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Prospects of Asian Fermented Foods in Global Markets

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Abstract

Consumption of ethnic fermented foods and alcoholic beverages is related to diversity of ethnicity with unparalleled rich food culture of every community in Asia. Diversity of functional microorganisms ranges from filamentous moulds to enzyme-producing to alcohol-producing yeasts and Gram-positive and few Gram-negative bacteria with several functional properties. Asian ethnic fermented foods and beverages have biological functions enhancing several health-promoting benefits to the consumers due to functional microorganisms associated with them such as bio-preservation of perishable foods, bio-enrichment of nutritional value, protective properties, bio-availability of minerals, production of antioxidants and omega-3-polyunsaturated fatty acids, therapeutic values and immunological effects. Low-cost, high food-valued, socially and culturally acceptable fermented foods and beverages are consumed as staple, curry, stew, side dish, fried, cooked, paste, seasoning, condiment, pickle, confectionery, salad, soup, dessert, savory, drink, candied, masticator, colorant, taste-maker, alcoholic and non-alcoholic beverages. Indian and Chinese have the diverse varieties of ethnic fermented foods and alcoholic beverages among the Asian communities. In Asia, ethnic fermented foods and alcoholic beverages are produced naturally by native microorganisms, whereas alcoholic beverages are produced by using traditionally prepared dry and mixed inocula or starter cultures (locally called *loogpang* in Thailand, *marcha* in India, *nuruk* in Korea, *bubod* in the Philippines, *ragi* in Indonesia, *men* in Vietnam, *chiu-yueh* in China). Ethnic foods are also source of revenue for many rural Asian people to sustain their livelihood. Few common Asian ethnic fermented foods and alcoholic drinks are already commercialized and marketed globally, such as *tempe*, *saké*, *natta*, *natto*, *shoyu*, *kimchi*, *nan*, *dahi*, *lassi*, etc. Many other Asian fermented foods claimed to have health-promoting benefits can also be exploited for enhancement of regional economy as well as for accessibility to consumers in non-Asian countries. Value addition to Asian fermented foods through interface of food biotechnology for better products is the need of the day. One has to respect and recognize the native skills and indigenous expertise of the Asian ethnic people for building up a global approach to ethnic foods.

Keywords: Asia, fermented foods and beverages, microorganisms, health-promoting benefits



Introduction

Cooked rice is a staple food for millions of people in many Asian countries, whereas wheat or barley is also staple food in north and west India, Mongolia, west and north China, Pakistan, Afghanistan, Iran, Iraq, and all mid-Asia in the baked form such as *chapatti*, *roti*, *nan*, etc. A typical diet of the Eastern World consists of boiled rice with many side-dish containing fermented and non-fermented soybean products, vegetables, pickles, fish, meat and alcoholic beverages (Tamang and Samuel 2010). Drinking of animal milk is not a food culture of ethnic Chinese, Koreans, Japanese, and many Mongolian-origin races despite of an abundance of cow in their possession. Whereas, the Indians, Europeans, Semites and the nomadic tribesmen of North Central Asia are traditionally milk drinkers (Tamang 2010b). In the Far East Asia, the soybean, is processed to make soy milk, tofu (soya curd), and fermented into a number of ethnic fermented soybean products such as *miso*, *shoyu*, *natto*, *kinema*, *thua nau*, *douchi*, *chungkokjang*, *tempe* and *sufu*. The Himalayan dietary culture has both rice and wheat or barley or maize as staple food along with varieties of ethnic fermented and non-fermented foods prepared from soybean, vegetable, bamboo, milk, meat, fish, alcoholic beverages, and wild edible plants (Tamang 2010a). Ethnic fermented foods are defined as foods produced by the ethnic people using their native knowledge from locally available raw materials of plant or animal sources either naturally or by adding starter culture(s) containing functional microorganisms which modify the substrates biochemically and organoleptically into edible products that are culturally and socially acceptable (Tamang 2010a). Cereals are commonly fermented into several ethnic alcoholic drinks in Asia. Tea, the second most popular beverage in the world after water, was originated in China and two common species of tea are *Camellia sinensis* var. *sinensis* and *Camellia sinensis* var. *assamica* (Schillinger et al. 2010). Though normal black tea is drunk everywhere, however, some ethnic Asian communities have special fermented tea such as *miang* of Thailand, *puer* tea and *fuzhuan brick* of China, and *kombucha*.

Besides drinking, ethnic alcoholic drinks have strong ritualistic importance among the ethnic people in Asia where social activities require provision and drinking of alcohol. Interesting, malting process for alcohol production is rare or unknown in Asia. Wine making is not a tradition in Asia since fruits are eaten directly without extracting into juice or fermenting into wines. Dry mixed amylolytic starters in a form of round-flattened cake-like containing consortia of microorganisms are traditionally used in fermentation of alcoholic beverages in many countries in Asia (Tamang and Fleet 2009). Indian and Chinese have the diverse varieties of ethnic fermented foods and alcoholic beverages among the Asian communities (Tamang 2010b). Asian fermented foods have several health-promoting benefits and biological importance (Tamang 2007, 2010b,c,d; Farhad et al. 2010). Some of the biological importance of Asian foods are discussed below.

(1) Tasty and flavoursome foods

Transformation of bland vegetable protein into meat-flavored amino acids sauces and pastes by fermentation is common in Japanese *miso* and *shoyu*, Thai fish sauce, Chinese soy-sauce and Indonesian *tauco* (Steinkraus 1996). In *ang-kak*, an ethnic fermented rice food of South-East Asia, *Monascus purpureus* produces a purple-red water-soluble color in the product, which is used as colorant (Beuchat 1978). Fermentation improves the taste of



otherwise bland foods, imparts typical flavor and texture to the fermented products such as *kinema* (Tamang 2001). During *tempe* fermentation, mycelia of *Rhizopus oligosporus* knit the soybean cotyledons into a compact cake which when sliced resemble non-textured bacons (Steinkraus 1994). In *ontjom*, an Indonesian fermented peanut product, *Neurospora sitophila* knits the particles into firm cakes imparting meat like texture (Steinkraus 1994).

(2) Biological preservation

Biological preservation refers to extended storage life without refrigeration by lactic acid fermentation. During fermentation of the Himalayan ethnic fermented vegetable products, *Lb. plantarum*, *Lb. brevis*, *Pediococcus pentosaceus*, *Leuconostoc fallax*, produce lactic acid and acetic acid and lower the pH of the substrates making the products more acidic in nature (Tamang et al. 2005, 2008). Due to low pH and high acid content and sun-drying process of freshly fermented vegetables in the Himalayas, perishable vegetables can be preserved without refrigeration and addition of any synthetic preservative for several years. Several fermented vegetable products preserved by lactic acid fermentation are *gundruk* and *sinki* of India and Nepal, *kimchi* in Korea, *sunki* of Japan, *pao cai* of China, etc. (Tamang 2001b).

(3) Biological enhancement of nutritional value

During fermentation, biological enrichment of food substrates with essential amino acids, vitamins and various bioactive compounds occur spontaneously. In *tempe*, the levels of niacin, nicotinamide, riboflavin and pyridoxine are increased by *Rhizopus oligosporus*, whereas cyanocobalamin or vitamin B12 is synthesized by non-pathogenic strains of *Klebsiella pneumoniae* and *Citrobacter freundii* during fermentation (Liem et al. 1977; Keuth and Bisping 1994). Thiamine, riboflavin and methionine contents in *idli* (fermented black gram-rice product of India) are increased during fermentation (Rajalakshmi and Vanaja 1967, Steinkraus et al. 1967). During *tempe* fermentation, isoflavone particularly Factor-II and aglycone contents are found to increase (Pawiroharsono 2002). During production of *kinema*, proteolytic enzymes produced by *Bacillus subtilis* break proteins into peptides and amino acids enhancing digestibility (Tamang and Nikkuni 1996, 1998). *Kimchi* has been selected as one of the world's healthiest foods in 2006 by the Health Magazine due to its many beneficial properties (Nam et al. 2009).

(5) Bio-improvement in lactose metabolism

People suffering from lactose intolerance or lactose mal-absorption, a condition in which lactose, the principal carbohydrate of milk, is not completely digested into glucose and galactose (Onwulata et al. 1989). Consumption of *kefir* minimizes symptoms of lactose intolerance by providing extra source of β -galactosidase (Hertzler and Clancy 2003). Himalayan ethnic fermented milk products are appropriate for lactose in-tolerant consumers (Dewan and Tamang 2006, 2007).

(6) Probiotic properties of fermented foods

Probiotic cultures are considered to provide health-promoting benefits by means of stabilizing the gastro-intestinal tract (Lee and Salminen 2009). In Japan, more than 53 different types of probiotic-milk products are marketed, whereas in Europe their use is largely restricted to the yoghurt sector (Hilliam 2000). Some strains of LAB primarily



species of *Lactobacillus* and *Enterococcus*, and species of *Bifidobacterium* are used as probiotic adjuncts and as biotherapeutic agents as protection against diarrhoea, stimulation of the immune system, alleviation of lactose intolerance symptoms, and reduction of serum cholesterol (Shah 2005). The Himalayan fermented yak milks have probiotics properties (Tamang et al. 2000, Dewan and Tamang 2007). Probiotic strain of *Lb. plantarum*, isolated from *kimchi*, inhibits the growth and adherence of *Helicobacter pylori* in MKN-45 cell line, with small peptides as the possible inhibitors (Lee and Lee 2006). Yakult is the Japanese commercial probiotic milk product which has several health-promoting benefits such as modulation of the immune system, maintenance of gut flora, regulation of bowel habits, alleviation of constipation, and curing of gastrointestinal infections (Kiwaki and Nomoto 2009).

(7) Bio-production of enzymes

During fermentation, indigenous microorganisms or starter cultures produce enzymes on the substrates to break down complex compounds to simple bio-molecules for several biological activities. Some of these strains produce a high amount of enzymes, which may be exploited for commercial production. *Bacillus subtilis* produces enzymes such as proteinase, amylase, mannase, cellulase and catalase during *natto* and *kinema* fermentation (Ueda 1989, Tamang and Nikkuni 1996). Species of *Actinomucor*, *Amylomyces*, *Mucor*, *Rhizopus*, *Monascus*, *Neurospora*, *Aspergillus* produce various carbohydrases (enzymes) such as α -amylase, amyloglucosidase, maltase, invertase, pectinase, β -galactosidase, cellulase, hemi-cellulase; pentosan degrading enzymes; acid and alkaline proteases; and lipases (Nout and Aidoo 2002). Taka-amylase A (TAA), a major enzyme produced by *A. oryzae* (present in *koji*) is well known worldwide to be a leading enzyme for industrial utilization (Suganuma et al. 2007). *Saccharomycopsis fibuligera*, *Sm. Capsularis* and *Pichia burtonii* have high amylolytic activities as shown in *marcha*, an ethnic amylolytic starters for alcohol production in the Himalayas (Tsuyoshi et al. 2005, Tamang et al. 2007). Considerable amount of glucomaylase is produced by *Rhizopus* spp. (Ueda and Kano 1975) and by *Sm. fibuligera* (Ueda and Saha 1983).

(8) Antimicrobial properties

Protective properties of LAB due to anti-microbial activities are useful in food fermentation, making foods safe to eat. Consumption of LAB in fermented foods without any adverse health effects is taken as their GRAS status and therefore their bacteriocins might have potential as bio-preservatives (Adams 1999). *Kimchi* has strong antimicrobial activity against *Listeria monocytogenes*, *Staphy. aureus*, *E. coli* and *Salmonella typhimurium* (Lee et al. 2009). Many strains of LAB isolated from *kimchi* produce antimicrobial compounds such as leuconocin J by *Leuconoctoc* sp. J2 (Choi et al. 1999), bacteriocin by *Lc. lactis* BH5 (Hur et al. 2000) and *Leuc. citreum* GJ7 (Chang et al. 2008), and pediocin by *P. pentosaceus* (Shin et al. 2008). *Lb. plantarum* IB2 isolated from *inziangsang*, fermented vegetable of India is found to produce a bacteriocin against *Staphylococcus aureus* S1 (Tamang et al. 2009).

(9) Medicinal values

Many fermented foods have medicinal values. Consumption of fermented foods containing viable cells of *Lb. acidophilus* decrease β -glucuronidase, azoreductase, and nitroreductase (catalyse conversion of procarcinogens to carcinogens), thus possibly remove



procarcinogens, and activate the immune system of consumers (Goldin and Gorbach 1984). Consumption of fermented milks containing very large populations of probiotic bacteria ($\sim 10^9$ bacteria/g) by hypercholesterolemic persons has resulted in lowering cholesterol level from 3.0 to 1.5 g/L (Homma 1988). *Kimchi* has large amounts of ascorbic acid, carotene and dietary fibre, which have anticarcinogenic effects (Cheigh and Park 1994, Park 1995). Lactic acid produced by *kimchi* is found to prevent fat accumulation and to improve obesity-induced cardiovascular diseases (Park et al. 2008). Antioxidants are found in *kimchi* (Sim and Han 2008, Sun et al. 2009). Glycoprotein antimutagenic substances have been isolated from *Lb. plantarum* isolated from *kimchi* (Rhee and Park 2001). Several health-benefits effects of *kimchi* have been reported such as prevention of constipation, colon cancer, reduction of serum cholesterol (Park et al. 2006), possession of anti-stress principles (Lee and Lee 2009), S-Adenosyl-L-methionine, a bioactive material used in the treatment of depression, osteoarthritis and liver disease (Lee et al. 2008), anti-obesity effect (Kong et al. 2008), inhibition of atherosclerosis (Kim et al. 2008b). Dietary fiber is especially important to help prevent chronic diseases, as its effects include reducing blood cholesterol, stabilizing blood sugar, regulating bowel movements among others in *kimchi* (Lee et al. 2008). Antioxidant activities have been reported in many ethnic fermented soybean foods such as *chungkokjang* (Shon et al. 2007), *kinema* (Tamang et al. 2009), *natto* (Iwai et al. 2002), *douchi* (Wang et al. 2007) and *tempe* (Horii 2008). *Kefir* has antitumor activity due to its antioxidative properties (Güven et al. 2003). Due to large amount of Group B saponin content (243.4 ± 25.8 – 590.3 ± 29.0 mg/100g) in ethnic fermented soybeans of India, it is presumed that these ethnic soybean foods have health promoting benefits (Omizu et al. 2011).

Puer tea extract are known to prevent cardiovascular disease and mortality of patients (Mo et al. 2008). *Natto* prevents hemorrhage in consumers caused by vitamin K deficiency in infants (Ueda 1989). Intake of *natto* increases serum level of MK-7 and γ -carboxylated osteocalcin in normal individual (Tsukamoto et al. 2000). Consumption of *tempe* reduces the cholesterol level which is due to inhibition of hydroxymethylglutaryl coenzyme A reductase, a key enzyme in cholesterol biosynthesis, by oleic acid and linoleic acid during fermentation (Hermosilla et al. 1993). Content of γ -aminobutyric acid in *tempe* can improve the brain bloodstream and retard high blood pressure (Aoki et al. 2003). Thrombolytic activity (average 450 IU/g dry weight) has been observed in *tempe* (Sumi and Okamoto 2003). *Douchi* produces angiotensin I-converting enzyme inhibitors with the potential to low blood pressure (Zhang et al. 2006). In the Himalayas, ailing persons and post-natal women consume the extract of ethnic fermented rice product *bhaati jaanr* due to high calorie content, to regain the strength (Tamang and Thapa 2006).

Conclusion

Ethnic fermented foods and beverages have been prepared and consumed by the Asian people for centuries for nutritional supplements, stability, taste, aroma and flavor, and also for therapeutic uses. Diversity of fermented foods in Asia is directly related to food culture of each and every community, and also availability of raw materials. The diversity of functional microorganisms ranging from mycelia fungi to enzyme-producing to alcohol-producing yeasts and both Gram-positive and few Gram-negative bacteria in fermented foods has several novel properties. Due to several health-promoting benefits of Asian



fermented foods, there is an ample scope for promotion of these age-old foods in the global markets as bio-foods, functional foods, etc.

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