

# Insight into Bamboo-based Fermented Foods by *Galo* (Sub-tribe) of Arunachal Pradesh, India

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**ABSTRACT-** Fermented foods play an important role in the social fabrication of a large number of populations throughout the world. Fermented foods offer several advantages over the raw materials by improving nutritional quality, digestibility, sensory attributes, enhancing vitamins and micronutrients, reducing anti-nutrients and replenishing intestinal microflora. Bamboo is indispensable to the people of Asia, Africa and Latin America due to its versatile uses. India is the second largest bamboo producer of the world and North-eastern states of India contribute the most. Edible bamboo shoots being seasonal and perishable are fermented for their future consumption. Ethnic people of Arunachal Pradesh are credited for developing a multitude of traditional bamboo-based fermented foods. Besides above mentioned attributes, toxic cyanogenic glycosidic compounds present in bamboo shoot can be destroyed during fermentation. Among the various tribes residing in Arunachal Pradesh, *Galo* is a culturally rich sub-tribe descending from *Adi* tribe. This article gives an overview of various bamboo based fermented foods prepared by a *Galo* sub-tribe of Arunachal Pradesh.

**Key-words-** Bamboo shoot, Fermented food, Ethnic people, *Galo* sub-tribe, Cyanogenic glycosides

## INTRODUCTION

Arunachal Pradesh is the largest among the North-eastern states of India covering a total area of 83, 743 sq. km and according to 2011 census report inhabited by 1,382,611 populations. It possesses a rich ecology, floral and faunal biodiversity and contributes most of the Eastern Himalayan Biodiversity Hotspot. The mesmerizing scenic beauty of this state is magnified by several ethnic communities having their distinct culture, custom and food habit. At present there are 25 major tribes and about 125 sub-tribes residing in this state [1]. It is generally accepted that the tribes of Arunachal Pradesh belong to the Tibeto-Burman group [2]. Having close proximity with nature, they are heavily dependent on the natural resources for their sustenance and livelihood. Their strong curiosity and keen observation of the nature, natural resources and natural phenomenon have inculcated into them a strong traditional knowledge system that is being transferred to the next generation from time immemorial.

*Galo* is one of the important sub-tribes inhabiting mainly the West Siang district and adjacent part of the East Siang and Upper Subansiri district of Arunachal Pradesh [3]. *Galo* sub-tribe has descended from *Adi* tribe and they belong to the *Tani* group.

Complex hill system and wide range of elevation has divided this state into varying agro-climatic zones viz., tropical, sub-tropical, temperate and alpine zones. Temperate and humid tropical climate have endowed the lower sub-Himalayan regions with diverse species of bamboo. Abundance of locally available bamboo plays an integral part in the culture, tradition and custom of ethnic peoples of this region. A total of 1200-1500 species of bamboo under 60-70 genera are known to exist worldwide [4] of which around 125 species under 23 genera grow in India. North Eastern states of India represent 84 species of bamboo resources [5]. The common species of bamboo found in this region are *Bambusa tulda*, *B. pallida*, *Dendrocalamus hamiltonii*, *D. hookerii*, *Pseudostachyum polymorphum*, *Arundinaria* sp. etc. Of these young shoots of *B. tulda* and *D. hamiltonii* are popular as edible [6]. However, massive deforestation for construction of road and building is a threat to their ecological distribution. Due to its very fast growth bamboo is preferred all over the world for reforestation.

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Rapid *in vitro* propagation of *Bambusa vulgaris*, commonly called Buddha bamboo, it is possible with addition of cytokines viz., IAA, NAA and 2,4-D<sup>[7]</sup>.

Bamboo is closely associated with the livelihood of the peoples of Asia, Africa and Latin America due to its versatile uses. Tender, soft, crisp and ivory yellow coloured bamboo shoots emerging out from the bamboo culm during monsoon is widely consumed as vegetables, pickles and fermented products by ethnic communities of Asia. High diversity of bamboo resources in North-eastern states of India plays a significant role in the food and nutritional security in the ethnic community residing in this area<sup>[8]</sup>. Locally available bamboo shoots being seasonally available and perishable are fermented for different periods in various traditional processes to increase their shelf life and delicacy. Though bamboo shoot fermentation by *Nyshi*, *Adi* and *Apatani* of Arunachal Pradesh has been well documented, no record from *Galos* could be found in the literature. This paper deals with the traditional processes employed in the fermentation of bamboo shoots to prepare various non-salted acidic end-products.

## MATERIALS AND METHODS

Information about bamboo-based fermented foods was gathered in September, 2015 from male and female respondents of some *galo* families residing in the Papumpare district of Arunachal Pradesh. The fresh bamboo shoots were collected from local market and some identified persons of the *galo* sub-tribe were requested to demonstrate the preparation of those fermented foods in their house hold.

### Preparation of *Kupe*

During preparation of *Kupe* (Fig. 1m), bamboo shoots are collected (Fig. 1 a,b) in the morning and the outer covering of leaf sheaths are removed with a sharp object. Soft and tender bamboo shoot tips separate from the more mature lower part of the shoot (Fig. 1c) and washed with water. The whole shoot tip of about 15–20 cm length is then fermented or it may be sliced vertically and horizontally to make pieces before fermentation (Fig. 1e). Fermentation can be done in two different ways. In the rural forest villages where bamboo is plenty and open field is available, fermentation is accomplished within the traditional bamboo basket (*eegin*). Inside of the basket is first covered with leaves of locally available herbs (preferably *ekkam* leaves (Fig. 1d); *Phrynium* sp.) and the whole or pieces of tender bamboo shoot tips are put into the basket. The open top of

the basket is similarly covered with leaves to make it air-tight. Then heavy weight is put on the top preferably with large stones to drain off excess water oozing out during fermentation. The bamboo baskets are then kept inside the pit near stream. In urban and suburban areas where pit and stream are not available, fermentation is carried out within pieces of mature bamboo having a single node to make a cylinder with a single opening (Fig. 1h,i). The bamboo shoots are then pressed tightly into this bamboo cylinder (Fig. 1j), little water added (Fig. 1k) and the open mouth of the cylinder is covered with *ekkam* or *banana* leaves, to make it air tight (Fig. 1l). The bamboo cylinders are then kept in moist places near stream or within pit. After 15–30 days of fermentation, the product is ready for consumption.

The product remains fit for consumption, even for 1–2 years, if the air tight condition of the basket is maintained after removing batches of *kupe* for consumption. Now-a-days the product is packed with *ekkam* leaves and kept within air-tight glass or plastic container in urban and sub-urban areas. *Kupe* is moist and creamish in colour. It is consumed raw or delicious curry is made with vegetables, meat and fish.

### Preparation of *eepe*

*Kupe* is sun dried for 7–10 days to make *eepe* (Fig. 1n). *Eepe* is dark brown in colour. It is more pungent and has more shelf life than *kupe*.

### Preparation of *eeku*

After removing the top tenderest shoot for *kupe*, the more mature lower portion is used for preparation of *eeku* (Fig. 1o). Outer leaf sheaths are removed and hard nodes of the stem are generally discarded. The internodes are cleaned with water and sliced and chopped into small pieces (Fig. 1f,g). Fermentation procedure and storage of *eeku* is similar to *kupe*. However, fermentation period may be little longer than *kupe* owing to more mature fibre in the raw material.

*Eeku* is also moist and creamish in colour. It is consumed raw or used to prepare curry with vegetables, meat and fish.

### Preparation of *eep*

*Eeku* is sun dried for 7–10 days to make *eep* (Fig. 1p). It is more pungent and has more shelf life than *eeku*. *Eep* is light brown in colour and the dried chips are smaller than that of *eepe*.





**a:** A *Galo* woman holding a *eegin* filled with bamboo shoot, **b:** A bamboo shoot, **c:** Soft shoot tip separated from more mature lower part, **d:** *Ekkam* leaves (*Phrynium* sp.; Family Marantaceae), **e:** Slicing of soft shoot tip for *kupe*, **f:** Slicing of mature lower portion of shoot tip for *eeku*, **g:** Sliced shoots chopped into small pieces, **h:** Cutting of mature bamboo, **i:** Bamboo cylinder with a single node and a single opening, **j:** Sliced shoots pressed tightly into bamboo cylinder, **k:** Addition of water, **l:** Cylinders covered with *ekkam* leaves to make air tight, **m:** *Kupe*, **n:** *Eepe*, **o:** *Eeku*, **p:** *Eep*

**Fig. 1 (a-p):** Processing of bamboo shoot to prepare fermented products by *Galo* sub-tribe of Arunachal Pradesh, India

## RESULTS AND DISCUSSION

The ethnic people of North-eastern states of India are credited for traditional preparation of a number of bamboo based fermented foods (Table 1.) Four different types of fermented products viz., *kupe*, *eepe*, *eeku* and *eep* from bamboo shoots are prepared by *Galos* (Fig. 1m-p.) in rainy season when sprouting occurs. *Dendrocalamus hamiltonii*, *D. hookeri*, *D. giganteus*, *D. longispathus*, *Bambusa balcuooa*, *B. pallida* and *Melocanna baccifera* are the most preferred bamboo species for fermentation. These fermented products are boiled in salted water and cooked with vegetables, Mithun (*Bos frontalis*), chicken or fish to make curry.

The ethnic people of India and their traditional wisdom is a treasure for the scientific community as they are well aware of the sustainable uses of natural products. An ethnic group (also called indigenous) shares a common ancestral and geographical origin and inherits similar culture, custom and language. Their physical appearance, art and craft, dress, cuisine, music, religious and mythological belief is also common. The indigenous or ethnic people live in complete harmony with the nature, adopting the art of living in extreme hostile natural conditions. Around 300 million ethnic or indigenous people are estimated to be present in the world. India is proud of 227 ethnic groups belonging to 573 tribal communities estimating a total of around 68 million people<sup>[9]</sup>. They collect wild edible plants, including their shoot, leaves, fruits, flowers, tubers or seeds from forests for their daily needs. The flower, fruits and tubers

are generally eaten raw while others boiled with water or fermented. Simple processing of the raw materials devoid of any food additive or preservative maintains high nutrition value of the finished products. Consumption of fermented foods which involve natural fermentation with mixed flora is an integral part of their religious ceremonies, culture and tradition. During food fermentation raw materials are acted upon by microorganisms or their enzymes producing desirable biochemical changes. While some of these modifications contribute organoleptic qualities, including texture, flavor, aroma and colour, others enhance the nutritional value of concentrating proteins, essential amino acids, free fatty acids, vitamins, minerals and antioxidants.

Ethnic groups residing in different states of North-east India process locally available bamboo shoot in various ways for production of fermented foods. More than 66% of bamboo species in India is represented by North-east India covering an area of around 18.4 million hectares. Freshly harvested young and tender bamboo shoots provide them proteins, carbohydrates, B-vitamins such as thiamin, riboflavin, niacin, pyridoxine and pantothenic acid, minerals such as potassium, manganese, copper, calcium, iron and phosphorus, dietary fibers, phytoosterols, phenols and little fat<sup>[10]</sup>. Free amino acid content has been found to increase during fermentation<sup>[11]</sup>. Some species of bamboo shoots viz., *Phyllostachys pubescens* and *Phyllostachys nigra* contain antioxidant and angiotensin converting enzyme inhibition activity<sup>[12]</sup>.

**Table 1:** Bamboo-based fermented foods of North-eastern states of India

Fermented product	Nature of product	Name of the state	Ethnic group	Fermenting microorganism	Fermentation period	Fermentation vessel	References
<b>Bastanga/ Bastenga</b>	Sun dried solid mass	Nagaland	Naga	LAB	2 weeks	Conical bamboo basket lined with banana leaves having a hole at the bottom. Jars and bamboo tubes ( <i>chung</i> )	13,14
<b>Bastangapani</b>	Liquid separated during fermentation of bastanga and traditionally stored in jar made of gourd	Nagaland	Naga	LAB	2 weeks	As in Bastanga	13,14
<b>Ekhung/Ekung</b>	Moist solid mass	Arunachal Pradesh	Nyishi, Adi	<i>Lactobacillus plantarum</i> , <i>L. brevis</i> , <i>L. casei</i> , <i>Tetragenococcus halophilus</i>	1–3 months	Bamboo basket ( <i>papur</i> ) kept in pit. One side open hollow bamboo stem ( <i>edung</i> )	14,15

<b>Eup/Eyup</b>	Sun dried solid mass		Arunachal Pradesh	Nyishi, Adi	<i>Lactobacillus plantarum</i> , <i>L. fermentum</i>	1–3 months	Bamboo basket ( <i>papur</i> ) kept in pit. One side open hollow bamboo stem ( <i>edung</i> )	14,15
<b>Poka Khorisa</b>	Moistened solid mass		Assam	Assamese, Garo, Rabha	<i>Lactobacillus plantarum</i>	6–7 days	Earthen pot ( <i>Koloh</i> ) covered with banana leaves kept in kitchen. Covered bamboo cylinder kept under pond or spring	16,17
<b>Khorisa</b>	Sun dried solid mass		Assam	Assamese, Garo, Rabha	<i>Lactobacillus plantarum</i>	6–7 days	Sun dried on bamboo trays called <i>saloni</i>	16-18
<b>Heccha</b>	Moist solid mass		Arunachal Pradesh	Apatani	<i>Lactobacillus plantarum</i> , <i>Leuconostoc</i> sp.	1–2 months	Bamboo basket	14,15,19
<b>Hikku</b>	Moist solid mass		Arunachal Pradesh	Apatani	LAB	1–2 months	Bamboo basket	14
<b>Hirring</b>	Moist solid mass		Arunachal Pradesh	Apatani, Nyishi	<i>Lactobacillus plantarum</i> , <i>L. lactis</i>	1–3 months	Bamboo basket kept in pit	14,15
<b>Iku</b>	Moist solid mass		Arunachal Pradesh	Apatani	LAB	1–2 months	Bamboo basket	13
<b>Lung-siej</b>	Moist solid mass		Meghalaya	Khasi	LAB	1–2 months	Green hollow bamboo stem (Traditional process); Glass bottle (Urban modification)	14,15
<b>Mesu</b>	Moist solid mass		Darjeeling hills (West Bengal), Sikkim	Limboo	<i>Lactobacillus plantarum</i> , <i>L. brevis</i> , <i>L. curvatus</i> , <i>Leuconostoc citreum</i> , <i>Pediococcus pentosaceus</i>	7–15 days	Green hollow bamboo stem	14,15,20
<b>Miyamikhri</b>	Moist solid mass		Assam	Dimasa	LAB	4–5 days	Earthen pot	14
<b>Soibum</b>	Moist solid mass		Manipur	Meitei	<i>Lactobacillus plantarum</i> , <i>L. brevis</i> , <i>L. coryniformis</i> , <i>L. delbrueckii</i> , <i>Leuconostoc fallax</i> , <i>L. lactis</i> , <i>L. mesenteroides</i> , <i>Enetrococcus durans</i> , <i>Streptococcus</i>	3–12 months	Traditional bamboo chamber (Noney/Kwatha type); Bulky roasted earthen pot (Andro type)	14,15, 21

<b>Soidon</b>	Moist solid mass	Manipur	Meetei	<i>lactis</i> , <i>Bacillus subtilis</i> , <i>B. licheniformis</i> , <i>B. coagulans</i> and yeasts <i>Candida</i> , <i>Saccharomyces</i> & <i>Torulopsis</i> <i>Lactobacillus brevis</i> , <i>Leuconostoc fallax</i> , <i>L. lactis</i>	3–7 days	Earthen pots (Traditional process); Earthen pot or plastic container layered with polythene cover (Modified process)	14,15,21
<b>Soidon mahi</b>	Liquid separated after fermenting a mixture of <i>Garcinia pedunculata</i> Roxb. fruits, rice water and <i>Schizostachyum capitatum</i> . Liquid starter used to prepare soidon	Manipur	Meetei	<i>Bacillus subtilis</i> , <i>Lactobacillus brevis</i> and <i>L. plantarum</i>	As in soidon	As in soidon	15,21,22
<b>Soijim</b>	Liquid separated during Andro type of bamboo fermentation to prepare Soibum. (used as starter of soidon)	Manipur	Meetei	LAB	As in soibum	As in soibum	13-15, 21
<b>Tuaithur</b>	Moist solid mass	Mizoram, Manipur	Hrangkhoh, Baite, Hmar	<i>Lactobacillus plantarum</i> , <i>L. brevis</i> , <i>Pediococcus pentosaceus</i> , <i>Lactococcus lactis</i> , <i>Bacillus subtilis</i> , <i>B. firmus</i> , <i>B. circulans</i> and <i>B. sphaericus</i>	6–7 days	Bamboo vessel	14
<b>Tuairoi</b>	Sun dried solid mass of tuaithur	Mizoram, Manipur	Hrangkhoh, Baite	Same as tuaithur	6–7 days	Bamboo vessel	14



## Microorganisms associated with bamboo shoot fermentation

Ethnic people of North-east India produce a variety of bamboo-based fermented foods in different ways using handmade containers of bamboo and cane. All are non-salted, acid fermentation dominated by lactic acid bacteria coming from the raw materials (Table 1). However, some ethnic groups add liquid separated during the previous batch of bamboo shoot fermentation as starter to hasten the fermentation period as well as to make quality products. This method of adding starter culture is being practiced during production of *soibum* and *soidon* by *Meetei* tribe in the Bishnupur village of Manipur. *Soidon mahi* and *soijim* are starter for *soidon* and *soibum*, respectively. *Soidon mahi* is prepared by fermenting a mixture of acidic juice extract of *Garcinia pedunculata* Roxb. fruits, rice water and *Schizostachyum capitatum*. Microflora associated with *Soidon mahi* are *Bacillus cereus*, *B. subtilis*, *B. pumilus*, *Lactobacillus brevis*, *L. plantarum* and *P. fluorescens* [22]. Of these *B. subtilis*, *L. brevis* and *L. plantarum* was presumed to have a predominant role in fermentation. Dominant microfloras associated with bamboo shoot fermentation are *Lactobacillus plantarum*, *L. brevis*, *L. casei*, *L. fermentum*, *L. lactis*, *L. curvatus*, *L. coryniformis*, *L. delbrueckii*, *Leuconostoc citreum*, *L. fallax*, *L. lactis*, *L. mesenteroides*, *Lactococcus lactis*, *Pediococcus pentosaceus*, *Enetrococcus durans*, *S. lactis*, *Bacillus subtilis*, *B. firmus*, *B. circulans*, *B. sphaericus*, *B. licheniformis*, *B. coagulans*, *Tetragenococcus halophilus* and yeasts, *Candida*, *Saccharomyces* and *Torulopsis* [11,13-15,19,20,23-25].

## Cyanogenic glycosides and Fermentation

Bamboo shoots contain high amount of cyanogenic glycosides as well as corresponding beta-galactosidase that breaks down the glycosidic bond to produce a sugar and acyanohydrin that is rapidly degraded to hydrogen cyanide and an aldehyde or a ketone [26]. Hydrogen cyanide present in bamboo shoot is a neurotoxin resulting high blood pressure, dizziness, headache, stomach pain as well as complications in child birth like miscarriage and abnormal child birth [27]. Traditional wisdom of Boiling and fermentation reduce the cyanide content significantly [28]. During traditional fermentation small holes are made in one side open hollow cylindrical bamboo stem (*edung*), chopped bamboo shoots are packed inside and the bamboo cylinders are kept near stream of water facilitating leaching of toxic cyanide compounds from the fermenting materials. However, this traditional processing is fast eroding and being replaced by glass bottles or plastic containers. The younger generation finds the modified fermentation process less time consuming and the products more shelf-stable [29].

## Functional attributes of fermenting microorganisms

Other than acidifying the raw bamboo shoots and extending their shelf life, fermenting microorganisms show various

activities. Phytic acid in bamboo shoot acts as an anti-nutritional factor chelating calcium, zinc, iron and copper resulting in their deficiency in the diet. *Lactobacillus plantarum* isolated during fermentation to prepare *ekung* and *eup* showed significant phytic acid degradation [15]. *Lactobacillus brevis* in *soidon* and *hiring* possessed similar property [19]. Production of lactic acid during degradation of sucrose present in bamboo shoot acidifies the fermented product inhibiting pathogenic bacteria [30]. Acid and bile tolerance are also important characteristics of fermenting bacteria exemplified by *Lactobacillus plantarum*, *L. brevis*, *L. casei*, *L. fermentum* [15,19]. *Lactobacillus plantarum* and *L. brevis* from *soibum* showed high hydrophobicity and thus are good colonizer of gastroenterocytes [19].

## CONCLUSIONS

The ethnic people of Arunachal Pradesh possess a rich tradition of using tender bamboo shoot to produce various fermented products. The various tribes of Arunachal Pradesh like *Nyshi*, *Adi*, *Apatani* produce different types of bamboo-based fermented foods viz., *Ekhung/Ekung*, *Eup/Eyup*, *Heccha*, *Hikku*, *Hiring*, *Iku* in bamboo basket or mature bamboo stem. Fermented bamboo shoots are popular among other ethnic groups in North-east India. Bamboo shoot is a rich source of essential amino acids, free fatty acids, phytosterols, minerals, edible fibres and phenolic compounds but the presence of cyanogenic glycoside compounds is a major public health concern. The traditional process of fermentation has been found to reduce the amount of toxic substances present. Thus, traditionally fermented bamboo shoots may be an important food additive. *Galo* is a sub-tribe of *Adi* tribal community. They also prepare fermented bamboo shoots for future use. In this research four different bamboo shoot fermented products prepared by *Galos* have been documented. Though preservation is the primary concern in bamboo shoot fermentation, reduction of toxic cyanogenic glycosides using the fermenting microflora should be the thrust area of future scientific research.

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