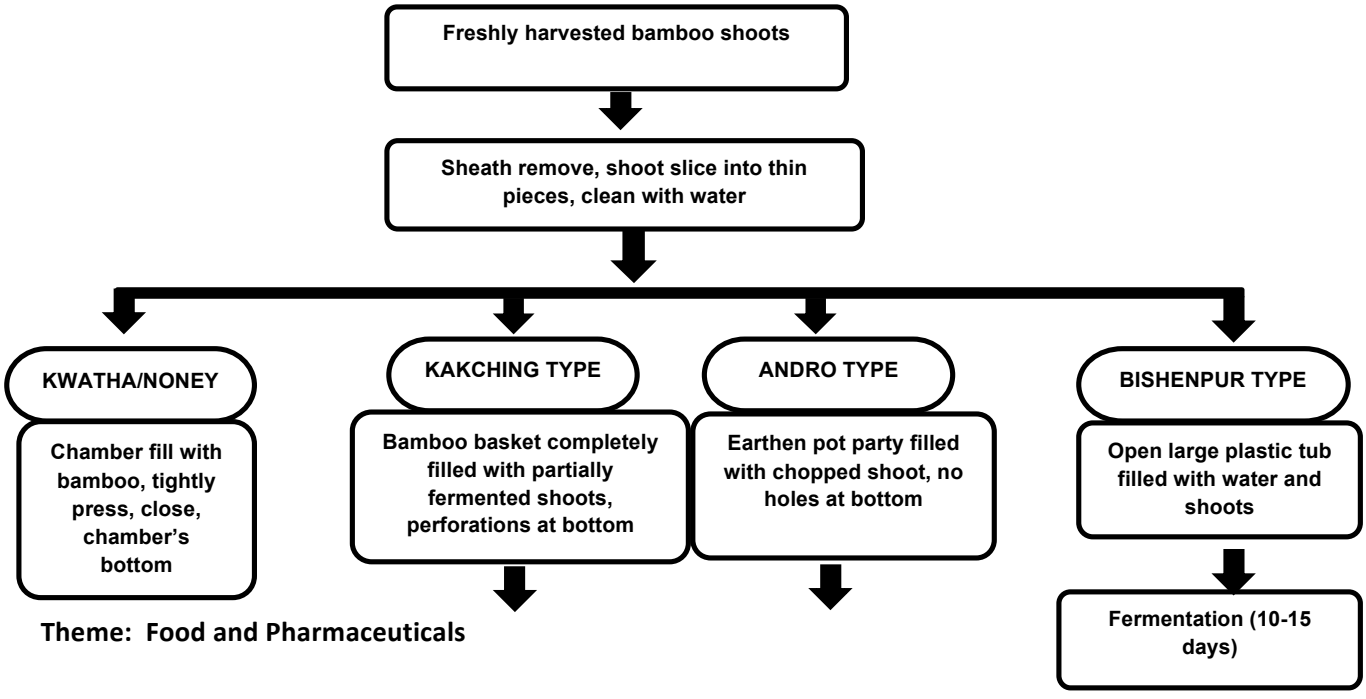

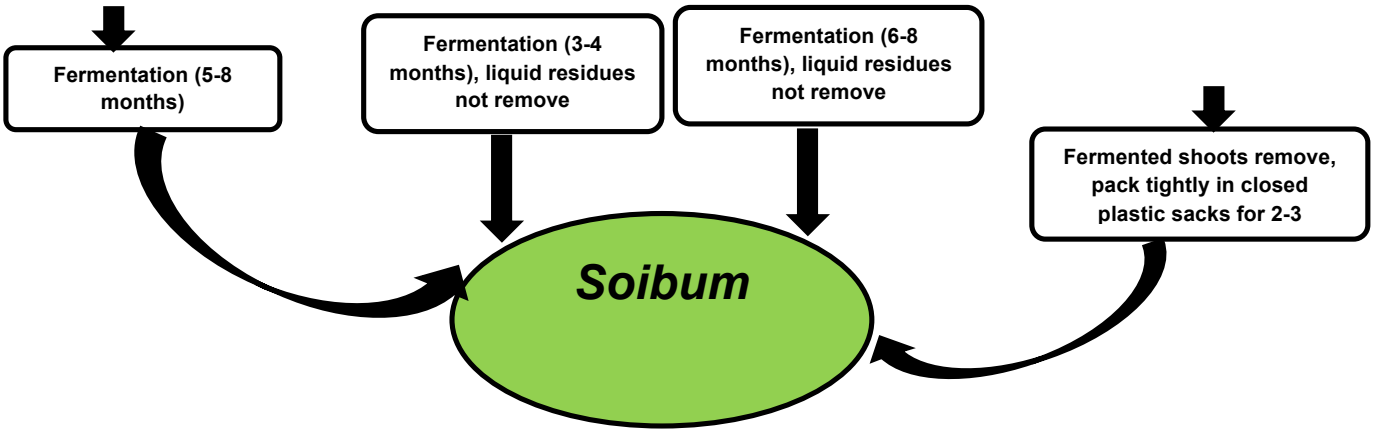

Figure1: Different methods of *soibum* production in Manipur.

Theme: Food and Pharmaceuticals

Figure 2: Traditional method *Kakching soibum* production. a) Fresh bamboo shoots with outer sheaths removed. b) Slicing of tender bamboo shoot into small pieces. c) Bamboo shoot pieces submerged in water in plastic tub and allowed to ferment in open. d) Partially fermented bamboo shoots packed into plastic bags. e) Bamboo shoots from plastic bags put into large bamboo basket. f) Bamboo shoots in the basket are tightly pressed and covered with plastic sheets. g) Bricks and stones placed at the top to put enough weight for sufficient draining of liquid at the perforated bottom layer. h) The cover is open after incubating around 5-6 months. i) The fermented bamboo shoot "*soibum* "being sold in local market.

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Figure 3: Bamboo based local fermented foods. a) Fresh bamboo shoots without hard outer sheaths. b) Shredded bamboo shoots fermented in plastic sheet lined container in *Bishenpur*. c) Earthen pots used in bamboo shoot fermentation in *Andro*. d) Fermented bamboo shoot product "*soidon*".e) The fermented bamboo shoot products sold in local market. f) Fermented bamboo liquid " *bastangapani/soijim/eup.*