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A Method for Making Kimchi Containing Snow Crab in a COVID-19 Environment

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Abstract

Purpose: The purpose of this study is to develop a kimchi recipe for immunity enhancement using snow crab, which has high food value in the era of COVID-19. **Research design, data and methodology:** The snow crab kimchi manufacturing method of this study includes the steps of preparing a kimchi seasoning containing snow crab seasoning and chitosan powder. Kimchi seasoning is made by adding 5 parts by weight of crab seasoning and 1 part by weight of chitosan powder to 100 parts by weight of the basic kimchi seasoning prepared by mixing radish, minced garlic, minced ginger, onion juice, anchovy sauce, red pepper powder and glutinous rice paste. **Results**: It was possible to develop new flavors, possibilities and characteristics of snow crab kimchi by extending the health and functional effects, taste, and preservation period without significantly changing the unique manufacturing method, taste and function of kimchi, including snow crab. **Conclusions:** Snow crab kimchi was excellent in taste and aroma while enhancing the health functions of the body, such as improving people's immunity. The developed snow crab kimchi manufacturing method can not only improve people's health, but also expand the choice of preference for kimchi taste and shelf life.

Keywords : Kimchi, Snow crab, Fermented food, Cabbage, Chitosan

JEL Classification Code : I00, I10, I12, I18, I19

1. Introduction

Kimchi is a famous traditional Korean fermented food made from vegetables and seasonings (Jang, Chung, Yang, Kim, & Kwon, 2015). Kimchi's popularity extends to the present, and it was re-ported to be one of the world's healthiest foods by the American Journal of Public Health in 2006 (Raymond, 2013). Kimchi is one of the representative fermented foods in Korea that is eaten after pickling vegetables such as cabbage, radish, and cucumber in salt and then mixing them with seasonings such as green onion, garlic, red pepper, and ginger for a certain period of time. Although more than 200 types of kimchi are involved, including lactic acid bacteria and yeast (Lee, Yoon, Ji, Kim, Park, Lee, Shin, & Holzapfel, 2011), especially Leuconostoc and Lactobacillus are the lactic acid bacteria

that play a key role (Kwon & Ahn, 2012). Kimchi is primarily fermented by lactic acid bacteria, however, in the later phase of fermentation, the activities of lactic acid bacteria decrease, while the activities of yeast on the surface of the kimchi increase.

Although there is a standardized kimchi manufacturing method suggested by the World Institute of Kimchi (WIK, 2021), the kimchi manufacturing method is different for each region, person (company), or season. There are also dozens of different types of kimchi depending on regional characteristics and specialties. Nevertheless, the most common kimchi is "whole cabbage kimchi". Regardless of the various types of kimchi, kimchi is nutritionally excellent as it is rich in vitamins, minerals, fiber, lactic acid bacteria and various organic products in common.

It gives the flavors of garlic, ginger, scallions, and chili. Kimchi is an ingredient with many culinary benefits as it is commonly added to soups, noodles, and rice dishes. In addition to its exotic and refreshing taste, kimchi also has its own unique nutritional value and ingredients that are linked to promoting health and preventing disease (Hongu, Kim, Suzuki, Wilson, Tsui, Park, 2017). In addition, in the era of COVID-19, kimchi has been recognized for its antioxidant, anti-obesity, and anti-cancer effects, and its value as a functional food is attracting attention (Cheigh & Park, 1994; Cho, Choi, Kim, Park, & Rhee, 2004; Lee, 1997; Park, 2020). In addition, it was recently confirmed that kimchi also has a certain inhibitory effect against COVID-19 infection in the body (Bousquet et al., 2021a; 2021b) and COVID-19 and SARS-CoV-2 (Das et al., 2021).

Meanwhile, in this study, seafood was used for the seasoning used in the production of kimchi. Seafood is considered an optimal protein source, as it is not only rich in macronutrients (e.g., proteins and fatty acids) but also micronutrients (e.g., vitamins A, B, and D) and minerals (e.g., selenium, iron, zinc, and iodine) (Mizan, Jahid, & Ha, 2015). Fermented fish products have been consumed as the fish itself, fish sauce, fish paste, and other types of food throughout the world (Koo, Lee, Chung, Jang, Yang, & Kwon, 2016). In particular, in this study, snow crab (including chitosan), a seafood, was used as a seasoning for kimchi. Snow crab (Chionoecetes opilio) is a type of crustacean that is known to have the best taste among various types of crabs caught in Korea. It is known that the skin of snow crab is rich in chitin and chitosan, and the flesh of snow crab is rich in protein, calcium, and nucleic acid components. Snow crabs have a thick, hard shell called chitin.

Chitin is produced by fungi, crustaceans, and insects, and is the second most common bio resource after cellulose, and chitosan is a chitin derivative that can be produced via the de-acetylation of chitin (Dutta, Dutta & Tripathi., 2004; Knorr, 1991; Shahidi, Arachchi & Jeon., 1999). In addition, chitosan, which is abundantly contained in crab shells, has cholesterol lowering effect (Shin, Oh, Yu, Lee, Kim, Park, Kwon, Singla & Chawla, 2001), anticancer effect (Pandit, Deshpande, Patil, Jain & Dandekar, 2020), antibacterial and antiviral activity (Jia & Shen, 2002), heavy metal excretion activity (Dash, Chiellini & Ottenbrite, 2011) and an important role in the diet and nutrition have already been studied (Lee, 1997). Chitosan is widely used in antibacterial, hypo lipidemic, and anticancer fields, and the preparation of low molecular weight chitosan with excellent solubility and hydrophilicity is beneficial for its application (Wang, Song, Liu, Ren, Zhang, Wang, Qu, 2021). Snow crab, which contains abundant chitosan with various effects, is widely known for its excellent nutritional value and is widely used in food (Aider, 2010; Dutta, Tripathi & Mehrotra, 2009).

However, although kimchi is a health functional food, it is not without problems as a food. First, the salinity of kimchi may be high depending on the manufacturing method (Song & Lee, 2008), and harmful bacteria such as biogenic amines may be generated (Mah, Lee, Jin & Lee, 2017; Park, Lee & Mah, 2019). Also, due to the sensory qualities (bitterness, saltiness, sourness, hotness) of Kimchi (Choi, Beuchat, Perkins & Nakayama, 1994), foreigners especially avoid kimchi.

Therefore, in order to supplement this point and to improve the immune system in the body, research on the production of kimchi was usually conducted. In the era of COVID-19, the main purpose is to develop a kimchi recipe using snow crab, which has high nutritional value as well as boosting immunity. There have been few studies on kimchi that uses snow crab or chitosan as an auxiliary ingredient for kimchi, which occupies a large proportion in the Korean diet. The detailed purpose is to develop, commercialize, and widely disseminate a manufacturing method for crab kimchi with excellent taste and flavor while enhancing the health functionalities of kimchi.

2. Theoretical Background

2.1. Definition and Concept of Kimchi

In history, kimchi is a lactic acid-fermented vegetable product that is known to date back at least 2,000 years, as a record of kimchi (Zu) appears in the "Book of Odes (Sikyung)" published around 500 BC (Kwon, Jang, Yang, Chung, 2014). The definition of 'kimchi' is clearly specified in the Food Code of the Ministry of Food and Drug Safety of Korea. Kimchi is a sub-item of 'pickles or stews' and included in 'kimchi'. Pickles or stews refer to kimchi, pickles, and stews (Ministry of Food and Drug Safety, 2021) that are pickled or heated by adding salt, vinegar, sugar or soy sauce to animal and vegetable raw materials.

For kimchi, “kimchisok” and “kimchi” are clearly specified according to the Food Standards Code. “Kimchisok” is defined as “a mixture of vegetable raw materials with red pepper powder, sugar, salt, etc. added and mixed with vegetables to be used to make kimchi.” Put simply, kimchisok is the kimchi seasoning that must be included in the production of kimchi. In addition, “kimchi” is stipulated as “a product made from vegetables such as cabbage, etc. as the main raw material and subjected to pickling and seasoning mixing processes as it is, fermented, or processed.”

In general, kimchi is a typical Korean traditional food with a unique taste made from fermented vegetables fermented and aged for a certain period of time by mixing seasonings (Park, 2020; Park, Song, & Cho, 2018; Shin et al., 2001). Meanwhile, according to WHO (World Health Organization) and FAO (Food and Agriculture Organization) Codex ALIMENTARIUS (2017), kimchi is defined as follows.

Kimchi is the product:

(a) prepared from varieties of Chinese cabbage, Brassica pekinensis Rupr.; such Chinese cabbages shall be free from significant defects, and trimmed to remove inedible parts, salted, washed with fresh water, and drained to remove excess water; they may or may not be cut into suitable sized pieces/parts;

(b) processed with seasoning mixture mainly consisting of red pepper (Capsicum annum L.) powder, garlic, ginger, edible Allium varieties other than garlic, and radish. These ingredients may be chopped, sliced and broken into pieces; and

(c) fermented before or after being packaged into appropriate containers to ensure the proper ripening and preservation of the product by lactic acid production at low temperatures.

2.2. Specifications of Kimchi

According to the Korean Ministry of Food and Drug Safety (2021), the advanced processing standards simply stipulate that “vegetables used as raw materials should be sufficiently washed to remove foreign substances.”

However, specific detailed criteria are as follows.

① Lead (mg/kg): 0.3 or less

② Cadmium (mg/kg): 0.2 or less

③ Tar color: should not be detected.

④ Preservatives: should not be detected.

⑤ Coliform group: n=5, c=1, m=0, M=10 (limited to sterilized products).

The above conditions are the minimum conditions that kimchi has as a food. In addition, safety and sanitation and refrigeration at each stage of kimchi storage, distribution, and sale, as well as hygiene during kimchi manufacturing, should be thoroughly to avoid cross-contamination due to various bacteria or contamination.

2.3. Prior Research on Kimchi

Kimchi-related researches are broadly classified according to content and topic., the domestic and international economic effects of the kimchi industry and the design of kimchi packaging. Since this study is to improve immunity, such as anticancer effect, and to improve taste and preservation period through seafood, snow crab, the existing prior research related to this topic is reviewed.

First, a study on the characteristics of kimchi using red crab meat (Chae, 2021), blue crab kimchi (Kim & Park, 2014), and development of a recipe for cabbage kimchi containing 14 kinds of seafood including sea squirt, clams, scallops, and flounder (Jang, Park, Park, Byun, Kim & Yoon, 2011), Kimchi (Nam, Jang, Seo, Nam & Park, 2013; Woo, Choi, Kim, Jang, Cho & Song, 2012), Skate (Raja kenojei) Kimchi (Kim & Cho, 2008), Kimchi with added Styela clava (Bae & Lee, 2008), kimchi with shellfish shell water extract added (Kim, Kim & Kim, 2003), gwamegi (saury) kimchi (Kim, Oh & Jung, 2007), octopus cabbage kimchi (Jang, Jung, Yun & Nam, 2016; Jung, Jung, & Kim, 2010), Squid and Octopus kimchi (Lee, Seo, Yang & Jang, 2013), Pollack Kimchi (Sung & Choi, 2009), Oyster Kimchi (Shin et al., 2001), Red Sea Cucumber Kimchi (Park, Lim, Park & Cho, 2012), Sea Tangle Added Korean Cabbage Kimchi (Ku, Noh, Yun, Kim, Kwon, Cheigh & Song, 2007a; Ku, Noh, Yun, Kim, Kwon, Cheigh & Song, 2007b; Oh, Kim, Park, Kim, Bae & Choi, 2015), as well as seafood kimchi (Jang, Park, Nam & Nam, 2013; Mannaa, Seo & Park, 2019; Park et al., 2018; Park et al., 2019; Toushik, Kim, Ashrafudoulla, Mizan, Roy, Nahar, Kim & Ha, 2021) were studied.

There is also a study of adding chitosan, a processed product of aquatic raw materials, rather than directly adding aquatic products. They were a study of kimchi with soybean leaves added with chitosan (Lee, Choi, & Kim., 2003c), a study of kimchi with chitosan-liquid calcium added (Jang & Jeong, 2005), a study of kimchi with chitosan-ascorbate added (Beik, Kim, Kim, Yang & Kim, 2006).

On the other hand, with respect to pickling of Chinese cabbage, deep sea water was used in this study, but there is also a study using similar deep sea water. Hahn (2005) has a study on Mineral Water in Sea Rock, deep seawater kimchi containing Chitosan Ascorbate (Lee, Shin, No & Kim, 2005). There is also a study using deep radish water used in seasoning for kimchi (Choi & Cho, 2015). An interesting study is the Comparison of quality changes in brined cabbage with deep sea water salt and a commercial brined cabbage product (Lim, Jung, Kim, Kim & Kim, 2014).

Therefore, the production of snow crab (including chitosan), deep sea water, and other kimchi by-products to be tested in this study does not exist in Korea or abroad. Such research will become a new method of manufacturing kimchi that goes one step further towards the globalization of kimchi and improvement of health functionalities.

3. Kimchi Manufacturing Process and Kimchi Manufacturing Stage

3.1. Kimchi Manufacturing Process

As mentioned above, WIK (2021) has suggested guidelines regarding the standard manufacturing method of kimchi. Kimchi is made by naturally fermenting live-breathing ingredients with whole cabbage and radish as the main ingredients and added red pepper powder, green onion, garlic, ginger, salted fish, and various spices. Kimchi is prepared with salted Chinese cabbage or radish as a predominant ingredient seasoned with red pepper powder (Capsicum annum L.), garlic and ginger, green onions, and fermented anchovy product (20% NaCl) (Choi, Yang, & Yoon, 2021).

In addition, the Rural Development Administration of Korea, jointly with the Ministry of Agriculture and Forestry, proposed the "Kimchi Production Standard Manual" in 2005 for hygiene and infection prevention and safety during kimchi manufacturing. In 2013, the WIK presented "Guidelines for Sanitary and Safe Manufacturing of Seafood Kimchi" for hygienic and safe kimchi production. In general, there are many types of kimchi depending on the type of raw material used, harvest time, manufacturing method, climate and place, and region. At home, each kimchi has been made and consumed through a unique manufacturing process.

Kimchi manufacturing companies go through their own manufacturing process. But there are some differences depending on the storage and distribution process. They go through a process similar to the self-manufacturing method in a traditional home. The general manufacturing process of cabbage kimchi (Cheigh & Park, 1994; Lee, 1991) is as follows.

3.1.1. Raw Material Selection and Pretreatment Process

Remove foreign substances, outer hulls, whole leaves, and roots of the purchased cabbage raw materials from the processing plant and trim them well. The amount of waste is about 15-25%.

3.1.2. Cutting Process

The trimmed cabbage is cut to suit the purpose of processing. In the case of kimchi, many companies cut it in 1/2, and some companies cut it in 1/4 depending on the size of the cabbage kimchi. At this time, an automatic cabbage cutting machine is used, and sometimes it is done by hand. Codex ALIMENTARIUS (2017) proposed this process as the "WHQS" stage.

(a) Whole - whole Chinese cabbage;

(b) Halves - Chinese cabbages divided lengthwise into halves;

(c) Quarters - Chinese cabbages divided lengthwise into quarters; and

(d) Slices or Chips - Chinese cabbage leaves cut into pieces of 1~6 cm in length and width.

3.1.3. Pickling Process

The next step is the pickling process. Most households and kimchi companies use sea salt. The pickling method is classified into a case of combining wet pickling using brine and dry pickling with salt again. Jung, Oh, Chen, Choi, Kim & Cho (2003) suggested that the dry salting method reduces the amount of salt, shortens the pickling time, and makes kimchi with a uniform taste because the stems and leaves are evenly pickled compared to the saltwater method. In the pickling process, salt concentration, pickling time, and temperature are very important, and the quality of the water used, the type of pickling, and the pickling method, etc., affect the fermentation mechanism and sensory in kimchi, a pickled food.

The concentration of brine is usually about 8 to 12% (v/v), and the used pickled brine is not used repeatedly more than twice. The pickling time varies depending on the season, that is, the temperature, so 6 to 8 hours in summer and 8 to 10 hours in winter are appropriate.

Table 1: Comparison of Pickling Process

Contents	Regular kimchi	Snow crab kimchi
Salt water	8~12%(v/v)	8~16%(v/v) or 12%(v/v), (15L of Salt water)
Hour	Summer: 6-8 hours Winter: 8-10 hours	10~20 hours

3.1.4. Desalting and Washing Process

Cabbage pickled for 6-10 hours is washed and desalted at the same time. The degree of desalination is adjusted so that the salinity of Chinese cabbage is 3~5% and washed so that there are no foreign substances.

Table 2: Comparison of Desalting and Washing Processes

Contents	Regular kimchi	Snow crab kimchi
Desalination	Simultaneous cleaning and desalting	Simultaneous cleaning and desalting
Salinity concentration	3~5%	Wash pickled cabbage 3 times

3.1.5. Dewatering Process

Washed cabbage should be dehydrated before mixing with seasoning. A commonly used method is to use a natural dehydration method or a dehydrator using a plastic container with a mesh structure or a specially designed dehydrator. The dehydration time is often 3 hours or 3 to 4 hours, and varies from 30 minutes to 1 hour, 1 to 2 hours, even 12 hours. Gat Kimchi added with Oyster Shell Powder (Jung et al., 2010), chitosan-added kimchi aging delay study (Seo, Bang & Jeong, 2004) etc.

3.1.6. Seasoning Preparation and Filling (Mixing) Process

Codex ALIMENTARIUS (2017) suggested two types of Basic Ingredients (Chinese cabbages, salt) and eight Other Permitted Ingredients (as shown below) as kimchi ingredients.

(a) fruits
(b) glutinous rice paste
(c) nuts
(d) salted and fermented seafood
(e) sesame seeds
(f) sugars (carbohydrate sweeteners)
(g) vegetables other than those described in Section 2
(h) wheat flour paste.

Various auxiliary materials necessary for kimchi production must be pre-treated as follows before mixing with each other (WIK, 2021).

1) Pickled Chinese cabbage

- Leave the cabbage at 10℃ to lower the product temperature, remove the inedible part, cut it into two, and pickle it as follows.
- Mix 0.139kg of sea salt and 1.2kg of water per 1kg of Chinese cabbage and marinate at room temperature for 16 hours using a wet method (the salt concentration in the pickled water is about 10% theoretically).
- When using refined salt, use 1:1.25 ratio of brine for cabbage and pickles.
- When pickling is complete, wash with running water 3 times and dehydrate for 2hours or more.

2) Red pepper powder

- Red pepper powder can be purchased at the market, or red pepper is purchased and prepared with a grinder.

3) Radish

- Wash well to remove foreign substances, and then use a radish maker to shred or pulverize.

4) Garlic

- After peeling, wash under running water and sort at the same time, and then pulverize after removing water.

5) Ginger

- Wash under running water using a brush, and pulverize after removing the skin.

6) Green onion

- Wash the selected green onion (green onion or chives) under running water to remove moisture and cut into 2-3cm pieces.

7) Salted fish

- Use anchovy fish sauce or a 1:1 mixture of anchovy fish sauce and shrimp sauce.

8) Glutinous rice paste

- Add 10 times the weight of glutinous rice flour to water, stir over high heat, and boil until the glutinous rice flour is completely dissolved. When it becomes thick, stop heating and allow to cool.

9) Broth

- Prepare broth using kelp, bonito flakes, onion, radish, and apple (refer to the recipe below) and add salt and sugar, or use a commercially available kelp extract (salinity 16%, approx. 52 Brix°).

- How to prepare kelp broth (based on 3L volume): Put 90g of kelp in 2,040mL of water and boil for 30 minutes, then add onion (360g), radish (120g), and apple (330g) and heat over high heat, then the broth starts to boil if not, change to low heat and heat for 40 minutes. Add 60g of skipjack tuna to the heated broth, infuse it for 10 minutes, filter it using sterile gauze, and use the liquid as broth.

Table 3: Composition Ratio of Regular Kimchi and Snow Crab Kimchi Seasoning (Regular Kimchi; WIK, Chinese Cabbage Porgy Kimchi Manufacturing Method, 2021)

Material	Regular kimchi	Snow crab kimchi	Note
	Mixing ratio(%)	Weight(g)	
Pickled cabbage	70.00	5,000	
Radish	8.82	500	
Poireau	3.18	220	Snow crab kimchi(onion juice)
Chilli powder	3.96	220	
Garlic	2.16	130	Snow crab kimchi(minced garlic)
Ginger	0.61	30	Snow crab kimchi((minced ginger)
Anchovy fish sauce	1.72	150	
Glutinous rice paste	3.44	250	

Water	5.21	15(chitosan powder)	
Gravy	0.90 (Kelp Broth : Salt : Suga = 75 : 15 : 10)	75 (snow crab sauce)	Snow crab meat and snow crab intestines, plum syrup, lemon juice, salt, red pepper powder, minced garlic, ginger (snow crab seasoning)
Sum	100.00	6,590	

3.1.7. Aging and Packaging Process and Shipment

For ripening and storage conditions, most homes and businesses use refrigerated conditions. In some households or kimchi companies, they are aged at room temperature for 12 hours in summer and 3 to 4 days in winter, and then stored in a low-temperature warehouse.

The lower the aging temperature, the fresher the taste of kimchi. This is thought to be because carbon dioxide gas or volatile organic acids produced during the fermentation and ripening of kimchi permeate into the kimchi tissue or into the kimchi juice at low temperatures. The shelf life is usually about 25 to 30 days under the low-temperature distribution system, and after this period, the taste of kimchi deteriorates and the marketability and taste deteriorate due to the deterioration of the taste of the kimchi and the expansion of the packaging.

Table 4: Shipment of Regular Kimchi and Snow Crab Kimchi

Contents	Regular kimchi	Snow crab kimchi
Ripening temperature	4~5℃	1~7℃
Storage time	Summer: 12 hours Winter: 3-4 days	18-30 days

3.2. Steps of Making Snow Crab Kimchi

The steps to make kimchi are largely
- Snow crab seasoning manufacturing stage
- Pickled cabbage step
- Kimchi seasoning manufacturing stage
- It is usually carried out in four stages, including the stage of making kimchi.

3.2.1. Steps to Prepare the Snow Crab Seasoning

First, wash raw snow crabs purchased from the market, cut them into easy-to-clean sizes, and apply the snow crab flesh and intestines. Although Seo (2008) Snow crab kimchi (Patent Registration Number, 1008347030000) uses snow crab broth, this study uses actual snow crab meat and intestines rather than crab broth. 20 parts by weight of trimmed snow crab meat and snow crab intestines, 10 parts by weight of plum syrup, 2 parts by weight of lemon juice, 2 parts by weight of salt, 15 parts by weight of red pepper powder, 1 part by weight of minced garlic, and 0.5 parts by weight of ginger are mixed. Thereafter, the mixture is aged at room temperature for about 3 hours to prepare.

Table 5: Composition and Weight of Snow Crab and Snow Crab Seasoning (part by weight)

Material	Weight(g)	Note
Snow crab meat and Snow crab intestines	20.00	Purchased raw snow crab, washed and cut and Extracted from snow crab
Plum syrup	10.00	
Lemon juice	2.00	
Salt	2.00	
Chili powder	15.00	
Minced garlic	1.00	
Ginger	0.50	After aging the mixture for 3 hours at room temperature, the snow crab seasoning is completed

3.2.2. Pickling Whole Cabbage in Deep Sea Water

This step is to pickle Chinese cabbage in 8~16% brine containing deep sea water for 10~20 hours. The deep sea water used for pickling Chinese cabbage is seawater from a depth of 200m or less. Often called deep water, this water is rich in minerals and there is little concern about contamination during the extraction process.

In the case of producing pickled cabbage with deep sea salt, it is possible to produce high-quality pickled cabbage that is superior and has high mineral and organic acid content compared to cabbage pickled with sea salt or refined salt (Lim et al., 2014).

However, in this study, salt-removed deep-sea water was used. In order to pickle Chinese cabbage, 12% (v/v) brine was prepared, but the brine was not distilled water, but deep sea water without salinity. This is because deep sea water with salinity may impair salinity control.

After cutting 5kg of washed Chinese cabbage, in this study, it was pickled in 15 L of 12% (v/v) brine for 10 to 20

hours. The pickled cabbage was washed 3 times and used in the next step. Although pickling in deep sea water rather than sea salt shows soft properties and firmness, pickling for too long may damage the amorphous tissue (Lee et al., 2003c).

3.3. Manufacturing Steps of Kimchi Seasoning

First, 500g of radish, 130g of minced garlic, 30g of minced ginger, 220g of onion juice, 150g of anchovy sauce, 220g of red pepper powder, and 250g of glutinous rice paste were mixed to prepare basic kimchi seasoning.

Table 6: Composition and Weight of Kimchi and Kimchi Seasoning

Material	Weight(g)	Note
Cabbage	5,000	After cutting, pickle for 10-20 hours in 15L of 12% (v/v) salt water
Radish	500	
Minced garlic	130	
Minced ginger	30	
Onion juice	220	
Anchovy fish sauce	150	
Chili powder	220	
Glutinous rice paste	250	
Sum	6,500	

3.4. Steps of Making Crab Kimchi

It refers to a manufacturing method that mixes pickled cabbage and kimchi seasoning in a 7:3ratio. The manufacturing method of snow crab kimchi further includes adding snow crab powder (or chitosan) and aging it at 1-7°C for 18-30 days. Add 1% by weight of snow crab powder based on the weight of snow crab kimchi, mix well, and then ferment at 4°C for 25 days. The snow crab powder in this study was used by completely drying the washed snow crab shells and pulverizing them into fine particles, but is not limited thereto, and commercially available snow crab powder or snow crab powder (or chitosan) can be used.

3.4.1. Aging and Packaging Process and Shipment

For ripening and storage conditions, most homes and businesses use refrigerated conditions. In some households or kimchi companies, they are aged at room temperature for 12 hours in summer and 3 to 4 days in winter, and then stored in a low-temperature warehouse.

The lower the aging temperature, the fresher the taste of kimchi. This is thought to be because carbon dioxide gas or volatile organic acids produced during the fermentation and ripening of kimchi permeate into the kimchi tissue or into the kimchi juice at low temperatures. The shelf life is usually about 25 to 30 days under the low-temperature distribution system, and after this period, the taste of kimchi deteriorates and the marketability and taste deteriorate due to the deterioration of the taste of the kimchi and the expansion of the packaging.

Table 7: Composition of Kimchi Seasoning, Snow Crab Seasoning, and Chitosan by Weight

Material	Weight(g)	Note
Kimchi sauce	100	Radish, minced garlic, minced ginger, onion juice, anchovy sauce, red pepper powder and glutinous rice paste mixture
Snow crab sauce	5	(3~8g)
Chitosan	1	(0.1~3g)

4. Measurement Method of Snow Crab Kimchi

In order to evaluate the health functionalities and preference of snow crab seasoned kimchi, which is the main purpose of this study, all measurements were performed in four stages, and snow crab kimchi and regular kimchi were compared and measured at each stage.

4.1. Physical Property Measurement Step

After maintaining a constant temperature and aging the snow crab kimchi and ordinary kimchi for a certain period of time, the pH and acidity of the kimchi were measured according to the change of time to measure the taste preference and whether the freshness was maintained.

4.2. Measurement of Calcium Content

The taste and aroma of snow crab kimchi and general kimchi, as well as the calcium content of kimchi were measured.

4.3. Sensory Evaluation

The sensory test of food refers to the scientific evaluation of the sensory quality characteristics of food, such as appearance, flavor, and texture, using the five senses of human taste, smell, sight, touch, and hearing (WIK, 2016)

For sensory evaluation of kimchi, adult men and women of a certain age were randomly selected as a sample, and they were asked to taste snow crab kimchi and regular kimchi, and texture, smell, taste, and overall preference were measured by applying a 10-point scoring method.

4.4. Anticancer Activity Measurement Step

Through each extract of snow crab kimchi and general kimchi, the killing effect of each extract on breast cancer cells was measured.

4.5. Evaluation and Measurement of Crab Kimchi Manufacturing Method

One of the main objectives of this study is to develop an independent method for manufacturing kimchi. Another is that the kimchi according to this manufacturing method improves health functionality and taste in the body. To measure this functionality and efficacy, the following four-step experiment was conducted.

4.5.1. Measurement of Physical Properties of Kimchi

The snow crab kimchi prepared in this study exhibits a favorable aging state in terms of pH and acidity according to aging compared to kimchi that does not contain snow crab seasoning. In this study, there was no significant change in hardness, confirming that the texture was maintained even after aging (Table 8). The physical properties were improved and the aging rate was improved (Chae, 2021).

The main purpose of this experiment is to check the preference and duration of ripening period of crab kimchi prepared by the method of this study. Usually, while kimchi and general kimchi were aged at 4°C for 25 days, pH and acidity during aging were measured. Since the increase in the acid content produced by lactic acid fermentation during kimchi ripening is the biggest change during the ripening of kimchi, measurement of pH or acidity is an indicator of the degree of ripening of kimchi.

Although there are differences depending on individual preference, it is generally known that the pH of kimchi during the ripe ripening period is about 4.2 to 4.4, and the acidity is about 0.5 to 0.8%. Specifically, the pH of kimchi was measured using a pH meter, and the acidity of kimchi was measured by immersing the pH electrode in 20ml of kimchi juice, and titrating with 0.1N NaOH solution until pH 9.0(Sodium hydroxide) was measured and calculated by the following formula. Titration acidity (%) = 0.1N NaOH consumption (ml) × 0.1N NaOH titer × 0.09 × 100 / sample weight(g). The pH and acidity values were measured in triplicate. The measurement results are shown in Tables 8 and 9 below as average values.

Table 8: Changes in pH Value according to Kimchi Ripening Period

Type	0	5 days later	after 10 days	after 15 days	after 20 days	25 days later
Snow crab kimchi	4.78	4.69	4.52	4.47	4.42	4.38
Regular kimchi	5.30	5.19	4.99	4.86	4.81	4.78

As a result of the pH measurement, as shown in Table 5 above, both kimchi and general kimchi showed a tendency to rapidly decrease in pH after 5 to 10 days. Snow crab kimchi containing snow crab seasoning has a pH of 4.78 right after making kimchi. It was confirmed that the snow crab kimchi prepared by the method of the present invention was relatively more acidic compared to the pH of 5.30 of general kimchi that does not contain snow crab seasoning.

Considering that kimchi in a state of being properly fermented in general has a pH of 4.2 to 4.4, in the case of atmospheric kimchi, the pH is 4.38 after 25 days of aging, indicating that the kimchi has a desirable fermentation state. On the other hand, in the case of general kimchi that does not contain crab seasoning, the pH was 4.78 even after 25 days of aging, which was slightly higher than the pH of the ripening period. According to the above measurement results, since snow crab is an acidic food, kimchi containing snow crab shows a low pH even immediately after production, and thus has a relatively high storage capacity compared to general kimchi. After 25 days of aging, it was confirmed to have a pH range of the desired fermentation and aging state. This study result was similar to the study result of Lee, Shin, Ko & Oh (2010).

Table 9: Changes in Acidity Value according to the Ripening Period of Kimchi (Unit: %)

Type	0	5 days later	after 10 days	after 15 days	after 20 days	25 days later
Snow crab kimchi	0.22	0.30	0.49	0.56	0.62	0.68
Regular kimchi	0.19	0.25	0.38	0.44	0.49	0.51

As shown in Table 9 above, as a result of acidity measurement, snow crab kimchi containing snow crab seasoning exhibited an acidity in the range of 0.6-0.8%, indicating that kimchi tastes best after 25 days of aging as well as immediately after production. However, it was confirmed that general kimchi, which does not contain crab seasoning, showed a rather slow increase in acidity over the aging period. The above measurement result shows that the

kimchi prepared according to this method of seasoning snow crab shows a relatively high acidity as it contains both basic Chinese cabbage and acidic snow crab as its ingredients, which is consistent with the results in Table 1.

Furthermore, in order to evaluate the texture of kimchi, which has an important influence on the preference for kimchi according to people, the hardness of the snow crab kimchi prepared by the method of the present invention and the general kimchi without the snow crab seasoning were compared. Specifically, using a hardness tester, the center of the leaf stem of the Chinese cabbage was selected, cut to a size of 2cm × 2cm, and measured repeatedly 5times to calculate the average value.

Table 10: Changes in Hardness Value according to the Ripening Period of Kimchi (Unit: kgf)

Type	0	5 days later	after 10 days	after 15 days	after 20 days	25 days later
Snow crab kimchi	1.85	1.84	1.77	1.78	1.76	1.75
Regular kimchi	1.98	2.08	1.85	1.79	1.74	1.69

As a result of hardness measurement, as shown in Table 7 above, the hardness of general kimchi was higher at the initial stage of ripening of kimchi. However, as the aging progressed, it was confirmed that the hardness of snow crab kimchi containing snow crab seasoning did not decrease significantly, whereas that of general kimchi gradually decreased.

From these results, it can be inferred that the texture of kimchi is maintained and the texture is not significantly changed even when aging is progressed by the calcium component contained in snow crab.

4.5.2. Calcium Content Measurement

In this study, it was confirmed that snow crab kimchi has a remarkable calcium content and superior flavor and taste compared to general kimchi that does not contain crab seasoning or snow crab powder (calcium content and sensory experiment). In addition, it was confirmed that the kimchi of this study has superior anticancer activity compared to general kimchi that does not contain chitosan powder (anticancer activity test). Considering the results of measuring the properties of kimchi above, the calcium content of snow crab kimchi and general kimchi was compared according to whether or not snow crab seasoning was included.

Specifically, 40ml of 70% nitric acid and 10ml of 30% hydrogen peroxide were added to 15g of each kimchi, and then mixed in a plate heater. Then, the calcium content was measured by inductively coupled plasma atomic emission spectroscopy (ICP-OES).

Table 11: Calcium (Ca^{2+}) Content Measurement Result

	Calcium (Ca^{2+}) content (mg/100g)
Snow crab kimchi 1	91
Snow crab kimchi 2	118
Regular kimchi 1	53
Regular kimchi 2	82
Regular kimchi 3	88

As a result of the calcium content measurement, as shown in Table 8 above, the calcium content of snow crab kimchi 1 containing snow crab seasoning was 91mg/100g, whereas general kimchi 1 without snow crab was 53mg/100g, and the calcium content was significantly higher. It was confirmed that there is a difference. This is a result depending on whether snow crab rich in calcium is included, and it can be seen that the snow crab kimchi prepared by the method of the present invention has a higher calcium content than general kimchi. In addition, it was confirmed that the snow crab kimchi 2, which had undergone the aging process including snow crab powder, was significantly superior in calcium content compared to the snow crab kimchi 1. Normal kimchi 2 and general kimchi 3 containing snow crab seasoning had higher calcium content than general kimchi 1 without snow crab seasoning. However, it was confirmed that the calcium content was lower than that of Kimchi 1 and 2 prepared by the method of the present invention.

4.5.3. Sensory Evaluation

In order to evaluate the preference for snow crab kimchi prepared by the method of this study, comparative sensory evaluation was performed on snow crab kimchi and general kimchi. The sensory test was conducted for about 2 months from January 15, 2021 to March 12, 2021 by selecting a random sample of 24 adult men and women in their 20s and 50s living in Seoul, Korea. Specifically, age and gender were evenly distributed for each group by 6, and the kimchi of Examples and Comparative Examples of this study was provided to evaluate texture (crispy), smell, taste, and overall preference. A 10-point scale was used for the rating, and the higher the preference, the higher the score. After consuming a piece of kimchi, each item was evaluated, and the process of rinsing the mouth with water and re-ingesting another kimchi after 5minutes was repeated and evaluated.

Table 12: Sensory Evaluation Result of Kimchi (Unit: points)

Type	Texture	Smell	Taste	Overall preference
Snow crab kimchi 1	9.2	8.6	9.1	8.8
Snow crab kimchi 2	9.1	8.5	9.5	9.2
Regular kimchi 1	9.1	8.2	8.7	8.6
Regular kimchi 2	8.9	8.5	8.9	8.7
Regular kimchi 3	7.5	8.1	8.2	7.9

As shown in Table 9, it was confirmed that the odor and taste of Snow Crab Kimchi 1 and 2, and General Kimchi 2 containing snow crab seasoning were highly evaluated. In addition, when comparing snow crab kimchi 2 and regular kimchi 3 that had been aged for 25 days, snow crab kimchi 2 containing snow crab powder did not significantly deteriorate the texture. However, it was found that in the case of general kimchi 3, which does not usually contain crab powder, the texture was significantly lowered. From these results, it can be inferred that the crispiness of kimchi is maintained even after the aging period due to the inclusion of crab powder. In the case of snow crab kimchi 2 that had been aged for a certain period, it was confirmed that the overall preference was increased compared to that of unaged snow crab kimchi 1.

4.5.4. Confirmation of Anticancer Activity

Chitosan is a polymeric material composed of α -(1-4) d-glucosamine units; it is obtained by chemical or enzymatic de-acetylation of the natural amino polysaccharide chitin, which is commonly found as a structural compound of arthropods (e.g., lobster and shrimp) and fungi, and is formed of α-(1-4) N-acetyl d-glucosamine units (Pillai, Paul & Sharma, 2009). Application of chitinous products in foods and pharmaceuticals as well as processing aids has received considerable attention in recent years as exotic synthetic compounds are losing their appeal (Shahidi et al., 1999). In order to confirm the anticancer activity of kimchi containing chitosan powder, extracts of Example (usually kimchi) 1 and Comparative Example (general kimchi) 2 were prepared, and the apoptosis effect on breast cancer cells was confirmed.

Specifically, each kimchi was freeze-dried, pulverized, and 20times (w/v) methanol of the dried sample was added, followed by repeated 12-hour stirring twice, followed by filtration, and concentration with a vacuum concentrator to obtain a kimchi extract. The obtained kimchi extract was diluted in DMSO (dimethyl sulfoxide) and used. After culturing MCF-7 (Michigan Cancer Foundation-7) cancer cells derived from human breast epithelium for 24 hours, 1, 1.5, 2, and 2.5mg/ml kimchi extracts were treated for 48 hours, respectively. Then, 100μl of 5mg/ml MTT assay (3-(4,5-dimethylthiazol-2yl)-2,5-diphenyl-2H-tetrazolium bromide) was added per well, and after reaction for 4 hours, absorbance was measured at 540nm.

As a result, as shown in Figure 1 below, Example (usually crab kimchi) 1 and Comparative Example (general kimchi) 2 kimchi showed concentration-dependent cancer cell killing effects from kimchi extract at a concentration of 2 mg/ml. However, in the case of Example 1 (usually kimchi) containing chitosan powder, it was confirmed that the cancer cell killing activity was significantly superior to that of Comparative Example (general kimchi) 2 not containing chitosan powder ($p<0.05$). This result showed similar results in the case of the previous study (Kong, Bahn, Kim, Lee, & Park, 2010).

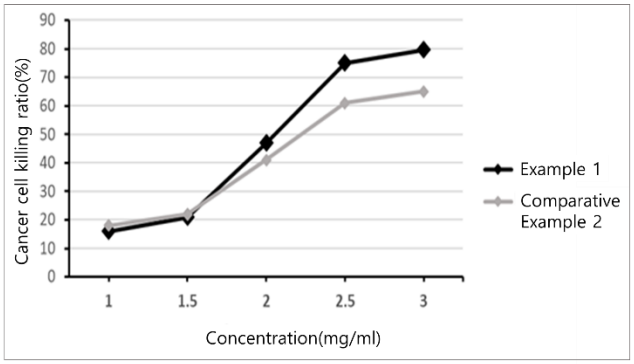

Figure 1: Cancer Cell Killing Ability by Kimchi Extract

From the above experiment, what improved the taste and function of kimchi unique to kimchi including snow crab in this research experiment without significantly changing the health functional effect, taste, and preservation period was extended. New tastes, possibilities, and characteristics of crab kimchi could appear. It should be understood that the usually kimchi described above are illustrative in all respects and not restrictive. That is, the scope of application of this study should be interpreted as including the meaning and scope of the scope of the study to be described later rather than the detailed description above, and all changes or modifications derived from the concept of equivalents to be included in the scope of this study.

5. Conclusions

5.1. Summary and Conclusion

The purpose of this study is to solve the food problems of traditional Korean kimchi, such as salinity, odor, amine generation, and shelf life. In addition, the main purpose is to develop a kimchi recipe using snow crab to improve the body's immunity in the era of COVID-19.

There are two specific purposes for this. One is to develop a snow crab kimchi manufacturing method by manufacturing kimchi containing snow crab (chitosan) without compromising the unique manufacturing method of kimchi. Another thing is that this developed snow crab kimchi improves health and other functions compared to conventional kimchi. In other words, if a snow crab kimchi manufacturing method with excellent taste and flavor is developed while improving the health functions of the body, such as improving people's immunity, it will improve people's health as well as improve the taste and shelf life of kimchi.

As a conclusion of this study, the "method for manufacturing crab kimchi" is completed in the following four steps, and a patent application for this manufacturing method has been completed in Korea.

1. Steps to prepare the crab seasoning
2. Pickling Chinese cabbage in 8~16% brine containing deep sea water for 10~20 hours.
3. Manufacturing step of kimchi seasoning including crab seasoning and chitosan powder
4. Usually, it is the manufacturing stage of kimchi.

In fact, the above manufacturing method completed a patent application (Patent Application Number, 10-2021-0043771) with the Korean Intellectual Property Office on April 5, 2021 under the name of "Kimchi Containing Snow Crab and Manufacturing Method thereof".

It was confirmed through the experiment that the anticancer effect and other functions were improved with crab kimchi, which is another purpose. Specifically, kimchi usually showed efficacy in killing human cancer cells. In addition, it was confirmed that the overall improvement in calcium content, extension of kimchi storage period, texture, odor, taste and preference, etc. was additionally confirmed. Kimchi prepared by this research method is characterized in that it not only exhibits a highly preferred taste and texture, but also increases calcium content and exhibits anticancer activity by including crab seasoning, chitosan powder, and/or snow crab powder.

In the era of COVID-19, it is expected that the method of making kimchi made by conducting this study will be of great help to the immune system in the human body as well as the antioxidant effect and health function. Although there are many types of kimchi and methods of making kimchi in Korea or around the world, this study mainly tried the method of making kimchi for the first time.

Through more research and experiments related to this in the future, the quality of the kimchi manufacturing method can be improved, and this will provide a basis for research related to kimchi food.

5.2. Future Research Direction

This study proposed a method for manufacturing kimchi containing chitosan for the first time in Korea and abroad, and improved health and other functions. However, many of the claims about the health-giving properties of Korean cuisine are mythologized and exaggerated, lacking substantial scientific evidence, despite there being some truth in them (Kim & Carter, 2018). Therefore, for more detailed and sophisticated research, the following should be added to future research. Various clinical health functional efficacy comparisons are required according to the seasoning ratio of snow crab or chitosan. In addition to animal experiments, more clinical trials and tests are needed. Additionally, snow crab and chitosan are expensive. Therefore, a cost-effective kimchi manufacturing method with improved taste, preservation period, and health functionality is required.

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