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MiniReview
Fermented foods and beverages of the North-East India

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Abstract: North East India is characterized by a diverse population of people with different ethnic background. Most of the people of this region are tribal and bear their own methods of fermenting food materials for the purpose of preservation and taste enhancement and they have been carrying these from time immemorial. All the fermented products are region specific and have their own unique substrates and preparation methods. Materials such as soybeans, bamboo shoots and locally available vegetables are commonly fermented by most of the tribes. The fermented alcoholic beverages prepared in this region are unique from the rest of the world in several aspects and bears deep attachment with the socio-cultural lives of the people. The starter cultures used and the utilization of indigenous microbes reflect the expertise of these people in customary microbiology. Microbes such as *Saccharomyces cerevisiae*, *Candida* sp., Lactic Acid Bacteria (LAB) and *Bacillus* sp. have been found to be abundant of common occurrence in these products. These products also serve as a source of economy to many of the rural people, who prepares them at home and market locally. Detailed studies on the nutritive and medicinal value of these products can provide valuable information would prove beneficial in the use of these products on a wider scale. Formulation of new techniques to increase their shelf life would help in the commercialization of these products.

Keywords: Fermented food, beverages, North-East India, tribes, microorganisms

Introduction

The term fermentation is derived from the Latin word *fervere* meaning "to boil". It basically describes the appearance of the action of yeast on extracts of fruit or malted grain during the production of alcoholic beverages. It may be defined as any process for the production of a product by the mass culture of microorganism (Stanbury, 1999). Indigenous people have been using microbes unknowingly for various purposes (Sekar and Mariappan, 2007). Fermentation is one of the oldest and most economic methods of preserving the quality and safety of foods. Moreover, fermented foods have further benefits of providing bio-nutrients and minerals and enhancement of flavour and aroma. The process also increases digestibility and exert health promoting benefits (Jeyaram *et al*., 2009). Fermentation may assist in the destruction or detoxification of certain undesirable compounds which may be present in raw foods. These are compounds such as phytates, polyphenols and tannins (Sharma and Kapoor, 1996). Fermented foods are encountered worldwide and their origin is due to their prolonged shelf life, reduced volume, shorter cooking times and superior nutritive value as compared to the non-fermented ingredients. The traditional way of carrying out fermentation at the household-scale is still followed using relatively simple processing facilities. These products often contain mixed microbial populations because of the lack of sterility and the use of natural fermentation (Nout and Sarkar, 1999).

In the Indian subcontinent, fermented food and beverages, prepared using local food crops and other biological resources have been going on since time immemorial and is a common practice even today (Roy *et al*., 2004). The North-Eastern region of India is comprised of the cluster of eight states namely Assam, Meghalaya, Arunachal Pradesh, Mizoram, Nagaland, Tripura, Manipur and Sikkim. The region can be physiographically categorized into the Eastern Himalayas, Northeast hills (Patkai-Naga Hills and Lushai Hills) and the Brahmaputra and Barak Valley plains. Approximately 225 tribes out of the 450 tribes of India reside in this region (Chatterjee *et al*., 2006). The people of these states have a very rich reserve of traditional knowledge owing to their livelihood in the hilly terrains. This area is inhabited largely by tribal people who make up 75% of the population of the region (Agrahar-Murungkar and Subbulakshmi, 2006). These people possess great knowledge of the environment and depend on the forests, plants and plant products for food and other purposes (Jaiswal, 2010). Learning about edible plants and processing and conservation of foods for consumption and medicinal purposes has been in the large part due to

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incremental and cumulative learning among these societies living in close connection with nature (Singh *et al*., 2007). A variety of region specific fermented foods and beverages are traditionally produced and consumed, and even locally marketed in North-East India. Different types of substrates and fermenting organisms are being employed for the production of these ethnic products and the process employed also varies from place to place. A summary of the different microbes involved in the fermentation of the various products is given in Table 1.This paper focuses on some of the practices followed by the different groups of indigenous tribal people of North-East India in the production of their respective fermented product.

Fermented vegetables

Many different forms of vegetables are fermented and preserved by the tribal people of this region. Similar products are like *sauerkraut* (Europe), *kimchi* (Korea), *oncom* (Indonesia), *tsukemono* (Japan), *suan cai* (China) and *atchara* (Phillipines) (Lee, 2009). Some common fermented vegetable products oh this region are being described here.

Gundruk

Gundruk is a fermented vegetable product indigenous to the *Nepali* people of the Himalayan region.

Table 1. Microbes associated with the fermentation of different traditional fermented food products of North-East India

SI No	Fermented Product	Microbes associated	Reference
1	Kinema	*Bacillus subtilis*, *Enterococcus faecium*, *Candida parapsilosis, Geotrichum candidum*	Sarkar *et al.*, 1994
2	Hawaijar	*Bacillus subtilis, B. licheniformis, B. cereus, Staphylococcus aureus, S. sciuri, Alkaligenes* sp. *Providencia rettger*	Jeyaram *et al.*, 2008a
3	Tungrumbai	*Bacillus subtilis, Enterococcus faecium*, *Candida parapsilosis, Saccharomyces bayanus, Saccharomycopsis fibuligera, Geotrichum candidum*	Sohliya *et al.*, 2009; Sarkar *et al.*, 1994
4	Bekang	*Bacillus subtilis*, other *Bacillus* sp.	Tamang *et al.*, 2009
5	Peruyyan	Lactic acid bacteria, *Bacillus subtilis,* other *Bacillus* sp.	Tamang *et al.*, 2009
6	Soibum	*Lactobacillus plantarum, L. brevis, L. coryniformis, L. delbrueckii, L lactis, Leuconostoc falllax, , Leuc. mesentroides, Enterococcus durans, Streptococcus lactis, Bacillus subtilis, B. licheniformis, B. coagulans, Candida* sp., *Saccharomyces* sp., *Torulopsis* sp.	Tamang and Tamang, 2009a ; Tamang *et al.*, 2008
7	Soidon	*Lactobacillus brevis, Leuconostoc fallax, Leuc. lactis*	Tamang *et al.*, 2008
8	Mesu	*Lactobacillus plantarum, L. brevis, L. pentosaceus, L. pentosaceus L. brevis, L. plantarum*	Tamang and Sarkar, 1996
9	Ekung	*Lactobacillus plantarum, L. brevis, L. casei, Tetragenococcus halophilus*	Tamang and Tamang, 2009a
10	Hirring	*Lactobacillus plantarum*, *L. lactis*	Tamang and Tamang, 2009 b
11	Ngari	*Lactococcus plantarum*, *L. plantarum, Bacillus subtilis, B. pumilus, Miocrococcus* sp., *Candida* sp.	Thapa *et al.*, 2004
12	Hentak	*Lactobacillus fructosus, L. amylophilus, Enterococcus faecium, Bacillus cereus, B. subtilis, Staphylococcus aureus, Enterococcus faecium, Candida* sp.	Thapa *et al*., 2004
13	Tungtap	*Lactobacillus coriniformis, L. lactis, L. fructosus, B. cereus, B. subtilis, Candida* sp., *Saccharomycopsis* sp.	Thapa *et al.*, 2004
14	Gnuchi	*Enterococcus faecium*, *Pediococcus pentosaceus*, *Bacillus subtilis, Micrococcus* sp	Thapa *et al*., 2006
15	Gundruk	*Lactobacillus brevis, L. plantarum, L. paracasei*, *Leuconostoc fallax, Pediococcus pentosaceus, P. acidilactici*	Tamang *et al*., 2005
16	Sinki	L*actobacillus plantarum, L. brevis, L. fermentum*	Tamang and Sarkar, 1993
17	Ziang-sang	*Lactobacillus plantarum, L. brevis*, *Pediococcus acidilactici*	Tamang *et al.*, 2005
18	Goyang	*Lactobacillus plantarum, L. brevis, Lactococcus lactis, Enterococcus faecium, Pediococcus pentosaceus*	Tamang and Tamang, 2007
19	Khalpi	*Lactobacillus plantarum, L. brevis, Lecuonostoc fallax*	Tamang, 2009
20	Ipoh	*Saccharomyces cerevisiae, Hanseniaspora* sp, *Kloeckera* sp, *Pischia* sp., *Candida* sp	Tanti *et al.*, 2010
21	Atingba	*Lactobacillus plantarum, Pediococcus pentosaceus Saccharomyces cerevisiae, Pichia anomala, Trichosporon* sp., *Candida tropicalis, P. guilliermondi, C. parapsilosis, Torulaspora delbrueckii, C. Montana, P. fabianii*	Tamang *et al.*, 2007 ; Jeyaram *et al*., 2008
22	Kodo ko Jaanr	*Mucor cicinelloides, Rhizopus chinensis, Rhizopus stolonifer* var. *lyococcus*, *Saccharomyces cerevisiae, S. bayanus, Hansenula anomala, Pediococcus pentosaceus, Lactobacillus sp., Candida glabrata, Saccharomycopsis capsularis, Saccharomycopsis fibuligera, Pichia burtonii Pichia anomala, Cryptococcus* sp., *Trichosporon* sp., *Debaryomyces* sp., *Kluyveromyces* sp., *Myxozyma* sp., *Bullera* sp., *Rhodotorula* sp., *Tremella* sp.	Tamang and Sarkar, 1995; Tsuyoshi *et al*., 2005; Tiwari *et al.*, 2007; Sekar and Mariappan, 2007
23	Zutho	*Saccharomyces cerevisiae*	Teramoto *et al.*, 2002

It is commonly prepared during winter i.e, October to December, when perishable leafy vegetables are plenty. These vegetables are mainly leaves of mustard (*Brasicca juncea*), *rayo-sag* (*Brasicca rapa*), cauliflowers (*Brasicca oleracea),* radish (*Raphanus sativus*) and some other locally grown vegetables (Tamang and Tamang, 2009a). The microorganism predominantly occurring in *gundruk* have been identified as *Lactobacillus brevis, L. plantarum, L. paracasei*, *Pediococcus pentosaceus, P. acidilactici* and *Leuconostoc fallax* (Tamang *et al*., 2005).

For its fermentation, fresh leaves of the selected vegetables are first wilted and shredded using a sickle or knife. These are then crushed mildly and pressed into an earthen pot. The container is then made air tight and left to ferment naturally at room temperature for about 7 to 10 days. After the incubation period the leaves takes a mild acidic taste which indicates the completion of fermentation. The *gundruk* is then removed and sun dried for 3 to 4 days, which helps in storage. *Gundruk* is sold in all the local markets of Darjeeling hills and Sikkim by the *Nepali* women. It is eaten as a soup or pickle. The soup which is prepared after mixing *gundruk* with certain ingredients serves as a good appetizer (Tamang and Tamang, 2009a).

Sinki

This is a form of fermented radish (*Raphanus sativus* L.) tap root and is consumed by the *Nepalis* in Darjeeling, Sikkim and Nepal. It is prepared during the months of winter when weather is least humid and there is ample supply of this vegetable (Tamang and Sarkar, 1993; Sekar and Mariappan, 2007).The microbes associated with its fermentation have been identified as *Lactobacillus plantarum, L. brevis* and *L. fermentum* (Tamang and Sarkar, 1993).

Fresh tap roots of radish are cleaned by washing, wilted by sun-drying for 1-2 days until they become soft. They are then shredded, dipped in lukewarm water, squeezed and placed tightly into an earthen jar with the help of a heavy wooden pestle. The jar is sealed with an earthen lid and is covered with radish leaves. It is then kept in a warm and dry place for 15-30 days (Tamang and Sarkar, 1993). Alternatively, a pit of about 1 metre depth and diameter is dug in a dry place. This is cleaned, and dried by lighting a fire. The ashes are removed and the sides are plastered with mud while still hot. It is then covered on all sides with dried leaves of bamboo, banana or radish. The shredded roots are pressed tightly into this pit, then covered with dried leaves and weighed with heavy stones or wooden planks. The top is then plastered with mud or cow dung and left to ferment for a period of 30-40 days. After this the fermented mass is taken out, cut into small pieces and sundried for 3-5 days. This product can be kept for 2 years or more at room temperature by exposing to sunlight periodically (Tamang and Sarkar, 1993; Tamang and Tamang, 2009a).

Sinki has a pH of 4.4, and a protein and fat content 14.6 g and 2.5 g respectively on dry weight basis. It has a highly acidic flavour, and is used as a base for soup and pickle. It is said to be a good appetizer, and is used as a remedy for indigestion (Tamang and Sarkar, 1993).

Ziang-sang/ Ziang-dui

This is a fermented leafy vegetable product which is common to both the states of Manipur and Nagaland. It is produced dominantly by the *Naga* women and sold in the local markets (Tamang and Tamang, 2009a). The microbes associated have been identified as *Lactobacillus plantarum, L. brevis* and *Pediococcus acidilactici* (Tamang *et al*., 2005).

Ziang-sang is prepared during the winter season. 2 to 3 days old withered leaves of *hangam* (*Brassica* sp.) are crushed using traditional wooden mortar and pestle and soaked in warm water. They are then squeezed to remove the excess water and put inside air tight container and allowed to go for semisolid fermentation for a period of 7-10 days at ambient temperature (20 - 30^{0}C). From the fermented product, the juice is extracted by squeezing with hands and the paste is sundried for 4 to 5 days, which can then be stored for more than a year. This is called *ziang-sang.* The liquid part is concentrated by boiling and can be stored in traditional bamboo containers for more than a year. This part is called *ziang-dui. Ziang-sang* is consumed as a soup with boiled rice and *ziang-dui* is used as condiment with meals (Jeyaram *et al*., 2009; Tamang and Tamang, 2009a).

Goyang

The *Sherpa* tribe belonging to the state of Sikkim and hills of Darjeeling prepare this fermented product from leaves of the wild plant *magane-saag* (*Cardamine macrophylla* Willd.) (Tamang and Tamang, 2009a). Samples have been found to contain the species *Lactobacillus plantarum, L. brevis, Lactococcus lactis, Enterococcus faecium* and *Pediococcus pentosaceus* (Tamang and Tamang, 2007).

During the rainy season the leaves of the plant *magane-saag* are found in plenty. They are collected, washed, chopped into pieces and squeezed to remove the excess water. The leaves are tightly pressed into a bamboo basket lined with 2-3 layers of fig (*Ficus carica*) leaves. The top of the basket is also

covered with fig leaves and is left to ferment at room temperature (15–25^{0}C) for a period of 1 month. After this the *goyang* may be transferred to an air tight container where it can be stored for a period of 2-3 months. The product may also be made into balls and sundried which increases its shelf life. Locally, *goyang* is boiled with beef or yak meat and noodles and made into a thick soup like dish called *thupka* (Tamang and Tamang, 2009a).

Khalpi

Khalpi is a cucumber product of the state of Sikkim and Darjeeling hills. It is generally prepared for home consumption by the *Nepali* Brahmins belonging to the *Bahun* and *Chettri* castes. Microbes associated with its fermentation have been identified as *Lactobacillus plantarum, L. brevis* and *Lecuonostoc fallax.* For preparation of *khalpi,* mature and ripened cucumbers are cut into definite sizes and sundried for 2 days. They are then put into bamboo vessels called *dhungroo* and sealed. Fermentation is allowed to take place for 4 to 7 days at room temperature. The product can be stored for about a week in an air tight container. It is taken as a pickle after mixing with mustard oil, chillies and salt (Tamang and Tamang, 2009a).

Anishi

Native to the state of Nagaland, this product is prepared mainly by the *Ao* tribe. For its preparation leaves of edible yam (*Colocasia* sp.) are used. The fresh mature green leaves are collected and washed properly. They are then piled one upon another and finally wrapped with a banana leaf. They are then left for about 6 to 7 days till the leaves turn yellow. The yellow leaves are then mixed with salt, chilli and ginger and grounded into a paste. This paste is then made into cakes and kept over the fireplace in the kitchen. After 2 to 3 days of drying they become ready for consumption. It is used as a condiment and is usually cooked with dry meat, especially pork (Mao and Odyuo, 2007).

Fermented Bamboo shoot

This is another fermented product which is extensively used in the states of North-East India and bears resemblance to *jiang-sun* (Chen *et al*., 2010) and *kardi* in Orissa, India. It is mainly used as a taste enhancer and flavour provider. Many varieties of bamboo are used separately by the different tribes using their own traditional techniques.

Soibum/ Soidon

These are fermented bamboo shoot products and are indigenous foods of the state of Manipur. They are consumed as an indispensible part of the *Manipuri* diet and are familiar with the social customs of the people. *Soibum* is produced exclusively from succulent bamboo shoots of the species *Dendrocalamus hamiltonii, D. sikkimensis, D. giganteus, Melocana bambusoide, Bambusa tulda* and *B. balcona.* The process of fermentation is carried out from the months of June to September when bamboo shoots sprout. The sites known for the production of *soibum* in Manipur are located mostly in the hills and are subjected to the availability and abundance of the raw material (Jeyaram *et al*., 2009; Bhatt *et al*., 2003). The organisms found to be associated with the fermentation of *soibum* have been identified as *Lactobacillus plantarum, L. brevis, L. coryniformis, L. delbrueckii, , L. lactis, Leuconostoc falllax, L. mesentroides, Enterococcus durans, Streptococcus lactis, Bacillus subtilis, B. licheniformis, B. coagulans,* and the yeasts *Candida* sp.*, Saccharomyces* sp.*, Torulopsis* sp.(Tamang and Tamang, 2009a ; Tamang *et al*., 2008).

Two types of fermentation procedures are followed for *soibum* preparation, namely *noney/ kwatha* type and *andro* type. In both the methods, the outer inedible and hard casings of succulent bamboo sprouts are peeled off and the soft portions are chopped and pressed tightly into wooden or earthen pots and left to ferment for 6-12 months. The *noney/ kwatha* type is the more preferred one which is batch type fermentation that results more acidic product with more acidic taste and is carried out in traditionally designed bamboo chamber which is covered with leaves of wild plants or polythene sheet. Slices of succulent and soft bamboo shoots are packed tightly into this bamboo chamber. After being filled to the full of its capacity the upper opening of the basket is sealed with polythene sheet and weights laid upon it to make the sealing intact. The bottom of this basket is perforated in order to allow seepage of the acidic juices produced during fermentation. The setup is left in this manner for 6-12 months for proper solid stage fermentation to take place. The product after completion of fermentation can be stored for more than a year. *Andro* type of fermentation is practiced only in Andro village of Manipur. In this process fed batch type of fermentation is carried out in bulky roasted earthen pots. A portion of the pot is first filled with bamboo shoot slices and fermentation is allowed to occur. After the mash volume gets reduced due to fermentation, additional slices of bamboo shoot are added and pressure is applied from

above to compact the mass. This process is continued until the pot is filled to the top and then it is kept for a period of 6-12 months. Here the juices are not allowed to drain out (Jeyaram *et al*., 2008a). The product is whitish in colour with faint aroma and sour taste. The prepared *soibum* is commonly sold in local vegetable markets exclusively by *Maitei* women. It is generally consumed with steamed rice as a side dish. It is also cooked with *Colocasia* sp corms, green peas, pumpkins, potatoes, etc in different recipes like chutney. Some people also fry it with fishes (Jeyaram *et al*., 2009; Tamang and Tamang, 2009a).

When the apical meristems of succulent bamboo shoots are fermented, the product is known as *soidon*. The species used are *Teinostachyum wightii, Bambusa tulda* Roxb., *Dendrocalamus giganteus* Munro, *Melocana bambusoide* Trin. (Jeyaram *et al*., 2009; Tamang and Tamang, 2009a). Species of *Lactobacillus brevis, Leuconostoc fallax* and *L. lactis* have been found to be associated with its fermentation (Tamang *et al*., 2008).

For preparing *soidon*, the tips of mature bamboo shoots are collected and the succulent tender meristems are taken out by removing the outer castings and the lower portions. The tips are then cut transversely into pieces and submerged in water in an earthen pot. Milky fermented sour liquid (*soijim*) of previous batch is added in 1:1 dilution to this mixture as a starter culture. Leaves of the locally available plant named *heibung* (*Garcinia pedunculata*) may be added to the fermentation mixture as an acidifier and also to enhance the flavour. Rice washed water called *chenghi* may sometimes be added in 1:10 dilution to improve the colour. The pot is covered and fermentation is allowed to take place for a period of 3-7 days. After this period the *soidon* is ready to be consumed. It can be kept for a period of up to one year if stored in plastic containers at room temperature (Jeyaram *et al*., 2009; Tamang and Tamang, 2009a). *Soidon* is consumed as a as well as pickle. The liquid part of it may also be used as a condiment to supply the sour taste in curry (Tamang and Tamang, 2009a).

Lung-seij

This ethnic fermented bamboo shoot product belongs to the state of Meghalaya and is produced mainly by the *Khasi* women. It is prepared from *Dendrocalamus hamiltonii* species of bamboo available locally in Meghalaya. To prepare *lung-seij*, 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. The protein content of the fermented product has been found to be 8.5 gm% which is more than unfermented bamboo shoots. It is consumed as a curry by mixing with meat or fish (Agrahar-Murungkar and Subbulakshmi, 2006; Tamang and Tamang, 2009a).

Mesu

Mesu is a fermented bamboo shoot product indigenous to the people of Himalayan regions of Darjeeling hills and Sikkim. It is prepared only during the months of June to September when Bamboo shoots sprout. The species of bamboo used are the locally available *choya bans* (*Dendrocalamus hamiltonii* Nees and Arnott), *bhalu bans* (*D. sikkimensis* Gamble) and *karati bans (Bambusa tulda* Roxb). Its chief producers are the *Limboo* women belonging to *Nepali* community (Tamang and Sarkar, 1996; Tamang and Tamang, 2009a; Sekar and Mariappan, 2007). Microbial analysis of young bamboo shoots demonstrated the presence of *Lactobacillus plantarum, L. brevis* and *L. pentosaceus*. It was found that *L. pentosaceus* was the initiator of fermentation, followed by *L. brevis* and finally dominated by *L. plantarum* (Tamang and Sarkar, 1996).

In order to carry out the fermentation of *mesu,* young edible shoots of the bamboo plant are defoliated, chopped finely and pressed tightly into green hollow bamboo stem. The opening of this bamboo is covered tightly with leaves of bamboo or other wild plants. This is then left to ferment at room temperature (20-

water is then poured upon the mixture and the brew that drips at the end is collected. The first draw is called *tokti* which is the strongest and the subsequent blackish brew is called *ennog* (Tiwari and Mahanta, 2007).

Atingba

The people of the state of Manipur prepare this alcoholic beverage called *atingba* from glutinous rice. The starter culture used for the preparation of *atingba* is called *hamei*. The recipes for their preparation are being kept secret and passed on from generation to generation (Jeyaram *et al*., 2008b).

To prepare *hamei* raw rice is crushed with powder of barks of the plant *yangli* (*Albizia myriophylla*) (0.25 kg per kg of rice) along with water to form a dough like mass. To this is added powdered *hamei* of previous batch and mixed well. This is then made into flat cakes of approximately 2-7 cm in diameter and 0.6-1.5 cm thickness. They are then kept over rice husks in the floor or bamboo baskets for 2 to 3 days at room temperature. After fermentation the cakes swells, produces alcoholic flavour and yellowish coloration. They can be dried and stored for up to a year (Tamang *et al*., 2007; Jeyaram *et al*., 2008b; Jeyaram *et al*., 2009). The lactic acid bacteria isolated from samples of *hamei* have been identified as *Lactobacillus plantarum* and *Pediococcus pentosaceus* (Tamang and Nikkuni, 1998). The fungal agents associated with fermentation have been found to be *Saccharomyces cerevisiae, Pichia anomala, P. guilliermondi, P. fabianii, Candida tropicalis, C. parapsilosis, C. montana Torulaspora delbrueckii and Trichosporon* sp. (Jeyaram *et al*., 2008b).

For the production of *atingba,* glutinous rice is first cooked, cooled and mixed with crushed *hamei* (5 cakes for 10 kgs). The mixture is the fermented in solid state in mud pots covered with '*hangla*' (*Alocasia* sp.) leaves for 3-4 days during summer and 6-7 days in winter. This is followed by 2-3 days of submerged fermentation in earthen pots. The beverage which is obtained after filtration of the fermented product is called *atingba* (Jeyaram *et al*., 2009).

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 *khaw-iang* (*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 *shet-kiad* 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).

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).

For 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* along with 2 to 3 *mod pithas*. The grounded powder is sieved in a *saloni* and the fine powder obtained is taken in a metallic

25^0C) for a period of 7-15 days. The completion of fermentation is indicated by the emission of a particular flavour. Fresh *mesu* has a shelf life of only about a week. However *mesu* is commonly used as a pickle by mixing it with salt, chilli and mustard oil, which can be stored for more than a year without refrigeration. *Mesu* is also used for preparing curry by frying and mixing with cooked meat (Tamang and Sarkar, 1996; Tamang and Tamang, 2009a).

Bas-tenga

Bas-tenga which means "sour bamboo" is the fermented form of bamboo shoots and produced by the *Nagas* of Nagaland. The fermentation process is carried out during the months of May to June when the new shoots are formed. The young and tender bamboo shoots of locally available bamboo are collected and the sheaths are removed. They are then sliced or pounded to into small pieces. A conical bamboo basket is taken and a hole is made at the bottom (tapered end) and a pointed bamboo stick which is a little longer than the length of the basket is inserted into the hole passing through the centre. The inner wall of this basket is lined with bamboo leaves. The sliced bamboo shoots are then put in this basket which is tied to a post and the upper portion is covered with banana leaves and stones placed above them as weights. The bamboo stick helps in the seepage of the juices/sap, which is twisted and turned from time to time in order to allow proper drainage of the juices. The juices are collected at the bottom in a container. The fermentation of the shoots and the juices takes place separately within a week (Mao and Odyuo, 2007).

The shoots can be stored in hollow internodes of bamboo with the open end plugged with leaves or wooden vat and the whole thing covered by banana leaves. The juice may also be stored in jar made of gourd which is used by the *Nagas*. The fermented shoots may also be dried in the sun which gives a different aroma and longer shelf life. All the above products are used in the preparation of meat, fish or other vegetable dishes. The juice also has a preservative property similar to vinegar and dishes cooked with it have longer shelf life (Mao and Odyuo, 2007).

Ekung/ Hirring

This is an ethnic fermented bamboo shoot product of the state of Arunachal Pradesh. It is called as *ekung* by the *Nyishing* tribe and *hirring* by the *Apatani* tribe of Arunachal Pradesh. It is prepared from mid April to early September when young bamboo shoots sprout. The species of bamboo used are *Dendrocalamus hamiltonii* Nees. et Arn. ex Munro, *D. giganteus* Munro, *Bambusa balcooa* Roxb., *B. tulda* Roxb and *Phyllostachys assamica* Gamble ex Brandis (Tamang and Tamang, 2009a; Tamang and Tamang, 2009b). The microbes associated with its fermentation have been found to be *Lactobacillus plantarum, L. lactis, L. brevis, L. casei* and *Tetragenococcus halophilus* (Tamang and Tamang, 2009a; Tamang and Tamang, 2009b).

The young and tender shoots of bamboo plant are collected and the outer sheaths removed and the edible part is chopped into very small pieces. A pit is dug in the ground and a bamboo basket is laid on it and lined with leaves. The basket is filled with chopped shoots, covered with leaves and then sealed. Heavy stones are laid upon the basket to drain off the excess water. They are then fermented for 1-3 months. The product can be stored for a year in air tight containers. It is consumed raw or cooked with meat, fish or vegetables. Sometimes this product is again cut into small pieces and dried in the sun for 5-10 days until the colour changes from whitish to chocolate brown. This can be stored up to 2 years at ambient temperature (Tamang and Tamang, 2009a).

Miya mikhri

It is produced by the *Dimasa* tribe of Assam. For its preparation, the bamboo shoots are collected, cleaned and cut into small pieces. They are then wrapped in banana leaf and kept inside an earthen pot. This pot is then left at room temperature for 4-5 days at room temperature. After the emission of smell, the shoots are shifted to a glass container. This can be stored for about a year. *Miya mikhri* can be taken as a pickle or even mixed with curry (Chakrabarty *et al*., 2009).

Fermented fish

Many tribes of North-East India prepare fermented fish, generally from the locally available small species of freshwater fish. Other products of this kind are *nampha* of Thailand, *patis* of Philippines and *kaomi* and *ounago* of Japan (Crisan and Sands, 1975).These products with their exquisite taste and smell serve as a source of protein in the diets of the people. Some of them are mentioned here.

Ngari

The fermented fish product *ngari* forms an intrinsic part of the diet of the *Manipuri* people in Manipur. The methods of preservation are traditionally used with cultural identity and these household arts are handed down through generations. The fish species

used for its preparation is *Puntius sophore* and they are used in the sun dried form called as *phoubu* (Jeyaram *et al*., 2009). Lactic acid bacteria are the chief fermenting organism found in samples of *ngari.* The species identified are *Lactococcus plantarum* and *Lactobacillus plantarum. Bacillus subtilis, B. pumilus* and *Miocrococcus* sp. have also been isolated from *ngari.* The fungal isolates have been identified as that of *Candida* sp. (Thapa *et al*., 2004).

The preparation of *ngari* is mostly confined to small-households in the villages. The fishes are incurred directly from the local fish ponds or imported from the Brahmaputra valley. Moreover, it is practised more frequently in the fishing seasons i.e. October to January when *Puntius* fish are easily available. The fishes as a whole are washed and intact ones are selected. They are then dried in the sunlight for 3-4 days. When the fishes become semi-dried, they are rubbed with some amount of essential oils like mustard oil or fish oil and little amount of salt is added to help absorb the oils into the fish body. The dried fishes are then used for fermentation directly or stored in gunny bags for further use. When stored fishes are used for fermentation, they are first washed with water in a porous bamboo basket and the water is allowed to drain for one night. The fishes are then placed in gunny bags and pressed in order to remove the excess water and break the head and bones. The fishes are then put in earthen pots called *chaphus* previously maintained by smearing mustard oil. For new pots 8-10 times oil coating are required at an interval of 7-8 days whereas in old pots only one coating is required. The oil coating may be to create an anaerobic condition inside the pot. After packing the fish tightly in the pots, they are sealed with polyethene sheet, fish scales, oil smear, mud and cow dung slurry. The mouths of the *chaphus* are filled with cover paste and finally overlaid with cover leaf. The pots are then kept in the dark at room temperature for about 4-6 months. At this time the fermented fished becomes ready for consumption and are also locally known as *chaphu kaiba*. It has a characteristic smell and has a shelf life of 12-18 months (Jeyaram *et al*., 2009; Singh *et al*., 2010).

Most strains of LAB isolated from *ngari* had a high degree of hydrophobicity, indicating their probiotic characters (Thapa *et al*., 2004). It is used for preparing different delicacies like *eromba* where it is added either after frying or steaming. It is also consumed as a side dish with rice (Singh *et al*., 2010).

Hentak

It is another fermented fish product prepared in the state of Manipur. It comes in the form of paste (Jeyaram *et al*., 2009). The microorganisms associated with *hentak* have been identified as *Lactobacillus fructosus, L. amylophilus, Enterococcus faecium, Bacillus cereus, B. subtilis, Staphylococcus aureus, Enterococcus faecium* along with fungus of *Candida* sp (Thapa *et al*., 2004).

For the preparing of *hentak*, fishes of the species *Esomus danricus* are first dried in the sun. They are then crushed to powder in a mortar-pestle. On the other hand, petioles of the aroid plant (*Alocasia macrorhiza*) are cut into small pieces, washed with water and exposed in the sunlight for about an hour. Now equal weights of both the fish powder and the plant material are mixed and crushed together in order to make a paste. These are then made into small balls and transferred into earthen pots. These pots are left at room temperature for fermentation to take place. The process takes about two weeks after which the product becomes ready to be eaten. These balls become hardened on being stored for a few months, which can then be propounded to paste with a little water and stored as balls for reserved food (Jeyaram *et al*., 2009).

Hentak is consumed as a curry as well as a supplement with boiled rice. Sometimes it is given to women in the final stages of their pregnancy (confinement) or patients recovering from sickness or injury (Sarojnalini and Singh, 1988).

Tungtap

This is indigenous to the *Khasi* tribe of Meghalaya. It is made at the household and village level and is sold throughout the district mostly at the weekly markets (Sekar and Mariappan, 2007; Agrahar-Murungkar and Subbulakshmi, 2006). The microbes found in *tungtap* have been identified as *Lactobacillus coriniformis, L. lactis, L. fructosus, Bacillus cereus, B. subtilis, Candida* sp.*,* and *Saccharomycopsis* sp. (Thapa *et al*., 2004).

Fishes of the species *Puntius sophore* are used for the preparation of *tungtap*. The fishes are washed, scaled and degutted initially followed by application of salt throughout the body, on the inside as well on the outside. They are then transferred to a clay pot which is subsequently filled with a mixture of salt and fish/ pork fat. The pot is then covered with banana leaf and tied tightly around the rim using a jute cord. The pot is then stored at room temperature for a period of 6-7 months. At the end of incubation period, the cord is untied and the fish is taken out, the extra salt and fat is removed with the help of a sharp knife (Agrahar-Murungkar and Subbulakshmi, 2006).

The protein and fat content of *tungtap* is 40.6%

and 19.6 g% respectively on a dry weight basis. The process of fermentation enhances the palatability of the small fishes, basically by softening the bones and improving the flavour and texture of the meat. The final product has a soft spongy texture and is commonly used in the form of *chutney* with green leaves, onions, and chillies (Agrahar-Murungkar and Subbulakshmi, 2006). *Tungtap* is also taken as a side-dish in the form of pickle (Sekar and Mariappan, 2007).

Gnuchi

Gnuchi is a smoked and dried fish product commonly eaten by the *Lepcha* community of Sikkim. The word *gnuchi* means smoked fish in the *Lepcha* language. It serves as an important source of protein in the local diet and is prepared using indigenous knowledge of the rural people. The fished used for its preparation are *Schizothorax richardsonii* Gray, *Labeo dero* Hamilton, *Acrossocheilus* spp., *Channa* sp., etc. The microorganisms associated with *gnuchi* fermentation have been identified as *Enterococcus faecium*, *Pediococcus pentosaceus*, *Bacillus subtilis* and *Micrococcus* sp. (Thapa *et al*., 2006).

For its preparation, the fishes are first kept on a big bamboo tray called *sarhang* to drain off the water, degutted and mixed with salt and turmeric powder. They are then hung one after the other in a bamboo stripe above the earthen-oven and smoked for 7–10 days. It is then ready to be consumed. It can be kept at room temperature for 2-3 months. It is made into curry with vegetables and eaten with boiled rice. It has a protein content of 21.3 g% on dry weigh basis (Thapa *et al*., 2006).

Fermented beans

Fermented foods made from legumes constitute an important part of the human diet in many developing countries, including India (Sandhu and Soni, 1989). Fermented soybean products have been reported to be used extensively in almost all the states of North-East India and bears resemblance to *tou-shi, hamanatto, chiang-yu, shi-tche, chiang* and *tofu* of China, *tempe kedele, kecap* and *taoco* of Indonesia, *shoyu* and *miso* of Japan (Wang and Fang, 1986; Nout, 1995). The whole grains contain flavinoids, terpenoids and other natural antioxidants like carotene, ascorbic acid and tocipherol. An increase in the content of crude protein and a decrease in fat content have been observed in some traditionally fermented bean product. Also, a significant decrease in crude fibre content has been observed (Gupta and Nagar, 2010). The high crude protein content may be attributed to the microflora developed during the fermentation process (Gupta *et al*., 2007).

Kinema

Kinema is a soybean based fermented food. The soybean (*Glycine max*) is locally known as *bhatmas* and the varieties used are "yellow cultivar" and "dark brown cultivar". It is produced individually or on household level and sold in the local markets. It is extensively prepared by the *Nepalis* belonging to the *Limboo* and *Rai* castes of Sikkim. The produce is sticky in nature and has an ammonical flavour. The skill of production of this delicacy has been protected as a hereditary right and passed from one generation to another (Tamang *et al*., 2009). It is produced by the natural fermentation of bacterial species namely *Bacillus subtilis* and *Enterococcus faecium*. The fungal species *Candida parapsilosis* and *Geotrichum candidum* have also isolated from commercially available *kinema* (Sarkar *et al*., 1994).

For preparation of *kinema*, soybeans are soaked overnight followed by boiling to soften them. The excess water is drained off and the cotyledons are split open by grinding lightly in a wooden mortar (*okhli*) and pestle (*muslo*). This is done to increase the surface area for speedy fermentation. Then about 1 % of firewood ash is added in order to maintain an alkaline condition. Soybean grits are then placed on a bamboo basket lined with fresh fern (*Glaphylopteriolopsis erubescens*). The basket is then covered with a jute bag and left to ferment naturally at ambient temperature (which is about 20–35^{0}C in Sikkim). The whole thing is placed over an earthen oven and left for 1-2 days after which the completion of fermentation is indicated by the appearance of white viscous mass upon the soybeans and the release of ammonical odour. Its shelf life is 2-3 days in summer and 5-7 days in winter (Tamang *et al*., 2009). The indigenous knowledge of microbiology is correlated by the practice of not cleaning up the mortar and pestle to preserve and supplement the microorganisms for spontaneous fermentation without the use of starter cultures (Tamang, 2003).

Water soluble nitrogen, formal nitrogen to total nitrogen and ammonia (upto 200 mg/100 gm) concentration of *kinema* rises rapidly during fermentation as a result of the high proteolytic activity of *Bacillus subtilis.* This leads to the release of free amino acids followed by de-amination. The final pH of the produce may be as high as 8.6 (Tamang and Nikkuni, 1998; Sarkar *et al*., 1993; Sekar and Mariappan, 2007). It serves as a major source of protein in the diet of the people of this region. *Kinema* contains about 48% (dry weight basis) of crude protein

and the free amino acids accounts to approximately 26 % of total amino acid content (Sarkar *et al*., 1997; Sarkar *et al*., 1994). *Kinema* is eaten as a curry with boiled rice. The curry is prepared by frying the *kinema* in vegetable oil followed by mixing with chopped onions, tomatoes and turmeric powder. They are then fried for about 2 minutes. Then salt and sliced green chillies are added and fried for 3-5 minutes. A little water is added to make thick gravy, and cooked for 5-7 minutes (Tamang *et al*., 2009).

Hawaijar

Produced in the state of Manipur, *Hawaijar* is a sticky fermented soybean product. Its name is derived from "*hawai"* meaning pulses and "*jar" which is* shortened form of *achar*, meaning pickle (Jeyaram *et al*., 2009; Premarani and Chhetry, 2010). It constitutes an important part of the diet of *Meitei* people since several last decades. The Brahmin community of Manipur is believed to have started the production and consumption of this delicacy. In Manipur soybean is known as *nung hawai* (*nung* = stone, *hawai*= legumes/ pulses) and two varieties, viz. the local variety with small seeds and the bigger, round seeded variety are used for the preparation on *Hawaijar.* The produce is brown in colour and covered with a white slimy substance (Jeyaram *et al*., 2009). The species *Bacillus subtilis, B. licheniformis, B. cereus, Staphylococcus aureus, S. sciuri, Alkaligenes* sp. and *Providencia rettger* have been found to be predominantly present in the fermented *hawaijar* (Jeyaram *et al*., 2008a).

For its preparation, soybean seeds are soaked overnight after which they are washed thoroughly with water and boiled till the seeds become soft. They are then washed with hot water and packed tightly in a small bamboo basket (*lubak*) with a lid. The base of the basket is layered with the leaves of fig plant (*Ficus hispida)* or banana plant *(Musa* sp.*)* leaves. The basket is then wrapped with a jute cloth and kept in the sun or near to stove or buried in paddy. This helps in maintaining the optimal temperature (> 40^0C) required for fermentation to take place. The fermented product becomes ready for consumption after 3-5 days. The final product is brown in colour, has a sticky texture and emits ammonia like odour. The fermented product is then wrapped with banana leaves for storage (Jeyaram *et al*., 2009; Premarani and Chhetry, 2010; Tamang *et al*., 2009).

Hawaijar has a very short shelf-life of 3-4 days. Hence, the product is sometimes dried in the sun for long-term storage. *Hawaijar* is known for its unique organoleptic properties. A special delicacy of the *Manipuris* called *chagempomba* is prepared using *hawaijar*, rice and other vegetables. It is also eaten as a paste with chilli and salt and is known as *ametpa.* A fermented fish product called *ngari* is sometimes added to *ametpa* to enhance the flavour. *Hawaijar* is also added while cooking other vegetables (Premarani and Chhetry, 2010).

Tungrumbai

The *Khasi* tribe of Meghalaya prepares *tungrumbai,* which is also a soybean *(Glycine max* L.Merril*)* based fermented food and is very common. It is sticky in nature and serves as a cheap source of protein in the diet of the masses. The bacterial species found to be associated with *tungrumbai* fermentation are *Bacillus subtilis* and *Enterococcus faecium*. The fungal strains have been identified as *Candida parapsilosis, Saccharomyces bayanus, Saccharomycopsis fibuligera* and *Geotrichum candidum* (Sohliya *et al*., 2009; Sarkar *et al*., 1994). Its production is still a traditional art carried out by local *Khasis* at the household level and various centres in the state (Agrahar-Murungkar and Subbulakshmi, 2006).

For preparing *tungrumbai* the soybean seeds are cleaned, washed and soaked in double the quantity of water for about 4-6 hours. The outer skins of the beans are then removed by rubbing them in between the palms. The soaked beans are then cooked in the same water for about 1 hour till all the water is absorbed. The cooked beans which can now be pressed easily are allowed to cool. They are then placed on a bamboo basket the inner surface of which is lined with leaves of *Clinogyne dichotoma* locally known as *lamet.* The whole basket is then covered with *lamet* leaves or jute bags in order to prevent contact with air. They are then left to ferment either in the ambient temperature (25 –40^0C) or near the fire place in order to provide the necessary temperature for fermentation to take place. The incubation time is usually 3-4 days after which the fermented product is obtained as a brown mass with a characteristic odour (Agrahar-Murungkar and Subbulakshmi, 2006; Sohliya *et al*., 2009; Tamang *et al*., 2009). The fermenting organisms i.e. LAB and yeast have been found to be supplied by the water source. Also some of the bacteria have been found to be present in the raw soybeans and the *lamet* leaves (Sohliya *et al*., 2009).

The protein content in *tungrumbai* has been found to be 45.9 g % on a dry weight basis. Whereas, fat, fibre and ash have been found to be 30.2, 12.8 and 5.5 g % respectively (Agrahar-Murungkar and Subbulakshmi, 2006). *Tungrumbai* is usually taken as a side dish with rice. For preparation of curry, *tungrumbai* is put into a container with water and

boiled till water evaporates and stirred continuously. It is mixed with fried, ginger, garlic, chilli, grinded black sesame and salt (Tamang *et al*., 2009).

Aakhone/ Bekang / Peruyyan

These are all fermented soybean products and known by different names among different tribes. They are prepared from soybean (*Glycine max* (L.) Merril). Lactic acid bacteria, *Bacillus subtilis* and other *Bacillus* species have been found in these samples. For preparation, the beans are first soaked in water, washed and boiled until they become soft. The excess water is then drained out. The cooked beans are then wrapped in leaves of either banana (*Musa* sp.) or *Phrynium pubinerve* Blume or *Macaranga indica* Wight or *Calliparpa aroria*, and kept over the fire place in order to provide the optimum temperature. The whole process of fermentation takes about a week. They are then ready to be taken. It is known as *aaknone* in Nagaland, *bekang* in Mizoram and *peruyyan* among the *Apatanis* of Arunachal Pradesh. For long term storage they can be kept above the fireplace by moulding into pastes or in the form of cakes. Sometimes individual beans are separated, dried in the sun and stored in containers. The fermented product with its characteristic odour can be used in the preparation of chutney along with chilli, tomato and salt. It can also be cooked along with meat to give flavour and taste to the dish (Mao and Odyuo, 2007; Tamang *et al*., 2009).

Fermented alcoholic beverages

Fermented alcoholic beverages of different forms have been reported to be consumed by the tribal people of North-East India since time immemorial. These products are similar to *shaosingiju* and *lao-chao* of China, *sake* of Japan, *chongju* and *takju* of Korea, *brem bali* and *tape-ketan* of Indonesia, *tapuy* of Indonesia, *khaomak* of Thailand and *tapai pulul* of Malaysia (Lee, 2009). This practice has its roots in many cultural and religious practices of the people of this region and practically has no ill effect upon the health of the hard working population. Some of them are mentioned here.

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 is emits a strong alcoholic smell. The stock is diluted with water before consumption (Tiwari and Mahanta, 2007).

Ennog/ Sai Mod

It is a form of black rice beer which is prepared and consumed by the tribal people of Arunachal Pradesh and the *Mishings* of Assam (Tiwari and Mahanta, 2007). Rice is first boiled and spread on a bamboo mat to cool. Simultaneously, paddy husk is filled into a large tin sheet or drum and allowed to burn slowly and evenly till they become black. The burnt husk, while still hot is mixed with the boiled rice and allowed to cool. After cooling, the mixture is again mixed with crumbled *ipoh* cakes. They are then transferred to a conical bamboo basket lined with leaves of *ekkam* (*Phryium capitulum* Wild). The whole basket is then covered with leaves and left to ferment for a period of 3 days when strong alcoholic smell is emitted. Now, the mixture is transferred to another U-shaped bamboo basket called *perop* lined with *ekkam* leaves. The basket is covered with more leaves and a piece of wood is placed on its top and a stone upon it for proper sealing. Fermentation is allowed to take place for a period of 10 days after which the beer becomes ready for filtration. For filtration, about 2 kilograms of the mixture is loaded into a cylindrical bamboo tube called *petok* which is fitted with a small opening at one end. Boiling hot

utensil. To this water id added and a paste is made by mixing. This is again made into small round cakes which are kept on clean and dry paddy straws called *kher* spread on a round bamboo utensil called *kula* and again covered with *kher.* The *kula* is then kept on a rectangular frame made of bamboo called *dhua-sang* above the fireplace. Upon drying the *mod pithas* become hard and they can be stored for 2 to 3 months. For brewing *sujen,* 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).

Kodo ko Jaanr

The tribal people of Sikkim prepare *kodo ko jaanr* from dry seeds of finger millet (*Eleusine coracana*), locally called *kodo.* It constitutes an integral part of dietary culture and religious beliefs among the ethnic people in the Sikkim (Tamang *et al*., 1996; Sekar and Mariappan, 2007). A traditionally prepared mixed inocula or starter called *murcha* is used for its preparation. The microbes associated with *murcha* and *kodo ko jaanr* has been identified as *Mucor cicinelloides, Rhizopus chinensis, R. stolonifer* var. *lyococcus*, *Saccharomyces cerevisiae, S. bayanus, Hansenula anomala, Pediococcus pentosaceus, Lactobacillus sp., Candida glabrata, Saccharomycopsis capsularis, S. fibuligera, Pichia burtonii, P. anomala, Cryptococcus* sp., *Trichosporon* sp., *Debaryomyces* sp., *Kluyveromyces* sp., *Myxozyma* sp., *Bullera* sp., *Rhodotorula* sp. and *Tremella* sp. (Tamang and Sarkar,1995; Tsuyoshi *et al*., 2005; Tiwari *et al., 2007;* Sekar and Mariappan, 2007).

For preparing *murcha,* glutinous rice is soaked in water for 6 to 8 hours and pounded on a foot-driven heavy wooden mortar and pestle. To 1 kg of the grinded rice, is added roots of *Plumbago zeylanica* L.(2.5 g), leaves of *Buddleja asiatica* Lour (1.2 g) flowers of *Vernonia cinere* Less (1.2 g), *Gingiber officinale* (5.0 g), red dry chilli (1.2 g) and previously prepared *marcha* (10.0 g).The mixture is kneaded into flat cakes placed on a bamboo mat lined with fresh fronds of ferns [*Glaphylopteriolopsis erubescens* (Wall ex Hook.) Ching] and covered with dry ferns and jute bags. This is placed above the kitchen and allowed to ferment for 1 to 3 days. These are then sun-dried for 2 to 3 days. The product is called *murcha* and can be stored in a dry place for more than a year (Tsuyoshi *et al*., 2005).

For preparing *kodo ko jaanr*, seeds of finger millet are cleaned, washed and cooked for about 30 min. Excess water is drained off and cooked millets are spread on a bamboo-mat called *mandro* for cooling. About 1 to 2% of powdered *marcha* is sprinkled over cooked seeds, mixed thoroughly and packed in a bamboo basket lined with fresh fern *(Thelypteris erubescens*), locally called *thadre unioon* or banana leaves, then covered with jute clothes, and kept for 2-4 days at room temperature. After this, the mass is transferred into an earthen pot or into specially made bamboo basked called *septu* and made air-tight. This is then fermented for 3 to 4 days during summer and 5 to 7 days in winter at room temperature. About 200-500 g of the fermented mass is put into a vessel called *toongbaa* and lukewarm water is added up to the edge of it. After about 10 to15 minutes, milky white extract of *jaanr* is sipped through a narrow bamboo straw called *pipsing* having a hole in a side near the bottom to avoid passing of grits. Water can be added 2-3 times after sipping up the extract (Singh and Jain, 1995; Tamang *et al*., 1996).

Xaj - pani

The *Ahoms* of Assam prepare a kind of rice beer which they locally call as *xaj-pani.* It is the most important beverage which is used frequently in religious rites and rituals practised among the *Ahoms.* They also use it during the *Bihu* festivals as a refreshing drink and also taken after hard labour. 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 dulsis* Linn., *Cinamommum 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 cerevisae* 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).

Zutho

Zutho is rice beer produced from sprouted rice grain by the *Angami* tribe belonging to Nagaland. *Saccharomyces cerevisiae* is the dominant microflora in the fermentation of *zutho* (Teramoto *et al*., 2002; Sekar and Mariappan, 2007). For preparing *zutho*, un-hulled glutinous rice grains are soaked in water for 3 days, then the water is drained off and the rice is allowed to germinate for 3-4 days in summer and 7 days in winter. The sprouted rice grains along with the hulls are then pounded in a wooden mortar and pestle to produce the grist. Along with polished glutinous rice grains are soaked in water. After drainage of the water, they are pounded in a wooden mortar pestle. To this rice powder is added boiling water (5 litres to 3 kgs) bit by bit with agitation. This soft rice porridge is allowed to cool and mixed with one handful of the grist in summer and two handfuls in winter. Fermentation of the mash is allowed to proceed in a wooden vessel for 2 to 3 days in summer and 7 days in winter. Then a portion of water is added to the fermented mash and strained through a bamboo basket. The filtrate is known as *jutho*. It is off-white slurry with alcohol content, pH and acidity of 5.0%, 3.6 and 5.1, respectively (Teramoto *et al*., 2002).

The *Zeme Naga* tribe of North Cachar Hills of Assam also prepares their local beverage in a similar manner and their product is called by the name of *dekuijao* (Chakrabarty *et al*., 2009).

Judima

Another type of rice beer prepared by the *Dimasa* tribe of Assam is *judima*. The starter culture needed for its preparation is known as *humao.* For preparing *humao,* brown rice is soaked in water for 10-12 hours at room temperature. It is then crushed with the barks of *Glycyrrhiza glabra* L. The mixture is then made into am paste by adding water and flat cakes are made out of it. These cakes are sundried and are known as *humao* (Chakrabarty *et al*., 2009).

For preparing *judima,* rice is first cleaned and washed. This is then cooked and dewatered. After cooling it is mixed properly with *humao* in appropriate quantity. This mixture is then spread on a banana leaf for overnight and then transferred to an earthen pot and made partially air tight. Fermentation is allowed to take place at ambient temperature for 3-4 days during summer and 6-7 days during summer. The resultant juices are known as *judima* (Chakrabarty *et al*., 2009).

Others

Kharoli

This is a kind of fermented mustard (*Brassica juncea* or *B. nigra*) seeds chutney and is prepared in the state of Assam. The mustard seeds are washed properly. After proper drying they are grinded and sieved. The powder is then placed over the dorsal side of a banana (*Musa* sp.) leaf which heated over the fire in order to soften it. A little salt is added and the mass is kneaded for about 15 minutes by adding *kolakhar* (indigenous soda water) little at a time. This is made into flattened balls and wrapped with the leaf which is again tied with a string. This parcel is kept in a warm place for about 3 days after which the *kharoli* gets ready. It is a sour favourite among the people of Assam and is eaten as chutney with rice (Hughes *et al*., 2001).

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 is 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).

Conclusion

The North-Eastern states are mostly agrarian with almost two-thirds of the population engaged in agriculture and allied activities. Majority of the land in these states is covered with forests which are rich source natural resources. The fermentation technologies practices by the ethnic people reveal a strong correlation of these people with nature and the assessment of microbial benefits. The rich microbial diversity in various sources of fermented foods and beverages reflects that the indigenous people have been harnessing indigenous microbiota for spontaneous fermentation. Climatic conditions also play major role in the type of fermented foods produced in the temperate, sub-tropical and tropical climates of this region. Besides the food items mentioned here, other products like. Modern science and technological knowledge should be united to produce beneficial results. Development of value added products by selecting productive microbial strains, genetic improvement, process improvement, raw material improvement, improving process control, the use of immobilised systems and/or enzymes, study of probiotic activity and use of genetically modified organisms will lead to industrialization of these food products. Multi-institutional collaborative research will lead to standardization of the fermented food products and increase their shelf life. At present these products are produced only for local consumption. A commercial unit of the traditional fermented foods of the North-Eastern states should be developed which would in turn help in proper marketing of the products in packed form. This would contributes to subsistence of regional economy and prove as a boost to the livelihood of the rural people. Up gradation of the technologies involved can be brought about without damaging the existing form of product. Different kind of neutraceuticals and novel compounds may be produced from fermented foods if proper research is meted out. A database can be developed listing all the fermented foods available in the region, along with their place of origin and production, raw materials used, microorganisms involved, nutritional value and the cost involved. These traditional methods of fermentation and preservation can be commercialised and productivity can be maximised if contributions in terms of financial support and technological development is provided by various governing bodies and institutes.

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