

Kimchi; Korean Fermented Vegetable Foods

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Abstract

The history of Kimchi fermentation technology in Korea was reviewed from the literatures and the changes in Kimchi making method during the last 200 years were investigated. The factors affecting the quality of Kimchi, especially, taste, nutrition, safety and storage stability were reevaluated from the recent scientific findings on Kimchi fermentation.

Introduction

Kimchi is a unique fermented vegetable product of long tradition in Korea. It has been a main sidedish served along with cooked rice and other dishes. The kinds of Kimchi may count up to more than 50 depending on the use of raw materials and processing methods, and also on the season and locality of preparation. Korean cabbage and Korean radish are the most popular vegetables, but cucumber, carrot, onion and even egg plant can be used as the major vegetable ingredient. Fermented fish sauce is an important sub-ingredient providing enzymes and flavor substances for the fermentation. Salt, garlic and red pepper play important role of controlling the type of microflora in Kimchi. Production of organic acids at the cost of carbohydrates and resultant pH reduction contribute to keep the freshness of vegetables during the storage period. In this paper, the history of Kimchi fermentation technology

is reviewed and recent scientific findings on Kimchi fermentation are summarized.

Historical Background

Although the history of Kimchi making in Korea can be traced back to AD 3-4 century by written record,¹⁾ the description of the processing method is found from the 17th century literature. One of the oldest Korean cookbook written by Madam Chang (1598-1680), Umsikdimibang, describes the processing methods of seven types of vegetable pickles. Hong Man-Su (1664-1715), as a pioneer of practical learning "silhak", taught 8 types of Kimchi making in his book, Sanlimkyungje. Yoo Chung-Im (1776) expanded Hong's book and described 34 kinds of vegetable pickles in Chungbosanlimkyungje. The most important classic literature about Kimchi processing is Imwonsibyukji written by Suh Yu-Geo (1764-1845). Suh listed 92 kinds of vegetable pickles, and recently Lee²⁾ classified them into four major groups accord-

1. Chang, J.H.; Studies on the origin of Korean vegetable pickles, Thesis Collection of Sung-Sim Womens College, 6, 149-174 (1975).

ing to the processing method. The four major groups are as follows;

Group 1. Pickles cured in high salt (20%) or brewer's grains (醃藏菜)

Group 2. Acid fermentation with cereal (酢菜)

Group 3. Sliced vegetables cured in soysauce, vinegar or spices (醬菜)

Group 4. Pickles soaked in brine (沈菜)

Table 1 summarizes the details of the characteristics of the four groups of vegetable pickles. Group 1 was usually consumed after washing or further preparation to make side-dishes. Group 2 was fermented with fish and can be classified as a fermented fish products. Group 3 was made by sliced vegetables soaked in salty sauce, vinegars or minced mixture of garlic, mustard and other spices. Today's Kimchi was firstly described in the name of Sukbakji on Imwonsibyukji. It was made from radish, cucumber or Korean cabbage mixed with garlic, ginger, fish sauce, shell fish, squid and salt. Kyuhapchongseo written by Madam Lee (1759-1829) describes in detail of the processing methods of three kinds of Kimchies including Sukbakji. Considering the introduction of red pepper into Korea in the 17th Century, today's Kimchi has already been formed at the beginning of 18th Century.

It was appeared that radish and cucumber were the most important ingredients for Kimchi making until 19th century, since core forming Korean cabbage was not available until that time.

Recently Cho³⁾ surveyed the types of Kimchi made in Korea and collected a total of 54 different types. Among the 54, five were belong to Group 1, six to Group 2 and seven to Group 3, and the rest were all belong to

Group 4, which was considered as ordinary Kimchies. Comparing to the number of varieties described in Imwonsibyukji the varieties of cured pickles reduced drastically from 34 to 5, but the number of Kimchi varieties increased remarkably from 11 to 36 in the course of the 200 years evolution.

Today Baechukimchi, made from Korean cabbage is the most important one, and Kkakdugi and Dongchimi made from radish are secondly important.⁴⁾

Procedure for Kimchi Making

The Kimchi making is the original Korean method of preserving the fresh and crispy texture of vegetables during the winter when fresh vegetables are not generally available. Kimchi has an unique sour, somewhat sweet and carbonated taste and usually served cold. In this respect Kimchi differs from Sauerkraut which is only acidic in taste and served in warm state.⁵⁾

Raw materials for Kimchi are mainly divided into 3 groups. Korean cabbage and radish are the major materials and minor ingredients include garlic, red pepper, green

2. Lee, S.W.; Studies on the movements and interchanges of Kimchi in China, Korea and Japan, *J. Korean Soc. Food Nutri*, 4(1), 71-95, (1975).
3. Cho, J.S.; Literature survey for the standardization of Korean Kimchi, Thesis Collection of Dongduk Women's College (1979).
4. Yu, T.J., Chung, D.H.; Studies on Kimchi for its standardisation for the industrial production, *Korean J. Food Sci. Technol.*, 6(2) 116-123 (1974).
5. Mheen, T.I., Kwon, T.W. and Lee, C.H.; Traditional fermented food products in Korea, *Korean J. Appl. Microbiol. Bioeng.* 9(4) 253-261 (1981).

Table 1. Classification of Korean vegetable pickles appeared in Imwonsibyukji (1764-1845)

Group	Curing stuffs	Vegetable ingredient	Pretreatment	Current products	Citation*
1. Cured pickles (醃藏菜) (34)	salt (20%) brewer's grains or + salt	cabbage leek cucumber cucumber ginger radish egg plant	 drying blanching copper coin	Oiji Zanji [5]	Chinese literature Chinese literature
2. Acid fermentation with cereal (酢菜) (7)	salt cooked cereal leaven spices	bamboo shoot, carrot	blanching	Sikhae [6]	Chinese literature
3. Sliced vegetable pickles (醬菜) (38)	soysauce, soypaste or fish sauce (18) vinegar salt (8) garlic mustard ginger (12)	onion cucumber egg plant pepper ginger garlic cucumber radish carrot various leafy vegetables	salting blanching drying blanching salting vinegar	Jangachi [7]	Korean literature Chinese literature Chinese literature
4. Soaked in brine (沈菜) (11)	brine sub: fish sauce garlic ginger red pepper onion leave	radish cucumber cabbage egg plant	salting	Kimchi [36]	Korean literature

() : Number of varieties described in Imwonsibyukji

[] : Number of varieties surveyed by Cho in 1979

*: Citation in Imwon sibyukji

onion, ginger and salt, and lastly fermented fishery products and other seasoning agents are often used as the optional ingredient. A recipe for the simplest Kimchi may include

Korean cabbage 100g, garlic 2g, green onion 2g, red pepper powder 2g, ginger 0.5g with optimum salt content of 3.0%.⁵⁾

Fig. 1 shows the procedure for Baechu-

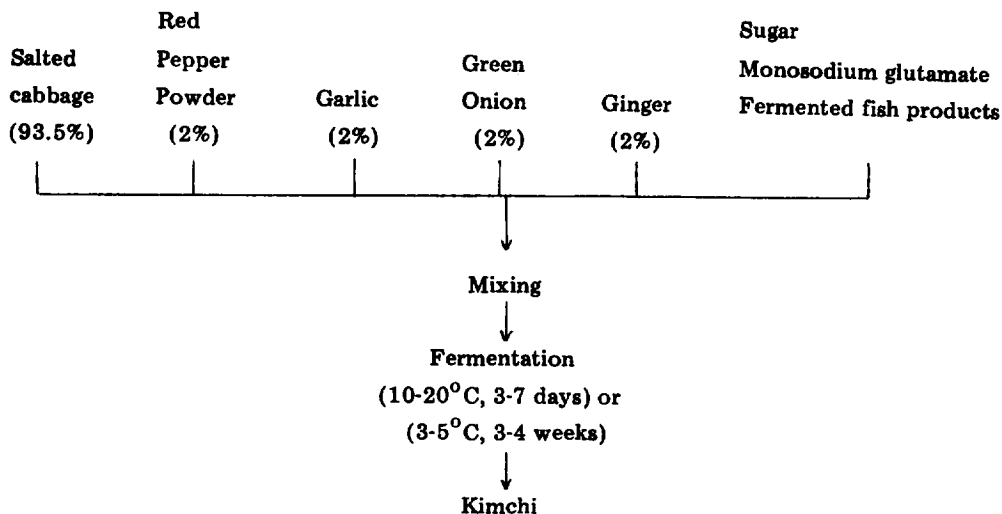


Fig. 1. Flow sheet of Baechukimchi making process

kimchi preparation. Whole cabbage (or cut- ed) are salted with 15% brine for 3-7 hours, which are then washed twice with fresh water and drained. Other minor ingredients, chopped and combined, are mixed to the treated cabbages and placed in the containers tightly sealed. Lastly, a proper fermentation will ensure to make an acceptable Kimchi. The length of time for completion of the fermentation depends on the salt content and temperature. In the winter season, the average ambient temperature in Korea is about 3-5°C, and winter Kimchi can be stored for 3-4 months at this temperature. In the summer, the average temperature is about 20°C, and summer Kimchi is made in 3-4 days.⁶⁾ Although statistical data on the production

of home-made Kimchi are not available, the amount of cabbages and radishes used for Kimchi is estimated at about 1 million tons per year.

Biochemical Changes During Kimchi Fermentation

Fig. 2 shows the changes in reducing sugar, total acid and pH during the fermentation of summer Kimchi. The optimum pH and acidity for the best taste is 4.2 and 0.6% (as lactic acid), respectively. It shows that the best taste is attained after 3 days of fermentation at 20°C and 3% NaCl.^{5,7)} Under a similar conditions, fermentation for sauekraut usually takes 20-30 days. Fig. 3 shows that the num-

6. Cho, J.S.; Korean fermented food researches, Kichonyonkusa, 91-112 (1981).
 7. Lee, Y.H., Yang, I.W.; Studies on the packaging and preservation of Kimchi, J. Korean Agric. Chem. Soc., 13(3) 207- 218 (1970).

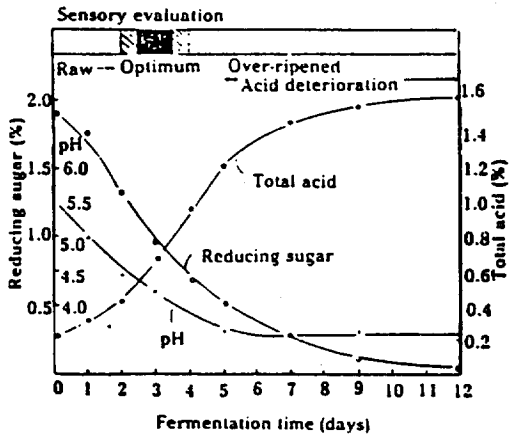


Fig. 2. Changes in reducing sugar, total acid and pH during Kimchi fermentation at 20°C (3% NaCl)

ber of aerobic bacteria decreases rapidly at the beginning of Kimchi fermentation, while anaerobic bacteria dominates. However, at the later stage of fermentation, surface film forming aerobic bacteria start to grow and the texture softening and taste deterioration take place.⁸⁾ Fig. 4 shows the changes

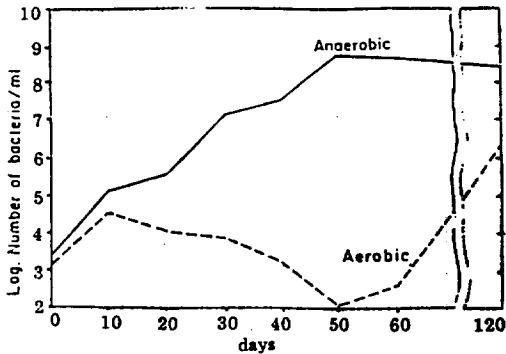


Fig. 3. Behavior of microorganisms involved during the fermentation of Kimchi

in the microflora during Kimchi fermentation at 14°C and in 3.5% salt content.⁹⁾ The number of *Leuconostoc mesenteroides* decreased after 10 days of the fermentation. The number of lactic acid forming bacteria and yeasts started to increase after 10 days of the fermentation, and this accompanied with the overripening and souring of Kimchi. It indicates that *Leuconostoc mesenteroides* is the important microorganism responsible for Kimchi fermentation, whereas *Lactobacillus plantarum*, which is considered to be responsible for te sauerkraut making, deteriorates the quality of Kimchi. It is also worthy to note that there are considerable increase in B vitamins during winter Kimchi fermentation. That is, the contents of B₁, B₂, B₁₂ and Niacin may reach as high as twice of initial contents at the optimal maturation of Kimchi (Fig. 5) and then decrease as the taste of Kimchi deteriorate due to the over fermentation¹⁰⁾ Vitamin C and A are slightly reduced

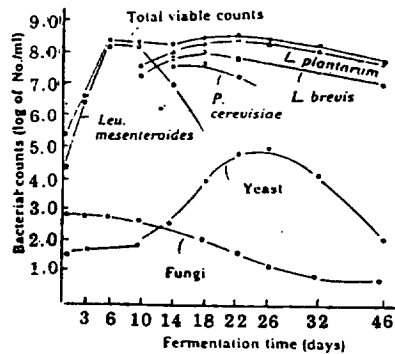


Fig. 4. Changes in microflora during Kimchi fermentation at 14°C (3.5% NaCl)

8. Kim, H.S. and Chun, J.K.; Studies on the Kimchi fermentation, J. Nuclear Sci. (Korea), 6, 112 (1966).
9. Mheen, T.I. and Kwon, T.W.; Effect of temperature and salt concentration on Kimchi fermentation, J. Food Sci. Technol., 16(4), 443-450 (1984).
10. Lee, T.Y., Kim, J.S., Chung, D.H. and Kim, H.S.; Studies on the composition of Kimchi, 2. Variations of vitamins during Kimchi fermentation, Bull. Sci. Res. Inst. (Korea), 5, 43 (1960).

during the fermentation, but it is an excellent way of preserving these vitamins during the winter season. It is very interesting to notice that the time to form the maximum B

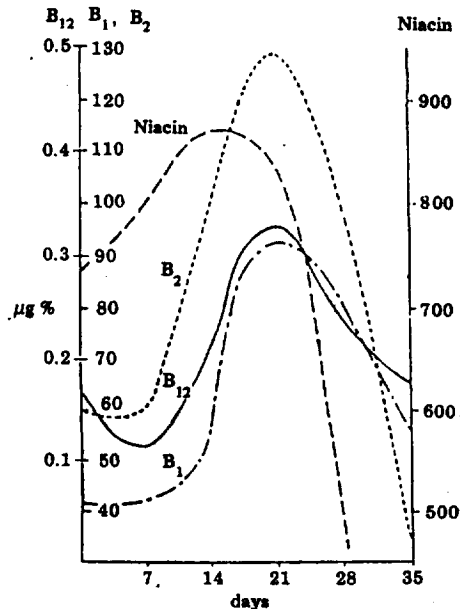


Fig. 5. Changes in contents of B vitamins during the fermentation of Kimchi

vitamin content coincides with the time for attaining optimum taste of the fermented products.

Table 2 shows chemical composition of three types of representative Kimchies and clearly indicates that such products are somewhat rich in B vitamins and thus serves as a good vitamin source to the people during winter in particular. According to a recent nutrition survey, an adult consumes 50-100 g/day of Kimchi in summer and 150-200 g/day in winter.⁵⁾

The formation of nitrite and secondary amines during Kimchi fermentation has drawn a great concern of many investigators in Korea. However, the contents of nitrite and secondary amines in Kimchi was very low compared to sausages and fishes, as shown in Table 3.¹¹⁾ The contents of nitrate in vegetables reduced rapidly during 4 days of fermentation at 20°C, while the contents of nitrite and secondary amines increased slightly and then decreased. (Fig. 6). The changes in ni-

Table 2. Chemical composition of fermented vegetables in 100g edible portion

	Baechukimchi	Kkakdugi	Dongchimi
Calories (Cal.)	19	31	9
Water (%)	88.4	87.0	93.6
Protein (g)	2.0	2.7	0.7
Fat (g)	0.6	0.8	0.2
Carbohydrate (g)	1.3	3.2	1.1
Ca (mg)	28	5	1
Thiamine (mg)	0.03	0.03	0.01
Riboflavin (mg)	0.06	0.06	0.03
Niacin (mg)	2.1	5.8	1.0
Ascorbic acid (mg)	12	10	7
β-carotene (µg)	295	568	0

11. Yim, T.K., Yoon, M.C. and Kwon, S.P.; Study on nitrosamines in foods, 1. The distribution of secondary amines and nitrites, Korean J. Food Sci. Technol., 5(3) 169-173 (1973).

trate reductase activity during Kimchi fermentation followed the same pattern as the changes in nitrate concentration.¹²⁾ It indicates that Kimchi fermentation reduces the nitrate level in vegetables by the action of microorganism without increasing the concentrations of nitrite and secondary amines in any significant level.

Table 3. Contents of nitrite and secondary amines in different foods

	Nitrite (ppm)	Secondary amines (ppm)
Sausages	3.5 - 18.7	0 - 1.0
Fishes	0.8 - 2.1	0.2 - 5.6
Canned fish	0.5 - 2.7	3.3 - 19.4
Salted fish	0.7 - 1.4	2.6 - 21.8
Kimchi (liquid)	0.1 - 0.7	0.1 - 2.5
(solid)	0.2 - 1.2	0.1 - 2.7

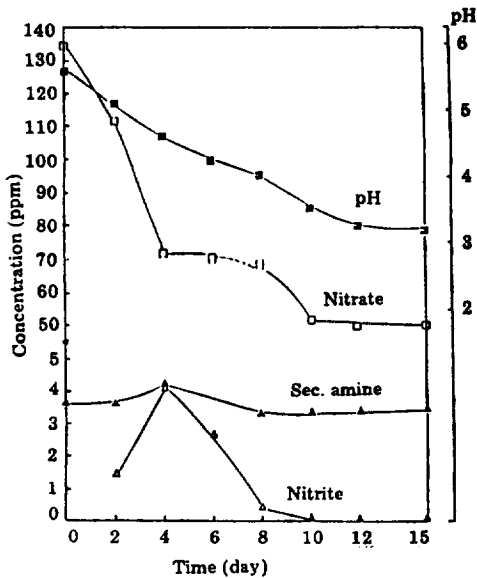


Fig. 6. Changes in nitrate, nitrite, secondary amine and pH during Kimchi fermentation (storage at 20°C)

Future Development

The changes in life style and rapid urbanization make the household Kimchi making practice no longer convenient. In addition, there are also growing export markets, and thus the expansion of industrial production of Kimchi is considered inevitable. The major obstacle for the mass production, however, is the inherent short shelf-life of Kimchi after completion of the fermentation. Although a number of attempts have been made to preserve Kimchi in the past, there is not a single procedure yet to ensure satisfactory product.^{13,14,15,16)} Canning of Kimchi, though good for preservation, usually brings softening of texture and some off-flavors. So far preservation of Kimchi under refrigeration of around 5°C is known to be a best way

12. Yang, H.C. and Kwon, Y.J.; Studies on the nitrite and nitrate in various Kimchi during the fermentation and raw materials, Thesis Collection of the College of Agriculture, Chonbuk University, 13: 111-120 (1982).
 13. Song, S.H., Cho, J.S. and Kim, K.; Studies on the preservation of Kimchi, I. Effect of preservatives on Kimchi fermentation, Report of Army, Res. Testing Lab. (Korea), 5, 5-9 (1966).

for a longer preservation ranging up to 5 months. on Traditional Foods and their Processing in Asia, held at Tokyo University of Agriculture, Tokyo, Japan, November 13-15, 1986.

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요 약

우리나라 김치 종류에 대한 문헌적 고찰들을 종합하고 지난 200년 사이에 일어난 김

치제조기술의 변화를 조사하였다.

또한 최근의 과학적 방법에 의한 김치 연구결과 중에서 김치의 품질에 영향을 미치는 요소들, 특히 맛, 영양, 안전성, 저장성에 관한 재검토를 시도하였다.

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15. Chun, Y.A.; Canning process for Kimchi, Korean Patent No. 348 934-A), (1967).

16. Lee, N.J. and Chun, J.K.; Studies on the Kimchi pasteurization, 1. Method of Kimchi pasteurization with Chinese Cabbage Kimchi and its effect on storage, J. Korean Agri. Chem. Soc., 24(4) 213-217 (1981).