**Fermentation: Kimchi**

Weon-Sun Shin  
*Laboratory of Food Chemistry & Molecular Gastronomy, Department of Food & Nutrition, Hanyang University, Republic of Korea*

For thousands of years, a dish based on fermented Chinese cabbages and/or radish with garlic, pepper and salt has been produced in Korea and given the name kimchi. Various localities and households use different side ingredients, such as green onion, ginger, sesame, water parsley, fish sauce, fish, meat and onion, giving specific flavours. These dishes will be explored in this chapter.

Kimchi can be categorized by the main vegetables in the recipe, including the Chinese cabbage (*Brassica campestris* L. *ssp. Pekinensis*), radish (*Raphanus sativus* var. *hortensis* for *acanthiformis* Makino), cucumber (*Cucumis sativus* L.), cabbage (*Brassica oleracea* L. var. *capitata f. alba*) and garlic chives (*Allium tuberosum* L.). Since the Korean peninsula has four seasons, kimchi has a seasonality based upon the raw materials that can be produced in a local place (Jang et al., 2015). In summer, watery kimchi is generally made with small loose-leaf type cabbage (*Brassica campestris* L. *ssp. pekinensis*), coarsely ground fresh pepper (red and green), garlic, fish sauce, salt, crushed ginger and rice flour slurry, for which sweet rice flour with one cup of water in a small saucepan is simmered over a low heat until it thickens to a thin paste, and then set aside to cool. As kimchi is well fermented and chilled, it gives a unique flavour and taste. In winter, dongchimi is a typical type of kimchi, made using whole radish, pear, whole green onion and salted water. All the materials are put into a big ceramic jar and fermented for a while (33–35 days) at a refrigerated temperature (about 4–6 °C). Well-fermented dongchimi is a strong, carbonated, clear and chilled soup, which can be served in one bowl as a side dish or a noodle soup as a winter speciality (Hong et al., 2017).

Lee et al. (1991) reported that kimchi’s shelf life at 4 and 28 °C was 33 and 3 days, respectively, based on kinetic modelling of total acidity for quality prediction. Hong et al. (2016) reported that the optimum ripening time for kimchi that was fermented at 4 and 20 °C was 35 and 2 days, respectively, after analysing volatile compositions of kimchi.

Basically, the procedure of making kimchi starts with salting the materials (cabbage, radish and cucumber). There are two categories: in one, the raw materials (e.g., a quarter-piece or small-piece cut cabbage) should be salted first, because the water inside the cabbage oozes out due to osmotic pressure, which makes the texture of kimchi more crispy. In the other, no salt is added to the materials (cabbage, radish and cucumber) prior to making kimchi, which allows more water to be retained, resulting in a less spicy and salty taste in the kimchi.

In the first case, the salted materials should be rinsed to remove the excessive salt from the surface of the vegetables and then cut into a customized size. Subsequently, the ingredients, such as garlic, ginger, green onion, red pepper powder, salt, fish sauce (optional) and sugar, should be prepared. Both garlic and ginger are supposed to be crushed, and green onion should be cut into 5 cm lengths. Then, all the ingredients are put into a large-sized bowl and mixed thoroughly (Figures 45.1–45.5).

During kimchi fermentation, sugar has a significant role in promoting the growth of the micro-organisms (lactic acid bacteria). During storage of kimchi at the correct temperature (about 4–6 °C), various micro-organisms are involved in fermentation. During kimchi fermentation, aerobic and anaerobic micro-organisms grow and produce the organic acids (mainly lactic acid and acetic acid). These organic acids decrease the pH of kimchi to 3.5–4.0.

A balance of aerobic and anaerobic micro-organisms has been recognized to be very important during kimchi fermentation, because proper fermentation gives a well-ripened taste and flavour. Currently, more than 20 varieties of lactic acid bacteria are known to be involved in kimchi fermentation; *Leuconostoc mesenteroides* is a representative bacterium at the initial step of fermentation, while *Lactobacillus plantarum* is dominant under acidic circumstances as fermentation reaches the end. The most savoury kimchi has a pH between 3.5–4.5 and is in a well-fermented state (Park et al., 2019).

The flavour and taste of kimchi are mainly related to the content of kimchi metabolites such as carbohydrates, amino acids and organic acids. Their changes can be influenced by the microbial community during kimchi fermentation (Jung et al., 2014).

Lee et al. (2018), using non-metric multidimensional scaling plots and by analysis of similarity, found that microbial-community differences were strongly reflected in the seasonality of kimchi samples. Additionally, the distribution patterns of *Leuconostoc, Lactobacillus* and *Weissella* spp. were well predicted by seasonality, demonstrating the importance of
FIGURE 45.1  Standard cabbage kimchi-making.
(Courtesy of WIKIM, 2018)

FIGURE 45.2  A seasonal kimchi, dongchimi.
(Courtesy of WIKIM, 2018)
comprehensive correlations of the bacterial community with variable environmental factors.

Various kimchi containers may be used, such as dok (ceramic jar); jungduri (small earthenware jar with full middle part); bataenggi (a small jar with a fuller girth); and hangari (ceramic pot), all depending on the type of kimchi and when it is to be eaten. It is believed that a kimchi jar that was wholeheartedly made by the artisan helps, in a spiritual way, to make tasty kimchi (World Institute of Kimchi, 2014). Various regions and households have their own traditional know-how on how to keep kimchi from freezing and turning unfavourably sour (Figure 45.6).

Kimjang (Intangible Cultural Heritage, UNESCO), winter kimchi-making, constitutes a significant part of Korean identity. Despite urbanization, Westernization and commercialization, the majority of Koreans still eat kimchi they make at home or kimchi made by relatives and sent to them regularly, thereby showing that kimjang is an important binding force of the family community in Korea. To make kimchi together and share it, especially with communities, strengthens social ties among Koreans.
Every year during the kimchi-making season, regional communities and volunteer groups hold large-scale kimchi-making events for the less privileged, a good example of kimchi-making strengthening ties among Koreans. These efforts had a great impact on building up “kimchiology”, a systematic way to integrate the scientific knowledge of kimchi in multiple ways, from the humanities to science.

REFERENCES


**FIGURE 45.7** Kimjang, making and sharing kimchi. (Courtesy of Cultural Heritage Administration, 2013)