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A new process on the basic formula of kimchi: derived kimchi from a combination of *yangnyeom* (kimchi sauce) and vegetables

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Abstract

This study proposes a way of reconsidering how to explain kimchi, which is quite diverse even though it is often referred to as if it expresses a single, universal dish, to non-Koreans, particularly given the worldwide rise in its popularity. Koreans are accustomed to the general process of explaining kimchi in terms of the different types of vegetables that are the main ingredients. However, this process makes it difficult for Westerners who are new to kimchi to fully understand the comprehensive meaning and value of the dish. For this reason, it is time to change the process of explaining kimchi for Westerners who are accustomed to food culture using sauces. We believe that our study makes a significant contribution to the literature and will be of interest to the readership of the *Journal of Ethnic Foods* journal because it reviews and draws from 15 kimchi recipes posted by the world-famous culinary YouTuber Maangchi and proposes that discussing and classifying the composition and structure of ingredients and the basic formula as the best way of introducing non-Koreans to the variety of this quintessentially Korean dish and encouraging them to create their own varieties of kimchi upon a simple foundation of ingredients. People worldwide will be able to evolve to the stage where they can recognize and reconstruct the basic formula in which various derived kimchi types are made by combining kimchi *yangnyeom* and vegetables.

Keywords: Basic formula, Derived kimchi, Kimchi juice, Kimchi paste, *Yangnyeom* (kimchi sauce), Healthy food

Introduction

Kimchi is a fermented food that improves immunity for people all over the world and has established itself as a representative food that leads the K-FOOD industry. The Ministry of Agriculture, Food and Rural Affairs announced that agricultural food exports for the first half of 2020 totaled US\$3.6 billion, an increase of 4.4% over the same period in the previous year. Kimchi was a popular recognition as a healthy food in the USA, and the export amount of kimchi increased to US\$74.7 million, up 44.3% from the previous year [1]. Domestic food consumption is increasing daily due to the movement

restrictions imposed by each country. Together with these changes in everyday life, kimchi has become globalized, with an increasing number of people choosing foods that are useful to improve immunity and health.

A country's food culture is formed over a long period of time. Therefore, it is necessary to understand the nature of culture in which the process of accepting and reconstructing the food culture of other countries takes place. When members of different cultures coexist within a particular society, a change occurs in which the cultures propagate each other and give rise to a spontaneous cultural acculturation phenomenon that selectively accepts other cultures according to individual preferences [2]. The researchers of the current article are this process and focus on how to inform people in other cultures around the world of the value and meaning of kimchi.

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As part of the globalization of kimchi, the early diffusion method of kimchi culture has been organized in the public sphere as an event hosted by the Korean Embassies and Korean Cultural Centers in each country. This has yielded some success but ultimately has been shown to be unsustainable due to a lack of ongoing interest by the public and limited budgetary support in the process of gaining acceptance in that country.

It should be noted that the principal agent of international cultural exchange itself has recently changed from the public to the private sector. This means a transformation into a horizontal network relationship, in which mutual respect, understanding, and cooperation are important goals, in addition to vertical culture dissemination and promotion. In this changing environment of international cultural exchange, people around the world easily accept the kimchi culture in the form of play. This is considered a suitable alternative that kimchi can become an element of global dietary practices.

Modern people can easily find recipes for foods they want to make via the Internet, smartphones, and social media. In addition, the act of making dishes in the order of recipes and posting scenes depicting people eating on a personal SNS (Social Network Service) has become “everyday play (routine).” The development of these smart media is breaking the boundaries of food culture by country and plays a major role in leading the globalization of kimchi in the private sector. Younger generations not only in Korea but also in other countries have begun to recognize kimchi as a cultural product rather than as simple food. Based on the experience of making kimchi directly, the number of consumers who want to understand and enjoy Korean culture is increasing, and a change in the consumption paradigm recognized as cultural consumer goods is emerging.

In such a situation, promoting the globalization of kimchi necessitates that the commonly used structure for introducing kimchi to foreigners must change. When most Koreans introduce the hundreds of types of kimchi, they classify them by first indicating the main vegetables that are the primary ingredients. For example, Koreans have explained classified kimchi by the ecological characteristics of vegetables—for example, *baechu* (kimchi cabbage) kimchi is made from leafy vegetables, *kkakdugi* is made from root vegetables like radish, and *Oi*-kimchi made from fruits and like as cucumber [3].

While this method of introducing kimchi is familiar to Koreans, who already use various vegetables for fermenting, it can be rather complicated for Westerners who are accustomed to food culture using sauces and dressings. Therefore, introducing kimchi by discussing the use of sauces and staking out common ground in the food culture of Westerners can facilitate the reconstitution of

the dish with the food practices and the familiar foods of the respective country. The successful globalization of Japanese “Kikkoman soy sauce” and Thai-style “Sriracha Sauce” is a typical example that targets the familiarity of sauces to the Western diet. In the case of kimchi, the popularity of “Kimchi seasoning,” which was the best seller in the seasoning section of Amazon.com in the USA in 2019, and British Wimbledon tennis players, “Kimchi juice” as an energy drink, is due to the familiarity of the sauce [4].

The sauce in Western Cuisine started with the history of French cuisine. Sauces served to enhance appetite by providing visual stimulation and adding flavor, aroma, color, and concentration to the food. Sauces are made from multiple ingredients, are nutritious, and blend well with the main dish to create harmony. Throughout the development process, French cuisine established Béchamel, Veloute, Espagnole, Hollandaise, and Tomato Sauce as the “mother sauces,” which are the basics of Western cuisine [5]. Thereafter, various sauces were created by the method of deriving while adding other ingredients to each mother sauce. Most Western dishes add sauces of various flavors, colors, and aromas to create perfect dishes.

Similarly, the types of vegetables used as the main ingredients in kimchi are important, but the taste, color, and aroma of *yangnyeom* (kimchi sauces) owe to salt (sun-dried sea salt), red chili pepper powder [6], garlic, ginger, and *jeotgal* (salted seafood) [7]. Kimchi has a structure that becomes the basis for various kimchi styles by mixing various vegetables in the sauce. Therefore, it is necessary to change the way of thinking that approaches people of the world based on the sauce. In order to make kimchi a global dish, it must be possible for people all over the world to easily see and make ingredients and procedures for kimchi recipes. In addition, vegetables produced in each country must be combined with *yangnyeom* to lead to spontaneous acculturation that produces various derived kimchi [8].

This study aims to provide a new process for basic formulas of kimchi and *yangnyeom* structure and components that must be understood before making kimchi. The basic formula and structure of kimchi described in this paper will provide new information that is different from the contents explained in the background of the kimchi-related papers published so far.

History and culture of kimchi

In Korea, kimchi is usually served with every meal, and at least one type of kimchi is always prepared. This confirms that kimchi symbolizes Korean food culture. Food culture is deeply rooted as part of national identity. This applies to every country in the world as the local

environment and way of life create cuisines with deep historical and sentimental bonds. Because of the distinct four seasons, Korea has developed a unique technology that tailors fermented vegetables to the natural environment. Fermented vegetables are an ideal combination of grains and can be stored for a long time. Kimchi in Korea has developed and changed throughout its long history. Korea has its own *gochu* (red chili) and *baechu* from thousand years ago [9]. Kimchi has been a part of Korean life since before the Three Kingdoms period [10, 11]. In *Samkuksaki* (written book History of Korea Three Kingdom; 6C-12C), Korea already cultivated red chili (*gochu*) and genetically analysis reviewed there are two types of red chili from half a million years [6, 12]. Also, it is found that *baechu* was cultivated for thousands of years [13]. According to *Samkukjiwiji-donguijeon* (History Book of Chinese Three Kingdom), there is a record that “the people of *Goguryeo* (ancients kingdom) made fermented food very skillfully,” a Chinese historical book in the third century [14]. It is not sure this Chinese book is exactly related to kimchi fermentation; however, in a couple of Korean books about thousand years such as *Samkuksagi* (History of Korea Three Kingdom, 6C-12C) and *Goreosa-jeolyo* (History of *Goryo*, 12C-14C), fermented kimchi is written as a proverb. Today’s main principle of finding kimchi is the same as *yangnyeom*, especially capsaicin from *gochu* and Allicin from garlic prevent from putrefaction and accelerating the lactic acid fermentation [15]. Therefore, kimchi is a traditional, cultural and indigenous food of Korea with a long history. It is a sententious invention from intentional endeavors of ancient Korean women with hundreds of vegetables, which is passed down from generation and generation with a slight modification; however, the main principle of kimchi fermentation is not changed. Vegetables are fermented by lactic acid with the help of *yangnyeom* as Capsaicin of chili and Allicin of garlic. Even now, kimchi continues to undergo endless transformations, while maintaining its tradition and identity, attracting global attention.

Definition and scope of kimchi

Kimchi was officially certified as an international standard food in 2001 by the Codex Alimentarius Commission, which was established to promote the international food trade and protect consumer health [16]. Subsequently, UNESCO recognized the value of the community life culture of making kimchi, and in 2013 kimchi was registered as a human intangible cultural heritage [17]. People around the world who place importance on immunity and health are increasingly interested in kimchi, and in the first half of 2020, the amount of Korean exporting of kimchi has increased, leading to a consumption effect [18].

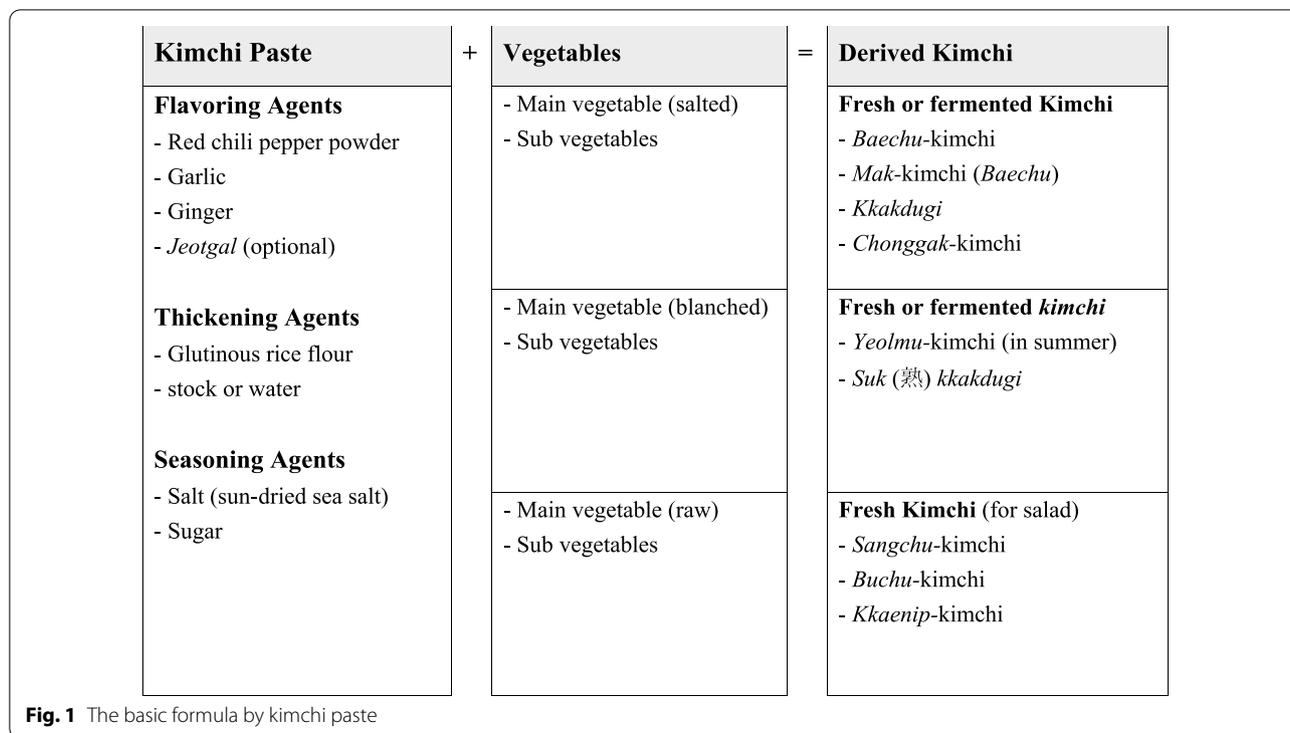
Codex Alimentarius defines kimchi as a product with the following three processing conditions. First, *baechu* of various varieties (*Brassica pekinensis* Pupr.) is soaked in salt, washed, dehydrated before use, or cut into an appropriate size. Second, the red chili pepper (*Capsicum annuum* L.), garlic, ginger, radish, and other ingredients are prepared in order to make the *yangnyeom*. Third, kimchi is a product as-is or by long period fermentation by aging at a low temperature to appropriately preserve the shelf life in order to produce lactic acid by mixing vegetables and *yangnyeom*. Similarly, according to the “Korean Food Standard Codex” of the Ministry of Food and Drug Safety, which was created for the safe management of foods and food additives in South Korea, kimchi is defined as using “vegetables such as *baechu* as the main raw material, processed through a mixing process of pickles and seasonings, as-is or by fermentation.” In addition, according to the “Certification of Traditional Foods” of the National Agricultural Products Quality Management Service, kimchi it is pickled by vegetables with salt water (brine) or salt, washed, dehydrated, and mixing with *yangnyeom*, as-is or fermented.

The definition and scope of kimchi according to domestic and international official standards can be summarized as “salt blended vegetables with sauces as-is or fermented.” In other words, vegetables, sauces, and the presence or absence of fermentation are the three components that define kimchi, and their inclusion is generally understood by Koreans as a fundamental making direction when making kimchi. Making the sauce the starting point for making kimchi through a simple shift in the received order of vegetables and sauce can make kimchi’s basic formula easier for Westerners familiar with sauce culture to relate to and feel comfortable with.

Basic formula of kimchi

In order to make kimchi well, it is important to understand the basic formula and the function and role of the ingredients used. Today’s kimchi recipes can be easily found by anyone via the Internet or cookbooks; however, they are often written without considering the user’s cooking level [19]. The general recipe for kimchi is described from a Korean viewpoint along the process from the pretreatment of vegetables to the process of mixing with *yangnyeom*. It is difficult for Westerners to understand the essential concept of such kimchi, due to the complexity of the pretreatment methods and cooking processes concerning the ingredients used. Therefore, before looking at the kimchi recipe, it is necessary to understand the culinary structure based on the three components of kimchi.

The basic formula of kimchi can be summarized as a combination of *yangnyeom* and vegetables. From a



culinary viewpoint, kimchi is a food that is made by cutting the vegetables you want to eat into appropriate sizes and then mixing them with *yangnyeom*. If you want to eat kimchi in a fresh state, mix *yangnyeom* with vegetables and eat it as it is. If you want to consume the lactic acid bacteria (LAB) naturally produced in kimchi as a healthy food, you can ferment it by storing it in a kimchi storage-only refrigerator that maintains a constant temperature. In South Korea, many kinds of vegetables such as *baechu*, radish, *yeolmu* (young radish), and cucumber are combined with *yangnyeom* to make various derived kimchi. The types of vegetables used to make kimchi are not fixed. If you use Korean vegetables, you can make original kimchi, but in countries where it is difficult to obtain Korean vegetables, you can use all the vegetables produced in each country to make kimchi. In addition, kimchi can be made using fruits such as melon and papaya.

When the basic formula of kimchi is taken out of its original Korean context and is used in a new national and cultural context, new kimchi is therefore created using the indigenous vegetables of that nation or culture. To do so, it is necessary to have a clear understanding of the basic formula of kimchi. Next, we will explain the *yangnyeom*, which is the starting point of various derived kimchi.

Classification of *Yangnyeom*

The taste of kimchi is determined by the *yangnyeom* rather than the vegetables used as the main ingredient. The taste of *yangnyeom* is influenced by the company or person who made it. *Yangnyeom* can be broadly divided into commercial *yangnyeom* and household *yangnyeom*. Commercial *yangnyeom* is made according to the tastes of consumers purchasing from kimchi manufacturing companies and the trends of the times. Different kimchi manufacturing companies have different types and capacities of materials used for *yangnyeom*, and in some cases, they have patented technology for the material mixture ratio. Each *yangnyeom* recipe used for several types of kimchi produced by kimchi manufacturing companies is standardized to one taste. Kimchi manufacturing companies need to consider the economic costs of production in terms of efficiency while satisfying the expectations of multiple consumers. Therefore, the material used for the *yangnyeom* has a characteristic with a unique flavor, and its use is limited when the price is high.

On the other hand, household *yangnyeom* refers to sauce used when making kimchi directly at home without purchasing it from a kimchi manufacturing company. The taste of *yangnyeom* is influenced not only by sociodemographic characteristics such as the region where the

Kimchi Juice	+	Vegetables	=	Derived Kimchi
<p>Liquid Agents</p> <p>① White juice</p> <ul style="list-style-type: none"> - Stock or water <p>② Red juice</p> <ul style="list-style-type: none"> - Stock or water - Dried red chili pepper powder <p>③ Brown juice</p> <ul style="list-style-type: none"> - Stock or water - Fermented soy sauce <p>Flavoring Agents</p> <ul style="list-style-type: none"> - Garlic - Ginger - <i>Jeotgal</i> (optional) <p>Thickening Agents</p> <ul style="list-style-type: none"> - Glutinous rice flour - stock or water <p>Seasoning Agents</p> <ul style="list-style-type: none"> - Salt (sun-dried sea salt) 		<ul style="list-style-type: none"> - Main vegetable (salted) - Sub vegetables 		<p>① Water kimchi with white juice</p> <ul style="list-style-type: none"> - <i>Dongchimi</i> - <i>Baek-kimchi</i> <p>② Water kimchi with Red juice</p> <ul style="list-style-type: none"> - <i>Nabak-kimchi</i> - <i>Yeolmu-mul-kimchi</i> <p>③ Water kimchi with brown juice</p> <ul style="list-style-type: none"> - <i>Jang-kimchi</i>

Fig. 2 The basic formula by kimchi juice

person makes kimchi residence area, family composition, income level, and marital status but also by additional factors such as season, type of ingredients, and mixing ratio. It is not standardized but comes in a variety of flavors, and the taste of *yangnyeom* is determined not only by the cooking technique and experience of the person who makes kimchi, but also according to social, cultural, and spatiotemporal attributes. The unstandardized kimchi taste shows a newly changing flexibility that depends on the diversity of *yangnyeom* and the characteristics of the person making the kimchi. Therefore, household *yangnyeom* plays an important role in explaining the diversity of hundreds of types of kimchi.

The two *yangnyeoms* categorized above are distinctly different from kimchi seasonings that are sold after being processed into other formulations such as powder or flakes. As a result, the criteria for dividing *yangnyeom* into industrial and household use are only whether the taste of kimchi is standardized or not, and whether the constituents are the same. Next, we would like to

examine the components and structure that makeup *yangnyeom* in detail.

Structure and components of *Yangnyeom*

Delicious kimchi is completed when kimchi is combined with the appropriate sauce depending on the type of vegetable. Different tastes can be added to the kimchi you want to make with different types and proportions of ingredients used for *yangnyeom*. *Yangnyeom* can be divided into two types: kimchi paste, which is used to make general kimchi that is mainly consumed with vegetables, and kimchi juice, which is used to make water kimchi that is eaten with vegetables and juice. In other words, whether one uses kimchi paste or kimchi juice depends on whether one eats only vegetables or one eats vegetables and juice together.

The materials used to make these two *yangnyeoms* can be bundled and described according to their function and role. Kimchi paste consists of three components:

flavoring, thickening, and seasoning (FTS) (Fig. 1). Kimchi juice used to make water kimchi consists of four components: liquid, flavoring, thickening, and seasoning (LFTS) (Fig. 2). The explanation focuses on the individual ingredients that constitute the two types of *yangnyeoms*, and the effects of the ingredients on the health functionality and kimchi fermentation are investigated.

Flavoring agents

Flavoring agents play the most important role in kimchi paste. These agents enrich the taste of kimchi as a combination of spice materials that give off various aromas and tastes, assist fermentation. The key ingredients of the flavoring agents are red chili pepper powder, garlic, ginger, and *jeotgal*. In addition, there are various flavoring ingredients that can be used for kimchi, but we will explain the representative ingredients.

First, red chili pepper powder is an important ingredient that shows the redness and spiciness of kimchi paste. Phytochemicals such as capsaicin contained in red chili pepper powder suppress spoilage bacteria that occur early when kimchi is made and create a LAB production environment [20]. For kimchi, dry red chili pepper powder is generally used, but in some parts of Korea, raw red chili pepper may be grated is also used. Making kimchi with a kimchi paste made from grating raw red chili pepper promotes the expression of *Leuconostoc mesenteroides* LAB produced in the early stages of fermentation [21].

Second, garlic is a typical foodstuff that plays an important role in kimchi fermentation. According to a paper recently published by the World Institute of Kimchi (WiKim), the multi-omics analysis revealed that LAB directly affecting kimchi fermentation is derived from garlic [22]. The taste of kimchi is determined by producing metabolites such as *mannitol* in *Leuconostoc*, which is a garlic-derived LAB, and lactic acid (lactate) in *Weissella* [23]. Garlic also delays the growth of microorganisms and delays the appearance of LAB during fermentation. This has the effect of maintaining the fermentation period of kimchi for a long time and increasing the storage period of kimchi that has been appropriately aged to improve storage quality [21, 24].

Third, ginger is a unique ingredient with a strong aroma and spicy taste and complements the lack of aroma and taste of vegetables. The spiciness of ginger is composed of 6-gingerol and 6-shogaol essential oil components, and it is used as a material for health foods that function as antioxidants, anti-inflammatory, antibacterial, and blood circulation functions [25]. Lee and Kim [26] report that adding ginger to kimchi delayed the growth of *Leuconostoc mesenteroides*, which is a lactic acid bacterium

produced in the early stage of fermentation. When ginger is used in *yangnyeom*, the preference of the eater may reduce due to its unique scent; it is, therefore, necessary to use it in accordance with the appropriate amount indicated in the recipe [27].

Fourth, *jeotgal* [7] is an ingredient that is selectively used in consideration of the eating habits of people who eat kimchi. *Jeotgal* is a fermented food made by salting various types of seafood products such as anchovies and shrimp. It is a complete fermented food that can be eaten with rice by itself. *Jeotgal* acts when added to kimchi as a spice that enriches the savory taste (also known as “Umami”) and aroma. *Jeotgal* can be divided into raw salted fish (*jeotgal*), which is fermented seafood as it is, and fish sauce (*aekjeot*), which filtered liquid from seafood fermentation. *Jeotgal* acts as a protein source for LAB in the process of fermentation of kimchi to increase the content of essential amino acids, increase various metabolites, and accelerate ripening [28]. However, *jeotgal* is one of the ingredients that vegetarians should consider when choosing kimchi. That an increasing number of vegetarian consumers use *jeotgal* as a key ingredient in kimchi by reducing or radically limiting the intake of animal ingredients for a healthy diet, including personal health, animal welfare, and environmental protection, should be recognized as an important issue [29]. As *jeotgal* was fish-derived, so it should be noted that vegetarians who may consume kimchi should be aware that it may contain added *jeotgal*. Although *jeotgal* is an important ingredient of *yangnyeom*, kimchi can be made with *yangnyeom* made without using *jeotgal*. An example of this kimchi is Korean Buddhist temple kimchi, which does not contain any animal ingredients [29]. At Buddhist temples, you may also put *doenjang*, or Korean fermented soybean paste, to replace the protein that may be lacking without *jeotgal*. Zabat et al. [30] have reported that kimchi containing fermented soybean paste instead of *jeotgal* has the same LAB as general kimchi.

Thickening agents

Thickening agents play a role in binding multiple ingredients used for *yangnyeom* to each other [5]. Glutinous rice pastes and wheat flour paste, which are commonly used for *yangnyeom*, are prepared by mixing flour and water at a ratio of 1:10 and boiling before cooling them. When the kimchi is made by adding a thickening agent to *yangnyeom*, microbial growth is activated and LAB fermentation is accelerated [31, 32]. Among them, it was found that kimchi containing flour paste promoted fermentation more than kimchi containing glutinous rice paste. Kimchi has requires a certain period of aging until it is completely fermented. However, Lee and Han [33, 34]

reported that kimchi containing flour paste had a shorter fermentation period, rather a stronger sourness, a lower sensory preference, and a shorter shelf life. For this reason, research is ongoing about thickening agents that can maintain the viscosity of *yangnyeom* continues until kimchi is aged appropriately [35]. Kim and Kim [36] reported that the viscosity at the early stage of the aging of kimchi made with strong Xanthan gum was maintained at a constant level by the 7th day of storage. This contrasts with the results of studies in which the viscosity of kimchi containing a glutinous rice paste and flour paste was fermented and dropped sharply [36]. The Codex Alimentarius officially recognizes food additives such as Xanthan gum and Carrageenan as thickening agents that can replace glutinous rice paste and flour paste.

Because thickening agents are highly affected by temperature, grain flours such as non-glutinous rice flour, barley flour, and wild sesame flour are used in addition to glutinous rice flour and flour and depending on the season and type of makes kimchi. Leftover rice from household cooking and water are sometimes mixed and ground in a mixer. In addition, in mountainous areas where it is difficult to obtain grain, materials with starch properties such as sweet potato, potato, and corn may be used.

Seasoning agents

The most basic ingredient of seasoning agents is salt, which is used for seasoning *yangnyeom* to enhance sensual preference. Salt is also used when pickling mixed vegetables with *yangnyeom* in advance. It is used to soak vegetables in salt water or to sprinkle salt to drain the water that vegetables have via osmotic pressure. The salt used to make kimchi plays an important role in assisting lactic acid fermentation by preventing the growth of harmful microorganisms generated by storage.

The best salt when making kimchi is sun-dried sea salt (*Cheonilyeom*), which is made by confining seawater in a space called a salt evaporation pond (*Yeomjeon*) and evaporating the water by sunlight and wind. According to Chang, Kim, and Jang [37], *baechu*-kimchi using sun-dried sea salt has less change in the hardness of *baechu* tissue during the fermentation process than *baechu*-kimchi using refined salt. This is the result of the sun-dried sea salt calcium (Ca) and magnesium (Mg) binding to the *baechu* pectin and maintaining the tissue firmness while improving the texture [38, 39]. In addition, when making kimchi, it is more effective to maintain the physical properties of kimchi if sun-dried sea salt aged for two to three years or more is used. It is important to remove bitterness during the process of aging sun-dried sea salt in order to make kimchi that can be stored and eaten for a long time while maintaining an appropriate texture. Bitterness

is composed mainly of magnesium chloride ($MgCl_2$) and magnesium sulfate ($MgSO_4$), which give a bitter taste, and are better removed. During this process, the bitterness comes out with the water remaining in the solar salt. Therefore, the water content of solar salt will decrease and the sodium chloride (NaCl) content will increase [40]. Sun-dried sea salt is about 85 to 90% less salty in taste than refined salt. It contains mineral components such as Ca, K, and Mg.

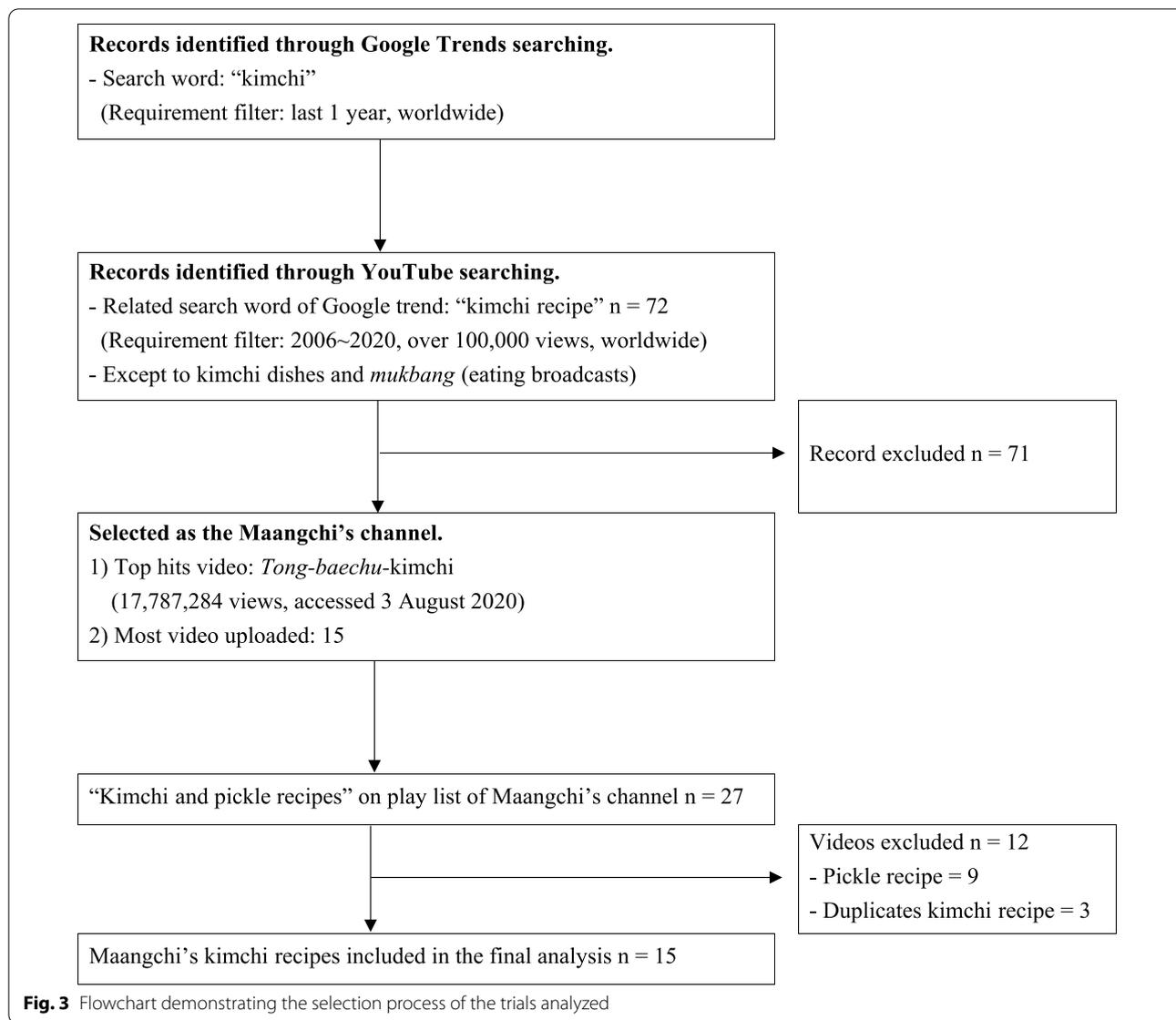
On the other hand, in addition to salt that gives a salty taste, seasonings that give sweetness to the seasoning agents of *yangnyeom* may be used. A commonly used ingredient for sweetness is sugar (sucrose). Sugar helps the growth of LAB during the fermentation process of kimchi, increases the rate of mountain formation, and helps kimchi ripening [41, 42]. Nowadays, sugar alcohol like Sorbitol and Stevioside is used as sugar alternatives [43–45]. In particular, sorbitol is a Codex Alimentarius material that is permitted to be used to improve the texture of kimchi and is mainly used in commercial *yangnyeom*. Ku et al. [42] have reported that Sorbitol has an effect of suppressing the generation of acid than sugar and starch syrup corresponding to Carbohydrate sweeteners and that the period during which kimchi can be preserved and eaten is twice as long as that of kimchi containing sugar. In addition, honey and starch syrup may be added to the *yangnyeom* as a sweetening ingredient according to the taste of the person who eats home-made kimchi.

Liquid agents

Liquid agents are equivalent to the water used to make water kimchi that includes vegetables and juice together and is the main component of kimchi juice. There are various types of water kimchi in Korea. Water kimchi uses a larger amount of water than common kimchi, which is mainly consumed by vegetables. Kimchi juice is used as a healthy drink in daily life because it has the effect of promoting digestion due to various nutrients and organic products that spring from vegetables and components of *yangnyeom* [46]. In general, kimchi juice can be distinguished by three colors: white, red, and brown. White juice is salted water made by dissolving salt in water. Red juice is made by adding red chili pepper powder to a cotton wrapping cloth and placing it in salt water to give a color. Brown juice is made by adding Korean fermented soy sauce (*Ganjang*) to salt water.

Pre-cooking method of vegetables used for kimchi

To make kimchi using various vegetables, the vegetables must be properly cooked before they are combined with the sauce. The cooking method must be applied



differently depending on the part to be used for kimchi, such as vegetable leaves, stems, fruits, and roots. The basic method for preparing vegetables for use in kimchi can be divided into three categories.

First, the vegetables are soaked in salt water or sprinkling them with salt. This method is the most often used in making kimchi. It is mainly used when making kimchi with vegetables with high water content, such as *baechu*, radish, cabbage, and cucumber. This is an important cooking method that drains the water contained in vegetables to prevent spoilage and enhance shelf life. This cooking method is a necessary process for eating kimchi during long-term storage.

Second, the vegetables are lightly blanched in boiling water. This method is used for stem vegetables with

strong textures or leafy vegetables with little water content. Vegetables are blanched lightly in boiled salt water, and then quickly put in ice water to cool. If vegetables are blanched to boiling water, the color of the vegetables will be clear. Kimchi made from blanched vegetables is a suitable food for the elderly who have weak teeth and patients who have difficulty digesting.

Third, it is a method of using raw vegetables, while it does not use a special cooking method. This cooking method is suitable for leafy vegetables with low water content. After the vegetables are thoroughly washed and cut into a size that is easy to eat, *yangnyeom* is added to complete the dish. Kimchi prepared in this way has the advantage that it can easily be eaten in the form of salad. When making kimchi using various vegetables, it

Table 1 Ranking by views of kimchi recipe clips on Maangchi’s YouTube Channel. Source: <http://www.youtube.com/user/Maangchi> (accessed 3 August 2020)

Rank	Title	Views	Upload date
1	Traditional kimchi recipe (<i>Tong-baechu</i> -kimchi)	17,787,284	June 23, 2014
2	Easy kimchi (<i>Mak</i> -kimchi)	14,626,540	January 24, 2010
3	Cucumber kimchi (<i>Oi-sobagi</i>)	6,178,142	July 18, 2013
4	Cubed radish kimchi (<i>Kkakdugi</i>)	2,456,413	August 2, 2011
5	Vegan kimchi (<i>Baechu</i> -kimchi)	1,853,791	November 3, 2019
6	Emergency kimchi (<i>Yangbaechu</i> -kimchi)	1,736,198	March 5, 2011
7	Chive kimchi & paris meetup (<i>Buchu</i> -kimchi)	1,483,701	December 16, 2016
8	Ponytail kimchi (<i>Chonggak</i> -kimchi)	1,035,808	February 23, 2012
9	Non-spicy kimchi (White kimchi: <i>Baek</i> -kimchi)	879,403	December 18, 2013
10	Spicy stuffed green chili pepper kimchi (<i>Gochu-sobagi</i>)	815,084	September 28, 2016
11	Small portion fresh kimchi (<i>Geotjeon</i>)	770,175	May 31, 2018
12	Vegetable and fruit water kimchi (<i>Nabak</i> -kimchi)	420,489	October 8, 2017
13	Korean radish water kimchi (<i>Dongchimi</i>)	315,447	May 8, 2012
14	Perilla leaf kimchi and perilla leaf pickles (<i>Kkaenip</i> -kimchi)	282,288	August 5, 2009
15	Young radish kimchi (<i>Yeolmu-mul</i> -kimchi)	165,680	May 18, 2008

is necessary to select and cook the optimal method that matches the characteristics of the vegetables.

Classification of recipes according to the basic formula of kimchi

Selecting kimchi recipes

This study explained the structure and ingredients of *yangnyeom* and the pre-cooking method of vegetables in order to illuminate the basic formula of kimchi presented in a new process. We attempt to verify that this formula is an easy way for people around the world to access it. The basic formula of kimchi presented above was analyzed against unstructured media content data and contrasts.

First, in order to identify what types of kimchi are well known to foreigners, we used Google Trends to identify search trends of users around the world and YouTube as research tools. In order to find keywords to search for types of kimchi that are highly preferred by foreigners, we looked for Google search trends involving “Kimchi” worldwide for the 12 months preceding the current study. The keyword “Kimchi recipe,” which has the highest search frequency among related searches displayed together with the search results, was selected as a search word [47]. Searching this a keyword on YouTube, excluding recipes for kimchi-applied dishes and *mukbang* (eating broadcasts originating in South Korea), which are video contents of kimchi dishes uploaded worldwide over the past 15 years, 72 videos that recorded more than each logged over 100,000 views were primarily selected.

We recorded the highest number of views among them and selected the channel of YouTube content creator Maangchi (Emily Kim), which uploaded videos with recipes for the most types of kimchi.

Maangchi runs an eponymous YouTube channel that introduces viewers to cooking Korean food by utilizing Korean ingredients purchased in the USA [48]. This channel is one of the most popular YouTube channels for culinary videos not only for immigrant Koreans and Americans but also for viewers around the world who are interested in Korean food [49]. Maangchi, who began her channel in 2007, has 4.87 million subscribers as of 2020 (accessed 3 August 2020). At the time of writing, she has uploaded 402 total videos and had a total of more than 510 million views. The “Kimchi and pickle recipes” list, which classifies the video content of kimchi dishes on the Maangchi Channel, consists of 27 recipes in total. Among them, 12 video contents with low views were excluded from kimchi recipes that were duplicated with pickles. Finally, 15 kimchi recipes introduced by Maangchi were selected as samples and categorized based on the basic formula of kimchi (Fig. 3, Table 1).

Classification by basic formula of kimchi

The 15 recipes for kimchi selected from the Maangchi Channel were categorized according to their components based on the basic formula of kimchi, which was presented as a new process. The kimchi recipe is classified

Table 2 Classification of Maangchi’s kimchi recipes by basic formula

Clsf	Yangnyeom (Kimchi Sauce)				Vegetables		Derivative kimchi
	Liquid	Flavoring	Thickening	Seasoning	Main vegetable	Sub-vegetables	
Kimchi Paste	-	Dried red chili pepper powder + garlic + ginger + <i>Jeotgal</i>	Glutinous rice flour	Salt + sugar	<i>Baechu</i>	Asian chives, radish, carrot, green onion, onion, water parsley	<i>Tong-baechu-kimchi</i>
	-	Dried red chili pepper powder + garlic + ginger + <i>Jeotgal</i>	Glutinous rice flour	Salt + sugar	<i>Baechu</i>	Asian chives, green onion, onion, carrot	<i>Mak-kimchi</i>
	-	Dried red chili pepper powder + garlic + ginger + <i>Jeotgal</i>	Glutinous rice flour	Salt + sugar	<i>Baechu</i>	Asian chives, green onion, onion, carrot	<i>Baechu-geotjeori</i>
	-	Dried red chili pepper powder + garlic + ginger	Glutinous rice flour	Salt + sugar	<i>Baechu</i>	Green onion, onion, radish, carrot	<i>Vegan kimchi</i>
	-	Dried red chili pepper powder + garlic + ginger	-	Salt + sugar	Radish	Green onion	<i>Kkakdugi</i>
	-	Dried red chili pepper powder + garlic + <i>Jeotgal</i>	Glutinous rice flour	Salt + sugar	<i>Chonggak-mu</i>	Green onion, onion	<i>Chonggak-kimchi</i>
	-	Dried red chili pepper powder + garlic + <i>Jeotgal</i>	-	Salt + sugar	Cucumber	Asian chives, onion, carrot	<i>Oi-sobagi</i>
	-	Dried red chili pepper powder + garlic	-	Salt + sugar	Cabbage	Green onion, carrot	<i>Yangbaechu-kimchi</i>
	-	Dried red chili pepper powder + garlic + <i>Jeotgal</i>	-	Salt + sugar	Green chili pepper	Asian chives, radish, onion, carrot	<i>Gochu-sobagi</i>
	-	Dried red chili pepper powder + <i>Jeotgal</i>	Glutinous rice flour	Sugar	Asian chives	Onion	<i>Buchu-kimchi</i>
	-	Dried red chili pepper powder + garlic + ginger + <i>Jeotgal</i>	-	Honey	<i>Kkaenip</i>	Green onion, onion, carrot	<i>Kkaenip-kimchi</i>
Kimchi Juice	Water	Garlic + ginger	-	Salt	<i>Baechu</i>	Asian chives, radish, carrot, red bell pepper, Korean pear, onion, jujube, chestnut, pine nut	<i>Baek-kimchi</i>
	Water	Garlic + ginger	-	Salt	Radish	Green onion, onion, green chili pepper, red chili pepper, Korean pear	<i>Dongchimi</i>
	Water	Dried red chili pepper powder + garlic + ginger	-	Salt	<i>Baechu</i>	Radish, cucumber, green onion, onion, green chili pepper, red chili pepper, apple, Korean pear, red radish	<i>Nabak-kimchi</i>
	Water	Dried red chili pepper powder + garlic + ginger + <i>Jeotgal</i>	Glutinous rice flour	Salt + sugar	<i>Yeolmu</i>	Onion, green chili pepper, red chili pepper	<i>Yeolmu-mul-kimchi</i>

into *yangnyeom* and vegetables, and derivative kimchi made by combining the two components is presented in Table 2 in the order of cooking. Derived kimchi may be explained by classifying it into “Kimchi Paste” and “Kimchi Juice” according to the type of *yangnyeom* that is the starting point of kimchi.

First, 11 kimchi samples derived from a combination of kimchi paste and vegetables are *tong-baechu-kimchi*, *mak-kimchi*, *baechu-geotjeori*, *vegan kimchi*, *kkakdugi*, *chonggak-kimchi*, *oi-sobagi*, *yangbaechu-kimchi*, *gochu-sobagi*, *buchu-kimchi*, and *kkaenip-kimchi*. The flavoring agents in kimchi paste commonly used red and spicy

peppers, and garlic was used in all kimchi except *Buchu*-kimchi. It can be seen that red chili pepper powder and garlic play an important role in kimchi paste. There are four kinds of kimchi derived from *baechu*-kimchi, which is combined with kimchi paste, as the main vegetable: *tong-baechu*-kimchi, *mak*-kimchi, *baechu-geotjeori*, and vegan kimchi. The ingredients used in the three agents (FTS) of kimchi paste are all the same, but vegan kimchi is made with flavoring agents and without *jeotgal*. By combining *baechu* with kimchi paste that does not contain *jeotgal*, one can make vegetarian-friendly *baechu*-kimchi. Instead of *baechu* and radish, which are often used as the main vegetables, cucumber, cabbage, peppers, Asian chives, and wild sesame leaves when combined with kimchi paste may also result in various types of kimchi. Even though the ingredients used for kimchi paste are the same, the capacities differ from each other, resulting in a wide variety of kimchi tastes.

Second, there are four kimchi derived from the combination of kimchi juice and vegetables: *baek*-kimchi, *dongchimi*, *nabak*-kimchi, and *yeolmu-mul*-kimchi. *Baek*-kimchi and *dongchimi* are kimchi with a salt water base and resulting from the combination of white juice and various vegetables. *Nabak*-kimchi and *yeolmu-mul*-kimchi are kimchi that combines various vegetables with red juice colored with red chili pepper powder in salt water.

Conclusion

While Koreans are accustomed to the normal process of explaining the hundreds of types of kimchi by mentioning the vegetables that are the basic ingredients, kimchi recipes in the text can be difficult for Westerners to learn how to make kimchi for the first time owing to the diversity of ingredients and the complicated cooking process. Therefore, this article attempts to help the Westerners accustomed to sauce culture through a change in the idea of changing the order of vegetables and sauce among vegetables, sauces, and the presence or absence of fermentation, which is the universal cooking step for kimchi. In addition, we also combined *yangnyeom* and vegetables to establish structures for derived kimchi and presented them by also discussing the basic formula of kimchi.

The general process on kimchi that Koreans think may be a stumbling block to the globalization of kimchi. Just as the mother sauce in Western cuisine combines with other ingredients to become a derivative sauce, it is necessary to introduce the fundamental basic structure in which various derived kimchi types emerge by combining vegetables produced in each country with *yangnyeom*. If so, Westerners familiar with sauce culture will be able to more easily understand the cooking process of kimchi. After this process, people around the world will be able to evolve to the

stage of reconstructing multinational derived kimchi by combining *yangnyeom* with local vegetables using the basic formula of kimchi. After all, we can expect the prosperity of kimchi culture that people around the world enjoy kimchi in their daily lives. This study is an early study that presents a new process on the basic formula of kimchi, and the lack of case analysis can be seen as a limitation. In a follow-up study, we intend to add a diversity of cases by applying the formula to the various kimchi recipes.

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Authors' contributions

All authors contributed to the idea and overall construction of this manuscript. The authors reviewed and have approved the final manuscript and have agreed to the submission policies of the Journal of Ethnic Foods. Both authors read and approved the final manuscript.

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Availability of data and materials

The data are obtained from reviewing original research and review articles from national and international journals, the details of which are attached in the reference section.

Declarations

Competing interests

The authors declare that they have no competing interests.

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References

- Kang YS. S. Korea's experts of agricultural foods up 4.4 pct in H1. Yonhap News Agency. 2020. <https://en.yna.co.kr/view/AEN20200702003200320>.
- Nicki LC. Understanding acculturation and why it happens. Thought Co. Press. 2019. <https://www.thoughtco.com/acculturation-definition-3026039>.
- Noh BS, Seo HY, Park WS, Oh SS. Chapter 19—safety of kimchi (regulating safety of traditional and ethnic foods). London: Academic Press; 2016. p. 369–80.
- Lim JW. Vegan kimchi seasoning captures global palate. The Korea Herald. 2020. <http://www.koreaherald.com/view.php?ud=20200616000691>.
- Choi SK. Theory and practice of the sauce. Seoul: Hyungseul; 2008.
- Yang HJ, Chung KR, Kwon DY. DNA sequence analysis tells the truth of the origin, propagation, and evolution of chili (red pepper). J Ethn Foods. 2017;4:154–62. <https://doi.org/10.1016/j.jef.2017.08.010>.
- Koo OK, Lee SJ, Chung KR, Jang DJ, Yang HJ, Kwon DY. Korean traditional fermented fish product: jeotgal. J Ethn Foods. 2016;3:107–16. <https://doi.org/10.1016/j.jef.2016.06.004>.
- Lee CH. Kimchi, into the healthy daily life of people around the world. Shanghai: Herald Economy; 2020.
- Kwon DY, Jang DJ, Yang HJ, Chung KR. Story of Korea red pepper. Seoul: Hyoyil; 2011.

10. Hongu N, Kim AS, Suzuki A, Wilson H, Tsui KC, Park S. Korean kimchi: promotion healthy meals through cultural tradition. *J Ethn Foods*. 2017;4:172–80. <https://doi.org/10.1016/j.jef.2017.08.005>.
11. Kwon DY, Jang DJ, Yang HJ, Chung KR. History of Korean gochu, gochu-jang, and kimchi. *J Ethn Foods*. 2014;1:3–7. <https://doi.org/10.1016/j.jef.2014.11.003>.
12. Kim SI, Park JE, Yeom SI, Kim YM, Seo EY, Kim KT, et al. Multiple reference genome sequences of hot pepper reveal the massive evolution of plant disease resistance genes by retroduplication. *Genome Biol*. 2017. <https://doi.org/10.1101/115410>.
13. Jang DJ, Chung KR, Yang HJ, Kim KS, Kwon DY. Discussion on the origin of kimchi, representative of Korean unique fermented vegetables. *J Ethn Foods*. 2015;2:126–36. <https://doi.org/10.1016/j.jef.2015.08.005>.
14. Chin S (陳壽). The chapter of Dongyi in the book of the records of Three Kingdoms (三國志魏志東夷展). China. 3th Century, pp. 233–297.
15. Song HS, Whon TW, Kim JS, Lee SH, Kim JY, Kim YB, et al. Microbial niches in raw ingredients determine microbial community assembly during kimchi fermentation. *Food Chem*. 2020;318:126481. <https://doi.org/10.1016/j.foodchem.2020.126481>.
16. Codex standard for kimchi Codex standard 223. Codex Alimentarius commission (Codex). Rome: Food and Agriculture Organization of the United Nations; 2001.
17. UNESCO. 2020. http://www.unesco.or.kr/unesco/unesco_korea/ and <https://ich.unesco.org/en/8-representative-list-00665#8.23/>.
18. Yonhap News Agency. S. Korea's kimchi exports soar in H1. Yonhap News Agency. 2020. <https://en.yna.co.kr/view/AEN20200722000900320>.
19. Choi JY, Han GS. Structural analysis of cooking recipe texts-based on kimchi jjigae recipe-. *Korean J Commu Living Sci*. 2017;28(2):191–201. <https://doi.org/10.7856/kjcls.2017.28.2.191>.
20. Jeong SH, Lee HJ, Jung JY, Lee SH, Seo HY, Park WS, et al. Effects of red pepper powder on microbial communities and metabolites during kimchi fermentation. *Int J Food Microbiol*. 2012;160:252–9. <https://doi.org/10.1016/j.jfoodmicro.2012.10.015>.
21. Yi JH, Cho Y, Hwang IK. Fermentative characteristics of kimchi prepared by addition of different kinds of minor ingredients. *Korean J Food Cook Sci*. 1998;14:1–8.
22. Song HS, Whon TW, Kim JS, Lee SH, Kim JY, Kim YB, et al. Microbial niches in raw ingredients determine microbial community assembly during kimchi fermentation. *Food Chem*. 2019;318:126481. <https://doi.org/10.1016/j.foodchem.2020.126481>.
23. Lee ME, Song JH, Lee SH, Jung MY, Chang JY. Effect of seasonal production on bacterial communities in Korean industrial kimchi fermentation. *Food Control*. 2018;91:381–9. <https://doi.org/10.1016/j.foodcont.2018.04.023>.
24. Cho NC, Jhon DY, Shin MS, Hong YH, Lim HS. Effect of garlic concentrations on growth of microorganisms during kimchi fermentation. *Korean J Food Sci Technol*. 1988;20:231–5.
25. Seo YH. Antioxidant and antimicrobial activities of ginger with aging and fermentation. *Korean J Food Preserv*. 2017;24(8):1180–7. <https://doi.org/10.11002/kjfp.2017.24.8.1180>.
26. Lee SH, Kim SD. Effect of various ingredients of kimchi in the kimchi fermentation. *J Food Sci Nutr*. 1988;17(3):249–54.
27. Kim MH, Shin MS, Jhon DY, et al. Quality characteristics of kimchis with different ingredients. *J Food Sci Nutr*. 1987;16:268–77.
28. Jung MY, Kim TW, Lee CS, Kim JY, Song HS, Kim YB, et al. Role of jeotgal, a Korean traditional fermented fish sauce, in microbial dynamics and metabolite profiles during kimchi fermentation. *Food Chem*. 2018;265:135–43. <https://doi.org/10.1016/j.foodchem.2018.05.093>.
29. Lee CH. A study on the Korean temple kimchi with the change of global vegetarian consumption trends. Daejeon: National Research Foundation of Korea (NRF-2019S1A4A8034423); 2020.
30. Zabat M, Sano WH, Cabral DJ, Wurster JI, Belenky P. The impact of vegan production on the kimchi microbiome. *Food Microbiol*. 2018;74:171–8. <https://doi.org/10.1016/j.fm.2018.04.001>.
31. Cha YJ, Kim H, Cho WJ, Jung YJ, Lee YM, Kim EJ. A survey on the sensory preference for making summer kimchi by nationwide region. *J Food Sci Nutr*. 2003;32(3):393–9. <https://doi.org/10.3746/jkfn.2003.32.3.393>.
32. Jeong DY, Lee JH, Chung HJ. Analysis of targeted metabolites and molecular structure of starch to understand the effect of glutinous rice paste on kimchi fermentation. *Molecules*. 2018;23(12):3324.
33. Lee GC, Han JA. Changes in physical and microbial properties of starchy pastes added kimchi during fermentation. *Korean J Food Cook Sci*. 1998;14(2):195–200.
34. Lee GC, Han JA. Changes in the contents of total vitamin C and reducing sugars of starchy pastes added kimchi during fermentation. *Korean J Food Cook Sci*. 1998;14(2):201–6.
35. Kim HY, Kim BC, Kim MR. Physicochemical and sensory properties of kakkugi added with various thickening agents during fermentation. *J Korean Soc Food Sci Nutr*. 2001;30(6):1060–7.
36. Kim HY, Kim MR. Physicochemical and sensory characteristics of kakkugi added with xanthan gum during fermentation. *J Korean Soc Food Sci Nutr*. 2002;31(2):196–203. <https://doi.org/10.3746/jkfn.2002.31.2.196>.
37. Chang JY, Kim IC, Jang HC. Effect of solar salt on kimchi fermentation during long-term storage. *Korean J Food Sci Technol*. 2014;46(4):456–64. <https://doi.org/10.9721/KJFST.2014.46.4.456>.
38. Park IK, Kim SH, Kim SD. Effect of initial temperature of salt solution during salting on the fermentation of kimchi. *J Food Sci Nutr*. 1996;25(5):747–53.
39. Choi YM, Whang JH, Kim JM, Seo HJ. The effect of oyster shell powder on the extension of the shelf-life of kimchi. *Food Control*. 2006;17(9):695–9. <https://doi.org/10.1016/j.foodcont.2005.04.005>.
40. Shin TS, Park CK, Lee SH, Han KH. Effects of age on chemical composition in sun-dried salts. *Korean J Food Sci Technol*. 2005;37(2):312–7.
41. Park WP, Kim ZU. The effect of seasonings and salted-fermented fish on kimchi fermentation. *Appl Biol Chem*. 1991;34(3):242–8.
42. Ku KH, Cho JS, Park WS, Nam YJ. Effects of sorbitol and sugar sources on the fermentation and sensory properties of baechu kimchi. *Korean J Food Sci Technol*. 1999;31(3):794–801.
43. Furia TE, editor. Handbook of food additives, 2nd edn. Chapter 10. Polyhydric alcohols (Authors by W. C. Griffin, M. J. Lynch). Cleveland: CRC Press; 1972. p. 438.
44. Fennema OR, editor. Food chemistry. 2nd ed. New Year: Marcel Dekker. Inc.; 1985. p. 656.
45. Kwon DJ, Chang YS, Jo KS, et al. Effects of sugars addition on physicochemical characteristics and sensory evaluation of kimchi. *Korean J Food Nutr*. 1999;12(6):608–14.
46. Park LY, Jeong TS, Lee SH. Effects of chaenomelis fructus water extract on the quality characteristics of mul-kimchi during fermentation. *Korean J Food Preserv*. 2008;15(5):669–74.
47. Google Trends. <https://trends.google.com/trends/explore?q=kimchi>. 29 April 2020.
48. Maangchi. <https://www.youtube.com/user/Maangchi?gl=KR&hl=ko>. 29 April 2020.
49. Bryan C. 7 YouTube channels that will teach you how to cook. 2020. <https://mashable.com/article/best-youtube-cooking-channels/>.

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