

## Microorganisms and Nutritional value of Ethnic fermented foods and alcoholic beverages of North East India

Jyoti Prakash Tamang\*, Namrata Tamang, Saroj Thapa, Sailendra Dewan, Buddhiman Tamang, Hannah Yonzan, Arun Kumar Rai, Rajen Chettri, Jayasree Chakrabarty & Niki Kharel

Food Microbiology Laboratory, Sikkim Government College, Sikkim University, Tadong 737102, Sikkim  
E-mail: jyoti\_tamang@hotmail.com

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Very few have realized that the North East India is the centre of the diverse food culture comprising fermented and non-fermented ethnic foods and alcoholic beverages. More than 250 different types of familiar and less-familiar ethnic fermented foods and alcoholic beverages are prepared and consumed by the different ethnic people of North East India, which include milk, vegetable, bamboo, soybean, meat, fish, cereal and alcoholic beverages. Diverse microorganisms ranging from filamentous fungi to enzyme and alcohol producing yeasts, lactic acid bacteria, bacilli and micrococci are associated with fermentation and production of ethnic foods and alcoholic drinks. Ethnic foods are fermented naturally, except the alcoholic beverages which are produced by using consortia of microorganisms in the form of dry, cereal-based starter. Diversity within the species of lactic acid bacteria and bacilli has created the ethnic foods with different sensory characteristics. It has demonstrated that functional microorganisms present in the ethnic fermented foods of North East have many biological functions enhancing the health-promoting benefits, bio-preservation of perishable foods, bio-enrichment of nutritional value, protective properties and therapeutic values.

**Keywords:** Ethnic fermented foods, Alcoholic beverages, North East India, Microorganisms

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Geographically North East (NE) India is located within the Eastern Himalayas and Purvanchal Himalayas. The Eastern Himalayan region lies between the latitudes 26° 40'-29° 30' North and longitudes 88° 5' - 97° 5' East and covers a total area of 93,988 km<sup>2</sup> comprising two North East states, viz. Sikkim and Arunachal Pradesh, besides eastern Nepal, Darjeeling hills in India, Bhutan and Tibetan Autonomous Region in China<sup>1</sup>. The Purvanchal Himalayas lie between the latitudes 21° 5'-28° 23' North and longitudes 91° 13'-97° 25' East, covering a total area of 108,229 km<sup>2</sup> comprising hills of Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. The major ethnic groups living in eight states of North East India are: Assam (*Ahom, Bodo, Karbi, Gorkha, Miri, Biate, Hmar, Dimasa, Hrangkhoh, Rabha, Bengali*); Arunachal Pradesh (*Monpa, Sherdukpen, Memba, Khamba, Khampati, Singpho, Adi, Aka, Apatani, Bangni, Nishi, Mishmi, Miji, Thongsa, Nocte, Wancho*); Manipur (*Meitei, Naga, Kuki, Meitei Pangal, Gorkha*); Meghalaya

(*Khasi, Garo, Jaintia, Gorkha*); Mizoram (*Mizo* is the generic name includes three main sub groups *Lushai, Pawi, Lakher*; besides *Gorkha*); Nagaland (*Angami, Chakhesang, Ao, Sema, Rengma, Lotha, Chang, Konyak, Sangtam, Phom, Zeliang, Mao, Maram, Tangkhul, Maring, Anal, Mayao-Monsang, Lamkang, Nockte, Haimi, Htangun, Ranpan, Kolyo, Kenyu, Kacha, Yachimi, Kabui, Uchongpok, Makaoro, Jeru, Somra, Gorkha*); Sikkim {*Ethnic Nepali/Gorkha* which includes *Tamang, Rai, Limboo, Gurung, Bahun, Chettri, Giri, Magar, Pradhan/Newar, Bhujel, Dewan, Sunwar, Khagatay, Sherpa, Kami, Damai, Sarki, Maji, Lepcha, Bhutia, Tibetan*}; Tripura (*Reang, Jamati, Noatia, Kuki, Halam, Chakma, Mogh, Lushai, Bengali*)<sup>1,2</sup>.

Major agro-resources of NE are rice, maize, finger millet, soybeans, leafy vegetables, local varieties of chili, potato, ginger, turmeric, large cardamom, seasonal fruits, edible bamboo shoots, etc., and animal resources are cow, ox, goat, pig, sheep, buffalo, poultry, yak, *joe/churru* (hybrid of cow and yak), and fishes from hill rivers, streams and lakes<sup>1</sup>. Ethnic fermented foods are produced by the ethnic

\*Corresponding author

people from locally available raw materials of plant or animal sources either naturally or by adding starter culture(s) containing functional microorganisms which modify the substrates biochemically and organoleptically into edible products that are cultural and socially acceptable to the consumers<sup>3</sup>. Microorganisms convert the chemical constituents of raw substrates of plant or animal-origins during food fermentation and enhance the nutritional value of the products, improve flavor and texture, preserve the perishable foods and extend the shelf-life, fortify the products with health-promoting bio-active compounds, vitamins and minerals, degrade undesirable compounds and anti-nutritive factors, produce antioxidant components and antimicrobial compounds, and stimulate the probiotic functions<sup>4,5</sup>. The ethnic people of NE have developed the ethnic foods to adapt to the harsh conditions and environment for centuries<sup>6</sup>. More than 250 types (Tables 1-8) of ethnic fermented foods and alcoholic beverages are produced and consumed in NE as staple, curry, side dish, fried, cooked, paste, condiment, pickle, confectionery, soup, drink, masticator, alcoholic and non-alcoholic beverages<sup>1,7</sup>. Daily per capita consumption of ethnic fermented foods and alcoholic beverages in Sikkim was 163.8 gm representing 12.6 % of total daily diet<sup>8</sup>. However no such data is available for other states of NE. Ethnic fermented foods of NE are classified into fermented soybean and non-soybean legume foods, fermented vegetable and bamboo shoot foods, fermented cereal foods, fermented and smoked fish products, preserved meat products, non-food mixed amyolytic starters, and alcoholic beverages. Ethnic fermented foods and alcoholic beverages and drinks have been consuming by the ethnic people of North East India for more than 2500 years old as per the historical records<sup>1</sup>. Few of these ethnic foods have been extensively studied and were presented in this paper.

### Fermented soybean foods

**Kinema:**-*Kinema* is a sticky fermented soybean food of *Gorkha/ethnic Nepali* of NE produced by natural fermentation<sup>9</sup>. *Kinema* is similar to other Asians *Bacillus*-fermented sticky soybean foods such as *natto* of Japan, *chungkukjang* of Korea, *thua nao* of northern Thailand, *pe-poke* of Myanmar and *sieng* of Cambodia<sup>10</sup>. During

production, local varieties of soybeans are soaked overnight, boiled, drained off and the cooked soybean seeds are cracked lightly to split the cotyledons. About 1 % of firewood ash is added to the cooked soybeans to maintain the alkaline condition and soybean grits are placed in a bamboo basket lined with locally grown fresh fern (*Glaphylopteriopsis erubescens*), covered in a jute bag and left to ferment naturally (25-40°C) for 1-2 days above an earthen oven kitchen<sup>11</sup>. Shelf-life of fresh *kinema* remains for 2-3 days in summer and 5-7 days in winter without refrigeration. Shelf-life may be prolonged by drying in the sun for 2-3 days. It is eaten as a curry with boiled rice. It is sold in all local markets of Sikkim.

### Microorganisms

*Bacillus subtilis* is a functional bacterium in *kinema* fermentation<sup>12,13,14,15,16</sup>. Other non-bacilli bacterium isolated from *kinema* is *Enterococcus faecium*, along with yeasts *Candida parapsilosis* and *Geotrichum candidum*<sup>12</sup>.

### Nutritional value

Moisture: 62.0 %, pH: 7.9, ash: 7.2 % DM (dry matter basis), protein: 47.7 % DM, fat: 17.0 % DM, carbohydrate: 28.1 % DM, food value: 454 kcal/100 gm DM, total amino acids: 42618.0 mg/100 gm, free amino acids: 5129.0 mg/100 gm, Ca: 432.0 mg/100 gm, Na: 27.7 mg/100 gm, Fe: 17.7 mg/100 gm, Mn: 5.4 mg/100 gm and Zn: 4.5 mg/100 gm<sup>12</sup>. *Kinema* is the cheapest source of plant protein as compared to milk and animal products on the basis of protein cost per kg<sup>9</sup>. Total amino acids, free amino acids and mineral contents are increased during *kinema* fermentation<sup>17,18</sup>. *Kinema* is rich in linoleic acid<sup>19</sup> and contains all essential amino acids<sup>20</sup>. Cholesterol-lowering effect is increased during *kinema* fermentation<sup>19</sup>. Riboflavin and niacin increase in *kinema* during fermentation<sup>21</sup>. *Kinema* has antioxidant activities<sup>11</sup>. Saponin content (Group B): 323.5 mg/100 g<sup>22</sup>.

**Hawaijar:**-*Hawaijar* is a sticky fermented soybean food commonly eaten in Manipur. Soybeans are boiled, packed tightly in a small bamboo basket having lid with a base layer of fig plant (*Ficus hispida*), or banana plant leaves<sup>23</sup>. The basket is kept in kitchen for natural fermentation for 3-5 days. *Hawaijar* is eaten directly or used as a condiment or made into curry. It is sold in local markets by the *Meitei* women.

Table 1—Ethnic fermented soybean and non-soybean legume foods of North East India

Fermented Food	Substrate	Nature of product	Microflora	Major consumers
<i>Kinema</i>	Soybean	Sticky, flavoured; curry	<i>Bacillus subtilis</i>	<i>Gorkha</i>
<i>Hawaijar</i>	Soybean	Sticky, flavoured; side-dish	<i>Bacillus</i> spp.	<i>Meitei</i>
<i>Tungrymbai</i>	Soybean	Sticky, flavoured; curry	<i>Bacillus</i> spp.	<i>Khasi</i>
<i>Tungtoh</i>	Soybean	Sticky, flavoured; pickle	<i>Bacillus</i> spp.	<i>Jaintia</i>
<i>Aakhone/axone</i>	Soybean	Sticky; side-dish	<i>Bacillus</i> spp.	<i>Sema Naga</i>
<i>Bekang</i>	Soybean	Sticky, flavoured; side-dish	<i>Bacillus</i> spp.	<i>Mizo</i>
<i>Peruyaan</i>	Soybean	Sticky, soybeans; curry	<i>Bacillus</i> spp.	<i>Apatani</i>
<i>Bemerthu</i>	Soybean	Semi-solid, soft; Curry	<i>Bacillus</i> spp.	<i>Biate</i>
<i>Maseura</i>	Black gram	Dry, ball-like; condiment	Bacilli, LAB and yeasts	<i>Gorkha</i>

Table 2—Ethnic fermented vegetable and bamboo shoot foods of North East India

Fermented Food	Substrate	Nature of product	Microflora	Major consumers
<i>Gundruk</i>	Leafy vegetable	Dried, sour-acidic; soup, pickle	LAB	<i>Gorkha</i>
<i>Sinki</i>	Radish tap-root	Dried, sour-acidic; soup, pickle	LAB	<i>Gorkha</i>
<i>Sinnamani</i>	Radish	Freshly fermented, sour; pickle	LAB	<i>Gorkha</i>
<i>Khalpi</i>	Cucumber	Sour; pickle	LAB	<i>Gorkha</i>
<i>Goyang</i>	Green vegetable	Freshly fermented; condiment, soup	LAB	<i>Gorkha (Sherpa)</i>
<i>Inziang-sang</i>	Mustard leaves	Dried, sour; soup, curry	LAB	<i>Naga</i>
<i>Inziang-dui</i>	Mustard leaves	Liquid, sour; condiment	LAB	<i>Naga</i>
<i>Anishi</i>	Taro leaves	Fermented; sour; curry	LAB	<i>Ao Naga</i>
<i>Antramthu</i>	Mustard leaves	Dried, acidic; pickle	LAB	<i>Hmar, Biate</i>
<i>Mesu</i>	Bamboo shoot	Sour; pickle	LAB	<i>Gorkha</i>
<i>Soibum</i>	Bamboo shoot	Sour-acidic; curry	LAB	<i>Meitei</i>
<i>Soidon</i>	Bamboo shoot tips	Sour-acidic; curry	LAB	<i>Meitei</i>
<i>Soijim</i>	Bamboo shoot	Liquid, sour; condiment	LAB	<i>Meitei</i>
<i>Ekung</i>	Bamboo shoot	Sour-acidic; curry, soup	LAB	<i>Nishi</i>
<i>Iku</i>	Bamboo shoot	Sour-acidic; curry, soup	LAB	<i>Adi</i>
<i>Hikku</i>	Bamboo shoot	Sour-acidic; curry, soup	LAB	<i>Apatani</i>
<i>Hirring</i>	Only tips of bamboo shoot	Sour-acidic; curry, soup	LAB	<i>Apatani</i>
<i>Hitch/Hitak</i>	Only tips of bamboo shoot	Sour-acidic; curry, soup	LAB	<i>Nishi</i>
<i>Eup</i>	Bamboo shoot	Dry, acidic; curry, soup	LAB	<i>Nishi</i>
<i>Hi</i>	Bamboo shoot	Dry, acidic; curry, soup	LAB	<i>Apatani</i>
<i>Nogom</i>	Bamboo shoot	Dry, acidic; curry, soup	LAB	<i>Khampti</i>
<i>Ipe</i>	Bamboo shoot	Dry, acidic; curry, soup	LAB	<i>Adi</i>
<i>Lung-siej</i>	Bamboo shoot	Sour-acidic; curry	LAB	<i>Khasi</i>
<i>Bastanga</i>	Bamboo shoot	Sour-acidic; curry	LAB	<i>Naga</i>
<i>Tuaitthur</i>	Bamboo shoot	Wet, sour, curry/pickle	LAB	<i>Hrangkhoh, Baite, Hmar</i>
<i>Tuairoi</i>	Bamboo shoot	Dry, sour; curry	LAB	<i>Hrangkhoh, Baite</i>
<i>Miyamikhri</i>	Bamboo shoots	Wet, sour, acidic; curry	LAB	<i>Dimasa</i>

Table 3—Ethnic fermented cereal foods of North East India

Fermented food	Substrate	Nature of product	Microflora	Major consumers
<i>Selroti</i>	Rice-wheat flour-milk	Pretzel-like, deep fried; bread	Yeasts, LAB	<i>Gorkha</i>
<i>Jalebi</i>	Wheat flour	Crispy sweet, deep fried pretzels; snacks	Yeasts, LAB	<i>Gorkha, Bengali</i>
<i>Hakua</i>	Rice	Strong off-flavour; fermented paddy	unknown	<i>Gorkha</i>

Table 4—Ethnic fermented milk products of North East India

Fermented food	Substrate	Nature of product	Microflora	Major consumers
<i>Dahi</i>	Cow milk	Curd; savoury	LAB, yeasts	All
<i>Misti Dohi</i>	Cow/buffalo milk	Sweet curd; savoury	LAB, yeasts	<i>Bengali, Assamese</i>
<i>Shyow</i>	Yak milk	Curd; savoury	LAB, yeasts	<i>Bhutia, Tibetan</i>
<i>Gheu</i>	Cow milk	Butter	LAB, yeasts	All
<i>Maa</i>	Yak milk	Butter	LAB, yeasts	<i>Bhutia, Tibetan</i>
<i>Mohi</i>	Cow milk	Buttermilk; refreshing beverage	LAB, yeasts	<i>Gorkha</i>
<i>Lassi</i>	Cow milk	Buttermilk; refreshing beverage	LAB, yeasts	<i>Gorkha, Bengali, Assamese</i>
<i>Chhurpi</i> (soft)	Cow milk	Soft, cheese-like; curry, pickle	LAB, yeasts	<i>Gorkha</i>
<i>Chhurpi</i> (hard)	Yak milk	Hard-mass, masticator	LAB, yeasts	<i>Bhutia, Lepcha, Monpa, Khamba, Tibetan, Gorkha</i>
<i>Dudh chhurpi</i>	Cow milk	Hard-mass, masticator	LAB, yeasts	<i>Bhutia, Lepcha, Tibetan, Gorkha</i>
<i>Phrung</i>	Yak milk	Hard-mass, masticator	unknown	<i>Monpa, Khamba</i>
<i>Chhu or sheden</i>	Cow/Yak milk	Soft, strong flavoured; curry	LAB, yeasts	<i>Bhutia, Lepcha</i>
<i>Chur yuupa</i>	Yak milk	Soft, flavoured; curry, soup	unknown	<i>Monpa, Khamba</i>
<i>Somar</i>	Cow/Yak milk	Paste, flavoured; condiment	LAB	<i>Gorkha (Sherpa)</i>
<i>Dachi</i>	Cow/Yak milk	Soft, cheese-like, strong flavoured; hot curry	LAB	<i>Bhutia</i>
<i>Philu</i>	Cow/Yak milk	Cream; fried curry with butter	LAB	<i>Bhutia</i>
<i>Pheuja or Suja</i>	Tea-yak butter	Fermented butter tea	unknown	<i>Bhutia, Tibetan, Khamba</i>
<i>Rasogolla</i>	Cow/buffalo milk	Sweet-product, juicy	LAB, yeasts	<i>Bengali</i>

Table 5—Ethnic preserved fish products of North East India

Food	Substrate	Nature of product	Microflora	Major consumers
<i>Suka ko maacha</i>	River fish	Smoked, sun-dried; curry	LAB, <i>Bacillus</i> , yeasts	<i>Gorkha</i>
<i>Sidra</i>	Fish	Dried fish; curry	LAB, yeasts	<i>Gorkha</i>
<i>Sukuti</i>	Fish	Dried fish; curry	LAB, yeasts	<i>Gorkha</i>
<i>Gnuchi</i>	River fish	Smoked; curry	LAB, <i>Bacillus</i> , yeasts	<i>Lepcha</i>
<i>Ngari</i>	Fish	Fermented fish; curry	LAB, yeasts	<i>Meitei</i>
<i>Hentak</i>	Fish and petioles of aroid plants	Fermented fish paste; curry	LAB, yeasts	<i>Meitei</i>
<i>Ayaiba</i>	Fish	Smoked fish; pickle, curry	unknown	<i>Meitei</i>
<i>Tungtap</i>	Fish	Fermented; pickle	LAB, yeasts	<i>Khasi</i>
<i>Karati</i>	Fish	Dried, salted; curry	LAB, yeasts	<i>Assamese</i>
<i>Bordia</i>	Fish	Dried, salted; curry	LAB, yeasts	<i>Assamese</i>
<i>Lashim</i>	Fish	Dried, salted; curry	LAB, yeasts	<i>Assamese</i>
<i>Mio</i>	Fish	Dried; curry	unknown	<i>Apatani, Adi</i>
<i>Naakangba</i>	Fish	Sun-dried; pickle, curry	unknown	<i>Meitei, Kuki</i>

Table 6—Ethnic preserved meat products of North East India

Food	Substrate	Nature of product	Microflora	Major consumers
<i>Lang kargyong</i>	Beef	Sausage-soft or hard, brownish; curry	LAB, Micrococci	<i>Bhutia, Tibetan, Monpa, Khamba</i>
<i>Yak kargyong</i>	Yak	Sausage-soft, brownish; curry	LAB, Micrococci	<i>Bhutia, Tibetan, Monpa, Khamba</i>
<i>Faak kargyong</i>	Pork	Sausage-soft or hard, brownish; curry	LAB, Micrococci,	<i>Bhutia, Tibetan, Monpa, Khamba</i>
<i>Lang satchu</i>	Beef meat	Dried or smoked meat, hard, brownish; LAB, Micrococci curry		<i>Bhutia, Tibetan, Monpa, Khamba</i>
<i>Yak satchu</i>	Yak meat	Dried or smoked meat, hard, brownish; LAB curry		<i>Bhutia, Tibetan, Monpa, Khamba</i>
<i>Suka ko masu</i>	Buffalo meat	Dried or smoked meat, hard, brownish- LAB chocolate; curry		<i>Gorkha</i>
<i>Yak chilu</i>	Yak fat	Hard, used as substitute of an edible oil	LAB	<i>Bhutia, Tibetan</i>
<i>Lang chilu</i>	Beef fat	Hard, used as an edible oil	LAB	<i>Bhutia, Tibetan</i>
<i>Luk chilu</i>	Sheep fat	Hard, used as an edible oil	LAB	<i>Bhutia, Tibetan</i>
<i>Yak kheuri</i>	Yak	Chopped intestine of yak; curry	LAB	<i>Bhutia, Tibetan,</i>
<i>Lang kheuri</i>	Beef	Chopped intestine of beef; curry	LAB	<i>Bhutia, Tibetan,</i>
<i>Bagjinam</i>	Pork	Fermented pork; curry	unknown	<i>Sema Naga</i>
<i>Honohein grain</i>	Pig/boar meat	Dried meat; curry	LAB, bacilli, micrococci	<i>Dimasa</i>
<i>Mogong- grain</i>	Meat of buffalo	Hard, dried meat; curry	unknown	<i>Dimasa</i>

Table 7—Ethnic Non-food amyolytic mixed starters of North East India

Amyolytic starters	Substrate	Nature of product	Microflora	Major producers
<i>Marcha</i>	Rice, wild herbs, spices	Dry, flattened, ball-like, white starter	Moulds, yeasts, LAB	<i>Gorkha</i>
<i>Mana</i>	Wheat, herbs	Dry, granular-type starter	<i>Aspergillus oryzae</i>	<i>Gorkha</i>
<i>Manapu</i>	Rice-wheat, herbs	Dry, flattened, ball-like, white starter	Yeasts, moulds	<i>Gorkha</i>
<i>Phab</i>	Wheat, wild herbs	Dry, flattened, ball-like, brownish starter	Moulds, yeasts, LAB	<i>Tibetan, Monpa, Khamba</i>
<i>Buth/Thanbum</i>	Rice, wild herbs	Dry, flattened, ball-like, white starter	Moulds, yeasts, LAB	<i>Lepcha</i>
<i>Ipoh/Siye</i>	Rice, wild herbs	Dry, flattened, ball-like, white starter	unknown	<i>Monpa</i>
<i>Hamei</i>	Rice, wild herbs	Dry, ball-like, white starter	Moulds, yeasts, LAB	<i>Meitei</i>
<i>Humao</i>	Rice, barks of wild plants	Dry, flat, cake-like starter	Moulds, yeasts, LAB	<i>Dimasa</i>
<i>Chol</i>	Rice, wild plants	Dry, flat, starter	Moulds, yeasts, LAB	<i>Hrangkhol</i>
<i>Nduhi</i>	Rice, wild plants	Dry, flat, starter	Moulds, yeasts, LAB	<i>Sema Naga</i>
<i>Thiat</i>	Rice-herbs	Dry, flattened, ball-like, white starter	unknown	<i>Khasi</i>
<i>Pham</i>	Rice-herbs	Dry, flattened, ball-like, white starter	unknown	<i>Apatani, Monpa</i>
<i>Khekhrii</i>	Germinated rice	Starter to ferment <i>zutho/zhuchu</i>	unknown	<i>Mao</i>

Table 8—Ethnic alcoholic beverages of North East India

Alcoholic Beverage	Substrate	Nature of product	Microflora/Amylolytic starter used	Major consumers
<i>Kodo ko jaanr</i>	Finger millet	Mild-alcoholic, slightly sweet-acidic; alcoholic beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Bhaati jaanr</i>	Rice	Mild-alcoholic, sweet-sour, food beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Makai ko jaanr</i>	Maize	Mild-alcoholic, sweet-sour, food beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Gahoon ko jaanr</i>	Wheat	Mild-alcoholic beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Simal tarul ko jaanr</i>	Cassava tuber	Mild-alcoholic, sweet-sour; food beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Jao ko jaanr</i>	Barley	Alcoholic beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Faapar ko jaanr</i>	Buck wheat	Alcoholic beverage	<i>Marcha</i>	<i>Gorkha</i>
<i>Poko</i>	Rice	Food beverage	<i>Manapu</i>	<i>Gorkha</i>
<i>Raksi</i>	Cereals	Clear distilled liquor; alcoholic drink	<i>Marcha</i>	<i>Gorkha</i>
<i>Arak</i>	Cereals	Clear distilled liquor; alcoholic drink	<i>Phab</i>	<i>Bhutia, Tibetan</i>
<i>Chyang</i>	Finger millet/barley	Alcoholic, slightly sweet-acidic; alcoholic beverage	<i>Phab</i>	<i>Bhutia, Tibetan</i>
<i>Chee</i>	Finger millet/barley	Mild-alcoholic, slightly sweet-acidic; alcoholic beverage	<i>Buth</i>	<i>Lepcha</i>
<i>Atingba</i>	Rice	Alcoholic, sweet-sour beverage	<i>Hamei</i>	<i>Meitei</i>
<i>Yu</i>	Rice	Distilled liquor	<i>Hamei</i>	<i>Meitei</i>
<i>Jou</i>	Rice	Alcoholic beverage	<i>Khekhrii</i>	<i>Naga</i>
<i>Zutho/Zhuchu</i>	Rice	Milky white, alcoholic beverage	<i>Khekhrii</i>	<i>Naga</i>
<i>Duizou</i>	Red rice	Alcoholic drink	<i>Khekhrii</i>	<i>Naga</i>
<i>Nchiangne</i>	Red rice	Distilled liquor	<i>Khekhrii</i>	<i>Naga</i>
<i>Ruhi</i>	Rice	Distilled liquor	<i>Khekhrii</i>	<i>Naga</i>
<i>Madhu</i>	Rice	Distilled liquor	Yeast, Mould	<i>Naga</i>
<i>Dekuijao</i>	Rice	Alcoholic beverage; Drunk directly	<i>Nduhi</i>	<i>Naga</i>
<i>Apong</i>	Rice	Mild-alcoholic, beverage	<i>Ipoh</i>	<i>Monpa, Apatani, Nishi, Adi</i>
<i>Pona</i>	Rice	Alcoholic, sweet-sour, food beverage; paste	<i>Ipoh</i>	<i>Monpa, Apatani, Nishi, Adi</i>
<i>Ennog</i>	Rice, paddy husk	Black rice beer	<i>Ipoh</i>	<i>Monpa, Apatani, Nishi, Adi</i>
<i>Oh</i>	Rice-millet	Soft, alcoholic beverage	<i>Ipoh/Siye</i>	<i>Monpa, Apatani, Nishi, Adi</i>
<i>Themsing</i>	Finger millet/barley	Alcoholic beverages	<i>Ipoh/Siye</i>	<i>Monpa, Apatani, Nishi, Adi</i>
<i>Mingri</i>	Maize-rice/barley	Alcoholic beverages	<i>Phab</i>	<i>Monpa, Sherdukpen, Memba, Khamba</i>
<i>Lohpani</i>	Maize-rice/barley	Alcoholic beverages	<i>Phab</i>	<i>Monpa, Khamba</i>
<i>Bhang-chyang</i>	Maize-rice/barley	Extract of <i>mingri</i> ; alcoholic beverages	<i>Phab</i>	<i>Monpa, Sherdukpen, Memba, Khamba, Tibetan</i>
<i>Aara</i>	Cereals	Clear distilled liquor; alcoholic drink	<i>Phab</i>	<i>Monpa, Khamba</i>
<i>Kiad-lieh</i>	Rice	Distilled liquor	<i>Thiat</i>	<i>Khasi</i>
<i>Judima</i>	Rice	Alcoholic beverage, drunk directly	<i>Humao</i>	<i>Dimasa</i>
<i>Juharo</i>	Rice	Distilled liquor, drunk directly/with water	<i>Humao</i>	<i>Dimasa</i>
<i>Zu</i>	Rice	Alcoholic beverages	<i>Humao</i>	<i>Dimasa</i>
<i>Bumong-baitui</i>	Rice	Alcoholic beverage	<i>Humao</i>	<i>Biate</i>
<i>Juhning</i>	Rice	Alcoholic beverage; drink	<i>Chol</i>	<i>Hrangkhoh</i>

**Microorganisms**

*Bacillus subtilis*, *B. licheniformis*, *B. cereus*, *Staphylococcus aureus*, *S. sciuri*, *Alkaligenes* spp., *Providencia rettgeri*<sup>24</sup>.

**Nutritional value**

Moisture: 60.1 %, pH: 7.4, Protein: 43.9 % DM, fat: 27.9 % DM, carbohydrate: 23.4 % DM, food value: 521.2 kcal/100 gm DM, Ca: 357.8 mg/100 gm, Na: 88.7 mg/100 gm, Fe: 92.3 mg/100 gm, K: 835.1 mg/100 gm, Zn: 63.0 mg/100 gm<sup>25</sup>.

**Tungrymbai:**-*Tungrymbai* is an ethnic fermented soybean food of the *Khasi* in Meghalaya. Soybean seeds are cleaned, washed and soaked in water for about 4–6 hrs. The outer skin is removed, cooked for 1 hr, allowed to cool, and packed with leaves *lamet* (*Clinogyne dichotoma*) lined in the bamboo basket and covered by thick cloth and kept over the fireplace for natural fermentation 3–5 days. *Tungrymbai* is transferred from leaves to bowl, mashed and put into a container with water and boil till water evaporates, and stir continuously<sup>11</sup>. It is served as side-dish with rice. *Khasi* women sell *tungrymbai* in the local markets.

**Microorganisms**

*Bacillus subtilis*, *B. pumilus* and *B. licheniformis*, *Enterococcus faecium*, *E. hirae*, *E. raffinosus*, *E. durans*, *E. cecorum*, *Lactobacillus brevis*, and yeasts *Saccharomyces cerevisiae*, *Debaryomyces hansenii* and *Pichia burtonii*<sup>26</sup>.

**Nutritional value**

Moistures: 60.0 %, pH: 7.6, protein (45.9 gm/100 gm), fat (30.2 gm/100 gm), fibre (12.8 gm/100 gm), carotene (212.7 µg/100 gm) and folic acid (200 µg/100 gm)<sup>26,27</sup>. Antioxidant activities such as DPPH scavenging activity: 670.9 µg/ml, ABTS radical scavenging activity: 190.9 µg/ml, total phenol content: 2.6 mg GAE/gm fresh weight<sup>26</sup>. Saponin content (Group B): 447.9 mg/100 gm<sup>22</sup>.

**Bekang:**-*Bekang* is an ethnic fermented soybean food of Mizoram. Small sized soybean are soaked for 10–12 hrs, boiled and wrapped in leaves of *Calliparpa aroria* locally called *nuhlhan* or leaves of *Phrynium* sp., locally known as *hnahtial*, and kept inside the bamboo basket and fermented spontaneously for 3–4 days<sup>11</sup>. *Bekang* is consumed as curry with rice. It is sold in local markets.

**Microorganisms**

*Bacillus subtilis*, *B. pumilus*, *B. licheniformis*, *B. sphaericus*, *B. brevis*, *B. coagulans*, *B. circulans*, *Enterococcus faecium*, *E. hirae*, *E. raffinosus*, *E. durans*, *E. cecorum* and yeasts *Saccharomyces cerevisiae*, *Debaryomyces hansenii* and *Pichia burtonii*<sup>26</sup>.

**Nutritional value**

Moistures: 63.5 %, pH: 7.1. Antioxidant activities such as DPPH scavenging activity: 477.2 µg/ml, ABTS radical scavenging activity: 158.9 µg/ml, total phenol content: 3.8 mg GAE/gm fresh weight<sup>26</sup>. Saponin content (Group B): 331.3 mg/100 gm<sup>22</sup>.

**Fermented Non-soybean legume food**

**Maseura:**-*Maseura* or *masyaura* is an ethnic fermented non-soybean product prepared from black gram by the *Gorkha* of NE. It is a cone-shaped hollow, brittle and friable product. *Maseura* is similar to North Indian *wari* or *dal bodi* and South Indian *sandige*. Black gram seeds are cleaned, washed, soaked, dehulled, ground into thick paste using mortar and pestle. Water is carefully until paste becomes sticky, which is then made hand-moulded into small balls or cones, placed on a bamboo mat and fermented in open kitchen for 2–3 days, and then sun-dried for 3–5 days<sup>28</sup>. *Maseura* can be stored in a dry container at room temperature for a year or more. It is used as condiment or adjunct to vegetable.

**Microorganisms**

*Bacillus subtilis*, *B. mycoides*, *B. pumilus*, *B. laterosporus*, *Pediococcus acidilactici*, *P. pentosaceus*, *Enterococcus durans*, *Lb. fermentum*, *Lb. salivarius* yeasts *Saccharomyces cerevisiae*, *Pichia burtonii* and *Candida castellii*<sup>28</sup>.

**Nutritional value**

Moisture: 8–10 %, pH: 5.6 to 6.3, protein: 8–10 %, carbohydrate: 67–70 %<sup>28,29</sup>. Increase in soluble protein, amino nitrogen, non-protein nitrogen, thiamine and riboflavin has been observed in *maseura*<sup>29</sup>.

**Fermented vegetable foods**

**Gundruk:**-*Gundruk* is a common non-salted dried fermented leafy vegetable food of the *Gorkha* of NE. Though dry in nature *gundruk* is similar to other wet fermented vegetable foods such as *kimchi* of Korea, *sauerkraut* of Germany, *sunki* of Japan and *pao cai*

and *suan-cai* of China. During its production, leaves of *rayo-sag* (*Brassicca rapa* sub-species *campestris* variety *cuneifolia*), mustard (*Brassicca juncea*) and cauliflower (*Brassicca oleracea* variety *botrytis*) are wilted, shredded, crushed mildly and pressed into a earthen jar or container, made air tight and fermented naturally for about 7-10 days<sup>30</sup>. Freshly fermented *gundruk* is removed from the jar and sun dried for 3-4 days, and is stored for 2 years or more. *Gundruk* is eaten as a soup or pickle. It is sold in all local markets.

#### Microorganisms

*Lactobacillus fermentum*, *Lb. plantarum*, *Lb. casei*, *Lb. casei* subsp. *pseudopantarum*, *Pediococcus pentosaceus*<sup>31,32</sup>.

#### Nutritional value

Moisture: 15 %, pH: 5.0, acidity: 0.49 %, ash: 22.2 % DM, protein: 38.7 % DM, fat: 2.1 % DM, carbohydrate: 38.3 % DM, food value: 321.9 kcal/100 gm DM, Ca: 234.6 mg/100 gm, Na: 142.2 mg/100 gm, K: 677.6 mg/100 gm<sup>33</sup>.

**Sinki**:-*Sinki*, a non-salted fermented radish tap root of the *Gorkha*, is prepared by pit fermentation<sup>34</sup>. When the leaves of radish are fermented it is *gundruk* and when the tap root is fermented, it is called *sinki*. About 2-3 ft pit of same diameter is dug in a dry place. The pit is cleaned, plastered with mud and warmed by burning, lined with bamboo sheaths and paddy straw. Radish tap-roots are wilted for 2-3 days, crushed, dipped in lukewarm water, squeezed and pressed tightly into the pit, then covered with dry leaves and weighted down by heavy planks or stones, the top of the pit is plastered with mud and left to ferment naturally for 22-30 days<sup>30</sup>. Fresh *sinki* is removed, cut into pieces, sun-dried for 3-5 days, and is stored for 2 years at room temperature. It is consumed as soup and pickle.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *Lb. casei*, *Leuconostoc fallax*<sup>31,35</sup>.

#### Nutritional value

Moisture: 22.8 %, pH: 4.1, acidity: 0.65 %, ash: 15.6 % DM, protein: 14.9 % DM, fat: 1.4 % DM, carbohydrate: 68.0 % DM, food value: 344.2 kcal/100 gm DM, Ca: 223.9 mg/100 gm, Na: 737.3 mg/100 gm and K: 2320.4 mg/100 gm<sup>33</sup>.

**Goyang**:-*Goyang* is a fermented vegetable food of the *Sherpa* living in Sikkim. Leaves of wild edible plants locally called *magane-saag* (*Cardamine macrophylla* Willd.) are collected, washed, cut into pieces, squeezed to drain off excess water, and are tightly pressed into a bamboo basket lined with leaves of fig plants. Top of the baskets are then covered with fig plant leaves, and fermented at room temperature for a month<sup>36</sup>. Fresh *goyang* is transferred into an air tight container and is stored for 2-3 months. Sometimes, freshly fermented *goyang* is made into balls and is sun dried, which can be kept for several months. It is made as soup.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *Lactococcus lactis*, *Enterococcus faecium*, *P. pentosaceus* and yeast *Candida* spp.<sup>36</sup>.

#### Nutritional value

Moisture: 92.5 %, pH: 6.5, acidity: 0.13 %, ash: 12.9 % DM, protein: 35.9 % DM, fat: 2.1 % DM, carbohydrate: 48.9 % DM, food value: 357.2 kcal/100 gm, Ca: 92.2 mg/100 gm, Na: 6.7 mg/100 gm and K: 268.4 mg/100 gm<sup>36</sup>.

**Inziangsang**:-*Inziangsang* or *ziangsang* is an ethnic fermented leafy vegetable product of the *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 air tight 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*<sup>30</sup>. It is consumed as soup. Fermented extract *ziang dui* is used as *condiment*.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *Pediococcus acidilactici*<sup>31</sup>.

#### Nutritional value

Moisture: 17.6 %, pH: 4.8, acidity: 0.50 %, ash: 16.9 % DM, protein: 38.7 % DM, fat: 3.2 % DM, carbohydrate: 41.2 % DM, food value: 348.4 kcal/100 gm, Ca: 240.4 mg/100 gm, Na: 133.7 mg/100 gm and K: 658.4 mg/100 gm<sup>33</sup>.



**Khalpi:**-*Khalpi* is a fermented cucumber (*Cucumis sativus* L.) product, consumed by the *Gorkha* of NE. Matured and ripened cucumber is cut into suitable pieces, sun dried for 2 days and then put into a bamboo vessel, made air-tight and fermented naturally at room temperature for 4-7 days<sup>30</sup>. *Khalpi* is consumed as pickle.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *Leuconostoc fallax*<sup>32</sup>.

#### Nutritional value

Moisture: 91.4 %, pH: 3.9, acidity: 0.95 %, ash: 14.2 % DM, fat: 2.6 % DM, protein: 12.3 % DM, carbohydrate: 70.9 % DM, food value: 356.2 kcal/100 gm DM, Ca: 6.4 mg/100 gm, Na: 2.2 mg/100 gm, K: 125.1 mg/100 gm<sup>33</sup>.

#### Fermented Bamboo shoot foods

**Mesu:**-*Mesu* is a fermented bamboo shoot consumed by the *Gorkha* of Sikkim. Locally grown edible shoots *choya bans* (*Dendrocalamus hamiltonii*), *karati bans* (*Bambusa tulda*) and *bhalu bans* (*Dendrocalamus sikkimensis*) are defoliated, chopped finely and pressed tightly into a green hollow bamboo stem. The tip of the vessel is covered tightly with leaves of bamboo or other wild plants and left to ferment under natural anaerobic conditions for 7-15 days<sup>30</sup>. *Mesu* is eaten as a pickle.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *Lb. curvatus*, *Leuconostoc citreum*, *Pediococcus pentosaceus*<sup>37,38</sup>.

#### Nutritional value

Moisture: 89.9 %, pH: 3.9, acidity: 0.88 %, ash: 15.0 % DM, fat: 2.6 % DM, protein: 27.0 % DM, carbohydrate: 55.6 % DM, food value: 352.4 kcal/100 gm DM, Ca: 7.9 mg/100 gm, Na: 2.8 mg/100 gm, K: 282.6 mg/100 gm<sup>33</sup>.

**Soibum:**-*Soibum* is a fermented tender bamboo shoot food produced and eaten by the *Meitei* of Manipur. *Soibum* is produced from bamboo shoots *Dendrocalamus hamiltonii* (Wanap, Unap, Pecha), *D. sikkimensis* and *D. giganteus* (Maribop), *Melacona bambusoide* (Moubi/Muli), *Bambusa tulda* (Utang), *B. balcona* (Ching saniebi), etc. by natural fermentation. Outer casings of young shoots are removed, the inner part is sliced into pieces, washed, placed in a covered earthen pot and fermented for 3-12 months<sup>23</sup>. It is consumed as side dish. *Soibum* is commonly sold in local vegetable markets.

#### Microorganisms

Bacteria- *Lb. plantarum*, *Lb. brevis*, *Lb. coryniformis*, *Lb. delbrueckii*, *Leuc. fallax*, *Leuc. lactis*, *Leuc. mesenteroides*, *Enetrococcus durans*, *Streptococcus lactis*, *Bacillus subtilis*, *B. licheniformis*, *B. coagulans* and yeasts- *Candida*, *Saccharomyces* and *Torulopsis*<sup>38,39,40,41</sup>.

#### Nutritional value

Moisture: 92.0 %, pH: 3.9, acidity: 0.98 %, ash: 13.3 % DM, fat: 3.2 % DM, protein: 36.3 % DM, carbohydrate: 47.2 % DM, food value: 362.8 kcal/100 gm DM, Ca: 16.0 mg/100 gm, Na: 2.9 mg/100 gm, K: 212.1 mg/100 gm<sup>33</sup>.

**Soidon:**-*Soidon* is a fermented tip of matured bamboo shoot product of Manipur and is a popular fermented bamboo shoot food in the diet of the *Meitei*. Tips of matured bamboo shoot (*Bambusa tulda* Roxb., *Dendrocalamus giganteus* Munro and *Melocana bambusoides* Trin.) are collected; outer casings and lower portions are removed. Whole tips are submerged in water in an earthen pot; sour liquid (*soijim*) of previous batch is added as starter in 1:1 dilution, covered and fermented for 3-7 days at room temperature. Leaves of *Garcinia pedunculata* Roxb., locally called *heibung*, may be added in the fermenting vessel during fermentation to enhance the flavour of *soidon*<sup>23</sup>. *Soidon* can be kept in closed container at room temperature for a year. *Soidon* is consumed as a curry as well as pickle. *Soidon* is sold in the local market by the *Meitei* women.

#### Microorganisms

*Lb. brevis*, *Leuconostoc fallax*, *Leuc. lactis*<sup>38</sup>.

#### Nutritional value

Moisture: 92.2 %, pH: 4.2, acidity: 0.96 %, ash: 13.1 % DM, fat: 3.1 % DM, protein: 37.2 % DM, carbohydrate: 46.6 % DM, food value: 363.1 kcal/100 gm DM, Ca: 18.5 mg/100 gm, Na: 3.7 mg/100 gm, K: 245.5 mg/100 gm<sup>33</sup>.

**Ekung:**-*Ekung* is an ethnic fermented bamboo tender shoot product of Arunachal Pradesh, produced by the *Nishi*. The word *ekung* is derived from the *Nishi* dialect, the *Adi* calls it *iku* and the *Apatani* calls it *hikku*<sup>1</sup>. Locally grown young bamboo tender shoots (*Dendrocalamus hamiltonii* Nees. et Arn. ex Munro, *Bambusa balcooa* Roxb. *Dendrocalamus giganteus* Munro, *Phyllostachys assamica* Gamble ex Brandis, *Bambusa tulda* Roxb.) are collected, leaf sheaths are removed, and chopped into very small pieces. Pit is

dug in the forest usually in and around water source to facilitate washing of bamboo shoot pieces. The bamboo baskets are laid into the pit and lined with leaves, chopped bamboo shoot pieces are put into the basket, 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 and is kept for a year in an air tight container<sup>30</sup>. *Ekung* is consumed as it is or is cooked with meat, fish and vegetables. It is sold in local markets.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *Lb. casei*, *Tetragenococcus halophilus*<sup>42</sup>.

#### Nutritional value

Moisture: 94.7 %, pH: 3.9, acidity: 0.94 %, ash: 14.0 % DM, protein: 30.1 % DM, fat: 3.8 % DM, carbohydrate: 52.1 % DM, food value: 363.0 kcal/100 gm DM, Ca: 35.4 mg/100 gm, Na: 10.9 mg/100 gm, K: 168.6 mg/100 gm<sup>33</sup>.

**Eup:**-*Eup*, the word derived from the *Nishi* dialect, is a dry fermented bamboo tender shoot product of Arunachal Pradesh. *Eup* has synonyms such as *hi* by the *Apatani*, *nogom* by the *Khampti*, *ipe* by the *Adi*<sup>1</sup>. Bamboo shoots are chopped into small pieces and fermented in similar manner as in *ekung*. Fermentation is completed in 1-3 months. *Eup* is a dry product and is again cut into smaller pieces and then dry in the sun for 5-10 days until its colour changes from whitish to chocolate brown<sup>30</sup>. *Eup* is kept up to 2 yrs. It is consumed as a curry along with meat, fish or vegetables.

#### Microorganisms

*Lb. plantarum*, *Lb. fermentum*<sup>42</sup>.

#### Nutritional value

Moisture: 36.8 %, pH: 4.1, acidity: 0.80 %, ash: 18.2 % DM, protein: 33.6 % DM, fat: 3.1 % DM, carbohydrate: 45.1 % DM, food value: 342.7 kcal/100 gm DM, Ca: 76.9 mg/100 gm, Na: 3.4 mg/100 gm, K: 181.5 mg/100 gm<sup>33</sup>.

**Hirring:**-*Hirring* is also a fermented bamboo shoot prepared by the *Apatani* of Arunachal Pradesh. The *Nishi* calls it *hitch* or *hitak*. During its production, tips of tender bamboo shoots are either cut longitudinally into 2-3 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, weighted down and fermented for 1-3 months<sup>30</sup>. *Hirring* is consumed as curry. It is commonly sold in the local markets.

#### Microorganisms

*Lb. plantarum*, *Lactococcus lactis*<sup>42</sup>.

#### Nutritional value

Moisture: 88.8 %, pH: 4.0, acidity: 0.81 %, ash: 15.0 % DM, protein: 33.0 % DM, fat: 2.7 % DM, carbohydrate: 49.3 % DM, food value: 353.5 kcal/100 gm DM, Ca: 19.3 mg/100 gm, Na: 3.4 mg/100 gm and K: 272.4 mg/100 gm<sup>33</sup>.

**Tuaitthur:**-*Tuaitthur* is an ethnic fermented bamboo shoot product prepared and consumed by the *Hrangkhoh*, the *Baite* and the *Hmar* of Assam. Tender shoots of bamboo are collected, outer hard casings are removed, and inner portion is cut into pieces, washed thoroughly, drained well and pressed tightly in cylindrical vessels made of bamboo. Water coming out from the bamboo shoot is decanted continuously for 2-3 days. A little amount of fresh water is added; vessel is made air tight and fermented under natural anaerobic condition for 6-7 days. *Tuaitthur* is prepared as curry or pickle. The sun dried *tuaitthur* is called *tuairoi* which is kept in poly-bags.

#### Microorganisms

*Lb. plantarum*, *Lb. brevis*, *P. pentosaceou*, *Lectococcus lactis*, *Bacillus circulans*, *B. firmus*, *B. sphaericus*, *B. subtilis*<sup>43</sup>.

#### Nutritional value

Moisture: 92.3 %, pH: 4.0, acidity: 0.83 %, ash: 4.6 % DM, fat: 3.4 % DM, protein: 4.6 % DM, carbohydrate: 87.4 % DM, food value: 398.6 kcal/100 gm DM<sup>43</sup>.

#### Fermented cereal foods

**Selroti:**-*Selroti* is a popular fermented rice product of the *Gorkha*/ethnic *Nepali* which is ring shaped, spongy, pretzel-like and deep-fried food. Rice washed, soaked for overnight or 4 to 8 h, decanted by using bamboo made sieve and spread over a woven tray and dried for 1 h. Soaked rice is pounded into coarse powder in a wooden mortar and pestle, larger particles of pounded rice flour are separated from the rest by winnowing in a bamboo tray. Then the rice flour is mixed with nearly 25 % refined wheat flour, 25 % sugar, 10 % butter or fresh cream and 2.5 % spices/condiments containing large cardamom, cloves, coconut, fennel, nutmeg, cinnamon, and small

cardamom are added to the rice flour and mixed thoroughly. Milk or water is added, kneaded into a soft dough and finally into batter with easy flow. Batter is left to ferment naturally at ambient temperature (20-28° C) for 2 to 4 h during summer and at 10-18° C for 6-8 hrs during winter<sup>44</sup>. The fermented batter is squeezed and deposited as continuous ring onto hot edible oil and fried until golden brown and is drained out from hot oil by poker and is served as confectionary bread.

#### Microorganisms

Bacteria- *Leuconostoc mesenteroides*, *Enterococcus faecium*, *Pediococcus pentosaceus*, *Lactobacillus curvatus*; yeasts- *Saccharomyces cerevisiae*, *Saccharomyces kluyveri*, *Debaryomyces hansenii*, *Pichia burtonii* and *Zygosaccharomyces rouxii*<sup>45</sup>.

#### Nutritional value

Moisture: 42.5 %, pH: 5.8, acidity: 0.08 %, ash: 0.8 % DM, protein: 5.7 % DM, fat: 2.7 % DM, carbohydrate: 91.3 % DM, food value: 410.3 kcal/100 gm DM, Na: 8.9 mg/100 gm, P: 29.7 mg/100 gm, Ca: 23.8 mg/100 gm<sup>45</sup>.

#### Fermented milk products

**Dahi:-**Dahi (curd) is a popular fermented milk product of EN for direct consumption as well as for the preparation of various ethnic milk products such as *gheu*, *mohi*, *chhurpi*, etc. Fresh cow or yak milk is boiled in a vessel, cooled to room temperature. A small quantity of previously prepared *dahi* (serves as source of inoculum) is added to the milk, and is fermented for 1-2 days in summer or for 2-4 days in winter<sup>1</sup>. *Dahi* is consumed directly as a refreshing non-alcoholic beverage.

#### Microorganisms

Bacteria- *Lactobacillus bifermentans*, *Lb. alimentarius*, *Lb. paracasei* subsp. *pseudopiantarum*, *Lactococcus lactis* subsp. *lactis*, *Lc. lactis* subsp. *cremoris*, yeasts- *Saccharomycopsis* and *Candida*<sup>46</sup>.

#### Nutritional value

Moisture 84.8 %, pH 4.2, acidity 0.73 %, ash 4.7 % DM, protein 22.5 % DM, fat 24.5 % DM, carbohydrate 48.2 % DM and food value: 503.6 kcal/100 gm DM<sup>47</sup>.

**Chhurpi:-**Two types of hard-*chhurpi* and soft-*chhurpi* are popular among the ethnic people of Sikkim and Arunachal Pradesh. Hard-variety *chhurpi* is prepared from yak milk in high altitudes mountains

(2100 to 4500 m) and has characteristic gumminess, and chewiness. Cream is separated from milk and the skimmed milk is boiled and curdled by adding whey. After straining, the coagulum is cooked until the remaining water dries up. The highly stringy mass is wrapped in a cloth and fermented under pressure at room temperature for about two days. After pressing, the mass is sliced and allowed to dry by keeping above earthen oven for about a month. Soft-*chhurpi* is a cheese-like fermented milk product<sup>48</sup>. It is slightly sour in taste. Butter-milk is cooked for about 15 min till a soft, whitish mass is formed. This mass is sieved out and put inside a muslin cloth, which is hung by a string to drain out the remaining whey. It is eaten as curry as well as pickle, mixed with wild edible ferns. Soup is also prepared from *chhurpi*. Soft-variety *chhurpi* is sold in all local markets.

#### Microorganisms of hard-*chhurpi*

*Lactobacillus farciminis*, *Lactobacillus casei* subsp. *casei*, *Lactobacillus confuses* and *Lactobacillus bifermentans*<sup>47</sup>.

#### Microorganisms of soft-*chhurpi*

*Lb. farciminis*, *Lb. paracasei* subsp. *paracasei*, *Lb. confuses*, *Lb. bifermentans*, *Lb. plantarum*, *Lb. curvatus*, *Lb. fermentum*, *Lb. paracasei* subsp. *pseudopiantarum*, *Lb. alimentarius*, *Lb. kefir*, *Lb. hilgardii*, *Enterococcus faecium* and *Leuconostoc mesenteroides*<sup>48</sup>.

#### Nutritional value of hard-*chhurpi*

Moisture 3.9-13 %, pH 5.3, acidity 0.3 %, ash 6.6-7.7 %, protein 53.4- 68.5 %, fat 7.7-12.3 %, and carbohydrate 20.4-23.2 %<sup>49,50</sup>.

#### Nutritional value of soft-*chhurpi*

Moisture 73.8 %, pH 4.2, acidity 0.61 %, ash 6.6 % DM, protein 65.3 % DM, fat 11.8 % DM, carbohydrate 16.3 % DM, Ca: 44.1 mg/100 gm, Fe: 1.2 mg/100 gm, Mg: 16.7 mg/100 gm, Mn: 0.6 mg/100 gm and Zn: 25.1 mg/100 gm<sup>47</sup>.

**Chhu:-***Chhu* or *sheden*, an ethnic fermented milk product of the *Bhutia*, the *Lepcha*, the *Monpa*, the *Sherdukpen*, the *Khamba*, the *Memba* and the *Tibetan* living in EN, is a strong-flavoured traditional cheese-like product prepared from yak milk. It has a rubbery texture with a slightly sour taste and strong flavour. *Shyow* (curd in the *Tibetan* language) is churned in a bamboo or wooden vessel, with addition of water to produce *maa* and *kachhu*. The latter is cooked

for 15 min till a soft, whitish mass is formed, sieved out and put inside a muslin cloth, which is hung by a string to drain out the remaining whey. *Chhu* is placed in closed vessel to ferment the product further after which it is consumed<sup>51</sup>. It is prepared into a curry and soup.

#### Microorganisms

Bacteria- *Lb. farciminis*, *Lb. brevis*, *Lb. alimentarius*, *Lb. salivarius*, *Lc. lactis* subsp. *cremoris*, and yeasts- *Saccharomycopsis* and *Candida*<sup>51</sup>.

#### Nutritional value

Moisture 75.5 %, pH 6.3, acidity 0.15 %, ash 1.9 % DM, protein 58.4 % DM, fat 5.8 % DM, carbohydrate 33.9 % DM, Ca: 111 mg/100 gm, Fe: 4.5 mg/100 gm, Mg: 64.3 mg/100 gm, Mn: 3.1 mg/100 gm and Zn: 87.6 mg/100 gm<sup>47</sup>.

**Somar:-** *Somar*, a soft paste, brownish with strong flavour, is an ethnic fermented milk (yak/cow) product of Sikkim traditionally consumed by the *Sherpa*. Buttermilk (*tara* in *Sherpa* dialect) is cooked till a soft, whitish mass is formed and the mass is sieved out with a cloth or plastic sieve. The product is called *sherkam* (same as fresh soft *chhurpi*) and is kept in a closed vessel for 10-15 days to ferment the product further. The final fermented product is called *somar*. In another traditional way, *somar* is cooked with milk, *mar* (butter) and turmeric to produce a soft-brown paste *somar*<sup>1</sup>. This type of *somar* is stored for 4-7 months. *Somar* soup is consumed with rice.

#### Microorganisms

*Lb. paracasei* subsp. *pseudopantarum* and *Lactococcus lactis* subsp. *cremoris*<sup>46</sup>.

#### Nutritional value

Moisture 36.5 %, pH 6, acidity 0.1 %, ash 2.7 % DM, protein 35 % DM, fat 15.4 % DM, carbohydrate 46.9 % DM, Ca: 31.2 mg/100 gm, Fe: 0.4 mg/100 gm, Mg: 13.7 mg/100 gm, Mn: 0.5 mg/100 gm and Zn: 17.2 mg/100 gm<sup>47</sup>.

**Philu:-** *Philu* is an ethnic fermented, cream-like dairy product, with an inconsistent semi-solid texture and is consumed by the *Tibetan*, the *Bhutia*, the *Sherpa* and the *Khamba* of NE. Fresh cow/yak milk collected in cylindrical bamboo vessels (called *dzydung* by the *Bhutia*) or in wooden vessels (called *yadung*) is slowly swirled around the walls of these vessels by rotating them for a few minutes.

Sometimes a thick mesh of dried creeper is kept inside the vessel to increase the surface area for the *philu* to stick. A creamy mass sticks to the walls of the vessels and around the creeper. Milk is then poured off and utilized elsewhere. The vessel is kept upside down to drain out the remaining liquid and the process is repeated daily for about 6-7 days until a thick, white creamy layer is formed on the vessel walls and the creeper surface<sup>1</sup>. The soft mass *philu*, is scraped off and stored in a dry place for consumption. Rich gravy from *philu* is prepared as a side dish along with boiled rice.

#### Microorganisms

*Lb. paracasei* subsp. *paracasei*, *Lb. bifementans* and *Enterococcus faecium*<sup>46</sup>.

#### Nutritional value

Moisture 38.2 %, pH 4.3, acidity 0.61 %, ash 3.6 % DM, protein 52 % DM, fat 32 % DM, carbohydrate 12.5 % DM, Ca: 34.9 mg/100 gm, Fe: 0.8 mg/100 gm, Mg: 16.9 mg/100 gm, Mn: 0.9 mg/100 gm and Zn: 27.1 mg/100 gm<sup>47</sup>.

#### Ethnic fermented fish products

**Ngari:-** *Ngari* is a fermented fish product of Manipur traditionally consumed by the *Meitei*. During its production, fish (*Puntius sophore* Hamilton) is rubbed with salt, dry in the sun for 3-4 days, washed briefly and spread on a bamboo mats, filled and pressed tightly in an earthen pot by leg. To the inner wall of the pot, a layer of mustard oil is applied before filling up the fishes. The pot is sealed airtight and then stored at room temperature for 4-6 months<sup>52</sup>. It is kept for more than a year at room temperature. *Ngari* is eaten daily as a side dish with cooked rice. It is sold in local markets.

#### Microorganisms

Bacteria- *Lactococcus lactis* subsp. *cremoris*, *Lc. plantarum*, *Enterococcus faecium*, *Lb. fructosus*, *Lb. amylophilus*, *Lb. coryniformis* subsp. *torquens*, *Lb. plantarum*; *Bacillus subtilis* and *B. pumilus*, *Micrococcus*; yeasts- species of *Candida* and *Saccharomycopsis*<sup>52</sup>.

#### Nutritional value

Moisture: 33.5 %, pH: 6.2, ash: 21.1 %, protein: 34.1 %, fat: 13.2 %, carbohydrate: 31.6 %, food value: 381.6 kcal/100 gm, Ca: 41.7 mg/100 gm, Fe: 0.9 mg/100 gm, Mg: 0.8 mg/100 gm, Mn: 0.6 mg/100 gm and Zn: 1.7 mg/100 gm<sup>53</sup>.

**Hentak:**-*Hentak* is also a fermented fish paste prepared from a mixture of sun-dried fish powder and petioles of aroid plants in Manipur. Finger sized fish (*Esomus danricus* Hamilton) is washed thoroughly, sun-dried and crushed to powder. Petioles of *Alocasia macrorrhiza* are cut into pieces, washed and then exposed to sunlight for 1 day. An equal amount of the cut pieces of the petioles of *Alocasia macrorrhiza* is mixed with powdered fish and a ball-like thick paste is made, kept in an earthen pot, tightly sealed and is fermented for 7-9 days<sup>52</sup>. *Hentak* is consumed as curry and is also used as condiment.

#### Microorganisms

Bacteria- *Lc. lactis* subsp. *cremoris*, *Lc. plantarum*, *Enterococcus faecium*, *Lb. fructosus*, *Lb. amylophilus*, *Lb. corynifomis* subsp. *Torquens*, *Lb. plantarum*, *Bacillus subtilis*, *B. pumilus*, *Micrococcus*, yeasts-species of *Candida* and *Saccharomycopsis*<sup>52</sup>.

#### Nutritional value

Moisture: 40.0 %, pH: 6.5, ash: 15.0 %, protein: 32.7 %, fat: 13.6 %, carbohydrate: 38.7 %, food value: 408.0 kcal/100 gm, Ca: 38.2 mg/100 gm, Fe: 1.0 mg/100 gm, Mg: 1.1 mg/100 gm, Mn: 1.4 mg/100 gm and Zn: 3.1 mg/100 gm<sup>53</sup>.

**Tungtap:**-*Tungtap* is a fermented fish paste of the *Khasi* in Meghalaya. Sun-dried fish (*Danio* spp.) is washed briefly, and is mixed with salt, sun-dried fish is kept in the earthen pot, made airtight and fermented for 4-7 days<sup>52</sup>. It is consumed as pickle and curry.

#### Microorganisms

Bacteria- *Lactobacillus amylophilus*, *Lb. corynifomis* subsp. *torquens*, *Lb. plantarum*, *Lb. fructosus*, *Lactococcus lactis* subsp. *cremoris*, *Lc. plantarum*, *Enterococcus faecium*, *Bacillus subtilis*, *B. pumilus*, *Micrococcus*; yeasts-species of *Candida* and *Saccharomycopsis*<sup>52</sup>.

#### Nutritional value

Moisture: 35.4 %, pH: 6.2, ash: 18.9 %, protein: 32.0 %, fat: 12.0 %, carbohydrate: 37.1 %, food value: 384.4 kcal/100 gm, Ca: 25.8 mg/100 gm, Fe: 0.9 mg/100 gm, Mg: 1.6 mg/100 gm, Mn: 0.8 mg/100 gm and Zn: 2.4 mg/100 gm<sup>53</sup>.

### Ethnic smoked and dried fish products

**Gnuchi:**-*Gnuchi* is a traditional smoked fish product of the *Lepcha* of Sikkim. Fish (*Schizothorax richardsonii* Gray, *Labeo dero* Hamilton,

*Acrossocheilus* spp., *Channa* sp.) is collected from river, kept on a big bamboo tray to drain off water, degutted, mixed with salt and turmeric powder. The bigger sized fish is selected and spread in an upside down manner on 'sarhang' and is kept above the earthen-oven in kitchen. The small sized fishes are hung one after the other in a bamboo stripe above the earthen-oven and keep for 10-14 days<sup>54</sup>. *Gnuchi* is kept at room temperature for 2-3 months and is eaten as curry.

#### Microorganisms

Bacteria- *Lactobacillus plantarum*, *Lactococcus lactis* subsp. *cremoris*, *Lc. lactis* subsp. *lactis*, *Leuconostoc mesenteroides*, *Enterococcus faecium*, *E. faecalis*, *Pediococcus pentosaceus*, yeasts-*Candida chiropterorum*, *C. bombicola*, *Saccharomycopsis* spp.<sup>54</sup>.

#### Nutritional value

Moisture: 14.3 %, pH: 6.3, ash: 16.9 %, protein: 21.3 %, fat: 14.5 %, carbohydrate: 47.3 %, food value: 404.9 kcal/100 gm, Ca: 37.0 mg/100 gm, Fe: 1.1 mg/100 gm, Mg: 8.8 mg/100 gm, Mn: 1.1 mg/100 gm and Zn: 7.5 mg/100 gm<sup>53</sup>.

**Suka ko Maacha:**-Traditionally smoked fish product is called *suka ko maacha* by the *Gorkha*. The hill river fish 'dothay asala' (*Schizothorax richardsoni* Gray) and 'chuchay asala' (*Schizothorax progastus* McClelland) are collected in a bamboo basket from the river or streams, and are degutted, washed, mixed with salt and turmeric powder. Degutted fishes are hooked in a bamboo-made string and are hung above the earthen-oven in kitchen for 7-10 days<sup>54</sup>. It can be preserved for 4-6 months and is eaten as curry.

#### Microorganisms

Bacteria- *Lactococcus lactis* subsp. *cremoris*, *Lc. lactis* subsp. *lactis*, *Lc. plantarum*, *Leuconostoc mesenteroides*, *Enterococcus faecium*, *E. faecalis*, *Pediococcus pentosaceus*, yeasts-*Candida chiropterorum*, *C. bombicola*, *Saccharomycopsis* spp.<sup>54</sup>.

#### Nutritional value

Moisture: 10.4 %, pH: 6.4, ash: 16.2 %, protein: 35.0 %, fat: 12.0 %, carbohydrate: 36.8 %, food value: 395.2 kcal/100 gm, Ca: 38.7 mg/100 gm, Fe: 0.8 mg/100 gm, Mg: 5.0 mg/100 gm, Mn: 1.0 mg/100 gm and Zn: 5.2 mg/100 gm<sup>53</sup>.

**Sidra:**-*Sidra* is a sun-dried fish product commonly consumed by the *Gorkha*. Fish (*Puntius sarana* Hamilton) is collected, washed, dry in the sun for

4-7 days and is stored at room temperature for 3-4 months. *Sidra* pickle is popular cuisine<sup>54</sup>.

#### Microorganisms

Bacteria- *Lactococcus lactis* subsp. *cremoris*, *Lc. lactis* subsp. *lactis*, *Lc. plantarum*, *Leuconostoc mesenteroides*, *Enterococcus faecium*, *E. faecalis*, *Pediococcus pentosaceus*, *Weissella confuse*, yeasts- *Candida chiropterorum*, *C. bombicola*, *Saccharomycopsis* spp.<sup>54</sup>.

#### Nutritional value

Moisture: 15.3 %, pH: 6.5, ash: 16.6 %, protein: 25.5 %, fat: 12.2 %, carbohydrate: 45.7 %, food value: 394.6 kcal/100 gm, Ca: 25.8 mg/100 gm, Fe: 0.9 mg/100 gm, Mg: 1.6 mg/100 gm, Mn: 0.8 mg/100 gm and Zn: 2.4 mg/100 gm<sup>53</sup>.

**Sukuti:-** *Sukuti* is also very popular sun-dried fish product cuisine of the *Gorkha*. Fish (*Harpodon nehereus* Hamilton) is collected, washed, and rubbed with salt and dry in the sun for 4-7 days, and is stored for 3-4 months<sup>54</sup>. *Sukuti* is consumed as pickle, soup and curry. It is also commonly sold at local markets.

#### Microorganisms

Bacteria- *Lactococcus lactis* subsp. *cremoris*, *Lc. lactis* subsp. *lactis*, *Lc. plantarum*, *Leuc. mesenteroides*, *Enterococcus faecium*, *E. faecalis*, *Pediococcus pentosaceus*, yeasts- *Candida chiropterorum*, *C. bombicola*, *Saccharomycopsis* spp.<sup>54</sup>.

#### Nutritional value

Moisture: 12.7 %, pH: 6.4, ash: 13.6 %, protein: 36.8 %, fat: 11.4 %, carbohydrate: 38.2 %, food value: 402.6 kcal/100 gm, Ca: 17.7 mg/100 gm, Fe: 0.3 mg/100 gm, Mg: 1.4 mg/100 gm, Mn: 0.2 mg/100 gm and Zn: 1.3 mg/100 gm<sup>53</sup>.

**Karati, Bordia and Lashim:-** *Karati*, *bordia* and *lashim* are sun dried and salted fish products of Assam. Fish is washed, and rubbed with salt and dried in the sun for 4-7 days. The sun-dried fish products are stored at room temperature for 3-4 months for consumption. *Karati* is prepared from *Gudusia chapra* Hamilton, *bordia* is prepared from *Pseudeutropius atherinoides* Bloch and *lashim* is prepared from *Cirrhinus reba* Hamilton<sup>55</sup>. These fish products are eaten as side-dish.

#### Microorganisms

Bacteria- *Lc. lactis* subsp. *cremoris*, *Leuc. mesenteroides*, *Lb. plantarum*; *Bacillus subtilis*, *B. pumilus*, and yeast- *Candida*<sup>55</sup>.

#### Nutritional value

Moisture: 9.6-12.0 %, pH: 6.3-6.4, ash: 12.8-15.3 %, protein: 24.5-35.0%, fat: 11.8-12.4%, carbohydrate: 38.1-47.9%, food value: 400.0-407.8 kcal/100 gm<sup>53</sup>.

#### Ethnic preserved meat products

**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, and combined with crushed garlic, ginger, salt, and mixed with water. The mixture is stuffed into the segment of gastro-intestinal tract locally called *gyuma*, used as natural casings with 3-4 cm in diameter and 40-60 cm length. 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 for 10-15 days<sup>56</sup>. *Kargyong* is eaten after boiling for 10-15 min, sliced and made into curry or fried sausage.

#### Microorganisms

Bacteria - *Lactobacillus sake*, *Lb. divergens*, *Lb. carnis*, *Lb. sanfransisco*, *Lb. curvatus*, *Leuc. mesenteroides*, *Enterococcus faecium*, *Bacillus subtilis*, *B. mycoides*, *B. thuringiensis*, *Staphylococcus aureus*, *Micrococcus*; yeasts- *Debaryomyces hansenii*, *Pichia anomala*<sup>57</sup>.

#### Nutritional value of yak-kargyong

Moisture: 21.9 %, pH: 6.9, ash: 2.8 % DM, protein: 16.0 % DM, fat: 49.1 % DM, carbohydrate: 32.0 % DM and food value: 634.5 kcal/100 gm<sup>58</sup>.

**Satchu:-** *Satchu* is an ethnic dried meat (beef/yak/pork) and is consumed by the *Tibetan*, the *Bhutia*, the *Lepcha*, the *Sherdukpen*, the *Khamba* in the EN. Red meat of beef or yak and also pork is sliced into several strands of about 60-90 cm and is mixed thoroughly with turmeric powder, edible oil or butter and salt. The meat strands are hung in the bamboo stripes or wooden stick and are kept in an open air in corridor of the house or are smoked above the kitchen oven for 10-15 days as per the convenience of the consumers<sup>56</sup>. *Satchu* can be kept at room temperature for several weeks. Deep fried *satchu* is eaten as side-dish.

#### Microorganisms

Bacteria- *Pediococcus pentosaceus*, *Lb. casei*, *Lb. carnis*, *E. faecium*, *B. subtilis*, *B. mycoides*, *B. lentus*, *S. aureus*, *Micrococcus*; Yeasts- *D. hansenii*, *Pichia anomala*<sup>57</sup>.

**Nutritional value of yak-satchu**

Moisture: 23.7 %, pH: 5.7, ash: 7.3 % DM, fat: 4.7% DM protein: 51.0% DM, carbohydrate: 37.0% DM, food value: 405.8 kcal/100 gm<sup>58</sup>.

**Suka Ko Masu:**-*Suka ko masu* is a dried or smoked meat product prepared from buffalo meat or chevon (goat meat). It is consumed by the non-vegetarian the *Gorkha*. It is prepared by cutting the red meat of buffalo or chevon (goat meat) into a stripe up to 25-30 cm, and mixed with turmeric powder, mustard oil and salt. Mixed meat stripes are hung on bamboo and kept above the earthen kitchen oven and smoked for 7-10 days and is for several weeks<sup>56</sup>. It is eaten as curry with cooked rice.

**Microorganisms**

Bacteria- *Lb. carnis*, *E. faecium*, *Lb. plantarum*, *B.subtilis*, *B.mycoides*, *B.thuringiensis*, *S.aureus*, *Micrococcus*, yeasts- *Debaromyces hansenii*, *Pichia burtonii*<sup>57</sup>.

**Nutritional value of yak-satchu**

Moisture: 23.2 %, pH: 5.2, ash: 1.8 % DM, protein: 44.8 % DM, fat: 2.0 % DM, carbohydrate: 51.4 % DM and food value: 403.1 kcal/100 gm<sup>58</sup>.

**Non-food amylolytic starters**

In Asia non-food amylolytic mixed cultures or inocula are traditionally prepared as starters to convert cereal starch to sugars and subsequently to alcohol and organic acids<sup>59,60</sup>. It is a consortium of filamentous molds, amylolytic and alcohol-producing yeasts and lactic acid bacteria with rice or wheat as the base in the form of dry, flattened or round balls of various sizes with different vernacular names such as *marcha* in India, Nepal and Bhutan, *ragi* in Indonesia, *bubod* in Philippines, *chiu/chu* in China and Taiwan, *loogpang* in Thailand, *nuruk* in Korea, and *men* in Vietnam, used as starters for production of cereal-based alcoholic beverages in Asia<sup>61</sup>.

**Marcha:**-*Marcha* is a dry flattened to round, solid ball-like mixed amylolytic starter, used to ferment starchy materials into number of fermented beverages and alcoholic drinks confined to the *Gorkha*. Glutinous rice (*Oryza sativa*) is soaked for 8-10 hrs, crushed in wooden mortar by a pestle. In one kg of ground rice, ingredients added include roots of some wild herbs 'guliyo jara' (*Plumbago zeylanica*), 2.5 gm; leaves of 'bheemsen paate' (*Buddleja asiatica*), 1.2 gm; flowers of 'sengrekna' (*Vernonia cinerea*),

1.2 gm; ginger, 5.0 gm; red dry chili, 1.2 gm; and previously prepared *marcha* as mother culture, 10.0 gm. The mixture is then made into a paste by adding water and kneaded into flat cakes of varying sizes and shapes. This is then placed individually on the kitchen ceiling floor made up of bamboo strips inlaid with fresh fronds of ferns, locally called 'pire uneu' (*Glaphylopteriolopsis erubescens*), and covered with dry ferns and jute bags. These are left to ferment for one to three days depending upon the temperature. Cakes of *marcha* are sun dried for two to three days and are stored at room temperature and in a dry place for more than a year<sup>62</sup>. This art of technology is protected as hereditary trade and passes from mother to daughters. The *marcha*-making villages have linkages to nearby markets where *marcha*-makers sell the products once or twice in a week in Sikkim. *Marcha* is similar to amylolytic mixed starters of other regions of NE such as *hamei* of Manipur, *pham*, *ipoh* and *phab* of Arunachal Pradesh, *humao* of Assam and *thiat* of Meghalaya<sup>61</sup>.

**Microorganisms**

Filamentous moulds- *Mucor circinelloides*, *M. hiemalis*, *Rhizopus chinensis* and *R. stolonifer* variety *lyococcus*; yeasts- *Saccharomycopsis fibuligera*, *Saccharomycopsis capsularis*, *Pichia anomala*, *P. burtonii*, *Saccharomyces cerevisiae*, *S. bayanus* and *Candida glabrata*, and lactic acid bacteria- *Pediococcus pentosaceus*, *Lb. bifementans* and *Lb. brevis*<sup>59,63,64,65,66,67</sup>.

The moisture, pH and acidity of *marcha* is 14 %, 5.6 with 0.1 % acidity, respectively<sup>1</sup>.

**Hamei:**-*Hamei* is a dry, round to flattened, solid ball-like mixed dough inocula used as starter cultures to prepare *atingba*, an alcoholic beverages in Manipur. Local varieties of rice, without soaking or soaking, and then dry, is crushed and mixed with powdered bark of 'yangli' (*Albizia myriophylla* Benth.) and a pinch of previously prepared powdered *hamei*. The dough is pressed into flat cakes and kept over paddy husk in a bamboo basket, covered by sack clothes for 2-3 days at room temperature, and then sun dried for 2-3 days<sup>23</sup>. Women sell *hamei* in local markets in Manipur.

**Microorganisms**

Filamentous moulds- *Mucor* spp., *Rhizopus* spp.; Yeasts - *Sacharromyces cerevisiae*, *Pichia anomala*, *P. guilliermondi*, *P. fabianii*, *Trichosporon* sp., *Candida tropicalis*, *C. parapsilosis*, *C. montana* and

*Torulaspora delbrueckii*; lactic acid bacteria - *Pediococcus pentosaceus*, *Lb. brevis*<sup>66,67,68</sup>.

### Alcoholic beverages

**Kodo Ko Jaanr:**-The most popular fermented finger millets-based mild alcoholic beverage with sweet-sour and acidic taste is *kodo ko jaanr* or *chyang* or *chee* prepared and consumed by the *Gorkha*, the *Bhutia*, the *Lepcha*, the *Monpa* and many ethnic groups of NE. Seeds of finger millet (*Eleusine coracana*), locally called *kodo*, are cleaned, washed and cooked for about 30 min, drained off and cooked millets are spread on a bamboo mat for cooling. About 1-2 % of powdered *marcha* is sprinkled over the cooked seeds, mixed thoroughly and packed in a bamboo basket lined with fresh fern, locally called '*thadre unew*' (*Thelypteris erubescens*), covered with sack cloths, and kept for 2-4 days at room temperature for saccharification. After 2-4 days, the saccharified mass is transferred into an earthen pot or bamboo basket called, made air-tight and fermented for 3-4 days during summer and 5-7 days in winter at room temperature<sup>62</sup>. Good quality of *jaanr* has a sweet taste with mild alcoholic flavor. *Kodo ko jaanr* is consumed by filling 200-500 gm of fermented millet grits into a vessel called *toongbaa* and lukewarm water is added up to its edge. After 10-15 min, the milky white extract of *jaanr* is sipped through a narrow bamboo straw called *pipsing* which has a hole in a side near the bottom to avoid passing of grits. Water can be added twice or thrice after sipping of the extract.

#### Microorganisms

Filamentous moulds- *Mucor circinelloides*, *Rhizopus chinensis*; yeasts - *Saccharomycopsis fibuligera*, *Pichia anomala*, *S. cerevisiae*, *Candida glabrata*; lactic acid bacteria - *Pediococcus pentosaceus*, *Lb. bifementans*<sup>69,70</sup>.

#### Nutritional value

Moisture: 69.7 %, pH: 4.1, alcohol: 4.8 %, ash: 5.1% DM, protein: 9.3 % DM, fat: 2.0 % DM, crude fibre: 4.7 % DM, carbohydrate: 83.7 % DM, food value: 389.6 kcal/100 gm, Ca: 281.0 mg/100 gm, K: 398.0 mg/100 gm, P: 326.0 mg/100 gm, Fe: 24.0 mg/100 gm, Mg: 118.0 mg/100 gm, Mn: 9.0 mg/100 gm and Zn: 1.2 mg/100 gm<sup>69</sup>.

Vitamin cynocobalamin, which is not present in finger millet, is synthesized by the fermenting microorganisms<sup>71</sup>. The essential amino acids like

valine, threonine, leucine and isoleucine are in higher concentration in *kodo ko jaanr* or *chyang*<sup>72</sup>. Because of high calorie, ailing persons and post-natal women consume the extract of *kodo ko jaanr* to regain the strength<sup>69</sup>.

**Bhaati Jaanr:**-*Bhaati jaanr* is an ethnic fermented rice beverage, consumed as a staple food beverage by the *Gorkha* in EN. Glutinous rice is cooked for about 15 min, drained off and 2 % 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 for saccharification. Then, the vessel is made airtight and fermented for 2-3 days in a summer and 7-8 days in a 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<sup>73</sup>. It is consumed directly as a food beverage.

#### Microorganisms

Filamentous moulds- *Mucor circinelloides*, *Rhizopus chinensis*; yeasts *Saccharomycopsis fibuligera*, *Pichia anomala*, *Saccharomyces cerevisiae*, *Candida glabrata*; lactic acid bacteria- *Pediococcus pentosaceus*, *Lb. bifementans*<sup>73</sup>.

#### Nutritional value

Moisture: 83.4 %, pH: 3.5, alcohol: 5.9 %, ash: 1.7 % DM, protein: 9.5 % DM, fat: 2.0 % DM, crude fibre: 1.5 % DM, carbohydrate: 86.9 % DM, food value: 404.1 kcal/100 gm, Ca: 12.8 mg/100 gm, K: 146.0 mg/100 gm, P: 595.0 mg/100 gm, Fe: 7.7 mg/100 gm, Mg: 50.0 mg/100 gm, Mn: 1.4 mg/100 gm and Zn: 2.7 mg/100 gm<sup>73</sup>.

Because of high calorie content, ailing persons and post-natal women consume the extract of *bhaati jaanr* to regain the strength<sup>73</sup>.

**Zutho:**-*Zutho* or *zhuchu* is an ethnic alcoholic beverage of the *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, left for cooling, amyolytic starter locally called *khekhrii*<sup>74</sup> powder is added and left about 6-8 hrs for brewing after which the whole mixture is poured into a big earthen jar. 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<sup>75</sup>. The similar alcoholic beverage called *nchiangne* is prepared from red rice in of Nagaland.



### Microorganisms

*Saccharomyces cerevisiae*<sup>76</sup>. It contains 5 % (v/v) alcohol, pH 3.6, acidity 5.1 %<sup>76</sup>.

### Conclusion

In North East India, diversity of ethnic fermented foods is related to diversity of ethnicity with unparallel food culture of each community. Microbial diversity ranges from filamentous moulds to enzyme-producing to alcohol-producing yeasts, and Gram-positive and few Gram-negative bacteria with biological functions enhancing several health-promoting benefits to the consumers. The ethnic fermented foods are food security of NE and are with the people at the time of famine, extreme environment and man-made disasters. These ethnic foods are also source of revenue for people to sustain their livelihood. Among the ethnic preferences, the *Gorkha* is the largest stakeholders as well as consumers of 80% of the ethnic fermented foods and alcoholic beverages in NE due to ethnic diversity within the *Gorkha* community from Brahmin to Kirat, Aryan to Mongoloid, and projection of indispensable food culture of the single community the *Gorkha*<sup>1</sup>. Some ethnic foods of NE are popular and widely preferred by the consumers, such foods may be popularised to non-consumers in other parts of the world.

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