

REVIEW PAPER

Indigenous Fermented Food Products of Eastern and Western Himalayan Region: A review

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ABSTRACT

The Indian Himalayan Region includes six Indian states from Jammu and Kashmir to Uttarakhand in the Western Himalayas and Sikkim, Arunachal Pradesh and parts of west Bengal in the Eastern. Due to diverse agroclimatic conditions in these regions, various indigenous fermented foods are prepared. These traditionally prepared fermented foods have been consumed through ancient times. The fermented foods prepared in these regions enrich human diets through development of diverse flavours, aromas and textures in these foods. The fermentation carried out in these products enriches the food substrate with proteins, essential amino acids, essential fatty acids and vitamins. These products also serve as a source of income to the local people and its maximum consumption is considered to be good for health and acts as a remedy for various ailments. In different regions various substrates ranging from cereals, soyabeans, vegetables, meat, fish, bamboo shoots, milk etc are used for the development of traditional fermented foods. The people in these areas also have their traditional starter cultures for the fermentation of raw material. Hence, in the present review different fermented products along with their production technology and starter cultures have been discussed. Further, it would also help the researchers for future refinement of the traditional technologies used by the people of these regions.

Keywords: Himalayan region, fermentation, traditional, fermented foods, Starter cultures

Fermentation is the oldest technique known to the mankind for the preservation of raw food. Not only preservation, fermented foods provide bioactive compounds enhancing the flavour, aroma and exerting health benefits (Darby, 1979; Steinkraus, 1998). Each fermented food is associated with distinctive group of micro-flora which enhances the level of protein vitamins, essential amino acids and fatty acids (Jeyram, *et al.* 2009). Fermentation may also assist in destruction of toxin or detoxification of certain undesirable compounds that may be present in raw food (Sathe *et al.* 2015). In India, fermented food products are as old as 3000 yrs (Steinkraus, 1996). The Rig Veda shows the connection with the fermentation technology, in the preparation of *soma*,

an alcoholic beverage and *sura*, a drink prepared from boiled rice or barley (Sekar *et al.* 2007; Rosma *et al.* 2016; Senapati *et al.* 2016; Ramesh *et al.* 2016). Table 1 shows the different roles of fermentation in food processing. Kumari *et al.* 2018 isolated micorganisms from wild fig fermentation having capacity to produce natural biopreservative.

Traditionally, there are variety of fermented foods that have been prepared and consumed since the ancient times in India like the *dosa*, *idli*, which are fermented foods from legumes and cereal, *kinema* from the eastern Himalayas, *hawaijar* from Manipur, *tungrymbai* from Meghalaya, are made from soya bean, fermented fish like *ngari*, *hentak* from Manipur, etc.

Table 1: Different roles played by fermentation by Steinkraus

Sl. No.	Roles
•	Enrichment of the human dietary through development of a wide diversity of flavours, aromas and textures in food
•	Preservation of substantial amounts of food through lactic acid, alcoholic, acetic acid and alkaline fermentations
•	Enrichment of food substrates biologically with protein, essential amino acids, essential fatty acids and vitamins
•	Detoxification during food fermentation processing
•	Decrease in cooking times and fuel requirements

Source: Steinkraus (1996).

PRODUCTS BASED ON CEREAL AND LEGUMES

Fermented Cereal Based Products

Anarshe: *Anarshe* is a gluten colloid type fermented food and traditionally used by the people of Sikkim and Himalayan India. The golden coloured crumbled snack, *anarshe*, is generally used during Diwali festival and Maharashtra *faral*. The traditional process of *anarshe* preparation starts with cooked polish rice which is used for dough preparation with addition of the starter, *marcha*. The dough is allowed to ferment in airtight conditions at room temperature for 3e4 days. Afterwards, the ripened dough is made into medium thick shaped *puri* and deeply fried into edible oil. The LAB and yeasts like *H. anomala* and *Mucor rouxianus* are the predominant microbes participating in the fermentation of dough (Blandino *et al.* 2003).

Babru: *Babru* is partially fermented rice-based food and is very popular among the people of the Lahaul and Spiti regions in Himachal Pradesh. Rice flour is the main raw material which is made into semisolid paste by adding water (2:1) and kept at room temperature for 3-4 hours for fermentation. The fermented batter is cooked as a flat pancake with edible oil until it becomes spongy. The microbial composition in the *babru* are mainly yeast and LAB, like *S. cerevisiae*, *Debaryomyces* sp., *L. plantarum*, *Lactococcus lactis*, etc. (Tamang *et al.* 2010; Satish *et al.* 2013).

Bhatooru: *Bhatooru* (*sumkeshi roti*, *tungi roti*) is an ethnic leavened bread or *roti* and constitutes the staple diet of rural population of Himachal. It is traditionally prepared by using wheat flour or sometimes barley flour. The inoculum, 'malera' (which mainly consists of lactic acid bacteria and yeasts), along with water is added and kneaded as dough and left for 3–5 h for fermentation. The fermented dough is then made into *roti*, spread on cotton/woollen sheet (*pattu*, etc.) and covered to allow further fermentation, and then baked (Savitri and Bhalla, 2007). The microflora of the fermented dough was found to be mainly dominated by yeast (*Saccharomyces cerevisiae*), lactic acid bacteria (*Lactobacillus plantarum*), and *Bacillus* sp. The gas-producing *Leuconostoc* sp. also appeared at 4 h of fermentation causing leavening of dough (Savitri and Bhalla, 2012).

Seera: It is a popular snack made in Bilaspur, Kangra, Hamirpur, Mandi, and Kullu districts of Himachal Pradesh. In the preparation of *seera*, wheat grains are soaked in water for 2–3 days to allow natural fermentation. After fermentation, grains are ground and steeping is done to allow the starch grains and some proteins to settle down, and then bran is removed. The settled solids are then, sun dried and the dried material is called *seera*. This dried material is made into slurry by soaking in water, which is then poured into hot *ghee*, and sugar is added, cooked, and served as sweet dish/snack. People suffering from jaundice/hepatitis are also given *seera*. It is also used during fast. The microflora isolated from *seera* comprised mainly yeasts (*Saccharomyces cerevisiae*, *Cryptococcus laurentii*, and *Torulaspora delbrueckii*) and bacteria (*Lactobacillus amylovorus*, *Cellulomonas* sp., *Staphylococcus sciuri*, *Weissella cibaria*, *Bacillus* sp., *Leuconostoc* sp. and *Enterobacter sakazakii* (Savitri *et al.* 2012).

Selroti: *Selroti* is very popular ethnic rice-based fermented product consumed with almost every meal by dwellers of hill areas in Himachal Pradesh, Sikkim, Darjeeling of India, Nepal, and Bhutan. The preparation starts with the preparation of the batter using rice and wheat flour, sugar, butter or fresh cream, and spices. It is kept for fermentation

at room temperature for 3-4 hours. After that, it is deep-fried into ring shapes (golden brown in colour) yielding spongy (bread-like) and pretzel like food items. The microbes associated with *selroti* batter fermentation are lactic acid producing microbes like *L. mesenteroides*, *Enterococcus faecium*, *Pediococcus pentosaceus*, and *Lactobacillus curvatus*, *S. cerevisiae*, *Saccharomyces kluyveri*, *D. hansenii*, *Pichia burtonii*, and *Zygosaccharomyces rouxii* (Tamang *et al.* 2010; Yonzan *et al.* 2010).

Sez: Sez is a popular rice-based festive food prepared by Bhotiyas and other communities in Himachal Pradesh. Traditionally, starter (*balam*) is used for sez preparation. *Balam* is prepared with old starter, spices, and different plant parts. Initially, starter is mixed with the cooked rice and kept in an air sealed wooden or earthenware container in a dark and cool place. The anaerobic fermentation takes place for at least 24 hours and semifermented rice is consumed as sez. The fermentation process may involve the saccharolytic and ethanol producing microbes which are responsible for starch to alcohol bioconversion. This is served as snacks with some spicy chutneys (Roy *et al.* 2009).

Sour rice: Sour rice is popularly known as '*poita bhat*' in Assam, '*panta bhat*' in Bengal, and '*pokhalo*' in Odisha, and is generally consumed during lunch and breakfast. The principal raw ingredients are rice and water. Sometimes *dahi* (Indian yogurt), salt, spices, and leafy vegetables are also added to increase taste. The cooked rice is cooled down to room temperature and adequate water is added to it. This watery rice is allowed to ferment overnight at room temperature. The fermented rice with water is consumed along with cooked vegetables/other ingredients. The fermentation is associated with LAB like *Lactobacillus bulgaricus*, *Lactobacillus casei*, *Pediococcus acidilactici*, *S. faecalis*, *Streptococcus thermophilus*, *Microbacterium flavum*, and *Saccharomyces* sp. (Blandino *et al.* 2003; Yonzan *et al.* 2010).

Fermented Soybean based Products

Aakhone: *Aakhone*, also called *axone*, is an ethnic fermented sticky soybean food of Sema Naga in

Nagaland. The preparation is the same as for other fermented soybean foods of northeast India. Soybean seeds are soaked, cooked, and the beans are wrapped in fresh leaves of banana or *Phrynium pubinerve* Blume (Family: Marantaceae) or *Macaranga indica* Wight (Family: Euphorbiaceae), and kept above the fireplace to ferment for 5-7 days. The shelf-life of freshly fermented *aakhone* is a maximum of 1 week. Fresh *aakhone* is molded and made into cakes and dried above the earthen oven (Fig 1 a, b). Sometimes, each fermented bean is separated by hand and dried in the sun for 2-3 days. Dried *aakhone* is stored in containers for future consumption. Pickle is made from freshly fermented *aakhone* by mixing with green chilli, tomato, and salt. The dried *aakhone* cakes are cooked with pork and are eaten as a side dish with steamed rice by Sema (Tamang, 2015).



Fig. 1 (a): Dried *aakhone* Cakes



Fig. (b): Dried *aakhone* pieces

Bekang: *Bekang* is an ethnic fermented soybean food commonly consumed by Mizo tribe in Mizoram. During the traditional method of preparation, small-sized, dry seeds of soybean are collected, cleaned, and soaked in water for 10-12 hours. Excess water is removed and beans are boiled for 2-3 hours in an open cooker until the beans become soft. Excess water is drained off and wrapped in fresh leaves of *Calliparpa aroria* (Family: Verbanaceae), locally called "*nuhlhan*", or in leaves of *Phrynium* sp. (Family: Merantaceae), locally known as "*hnahtial*". The wrapped beans are kept inside a small bamboo basket and placed near the earthen oven or in a warm place and is allowed to ferment naturally for 3-4 days. Sticky soybean with an emission of ammonia odour is produced. *Bekang* is consumed as it is, or made into curry with the addition of salt, green chillies, and

tomatoes. It is consumed as a side dish with steamed rice (Tamang, 2015).

Hawaijar: *Hawaijar* is a traditionally alkaline fermentation of soybeans. In the traditional method of preparation, the soybean seeds are soaked overnight. They are then, washed thoroughly with water and are boiled well in a pressure cooker or a pot till the seeds became soft, washed with hot water and packed tightly in a small bamboo basket with lid and a base, called 'lubak' with a base layer of *Ficus hispida* (local name: ashee heibong) plant leaves. Since these leaves are mainly used for *hawaijar* preparation they are also known as "*hawaijar mana*" (*hawaijar* leaves). Instead of using *Ficus hispida* leaves, the boiled and washed seeds can also be wrapped with a clean cotton cloth. The box is then wrapped with a jute cloth and kept in the sun or buried in paddy. This is to maintain the optimal temperature (> 40°C) required for *hawaijar* fermentation. The palatable stage of fermented soybean is noticed in 3-5 days. After fermentation, the soybeans develop a brown colour, a sticky texture and a distinctive fermented odour and taste. The fermented product is then wrapped with banana (*Musa* sp.) leaves. Polyethylene bags are not used for packing *hawaijar* (Premarani *et al.* 2010). Pictorial representation of traditional alkaline fermented soyabean product (Fig. 2 a, b and c).

Hakhumata: *Hakhumata* is a fermented soyabean food popular among the Mao-Naga tribe of Manipur. Chaff and inert matter are removed from soybean seeds by putting in water and properly dried in

partial shade and boiled in water for about half an hour. When the seeds become soft, water is drained out using the bamboo made sieve. Then, seeds are spread on the cotton cloth in partial shade for cooling and drying. The dried seeds are wrapped in banana leaves and packet is made with bamboo rope and hung above the fireplace in kitchen in completely dark condition to initiate fermentation. Fermentation takes place in about 15-20 days in winter and 5-7 days in summer. When the leaf of banana becomes completely wrinkled, it indicates that fermentation of soybean seeds is complete. The seeds are taken out from leaves and roasted with salt without any oil. These seeds are again packed in fresh banana leaves and stacked over the shelf near smoke in kitchen. After 3-5 days this is ready to eat and sale (Singh *et al.* 2007b).

Kinema: *Kinema* is an ethnic fermented soybean food of the Nepali community in the Eastern Himalayas. It is a sticky, slightly alkaline product with a slight ammoniacal flavour that is produced by natural fermentation. It is a whole-soybean fermented food with a sticky texture, grey tan colour, and is flavoursome. During traditional production of *kinema*, the small-sized (~6 mm) "yellow cultivar" soybean dry seeds are selected, washed, and soaked overnight (8-10 h) in water. Soaked soybean seeds are taken out and put into a container with fresh water, and boiled for 2-3 hours until they are soft. Excess water is drained off and the cooked soybean seeds are placed into a wooden mortar (locally called



Fig. 2 (a): Hawaijar



Fig. (b): Packaging of hawaijar in banana leaf for fermentation



Fig. (c): On right: utensil for boiling soybean on left: soybean before and after boiling, leaching of water is done on bamboo container (which do not have holes) called thumok

“okhli”) and are cracked lightly using a wooden pestle (locally called “muslo”) to split the cotyledons. This practice of cracking the cooked seeds of soybeans is observed only during kinema production, unlike other similar fermented soybean foods of Asia and north-east India, probably to increase the surface area for speeded fermentation by aerobic spore-forming *Bacillus* spp. Approximately 1% of firewood ash is added directly to the cooked soybeans and mixed thoroughly to maintain the alkaline condition of the product. Soybean grits are placed in a bamboo basket lined with locally grown fresh fern called (*Glaphylopteriolopsis erubescens*). The basket is covered for 1-3 days above an earthen kitchen oven. During summer, the fermentation time may require 1-2 days whereas in winter it may require 2-3 days. In eastern Nepal, local consumers prepare dark brown local varieties of soybean seeds rather than yellow-coloured seeds for making *kinema*. Similarly, they commonly use *Ficus* (fig plant) and banana leaves as wrapping materials instead of fern fronds. Other methods remain the same. Completion of fermentation is indicated by the appearance of a white viscous mass on the soybean seeds and the typical kinema flavour with a slight odour of ammonia. The shelf-life of freshly prepared kinema is 2-3 days in summer and a maximum of 1 week in winter without refrigeration (Tamang, 2015).

Peruyaana: *Peruyaana* is an ethnic fermented soybean food of *Apatani* tribes in Arunachal Pradesh. The word “*peruyaana*” has been derived from the *Apatani* dialect “*perun*” means beans and “*yannii*” means packing in leaves. During the traditional preparation, soybean seeds are collected, washed, and cooked for 2-3 hours until the beans become soft. The excess water is drained off and is cooled for some time and are kept in a bamboo basket (vessel) lined with fresh ginger leaves, locally called “*taki yannii*”. The basket is loosely covered with ginger leaves and is kept on the wooden rack above the fireplace for fermentation for 3-5 days. The stickiness of the product is checked, and if the product is considered sticky enough then it is ready for consumption. *Peruyaana* is consumed mostly as a side dish with steamed rice by the *Apatani* tribes in Arunachal Pradesh. It is mixed with

hot water, chillies locally called “*tero*”, and salt, and directly consumed without frying or cooking, unlike *kinema* curry preparation (Tamang, 2015).

Tungrymbai: *Tungrymbai* is an ethnic fermented soybean food of Khasi and Garo in Meghalaya. Soybean seeds are collected, cleaned, washed, and soaked in water for approximately 4-6 hours. The seed coat of the soybean is normally removed before cooking by rubbing the soaked seeds gently. The soaked soybeans are cooked for about 1-2 hours until all the water is absorbed. Cooked beans are allowed to cool, and then they are packed with fresh leaves of *Clinogyne dichotoma* (locally called “*lamet*”), placed inside a bamboo basket, and covered with a thick cloth. The covered basket is kept over the fireplace and fermented naturally for 3-5 days to obtain *tungrymbai*. *Tungrymbai* is mashed and put into a container with water and boiled until the water evaporates with continuous stirring. It is mixed with fried onion, garlic, ginger, chilli, ground black sesame (locally called “*til*”), and salt. A thick curry is made and is served as a side dish with steamed rice by Khasi in Meghalaya. Pickle is also made from *tungrymbai*. Khasi women are commonly seen selling *tungrymbai* packed in fresh leaves of “*lamet*” or banana at the vegetable markets of Shillong (Tamang, 2015).

Fermented Vegetable based Products

Ankamthu: *Ankamthu* is prepared by the people of Churhandpur district of Manipur from leaves extract of mustard green *Brassica juncea*, *Brassica campestris*. During peak season the leaves are plucked in bulk, clean and washed in tap water and then spread over bamboo mat (locally called *pheh*) and wilted in the sun. The wilted leaves are then crushed in a traditional wooden crusher. The mesh was then kept in an air tight fermentation basket made of bamboo with a lid. The exudates or the leaves extract was squeezed and collected in a pot and boiled till the extract become condensed. The extract is then transferred to a hollow bamboo container and the mouth is tightened and kept near the fire or under the sun to undergo further fermentation for three to five days. This fermented mustard green extracted is

called *Ankamthu* (Hoikhokim, 2017). The complete flow sheet for the production of *Ankamthu* has been depicted in Fig. 3.

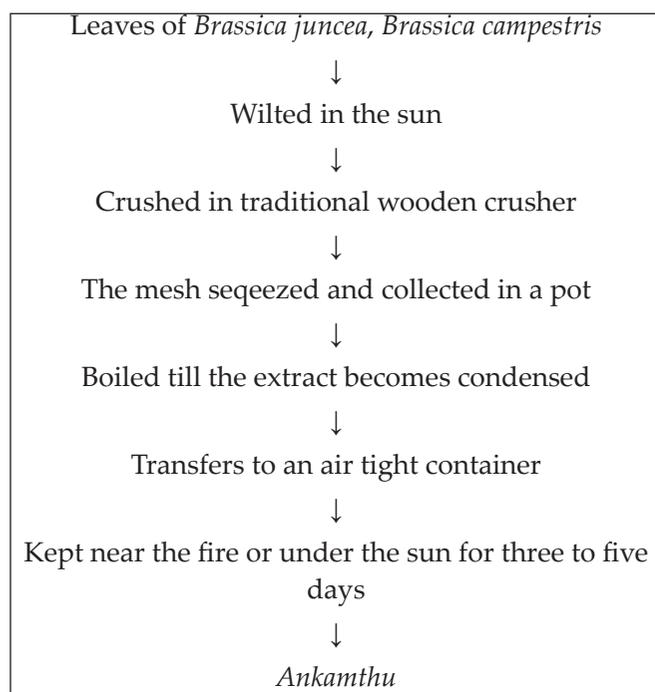


Fig. 3: Flow sheet for the production of *Ankamthu* (Source: Hoikhokim, 2017)

Gundruk: *Gundruk* is an ethnic fermented vegetable of the Gorkha in India. *Gundruk* is prepared from fresh leaves of local vegetable called rayo - sag (*Brassicca rapa* subspecies *campestris* variety *cuneifolia*), mustard, and cauliflower which are wilted and shredded, crushed mildly, and pressed into an earthen jar or container, which is made airtight. The container is kept in a warm place and allowed to ferment naturally for about 7–10 days. Unlike, kimchi and sauerkraut, freshly fermented *gundruk* is sun dried for 3–4 days before consumption, and dried *gundruk* is preserved for more than 2 years at room temperature. *Gundruk* is eaten as a soup or pickle. *Lb. fermentum*, *Lb. plantarum*, *Lb. casei*, *Lb. casei* subsp. *pseudoplantarum*, and *P. pentosaceus* have been isolated from *gundruk* (Tamang *et al.* 2005).

Inziangsang or ziangsang: *Inziangsang* or *ziangsang* is an ethnic fermented leafy vegetable product of Naga living in Nagaland and Manipur. It is very

similar to *gundruk*. Leaves of mustard locally called *hangam* are crushed and soaked in warm water. Leaves are then squeezed to remove excess water and put into airtight container and fermented at room temperature for 7–10 days. Like *gundruk*, freshly prepared *inziangsang* is sun dried for 4–5 days and stored in a closed container. Freshly fermented *inziangsang* juice is also extracted, instead of sun drying, by squeezing with hand and concentrated by boiling. The liquid form of fermented extract is called *ziang dui* and the concentrated paste is *ziang sang* (Tamang and Tamang 2009). It is consumed as soup. Fermented extract *ziang dui* is used as condiment. *Lb. plantarum*, *Lb.brevis*, and *Pediococcus acidilactici* were isolated from *inziangsang* (Tamang *et al.* 2005).

Khalpi: *Khalpi* is an ethnic fermented cucumber product of Sikkim and Darjeeling hills. During its preparation, ripened cucumber is cut into pieces and sun dried for 2 days and then put into a closed bamboo vessel and fermented naturally at room temperature for 3–5 days. *Khalpi* is consumed as pickle. *Leuc. fallax*, *P. pentosaceus*, *Lb. brevis*, and *Lb. plantarum* are the dominant LAB in *khalpi* fermentation (Tamang *et al.* 2005).

Kharoli: *Kharoliis* fermented food product prepared from mustard seeds (*Brassica campestris*) by the Assamese community. The raw materials include black mustard seeds, earthen pot, cover plate, and grinder. First, mustard seeds are washed and dried. They are then grinded in *dheki* (traditional grinder). The grinded mustard seeds are then transferred to '*koloh*' or earthen pot. If the pot is new, it is hardened by burning it in furnace, and locally made alkali called *khar* is added to this mixture. Then, the mixture is pressed properly and its mouth is covered by a plate and left for 15 days for fermentation in the kitchen. *Kharoli* can now be taken out and cooked as condiment and eaten as a side dish with rice (Narzary *et al.* 2016).

Mula Gundru: *Mula gundru* is a vegetable-based semifermented food prepared by the Bodo tribe. It is prepared from radish tap root. Radish roots are first cut into small pieces and then sun dried till they become smaller in size. The dried radish root pieces

are then stored in containers and kept in bamboo racks in kitchen. This product is used with black gram (*Phaseolus mungo* L.), potato curries etc. to add up the flavour and aroma of the food (Narzary *et al.* 2016).

Narzi: *Narzi* is a semifermented food product prepared from jute leaves (*Corchorus capsularis*). For the processing of narzi, jute leaves are first sundried for 6-7 days and then stored by keeping in poly bags. *Narzi* plays a significant role in the life and culture of the Bodo tribe where one of its surnames Narzary is derived from this food product. It is also regarded as a purifier and is offered to the people coming from funeral. The curry prepared from it is bitter in taste. The bitterness is removed by boiling and adding *khardwi* (locally prepared alkali) while cooking (Narzary *et al.* 2016).

Rai: *Rai* is a fermented food made from the seeds of the *Brassica juncea* made by the Bhutia tribe of the Sikkim, India. It is prepared by taking appropriate amount of the seeds, then washing and boiling in water. The lukewarm seeds are kept in an earthen pot and pressed with stone to keep it airtight and is left for 2-3 months for fermentation (Singh *et al.* 2007).

Shithu: *Shithu* is an ethnic fermented food prepared by the people of Churachandpur district of the state of Manipur. A seed of *Sesamum indicum* (black seed varieties) is fried without oil, till it produces charismatic smell. It is then, pounded into powder by using traditional wooden crusher. The paste is then mixed with water to make a sticky colloid and then put inside an air tight container and place near the fire for five days to undergo fermentation. This fermented *Sesamum indicum* seed is called *Shithu* by the people of Churachandpur (Hoi Kho Kim, 2015).

Sinki: It is a non-salted fermented radish tap root of the Gorkha (Tamang, 2005) and Gurung tribe of Sikkim prepared by fermentation in a 1m deep pit which is plastered with mud and warmed by burning (Tamang, 2005; Singh, 2014; Tamang and Tamang, 2009b). It is prepared by washing of radish, cut into small pieces and dried under sunlight in naaglo (local utensil made of bamboo for winnowing

the grains) for 3-4 days. Dried pieces are packed in polythene and placed inside a pit. The pit is covered with cow dung and soil paste and left for over 15 days for fermentation (Singh, 2014). Microorganisms observed were as *Lactobacillus fermentum*, *L. brevis* and *L. plantarum* (Tamang, 1993). It has an acidic flavour, mostly and used for soup and pickle (Tamang and Tamang, 2009b).

Fermented Fish based Products

Ngari: *Ngari* is a fermented fish product prepared locally by the people of Manipur. Sun dried, non-salted dry fish called Phoubu (*Puntius sopore*) is collected and different grades/sizes are mixed together and stored in gunny bags as dried form. Before fermentation, it is washed with water using porous bamboo-based baskets and allowed to drain the water for one night. Next day morning, pressed by legs using gunny bags excess water is removed by breaking the head and bones. Oil released from head during pressing is believed to cause fermentation. The inner side of the earthen pot called *ngarikharung* (Fig. 4 a and b) is lined with mustard oil. For new pots, 8-10 times oil coating are required with interval of 7-10 days. In old pots, only one coat is sufficient for quality fermentation. Oil coating might be creating anaerobic environment inside the chamber. Above, pressed dry fish is packed tightly inside the pot by pressing legs. After packing, pots are sealed with polythene sheet, fish scales, oil slurry, mud and cow dung slurry. These packed pots are kept in dark up to 6-12 months at room temperature. The microbial composition of *ngari* includes bacteria (*L. lactis* subsp. *cremoris*, *L. plantarum*, *E. faecium*, *L. fructosus*, *L. amylophilus*, *L. coryniformis* sub sp. *Torquens*, *L. plantarum*, *B. subtilis*, *B. pumilus*, and *Micrococcus*) and yeasts (species of *Candida* and *Saccharomyces*) (Jeyram *et al.* 2009).

Hentak: *Hentak* is a traditional fermented fish paste prepared by the Manipur people. During indigenous preparation process, the sun dried *Esomus danricus* are crushed to powder (Fig. 5 a, b and c). The petioles of *Alocassia macrorrhiza* are cut into pieces washed with water and exposed to sunlight for an hour. An equal



Fig. 4 (a): Ngari

weight of the cut pieces is then crushed along with fish powder to make a paste. Small balls are prepared and put in earthen pots and stored. After two weeks of fermentation, it is ready to use and are preserved. These become hardened on keeping for few months and are then propounded to paste with a little water and stored as balls for reserve food (Jeyram *et al.* 2009)

Napham: *Napham* is a fermented fish-based product prepared mostly by the Bodo tribe of Assam state and one of their very important and favourite dishes. The raw materials used in the preparation of *napham* are dried fish, tender shoots of Arum (*Colocasia esculanta*), hollow cylinder of matured *Bambusa balcoa* stem, clay paste, and straw. Small fishes are first gutted, cleaned, and then dried in sun for about 2 hours till the water is completely drained off. The dried fishes are then smoked under low flame by burning dry chaff of rice grains till they are fully dried. These dried fishes are then grounded with the help of mortar and pestle known as uwal and gaihen in local Bodo dialect. At the time of grounding, the stems of Arum are also added. There is a tradition of adding chilly in this mixture to remove bad omen, according to the Bodo folklore. After the mixture is ready, it is transferred to a container made of hollow bamboo stem that is open from one side.

The fish paste is then covered with dry banana (*Musa*) leaves, and the opening of the bamboo container is



Fig. 4 (b): Ngarikharung

sealed with clay paste prepared by mixing with straw. It is sealed tightly to ensure anaerobic condition, and the whole preparation is then, kept for 2-3 months for fermentation. After this aging time, *napham* is ready to be cooked and eaten as condiment with *Colocasia* stems, leaves of *Hibiscus sabdariffa*, and also as soups (Narzary *et al.* 2016).

Nakham: *Nakham* is a fermented fish product prepared by the Garo community of Meghalaya. The raw materials used for its preparation include dry fish, a locally prepared alkali called *khar*, dry hollow bamboo stems or jars. In this method, *khar* is added to the grounded dry fish instead of *Colocasia* stem, and the whole preparation is kept inside the bamboo as is done in the preparation of *napham* or in jars. Fermentation time is about 1 week to 1 month as stated by the local Garo people (Narzary *et al.* 2016).

Shidal: *Shidal* is non-salted and semifermented ethnic fish product of Tripura prepared using minor carp (*Puntius* spp.) in specially designed earthen pots. It has several local names such as *seedal*, *seepa*, *hidol*, and *shidol* in Assam, Tripura, Arunachal Pradesh, and Nagaland. During preparation of *shidal*, *Puntius* spp. are sundried, placed in vats/earthen pots and fermented naturally for 4-6 months under anaerobic condition until the product gains a characteristic odour, texture, and appearance. *Shidal* is a delicacy for most of the tribal, Bengali, and other people of Tripura for its characteristic taste and flavour.



Fig. 5. (a) Drying of *Esomus danricus* for preparation of hentak



Fig. 5 (b): hentak



Fig. 5 (c): Petioles of *Alocassia macrorrhiza*

Staphylococcus aureus, *Micrococcus* spp., *Bacillus* spp., and *Escherichia coli* were isolated from shidal (Thapa 2016).

Tungtap: *Tungtap* is an ethnic fermented fish paste of the *Khasi* in Meghalaya. Sun-dried fish (*Danio* spp.) are washed briefly, and mixed with salt. The sun-dried fish are kept in the earthen pot, made airtight, and fermented for 4-7 days. It is consumed as pickle and curry. Bacteria (*L. lactis* subsp. *cremoris*, *L. plantarum*, *E. faecium*, *L. fructosus*, *L. amylophilus*, *L. coryniformis* subsp. *Torquens*, *L. plantarum*, *L. puhozihi*, *B. subtilis*, *B. pumilus*, and *Micrococcus*) and yeasts (*Candida* and *Saccharomycopsis*) have to be present in *tungtap* (Thapa, 2016).

Crab: It is one of the favourite items of several tribes, such as Lotha, Mao, Angami, of the Naga tribes of India. Crabs are washed, hard appendages and entrails are removed, ground and mixed with ground black sesame (*Sesamum orientale* L.). after mixing is properly done, it is wrapped in banana leaf (*Macaranga indica* or *Phrynium pubinerve*) and kept over the fireplace in the typical Naga kitchen for a week to ferment. On opening the wrapped banana leaf, it gives a strong inherent smell, and is ready for use in cooking or chutney preparation. (Mao *et al.* 2007).

Fermented Meat based Products

Honoheingrain: *Honoheingrain* is an ethnic fermented pork or boar (wild pig) product consumed by Dimasa tribe of North Cachar Hills of Assam (Chakrabarty

et al. 2014). Freshly killed wild boar/hog (*Sus scrofa* L.) is collected and the upper skin along with its hair is removed with a knife and washed thoroughly and dipped into boiled water for a few minutes to remove excess hair. It is then cut into several small pieces, kept in a bamboo mat above the kitchen oven which is about 2–3 ft above the fireplace, and allow to fermented naturally for 4–5 days till it completely dries. Microbial diversity in *honohein* grain includes *Lb. brevis*, *Lb. plantarum*, *Leuc. mesenteroides*, *Ent. faecium*, *Bacillus cereus*, *B. pumilus*, *B. firmus*, *B. circulans*, *B. stearothermophilus*, *Micrococcus*, and *Staphylococcus* and yeasts *Debaryomyces hansenii* and *Saccharomyces cerevisiae* (Chakrabarty *et al.* 2014).

Jamma or geema/ juma: *Jamma* or *geema/ juma* is an ethnic fermented sausage of the Western Himalayas prepared from chevon meat. Red meat is chopped into fine pieces and mixed with 1% ground finger millet (*Eleusine coracana*), 0.5% wild pepper locally called “timbur” (*Zanthoxylum* sp.), 0.5% chili powder, and salt (Rai *et al.* 2009). A little fresh animal blood is also added. The meat mixture is made semiliquid by the addition of water and is poured into the small intestine of the goat with the help of funnel. Both ends of the filled intestine are tied, and then it is pricked randomly to prevent bursting while boiling. After boiling for 15–20 min, the stuffed intestine is smoked above earthen oven in the kitchen for 15–20 days if they are not eaten immediately after boiling. The method of preparation of *jamma* is similar to *kargyong* of the Eastern Himalayas (Rai *et al.* 2009). It is eaten as cooked sausage or as a curry component. Lactic acid

bacteria from *jamma* were identified as *Enterococcus durans*, *E. faecalis*, *E. faecium*, *E. hirae*, *Leuconostoc citreum*, *Leu. mesenteroides*, *Pediococcus pentosaceus*, and *Weissellacibaria* (Oki *et al.* 2011).

Kargyong: *Kargyong* is a sausage-like meat product of Sikkim and Arunachal Pradesh prepared from meat. Meat (yak/beef/pork) with its fat is chopped finely; combined with crushed garlic, ginger, and salt; and mixed with water. The mixture is stuffed into the segment of gastrointestinal tract locally called “gyuma” used as natural casings. One end of the casing is tied up with rope, and other end is sealed after stuffing and boiled for 20–30 min. Cooked sausages are taken out and hung in the bamboo stripes above the kitchen oven for smoking and drying for 10–15 days to make *kargyong* (Rai *et al.* 2009). *Kargyong* is eaten after boiling for 10–15 min, sliced and made into curry or fried sausage. Bacteria from *Kargyong* were identified as *Lb. sake*, *Lb. divergens*, *Lb. carnis*, *Lb. sanfransisco*, *Lb. curvatus*, *Leuc. mesenteroides*, *E. faecium*, *Bacillus subtilis*, *B. mycoides*, *B. thuringiensis*, *Staphylococcus aureus*, and *Micrococcus* and yeasts *Debaryomyces hansenii* and *Pichia anomala* (Rai *et al.* 2010a).

Saphak/ sathu: It is a form of fermented pork fat and is called as *saphak* and *sathu* by the Hrangkol, the Vaipei tribes respectively, residing in the north Cachar Hills District of Assam. The fats of pork are first washed and cut into small pieces. These are half boiled in water for about 15 to 20 minutes. The Hrangkol tribe keep these fats in air tight containers for 10 to 15 days after which they are consumed. The Vaipei tribe carry out the fermentation process inside containers made dried gourd cover called as *sathu-um*, by capping the mouth of the container air tight. The gourd is kept near the fire place for a period of 4 to 5 days. The fermented product can be stored for up to a year. These are consumed as pickle or as complement with other cuisine (Chakrabarty *et al.* 2009).

Fermented Bamboo Shoot based Products

Ekung: *Ekung* is an ethnic fermented bamboo shoot product of India, prepared in Arunachal Pradesh. A pit of about 3–4 ft is dug in the forest, bamboo baskets are laid into the pit and lined with leaves,

and chopped bamboo shoot pieces are put into the basket. When the basket is full, it is covered with leaves and then sealed. Heavy stones are kept to give weight to drain excess water from the bamboo shoots and fermented for 1–3 months. It can be kept for a year in an airtight container at room temperature. It is consumed raw or is cooked with meat, fish, and vegetables. *Lb. plantarum*, *Lb. brevis*, *Lb. casei*, and *Tetragenococcus halophilus* were isolated from *ekung*. (Tamang and Tamang, 2009).

Eup: *Eup* is a dry fermented bamboo tender shoot food commonly prepared and consumed by different tribes of Arunachal Pradesh (Tamang, 2010a). Bamboo shoots are chopped into small pieces and fermented in similar manner as in *ekung*. Fermentation is completed within 1–3 months. After fermentation, the fermented product, now, *eup*, is again cut into smaller pieces and then sun dried for 5–10 days until its colour changes from whitish to chocolate brown. *Eup* is consumed as a side dish with steamed rice, meat, fish or vegetables. *Lb. plantarum* and *Lb. fermentum* were isolated from *eup*. (Tamang and Tamang, 2009).

Hirring: *Hirring* is a fermented topmost whole bamboo shoot product, commonly prepared in Arunachal Pradesh of India. Outer leaf sheaths of tender bamboo shoots are removed. The topmost tender edible portions are either cut longitudinally into two to three pieces or whole shoots are flattened by crushing and are put into bamboo baskets lined with leaves. The baskets are placed into the pit, covered with leaves, sealed, and weighted down with heavy stones, and its contents are fermented for 1–3 months. Baskets are taken out from pits after the fermentation, and *hirring* is ready for consumption. *Hirring* is kept for 2–3 months at room temperature. *Lb. plantarum* and *Lc. lactis* are the functional LAB in *hirring* (Tamang and Tamang, 2009).

Lung -seij: It is an ethnic fermented bamboo shoot product popularly produced mainly by the Khasi women of Meghalaya, India. It is prepared from *Dendrocalamus hamiltonii* species of bamboo available locally in Meghalaya. The tender bamboo shoots of

about 0.5 meters in length are selected and cut from the bamboo grooves. The bracts and sheaths are removed and then they are washed thoroughly with water, cleaned and the shoots are sliced into small pieces. These are then pressed either into bamboo cylinders or glass bottles. Lactic acid bacteria have been found to be present in the fermented product (Tamang and Tamang, 2009a). The bamboo cylinders used for fermentation are made by cutting one side open and the other side closed with the node. They are filled with the sliced shoots to the full capacity and the open side is closed with dried leaves and sealed by tying the rim with thread or grass. Care is taken to prevent the accidental seepage of water into the cylinder which makes the product black and unfit for consumption. These cylinders are then immersed in streams for a period of 1-2 months for fermentation to take place. The water in which the cylinders are kept should be cold; otherwise it is thought proper fermentation does not take place. This process is preferred more by the farmers and the rural people. This product can be stored up to 1 to 2 months. In case when glass bottles are used, the sliced bamboo shoots are filled inside the bottle and water is added till all the shoots are submerged. The bottle is then capped and kept at room temperature or near the fire place for fermentation. The shoots in the bottle can be kept up to 1 year. This process is preferred more by the urban people. It is consumed as a curry by mixing with meat or fish (Tamang and Tamang, 2009a).

Soibum: *Soibum*, an indigenous fermented food, prepared in Manipur state of India. It is

exclusively prepared from succulent bamboo shoots (*Dendrocalamus hamiltonii* (Wanap/Unap/Pecha), *D. sikkimensis* and *D. giganteus* (Maribop), *Melocana bambusoide* (Moubi/Muli), *Bambusa tulda* (Utang), *B. vulgaris*, *B. balcooa* (Ching Saneibi) and *B. pallia* is consumed. In the traditional method, succulent bamboo shoot sprouts are defoliated, chopped, pressed tightly into the wooden or earthen pots to ferment for 6-12 months (Fig 6 a, b and c) (Jeyram *et al.* 2009)

Soidon: *Soidon* is prepared from *Teinostachyum wightii* (Nath) apical meristem by the people of Manipur. The unwanted portions are removed and cut transversely into pieces. Milky fermented soup of previous batch (1:1 dilution) is used as a starter for fermentation. This submerged fermentation in open plastic container is prolonged up to 5 days with intermittent stirring. In some cases, addition of *Garcinia pendunculata* (locally called *Heibung*) as an acidifier had given the best quality products. Addition of rice washed water (Chenghi) in the ratio 1:10 improved the colour of soidon. The difference between Soibum and soidon is that Soibum is complete fermentation whereas soidon is partially fermented (Jeyram *et al.* 2009).

Mesu: It is bamboo shoot derived fermented food prepared by people of Himalayan regions of Darjeeling hills and Sikkim (Nehal, 2013). The months of June to September are suitable for the preparation of *mesu* when Bamboo shoots sprout. Locally available species of bamboo are used such



Fig. 6 (a): bamboo shoot for making of soibum



Fig. 6 (b): Cleaned bamboo shoot



Fig. 6 (c): Soibum

as *choya bans* (*Dendrocalamus hamiltonii* Nees and Arnott), *bhalu bans* (*D. sikkimensis* Gamble) and *karati bans* (*Bambusatulda* Roxb) (Tamang and Sarkar, 1996) which are defoliated, chopped and pressed tightly into a green bamboo hollow stem, the tip of stem is covered tightly with leaves and left to ferment for 7-15 days. The microflora of Mesu is mainly *Lactobacillus plantarum*, *L. brevis* and *L. pentosaceus*. Mesu is mostly consumed as pickle (Sekar and Mariappan, 2007; Tamang and Sarkar, 1996; Tamang and Tamang, 2009a; Tamang and Tamang, 2009b).

Miya mecheng: *Miya mecheng* is fermented product prepared by the Garo population from young bamboo shoots (*Bambusa balcoa*, *B. tulda*, and *B. vulgaris*). The raw materials consist of bamboo shoots and jar. First, the bamboo shoots are peeled, washed, and cut into small pieces. The pieces are then transferred into jars or containers with a small amount of water sprinkled over them, and the whole preparation is allowed to ferment for 5-6 days (Narzary *et al.* 2016).

Khoricha: *Khoricha* is a fermented bamboo shoot product prepared by the Assamese community. First, the bamboo shoots are washed properly, peeled, and then grinded. This *grinded* material is kept in earthen pots called *koloh*. Some amount of water is added to it, and the mouth of earthen pot is covered with banana leaves and kept for 6-7 days for fermentation. This pot is kept in bamboo racks inside the kitchen. Another method of preparing *khoriga* is by transferring the *grinded* bamboo shoots in hollow bamboo cylinder with the mouth closed with a piece of wood or piece of bamboo itself, which is then kept under a pond or spring safely for 6-7 days for fermentation. In the due course of time, fermentation gets completed, and it is ready to be used as food. For dry *khoriga*, the fermented bamboo shoots are taken from earthen pot, their water content is squeezed, and then sun dried in bamboo trays called *saloni*. The dried *khoriga* is then pickled by adding mustard seeds and locally available Raja or Naga chilies (*Capsicum chinense*). (Narzary *et al.* 2016).

Tuaitthur: *Tuaitthur* is an ethnic fermented bamboo shoot product with sour-acidic taste prepared and

consumed by the Hrangkhoh, Baite, and Hmar tribes of North Cachar Hills district of Assam (Chakrabarty *et al.* 2014). Dimasa tribe of Assam and Nagaland state calls it as *miyamikhri*. It is similar to other ethnic fermented bamboo shoot products of Northeast India and the Himalayas such as mesu of Nepal, Darjeeling hills, Sikkim, and Bhutan; soidon and soibum of Manipur; ekung and hiring of Arunachal Pradesh; and lung- siej of Meghalaya (Tamang and Tamang, 2009). During the traditional method of preparation of *Tuaitthur*, young tender shoots of bamboo (*Dendrocalamus hamiltonii* Nees. et Arn. ex Munro, *Melocanna bambusoides* Trin., and *Bambusa tulda* Roxb.) are collected, their outer hard casings are removed, and inner portion is then chopped into small pieces with a knife. The chopped pieces are washed thoroughly with clean water, drained well, and pressed tightly in cylindrical vessels made of bamboo or in bottles. The vessel is made airtight with a lid and it is fermented under natural anaerobic condition for 6–7 days. It is kept in an airtight container or in sealed plastic bags for few months at ambient temperature. *Tuaitthur* is prepared as curry with dry fish or meat product mixing with salt. It is also made as pickle and can be preserved for several months. *Tuaitroi* is a similar dry fermented bamboo tender shoot product consumed by the Hrangkhoh and Baite tribe of Assam. *Lb. plantarum*, *Lb. brevis*, *P. pentosaceus*, *Lactococcus lactis*, *Bacillus circulans*, *B. firmus*, *B. sphaericus*, and *B. subtilis* were isolated from *tuaitthur* (Chakrabarty *et al.* 2014).

Fermented Milk based Products

Mar, chhurpi, churkam: *Mar* is a short time fermented dairy product popularly made in Arunachal Pradesh. *Mar* (artisanal butter) is a fat-rich product that is separated from the whole milk by a *churning* process in a specially made wooden vessel locally known as a *sop*, leaving behind *dhara* (buttermilk). *Dhara* is further boiled for 25-30 minutes until a clumping solid (chhurpi) is formed, which is collected leaving the liquid residue (*churku*) behind.

Chhurpi: It is spontaneously fermented at room temperature for only a few days and is also the main

source of the production of two other products, *churkam* and *churtang*.

Churkam: For the preparation of *churkam*, *chhurpi* is immediately collected in a cloth after boiling and is hanged for a few minutes, which is later placed in between two stones for drying the remaining liquid up to 4-5 hours. The covering cloth is then carefully unwrapped and the semidried product is cut into small cubes of variable length (2-4 cm) and breadth (1-1.2 cm), which are then boiled along with *churku* until it is almost dried. The pieces are then sewn together in a thread with 20 pieces each making a roll. The dried products (*churkam*) are then hung for 3-4 days at room temperature inside the tent and are supplied to the local market for selling. Besides *churkam*, *chhurpi* can also be used to prepare *churtang/chhurpupu* (longer-period fermentation). However, in this process, *chhurpi*, after collection, is packed in an animal skin (calf skin by Zhorchut tribes, and Yak skin by Mongnang) and fermentation is for a duration of 6 months to less than 1 year and some would even keep it longer for 3-20 years. This practice is also a form of preservation of *chhurpi* for a longer time (Rai *et al.* 2016).

Gheu, mohi, soft chhurpi and chhu: Dahi is the main naturally fermented product of Nepal, Darjeeling Hills, and Sikkim of India and it also used for the preparation of several other milk products: *gheu*, *mohi*, *soft chhurpi*, and *chhu*.

Dahi: For the preparation of *dahi/shyow*, fresh or boiled milk (after cooling to room temperature) is fermented for 1-2 days by the addition of an old culture (*dahi*); a process known as back-sloping technique. Milk (fresh/boiled) is churned in a hollow wooden vessel container (*theki*), leaving behind *gheu* at the top of the container and a liquid by-product, *mohi* (buttermilk). In Bhutia and Lepcha dialect, *mohi* is known as *kachhu*, whereas in the Western Himalayas, buttermilk is called *lassi*.

Philu: It is a cream-like fermented product that is prepared by pouring fresh milk into a wooden vessel, where a thick mesh of dried creeper or sticks are kept inside that holds the milk. For two or three times a

day, the milk is poured into the vessel, which is kept for 6-7 days, and some would even keep it for up to 15 days of fermentation.

Gheu: *Gheuis* an artisanal butter in Nepali, which is also known as *ghee* or *makhan* in Hindi, *maa* in Tibetan, and *mor* in Lepcha.

Soft chhurpi/chhu/sheden: It is formed when the buttermilk '*mohi*' is boiled for about 15 minutes and is collected by sieving out using a cloth, which is hung by a string to drain out the remaining whey. When some fresh *chhurpi* is kept in a tight container for 10-15 days, the final product is known as *somar*. Soft *chhurpi* is further processed to form hard *chhurpi*, which is prepared by over-pressing the highly stringy mass that is wrapped in a cloth over stones, and is usually fermented under pressure at room temperature for about 2 days. However, the hard variety, which is prepared from yak's milk, is called *dudh-chhurpi* (Rai *et al.* 2016).

Lassi: *Lassi* is a traditional fermented milk beverage consumed in summer season for refreshment and is prepared from *dahi*. It is prepared by blending *dahi* with water, sugar, salt, and spices such as cumin seeds and coriander leaves. The presence of spices decreases thirst. *Lassi* is a probiotic product due to the presence of *L. acidophilus* and *S. thermophilus* as active cultures (Patidar and Prajapati, 1998; Sarkar *et al.* 2015). Based on the use of ingredients in *Lassi*, it is classified as salty *Lassi* or sweet *Lassi*. *Bhang lassi* is a special type of *lassi* prepared using the extract of *Cannabis* plant leaves. It is prepared, especially on the occasion of Holi and Shivaratri festival. *Bhang Lassi* shows health benefits due to the presence of cannabis plant extracts, which help in relieving digestive problems, skin-related problems, fever, and sunstroke (Backes, 2014).

Fermented Beverages

Atingba: *Hamei* is a natural starter (flat rice cake), similar to *Ragi* of Indonesia, *Budob* of Philippines, *Chu* of China, *Naruk* of Korea and *Marcha* of Darjeeling hills and Sikkim that has been traditionally used for the preparation of rice wine, *Atingba* in Manipur.

The *Hamei* cakes are prepared from crushed raw rice with *Yangli* (*Albizia myriophylla*) bark powder and pressed into flat cakes approximately 2-7 cm in diameter and 0.6-1.5 cm thickness. The rice cakes are kept over rice husk in bamboo basket for 2-3 days at room temperature. The desired state of fermentation is indicated by the swelling of cakes, alcoholic flavour production and yellowish coloration. Mostly preparation of *Hamei* is done during summer (May-July) and dried cakes are stored yearlong. *Hamei* is used by crushing the flat cake then mixing the powder with cooked, cooled glutinous rice. The mixture is fermented for 3-4 days under Solid State Fermentation (SSF) in earthen pots covered with *Hangla* (*Alocassia* sp leaves) during summer and 6-7 days in winter. Then, followed by 2-3 days submerged fermentation in earthen pots. The fermented beverage is called Atingba and distilled clear liquor (using traditional assembly) is called Yu. (Jeyram *et al.* 2009).

Apong: *Apong* is an alcoholic beverage prepared in the state of Arunachal Pradesh and is familiar to almost all the tribes of the state. It is also prepared by the *Mishings* of Assam. It bears a very important place in the tradition of the people of this region. The starter culture used for its preparation is called "ipoh" which contains the yeast to carry out the fermentation (Tiwari and Mahanta, 2007). The yeasts associated are *Saccharomyces cerevisiae*, *Hanseniaspora* sp, *Kloeckera* sp, *Pischia* sp. and *Candida* sp., with *S. cerevisiae* being the dominant one (Tanti *et al.* 2010). For preparation of *ipoh* rice is first dried and grinded into fine powder. This is then mixed with powder of seeds and barks of the locally available plants *Veronia cinerea* Less and *Clerodendron viscosum* Vent. This mixture is taken into a vessel called *Dekchi* and made into a paste using water of previously prepared apong. This paste is poured and spread on bamboo mats and made into disc shaped small cakes. They are then carefully dried over the fireplace or left in a cool place for 3 to 4 days. After drying they can be stored for up to a year (Tiwari and Mahanta, 2007). For preparing apong, rice is first washed and boiled in a large aluminium vessel with a wide bottom. Care should be taken not to overcook the rice such

that it becomes soggy. The *ipoh* is then thoroughly mixed with the rice in proper quantity. This is then transferred to another vessel with a lid and a little amount of water is added to it. It is then, left to ferment at room temperature for a period of 3 to 5 days after which it emits a strong alcoholic smell. The stock is diluted with water before consumption (Tiwari and Mahanta, 2007).

Bhaatijaanr: *Bhaati jaanr* is the Indian Himalayan sweet-sour, mild alcoholic food beverage paste prepared from rice and consumed as a staple food. Rice is cooked and spread on a bamboo mat for cooling; 2-4% of powdered 'marcha' is sprinkled over cooked rice, mixed well, and kept in a vessel or an earthen pot for 1-2 days at room temperature. The vessel is made airtight and allowed to ferment for 2-3 days during summer and 7-8 days during winter. *Bhaati jaanr* is made into a thick paste by stirring the fermented mass with the help of a hand-driven wooden or bamboo stirrer. It is consumed directly as a food beverage. The similar product is called 'poko' in Nepal. Occasionally *bhaati jaanr* is stored in an earthenware crock for 6-9 days, and thick yellowish white supernatant liquor locally called 'nigaaris' collected at the bottom of the earthenware. 'Nigaar' is drunk directly with or without addition of water. Alcohol content of *bhaati jaanr* is 5.9 % (Tamang, 2010a). *Saccharomycopsis fibuligera* and *Rhizopus* spp. and *Mucor* spp. contribute in saccharification and liquefaction of glutinous rice, breaking starch of substrates into glucose for alcohol production and also in aroma formation in *bhaati jaanr* preparation (Tamang and Thapa, 2006).

Chhang/lugri: An indigenous rice beer made in the tribal belt of Lahaul and Spiti district of Himachal Pradesh is called chhang/lugri. The preparation of *chhang* involves solid-state fermentation as no additional water is added to the ingredients, i.e., cooked rice and 'phab' (the traditional inoculum). Chhang is also prepared from barley; however, it takes longer time (1 week) to ferment and beverage is called *lugri* in Lahaul. The traditional vessel made of metal or stone used to store chhang is called "uthi" in Lahaul, and it is served in traditional jugs called

“chapkiayan”. Microorganisms include *Lactobacillus plantaru*, *Lb. casei*, *Enterococcus faecium*, and *Pediococcus pentosaceus*. *Saccharomyces cerevisiae*, *Saccharomyces fi buligera*, *Pichia kudriavzevii*, and *Candida tropicalis* have been isolated and identified from chhang (Thakur, 2013).

Chu: *Chu* is a type of rice beer prepared by the Garo tribe of Assam and Meghalaya. It is made from cooked rice which is boiled for 1 hour until it becomes soft and edible. The starter cake used for the preparation of the beverage called *wansi*. The cooked rice is spread on a thin polythene sheet for cooling, and the starter cake “*wansi*” is mixed in it. The quantity of the starter cake required is proportionate to the quantity of rice used to ferment. This mixture is then kept in an airtight container where bamboo sieve called *dekeli* is inserted for easy harvesting of beer. The mouth of the container is sealed by a piece of cloth and is kept in a dark warm place for fermentation. The rate of fermentation is slower during winter than during summer. However, for a good quality rice beer, slow fermentation at low temperature is required where the process of fermentation occurs anaerobically, and usually, 1 week is required for the whole process to complete (Narzary *et al.* 2016).

Chako: *Chako* is a rice beer prepared by an indigenous tribe of the state Assam called *Rabha* tribe. The starter cake used by them is known as “*bakhor*” or “*phab*”. Rice beer *chako* are of two types. This alcoholic product is yellowish in colour with a very strong taste. During its preparation, water is first put in an aluminium pot “*motok*” and a funnel “*jokroth*” made of bamboo is fitted in its mouth. One banana leaf is placed over the aperture of *jokroth* so that it is completely closed. Then properly washed rice is put in the funnel *jokroth*, and the whole device is set in an oven. The rice is cooked by the steam coming from the boiling water present in *motok*. Cooked rice is spread on a jute bag for drying and a half tablet of *chokot bakhor* is mixed with it. After mixing properly, it is kept for 30 minutes, packed in the jute bag in a shady place or room, and allowed to get heated by the action of microbes. The mixture is now transferred to a fermenter *motok*, covered with

a banana leaf, and kept for fermentation. The rate of incubation varies with temperature in different seasons. Generally, it takes 1-2 days in summer and 3-4 days in winter. After proper aging, a yellow liquid from the fermented stock is produced with a strong smell (Narzary *et al.* 2016).

Chulli: A beverage prepared from the wild apricot popularly consumed in Kinnuar and Shimla district of Himachal Pradesh district of India. The preparation is done by crushing the wild apricot and mixed with water. Then, a small amount of inoculum called *phab* is added and kept for fermentation for 2-3 days it is then filtered and the filtrate is called *chulli* (Joshi *et al.* 1990; Savitri and Bhalla, 2007). The Fig. 7 depicts the complete flow sheet for the preparation of *chulli*.

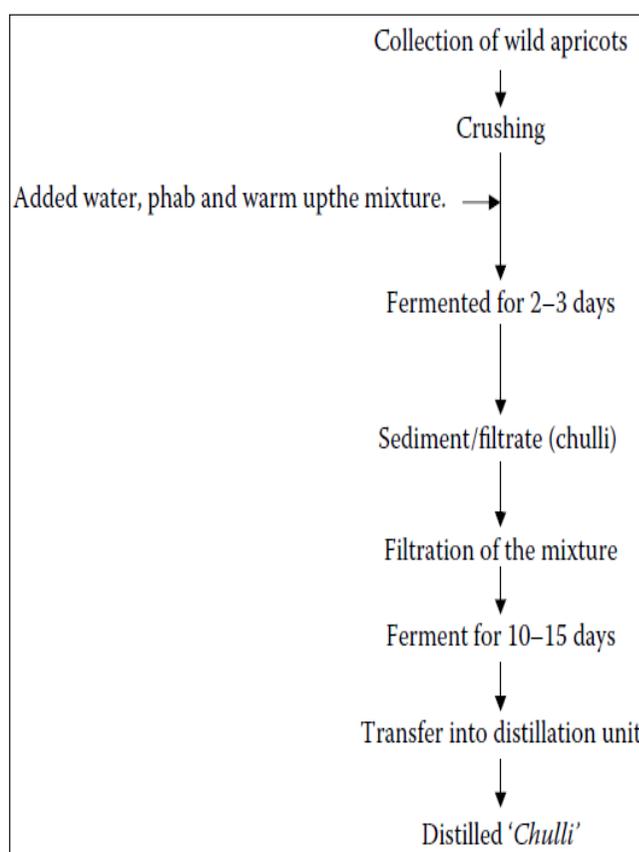


Fig. 7: Flow diagram for *chulli* beverage by the traditional method employed

Haria: *Haria* is prepared using boiled scorched rice which is mixed with ‘*bakhar*’ (1:100), transferred to an

earthen pot, and kept in a dark room for 3-5 days for fermentation. It is diluted with water and sieved to get the *haria*. It is consumed in west Bengal, Orissa, and Jharkhand (Ghosh *et al.* 2014; Ghosh *et al.* 2015; Ghosh *et al.* 2015).

Jou: *Jou* is a popular drink in the tribe of *Boro* of the Assam state in India. Its preparation is started by mixing the air dried cooked rice with starter '*amao*' (1 cake per 1 kg of rice) along with three to four pieces of chilli and charcoal, then transferred to an earthen pot. The ferment is diluted and filtered for consumption. The *Boro* tribe consumes this as a refreshing drink and it has a significant role in their socio-cultural events (Das *et al.* 2012).

Judima: The fermented beverage '*judima*' is popular to the Dimasa tribe of the North Cachar hill district of Assam state of India. It is prepared through mixing the starter powder *humao* or *umhu* (a mixture of rice and bark of '*thempra*' plant (*Acacia pennata*). For variation in test and flavour they use to mix leaves powder of *Piper betle* (leaves), *Buddleja asiatica* (leaves/twigs) and *Hedyotis scandens* (leave/ twigs). The barks of *Acacia pennata* are cut into small pieces and dried in the sun. Glutinous rice (*Oryza glutinosa* Lour) is soaked in water until it is softened. It is then *grinded* in a wooden or metallic mortar and pestle called '*rimin*' along with the barks of *thempra* plant. A little water is added in order to make a paste; it is then made into cakes of appropriate sizes. The old rice cake (15-20 g) was then powdered and sprinkled over the new rice cake. New rice cake was then kept for at least 24 hours, and then it is sun dried till it becomes hard and it can be stored for many months. For preparing *Judima*, rice is boiled and allowed to cool. It is mixed with powdered *humao* and kept in a large container which is covered with jute gunny bags. After 5-7 days, slightly yellowish juices come out from the fermented mass which indicates the completion of fermentation process. This can further be diluted with water and filtered for consumption. (Chakrabarty *et al.* 2014; Arjun *et al.* 2014).

Ennog: *Ennog* is black rice beer requiring rice, *ipoh*, paddy husk half the quantity of rice are main

ingredients. The method of *Ennog* preparation is almost same to that of *Apong*. Rice is boiled and spread on a good-sized bamboo mat to cool completely. Meanwhile, the paddy husk is prepared by filling it in to a large tin sheet or metal drum and allowed burn slowly and evenly over light flame till it is completely black. Then, the hot burnt husk is mixed well with the boiled rice and is left to cool down. After cooling of the rice husk mix, biscuits, cakes of *Ipoh* are carefully crumbled and mixed well. The mixture is now transferred into a conical bamboo basket lined with *ekkam* (*Phryium capitulum* Wild) leaves. This is the *nogabaye*. The basket is tightly covered with more leaves and stored in a cool dry place which is the initial step towards prompting fermentation and the mixture is left for about 3 days or until strong alcoholic smell begins to permeate. Then, the mixture is transferred for final storage into another basket lined with *ekkam* leaves, wide U-shaped bamboo woven contraption, called the *Perop*. *Perop* is covered with more leaves; a piece of wood (*Pamtang*) is placed on the top to seal it and a stone (*Ennog-Lisak*) is placed on the wood for added weight. Fermentation takes about 10 days for making the beer ready for filtration. Approximately, 2 kg or more of the mixture is scooped out at a time into a cylindrical bamboo tube (*Petok*) fitted with a small opening at one end. Boiling hot water is poured slowly over the mixture and the resultant brew that drips out is the first draw, which is considered the strongest. The first draw called, *Tok-Til* is always warm and the subsequent brew (*Ennog*) is blackish in colour (Tiwari and Mahanta, 2007).

Sujen: *Sujen* is a form of rice beer which is popular among the Deori tribe of Assam. It is also considered to be pure and used as a holy water by the Deori priests during various festivals and ceremonies. *Sujen* is prepared in two stages, first is the preparation of the natural starter called *mod pitha* and then the brewing of *sujen* (Deori *et al.* 2007). Preparation of *mod pitha* a variety of plant species (about 32 in number) are used. Some of these are *Artocarpus heterophyllus*, *Cinnamomum bejolghota*, *Costus speciosus*, *Desmodium pulchellum*, *Coffea bengalenses*, *Cyperus* sp., *Equisetum* sp., *Lygodium flexuosum* and *Melastoma malabathricum*.

A handful of each of the plant's cleaned leaves, fronds, barks, roots and bulbs are put in a round bamboo mesh called *saloni* and sun-dried for a day. Then 3 to 5 kgs of *saol* (rice) is soaked in water for about 2 hrs and mixed with the dried plant materials in a grounded in a wooden grinder called *dheki*. The grounded powder is taken out, sieved in a *Saloni* (a bamboo sieve) and the coarse part is returned to the *Dheki* for grinding. The process is continued until a fine powder is obtained. 2-3 old *Mod pitha* are added to the mixture while grinding, which acts as an inoculant. Grounded powder is put into a *Soriya* (aluminium utensil), water is added to make a sticky paste and small round are prepared. Cakes are then kept on clean, dry paddy straws spread on a *Kula* (a round bamboo utensil) and again covered with straws. *Kula* is then kept on a *Dhua sang* tied about 1 m above the fireplace in the kitchen for drying. This procedure of baking continues for a couple of weeks until the *Mod pitha* becomes hard. *Pitha* is then ready for use in *Sujen* brewing. Unused *Mod Pitha* is stored in *Tekele* (small earthen pot), mouth of which is covered with a bunch of straws. It can be stored for 2-3 months and can be used as and when required.

For *sujen* brewing, 4 to 5 kgs of *saol* is mixed with rice husk called *tuh* and water and cooked with stirring. Cooked *saol* is poured on a round bamboo utensil called *dola* covered with clean banana leaves. 2 to 3 powdered *mod pithas* are added to the warm *saol* and mixed thoroughly. The mixture is gathered into a round mount and on top of it three *jalokias* (chillies) and three pieces of burning *koila* (charcoal) are kept. Fronds of *Pteridium aquilinum* called *bihlongoni* are spread over the mount and covered with "*kolpat*" (banana leaves) above which a *dola* is placed. A big earthen pot called *koloh* is sterilized by washing with ashes and the drying above a smoking fireplace. The mixture is transferred to this pot and the mouth of the pot is sealed with *bihlongoni* and *kolpat* and wrapped tightly with a cloth. This is left to ferment for 3 to 4 days in summer and 7 days in winter. After fermentation the mass is filtered and *sujen* is obtained as the filtrate. This can be stored for a month in winter and 2-3 weeks in summer. It can be further diluted according to need (Deori *et al.* 2007).

Kanji: *Kanji* is an ethnic Indian strong-flavoured mild alcoholic beverage prepared from beet root and carrot by natural fermentation (Batra and Millner, 1974). During its preparation, carrots or beets are washed, shredded, and mixed with salt and mustard seeds and placed in earthen pot and allowed to ferment naturally at 26–34 °C for 4–7 days. Sometimes, the mixture is inoculated with a portion of a previous batch of *kanji*. After fermentation, pink alcoholic liquor is drained off and bottled or drunk directly. In north India, it is prepared with purple or occasionally orange cultivars of carrots plus beets and spices, whereas in South India, *torami*, yeast-containing fermented rice gruel, is used as starters for *kanji* production. *Hansenlu anomala*, *Candida guilliermondii*, *C. tropicali*, and *Geotrichium candidum* are involved in *kanji* fermentation (Batra and Millner, 1974). *Leuc. mesenteroides*, *Pediococcus spp.* and *Lactobacillus dextranicum* were isolated from *kanji* fermentation (Sura *et al.* 2001). Kingston *et al.* (2010) reported *Lb. paraplantarum* and *Lb. pentosus* from *kanji* based on rep-PCR identification method. Joshi *et al.* (2011) also prepared and evaluated appetizers from lactic acid fermented vegetables.

Raksi: *Raksi* is an ethnic alcoholic drink of the Himalayas with characteristic aroma and distilled from the traditional fermented cereal beverages (Kozaki *et al.* 2000). *Raksi* is a common term in Nepali meaning alcoholic drink. *Bhaati jaanr*, *poko*, *makai ko jaanr*, *kodo ko jaanr*, *gahoon ko jaanr*, fermented masses of buckwheat, potato, canna, and *cassava* roots are distilled in a large cylindrical metallic vessel for 2–3 h continuously over firewood in an earthen oven (Tamang, 2005). A perforated container locally called *phunga* is placed above the main cylindrical vessel inside which a small metallic collector called *poini* is kept on an iron tripod called *odhan* to collect the distillate called *raksi*. Another a metallic vessel with cold water is placed above the *phunga* as condenser. The bottom of the condenser vessel is plastered by mud with the tip of the *phunga* to prevent excess ventilation during distillation. Water is replaced three to five times after it gets heated.

Tchang/jhar and rokshi: The tribal people of Sikkim consume beverages called *tchang / jhar* and *rokshi*, in which *tchang* is prepared using millet (*Paspalum* sp.) and *rokshi* is prepared using certain plants and plant parts. The fermented millet is transferred into bamboo or wooden cylindrical cups. Lukewarm water is poured inside the cups and drunk by suction through a small pipe of bamboo. It can be repeated until the flavour is available. *Canna edulis* Ker Gawl. and *Zea mays* L. are the important plants used in the preparation of *rokshi* by the ethnic people of Sikkim, namely, Lepcha, Bhutia, and Nepali. *Jhar* and *rokshi* samples contain filamentous molds and yeasts (*Mucor cicinelloides*, *Rhizopus chinensis*, *R. stolonifer* var. *lyococcus*, *Saccharomycopsis fi buligera*, *Saccharomyces cerevisiae*, *Hansenula anomala*, *Pediococcus pentosaceus*, and *Lactobacillus* sp.) (Sekar and Mariappan, 2007).

Zutho: *Zutho* or *zhuchu* is an ethnic alcoholic beverage of Mao Naga prepared from rice. Rice is soaked overnight, drained off, pounded into flour, put in a big bamboo bucket and mixed with boiling water, stirred, and left for cooling; amylolytic starter locally called *khekhrii* powder is added and left about 6–8 h for brewing after which the whole mixture is poured into a big earthen jar (Mao and Odyuo, 2007). More water is added to make the volume up to the neck and kept for fermentation for 3–4 days during which it forms a profuse whitish froth to get *zutho* which has sweet taste with acidic flavour (Mao, 1998). The similar alcoholic beverage called *nchiangne* is prepared from red rice in of Nagaland. *Saccharomyces cerevisiae* was isolated from *zutho* (Das et al. 2012; Teramoto et al. 2002).

Kiad: *Kiad* is popular local liquor prepared by the Jaintia tribe (also known as Pnar or Synteng) of the Jaintia hills of the state of Meghalaya. It plays an important role in Jaintia socio-cultural life and accompanies every religious festival and ceremony. The preparation of *kiad* is carried out in two stages; first the preparation of natural yeast called *thiat* and second is the brewing of the liquor *kiad* (Jaiswal, 2010; Samati and Begum, 2007). For preparation of *thiat*, a handful of washed and cleaned leaves of the locally available plant *khawiang* (*Amomum aromaticum*

Roxb.) are sun dried and grounded into powder in a wooden mortar pestle called as *thlong-surai*. 1-2 kgs. of a local variety of rice called *kho-so* is soaked and then grounded to powder in a *thlong-surai*. These two powders are then mixed in a cone shaped basket caked *khire* and spring water is added to make a sticky paste. Small round cakes of about 4-5 cm in diameter and about 1 cm in thickness are made of the paste. These are kept in a round basket called *malieng* and covered by banana leaves. The *malieng* is hanged on a rectangular frame made of bamboo called *la-er* and exposed to sunlight or held above the fire place. After drying the cakes gets hardened and they are known as *thiat* and used as the yeast inoculum. For brewing *kiad*, 4-5 kgs. of *kho-so* is mixed with spring water and cooked in a metallic vessel with continuous stirring. The cooked rice is then spread on a *malieng* for cooling and drying. Then to this 2-3 cakes if finely crushed *thiat* are mixed. The mixture is then put in a cone shaped basket called *shang*. The whole basket is covered with a cloth and left for 2-3 days. The fermented mash known as *jyndem* is distilled in a set of apparatus called *shetkiad* which is made by piling different sized vessels one above another. The distillate is known as *kiad* (Jaiswal, 2010; Samati and Begum, 2007). *Kiad* production serves as a source of income to the local people and its minimum consumption is considered to be good for health and acts as a remedy for various ailments (Samati and Begum, 2007).

Xaj-pani: The Ahoms of Assam prepare a kind of rice beer which they locally call as *xaj-pani*. For preparing *xaj pani*, the starter culture called *vekur pitha* first needs to be prepared (Saikia et al. 2007). For preparing *vekur pitha*, leaves of *Lygodium flaxuosum* Linn., *Leucas aspera spreng*, *Cissampelos pereira*, *Scoparia dulcis* Linn., *Cinamomum glanduliferum* Meissn. and *Piper betle* Linn. are collected and dried in the sunlight for 1-2 days. These are then grounded to powder and mixed with powdered rice in a vessel with some amount of water. To this powder of previously prepared *pitha* called *ghai pitha* is added which serves as a source of yeast. The mixture is then made into disc shaped cakes and wrapped with banana leaves (*Musa paradisiaca*

Linn.) and kept in air locked condition above the fire heart for 4 to 5 days. After getting dried, the cakes are known as *vekur pitha* which serves as the source of *Saccharomyces cerevisiae* and can be stored for future use. For preparation of rice beer, the main variety of rice used by the Ahoms is Bora rice belonging to Sali variety. The rice is first cooked and spread on a plain plate and is left open for about an hour. The cooled and dried rice is then mixed with *vekur pitha*. This mixture is then transferred to an earthen pot called *kalah* which is kept at a dark place on a corner of the house for a period of 4-5 days in air locked condition. After this period, the concentrated alcoholic juice is collected from the *kalah* by filtration process. This is done by placing a vessel of appropriate size on the mouth of the pot to act as a lid or by placing rice straw to prevent the exit of semi solid rice. The filtrate is known as *xaj pani* which is highly aromatic, alcoholic and has a sweet taste (Saikia *et al.* 2007).

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