*Indian Journal of Agricultural Sciences* **88** (10): 1496–1501, October 2018/Review Article

# Prospects of Indian traditional fermented food as functional foods

ANITA CHAUDHARY[1], D K SHARMA[2] and ANJU ARORA[3]

*ICAR-Indian Agricultural Research Institute, New Delhi 110 012*

Received: 3 March 2018; Accepted: 15 June 2018

ABSTRACT

The burgeoning population of the developing countries, climate change and shrinking resources are putting pressure on the food security. Thus it implies that in future we not only have to produce more but also do smart agriculture for sustaining on this planet. Moreover, in the era of globalization, people are looking more towards the healthy food, which can provide the nutrients, vitamins and minerals to the body. Hence, in future, the consumption of fermented food is going to increase not only across the world, but also in the developing countries. Traditionally people of India are trying to preserve the food with the fermentation and unknowingly, they are able to produce more nutritious and healthy food, which is able to alleviate many health problems. Scientific evidence has now started emerging in support of the traditional practices being practiced in the ancient times. However, the traditional practice of producing fermented food need to be done scientifically, as sometimes uncontrolled fermentation have led to the spoiled food, due to production of some toxic substances such as bacterial and mold toxins, which instead of providing benefits to the human beings may harm them.

**Key words**: Bioactive constituents, Fermented food, Functional food, Traditional practice

Food provides our bodies with the nutrients what they need to stay alive, and build new cells and tissues for growth, stay healthy and heal themselves. Due to globalization and urbanization, consumers are more aware about the nutritional quality of the food and their associated health benefits.With this, different terminology such as nutraceuticals, vitafoods, dietary supplements and fortified foods came into existence, for describing the function of the food. However, the term functional food has taken a lead and it was first introduced in Japan and defined as the processed foods containing nutritious ingredients that support healthy body. According to International Food Information Council (IFIC), the functional foods are dietary components with a health benefit beyond basic nutrition. On the other hand, International Life Sciences Institute of North America (ILSI) also defines functional foods as physiologically active food components which provide health benefits. For the practical purposes, Prado *et al.* (2008), defined them as the "Foods that in addition to nutrients, supply the organism with components that contribute to the treatment of diseases, or to reduce the risk of developing them". Thus the whole foods, viz. fruits and vegetables represents the simplest form of functional food as they contain specific bioactive components which have the potential role in the improvement of human health. Moreover, the most powerful trend amongst the consumer is their desire for foods and ingredients that is "naturally functional" which is witnessing high growth in terms of different products, such as Turmeric Latte – a drink of dairy milk with large doses of turmeric.

This miracle drink which is earlier used to be "Haldi-doodh" in India is becoming the favourite drink with the consumers in different parts of the world. However, the preparation of the turmeric latte is different than that of our traditional "Haldidoodh" as in the latter, the cold-pressed turmeric juice is added to hot or iced non-dairy milk of soy, almond or coconut.

Throughout the ancient history, health-promoting fermented foods have played a role in sustaining civilizations. Food fermentation is regarded as one of the oldest ways of food processing and preservation and it took its first step during the preparation of soma juice (alcoholic beverage), and sura (wine/beer), prepared by fermentation of boiled rice/barley (Sekar and Marriapan 2007). During the post-Vedic period (600 BC to 100 CE) many other beverages like medaka (spiced rice beer), prasanna (spiced barley or wheat beer), asava (sugarcane beer), etc., were some of the most popular drinks.

Internationally, consumption of fermented foods, viz. sauerkraut, kimchi and naturally cultured dairy products is a common phenomenon as these contain vital enzymes, ω 3 fatty acids and probiotics which give boost to health benefits–in terms of improved digestion and nutrient absorption. Recently the intake of fermented foods has also been linked with the improvement in cardiovascular health and in sugar control.Ready to eat fermented foods such as kefir, kimchi and kombucha products are common in the

[1,2]Principal Scientist (e mail: anita_envr@iari.res.in, dks_env@rediffmail.com), CESCRA; [3]Senior Scientist (e mail: Anjuarora@iari.res.in), Division of Microbiology.

US super markets and in Europe German companies are trying to enter into this innovative market.The Irish market is also witnessing the growth in the area of indigenously-produced sauerkraut, kefir, and fermented beverages.The leading companies involved in the production of fermented foods include Chr. Hansen (Denmark), Angel Yeast Co. Ltd (US), Koninklijke DSM NV (Netherlands), EI du Pont de Nemours and Company (US), and Döhler (Germany), Lallemand Inc. (Canada) and Lonza (Switzerland).The potential of fermented foods as functional foods is further witnessed by the purchase of fermented drinks maker Kevita in 2016, by PepsiCo, the world's second-biggest food and beverage company.

Fermentation occurs due to slow decomposition of organic substances by microorganisms under the anaerobic or partial anerobic conditions (Fig 1). In the fermentation process, microorganisms play a crucial role in the food preservation and enhancement of the flavour, and improvement in the nutritional quality of food. The term fermentation is defined as any process which involves the mass culturing of microorganisms for the formation of a product. Fermentation can either occur naturally or through the addition of starter culture, resulting in the different kinds of products. The natural fermentation process takes place in presence of a mixed colony of microorganisms such as fungi, bacteria, and yeast. Bacteria and yeast are microorganisms, responsible specifically, for lactic acid fermentation and ethanol fermentation respectively. Fermentation transforms the raw materials into biochemically and organoleptically useful products with the simultaneous destruction of the harmful products like phytate (Sharma and Kapoor 1996). Fermentation reduces not only the nondigestible carbohydrates, but also helps in the enrichment of the essential amino acids, vitamins, and minerals, and increases the overall quality of the food (Jeyram *et al.* 2009). Besides this such kind of foods are helpful in maintaining the healthy gut with the beneficial intestinal microbiota, which are essential for protection from various diseases. Therefore, fermented food has been designated as "naturally fortified functional food".

Traditionally India is rich in fermented foods using local food crops and fermented food such as Idli and Dahi which can even found their description as early as 700 BC. The selection of starter cultures for preparation of fermented food can be done on the basis of functional properties such as probiotics properties, antimicrobial properties, antioxidant and degradation of antinutritive compounds (Hill *et al.* 2014). All types of cereals, fruits, vegetables, fish and meat products undergo a number of beneficial biochemical changes, nutritional enrichments during the fermentation process by the action of a number of beneficial microorganism (Vijayendra and Halami 2015). Both functional and non-functional microorganisms are present in naturally fermented foods and beverages (Tamang *et al.* 2016). Lactic acid bacteria (LAB) and bifidobacteria are the most common types of microbes used as probiotics and are commonly consumed as part of fermented foods,

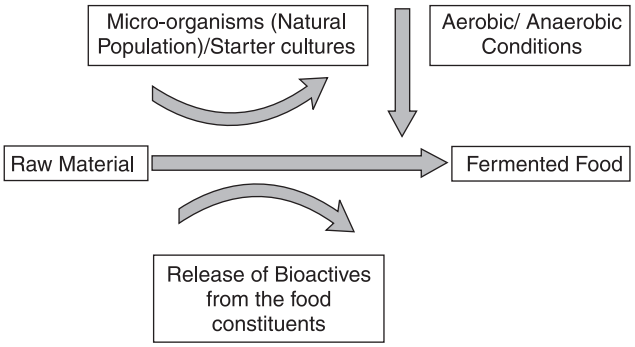


Fig 1 Schematic diagram of the fermentation process.

viz. yogurt, soy yogurt and dahi etc.

Lactic acid bacteria (LAB) comprising of homo and hetero-lactic acid organisms, viz. *Lactobacillus*, *Streptococcus*, *Enterococcus*, *Lactococcus* and *Bifidobacterium*, are among the most commercially used bacteria leading to sauerkraut, yogurt, kimchi and kefir production, curing of fish, and many other dishes around the world (Rhee *et al.* 2011). However, the yeast *Saccharomyces cerevisiae* produces carbon dioxide and ethanol from pyruvate molecules, and is used in bread making, helping the dough rise through the production of carbon dioxide. With other yeast species combination different strains of *S. cerevisiae* are used in alcohol production in beer and wine (Sicard and Legras 2011).

*Market size and forecast growth of functional foods*

In 2014-15, the size of the Indian functional food and beverage market was between ₹ 46 billion and ₹ 49 billion, and was growing at 14-15%. Functional beverages have emerged as fastest growing category in the Indian market in the last 1-2 years, and are expected to grow at a compound annual growth rate (CAGR) of 21.7% by 2018.The largest segment of this market comprises foods designed to improve gut health such as probiotics, prebiotics and synbiotics. Besides this, the product which improves the cardiovascular health, lowering the cholesterol and blood pressure are gaining popularity. India is also undergoing a micronutrient crisis, with over 50% of the nation's population reportedly under-nourished, and the world's highest proportion of low birth weight infants. Seventy percent of the Indian population consumes less than 50% of recommended daily allowance (RDA) of micronutrients in daily diet. Food based strategies which can be dairy and non-dairy based can be adopted to improve the human health and also prevent micronutrient deficiency.

The aim of this review is to get insight of the traditional fermented foods, their bioactive constituents and the associated microbiota, which have the potential to impart the health benefits to humans.

*Non dairy based fermented foods*

*Rice beer- Haria:* In central and eastern India, Haria-traditional rice beer, is consumed by the tribal people. It is prepared through the boiling of rice up to charring and after

cooling, bakhar, the starter culture which is obtained from the previous fermented material (mixed culture of yeasts, filamentous molds, lactic acid bacteria), different parts of fresh roots and leaves, and rice dust (Ghosh *et al.* 2014) is mixed in the earthen pot and then kept for 3- 4 days in the dark room. The fermentation leads to the formation of creamy butter milk like filtrate consisting of lactic acid and bioactive constituents of plant materials as well as microorganisms (Fig 2a and b).

This drink is believed to be energy drink and it has been shown to protect and improve intestinal function due to the accumulation of different maltooligosaccharides which are very effective in inhibiting the intestinal pathogens (Ghosh *et al.* 2015a). Moreover, during fermentation lot of pyranose derivatives get accumulated which have immense immunostimulatory, and antioxidant properties (Ghosh *et al.* 2015b). The fermentation of brown rice and rice bran has been shown to provide cancer fighting properties in mice (Phutthaphadoong *et al.* 2009). Three different tribal communities of Assam Bodo, Garo and Rabha also consume rice beer, but they call it by Jou, Chu and Chako respectively. These rice beer are processed by unique starter cultures consisting of yeasts and other associated microorganisms to carry out fermentation (Narzary *et al.* 2016).

*Apong and Bhatijaanr*

In north east India, rice based fermented beverage known as Apong is consumed by the community. It is prepared with raw materials of rice, ash of paddy husk and straws, and traditional starter, epop (mixture of old ferments and plant parts). After fermentation of 20 days at 30-35$^0$C a clear brownish filtrate, is obtained which is considered as energy-rich refreshing drink. It is believed to be loaded with the antimicrobial, antioxidant properties, and prevents the formation of stones in kidney (Kardong *et al.* 2012). Bhati jaanr another rice based mild alcoholic sweet tasting beverage is also consumed by the ailing persons and postnatal women of north east India for regaining their physical strength (Tamang and Thapa 2006).

*Cereal and legume based products*

Most common rice-based fermented food available in India are idli, dosa, dhokla, uttapam, etc. (Ray *et al.* 2016). Idli makes an important contribution towards calories, proteins and vitamins specifically B complex vitamins, with simultaneous decline in phytic acid. It can be used as supplement for the people having protein malnutrition and kwashiorkor and also aid in losing weight. In Idli the lactic acid bacteria such as *Lactobacillus plantarum* and *Lactobacillus lactis* can produce vitamin B12 and beta galactosidase enzyme which enhances the probiotic activity and promote health (Iyer *et al.* 2013). Dosa is considered as an appropriate diet for individuals with wheat allergies or gluten intolerance. The fermentation process in dosa increases the amount of total acids, free amino acids, amylase, proteinases, vitamin B1, vitamin B2, folic acid, and antimicrobial and antioxidant substances. It also reduces the antinutrients and enhances the bioaccessibility of zinc and iron. Dosa also help to fight diabetic conditions because of low glycemic load and glycemic index and it is also believed to provide cure for rheumatism and neural disorders (Gupta and Tiwari 2014). Even certain food borne pathogens have been shown to be inhibited by the *Lactobacillus plantarum* strain isolated from the common Indian fermented food dosa (Gupta and Tiwari 2014).

In southern and western India, Dhokla – a soft, spongy, and acid fermented cake is generally taken as a breakfast item. The dominant LAB present in dhokla are *L. fermentum, L. mesenteroides, Pichia silvicola, S. faecalis* etc. (Moktan *et al.* 2011). It is very useful for diabetic patients because of its low glycemic index. It also helps in reduction of blood cholesterol, and protects from cardiovascular diseases.

*Millet based products*

India is the world's largest producer of millet with the production of 11620 (1000 MT) in 2016. The annual millet production had increased in India, but per capita consumption of millet had declined about 50 to 75%. Earlier the millet crops were used as a food staple because of its nutritious and medical functions ( Yang *et al.* 2012) but presently the millets are being used more for the alcohol production and livestock fodder. The gradual decline of this nutritious food probably might have occurred due to their taste, lower cooking quality and low bioavailability. Millets are rich in fibers, proteins and micronutrients such as iron, zinc and calcium and also have lower glycemic index.

*Kambu koozh*

Koozh is a non-alcoholic naturally fermented pearl millet porridge, consumed as a traditional beverage in rural India. Koozh is unique as it is fermented twice-before and after cooking, and is considered to be nutritious and health promoting due to its therapeutic properties such as prevention of diarrhoea and constipation (Ilango and Antony 2014).

*Ambali*

Ambali is a finger millet-based fermented product of Karnataka and Tamil Nadu. The fermentation process not only increases the concentration of thiamin, riboflavin, and tryptophan and bioavailability of minerals but simultaneously decreases the leucine to lysine ratio. It is considered as good food for elderly people as it contains high calcium and low resistant starch (Mangala *et al.* 1999)

*Soya food*

In Meghalaya, Khasi tribe uses soybean seeds for the preparation of tungrymbai, a traditional fermented food product. For preparing tungrymbai, the cooked soybean seeds are pressed in a bamboo basket, lined with leaves of *Clinogyne dichotoma* and left to ferment for 3-4 days either in the ambient temperature (25–40$^0$C) or near the fire place. The sticky fermented product obtained as a brown mass (Fig 2c) with a characteristic odor serves as a source


Fig 2 Incubation of the earthen pots for the fermentation of plant material (a) and prepared haria (b), after fermentation (Source :Ghosh *et al.* 2014) tungrymbai (c), and Kinema (d).

of high protein food in local diet (Sohliya *et al*, 2009).

*Kinema*

In the Sikkim and Darjeeling hills, Kinema- a soybean based fermented food (Deka 2012) serves as a good and cheap source of protein ( Fig 2d). For the preparation of Kinema, soaked and cracked soybean seeds are placed in bamboo basket lined with fresh fern fronds. For maintain the temperature for the fermentation, it is covered with a jute bag and left to ferment at 25°-40°C for 2-3 days above an earthen oven. This fermented product is consumed along with rice and vegetables.

*Hawaijar*

In Manipur, Hawaijar a fermented soybean is consumed in Manipur as a source of high protein food (Devi and Kumar 2012) and is known for their anticancer, anti-osteoporosis and hypocholesterolemic effects.Thaunaoa similar product to Hawaijar has been shown to have approximately 6-9 times increase in essential amino acids such as trypsin followed by glutamine, cystine, lysine and leucine. During the fermentation, microorganisms convert the raw substrate into bioactive constituents, thereby enhancing the nutritional value of the products, with health promoting bio-active compounds. After the fermentation, the antioxidant and antidiabetic activity of hawaijar showed a significant increase, which can help in overcoming malnutrition and degenerative diseases (Keishing *et al.* 2015).

*Axone-Akhuni*

Axone, a fermented soybean food of Nagaland, have been shown to prevent diseases and gives longevity to the human being because of their numerous functional properties, viz. antimicrobial, fibrinolytic, immunohistochemical, hypocholestremic and antioxidant effects (Dajanta *et al.* 2012). Fermented soy foods such as chungkukjang have also been shown to possess anticancer activities.

*Fermented food with probiotic properties*

Fermented foods in its various forms like 'lassi' and 'chhaachh', has also been an intrinsic part of people's diets in north India. The consumption of fermented food specifically milk supplemented with probiotics can improve immunity and intestinal health (Wang *et al.* 2012) and also leads to reduction in respiratory infections (Makino *et al.* 2010). Recently, Yogurt nutrient dense food has also evolved an interest in Indian consumers. A single serving of yogurt contains a significant boost of phosphorous, potassium, B12, riboflavin, zinc, iodine, and vitamin B5. Dairy consumption is beneficial for weight control, coronary diseases, diabetes, and hypertension.

Dahi is an Indian homemade yogurt prepared using mixed starter of mesophillic lactoccoci, viz. *Lactococcus lactis* ssp. *Lactis*, *Lactococcus lactis* ssp. *Diacetylactis* and *Lactococcus lactis* ssp. *Cremoris*. It differs from yogurt in its metabolites which imparts flavor due to the presence of diacetyl rather than the acetaldehyde flavour in yogurt (Yadav *et al.* 2007). *Lactococcus lactis* an isolate of dahi produces nisin like bacteriocin which inhibits important food pathogen such as *L.monocytogenes* and *S. aureus* (Mitra *et al.* 2007). Dahi can be treated as functional food because of their antidiarrheoal, anticarcinogenic, cholesterol lowering ability, and immune-boosting properties (Sarkar 2013). To improve the dietetic properties of traditional dahi, certain probiotic and beneficial bacteria have been included in that. Yogurt, is generally well tolerated by lactose intolerant people because of the presence of β-galactosidase by yogurt cultures (Savaainao 2014)

*Fish products*

Hentak is prepared by fermentation of a mixture of sun-dried fish powder and petioles of aroid plants in Manipur. The mixture is kept in an earthen pot for fermentation and is eaten as curry with boiled rice after 15 days of complete fermentation. It is given to the sick patients as well as to the women who are in the final stages of their pregnancy (Sarojnalini and Singh 1988).

*Fruits and vegetables*

Sinki is a non-salted fermented radish tap root (*Raphanus sativus* L.), consumed by the *Nepalis* tribe in Darjeeling, Sikkim, and Nepal. It is prepared during the months of winter when weather is least humid and there is ample supply of this vegetable. It is said to be a good appetizer and is used as a remedy for indigestion (Tamang and Sarkar 1993).

Gundruk a common non-salted dried fermented leafy vegetable food of the *Gorkha* tribes is commonly prepared during winter season from the leaves of cauliflowers, mustard, radish *rayo-sag*, and some other locally grown

vegetables. It improves the milk efficiency in new mothers and the soup is eaten as a good appetizer which possesses a higher quantity of ascorbic acid, lactic acid, and carotene with anticancer properties (Tamang *et al.* 2005). The fermented bamboo shoots, which are rich in phenolic compounds and tannin, possess antioxidant, anticancer, and anti-aging properties (Tamang and Tamang 2009)

Kimchi (fermented vegetables), a popular dish of Korea, has been shown to provide health benefits, in terms of cholesterol levels reduction and prevention of cancer and obesity and boosting the immune system (Park *et al.* 2014).

Sauerkraut – one of the more common fermented foods, is made from cabbage and salt. It is often used as a condiment with a variety of foods and it delivers a high dose of probiotics and fibre and can be easily made at home.

Mesu – a fermented dish made from bamboo shoot by people of Darjeeling hills and Sikkim is consumed as pickle. The bamboo shoots possess immense nutritive and medicinal properties as it is rich in potassium, carbohydrates, dietary fibres, vitamins and antioxidants.It has great potential as functional food , due to the presence of different lactic acid bacteria which possess functional probiotic properties and also supply vitamin B to human being (Tamang *et al.* 2008)

Soibum - a fermented dish produced exclusively from succulent bamboo shoots and is consumed as a regular dish along with steamed rice. The leaves of fermented bamboo shoots in the Soibum possess lot of antioxidant properties (Singh *et al.* 2011). Lactic acid bacteria during the fermentation besides showing antimicrobial activities also degrade the phytic acid.

Recently the clinical trials of fermented foods on humans have revealed strong correlation between the consumption of fermented foods and reduction in risk of different diseases such as cardiovascular diseases, type 2 diabetes etc. (Tapsel 2015). These benefits might extend to immediate physiological responses, a possibility recently indicated by the finding that fermented milk consumption improved glucose metabolism and reduced muscle soreness induced by acute resistance exercise.

*Conclusion*

In India, almost all communities in India have some rituals that revolve around fermented food, which is being considered as a good mechanism of introducing the probiotic in the human beings. Fermented fish paste, fermented soybeans and pantabhat or pakhalabhat are common among Indian regional cuisine as well as the tribal cuisine. Many tribes make fermented beverages in their own way using different grains or fruits or starchy tubers, whatever grows in abundance locally. The consumption of these kind of food and beverages, which provides them the essential vitamins, minerals and nutrients, by the people helped them to take care of their health and building of immunity. These traditional foods and beverages not only help them in terms of nutrition, but also act as preventive measures for life style diseases such as hypertension, diabetes, cardiovascular diseases associated with the hypercholestrol. It is time to link the people knowledge of preparation and the traditional food commodities having numerous health benefits with different food and beverage manufacturing agencies, which will help in bringing innovative products into the market, thereby creating a win-win situation.

ACKNOWLEDGEMENT

Authors are thankful to Head, CESCRA and Head, PHT, ICAR-IARI for all the support.

REFERENCES

Dajanta K, Chukeatirote E and Apichartsrangkoon A. 2012. Nutritional and physicochemical qualities of Thua Nao (Thai traditional fermented soybean). *Chiang Mai Journal of Science* **39**: 562-74.

Das A, Raychaudhuri U and Chakraborty R. 2012. Cereal based functional food of Indian subcontinent: a review. *Journal Food Science Technology* **49**: 665-72.

Deka S C. 2012. Mini review on fermented foods and beverages of the north-east India. *International Food Research Journal* **19(2)**: 377-92.

Devi P and Kumar S P. 2012. Traditional ethnic and fermented foods of different tribes of Manipur. *Indian Journal of Traditional Knowledge* **11**: 70-7.

Ghosh K, Maity C, Adak A, Halder S K, Jana A, Das A, Parua S Das, Mohapatra P K, Pati B R and Mondal K C. 2014. Ethnic preparation of haria, a rice-based fermented beverage, in the province of lateritic West Bengal, India. *Ethnobotanical Research Applications* **12**: 39–49.

Ghosh K, Ray M, Adak A, Dey P, Halder SK, Das A, Jana A, Parua (Mondal) S, Das Mohapatra P K, Pati B R and Mondal K C. 2015.Microbial, saccharifying and antioxidant properties of an Indian rice based fermented beverage. *Food Chemistry* **168**: 196-202.

Ghosh K, Ray M, Adak A, Halder S K, Das A, Jana A, Parua (Mondal) S, Vagvolgyic C, Das Mohapatra P K, Pati B R and Mondal K C. 2015. Role of probiotic *Lactobacillus fermentum* KKL1 in the preparation of a rice based fermented beverage. *Bioresource Technology* **188**: 161-8.

Gupta A and Tiwari S K. 2014. Probiotic potential of *Lactobacillus plantarum* LD1 isolated from batter of dosa, a south Indian fermented food. Probiotics. *Antimicrobial Proteins* **6**: 73-81.

Hill C, Guarner F, Reid G, Gibson G R, Merenstein D J and Pot B *et al*. 2014. Expert consensus document: the international scientific association for probiotics and prebiotics consensus statement on the scope and appropriate use of the term probiotic. *National Review Gastroenterology Hepatology* **11:** 506–14.

Ilango S and Antony U. 2014. Assessment of the microbiological quality of koozh, a fermented millet beverage. *African Journal of Microbiology Research* **8**: 308–12.

Iyer B K, Singhal R S and Ananthanarayan L. 2013. Characterization and in vitro probiotic evaluation of lactic acid bacteria isolated from idli batter. *Food Science Technology* **50**: 1114–21.

Jeyaram K, Singh T A, Romi W, Devi A R, Singh W M, Dayanidhi H, Singh N R and Tamang J P. 2009. Traditional fermented foods of Manipur. *Indian Journal Traditional Knowledge* **8**: 115–21.

Kardong D, Deori K, Sood K, Yadav R N S, Bora T C and Gogoi B K. 2012. Evaluation of nutritional and biochemical aspects of apong (saimod); a homemade alcoholic rice beverage of Mising tribe of Assam, India. *Indian Journal of Traditional Knowledge* **11**: 499–504.

Kumar R S, Varman D R, Kanmani P, Yuvaraj N, Paari K A, Pattukumar V and Arul V .2010. Isolation, characterization and identification of a potential probiont from south Indian fermented foods (Kallappam, Koozh and Mor Kuzhambu) and its use as biopreservative. *Probiotics Antimicrobial Proteins* **2**: 145–51.

Mangala S L, Malleshi N G and Tharanathan R N. 1999. Resistant starch from differently processed rice and ragi (finger millet). *European Food Research Technology* **209**: 32–7.

Mitra S, Chakrabartty P K and Biswas S R. 2007. Production of Nisin Z by *Lactococcus lactis* isolated from Dahi. *Applied Biochemistry Biotechnology* **143**: 41–53.

Moktan B, Roy A and Sarkar P K.2011. Antioxidant activities of cereal-legume mixed batters as influenced by process parameters during preparation of dhokla and idli, traditional steamed pancakes. *International Journal Food Science Nutrition* **62**: 360–9.

Park K Y, Jeong J K, Lee Y E and Daily J W. 2014. Health benefits of kimchi (Korean fermented vegetables) as a probiotic food. *Journal Medicine Food* **17**: 6–20.

Parvez S, Malik K A, Kang S A and Kim H Y. 2006. Probiotics and their fermented food products are beneficial for health. *Journal Applied Microbiology* **100**: 1171–85.

Phutthaphadoong S, Yamada Y, Hirata A, Tomita H, Taguchi A, Hara A, Limtrakul P N, Iwasaki T, Kobayashi H and Mori H. 2009.Chemopreventive effects of fermented brown rice and rice bran against 4-(methylnitrosamino)-1- (3-pyridyl)-1-butanone-induced lung tumorigenesis in female A/J mice. *Oncology Reports* **21**: 321–7.

Prado F C, Parada J L, Pandey A and Soccol C R. 2008. Trends in non-dairy probiotic beverages. *Food Research International* **41**: 111–23.

Purushothaman D, Dhanapal N and Rangaswami G. 1993. Indian idli, dosa, dhokla, khaman, and related fermentations. (*In*) *Handbook of Indigenous Fermented Food*. Steinkraus K H (Ed). Marcel Dekker, New York.

Rai K N, Gowda C L L, Reddy B V S and Sehgal S. 2008. Adaptation and potential uses of sorghum and pearl millet in alternative and health foods. *Comprehensive Reviews in Food Science and Food Safety* **7**: 340–52.

Ray M, Ghosh K, Singh S N and Mondal K C. 2016. Folk to functional: an explorative overview of rice-based fermented foods and beverages in India. *Journal Ethnic Food* **3**: 5–18.

Rhee S J, Lee J E and Lee C H 2011. Importance of lactic acid bacteria in Asian fermented foods. *Microbial Cell Factories* **10:** 1475-2859-10-S1-S5.

Sarkar S. 2013. Probiotics as functional foods: documented health benefits*. Nutrition Food Science* **43**: 107–15.

Sarojnalini C and W V Singh. 1988. Composition and digestibility of fermented fish foods of Manipur. *Journal Food Science Technology* **25**: 349–51.

Savaiano D A. 2014. Lactose digestion from yogurt: mechanism and relevance. *American Journal Clinical Nutrition* **99**: 1251–5.

Sekar S and Mariappan S. 2007. Usage of traditional fermented products by Indian rural folks and IPR. *Indian Journal Traditional Knowledge* **6**: 111–20.

Sharma A and Kapoor A C. 1996. Levels of antinutritional factors in pearl millet as affected by processing treatments and various types of fermentation. *Plant Foods Human Nutrition* **49**: 241–52.

Singh S A, Singh H D, Nongmaithem R, Bora T C and Singh T R .2011. Comparative study of chemical properties of soibum- a traditional fermented bamboo shoot product and its biological investigation. *International Journal of Bioscience, Biochemistry and Bioinformatics***1(2)**: 1114–8.

Sohliya I, Joshi S R, Bhagobaty R K and Kumar R. 2009. Tungrymbai- A traditional fermented soybean food of the ethnic tribes of Meghalaya. *Indian Journal Traditional Knowledge* **8**: 559–61.

Somishon K, Thahira B and Umadevi M. 2015. Effect of fermentation on the nutrient content, antioxidant and antidiabetic activities of hawaijar, anindigeneous fermented soya of Manipur, India. *Journal Human Nutrition Food Science* **3(3)**: 1066.

Stanbury P F. 1999. Fermentation technology. (*In*) Principles of Fermentation Technology. Stanbury P F, Whitaker A and Hal S J (Eds). Butterworth Heinemann, Oxford (UK).

Syal P and Vohra A. 2013. Probiotic potential of yeasts isolated from traditional Indian fermented foods. *International Journal Microbiological Research* **5**: 390–8.

Tamang B, Tamang J P, Schillinger U, Franz C M A P and Gores M *et al*. 2008. Phenotypic and genotypic identification of lactic acid bacteria isolated from ethnic fermented bamboo tender shoots of North East India. *International Journal Food Microbiology* **121(1)**: 35–40.

Tamang J P and Thapa S. 2006. Fermentation dynamics during production of bhaatijaanr, a traditional fermented rice beverage of the eastern Himalayas. *Food Biotechnology* **20**: 251–61.

Tamang J P and Sarkar P K. 1993. Sinki: a traditional lactic acid fermented radish tap root product. *Journal General Applied Microbiology* **39**: 395–408.

Tamang J P, Tamang B, Schillinger U, Franz C M A P, Gores M and Holzapfel W H. 2005. Identification of predominant lactic acid bacteria isolated fromtraditionally fermented vegetable products of the Eastern Himalayas. *International Journal Food Microbiology* **105**: 347–56.

Tamang J P, Watanabe K and Holzapfel W H .2016.Review: Diversity of microorganisms in global fermented foods and beverages. *Frontiers Microbiology* **7**: 377.

Tapsell L C. 2015. Fermented dairy food and CVD risk. *British Journal Nutrition* **113**: 131–5.

Thakur K and Tomar S K. 2016. *In vitro* study of riboflavin producing lactobacilli as potential probiotic. *LWT-Food science Technology* **68**: 570–8.

Thapa N, Pal J and Tamang J P. 2004. Microbial diversity in ngari, hentak and tungtap, fermented fish products of North East India. *World Journal Microbiology Biotechnology* **20*(*6)**: 599–607.

Vijayendra S V N and Halami PM. 2015. Health benefits of fermented vegetable products. (*In*) *Health Benefits of Fermented Foods and Beverages*. Tamang J P (Ed). P 325–42. CRC Press, Taylor & Francis Group, Boca Raton (NY).

Wang S, Zhu H, Lu C, Kang Z, Luo Y, Feng L and Lu X. 2012. Fermented milk supplemented with probiotics and prebiotics can effectively alter the intestinal microbiota and immunity of host animals. *Journal Dairy Science* **95**: 4813–22.

Yadav H, Jain S and Sinha P R. 2007. Evaluation of changes during storage of probiotic dahi at 78°C. *International Journal Dairy Technology* **60(3)**: 205–10.

Yang X, Wan Z, Perry L, Lu H, Wang Q and Zhao C *et al*. 2012. Early millet use in northern China. *Proceeding National Academy Science U S A* **109**: 3726–30.

Yutika N, Jahnovi B, Chandan B and Sandeep D. 2016. A study on indigenous fermented foods and beverages of Kokrajhar, Assam, India. *J. of Ethnic Foods* **3**: 284–91.