Review

Lactic acid bacteria in fermented foods in Thailand

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Traditional fermented foods (fish, meat and vegetable products), produced by many different processes, are eaten in many parts of Thailand. Lactic acid bacteria are responsible for the souring and ripening of these foods. Homofermentative strains of Lactobacillus pentosus, L. plantarum and Pediococcus pentosaceus are dominant in foods with low salt concentrations whereas P. halophilus strains are present in foods containing high salt. Strains of Lactobacillus sake, other Lactobacillus spp., P. acidilactici and P. urinaeaequi are frequently found. Heterofermentative strains of L. brevis, L. confusus, L. fermentum, L. vaccinostercus, other Lactobacillus spp., and of Leuconostoc spp. are distributed as minor bacteria and strains of Staphylococcus, Enterococcus and Halobacterium are occasionally isolated.

Key words: Enterococcus, lactic acid bacteria, Lactobacillus, Pediococcus, Staphylococcus.

Numerous fermented products are found in Thailand. For example, rice wines, such as sa-to, nam-khao, kra-cha and ou, are produced, with a starter cake (loog-pung) (Lotong 1985), by Saccharomyces cerevisiae, Saccharomycopsis fibuligera, Aspergillus oryzae, Amylomyces rouxii, Rhizopus spp. and Mucor spp. (Sukhumavasi et al. 1975; Lotong 1985). Aspergillus oryzae is also important for producing koji in the soy sauce fermentation (Lotong 1985). More than 20 kinds of fermented foods, including fish, meat, vegetables and fruits, are produced in Thailand (Saisithi et al. 1966; Sundhogul et al. 1975; Anon. 1981–1982; Tanasupawat & Daengsabha 1983; Uchimura et al. 1991, Tanasupawat et al. 1991, 1992a, b, c, 1993a, b; Thongthai et al. 1992). Although yeasts are found in these fermented products (Suzuki et al. 1987) it is lactic acid bacteria (LAB) which are responsible for their souring and ripening (Tanasupawat & Daengsabha 1983; Tanasupawat et al. 1992a, 1993a, b). This review is on the distribution and functions of LAB in traditional fermented foods in Thailand.

Traditional Fermented Foods in Thailand

Fermented fish products, which are high in protein and amino acids, are often used to complement the amino acids obtained from cereals. In Thailand such products include nam-pia (fish sauce), a much-used by-product of fermented fish and bu-du, ka-pi, tai-pla and pla-ra, all of which contain > 8% salt. The pH of these products ranges from 4.7 to 6.0 or even 8 and the total bacterial counts range from 1.8 \times 10^2 to 8.9 \times 10^9 cells/g. Kang-chom, hoi-dong, pla-chao, pla-paeng-dang, pla-chom, pla-som and som-fug are also fermented fish but contain < 8% salt, have a pH between 3.9 and 6.1 and contain 2.4 \times 10^5 to 6.0 \times 10^9 bacterial cells/g. Fermented meat and fermented vegetables are low salted products (1% to 4% salt) with a pH between 3.8 and 4.6 and bacterial counts of 3.2 \times 10^2 to 5.3 \times 10^9 cells/g. Nham (fermented pork or beef) and sai-krog-prio (a sausage of sour pork or beef) are made by mincing or chopping the meat. Pickled, fermented vegetables include phuk-yard-dong (black mustard leaves), phuk-kom-dong (leaves and flowers of Crapea erythrorhiza), phak-nam-dong (young Lasia heterophylla), phak-sian-dong (young Gynandropsis pentaphylla), sauerkrat, thu-nok-dong, hom-dong and nau-mai-dong and fruits are also salted and fermented in brine. Fermented tea leaves (miang) contain tannin and have a pH between 4.1 and 4.6. Bacterial counts in fermented tea leaves range from 3.4 \times 10^3 to 1.4 \times 10^6 cells/g.

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Khaomak is sweetened glutinous rice fermented to give the special taste and flavour of alcohol and lactic acid. The pH of Khaomak is 4.0 to 5.8 and bacterial counts are 1.2 x 10^6 to 4.3 x 10^6 cells/g. Khanoj-jeen (fermented rice noodle) is fermented rice flour (from non-glutinous rice) and contains 4.9 x 10^6 to 5.0 x 10^6 bacterial cells/g.

The use of these fermented products varies. Fermented fish (pla-ra) is either chopped, flavoured with vegetables such as chilli, citrous leaves and lemon grass, and eaten raw or cooked, alone or as an ingredient of more complex dishes. Som-fug and nham are simply eaten with chilli, lettuce or ginger whereas fermented fruits and vegetables are generally eaten as a side-dish. Phak-gard-dong is cooked and served as a soup or a side-dish, whereas phak-koam-dong and phak-sian-dong are always side-dishes. Miang is eaten as a snack and khaomak as dessert. Khanoj-jeen is cooked and eaten with nam-ya, a red curry of fish cooked with red chilli paste and coconut milk, in a dish called khanoj-jeen nam-ya. Khanoj-jeen kuaeng-kai (green curry with chicken) and khanoj-jeen kuaeng-mua (green curry with beef) are also popular dishes. The components and production areas of various kinds of fermented Thai foods are described by Sundhgdul et al. (1975), Appleton et al. (1978–1980) and Anon. (1981–1982).

Production of Fermented Foods

Traditional fermented foods are produced by natural fermentations in processes which vary from the simple to the complex (Sundhgdul et al. 1975; Appleton et al. 1978–1980; Anon. 1981–1982). In general, each fermentation takes place under conditions that the producers have found to be favourable for the appropriate growth and action of microorganisms. Most fermentation methods involve the addition of salt. Fermented fish, such as pla-ra, is produced from a variety of freshwater, brackish-water and seawater fish. The fish meat is mixed well with salt before roasted rice is added, and the mix is placed in a closed jar for at least 6 months. Som-fug (fish cake) is produced only from the skinned fillets of freshwater fish. These are minced with cooked rice, salt and garlic to form a sticky paste which is pressed tightly into a bowl, wrapped in banana leaves or packed in plastic bags, and fermented for a few days.

Nham is produced from minced pork mixed with sliced pork skin, garlic, pepper, salt and a small amount of potassium nitrate. The mixture is wrapped with banana leaves or plastic sheets and fermented for a few days. Miang (fermented tea leaves) is produced in the northern part of Thailand. The steamed tea leaves are wrapped tightly in individual bundles and packed into containers (small baskets for young tea leaves and large underground cement wells for mature tea leaves). The tea leaves are pressed tightly, weighted down, covered with banana leaves or plastic sheets, and fermented for a week or many months. Yeasts, moulds and lactic acid bacteria play a vital role in the fermentation of khaomak and lactic acid bacteria also contribute to the fermentation of khanoj-jeen. A number of fermented foods are home-made but some are produced at commercial plants using natural fermentation.

Lactic Acid Bacteria in Fermented Foods

Lactic acid bacteria have been isolated from various fermented products (Tanassupawat & Daengsubha 1983; Tanassupawat et al. 1992a). Homofermentative strains of Lactobacillus pentosus, L. plantarum, L. sake and other Lactobacillus spp. occur in a variety of fermented Thai food (Uchimura et al. 1991, Tanassupawat et al. 1992a, 1993a). Heterofermentative strains of L. vaccinostercus, L. fermentum, L. brevis, L. confusus, other Lactobacillus spp. and Leuconostoc spp. can also be found (Okada 1992; Tanassupawat et al. 1993b) along with Pediococcus pentosaceus, P. acidilactici, P. wimeraequi and P. halophilus strains (Tanassupawat & Daengsubha 1983; Tanassupawat 1993a; Potacharoen et al. 1994). Pediococcus halophilus is now included in the genus Tetragenococcus (Collins et al. 1990).

Lactobacillus pentosus strains were isolated in at least six samples out of 10 of nham and miang and P. halophilus strains occurred in almost all tested samples of pla-ra (unpublished work). Although yeasts and other bacteria are also seen, their numbers are much smaller than those of LAB. Other bacteria present include Halobacterium salinarum, Staphylococcus carnosus, S. piscifermentans, Enterococcus hirae, E. faecalis, E. casseliflavus and other Enterococcus spp. (Tanassupawat et al. 1991, 1992b, c; Thongthai et al. 1992) (see Table 1). The predominant LAB (L. pentosus, L. plantarum, Pediococcus pentosaceus and P. halophilus) are clearly different from the L. acidophilus, L. casei, L. bulgaricus, Lactococcus lactis, and Lactoc. cremoris which are used for and found in dairy products (Sanders 1991).

Functions of Lactic Acid Bacteria

The growth and activity of microorganisms play an important role in controlling the whole environment and ecosystem. The type of bacterial flora that develops in each fermenting food depends on the water activity, pH, salt concentration, temperature and the composition of the food. Lactic acid bacteria are perhaps the most widespread and desirable microorganisms in food fermentations. They convert most available carbohydrates to lactic acid, with small amounts of acetic acid, resulting in a lowering of the pH. If the fermentation is prolonged, the environment will be changed to become more suitable for yeast growth (Campbell-Platt 1987).

Lactobacillus pentosus and L. plantarum strains that contain meso-diaminopimelic acid in the cell wall are the predominant rod-shaped LAB in fermented Thai foods. Pediococcus