

## Traditional technology and product characterization of some lesser-known ethnic fermented foods and beverages of North Cachar Hills District of Assam

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The present paper is aimed to document traditional knowledge, microbial profiles and nutritional value of some ethnic fermented foods and beverages of North Cachar (NC) Hills district of Assam. We selected two popular ethnic fermented bamboo shoot products (wet-*Tuaitthur* and dry-*Tuairoi*), an ethnic fermented pork/boar meat product (*Honoheingrain*), a non-food dry mixed amylolytic starter (*Humao*), and an ethnic fermented beverage (*Judima*) for studies. Based on observation and interviews with the producers and consumers, traditional knowledge of ethnic fermented foods and beverages production, their mode of consumption, socio-economy and ethnical value were documented. A total of 21 samples of *Tuaitthur*, *Tuairoi*, *Honoheingrain*, *Humao* and *Judima* of NC Hills were analyzed for the microbial population which was recorded at the level of  $10^4$  to  $10^9$  cfu/gm. Microorganisms isolated and identified from *Tuaitthur*, *Tuairoi*, *Honoheingrain*, *Humao* and *Judima* were: bacteria- *Lactobacillus brevis*, *Lb. plantarum*, *Enterococcus faecium*, *Leuconostoc mesenteroides*, *Pediococcus pentosaceus*, *Lactococcus lactis*, *Bacillus subtilis*, *B. cereus*, *B. circulans*, *B. firmus*, *B. pumilus*, *B. licheniformis*, *B. stearothermophilus*, *B. sphaericus*, *B. laterosporus*, *B. polymyxa*, *Staphylococcus aureus* and *Micrococcus* sp.; yeasts- *Debaryomyces hansenii* and *Saccharomyces cerevisiae*; moulds- *Mucor* and *Rhizopus*. The nutritional composition of ethnic fermented foods showed the nutritional value essential for local people in their diet. Higher minerals contents in *Judima* indicate contribution of mineral intake in the daily diet of the local people in NC Hills of Assam. Documentation of cultural and biological importance of ethnic fermented foods and beverages of NC Hills of Assam would help to understand the role of native microorganisms in traditional food fermentation.

**Keywords:** Product characterization, Fermented foods, Beverages

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Foods prepared by different communities are unique and distinct due to the geographical location, environmental factors, food preference and availability of plant or animal sources<sup>1</sup>. Ethnic fermented foods are defined as foods produced by the ethnic people using their native knowledge 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 culturally and socially acceptable to the consumers<sup>2</sup>. Three major groups of microorganisms are associated with ethnic fermented foods: bacteria, yeasts and fungi<sup>2</sup>. Microorganisms transform the chemical constituents of raw materials during food fermentation and enhance the nutritive value of the products, and promote health benefits to consumers<sup>3</sup>.

Ethnic people of North Cachar (NC) Hills District of Assam traditionally practice integrated agriculture, animal husbandry, agro-forestry and forestry. Documentation of various ethnic fermented foods and beverages of Cachar Hills of Assam, microbiological profiles, and nutritional value have not been studied yet. The present paper is aimed to document the traditional knowledge of ethnic people for production of some popular fermented foods of NC Hills and also to study microbial profile and nutritional value of the products.

### Materials and methods

#### Survey

A field survey was conducted in different regions of North Cachar Hills district of Assam. The following villages of NC Hills district of Assam were surveyed for collection of information and samples:

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Semkhor village; Maibong bazaar, Maibong; Dibarai basti; Tularam-raji; Dimalik-raji; Sainja-raji; Fiangpui–basti; Zion-basti; Lodi-basti; Boro-haflong; Gunjung; Mouloi; Lungkhok; Jatinga village; Haflong bazar, Haflong; Laisongbasti; Toulpui; Asalu; Songpijang and Purana laikul. The information gathered from ethnic communities represented by *Dimasa, Hmar, Zeme Naga, Rangmei Naga, Baite, Vaiphei, Hrangkhok, Karbi, Kuki, Khasi, Jayantia* and *Khelma*. Indigenous knowledge on the various types of ethnic fermented foods and alcoholic beverages and drinks, traditional methods of preparation, mode of consumption, socio-economy and ethnic value of the products was also documented based on the information sought from the local people of the respective places using a standard procedure as described by Tamang *et al.*<sup>4</sup>.

### Collection of samples

A total of 21 samples of ethnic fermented foods, dry amyolytic starter and alcoholic beverage (4 samples of *Tuaitthur*, 5 samples of *Tuairoi*, 4 samples of *Honoheingrain*, 4 samples of *Humao* and 4 samples of *Judima*) were collected from different villages of NC Hills district of Assam. All samples were collected aseptically in pre-sterile poly-bags and pre-sterile bottles and were stored at  $-20^{\circ}\text{C}$  for further studies.

### Microbiological analysis

Sampling, series dilution and microbiological analysis of samples were done as per the method described by Tamang *et al.*<sup>5</sup>. Ten g of sample were homogenized with 90 ml of 0.85 % (w/v) sterile physiological saline in a stomacher lab-blender (400, Seward, UK) for 1 min. A serial dilution ( $10^{-1}$  to  $10^{-8}$ ) in the same diluent was made. Enumeration and isolations were targeted for few selected bacteria: lactic acid bacteria, bacilli, and micrococcaeae (only in meat product); yeasts and filamentous moulds. Lactic acid bacteria (LAB) were isolated on MRS agar (M641, HiMedia) plates supplemented with 1 %  $\text{CaCO}_3$ <sup>6</sup> and were incubated at  $30^{\circ}\text{C}$  under anaerobic condition kept in an Anaerobic Gas-Pack container (LE002, HiMedia) for 48-72 hrs. Spore-forming bacilli were isolated on nutrient agar (MM012, HiMedia), after inactivation of vegetable cells by heating at  $100^{\circ}\text{C}$  for 2 min<sup>7</sup> and then incubated at  $37^{\circ}\text{C}$  for 24 hrs. Micrococcaeae in fermented meat samples were enumerated and

isolated in Mannitol-salt Phenol-red Agar (Merck) following the method of Papamanoli *et al.*<sup>8</sup> and plates were incubated at  $30^{\circ}\text{C}$  for 48 hrs. Identity of micrococci was further confirmed by growing in FTO (furazolidone) agar<sup>9</sup>. Spread plates of Baird Parker agar base (M043, HiMedia) with appropriate additions of Egg yolk tellurite emulsion (FD046, HiMedia) was used for selective enumeration of *Staphylococcus aureus*. Yeasts were isolated on yeast-malt extract (YM) agar (M424, HiMedia), supplemented with 10 IU/ml benzylpenicillin and 12 g/ml streptomycin sulphate, respectively; and plates were incubated aerobically at  $28^{\circ}\text{C}$  for 72 hrs<sup>10</sup>. Filamentous moulds were isolated on potato dextrose agar (M096, HiMedia), supplemented with 10 IU/ml benzylpenicillin and 12 g/ml streptomycin sulphate, respectively and were incubated aerobically at  $25^{\circ}\text{C}$  for 72 hrs<sup>11</sup>.

LAB were identified following the taxonomical keys of Wood and Holzapfel<sup>12</sup> and by APILAB PLUS database software (bioMérieux, France). Endospore-forming bacilli were identified according to the keys described by Slepecky and Hemphill<sup>13</sup>. Micrococcaeae strains were characterized and identified following the keys described by von Rheinbaben & Hadlok<sup>9</sup>. Yeasts were identified according to Kurtzman & Fell<sup>14</sup>. Filamentous moulds were identified according to the taxonomical method described by Hesselstine<sup>15</sup>.

### Nutritional value

The pH of the sample was determined directly using a digital pH meter (Type 361, Systronics) calibrated with standard buffer solutions (Merck). Titratable acidity of sample was calculated by titrating the filtrates of a well blended 10 gm sample in 90 ml carbon-dioxide free distilled water with 0.1 N sodium hydroxide to end point of phenolphthalein (0.1 % w/v in 95 % ethanol)<sup>16</sup>. Moisture content was determined by weight loss of accurately weighed 1 gm of sample (in triplicate) after heating at  $135^{\circ}\text{C}$  for 2 hrs. Ash content was measured by heating the sample at  $550^{\circ}\text{C}$  until the difference between two successive weighing was  $\leq 1\text{mg}$ <sup>16</sup>. Protein content was determined by multiplying total nitrogen, estimated by standard Kjeldahl method, by 6.25<sup>16,17</sup>. Fat content was determined by ether extraction using glass soxhlet<sup>16</sup>. Carbohydrate content was estimated by difference:  $100 - (\% \text{ protein} + \% \text{ fat} + \% \text{ ash})$ <sup>18</sup>. Energy value of a sample was estimated as the method described

by Indrayan *et al.*<sup>19</sup>. Minerals (copper, chromium, manganese, iron, zinc, magnesium, potassium, sodium, lead, nickel and selenium) present in uncooked rice, raw bamboo shoots and raw pork meat, and fermented products (*Tuaithur*, *Tuairoi*, *Honoheingrain*, *Judima* and *Juharo*) were estimated using Atomic Absorption Spectrophotometer (Model 2380, Perkin-Elmer).

The statistical data were analysed by determining the standard deviation (SD) as described by Snedecor and Cochran<sup>20</sup>.

### Results and discussion

Based on personal observation and interviews with the local producers and consumers, more than 49 varieties of common and lesser-known ethnic fermented foods and beverages of Cachar Hills of Assam were listed (Table 1). For the present study, two common ethnic fermented bamboo shoot products (*Tuaithur* and *Tuairoi*), one fermented meat product (*Honoheingrain*), one dry mixed starter (*Humao*), and fermented beverage (*Judima*) were studied concerning traditional methods of preparation, their mode of consumption, socio-economy, microbiological profiles and nutritional value.

#### *Tuaithur*

*Tuaithur* (Fig. 1; a) is an ethnic fermented bamboo shoot product with sour-acidic taste prepared and consumed by the *Hrangkhol*, *Baite* and *Hmar* tribes of North Cachar Hills district of Assam. *Dimasa* calls it as *miyamikhri*. It is similar to other ethnic fermented bamboo shoot products of North East India and the Himalayas such as *mesu* of Nepal, Darjeeling hills, Sikkim and Bhutan; *soidon* and *soibum* of Manipur; *ekung* and *hiring* of Arunachal Pradesh; *lung-siej* of Meghalaya<sup>21</sup>. During the traditional method of preparation of *Tuaithur*, young tender shoots of bamboo (*Dendrocalamus hamiltonii* Nees. et Arn. ex Munro, *Melocanna bambusoides* Trin. and *Bambusa tulda* Roxb.) are collected, their outer hard casings are removed and inner portion is then chopped into small pieces with a knife. The chopped pieces are washed thoroughly with clean water, drained well and pressed tightly in cylindrical vessels made of bamboo, or in bottles. Water coming out from the bamboo shoot is decanted continuously for 2-3 days. Then, a little amount of fresh water is added. The vessel is made air tight with a lid and fermented under natural anaerobic condition for 6-7 days (Fig. 2). Now, *Tuaithur* is ready for consumption. It is kept in an air-tight

container or in sealed plastic bags for few months at ambient temperature.

*Tuaithur* is prepared as curry with lentil, vegetables such as brinjal, *Arum* stem, etc. Curry is also prepared as curry with dry fish or meat product mixing with salt. It is also made as pickle and can be preserved for several months. *Tuaithur* is sold in the local markets during the months of June to September. It costs Rs. 40-45 per Kg. Some rural women are dependent on this product for their livelihood.

#### *Tuairoi*

*Tuairoi* (Fig. 1b) is a dry fermented bamboo tender shoot product consumed by the *Hrangkhol* and *Baite* tribe of NC Hills district of Assam. It is slightly acidic in taste and similar to *eup* of Arunachal Pradesh; both are dried fermented bamboo shoot products<sup>21</sup>. During the traditional method of preparation of *Tuairoi*, young tender shoots of bamboo (*Dendrocalamus hamiltonii* Nees. et Arn. ex Munro, *Melocanna bambusoides* Trin. and *Bambusa tulda* Roxb.) are collected, their outer hard casings are removed and washed with water and inner portion is then chopped into small pieces with a knife. Boil for few min and excess water is decanted out and spread in a bamboo mat, and kept above the kitchen oven or in the sunlight for 6-7 days to completely dry (Fig. 3). Now, *Tuairoi* is ready for consumption. It is kept in poly-bags for few months. It is cooked with meat, dry-fish or with vegetables, and is eaten with boiled rice. Dry bamboo shoot is sold in the local markets during the months of June to September. It costs Rs. 50-55 per Kg.

#### *Honoheingrain*

*Honoheingrain* (Fig. 1c) is an ethnic fermented pork or boar (wild pig) product consumed by *Dimasa* tribe of North Cachar Hills. *Honoheingrain* is similar to ethnic meat products of the Himalayas such as *satchu* and *suka ko masu* of Nepal, Darjeeling hills and Sikkim<sup>22</sup>. Freshly killed wild boar/hog (*Sus scrofa* L.) is collected for preparation of *Honoheingrain*. Upper skin along with its hair is removed with a knife and washed thoroughly and dipped into boiled water for few min for removing of excess hair. Then cut into several small pieces, kept it in a bamboo mat above the machang which is about 2-3 ft above the fire places or kitchen oven and fermented for 4-5 days till it completely dries (Fig. 4). *Dimasa* prefers wild boar but since it is not available all the time, pork and other meat replaces the wild boar. *Honoheingrain* is made

Table 1—Ethnic fermented foods and beverages of North Cachar Hills district of Assam

SL	Product	Raw material	Product nature	Mode of consumption	Major consumer
1	<i>Judima</i>	Rice	Alcoholic beverage	Drunk directly	<i>Dimasa</i>
2	<i>Juharo</i>	Rice	Distilled liquor	Drunk directly/with water	<i>Dimasa</i>
3	Fruit Beer	Banana, Pineapple	Acidic/alcoholic	Drunk directly	<i>Dimasa/Hmar</i>
4	<i>Enjang</i>	Seeds of lady's finger or <i>Hibiscus sabdarifa</i>	Sour, soft/hard	Pickle	<i>Dimasa/Hrangkhol</i>
5	<i>Miya mikhri</i>	Young bamboo shoots	Sour, acidic, solid	Curry with vegetables	<i>Dimasa</i>
6	<i>Nah-grain</i>	Small fish	Dry, solid	Pickle; curry	<i>Dimasa</i>
7	<i>Mogong- grain</i>	Meat of buffalo/pig, boar/deer	Rough, hard, dried meat	Curry	<i>Dimasa</i>
8	<i>Honohein grain</i>	Pig/boar meat	Rough, hard, dried meat	Curry	<i>Dimasa</i>
9	<i>Kari</i>	Bamboo or banana plant	Liquid, alkaline	Condiment	<i>Dimasa</i>
10	<i>Bikhann</i>	Soybeans	Semi-Solid	Curry	<i>Zeme Naga</i>
11	<i>Dekuijao</i>	Rice	Alcoholic beverage	Drunk directly	<i>Zeme Naga</i>
12	<i>Nduijao</i>	Rice	Alcoholic beverage	Drunk directly	<i>Zeme Naga</i>
13	<i>Bastangha</i>	Bamboo shoot	Solid, sour	Curry	<i>Zeme Naga</i>
14	<i>Thunkhiang</i>	Bamboo shoot	Solid, sour	Curry	<i>Rongmei Naga</i>
15	<i>Ganeng-Kaang</i>	<i>Brassica</i> leaf	Crushed, dried	Curry	<i>Rongmei Naga</i>
16	<i>Ndui</i>	Any dried edible leaves (Banana leaves/ <i>Mattikalai</i> plant)	Alkaline	Given in vegetable/dry meat curry preparation	<i>Rongmei Naga</i>
17	<i>Gwai-Rou</i>	Cow's/buffalo's fat and intestine	Semi-solid, soft	Pickle/added in vegetable or dry meat curry	<i>Rongmei Naga</i>
18	<i>Gwag-Ruum</i>	Pork fat and meat	Semi-solid, soft	Pickle/added in vegetable or dry meat curry	<i>Rongmei Naga</i>
19	<i>Kharum</i>	Small fish	Soft, mashed	Pickle, curry with vegetable	<i>Rongmei Naga</i>
20	<i>Sathu</i>	Pig's fat	Hard, used as an edible oil	Pickle/with vegetables	<i>Hmar</i>
21	<i>Ngathu</i>	Fish	Half -dried	Pickle/curry	<i>Hmar</i>
22	<i>Tuithur</i>	Bamboo shoot	Solid, sour	Pickle/curry	<i>Hmar</i>
23	<i>Bekanthu</i>	Soybean	Semi-solid	Curry	<i>Hmar</i>
24	<i>Sithu</i>	Sesame	Semi-solid/soft	Pickle/or with rice	<i>Hmar, Vaiphei, Kuki</i>
25	<i>Antramthu</i>	Mustard leaves	Dried/semi-liquid	Pickle/with Rice	<i>Hmar, Biате</i>
26	<i>Tuaithur</i>	Bamboo shoot	Solid, wet, sour	Curry/pickle	<i>Biате</i>
27	<i>Tuairoi</i>	Bamboo shoot	Solid, dry, sour	Curry	<i>Biате</i>
28	<i>Bemerthu</i>	Soybean	Semi-solid, soft	Curry	<i>Biате</i>
29	<i>Sithu</i>	Sesame	Semi-solid, soft	Pickle/with rice	<i>Biате</i>
30	<i>Samthu</i>	Mixture of corn and sesame with hot water	Semi-liquid	Pickle/condiment	<i>Biате</i>
31	<i>Inchangthu</i>	Seeds of <i>Hibiscus sabdarifa</i>	Sour, soft/hard	Pickle	<i>Biате</i>
32	<i>Antramthu</i>	Leaves of <i>Brassica</i> sp.	Dried	Curry	<i>Biате</i>
33	<i>Dolroi</i>	Leaves and stem of Arum plant	Dried	Curry	<i>Biате</i>
34	<i>Sathu</i>	Pork meat with fat	Hard, used as an edible oil	Pickle/with vegetables	<i>Biате</i>
35	<i>Bumong-baitui</i>	Rice	Alcoholic beverage	Drunk directly	<i>Biате</i>
36	<i>Ngathu</i>	Small fish	Half-dried	Pickle	<i>Biате</i>
37	<i>Sathu</i>	Fats of buffalo/pig/ cow	Hard, used as an edible oil	Pickle/with vegetable	<i>Vaiphei</i>
38	<i>Ngathu</i>	Fish	Half-dried	Pickle	<i>Vaiphei</i>

Contd.

Table 1—Ethnic fermented foods and beverages of North Cachar Hills district of Assam (Contd.)

SL	Product	Raw material	Product nature	Mode of consumption	Major consumer
39	<i>Bekanthu</i>	Soybean	Semi-solid	Curry	<i>Vaiphei</i>
40	<i>Ankamthu</i>	Leaves of <i>Brassica</i> , spinach	Dried, liquid extract	Pickle, liquid extract as soup	<i>Vaiphei</i>
41	<i>Juhning</i>	Rice	Alcoholic beverage	Drunk directly	<i>Hrangkhol</i>
42	<i>Tuaitthur</i>	Bamboo shoot	Solid, sour	Curry/pickle	<i>Hrangkhol</i>
43	<i>Tuaihroi</i>	Bamboo shoot	Solid, dry, sour	Curry	<i>Hranhkhol</i>
44	<i>Saphak</i>	Pig's meat with fats	Soft or hard	Pickle/curry	<i>Hrangkhol</i>
45	<i>Tungtoh</i>	Soybean	Soft, semi-solid	Pickle	<i>Jayantia</i>
46	<i>Tungrymbai</i>	Soybean	Soft, semi-solid	Pickle	<i>Khasi</i>
47	<i>Ngathu</i>	Fish	Half-dried	Curry/pickle	<i>Kuki</i>
48	<i>Sathu</i>	Pig's fat	Hard, used as an edible oil	Pickle/with vegetables	<i>Kuki</i>
49	<i>Humao</i>	Rice, barks of wild plants	Dry, flat, cake-like starter	Non-food starter for <i>Judima</i> production	<i>Dimasa</i>

into curry. *Honoheingrain* is sold in the local market in North Cachar Hills, and some people are economically dependent upon it. The existing local price of *Honoheingrain* is around Rs. 350-355/kg. During 'hirimdi puja' of *Dimasa*, pig is sacrificed to Goddesses. *Honoheingrain* curry is prepared to solemnize the marriage ceremony.

### **Humao**

*Humao* is the traditionally prepared mixed amylolytic dough inocula used as a starter for the production of various indigenous alcoholic beverages and drinks. *Humao* is a dry, flat- rounded and oval, creamy white to dusty white, solid starter ranging from 1.5 - 10.8 cm in diameter with the weight ranging from 20 - 25 gm (Fig. 1d). *Dimasa* calls it *Humao*, *Hrangkhol* calls it *Chol* and *Jeme Naga* calls it *Nduhi*. Sticky rice is soaked for 10-12 hrs at room temperature and crushed with bark of *Albizia myriophylla* and 1-2 % of previously prepared starter in the form of powder. The mixture is then made into paste by adding water and kneaded into flat rounded and oval cakes of varying sizes and kept it for one to three days at 25-30°C and sun dried (Fig. 5). The traditional method of preparation of *Humao* is protected as hereditary trade and passes from mother to daughters. *Humao* is produced at home and is sold in local periodical markets exclusively by the rural women. Cost of a single *Humao* (size, 20-25 gm) is around Rs.10/.

In any religious festivals, the ethnic people offer *humao* to each male and female in the name of family God and Goddesses. *Humao* is simile to other ethnic amylolytic dry, mixed, flat to round-shaped starters such as *marcha* of Darjeeling hills, Sikkim and Nepal,

*hamei* of Manipur, *manapu* of Nepal, *phab* of Tibet and Ladakh, *poo* of Bhutan, *pham* and *ipoh* of Arunachal Pradesh, *bakhar* of Himachal Pradesh, *thiat* of Meghalaya, and *balan* of Uttarakhand<sup>23</sup>.

### **Judima**

*Judima* or *Zu* (Fig. 1e) is a mild-alcoholic beverage, with distinct sweet aroma, prepared from steamed glutinous rice. Different ethnic groups of people call it by their own dialect such as *judima* (by *Dimasa*), *juhning* (*Hrangkhol*), *jeme naga* (*Deuijao* and *Nduijao*), *remalu baitui* and *bumong baitui* (*Baite*). *Dimasa* prefers sticky rice (*Oryza sativa* L., local cultivar "Bairong"/"Maiju-walao"/"Maiju-walao-gedeba"/"Maiju-hadi") for better quality of *Judima* preparation or sometimes if sticky rice is not available they mix 80% ordinary rice with 20 % of sticky rice. During the traditional method of preparation of *Judima*, the sticky rice is cleaned, washed, cooked and excess water is drained out. Cooked rice is spread over in bamboo mats or banana leaves (rice is spread over in 6-8 inches thickness) for cooling, nowadays, polythene sheet is also used, and then ~ 1 % of *humao* is mixed (Fig. 1a) thoroughly and added a little amount of water. The fermenting mass is placed in a fresh banana leaves and again externally covering by another leaves of banana or polythene sheet and fermented for 1-2 days (in summer), or 3-4 days (in winter) at room temperature. When sweet flour is emitted (saccharification), the fermented mass is transferred in a *khulu* (triangle shape bamboo made cone) (Fig. 1c) covering by banana leaves or hollow earthen pot (Fig. 6). Now, an empty vessel or *hundy* is kept below *khulu* and the juices are collected in the vessel



Fig. 1—(a) *Tuaitthur* in poly-bags for selling, (b) *Tuairoi*, (c) *Honoheingrain*, (d) *Humao*, (e) *Judima*

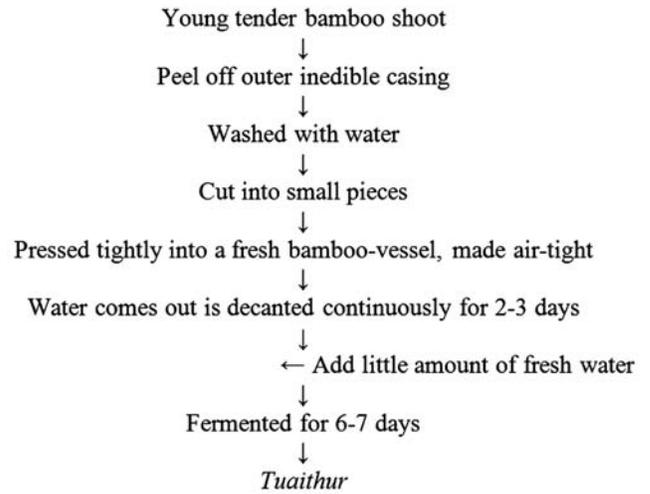


Fig. 2—Flow sheet of traditional method of *Tuaitthur* preparation in NC Hills of Assam

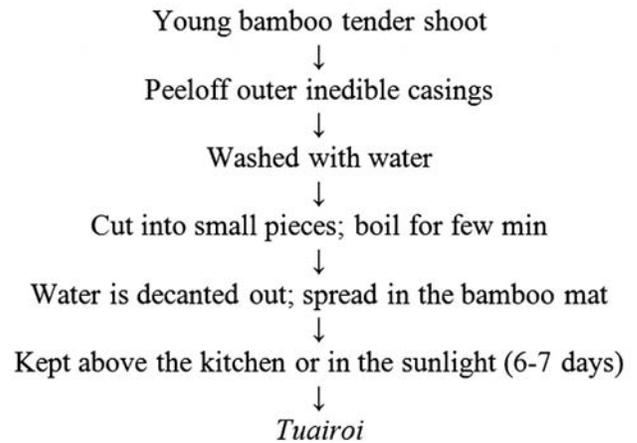


Fig. 3—Flow sheet of traditional method of *Tuairoi* preparation in NC Hills of Assam

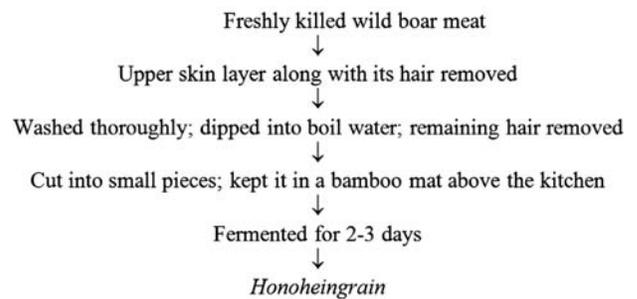


Fig. 4—Flow sheet of traditional method of *Honoheingrain* preparation in NC Hills of Assam

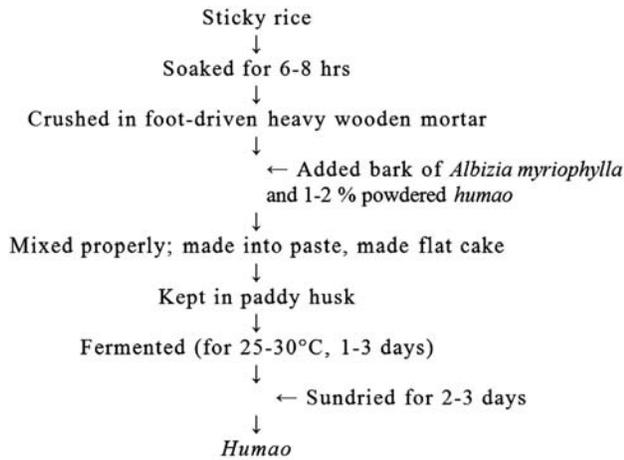


Fig. 5—Flow sheet of traditional method of *humao* preparation in NC Hills of Assam

(it requires 1-2 days) which is called as *Judima*. After collection of *Judima*, left out rice, called *Jugap*, is distilled to make high alcohol content liquor, locally called *Juharo*. *Judima* is similar to *bhaati jaanr* of the Himalayan regions of India, Nepal and Bhutan<sup>11</sup>.

*Judima/Zu* is drunk directly with or without water. After celebration of the traditional rituals and festivals, *Judima* is served with meats. *Juharo*, the distilled liquor is more alcoholic and acidic in taste. It is a traditional diet for women in villages who believe that it helps them to regain their strength. Ethnic people believe that the quality of *Zu* depends upon the richness of the family, i.e. better quality of *Judima* is prepared by rich family. Best quality of *Judima* is pineapple juice colour or yellowish-red in colour. The colour of the products depends on the quality of rice. Besides home consumption, *Judima* is sold in the local market of NC Hills by some people who are economically dependent upon *Judima*. It costs Rs.45-50 per 750 ml bottle.

Besides food culture, *Judima* is an integral part of ritual for *Dimasa*. During religious festivals, freshly prepared *Judima* is offered to the family God and Goddesses. During birth, a drop of *Judima* is administered in the lips of new born baby to protect from any devil forces. *Judima* and *Juharo* are essential to solemnize their marriage ceremony. Traditionally, newly wedded bride visits her parents' house once in a year, when she returns back to her husband's house she should carry the *Judima*. The traditional festival '*busudima*' of *Dimasa* is celebrated with freshly prepared *Judima*. In death ceremony, freshly prepared *Judima* is offered to death

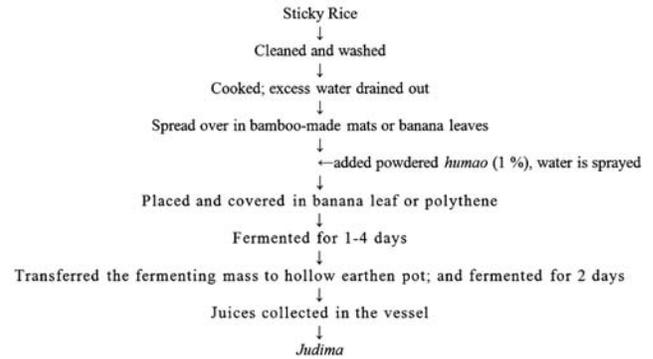


Fig. 6—Flow sheet of traditional method of *Judima* preparation in NC Hills of Assam

persons and also to ancestors. Guests are also served with *Judima*. Without *Judima* no celebration or religious ceremony is completed.

The native skills of food fermentation have been passed from mothers to daughters, fathers to sons through the traditional knowledge of the elders which include grand-mothers/fathers, mothers/fathers and village elders, self practice, family tradition, community knowledge and neighbours<sup>18</sup>. It was observed during survey that despite of popularity of these ethnic fermented foods and beverages in NC Hills of Assam, both from cultural as well as economical point of view, no affords by state Government or corporate sectors have been made to promote these ethnic foods and drinks. Even these culturally rich ethnic foods have not been included in any financial institutions, small cottage industries for employment generation, and food processing programmes. We recommend that the ethnic fermented foods and alcoholic drinks of NC Hills of Assam should be included in food processing section of Government's scheme for enhancement of regional economy, generation of employment, and also promotion of age-old food culture of Assam in the global markets. Role of indigenous women in NC Hills of Assam for production and marketing of ethnic fermented foods and beverages should be highlighted.

### Profiles of microorganisms

The microbial population of *Tuaitur*, *Tuairoi*, *Honoheingrain*, *Humao* and *Judima* collected from different villages and markets of NC Hills of Assam showed composition of lactic acid bacteria (LAB) which was represented by 5 genera- *Lactobacillus*, *Leuconostoc*, *Pediococcus*, *Enterococcus* and *Lactococcus* in a viable number of  $10^6$  cfu/gm (Table 2). Based on phenotypic characteristics and

Table 2—Profile of microorganisms isolated from *Tuaithur*, *Tuairoi*, *Honoheingrain*, *Humao* and *Judima* of North Cachar Hills district of Assam

Product	Microorganisms		
	Bacteria	Yeast	Moulds
<i>Tuaithur</i>	<i>Lb. plantarum</i> , <i>Lb. brevis</i> , <i>P. pentosaceou</i> , <i>Lectococcus lactis</i> <i>Bacillus circulans</i> , <i>B. firmus</i> , <i>B. sphaericus</i> , <i>B. subtilis</i>	NR	NR
<i>Tuairoi</i>	<i>Lb. plantarum</i> , <i>E. faecium</i> , <i>P. pentosaceous</i> , <i>Leuc. Mesenteroides</i> <i>B. laterosporus</i> , <i>B. circulans</i> , <i>B. stearothermophilus</i> , <i>B. firmus</i> , <i>B. cereus</i>	NR	NR
<i>Honoheingrain</i>	<i>Lb. brevis</i> , <i>Lb. plantarum</i> , <i>Leuc. mesenteroides</i> , <i>E. faecium</i> <i>Bacillus cereus</i> , <i>B. pumilus</i> , <i>B. firmus</i> , <i>B. circulans</i> , <i>B. stearothermophilus</i> , <i>Micrococcus</i> , <i>Staphylococcus</i>	<i>Debaryomyces hansenii</i> , <i>Saccharomyces cerevisiae</i>	<i>Mucor</i> , <i>Rhizopus</i>
<i>Humao</i>	<i>P. pentosaceous</i> <i>B. polymyxa</i> , <i>B. licheniformis</i> <i>B. stearothermophilus</i>	<i>D. hansenii</i> , <i>S. cerevisiae</i>	<i>Mucor</i> , <i>Rhizopus</i>
<i>Judima</i>	<i>P. pentosaceous</i> <i>B. circulans</i> , <i>B. laterosporus</i> , <i>B. pumilus</i> , <i>B. firmus</i>	<i>D. hansenii</i> , <i>S. cerevisiae</i>	NR

NR, nor recovered

API sugar profiles data (bioMérieux, France), strains of LAB isolated from samples of *Tuaithur*, *Tuairoi*, *Honoheingrain*, *Humao* and *Judima* collected from NC Hills of Assam were identified as *Lactobacillus brevis*, *Lb. plantarum*, *Enterococcus faecium*, *Leuconostoc mesenteroides*, *Pediococcus pentosaceou* and *Lactococcus lactis* (data not shown). The isolated, identified and preserved microorganisms from lesser-known ethnic fermented foods and beverages contribute significant database information on unknown microbial gene pool as genetic resources<sup>24</sup>. Due to presence of LAB in ethnic fermented foods of NC Hills of Assam, food safety for rural people may be ensured.

Several species of *Bacillus* were isolated from ethnic fermented foods and beverages of NC Hills of Assam showing species diversity of *Bacillus*. These included *Bacillus subtilis*, *B. cereus*, *B. circulans*, *B. firmus*, *B. pumilus*, *B. licheniformis*, *B. stearothermophilus*, *B. sphaericus*, *B. laterosporus* and *B. polymyxa*. Earlier reports also confirmed the presence of bacilli (*Bacillus subtilis*, *B. licheniformis*, *B. coagulans*, *B. cereus*, *B. pumilus*) in similar ethnic fermented bamboo shoot products of Manipur

Table 3—Nutritional value of *Tuaithur*, *Tuairoi* and *Honoheingrain*

Parameter	Product		
	<i>Tuaithur</i> (n=3)	<i>Tuairoi</i> (n=4)	<i>Honoheingrai</i> n (n=2)
pH	4.0 ± 0.1	5.4 ± 0.1	6.0 ± 0.06
Titrate acidity % (as lactic acid)	0.83 ± 0.01	0.68 ± 0.01	0.34 ± 0.01
Moisture %	92.3 ± 2.0	27.3 ± 2.0	24.1 ± 1.0
Ash (% DM)	4.6 ± 1.0	21.0 ± 1.0	12.4 ± 1.0
Fat (% DM)	3.4 ± 0.1	2.9 ± 0.1	9.0 ± 0.5
Protein (% DM)	4.6 ± 1.2	15.6 ± 1.2	13.1 ± 1.1
Carbohydrate (% DM)	87.4 ± 2.3	60.5 ± 2.3	65.5 ± 2.6
Food value (Kcal/100 g DM)	398.6 ± 1.2	330.5 ± 1.2	395.2 ± 1.4

n, total number of samples (n) collected from each source is given in parenthesis. DM, dry matter  
Data represents the means (± SD) of triplicate of each sample.

*soibum* and *soidon*<sup>25</sup>. Two genera *Staphylococcus* and *Micrococcus* belonging to Micrococcaceae were isolated from *Honoheingrain* of NC Hills of Assam. Micrococcaceae along with LAB and yeasts

Table 4—Mineral contents of raw substrates and their fermented products

Product	Mineral (ppm)										
	Cu	Cr	Mn	Fe	Zn	Mg	K	Na	Pb	Ni	Se
Rice	0.34	ND	0.68	0.95	2.40	1.13	2.06	0.29	0.15	0.01	1.20
Bamboo shoot	0.01	ND	2.06	4.07	2.89	2.00	8.83	0.24	0.12	0.09	1.98
Pork meat	0.02	0.01	0.07	0.50	1.05	1.70	4.65	0.75	ND	0.03	0.44
<i>Tuaithur</i>	0.46	0.02	2.56	4.72	3.32	2.16	11.68	0.34	1.11	1.23	ND
<i>Tuairoi</i>	0.56	ND	3.48	8.12	3.25	3.54	11.26	0.39	1.05	1.05	ND
<i>Honoheingrain</i>	1.27	0.01	0.80	6.18	4.92	2.75	10.45	1.06	ND	0.19	ND
<i>Judima</i>	1.10	0.01	1.57	1.93	ND	2.48	2.78	0.53	0.24	ND	2.21
<i>Juharo</i>	0.46	0.03	1.14	1.35	ND	2.06	2.10	0.34	0.04	ND	2.88

ND, not detectable.

Cu, copper; Cr, chromium; Mn, manganese; Fe, iron; Zn, zinc; Mg, magnesium; K, potassium; Na, sodium; Pb, lead; Ni, nickel; Se, selenium.

are the typical microflora in meat products<sup>26</sup>. Micrococcaceae was also reported from ethnic meat products of the Himalayas<sup>27</sup>.

Though, the dominant microflora was bacteria, sizable number of yeasts was also recovered in the samples of *Honoheingrain*, *Humao* and *Judima* collected from NC Hills of Assam. Two genera of yeasts *Debaryomyces hansenii* and *Saccharomyces cerevisiae* were identified from samples of *Honoheingrain*, *Humao* and *Judima*. Species of *Mucor* and *Rhizopus* were isolated only from *Humao*. Yeasts and filamentous moulds contribute in saccharification and liquefaction of glutinous rice, breaking starch of substrates into glucose for alcohol production and also in aroma formation in *bhaati jaanr* preparation<sup>11</sup>.

Compiling the identification profiles of the microorganisms isolated from *Tuaithur*, *Tuairoi*, *Honoheingrain*, *Humao* and *Judima* of NC Hills of Assam, it was found that eight genera with eighteen species of bacteria, two genera and species of yeasts and two genera of filamentous moulds were recovered (Table 2). These were: LAB - *Lactobacillus brevis*, *Lb. plantarum*, *Enterococcus faecium*, *Leuconostoc mesenteroides*, *Pediococcus pentosaceus*, *Lactococcus lactis*; Bacilli: *Bacillus subtilis*, *B. cereus*, *B. circulans*, *B. firmus*, *B. pumilus*, *B. licheniformis*, *B. stearothermophilus*, *B. sphaericus*, *B. laterosporus*, *B. polymyxa*; Micrococcaceae: *Staphylococcus aureus* and *Micrococcus* sp.; Yeasts: *Debaryomyces hansenii* and *Saccharomyces cerevisiae*; Filamentous moulds: *Mucor* and *Rhizopus* species.

### Nutritional value

The nutritional value of *Tuaithur*, *Tuairoi* and *Honoheingrain* collected from NC Hills were analyzed (Table 3). The pH of *Tuaithur*, *Tuairoi* and *Honoheingrain* was in between 4.0-6.0 with the

titratable acidity ranging from 0.34-0.83 % (Table 3). The pH of *Judima* was  $4.4 \pm 0.1$  and titratable acidity was  $0.45 \pm 0.01$  (table not shown). The pH of *Tuaithur* and *Tuairoi* was slightly acidic in nature due to the predominance of the LAB flora. Moisture content in *Tuairoi* and *Honoheingrain* is low due to drying after fermentation; whereas *Tuaithur* is freshly prepared with high moisture content. Moisture content of *Tuaithur*, *Tuairoi* and *Honoheingrain* was 24.1-92.3 %, ash was 4.6-21.0 % DM, fat was 2.9-9.0 % DM, protein content was 4.62-15.6 % DM and carbohydrate was 60.5-87.4 % DM (Table 3). The food value or calorie value (Kcal/100 gm dry matter basis) of *Tuaithur* was 398.6, *Tuairoi* was 330.5 and *Honoheingrain* was 395.2, respectively (Table 3). Due to the low moisture content and slightly acidic nature *Tuairoi* and *Honoheingrain* can be kept for longer period and are safe for consumption. Due to relatively high calorie value, *Honoheingrain* is good source of animal protein for rural people of NC Hills. The results showed higher content of minerals in fermented products of NC Hills particularly in *Judima* than raw substrates (Table 4), contributing to mineral intake in daily diet of the local people in NC Hills. Increase in mineral contents mostly calcium, iron, sodium, potassium and phosphorus was also observed in *bhaati jaanr* due to fermentation<sup>11</sup>

### Conclusion

Diversity of ethnic fermented foods in NC Hills of Assam has been documented which is related to diversity of ethnicity with unparallel food culture of each community. It has been noticed that consumption of lesser-known ethnic foods is common and age-old traditional technology still exists in NC Hills of Assam despite of rapid

urbanization. Native microorganisms with vast biological importance as potential genetic resources associated with ethnic fermented foods should be preserved before they are forced to disappear. However, as a future plan of work, the microbes isolated from different fermented products have to be identified by culture-independent technique using molecular tools.

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