JMBFS
Journal of Microbiology, Biotechnology and Food Sciences
International peer-reviewed scientific online journal
Published by Faculty of Biotechnology and Food Sciences

TRADITIONAL FERMENTED FOOD AND BEVERAGES OF WEST BENGAL: AN EXTENSIVE REVIEW ON MICROBIOLOGY, NUTRITION, AND ITS IMPACT ON SOCIO-ECONOMIC CONDITION OF THE ETHNIC COMMUNITIES

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https://doi.org/10.55251/jmbfs.9730

ARTICLE INFO

Received 24. 12. 2022
Revised 23. 1. 2024
Accepted 1. 2. 2024
Published 1. 4. 2024

Review

OPEN ACCESS

ABSTRACT

From ancient times, fermentation has been utilized globally by various ethnic communities to preserve and store locally available food items. Traditionally, fermented food and beverages have been an integral part of cultural and social ceremonies of these communities. Fermented food products have been shown to have immense health benefits and are slowly gaining popularity among younger generations. The state of West Bengal (India) has an array of geographically diverse ethnic communities and rich food culture. In this article, a few of the most popular fermented food and beverages across entire West Bengal have been looked into from microbiological and nutritional point of view. The preparation process of each product has been discussed in brief along with the positive and negative aspects of fermented food and beverages. We also compared the main ingredients and end product of fermentation with respect to nutritional value. Many families earn livelihood from selling homemade fermented food and beverages but they should be trained properly to avoid food borne infections, poisoning or fatalities from consumption of fermented products. Development is also needed in making specific government regulations regarding the fermented food and beverages. It is also essential to document and study the existing as well as unexplored fermented food and beverages and standardizing their preparation process as there is a huge scope of commercialization of fermented food products.

Keywords: ethnic communities, West Bengal, nutritional value, commercialization, food borne infections, bioamines

INTRODUCTION

From ancient times, various communities across the globe have employed their own self-developed traditional food preparation and preservation processes such as smoking, drying or salting to maintain the quality and characteristics of food items for a year or two. Mostly grains and pulses are sundried and stored while fruits and vegetables are dried after adding salt or sugar. Smoking followed by drying is used majorly to preserve meat (**Chakraborty and Roy, 2018**). Apart from these food preservation processes; ethnic communities have also been using fermentation to preserve and store seasonal or perishable food items. This versatile and complex technique is usually passed on from one generation to the next as a family or community secret and the authenticity is judged by the specific flavour and aroma of the end product (**Ghimire *et al.*, 2020**). Fermented food and beverages are an important part of heritage of the ethnic Indian communities. Indigenous people apply their inherited technical knowledge for preparing different traditional fermented foods by using locally available plant or animal raw materials **(Rawat et al. 2018)**. Fermented food and beverages are usually consumed with staple or as condiments and beverages. These food items and drinks are at times consumed for their therapeutic and ethnomedicinal values as well **(Ghosh *et al.*,2014a; Ray *et al.*, 2016**). The community-based food and beverages are an integral part of all the traditional functions and social ceremonies of the indigenous ethnic communities. More than 5,000 fermented foods and beverages have been documented world-wide, most of which are region and community specific (**Ray *et al.*, 2016**).

Fermentation is the biochemical process carried out by microorganisms to convert organic complex food components into more simple ones like ethanol or lactic acid **(FAO, 1998)**. This naturally occurring metabolic process has been exploited by various ethnic communities since time immemorial to carry out controlled fermentation thereby giving food a desired level of acidity with no understanding of the potential role of the microorganism(s) involved in the process. It is still extensively used to preserve food without the requirement of refrigeration or any chemical preservatives. Ethnic people carry out fermentation in two ways-firstly, without adding any starter culture i.e., natural spontaneous fermentation and secondly, by adding starter culture to the fermentable ingredients. In some fermentation process, leftover food (old fermented product) is added for new fermentation while in others traditionally prepared starter tablets (*modguli, bakhar, marcha*) are used. An array of techniques is used to prepare the starter cultures and it mainly depends on the type of fermentation intended (**Ghosh *et al.*, 2020; Mondal *et al.*, 2016**). In many places, various locally available medicinal plants are also used in starter culture preparation (**Mishra *et al.*, 2018; Ghosh *et al.*, 2014a; Tamang and Thapa, 2006**). A number of works across the world have reported various microbial consortium from fermented food and beverages (**Tamang *et al.*, 2009**). During fermentation, microbes act upon one or more constituent of the various starting ingredients thereby converting them biochemically into palatable final products. In earlier days, people did not know the science of fermentation, they even were not aware about the benefits of fermented foods but used this technique for food preservation, improving shelf-life of foods, enhancing flavour, taste, and texture of foods (**Behera *et al.*, 2020; Ray *et al.*, 2016**). Recent studies on fermented foods have shown the various aspects of health benefits like improvement of nutritional and nutraceutical value, better digestibility of foods and improved gut microbiota (**Sanlier *et al.*, 2017**). In fermented food products, the sugars present in the fruits and vegetables are fermented mostly by Lactic Acid Bacteria (LAB) to form lactic acid whereas in fermented beverages, ethanol fermentation occurs majorly. LABs produce acid which act as preservative and increases the shelf-life of fermented products (**Ghimire *et al.*, 2020**). LABs responsible for fermentation, also produce vitamins, minerals and biologically active peptides like conjugated linoleic acids (CLA), exopolysaccharides, bacteriocins, sphingolipids and other bioactive peptides have blood pressure lowering effect, prebiotic properties, anti-microbial properties, anti-carcinogenic and anti-microbial properties and exhibited anti-allergic, anti-oxidant, antagonistic activity respectively. It can conclude that fermented foods have diverse type of health benefits such as anti-microbial, anti-inflammatory, anti-diabetic, anti-oxidant and anti-atherosclerotic activity (**Sanlier *et al.*, 2017**).

Mostly yeast and bacteria are reported as a fermenting agent for making edible fermented food and beverages. The consumable final end products are beneficial in respect to nutritional value, economy and holistic health. Some of the reported microorganisms or fermenting agents are *Lactobacillus plantarum, Lb. brevis, Lb. fermentum, Lb. Salivarius, Lb. bulgaricus, Lb. acidophilus, Lb. helveticus, Lb. cremoris, Lactococcus lactis, Enterococcus faecium, Enterococcus durans, Saccharomyces cerevisiae, Streptococcus thermophilus, Streptococcus cremoris, Leuconostoc mesenteroids, Bacillus subtilis, B. mycoides, B.pumilus, B. laterosporus, Pediococcus pentosaceus, P. acidilactici, , Pichia burtonii, Candida*

castellii etc. (**Chandrasekhar *et al.*, 2012; Ray *et al.*, 2016; Tamang *et al.*, 2012; Ghosh *et al.*, 2014a**). Despite the immense benefits of microorganisms, our understanding about their diversity and functions is very limited **(Alam and Pandey 2014)**. Researchers also reported some pathogenic microorganisms e.g., *Klebsiella, Micrococcus, Serratia* etc. that may spoil the fermented food and beverages and upon consumption of such spoiled fermented food products; diarrhoea, hernia, and headaches etc. are caused. These types of ailments might be caused by the unwanted by-products formed due to over fermentation or contamination of final food products (**Chandrasekhar *et al.*, 2012**).

In modern times, people have shifted from healthy traditional diet to unhealthy ready to eat junk foods. Now a days people are showing keen interest on well-studied beneficial fermented foods (**Raghuvanshi *et al.*, 2019**). With Global revolution of science and technology and industrialization of fermentation techniques, fermented products are gaining popularity and mass marketplace (**Melini *et al.*, 2019**). Advancement of fermentation technology not only increasing the world's food security and safety, but also improving the overall health of its consumers. Indian fermented foods have also been widely studied and most of the work in India have been done in the areas of Northeast, Southern India and some parts of West Bengal (**Savitri and Bhalla, 2007; Ghosh *et al.*, 2014a; Ghosh *et al.*, 2014b; Sha *et al.*, 2018; Mishra *et al.*, 2018**). West Bengal has a geographically diverse (sea level to higher altitude) area populated by various ethnic communities having different regional food cultures. Good and healthy food practices need to spread all over the globe for the benefit of mankind. There is not much review work on popular fermented food and beverages across West Bengal emphasizing on various aspects like microbiology, nutritional value, socio economic importance etc. This review explores the major fermented food and beverages reported from the Indian state of West Bengal from a microbiological and nutritional point of view. It also discusses the positive and negative aspects of fermented food and beverages as well as comparative study between main ingredients and edible fermented end products and its economic influences and prospects.

FERMENTED FOOD AND BEVERAGES OF WEST BENGAL

India has a diverse culture and geography which largely contributes to the differences in food habits and local cuisines. West Bengal is an eastern Indian state located at 22.9868 º N and 87.855 ºE. It has 23 districts of which the northern ones are located at the foothills of the Himalayas while the middle and southern districts are plains. West Bengal has a rich heritage, culture and is diverse in geography and ethnic communities. The Schedule Tribes (STs) in the state is predominantly residing in the rural areas. In West Bengal, tribal population is 52,96,963 as per Census 2011, which is about 5.8% of the total population of the state. The Santal represents more than half of the total ST population of the state, Oraon, Munda, Bhumij and Kora are the other major STs having sizeable population. Higher concentration of Tribal population is seen in the Districts like Darjeeling, Jalpaiguri, Alipurduar, Dakshin Dinajpur, Paschim Medinipur, Bankura and Purulia ("Tribal Development Department, Government of West Bengal". adibasikalyan.gov.in.). The ethnic communities of West Bengal can therefore be classified as the hilly tribal communities (Bhutia, Lepcha, Nepali etc), the junglemahal tribal communities (Santhals, Majhis etc), the tribal communities of plain area (Santhal, Oran) and the non-tribal communities (Bengali Hindus and Muslims, Biharis) residing in the plains. All these ethnic communities and indigenous tribes have their own food culture. These communities prepare a lot of fermented food and beverages of which some are common while others are unique to the community itself. Fermented food products are a vital part of the day-to-day life of these communities and their social functions. Some families also make a livelihood out of selling fermented food products. A number of substrates are used as the main ingredients for fermentation. The choice of substrate depends on the main agricultural products of the area like grains (*Haria, Bhati Jannar, Pithas*) and pulses (*Dalbori),* easily available seasonal fruits like berries (kul, Indian olive), mangoes (aam) and vegetables (radish, leafy greens), seasonal regional food items like bamboo shoots or ferns, and local tropical fruits sap-based beverages (*tal tari and khajur tari*) or milk-based items such as *churpis, tok doi* etc. (**Tamang and Thapa, 2006; Sha *et al.*, 2013; Ghosh *et al.*, 2020; Chandrasekhar *et al.*, 2012; Tewari *et al.*, 2020; Rai *et al.*, 2012**).

The following are the most reported and well-studied fermented products of West Bengal. These products are largely prepared and consumed by the various ethnic communities in a day-to-day basis as well as during social functions or festivities. They also serve as source of income for many families and small businesses. Figure 1 shows the distribution of these fermented food and beverages across West Bengal.

Achar (pickle)

Different variety of pickles, called *achar* in bengali, is an elegance along with staple foods such as rice, chapati etc. (**Roy and Rai, 2017**). Pickles are an integral part of all most all ethnic communities of West Bengal and India in general. This sweet or savoury delicacy is prepared from a wide range of seasonal fruits and vegetables as well as fish and meat. Based on the preparation process, pickles can either be fermented or non-fermented (Relishes and Chutneys). In West Bengal, *Aamer achar* (Mango Pickle) is one of the most popular fermented pickles made from matured green mangos. The nutritious pickles are prepared by cleaning and dicing the mangoes followed by salting and sun drying for 4-5 days. Roasted spices are then grounded and mixed with dried mangoes along with a small amount of mustard oil. The mixture is bottled in clean glass jar and sun dried for 2-3 weeks. A thin layer of mustard oil or organic acids is used for long time preservation. If the pickles are handled hygienically and sun dried occasionally then it can be stored at room temperature for 2-3 years. *Leuconostoc mesenteroides, Pediococcus pentosaceus, Enterococcus faecalis, Bacillus subtilis, Staphylococcus aureus, Candida sp. and Saccharomyces sp.* are some of the commonly found microbes in *achar* (**Chakraborty and Roy, 2018; Behera *et al.*, 2020**).

Bhati Jannr/ Bhaati Jaanar

This traditional fermented rice-based beverage is prepared by the ethnic Eastern Himalayan population. In West Bengal, Bhaati Jannar is popular in the rural Darjeeling areas. It is a sweet alcoholic semi liquid rice paste made by fermenting glutinous rice. Locally available starter culture called *marcha* is powdered and mixed with cooked and air-dried rice. Starter culture is added at the rate of 2% of the substrate amount used. The mixture is then kept for saccharification in earthen pot at room temperature for 1-2 days. Post saccharification, the pot is closed tightly and kept for fermentation. The final product is formed within 2-3 days in summer but takes 7-8 days in winter. Post fermentation, the mixture is stirred using wooden/bamboo stirrer to make a thick paste which can be consumed immediately or within one week. *Bhaati jannar* is widely consumed as a staple as well as a therapeutic agent. A large number of microbes such as *Mucor circinelloides, Rhizopus chinensis, Saccharomyses cerevisiae, Saccharomycopsis fibuligera, Pichia anomala, Candida glabrata etc.* are present in *bhati jannr* (**Tamang and Thapa, 2006; Mondal *et al.*, 2016**).

Bori (Dalbori/Vegetable Bori/ Masyaura)

It is a dried cone shaped fermented food made from various types of dal (pulses) like masoor dal (lentils), chana dal (Bengal gram), kolai dal (Black gram) and moong (Green gram) prepared mainly by the Bengali communities of West Bengal. The Nepali Newari community of West Bengal also prepare a similar product and call it *Masyaura. Bori/Masyaura* has a pulses base to which seasonal vegetables such as ash gourd, colocasia, radish or leafy greens are also added at times. To make *boris/masyaura*, pulses are soaked overnight followed by cleaning and grinding to a fine sticky paste. Shredded vegetables are added to the pulses paste, mixed and left for natural fermentation for 2-3 days. The mixture is then shaped into small cones and sundried for 3-5 days or until the product is dried completely. Another variety of ornamental decorative *bori* called *gahana bori* have been reported by Mondal et al. The batter preparation of this *bori* is similar to that of normal *dal bori* but they are shaped in the form of flowers and ornaments. Fermentation improves the the nutrional value of the *boris* by increasing probiotic content along with vitamins and antioxidants like flavonoids. However, the nutrient level of *boris* gets reduced due to sun dry and the cooking processes involved. Various types of *boris/masyaura* are a staple in Bengali cuisines and are enjoyed in curries and soups. The microflora and nutritional profile of *boris* are not well studied but the major microflora of *Masyaura* includes bacteria like *Lactobacillus fermentum, Bacillus subtilis, Bacillus laterospora*s and Yeast like *Saccharomyces cerevisiae* (**Sha *et al.*, 2013; Ghosh *et al.*, 2020; Chettri and Tamang 2008; Mondal *et al.*, 2022**).

Churpi

Churpi is a fermented milk product quite similar to cottage cheese and is prepared by the Gorkha, Lepcha and Bhutia tribes residing in the hilly areas of West Bengal. Traditionally, *churpi* is prepared from yak milk. The process involves skimming of whole milk to separate cream following which old curd inoculum is added to ferment the skimmed milk into curd. The curd is churned to prepare buttermilk which is then coagulated by boiling. The coagulated semi-solid mass is wrapped in a cloth and fermented again for 2-3 days at 15-20°C. This coagulated mass is kneaded thoroughly to make a smooth dough which is then shaped to approximately 40 mm long pieces of soft *churpi*. These *soft churpis* have high moisture content and is full of instant energy. *Hard churpi* is made by sun drying the soft churpis for 5-7 days and they have longer shelf-life due to reduce water activity. It is eaten in soups and curries. The microbes present in *churpi are Lactobacillus farciminis, Lactobacillus plantarum* etc. (**Tamang *et al.*, 2012; Panda *et al.*, 2016**).

Desi Daru/Deshi Daru (Chullu)

It is one of the most consumed rice or jaggery based fermented beverages of West Bengal and its adjoining states. This traditional country liquor forms an integral part of daily life as well as social functions of the ethnic communities like Oraon and Santal. This beverage recipeuses locally prepared starter tablet *(modguli/ bakhar)* made by mixing various indigenous medicinal plant parts with rice grains. *Chullu* is prepared by first fermenting cooked rice along with water and starter

tablets for 3-4 days. The fermented rice is diluted using water and kept for 12-18 hours followed by distillation using traditional distillation unit. The initial distillate has highest alcohol content while the last portion of distillate contains very low concentration of alcohol. The middle distillate has moderate level of alcohol and is of the best quality for consumption. The leftover undigested residue after *chullu* preparation is used as animal feed. (**Saha *et al*., 2015; Jha *et al*., 2019**). Microbiology of *chullu* is not well reported.

Goyang

It is an ethnic non-salted fermented leafy vegetable product prepared mainly by the Sherpa community of Darjeeling district, West Bengal. *Goyang* is prepared by collecting magane-saag (*Cardamine macrophylla*) from the wild followed by washing and draining excess water. The leaves are then shredded and packed tightly inside a bamboo basket lined with fig leaves. The mouth of the basket is closed tightly using fig leaves and fermented in natural anaerobic condition for about a month. The shelf-life of *Goyang* can be increased by sun drying and storing it in air tight container. This product is consumed mainly in thukpa soup. Common microbes found in *Goyang* include *Lb. plantarum, Lb. casei, Lb brevis, Lactococcus sp, Enterococcus sp and Candida sp.* (**Tamang and Tamang, 2007**).

Gundruk

This is naturally fermented leaves of various plants such as mustard (*Brassica juncus*), cauliflower (Brassica *oleracea*) or rayo saag (*Brassica rapa*). This acidic fermented product is prepared by the mountain dwelling Nepali communities of West Bengal (India), Nepal and Bhutan. The process involves shredding of the leaves and wilting them followed by packing tightly inside earthen pots. The pot is then sealed with leaves, warmed and naturally fermented for about 10 days. Post fermentation, the product is sun dried for 3-4 days before storing and can be consumed for a year or two as pickles or in soups. The major microflora of *gundruk* include *Lactobacillus fermentum, Lactobacillus planterum, Pediococcus pentosaceus etc*. (**Ghimire *et al.*, 2020**).

Haria

This is one of the most consumed rice-based fermented beverages produce locally by various tribes of West Bengal like Santhal, Bonda, Kolha, Bhuinya, Bhumij, Didayi, Paroja, Sabar, Mundari, Bhatoda etc. *Haria* is an integral part of tribal culture and social functions (marriage, funeral and festivals) as well as their daily life. To make *haria*, well-cooked rice is air dried under shade and is mixed with starter tablets (bakhar/*ranu*). After mixing the dust of crushed starter tablet, it kept for fermentation in an earthen pot for 3 days during summer and 5 days during winter. The fermented product i.e., *haria* is either served directly or at times diluted with drinking water and sieved before consumption. Most common microorganisms are *Saccharomyces cerevisiae, Saccharomyces boulardii, Candida nitratophila, Candida tropicalis, Bifidobacterium, Lactobacillus plantarum, Lactobacillus brevis, Lysinibacillus sp., Lysinibacillus fusiformis*, and a group of uncultured *Bacillus sp.* found in *haria*. The lactic acid bacteria play an important role in *haria* preparation and these are originated from the herbal parts (**Ghosh *et al.*, 2014a; Sha *et al.*, 2012; Ghosh *et al.*, 2021; Jha *et al*., 2019**).

Jilipi (Jalebi)

This is one of the most popular fermented sweet desserts consumed largely in West Bengal as well as the entire country of India. To make *jilipi*, firstly a batter of maida (all-purpose flour), doi (curd) and water is prepared and kept for 4-6 hours for fermentation to occur. The batter is taken in a clean cloth with a small hole and then squeezed directly into hot oil making spiral shaped *jilipi*. Once the *jilipis* are deep fried, they are dipped into sugar syrup for 5 min and then taken out. This delicacy is prepared in almost all sweet shops all throughout the year and it is more common snacks available in any type of social gathering in West Bengal. Microorganisms such as *Lb. fermentum, Lb. buchneri, Streptococcus lactis, Streptococcus faecalis* etc. are found in *jilipi* (**Ghosh *et al.*, 2020; Sekar and Mariappan, 2007**).

***Khajur tari* (Dates Wine)**

This wine is made from dates sap and is largely consumed in the rural parts of West Bengal and Bihar. This naturally fermented beverage is mostly a seasonal product (October to February) prepared by collecting silver date palm tree sap. The sap is collected twice per day by tapping done preferably in evening hours. it undergoes natural fermentation during the collection process itself. The shelf-life of this product is very less and it needs to be consumed the same day itself. This wine is quite exotic and enjoyed by the ethnic communities in their day-to-day life as well as during social ceremonies. Fermented *khajur tari* mainly contains yeast species like *Saccharomyces sp. Candida sp.* and bacteria like *Streptococcus sp. Lactobacillus sp.* etc. (**Bakshi *et al.*, 2020; Chandrasekhar *et al.*, 2012; Sha and Ghatani, 2013**).

Kinema

This is a fermented soybean product with a unique flavour and aroma. It is more of an umami condiment use as a substitute for meat by the Nepali communities. In West Bengal, this product is very popular in the Darjeeling district and is very easily available in local markets. *Kinema* has undergone a lot of evolvement and modification leading to a multi-ethnic recipe enjoyed by a lot of communities. *Kinema* is prepared by washing and soaking soybeans overnight followed by boiling for 2-3hours. The beans are then smashed lightly, wrapped in fern/banana leaves and packed inside bamboo baskets. Spontaneous natural fermentation for 1-3 days results in final product *kinema*. The main microorganisms of *kinema* include *Bacillus sp., Enterococcus sp., Candida sp.* etc. (**J.P. Tamang, 2003; Sarkar and Nout, 2014**).

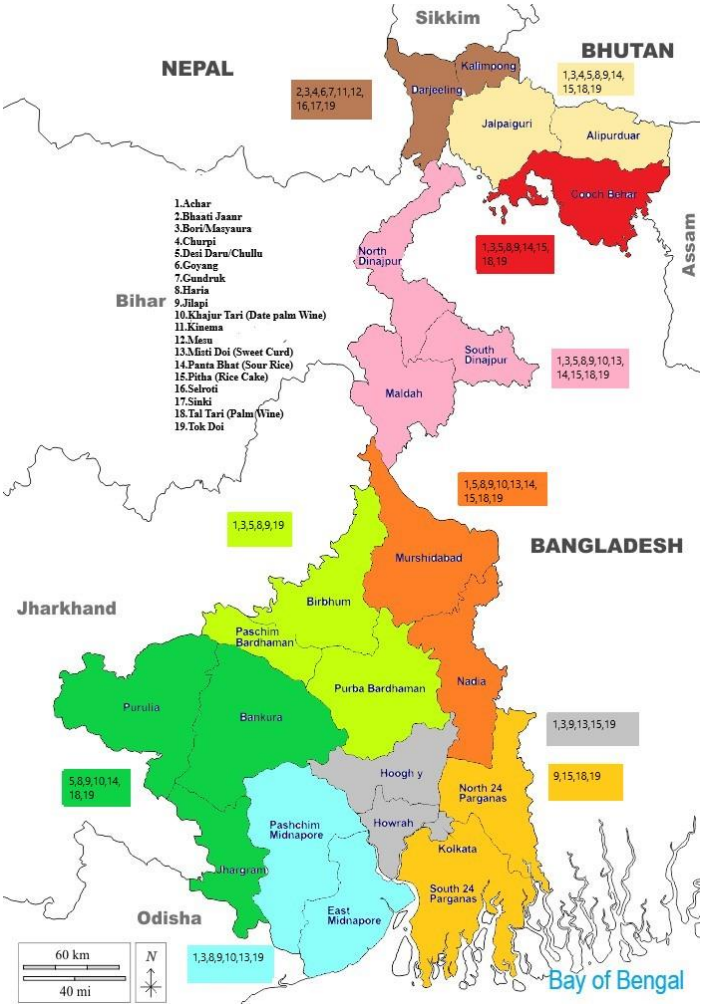

Figure1 Map of West Bengal showing the distribution of fermented food and beverages

1.*Achar* (Pickle) *2.Bhaati Jaanr* *3.Bori/Masyaura* *4.Churpi*

5. Desi Daru/Chullu *6.Goyang* *7.Gundruk* *8.Haria/Jhara*

Figure 2 Popular fermented food and beverages of West Bengal. **Images:** 1, 3, 5, 7, 8, 9, 10, 13, 14, 17, 18, 19 collected by Rabiul Alam; 2 and 15 from **Ray *et al.,*** 2016; 4, 6, 11, 12, 16 from **Thapa and Tamang, 2020**

Mesu

Mesu is non salted and naturally fermented bamboo shoot pickle prepared by the ethnic communities residing in Darjeeling district of West Bengal and the North-eastern states of India. This unique pickle is prepared during monsoon when new bamboo shoots sprout. To prepare this unique delicacy, bamboo shoots are cleaned, shredded and then packed tightly inside hollow bamboo stems. The mouth of the stem container is sealed very tightly using leaves and fermented in a natural anaerobic condition for a week or two. ***Mesu*** is eaten in soups and curries and can be consumed throughout the year. Major microorganisms found in *mesu* include *Lactobacsillus brevis, L. planterum, Pediococcus sp*_etc. (**Tamang and Sarkar, 1996; Behera and Balaji, 2021**).

***Misti Doi* (Sweet Curd)**

Misti doi literally translate to sweet (misti) curd (doi) and is one of the traditional milk-based fermented dessert of the ethnic Bengali communities. This curd is an integral part of Bengali culture and is largely consumed by both the rural and urban population. *Misti doi* is prepared by lactic acid fermentation of sweetened milk in an earthen pot and it has a distinct brownish colour with earthy caramelized flavour. To prepare *misti doi*, the milk is boiled for 15-20 minutes and mixed with caramelized sugar. The mixture is cooled down at room temperature and a small amount of old culture of *misti doi* is added as inoculum. The vessel is closed and kept for fermentation for 6-8 hours at 37-40^{o}C to form *misti doi.* This delicious dessert is prepared at home as well as commercially in sweet shops. Mostly *Streptococcus thermophilus, Lactobacillus sp., Lactobacillus acidophilus, Leuconostoc sp*. have been reported from *misti doi (***Chatterjee *et al.,* 2015; Saikia and Mishra, 2017**).

***Panta Bhat* (Sour Rice)**

This naturally fermented rice dish is consumed by a large population in both rural and urban parts of West Bengal. *Panta Bhat* is an excellent way of using leftover rice to make a cooling and easy to digest nutritious dish. The process involves overnight spontaneous natural fermentation of cooked rice by soaking it in excess water. Following morning, this sour soft rice is seasoned with salt and chilli and consumed along with onions, lemons, fish fry or vegetables. A lot of microbes have been reported from *panta bhat* and some of them are *Lactobacillus bulgaricus, Streptococcus thermophilus, Saccharomyces sp*. etc. (**Goswami *et al.,* 2016; Ghosh *et al.,* 2020**).

Pitha

Pithas are rice-based delicacies prepared mostly by the Bengali communities in West Bengal. Along with rice, other ingredients like coconut, jaggery, sugar, legume flour, palm, white gourd etc are also used in *pithas*. *Pithas* are prepared mostly in the winters during *nabanna* (harvest celebration), *Makar Sankranti/Poush parban* and also during festivals like holi. Some of the fermented *pithas* of West Bengal are *Chitou pitha* (pan-cooked), *Chaul bara* (deep fried), *Poda pitha* (steamed) and Enduri *pitha* (steamed). *Pithas* are low in fat/cholesterol and high in minerals, dietary fibers, antioxidants like flavonoids, carotenoids, gentisic acid etc. *Chhuchipatra pitha* is one of the most popular fermented *pitha* of West Bengal. To prepare this square shaped delicacy, a batter is made by mixing rice flour and black gram flour and fermented for 10-12 hours at room temperature. At times, curd is also added to the batter to enhance fermentation. Once the batter is set, the *pitha* is prepared by spreading the batter thinly onto a hot flat pan. To this, coconut and sugar or cheese is added and folded into a square shape. The *pithas* are fried well on both sides. The microbiology of *pitha* is not well studied but studies on enduri *pitha* has shown the presence of *Lactobacillus fermentum* (**Tewari *et al.,* 2020; Roy *et al.,* 2007; Ghosh *et al.,* 2020**).

Selroti

This is a rice-based fermented confectionary bread prepared by the Nepali Gorkha, Lepcha and Bhutia communities of West Bengal. It is a ring-shaped spongy deep-fried bread consumed with pickles, potato curry (alur dom) or meat. To make *selroti* cleaned and soaked rice is air dried in "Naanglo" and grounded. The rice powder is mixed with milk, honey, wheat flour, sugar, fresh cream and spices to make a soft dough. The dough batter is then kept for spontaneous natural fermentation for 30 min to 2 hours. The *selroti* batter is shaped into rings and deep fried till golden brown and it can be enjoyed for a week or so. This delicacy is an important part of social ceremonies like marriages, festivals (Diwali and bhai tikka) or other traditional functions. *Leuconostoc mesenteroides, Enterococcus faecium, Pediococcus pentosaceus, Lactobacillus curvatus, Saccharomyces cerevisiae* are some of the common microbes isolated from *selroti.* (**Tamang *et al.,* 2012**).

Sinki

This is a highly aromatic and flavoured fermented food used in soups and pickles. It is a seasonal product prepared by fermenting radish for about a month during the winters. For making *sinki*, radishes are cleaned and sundried for a day or two and then shredded and washed. These are packed tightly inside earthen pots, covered with radish leaves and the pots are closed using earthen lids. These pots are kept in warmer places for about a month for natural fermentation to occur. Alternatively, radishes are also packed inside pits under the ground and fermented for around 30-40 days. The product has a shelf-life of about a year at room temperature. In India, *sinki* is consumed largely by the Gorkha tribe in West Bengal's Darjeeling district and in Sikkim. Microbes such as *Lb. plantarum, Lb. casei, Lb brevis, Leuconostoc fallax* etc; are usually present in *sinki* (**Tamang and Sarkar,1993**).

***Tal Tari* (Palm Wine)**

This exotic sweet and colourless wine is basically the naturally fermented sap collected from tal (palm) tree. The sap is collected from both male and female young inflorescence of growing palm tree by a process called tapping. Spontaneous natural fermentation occurs in the palm sap during collection process itself. The product has a very small shelf-life of 5-12 hours post collection as with time it develops sour and off taste due to microbial sugar breakdown. Microorganisms reported in palm wine include both bacteria and yeasts; some of the major ones include *Lactobacillus sp., Streptococcus sp., E. coli, Micrococcus sp., Pediococcus sp.* etc and yeast like *Saccharomyces sp.* (**Chandrasekhar *et al.,* 2012; Hebbar *et al.,* 2018**).

***Tok Doi* (Curd)**

Tok Doi is one of the most consumed milk-based fermented food in all over West Bengal. Old Ayurvedic scriptures strongly recommends the consumption of curd for curing various diseases like dyspepsia and dysentery or to improve appetite and vitality. To prepare curd, milk is boiled for 10-15 minutes and then cooled to a temperature of 45-50^{o}C in an earthen vessel. Old curd inoculum is then added and mixed well. The vessel is closed and kept for incubation for 6-8 hours at 37-40^{o}C to form curd. Common bacteria found in curd are *Lactococcus cremoris, L. lactis, S thermophilus.* Probiotic yeasts like *Saccharomyces cerevisae, Kluyveromyces marxianus* and *K. lactis* have also been reported in curd and they have been shown to have antibacterial properties and can penetrate various mucosal sites (**Rai *et al.,* 2012; Tamang *et al.,* 2012; Lama and Tamang, 2022**).

COMPARATIVE NUTRITIONAL PROFILE BETWEEN MAIN INGREDIENTS AND FERMENTED END PRODUCTS

Cereals are grown in over 73.5% of the total world harvested area as one of the principal crops and contribute over 60% of the total world food production. But cereals have some nutritional limitations. Compared with food legumes and oilseeds, cereal grains are low in total protein content, with rice being the lowest. Among the amino acids essential to humans, lysine is first limiting in all the cereal grains. The proteins of barley, sorghum, rye, and oats exhibit lower digestibility compared with rice, wheat, or corn. Several methods have been employed to improve the nutritional quality of cereals. The microbial fermentation of cereals

and cereal-legume blends improves their relative nutritive value, availability of proteins, amino acids (lysine, threonine, tryptophan, and methionine), carbohydrates, certain B-group vitamins, and minerals. Thus, fermentation reduces and / or eliminate antinutrients in cereals and legumes (**Chavan *et al.*, 1989**). Usually, 100g of white glutinous raw rice contain-energy 370Kcal, protein 6.81g, total lipid 0.55g, carbohydrates 81.68g, fiber 2.8g (Rohman et al. 2014) and 100g of soft wheat contain: energy 332Kcal, protein 9.61g, total lipid 1.95g, ash 1.53g, carbohydrates 74.48g, total dietary fiber13.1g (**Tsafrakidou *et al.*, 2020**). Upon fermentation, enhanced nutritional value of cereal-based food and beverages have been observed. Fermentation also changes the composition in the final product considerably (See table 1). In West Bengal, rice is the staple diet of almost all the communities. Popular cereal based fermented food and beverages are *bhaati jaanr, deshi daru, haria, jilapi, panta bhat, pitha*s and *selroti*. These are suitable for vegetarian or vegan dietary people and people with lipid restriction (**Tamang and Thapa, 2006; Ghosh *et al.*, 2014a; Sha *et al.*, 2012; Sekar and Mariappan, 2007; Sharma *et al.*, 2013; Ray *et al.*, 2016 and Tsafrakidou *et al.*, 2020**).

Milk is the most balanced complete food in nature. It is protein rich food containing almost all the essential nutrients like calcium, vitamins and other minerals. 100g of cow's milk contains approximately 87.2g water, 3.5g protein, 3.7g fat, 4.9g lactose and o.72g ash (**Guetouache *et al.*, 2014**). Even though milk is such a nutritious food, it cannot be directly consumed by people with metabolic disorder like lactose intolerance, but they can consume fermented milk products like curd (*tok doi, misti doi*), *churpi* etc. Fermented milk products are more nutritious (see table 1) and contain higher amount of calcium, protein, healthy fat in comparison to normal non-fermenting milk. These fermented products are also easy to digest and consumed with staples on a daily basis by all the communities (**Khadse *et al.*, 2020; Milind and Jyoti, 2014**).

Pulses are one of the most widely grown and consumed food items in the world. Pulses are primary source of plant-based protein and it also contains carbohydrates, fat, vitamins and micronutrients like zinc, iron etc. Various types of pulses have varied energy content ranging from 300 to 540Kcal/100g (**Mukherjee *et al.*, 2017**). Regular consumption of pulses causes digestive discomfort, bloating and flatulence in many people. But fermented pulse products like *dalbori/bori/masyaura* do not have these issues and also have higher nutritional value (see table 1) (**Ghosh *et al.*, 2020**).

Mostly people want to preserve popular seasonal nutritious vegetables and fruits for long time. Fermentation of fruits and vegetables in the form of *achar* (pickle), *goyang, gundruk, sinki, mesu* etc. is a simple and convenient way to increase their shelf-life. The natural microflora presents in these vegetables and fruits carry out the fermentation thereby delaying the spoilage and preventing the growth of unwanted microorganisms. Along with improved taste and aroma, fermentation also increases the nutritional value of the vegetables and fruits (See table-1) (**Chakraborty and Roy, 2018; Behera *et al.*, 2020; Hossain and Kabir, 2016; Tamang and Tamang, 2007; Tamang *et al.*, 2012; Behera and Balaji, 2021**). The probiotics present in fermented fruits and vegetables can alleviate the symptoms of cirrhosis and diarrhoea, anti-oxidants present in fruits and vegetables can help to fight with harmful free radicals which are involved in developing degenerative diseases (**Sanlier *et al.*, 2017**).

The non-fermented soybeans have carbohydrates 30%, fat 20% and protein 36% (**Liu *et al.*, 1997**). It is a rich source of amino acids such as valine, leucine, isoleucine, threonine, tryptophan, lysine, histidine, tyrosine, proline. Among them valine, histidine, leucine, proline and tyrosine possess antioxidant activity (**Yang *et al.*, 2019**). Per 100g of vegetable soybeans also contains thiamine 0.874mg, riboflavin 0.87mg, calcium 277mg, iron 15.7mg, phosphorus 704mg, sodium 2mg, vitamin C 23.82 mg (**Ebert *et al.*, 2017**). The nutritional value of soybean and soy-based meals is much lower than actual. This is due to the presence of unhealthy compounds usually known as antinutritional factor, which reduces nutrient availability. The main factor is phytic acid, the storage form of phosphorus in seeds, acting as an antinutrient as it chelates various metals (Fe2+, Ca2+, Mg2+, Zn2+) (**Palermo *et al.*, 2012**). One of the most important soybeans based fermented product is *kinema* which is a sticky fermented soybean-based food for Gorkha or Nepali produced by natural fermentation (**Sharma *et al.*, 2015**). After fermentation of soybeans, it not only reduces the anti-nutrient factors but also increases the nutritional value (see table 1) (**Sarkar *et al.*, 1994**).

Some exotic regional beverages are prepared from a variety of palm tree sap found primarily in the tropics. Sap is usually collected from growing palm trees. Since the palm sap has a very high sugar content, it undergoes fermentation during the collection process itself. Palm sap is enriched with vitamin B and Vitamin C. Post fermentation, palm wine has better nutritional profile (see table 1 for *tal tari* and *khajur tari*) and mild alcohol content (upto 4%) (**Chandrasekhar *et al.*, 2012; Bakshi *et al.*, 2020**).

Table 1 Fermented food and beverages of West Bengal: Microbes, Main Ingredients, Nutritional Value

Fermented Food & Beverage Name	Microbes/Culture Involved	Main Ingredients	Nutritional Value	References
Achar (Pickle)	LABs (e.g., *Lc. lactis and Streptococcus thermophilus*), *Leuconostoc mesenteroids*	Different fresh vegetables and fruits	Enhancement or creation of unique flavours, change in textural properties and improve palatability and digestibility of foods. Pickles contain subsided amounts of fat and cholesterol, which are rather beneficial to human health. In addition, vitamins (riboflavin, folate, cobalamin, menaquinone, and thiamine), abundant quantities of nutritious and bioactive components (proteins and amino acids) and antioxidants (flavonoids, phenols, and sterols) have been analyzed and reported from the fermented pickles.	**Behera *et al.*, 2020; Hossain and Kabir, 2016**
Bhaati Jaanr	Marcha (Mixed Culture of Yeasts were identified as *Saccharomycopsis fibuligera, Pichia anomala, Saccharomyces cerevisiae, Candida glabrata and* Lactic Acid Bacteria, Filamentous Molds-*Mucor circinelloides, Rhizopus chinensis* and *Rhizopus stolonifera)*	Steamed glutinous rice	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/100g, Ca: 12.8 mg/100g, K: 146.0 mg/100 gm, P: 595.0 mg/100g, Fe: 7.7 mg/100 g, Mg: 50.0 mg/100 g, Mn: 1.4 mg/100 g and Zn: 2.7 mg/100 g	**Tamang and Thapa, 2006**
Bori (Dal Bori/Vegetable Bori/ Masyaura)	*Bacillus subtilis, B. mycoides, B.pumilus, B. laterosporus, Pedicoccus acidilactici, P. pentosaceous, Enterococcus durans, Lb. fermentum, Lb. Salivarius* Yeasts-*Saccharomyces cerevisiae, Pichia burtonii and Candida castellii*	***Masyaura*** -Kolai Dal (Black gram), ***Dal bori***-kolai dal/Urad dal (Black gram)/Moong dal (Green gram) /Chana dal (Bengal gram)/ Masoor dal (Lentil) ***Vegetable bori***-Chal kumro/ Kochu pata	***Dried Masyaura -*** Moisture: 8%-10%, protein: 18%-20% on fresh weight, carbohydrates: 67%-70% on fresh weight, pH: 6.1-5.4, Crude fiber: 5.12%, ash: 4.8% and minerals like Vitamin B1, Vitamin B2 are present.	**Khadka and Lama, 2020**
Churpi	*Lactobacillus farciminis, Lactobacillus casei, Lb. bifermentans, Lb. plantarum, Enterococcus faecium*	Fresh milk	Moisture: 15.41%, fat: 7.80%, protein: 64.96%, lactose: 3.16%, glucose-galactose: 0.76%, total sugar: 4.94%, and ash: 6.90%	**Hossain *et al.*, 2002; Tamang *et al.*, 2012**
Deshi Daru (Chullu)	Not reported	Low-cost rice/jaggery/molasses	Strong alcoholic	**Saha *et al.*, 2015**
Goyang	*Lactobacillus plantarum, Lb. brevis, Lactococcus lactis, Enterococcus faecium and Pediococcus pentosaceus*	Fresh leafy wild herbs	Protein: 35.9% DM, fat: 2.1% DM, carbohydrate: 48.9% DM, calorie value: 357.2 kcal/100 g, ash: 12.9% DM, calcium: 92.2 mg/100 g, sodium: 6.7 mg/100g and potassium: 268.4 mg/100 g	**Tamang and Tamang, 2007**

Continue Table 1

Gundruk	*Lactobacillus fermentum,Lb. plantaram, Lb. casei, Lb. casei subsp. Pseudoplantarum, Pedicoccua pentosaceus*	Leafy vegetables specially leaf of rayo-sag (Brasicca rapa), mustard (Brasicca juncea) and cauliflower (Brasicca oleracea variety botrytis)	Moisture:15%, pH: 5.0, Acidity: 0.49%, Ash: 22.2%DM, Protein: 38.7% DM, Fat: 2.1% DM, Carbohydrate: 38.3% DM, Energy: 321.9Kcal/100g DM, Ca: 234.6 mg/100 g, Na: 142.2 mg/100 gm, K: 677.6 mg/100 g	**Tamang *et al.*, 2012**
Haria /Jhara	Bakhar/ *Pichia anomala, Issatchenkia sp., saccharomyces cerevisiae, Saccharomyces boulardii, Candida nitratophila, Candida tropicalis, Candida musae, Candida glabrata, Saccharomycopsis fibuligera, Zygosaccharomyces cidri, Lactobacillus plantarum, Lactobacillus brevis, Lysinibacillus sp., Lysinibacillus fusiformis*	Glutinous rice	pH: 3.46, Acidity: 1.42, Alcohol Content 11% (Consumable one is diluted at least 3times), lactic acid:17.63 mg/g, acetic acid: 0.18 mg/g and significant amount of folic acid, thiamine, pyridoxine, ascorbic acid, linolenic acid, linoleic acid, palmitic acid, oleic acid is present.	**Ghosh *et al.* 2014a; Sha *et al.* 2012; Ghosh *et al.*, 2021**
Jilipi	LAB -*Lactobacillus (Lb.) fermentum, Lb. buchneri, Lb. bulgaricus, Streptococcus (Strep.) lactis, Strep. thermophilus and Enterococcus faecalis.* Yeasts- *Saccharomyces (S) bayanus, S. cerevisiae*	Wheat flour, sugar and curd	pH: 4.4–3.3, protein: 24.1 mg/g, carbohydrate: 13.9 mg/g, reducing sugar: 29.9 mg/g, fat: 4.31 g/100 g, lactic acid	**Sekar and Mariappan, 2007; Sharma *et al.*, 2013**
Khajur Tari (Dates Palm Wine)	*Saccharomyces sp., Candida sp., Endomycopsis sp., Lactobacillus sp., Leuconostoc sp., Bacillus sp., Streptococcus sp., Zymomonas sp., E. coli, Brevibacterium, Micrococcus,*	Khajur sap (Silver date palm sap)	Antioxidants like flavonoids and phenolic compounds are present **(Mukherjee et. al. 2014)**. Carbohydrates, prebiotics and probiotics are present (Unpublished).	**Mukherjee *et al.*, 2014; Chandrasekhar *et al.*, 2012**
Kinema	*Bacillus subtilis, Enterococcus faecium, Candida parapsilosis, Geotrichum candidum*	Soybean	Moisture: 62.0%, pH:7.2, Ash: 7.2 % DM, Protein: 47.7% DM, Fat: 17.0%DM, Carbohyrate:28.1%DM, Energy: 454Kcal/100gm DM, Total Amino acids: 42618.0 mg/100g, Ca: 432.0 mg/100g, Na: 27.7mg/100g, Fe: 17.7 mg/100g, Mn: 5.4mg/100g and Zn: 4.5mg/100g.	**Tamang *et al.*, 2012**
Mesu	*Lactobacillus brevis, L. plantarum, L. curvatus Leuconostoc citreum, and Pediococcus pentosaceus*	Bamboo shoots	Moisture: 89.9%, acidity: 0.88%, pH: 3.9, ash: 15.0% DM, protein: 27.0% DM, fat: 2.6% DM, carbohydrate: 55.6% DM, Ca: 7.9 mg/100 g, K: 282.6 mg/100 g, Na: 2.8 mg/100 g, food value: 352.4 kcal/100 g DM	**Behera and Balaji, 2021**
Misti Doi (Sweet Curd)	*Str. Thermophilus, Lb. delbueckii subsp. bulgaricus, Lb. acidophilus, Streptococcus (Str.) lactis, Str. diacetylactis, Str. cremoris, and Leuconostoc sp*	Buffelow milk or cow milk, Sugar	Sugar: 13%–19%, fat: 6%–12%, pH: 5.1, free reducing sugar: 3.78%, hydrosoluble protein: 1.25%, free amino acids: 0.54%, lactic acid (0.96% titratable acidity)	**Puniya and khatkar, 2019; Ghosh *et al.*, 2020**
Panta Bhat (Sour Rice)	LAB - *Lactobacillus bulgaricus, Lactobacillus casei, Pediococcus acidilactici, S. faecalis, Streptococcus thermophilus, Microbacterium flavum, and Saccharomyces sp.*	Rice and water	Fermentation process increases the amounts of vitamin B complex, and vitamin K. About 100 g of sour rice contains 73.91 mg iron, 303 mg sodium, 839 mg potassium, and 850 mg calcium	**Ray *et al.*, 2016**
Pitha (Rice Cake)	Lb. fermentum (*Enduri Pitha*), most of the *pithas* microbiota is not reported	Rice flour	Phytic acid is degraded and thus increased the availability of minerals (zinc and iron) and vitamins (vitamin B and C)	**Ray *et al.*, 2016; Sahoo *et al.*, 2017**
Selroti	LAB-*Leuconostoc mesenteroides, Enterococcus faecium, Pediococcus pentosaceus and Lactobacillus curvatus and* Yeasts- *Saccharomyces cerevisiae, Saccharomyces kluyveri, Debaryomyces hansenii, Pichia burtonii, and Zygosaccharomyces rouxii*	Rice flour, Wheat flour, Sugar, Butter	pH: 5.8-6.2, Titratable acidity (as lactic acid): 0.08-0.09%, Moisture: 42.5-47.1%, Reducing sugar: 2.1-2.6%, Total sugar: 69.2-73.6 %, Ash: 0.80-0.88%DM, Fat: 2.7-3.0% DM, Water-soluble nitrogen: 0.06-0.08%DM, TCA-soluble nitrogen: 0.004-0.006% DM, Protein: 5.7-6.2% DM, Carbohydrate: 91.3-91.9% DM, Sodium: 8.9-9.5mg/100g, Potassium: 29.7-30.8mg/100g, Calcium: 23.8-25-4 mg/100g, energy 410.3-410-8 Kcal/100g DM	**Yonzan and Tamang, 2010**
Sinki	*Lb. plantarum, Lb. brevis, Lb. casei, Leuconostoc fallax*	Radish taproot	Moisture: 22.8%, pH: 4.1, acidity: 0.65, ash: 15.6%DM, protein: 14.9 %DM, fat:1.4%DM, Carbohydrates: 68%DM, food value: 344.2Kcal/100g DM, Ca:223.9mg/100g, Na-737.3 mg/100g	**Tamang *et al.*, 2012**
Tal Tari (Palm Wine)	*Saccharomyces sp., Candida sp., Endomycopsis sp., Lactobacillus sp., Leuconostoc sp., Bacillus sp., Streptococcus sp., Zymomonas sp., E. coli, Brevibacterium, Micrococcus,*	Palmyra sap	Alcohol: 5-8 %, pH: 4.5-6.0, Ascorbic acid: 16 -30 mg/100ml, Sucrose: 12.3-7.4%, Protein: 0.23-0.32%, Ash: 0.11-0.41%, Copper: 0.286-1.630 mg/100ml, Manganese: 0.140-0.166 mg/100ml, Sodium: 50.1-78.2mg/100ml, Calcium: 82.3-101.0 mg/100ml, Lead: 3.1-4.59 mg/100ml, Zinc: 0.151-0.168 mg/100ml, Potassium: 669-710mg/100ml, Lithium: 1.3-107mg/100ml, Nitrate: 23-27.7mg/100ml	**Chandrasekhar *et al.*, 2012**
Tok Doi (Curd)	*Streptococcus cremoris, S. lactis, S. thermophilus, Lactobacillus bulgaricus, L. acidophilus, L. helveticus and Lactobacillus cremoris*.	Fresh milk	pH: 4.4-5.0, acidity: 0.6-1.0%, carbohydrates: 4.7%, Protein: 5.1%, fat: 3.5%, Calcium: 121mg/100g, iron: 0.1mg/100g, phosphorus 141mg/100g, magnesium: 12mg/100g, selenium: 2.2microgram/100g, zinc: 0.6mg/100g, potassium: 155mg/100gm, Sodium: 46 mg/100g and Vit A, C, K, B12, B6, B2, D are present.	**Rai *et al.*, 2012; Milind and Jyoti, 2014**

DM-Dry Matter, TCA-Trichloro-acetic acid

POSITIVE IMPACTS OF FERMENTED FOOD AND BEVERAGES

Traditional fermentation process is widely used by ethnic people to preserve locally available food items and to prevent food spoilage/wastage thereby increasing their food security (**Zilberman and Kim, 2011**). Fermentation improves shelf-life of food products and increases the taste and aroma of food products. It also increases the bioavailability of nutrients and reduces various antinutritive factors. A number of studies have shown the beneficial aspects of fermented food products on gut health (**Sathe and Mandal, 2016**). The gut microflora is made up of a plethora of microbes and the microbial composition varies widely in healthy and ailed humans. A balanced gastrointestinal microflora is of utmost importance to maintain the overall health and immunity thus preventing the onset of many diseases. Various factors can trigger an imbalance in the gut microflora thereby leading to health disorders and diseases (**Patel *et al.*, 2023**). Fermented food and beverages being a major source of prebiotics and probiotics, largely influence the gut microflora thereby impacting gut health in particular and the overall health in general (**Tsafrakidou *et al.*, 2020**). Most of the studies done *in vitro* or in mice models have shown strong corelation between fermented food and the gut microflora profile. These gut microbiota not only help in maintaining digestive health but have also been shown to interact with the peripheral and central nervous system thereby affecting the overall health. Advancement in such types of studies can be very useful for developing newer diet therapies to combat various ailments (**Carvalho *et al.*, 2018**). Fermented food and beverages are a rich source of various enzymes. Regular consumption of these food products can reduce the pressure on pancreatic gland thus lowering the risk of chronic diseases and mortality rate. These food products are also good natural supplements of macronutrients and micronutrient, being affordable and healthier in comparison to the artificial health supplements (**Adesulu and Awojobi, 2014**). Grains have quite poor nutritional profile but are consumed largely by the low-income populations as staples. Fermentation of grains increases their nutritional value by increasing the quality and quantity of proteins (amino acids) and water-soluble vitamins (**Ray *et al.*, 2016**). Additionally, the process of fermentation removes/reduces various antinutritive substances like tannins and phytic acid from grains thus making it much healthier and nutritious (**Adesulu and Awojobi, 2014**). Another great way of improving the nutritional profile of grain-based food is by co-fermenting them with legumes and herbs. In these types of natural mixed fermentation, complimentary action is carried out by bacteria and yeasts thereby making the final product more energy dense with improved protein and mineral content. (**Ray *et al.*, 2016**). Fermented rice-based product *haria* has been shown to have positive effect on intestinal function by protecting the mucosal layer and intestinal microflora. It has also been shown to function as a stimulant for the immune system, endocrine glands and the brain. If consumed in moderation, *haria* has been shown to reduce cholesterol, thereby lowering the risk of cardiac diseases (**Ghosh *et al.*, 2014a**). Fermented bamboo shoots have a number of applications in the food and pharmaceuticals industry. These bamboo shoot delicacies are very rich in probiotic microorganisms and other bioactive compounds that are health benefitting and therapeutic in nature. These products have been reported to be useful in generating green energy in the form of biofuels like bioethane and biomethane (**Behera and Balaji, 2021**). Several studies across the world have time and again showed the various positive impacts of fermented food and beverages consumption on overall health and wellbeing. Regular intake of fermented food products i.e., live organisms are encouraged and recommended for adults in general and children (**Rezac *et al.*, 2018**). Fermented food products are thus an excellent source to combat malnutrition and nutritional deficiency diseases in developing and underdeveloped countries. The enzymes like proteinases and peptidases, used during fermentation have been studied extensively for their extraordinary reactivity as well as the ability to act upon complex substrates. In addition to that the role of amylase and glucosidase in the process starchy food substrate fermentation cannot be denied (**Jana *et al.*, 2013**). Recent works are also focusing on the production of value-added food products by utilizing fermenting biowastes from food industries. In this way bioactive compounds like flavonoids, caffeine, carotenoids, creatine etc. are harvested and used to fortify food products (**Sadh *et al.*, 2018**).

Traditional fermented food and beverages are widely prepared and sold by people in local haat/bazar for their livelihood. Some of the fermented food and beverages are made and sold by sweet shops and other small scale cottage industries. Various fermented food items like pickles and curd are also manufactured and marketed at large scales by commercial industries (**Sha *et al.*, 2013**). Thus, fermented food and beverages contribute to both microeconomy and macroeconomy by generating revenues and providing self-employment.

NEGATIVE IMPACTS OF FERMENTED FOOD AND BEVERAGES

Fermented food and beverages have a plethora of positive impact in health, economy and environment but it does have a negative side as well. These food products are not always safe and the ill effects are quite under reported. Food borne infections are quite common and due to lack of standard preparation techniques, many of these fermented products pose health hazards occasionally (**Alam and Basak, 2016**, **Sivamaruthi *et al.*, 2018**). The fermented products are at times contaminated with food borne pathogens mainly coliforms or toxin producing bacteria *(E. coli, Sanmolella sp, Clostridium botulinum* etc) and fungus which can affect the gut microflora and overall health. Food borne illness like diarrhoea, nausea, vomiting etc are mostly caused by bacterial contamination whereas food borne intoxication can be caused by bacterial toxins or fungal toxins (**Carvalho *et al.*, 2018, Behera *et al.*, 2020**). Water can be one of the major sources of coliform contamination during fermented food and beverage preparation. Hence properly treated clean water should be used to prepare various fermented foods and beverages. Local fermented beverage "hooch" related poisoning occurs frequently in West Bengal and other parts of India resulting in serious illness and even fatality. This poisoning occurs due to consumption of methanol formed by contaminating microbes in liquor like *chullu* (**Goutam *et al.* 2022; V. Verma, 2019; Vaibhav *et al.*, 2022; E.I.Ohimain, 2016; BBC News, December 15, 2011; Hindustan Times, November 28, 2018; The Indian Express, July 27, 2022**). Another major source of contamination can come from the packaging material or containers in which fermented food and beverages are sold in. Fermented food products like *jilapis* and *pithas* contain sugar and other carbohydrates which are a good medium for microbial growth and can cause food spoilage and illness (**Atique *et al.*, 2013**). Also fermented beverages like *khajur tari* and *tal tari* are very perishable due to high sugar content and if they get contaminated then unwanted microbial activity will degrade the nutrient and reduce sensory qualities. Upon consumption, this spoiled product will cause sickness and indigestion. Because of this, tari is usually consumed garden-fresh or within the same day or else it is boiled down into jaggery (**Bandopadhayay *et al.*, 2012**). Also, some fermented products like curd (*tok doi*) and mishti doi are sold in quite unhygienic ambiances full of flies and with inappropriate handling, the risk of contamination also increases. *Achar* (pickles), *gundruk* and *goyang* can get spoiled and contaminated if handle unhygienically or encounter moisture. Now-a-days, fermented food like *pithas* have become street foods and hence care should be taken in handling and preparing such delicacies by the street vendors and hawkers. This is because *pithas* are cereal based fermented food products having restrictive water activity and hence are more prone to microbial contamination during various stages of preparation process (**Atique *et al.*, 2013**). Another serious health hazard is the presence of high levels of bioamines reported from fermented sauerkraut and commercial fish-based pickles. Biogenic amines like histamine, tryptamine, cadaverine etc; are produced due to microbial decarboxylation of amino acid in the pickles by bacteria such as *Proteus* and *Klebsiella*. The bioamines causes several health issues like intoxication or hypertension mainly in consumers with weak or abnormal metabolism (**Carvalho *et al.*, 2018**). The formation of bioamines can be reduced by adding probiotic strains (*Lactobacillus plantarum, Lactobasillus casei etc*) during the fermentation (**Behera *et al.*, 2020**).

ECONOMICAL ASPECT OF FERMENTED FOOD AND BEVERAGES

Fermentation technique is an important part of traditional bio-economy wherein agricultural products (mainly seasonal and perishable foods) are preserved for future use. This helps in maintaining food supply during harsh weather conditions or famine. In modern days, fermentation technology is also used in production of green energy or to manage biowastes generated from food industry (**Behera and Balaji, 2021**). Locally available fruits and vegetables are used to make more nutritious, easily digestible healthier low-cost products which are easily affordable. A study on kinetics of *gundruk* fermentation by Ghimire et al. 2020 have looked on various aspects like biomass production, pH and lactic acid production. More of such types of studies should be conducted to better understand the fermentation kinetics of various fermented food and beverages as these will contribute largely in standardizing and commercializing purposes. The *kinema* fortified cookies can be nutritious alternatives prepared from traditional fermented food (**Sarkar and Nout, 2014**) for economically poor state like West Bengal. Traditional home-made fermented food and beverages serve as a major income source for many rural families. The food products like *dalbari, kinema, selroti, haria, chullu, achar, mesu* etc are sold in local haat or bazzar. Other products like *tok doi, jilipi, misti doi* etc are prepared and sold daily in sweet shops. *Pitha, tal tari* and *khejur tari* are some of the seasonal fermented food and beverages sold to generate income (**Bakshi *et al.*, 2020**). Some of these fermented food and beverages like *dalbari, desi daru, tok doi, misti doi, achar, mesu* are commercially produced at large scale and marketed widely. *Kinema* production and selling is one of the primary income sources of many families residing in the Eastern Himalayan Region. It is sold mostly by rural women in local periodical market called "haat." *Kinema* is usually sold by weight and wrapped in fig leaves, locally known as "nevara", instead of polybags. A kilogram of *kinema* is usually priced at about Rs. 100 and one vendor can sell up to 5 kg of *kinema* in each "haat". In kinema making, approximately 60% of total expenditure is done on soybean purchase, fuel and transportation thereby generating an overall profit of about 40% (**J.P.Tamang, 2015**). In the 2022-2027 forecast period, a surge in fermented food and beverage market is expected at a rate of 6.35% CAGR (Compound Annual Growth Rate). Also, the recent COVID-19 pandemic has shown the importance of health supplements and there is an increased tendency towards health benefitting fermented food and beverages among health-conscious people (**Patel *et al.*, 2023**).

REGULATIONS REGARDING FERMENTED FOOD AND BEVERAGES

Majorly, fermented food and beverages are usually prepared at homes or in small scales cottage industries. Traditional methods of fermentation need to be standardized and properly regulated for large scale commercialization purpose. This will be helpful in quality control to avoid health hazards as well as in marketing. The Food Safety and Standards Authority of India (FSSAI) looks after the various aspects of food safety (mainly packaged food) in India like the manufacturing process, storage or export/import. The Food Safety and Standard Regulations 2011, for fermented milk specifies the acceptable composition and nutritional profile of various dairy products like curd and cheese. It also imposes standards on permissible food additive in dairy products. The Food Safety and Standards (Health Supplements Nutraceuticals, Food for Special Dietary Use, Food for Special Medical Purpose, Functional Food and Novel Food) Regulations, 2016, regulates any "food with added probiotic ingredients" or food claiming health benefits is indirectly relevant to fermented food and beverages. In India, it is mandatory to put "probiotic" labels in health claiming therapeutic food items. Also, this food items need to be well researched scientifically and evaluated for their health claims. There are regulations to maintain specific counts of probiotic organisms (> 10^8 CFU/g) in the food items and proper labelling of the approved probiotics as per the updated list provided by the regulatory body (**Mukherjee *et al*., 2022**).

Although the fermented food products have immense benefit on health and environment, it does pose severe health hazards arising mainly from poor handling and preparation technique (**Alam and Basak, 2016; Sivamaruthi *et al*., 2018**). With the gaining popularity of fermented food and beverages, attention should be given to their production technique as per the Hazard Analysis and Critical Control Point (HACCP) guidelines **(FDA)**.

CONCLUSION

Fermented food and beverages are an integral part of almost all ethnic communities throughout the world. This technique is vital for natural food storage without the use of modern food preservation techniques like use of preservatives or cold temperature. It also helps in maintaining food security by conserving locally available seasonal food items. Fermented food and beverages are nutritious and healthier in comparison to the initial raw material and contains both prebiotics and probiotics. This state has an economically backward and malnourished populations. There is a huge deficiency of protein and micronutrients (Iron) mostly in children and women due to lack of balanced diet and fermented food products can be a low-cost effective solution to these problems. Sometimes consumption of home-made fermented food and beverages causes disease or food intoxication and even death. To avoid such health problems and fatality, training programmes should be conducted to teach these communities about food preparation hygiene and handling to avoid contamination. Also, many of the local ethnic communities are losing these fermentation knowledges due to lack of interest in learning these techniques by their younger generation. This calls for an urgent need for documentation of these products and their preparation process. Government can take initiative in preserving these techniques by teaching them in ITIs (Industrial Training Institutes) and by giving vocational training. Research work needs to be done in selecting good strains and improving them as it will help in generating better fermented products with reduced cross contaminants like methanol formation in *chullu*. With modernization and urbanization, fermented food and beverages are becoming popular globally and so work needs to be done to standardize and commercialize these fermentation processes. This will enable to set up cottage industries as well as larger industries to manufacture and market the healthy fermented products. A lot of the fermented food and beverages of West Bengal are not even reported or documented. Thus, there is a huge scope of microbiological research work in this field which will help in discovering the indigenous microbes and understanding their health benefits or to develop fortified products from them. West Bengal is a populous and poor state with an agriculture driven economy. Fermentation technology can be very useful to combat nutritional deficiencies and food insecurities as well as to uplift economic condition of people by boosting optimal use of each seasonal agriproducts.

Acknowledgment: We are grateful to Raiganj University for all the support.

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