

discussed by van Veen and Stemmer (1977). See Table 16-2 for other related products.

### Nonbeverage Food Products of Plant Origin

**Sauerkraut** is a fermentation product of fresh cabbage. The starter for sauerkraut production is usually the normal mixed flora of cabbage. The addition of 2.25 to 2.5% salt restricts the activities of gram-negative bacteria, while the lactic acid rods and cocci are favored. *Leuconostoc mesenteroides* and *L. plantarum* are the two most desirable lactic acid bacteria in sauerkraut production, with the former having the shorter generation time and the shorter life span. The activities of the coccus usually cease when the acid content increases to 0.7 to 1.0%. The final stages of kraut production are effected by *L. plantarum* and *L. brevis*. *P. cerevisiae* and *E. faecalis* may also contribute to product development. Final total acidity is generally 1.6 to 1.8%, with lactic acid at 1.0 to 1.3%.

**Pickles** are fermentation products of fresh cucumbers, and as is the case for sauerkraut production the starter culture

purpose of removing some of the bitter principal. Following the complete removal of lye by soaking and washing, the green olives are placed in oak barrels and brined so as to maintain a constant 28° to 30° salinometer level. Inoculation with *L. plantarum* may be necessary because of destruction of organisms during the lye treatment. The fermentation may take as long as 6 to 10 months, and the final product has a pH of 3.8 to 4.0 following up to 1% lactic acid production.

Soy sauce or shoyu is produced in a two-stage manner. The first stage, the koji (analogous to malting in the brewing industry), consists of inoculating either soybeans or a mixture of beans and wheat flour with *A. oryzae* or *A. soyae* and allowing them to stand for 3 days. This results in the production of large amounts of fermentable sugars, peptides, and amino acids. The second stage, the moromi, consists of adding the fungal-covered product to around 18% NaCl and incubating at room temperatures for at least a year. The liquid obtained at this time is soy sauce. During the incubation of the moromi, lactic acid bacteria, *L. delbrueckii* in particular, and yeasts such as *Zygosaccharomyces rouxii* carry out an anaerobic fermentation of the koji hydrolysate. Pure cultures of *A. oryzae* for the koji and *L. delbrueckii* and *Z.*

*rouxii* for the moromi stages have been shown to produce good quality soy sauce (129).

**Tempeh** is a fermented soybean product. Although there are many variations in its production, the general principle of the Indonesian method for tempeh consists of soaking soybeans overnight in order to remove the seedcoats or hulls. Once seedcoats are removed, the beans are cooked in boiling water for about 30 min and spread on a bamboo tray to cool and surface dry. Small pieces of tempeh from a previous fermentation are incorporated as starter followed by wrapping with banana leaves. The wrapped packages are kept at room temperature for 1 or 2 days during which mold growth occurs and binds the beans together as a cake—the tempeh. An excellent product can be made by storing in perforated plastic bags and tubes with fermentations completed in 24 h at 31°C (29). The desirable organism in the fermentation is *Rhizopus oligosporus*, especially for wheat tempeh. Good soybean tempeh can be made with *R. oryzae* or *R. arrhizus*. During the fermentation, the pH of soybeans rises from around 5.0 to values as high as 7.5.

**Miso**, a fermented soybean product common in Japan, is prepared by mixing or grinding steamed or cooked soybeans with a starter culture and allowing