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Jang, Korean fermented soybean product, the result of endeavors of ancients for the best taste of Korean diet

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Abstract

Each ethnic group has developed a food culture that enjoys delicious food by consuming natural materials or agricultural products from their respective regions. Because soybeans originated in Korea and are abundant there, a way to make delicious soybeans has been developed. *Jang* is a food made by fermenting soybeans, and representative types include *doenjang*, *gochujang*, *kanjang*, and *cheongkukjang*. Koreans usually season their food with *jangs* instead of salt. The representative seasoning of Korea traditional food is *jang* and *yangnyom*. When soybeans are fermented, soybean proteins decompose and produce fermentation by-products such as peptides, amino acids, and organic acids that provide new taste and flavor. Therefore, seasoning with *jang* provides a much richer taste than salt alone. *Jang* is an essential element of Korean food, adding taste and flavor to other dishes. Since *jang* is the most important and widely used food in Korean cuisine, Koreans have devoted all their efforts to making *jang*. These efforts include cleaning the surrounding environment, hanging *meju* (the blocked soybean) under the roof to dry, using charcoal and red pepper, and more. From a modern scientific perspective, their earnest devotion served functions of hygiene, moisture control, microbial inoculation, and salt control. *Jang* is a unique Korean food culture born from the tireless efforts of Korean mothers to feed their families with the most delicious food possible, even during times of food scarcity when they had to survive on rough grass.

Keywords Soybean, *Jang*, *Doenjang* (soybean paste), *Kanjang* (soy sauce), *Gochujang* (red pepper paste), *Cheongkukjang*, *Meju* (block made with cooked soybean), *Kan* (Salinity in Korean food), Fermentation

Introduction

Direction of world food development: background for the birth of ethnic food

The development of food culture is one of the greatest contributions to human progress. Available edible resources vary according to the natural environment

in which humans live. This means that the biological resources that can be obtained from the surroundings are different depending on the geographical environment and climatic conditions such as beaches, land, plains, and mountains. Food materials vary from region to region, but the process of making and developing food has a consistent direction everywhere in the world. Food is born in the process of solving the following three challenges [1].

Firstly, the challenge of satisfying hunger must be addressed, and the food must be edible and safe to consume to prevent anyone from getting sick or dying from it. *Secondly, how can we make food more delicious?* The initial task for humans was to satisfy their hunger, but once this was accomplished, they wanted to enjoy their

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food. The concern of gourmets about how to make the same ingredients more delicious is a human instinct that has been passed down from ancient times to the present day. *Thirdly, how can we safely eat leftovers later?* Food is not always available, especially in the case of ingredients with a short shelf life, such as hunted meat, fruits, and vegetables, which spoil quickly. Therefore, it was difficult to save leftovers for the next time when food was scarce. Every region or nation in the world develops food by addressing these concerns, and the process of solving these three issues is called food development. Food is made according to the conditions and environment of the region, and each region has its unique characteristics, which is what makes ethnic food.

The discovery of fire in the Paleolithic era solved the first two problems of hunger and taste. Eating uncooked rice, beans, or meat can cause stomach upset and can sometimes be life-threatening. Cooking food over fire made it safe to eat, and the taste also improved. Heating with fire sterilizes microorganisms, making food safer. In addition, as proteins are denatured by heat, digestion and absorption are improved by facilitating the action of digestive enzymes, and the taste is enhanced. For instance, in the case of raw soybeans, their strong fishy smell and trypsin inhibitors make them difficult to eat, causing indigestion and upset stomach. However, when cooked over fire, lipoxigenase and trypsin inhibitors are inactivated, making them both delicious and safe to eat [2]. Therefore, the discovery and use of fire became a significant turning point for soybeans to become a part of the human diet and paved the way for humans to safely consume food.

In human history, as the availability of food increased, the population also grew rapidly. However, food shortages have been a universal problem in all eras around the world. Moreover, natural disasters such as floods and droughts have exacerbated food shortages beyond human control. In such circumstances, people had to cope with hunger by consuming any organisms around them. Not only natural conditions, but also man-made situations have led to food shortages. During the Bronze and Iron Ages, after the Paleolithic and Neolithic Ages, this increased the scale of war and resulted in more casualties. In fact, as genome analysis using ancient DNA has shown (see Fig. 4 in reference [1] also see the reference [3]), female genetic diversity and population size continued to increase over time, while males showed some inflection points. There is also a point where the diversity and size of males decline rapidly, corresponding to the Bronze/Iron Age around 5000 BC [3]. The rapid decline in such trends may not have occurred without male genocide. Meanwhile, the female population has steadily increased over the same period. Combining these results,

it can be inferred that during war, men were slaughtered while women were subjected to humiliation by the invaders. As a result of genetic analysis of ancient people, it was revealed that the Korean people, which were considered to be a single race and single lineage, were gradually genetically mixed [1, 4].

The Korean language and food culture were vastly different from China, a neighboring country. Korea spoke the Ural-Altai language and used oil sparingly for cooking. Vavilov, a Russian botanist who first visited Korea in the early 1900s to investigate plant resources, expressed surprise in his travel essay at the fact that Korea, China, and Japan were geographically close yet had very different cultures and languages [5]. Before the results of genetic analysis emerged, it was believed that the unique culture of Korea had been preserved and inherited through the pure blood lineage of Koreans [6]. However, like other countries in the world, genetic analysis of ancient people has revealed that the Korean people have become blood-mixed due to numerous wars and foreign invasions and cannot be considered a single lineage [1]. Nonetheless, the language, culture, and food have been preserved at the level of a single ethnic group and are completely different from those of China. It can be inferred that even though men died and women were humiliated due to numerous wars and invasions between tribes, the culture, language, and food were preserved. In many cases, invaders would have killed husbands and sons, leaving it to women to bear the responsibility of giving birth to, raising, and even saving the children of the invaders. Therefore, it is believed that the uniqueness of food, culture, and language has been maintained by women. The massacre of men also meant that the food supply for the remaining women and their children became very difficult, given that men were primarily responsible for hunting, farming, and providing food for their families. In this way, not only natural disasters but also man-made environments such as wars continued to cause shortages of food resources. In such extreme environments, mankind would have been forced to eat plants such as grass and trees, insects, and even strange creatures on the beach as food to survive. However, things like grass and tree sprouts are usually tasteless, rough, and crude, so people do not want to eat them unless they are short on food. Since they had to force themselves to eat these hard-to-eat things to survive starvation, the remaining women were in charge of making them as edible as possible, and food may have developed in the process of resolving these problems. The food, lifestyle, and culture that can be encountered are different depending on the environment of each region and ethnic group. Ethnic foods have been developed according to the given environment. In other words, ethnic food is a product of efforts to cope

with and overcome food shortages, and at the same time, it would be a tradition created by accumulated wisdom that actively survives in the given geographical and natural environment [1].

Korean ethnic food: characterized by vegetables, soybeans, and the fermentation products

From ancient times to modern times, Korea has always faced food shortages. Korea is an agricultural culture, and rice is the staple food. As rice farming requires a lot of water, plains are suitable for rice cultivation. However, in Korea, mountainous regions account for about 65% of the total area (data was supplied from Forest Status, Korea Forest Service), and the northern region, in particular, is not suitable for rice farming due to climatic and geographical conditions resulting from the high latitude. Consequently, rice, as the staple food, was often in short supply, and meat was even scarcer. People had to satisfy their hunger with grains such as beans, millet, or wild grasses from the mountains and fields. Oil (for frying) and sugar, two ingredients universally loved by mankind, were also in short supply. When fried in oil, food can be cooked at high temperatures, producing aromatic components that improve the flavor of the food while removing moisture for later consumption. In addition, sweet ingredients such as sugar improve the flavor of food and lower the water activity in sugar-sweetened foods, making them suitable for later consumption. However, Korean ancestral mothers had to make food delicious without relying on sugar or oil as flavoring ingredients. While palm oil, soybean oil, rapeseed oil, sunflower seed oil, and palm kernel oil are among the most commonly used edible oils worldwide [7], they either do not exist or exist in very small amounts in Korea. Although there were plenty of soybeans, Koreans mainly used them to make tofu or *jang*, rather than extracting oil from them. Instead, sesame and perilla oils are the main oils used in Korea. These oils are not suitable for high-temperature heating but are used in small amounts to flavor food [8]. Moreover, meat was a rare commodity in Korea as there were no large grasslands and the livestock industry was not well-developed. In Korea, cows were mainly used for agricultural purposes and were raised as bulls, not for meat production, which meant that they could not produce much milk. As cattle played a vital role in crop production, they were not allowed to be slaughtered, making it uncommon for ordinary people to consume beef [9]. It was not until the twentieth century that group breeding of chickens or pigs became possible after being introduced from the West. Before then, it was challenging to find a lot of chicken or pork to eat.

On the other hand, soybeans are native to Korea and were relatively abundant. There are three reasons

why Korea can be considered the country of origin for soybeans.

Firstly, the distribution of wild species is used as an important indicator for estimating the birthplace of crops in botany. Scholars define the place where wild, intermediate soybeans, and cultivated soybeans grow in one place as the place of plant origin, which applies to the Korean Peninsula and Manchuria as the origin for soybeans [1, 10, 11]. In his 1926 article, "The Origin of Cultivated Crops," Russian botanist Vavilov stated that the region with abundant crop variation and primitive dominance is the place of plant origin. In this respect, Manchuria and the Korean Peninsula, where wild soybeans are most widely distributed, are considered to be the origins of soybeans [5]. Soybeans are a representative pulse, along with lentils in India and chickpeas in Egypt and the Middle East. Soybeans have been around for hundreds of years before humans appeared on Earth, but each type of soybean grows only in a specific area because soybeans cannot be transplanted without human intervention. Peppers, which appeared on Earth at the same time, were spread by birds, not humans, for millions of years. Since they have already developed into more than 100 varieties, the origin of peppers cannot be specified [1]. With the recent development of life science technology, it has become possible to identify the country of origin for soybeans through genome analysis. Korean soybeans were found to be located in the early stages of the evolutionary tree [12]. Just as the analysis of the human genome revealed the human migration out of Africa (See Fig. 4 in the reference [1]), this finding suggests that soybeans might be native to Manchuria and the Korean Peninsula.

Secondly, it can be known through literature records in the Chinese book *Kwanja* (管子) that the Duke of Qi (齊桓公, BC. 685~643) attacked Shan rong (山戎) in the north and brought winter onions and Rong shu (戎菽), which he spread all over the world (北伐山戎, 出冬蔥與戎菽, 布之天下) [13]. This means that after conquering Shan rong, the Duke brought soybeans, which were a specialty of the region, and introduced them to China. The *YiZhouShu* (逸周書), a history book of the Chinese Zhou Dynasty recorded in the sixth century B.C., mentions that "Shan rong is a Northeast barbarian, and Rong shu is produced. Rong shu means a large soybean (山戎, 亦東北夷. 戎菽, 巨豆也)" [14]. Kwak Park (郭璞: 276–324) of China's Qin Dynasty recognized the newly introduced Rong shu (戎菽) as a large soybean. He did not use the word 菘菽, which was used to describe beans in the Book of Poetry (詩經), but used the term 戎菽 [13]. By combining the records in these books, it can be seen that Shan rong's soybeans were recognized differently from the existing Chinese beans in the eyes of the Chinese. They were brought into China and spread because they were

larger and of better quality. Shan rong is a region in Manchuria where the territory of *Gojoseon*, an ancient Korean state, was located, and it is also connected to the cultural sphere of *Goguryeo* and *Balhae*. In the soybean section of the Chinese agricultural book *Cheminyosul* (Ka, 齊民要術, 532), it was written that there were two types of soybeans—white and black soybeans—and three types of small beans: green, red, and white beans. The yellow and black soybeans of *Goguryeo* were introduced first as soybean varieties (今世大豆有白. 黑二種及長梢牛踐之名. 小豆有菘. 赤. 白三種. 黃高麗豆黑. 高麗豆. 鶯豆. 豌豆, 大豆類也) [15]. The author of this book intentionally added the name *Goguryeo* (the ancient dynasty of Korea) to the name of soybean. This suggests that *Goguryeo* was the origin of soybeans, where soybeans were produced and consumed the most, or that processed products or soybeans of exceptional quality were produced [13].

Thirdly, carbonized soybeans, which are the remains of soybeans, have been consistently excavated on the Korean Peninsula from the Neolithic Age to the Bronze Age [16]. Even relics of soybeans from around the third century AD have been found, which are presumed to be *Meju*, a type of dough made by crushing moist soybeans. This suggests that not only were soybeans cultivated, but they had also become so commonplace that Koreans were consuming soybean-based dishes [17]. Since Manchuria and the Korean Peninsula are the origins of soybeans, soybeans are relatively abundant in Korea. As a result, Korea has been able to develop soybean-based foods such as *tofu*, *doenjang*, and *kanjang* since ancient times.

Fermented foods were discovered accidentally as a way to store food for later consumption. Over time, the taste and aroma of the food changed, resulting in a desirable flavor without the risk of food poisoning. As a result, this method was continued and fermented foods were born. In the West, yogurt and cheese were discovered through the process of storing milk-based leftovers. However, as Koreans traditionally consume less milk, plant-based fermented foods have developed, such as *Jang* (fermented soybean paste) and kimchi (fermented cabbage), which are the representative fermented foods of Korea.

In the past, Korea faced food shortages and had to rely on coarse, wild vegetables for sustenance. However, these vegetables were often difficult to eat due to their rough texture and lack of flavor. Consequently, mothers made constant efforts to cook these ingredients deliciously and provide for their families. These efforts to overcome food scarcity and improve flavor represent the history of Korean food development. Through the accumulation of knowledge and wisdom, they have become the traditions and culture of Korean food. The abundant natural environment of Korea's mountainous areas and fields has led

to the use of many vegetables and the development of fermented soybean foods, making these two characteristics the defining features of Korean national food [8].

What is *Jang*?

Introduction of representative *Jangs*

Jang is an essential element of Korean cuisine, used to season other foods and enhance their flavor. While the concept may be similar to sauces or dressings in Western cuisine, those are typically made by simply mixing liquid or powdery seasonings. In contrast, Korean *Jang* is a fermented food, in which the original ingredients are transformed into new metabolites through the fermentation process. The resulting food has a taste and aroma completely different from the original.

Jang can be classified according to the ingredients and fermentation method (Fig. 1). *Cheongkukjang*, *doenjang*, and *kanjang* are made using only soybeans as the main ingredient, while *gochujang* is made by adding red pepper powder to soybeans and fermenting them. Additionally, *Jang* can be divided according to whether or not salt is added. *Cheongkukjang* is fermented without salt, resulting in a short fermentation time and a short shelf life, typically lasting only a few days. In contrast, *Jangs* fermented with salt have a slower fermentation process due to the presence of salt and can be fermented for 6 months to 1 year. Salted *Jang* has a longer shelf life and can be stored for more than a year. Here are some additional characteristics of each type of *Jang*.

Cheongkukjang

Cheongkukjang is a fermented food made by placing boiled soybeans on rice straw and leaving them in a warm place at 40–50 °C for 2–3 days (Fig. 1). *Cheongkukjang* is believed to be the first type of *Jang* to have been made because it is the simplest form of fermentation. During the fall harvest, soybeans were boiled, and the leftovers were kept in the room to prevent mice from eating them. After a few days, the appearance and smell of the food changed, and it resembled spoiled beans. However, it was considered a waste to throw it away. Not only does *cheongkukjang* not cause stomach upset, it also seems to taste even better when cooked in a soup or dish with broth, known as *kuk* in Korean cuisine. Despite its initial discovery being accidental, *cheongkukjang* gradually became a deliberately made food due to its unique taste and texture. Unlike other *Jangs*, *cheongkukjang* is not made with salt and therefore has seasonal restrictions as spoilage occurs faster after fermentation in warmer seasons. In fact, *cheongkukjang* was not initially categorized as a *Jang* until the early *Chosun* Dynasty and was simply called *Cheongkuk*, as it was mainly eaten by itself rather than used as a seasoning for other dishes. Over time, it

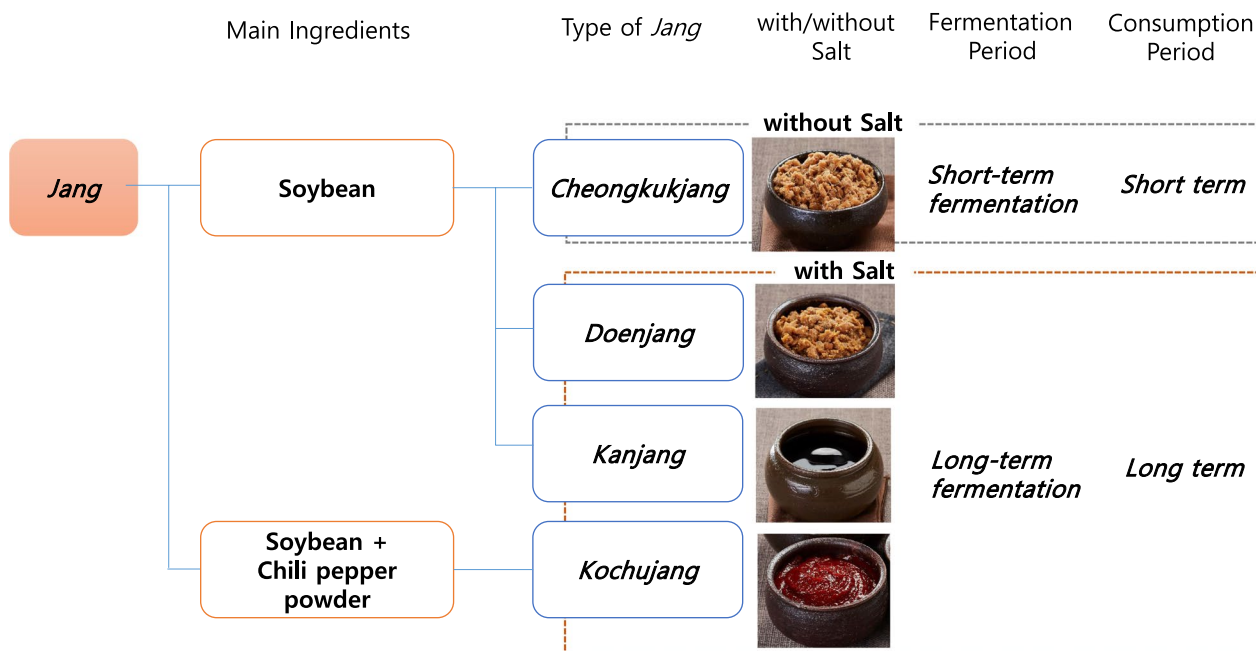


Fig. 1 Jang classifications according to ingredients and fermentation methods. *Cheongkukjang*, *doenjang*, and *kanjang* are fermented using only soybeans as the main ingredients, and *gochujang* is made by adding red pepper powder to soybeans (*meju* powder) and fermenting them. Also, the *Jangs* can be divided according to whether salt is added or not. *Cheongkukjang* is fermented without salt, and *doenjang*, *gochujang* (called as *Kochujang*), and *kanjang* are fermented with salt. *Cheongkukjang* is fermented in a short time and consumed within a few days, while *doenjang*, *gochujang*, and *kanjang* go through a long fermentation period of 6 to 12 months and are edible for more than a year

was classified as a *Jang* and renamed *cheongkukjang*. [1]. The main way of consuming *cheongkukjang* is by boiling it with vegetables to make *kuk* or *chigae* (dishes with broth). Microorganisms present in the rice straw laid under the boiled soybeans are naturally transferred to the soybeans and inoculated for natural fermentation. *Bacillus subtilis* is the main bacterium responsible for the fermentation of *cheongkukjang* [18, 19]. When soy protein is fermented by microorganisms, it produces thread-like mucoid. Its main component is poly- γ -glutamic acid (PGA), which is known to have an immune-enhancing effect [20]. In addition, isoflavones, which are functional components of soybeans, exist as β -glucoside conjugates and have a low absorption rate. However, when soybeans are fermented into *cheongkukjang*, they are converted into aglycones such as daidzein, glycitein, and genistein by the β -glucosidase of microorganisms, increasing the absorption rate [21].

Doenjang and Kanjang

Cheongkukjang has the disadvantage of being difficult to preserve for a long time because it easily deteriorates after fermentation. Boiled soybeans can be eaten later if they are dried well, but parts that are not completely dried may become rotten and inedible. Especially during the drying process, the parts that come into contact with

the solid surface do not dry well and are prone to rotting. However, Korean ancestors knew that boiled soybeans dried better on rice straw. This was because the gaps between the rice straw allowed the wind to pass through and ventilate the soybeans. Our ancestors also discovered that if boiled soybeans were crushed into lumps (*meju*), tied with rice straw, and hung under the roof, they would be well ventilated and dried without rotting. Moreover, they may have noticed that fermentation worked better if the *meju* was allowed to dry moderately slowly. If the *meju* was dried too quickly in the sun, it would split and break, and microorganisms would not have enough time to grow and ferment, resulting in a deteriorated taste of *Jang*.

Well-dried *meju* can be stored for a long time, but it has no taste. Salt enhances the taste of food and allows it to be stored for a long time. However, our ancestors used salt water because the salt would not dissolve or be absorbed if added directly to the dried *meju*. *Meju* was soaked in salt water for several days to several months to absorb the salty taste, and fermentation had to occur in it. The solid matter that sinks to the bottom has a '된 (*doen*)' physical property. '된' (*doen*) is the adjective form of '되다 (*doeda*)', and it means (dough, etc.) thick or stiff due to low moisture. Therefore, it is called '된장 (*doenjang*)' (Fig. 1). The above liquid was originally salt water

and tasted salty, so it was suitable for adjusting 간 (*kan*; the salinity of food), which is called '간'장 (*'kan'jang*).

As seen above, *doenjang* and *kanjang* are made at the same time, similar to the process of making *cheongkukjang* where soybeans are first steamed. However, unlike *cheongkukjang*, which undergoes a single fermentation process, *doenjang* and *kanjang* undergo two stages of fermentation. The first stage involves the production of *meju* by steaming soybeans, weaving them with rice straw, and drying them. The second stage involves soaking the *meju* in salty water and allowing it to ferment for over six months [22]. Over the course of several months of fermentation, the components in the soybeans undergo a non-enzymatic browning reaction and dissolve into the brine. This process results in the initially transparent brine turning into dark brown *kanjang*, acquiring a new flavor (Fig. 1).

Gochujang

Unlike other *Jangs* that only ferment soybeans or add salt to soybeans, *gochujang* (also translated as red pepper paste) is fermented by adding red pepper powder to *meju*. To make *gochujang*, *meju* is ground into powder so that the red pepper powder and *meju* are evenly mixed, unlike *doenjang* which uses dried *meju* as it is. *Gochujang* is made by mixing *meju* powder, red pepper powder, water, and salt thoroughly, and then fermenting it in a jar for more than six months. Rice flour and malt are often added together and fermented to improve the taste of *gochujang* by adding sweetness and umami. The color and taste of *gochujang* are distinct from those of other *Jangs* because the red color and spicy taste of the red pepper powder are directly transferred to the *gochujang*, as shown in Fig. 1.

Only Korean red pepper is suitable for making *gochujang*. The development of all food products is based on the characteristics of local produce. In other words, *gochujang* was able to be made because there was Korean red pepper powder. While there are over 100 types of pepper in the world, if Peruvian or Indian peppers were in Korea, a food like *gochujang* may not have been created. Red pepper paste made with such peppers can be fatally spicy. Kimchi and *gochujang* were able to be created because of Korean peppers. Red pepper, which has grown naturally in Korea for 500,000 years, is a type of *Capsicum annuum* L. and has a moderately spicy taste. Thus, even when a lot of red pepper is added, like in *gochujang* or kimchi, the food remains moderately spicy [23]. Peppers that are too spicy, such as those from Southeast Asia or South America, cannot be used as the main ingredient in food because only a small amount can be added to flavor the food.

Through the analysis of genetic diversity of various pepper varieties belonging to *Capsicum annuum*, it was found that Far East Asian peppers might be clustered separately, centered on Korean red peppers [24]. This suggests the unique characteristics of Korean red peppers that are suitable for making *gochujang*. The average capsaicinoid content of general pepper powder used in Korean food is about 100–200 ppm, which corresponds to about 2,300–5,200 on the Scoville scale [25, 26]. Since the water content of fresh pepper is over 90% [27], the capsaicin content of fresh pepper is about 10–20 ppm. Considering that the Scoville index of less than 5,000 belongs to the mild grade, it can be seen that the spiciness of Korean peppers is at a level that can be enjoyed even with a large amount added. For *gochujang* and kimchi, which use red pepper powder as the main ingredient, the capsaicin concentrations are usually 41.4–58.3 ppm and 3–15 ppm, respectively, which are 2–10 times less spicy than red pepper powder itself [25, 28]. The red color of the pepper paste also has an appetizing visual effect.

The spicy taste of *gochujang* stimulates the appetite, making it a popular dipping sauce for raw fish or vegetables. *Gochujang* also gave rise to a dish called *bibimbap*, where leftover side dishes are mixed with rice and *gochujang* to create a new meal. Additionally, *gochujang* is used in other dishes like *bibim* noodles or *gochujang chigae*. In summary, *Jang* has allowed Koreans to enjoy *namul* (greens) [29] and vegetables in new and exciting ways by combining them with different types of *Jang*.

On the other hand, *gochujang* has been used as a medicinal food. This is because serving boiled *chigae* (dishes with broth) with *gochujang* to patients who have lost their appetite due to illness stimulates their appetite, helping them to eat well and facilitating intestinal movement to aid digestion. In the *Yangrobongchinseo* (養老奉親書) chapter of *Hyangyak-jipsongbang*, a Korean medical book that lists medicinal herbs for doctors, a porridge made with carp, rice, tangerine peels, green onions, and *gochujang* was recommended for elderly people who suffer from loss of appetite or dysentery [30]. *Chojang* (椒醬) and *chosi* (椒豉) are fermented soybean products used in the making of *gochujang*, and were introduced in the *Euibangyuchi* (醫方類聚), a Korean medical encyclopedia from 1445, during the 27th year of King Sejong's reign. The book recommended a dish made with *gochujang* and rice (*hwangjagyegogi*, 黃雌鷄肉; similar to modern Korean spicy chicken stew) for elderly people with weak spleens and stomachs [31]. According to the *Siknyochanyo* (食療纂要, 1460), *Uirimchwalyo* (醫林撮要), and *Sauigyeongheombang* (四醫經驗方), which are medical books, boiling and eating *chigae* with *gochujang* was advised for stimulating appetite by restoring energy

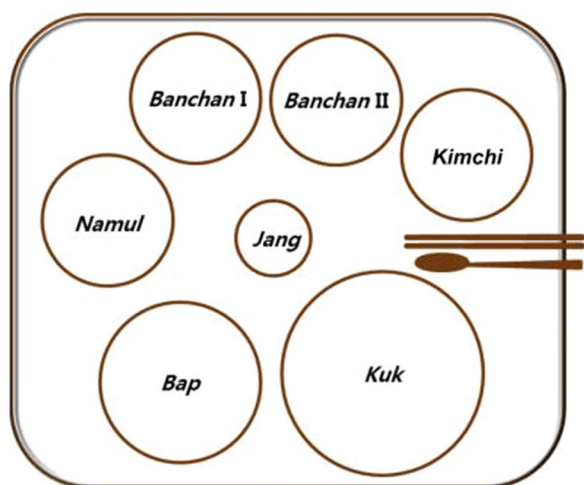


Fig. 2 The structure of Korean diet. Korean diet consists of *bap* (cooked rice) and *banchans* (side dishes). In more detail, *banchans* are comprised of *kuk*, one type of kimchi, one *namul*, one vegetable dish (*banchan I*), and one high protein dish (*banchan II*), usually made from fish or meat. *Jang*, or salted dishes such as *jeotgal*, are used to season food and stimulate one's appetite. Adapted from Kim et al. [1, 8]

and promoting digestion in cases of indigestion or loss of appetite due to poor stomach or digestive organs [32].

Why *Jang* is important?

Role of *jang* in Korean Cuisine

Jang was first prepared accidentally when it was stored for later consumption, but since then it has become an indispensable ingredient in Korean cuisine. Korean food consists of *bap* (cooked rice) and *banchans* (side dishes) (Fig. 2) [8]. The way to eat Korean food is to take *bap* and *banchans* at the same time. *Bap* is a food cooked by boiling only rice, and it has a simple and mild taste because no salt is added. On the other hand, *banchans* are a bit salty on their own, but when eaten with *bap*, they have a very appropriate level of saltiness. The staple food in Korean cuisine is *bap*, but it is always eaten with *banchans* rather than alone. Therefore, *banchans* are important to enjoy a delicious meal. *Jang* plays a role in enhancing the flavor of *banchans*.

Korea has the highest vegetable intake in the world among OECD countries [33], and *namuls* are considered to be the driving force behind consuming a lot of vegetables [29]. *Namul* originated from poor people who had nothing to eat in the past and had to appease their hunger with grass from the mountains and fields. Generally, *namuls* were not a highly preferred food because they were rough, bitter, and had a strong scent. Nevertheless, even in modern times, with abundant food, *namul* has become a representative food of Korean cuisine. It is no longer just food for the poor. This is because *namuls* have

developed into delicious dishes with the help of *Jang*. In *Mokminsimseo* (牧民心書), the author gave the following advice: "In years of poor harvest, people replace food with *namuls*, but they are difficult to swallow without adding salt. At that time, the price of salt will be expensive, so make plenty of *Jang* in advance" [34]. As seen in this book, people had to prepare *Jang* to eat *namuls*, and *Jang* was an indispensable element for enjoying *namuls*.

An important concept in Korean cuisine is '간 (*kan*)'; and when the salinity of food is appropriate, it is expressed as '간이 맞다' (*Kan* is suitable; Salinity of food becomes appropriate) [1]. Proper *kan* for Koreans is the standard for completeness and taste of a dish [35]. Worldwide, salt is mainly used to control the salinity of food. When seasoning Korean food, salt is rarely used, but *Jang* is often used for seasoning. *Kanjang*, *gochujang*, and *doenjang* all contain salt, so the food is basically seasoned with *Jang*, and the rest of the seasoning is adjusted additionally with salt if it's not enough.

In fact, *kanjang*, *gochujang*, and *doenjang* are the most commonly consumed *yangnyeom* (seasonings) by Koreans on a daily basis, in that order. The combination of these three *Jangs* is consumed more than 10 times as much as salt (Fig. 3) [36]. *Ssamjang*, the fifth most commonly consumed seasoning, is made by mixing *doenjang* and *gochujang*, so it can also be considered as consumption of both *doenjang* and *gochujang*. As per the survey of frequently consumed foods in Korean cuisine, *kanjang* was ranked 4th, *gochujang* 17th, and *doenjang* 27th, which indicates the significant role of *Jangs* in Korean food [36].

Except for rice, most Korean dishes such as *kuk* (broth-based dishes), kimchi, *namul*, stir-fries, *chigae*, and grills [8] are seasoned with *Jang*, making it an essential ingredient to enhance the taste of other foods. This is why there is a Korean proverb that says, "The taste of food depends on *Jang*." The cookbook "Chosun's Incomparable Up-to-Date Cookbook" (朝鮮無雙新式料理製法, 1924), which recorded Chosun cuisine, states, "*Jang* is added to various dishes for seasoning and taste. Therefore, it is the most important ingredient among Korean foods and must be prepared with the utmost sincerity in family affairs. *Jang* must be made at the right time, without missing the timing" [37]. *Jang* occupies an important position in Korean cuisine to the extent that it is considered the best ingredient among all foods.

Also, the *Jeungbosanrimgyeongje* (增補山林經濟, 1766) states that "*Jang* (醬, fermented soybean) is *Jang* (將, a commander of an army)." This implies that *Jang* is the ultimate commander of all taste. If the flavor of the *Jang* is not good, even good vegetables or delicious meat cannot make a good dish. According to the same book, even if the villagers cannot easily obtain meat, they do not

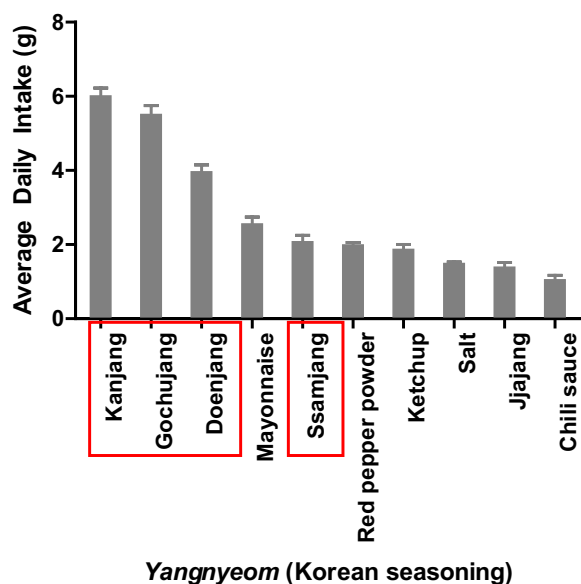


Fig. 3 A survey on daily average seasoning consumption by Koreans. The seasonings used most by Koreans were *kanjang*, *gochujang*, and *doenjang* in that order. The combined daily intake of *Jangs* is more than 10 times the salt intake. *Ssamjang* is made by mixing *doenjang* or/and *gochujang*, which is added on grilled meat or barbecue during wrapping them with perilla leaf Modified from Korea Health Industry Development Institute [36]

have to worry about *banchans* (side dishes) if there are various *Jangs* available [38]. This record highlights how highly Koreans value *Jang* and its importance in Korean cuisine.

Why do Koreans season with *Jang* instead of salt?

Foods such as *namul* [29], made with edible grass from mountains and fields, were a necessity in times of scarcity. Korean ancestors expected mothers to cook these tough and less favored ingredients as deliciously as possible. *Jang* contains various metabolites produced by the breakdown and fermentation of soybean protein, giving it a rich flavor. Seasoning with *Jang* enhances the flavor of other foods much more than simply using salt. As a result of analyzing *Jang* components, by-products were produced after fermentation that were not originally present in soybeans. Sensory tests showed that these by-products enhance the taste of food [39].

The representative taste components of *kanjang* are amino acids and organic acids, such as glutamic acid, methionine, and oxalic acid. These components are known to be produced when soy protein breaks down into amino acids by fungi, such as *Aspergillus oryzae*, during fermentation [40, 41]. An analysis of the major taste components of *doenjang* revealed threonine and maltose as sweet tastes, aspartic acid and glutamic acid

as savory tastes, salt as a salty taste, and tryptophan as a bitter taste [42, 43]. It appears that these components combine to create the taste of *doenjang*. *Gochujang* is fermented by adding red pepper powder and malt to the ingredients of *doenjang* and *kanjang*. However, *gochujang* has a distinctly different taste from *doenjang* and *kanjang* because it also contains the spicy component of red pepper. Capsanthin, a pigment in red pepper, gives *gochujang* its characteristic red color. Foods seasoned with *gochujang* naturally turn red, making them more appetizing.

Jang, the most meticulously prepared food in Korean cuisine: science in sincerity

Korean food is often described as having the taste of a mother's hand, while Chinese food is often characterized as having a "fire" taste. The former refers to the taste born of a mother's sacrifice and sincerity to feed her family despite difficult economic conditions, while the latter emphasizes the taste of food cooked in oil at high temperatures. *Jang* was developed as a way to create delicious food even in situations where high heat and sugar, which are elements that enhance flavor, cannot be used. As mentioned earlier, Koreans season almost all their food with *Jangs*, meaning that *Jangs* play a vital role in determining the taste of Korean cuisine. Given the importance of *Jang* in Korean cuisine, it is no surprise that Koreans place great emphasis on making it delicious.

In addition, there is another important reason why making delicious *Jangs* is crucial. As previously mentioned, *Jangs*, other than *cheongkukjang*, require at least six months to ferment. If people fail to make delicious *Jang*, they must wait another six months or more. The fermentation of *Jang* is influenced by weather conditions, especially temperature, which directly affects the growth of microorganisms. In Korea, *Jang* is traditionally made during late fall to early winter. If *Jang* fermentation fails, it cannot be immediately remade, and people must wait until the next fall, effectively a year, to try again. Even if *Jang* is successfully made the following year, it still requires six months to ferment properly.

The same goes for materials. Once made, *Jangs* are eaten for the next year, so the amounts required are for one year. When food was scarce, it was a huge loss to ruin a year's worth of food by throwing the *Jang* away. Therefore, *Jang*-making was an extremely important task for Koreans, both to season food deliciously and to prevent failure due to materials and time.

However, since *Jang* is a fermented food, human efforts alone are not enough; fermenting microorganisms are needed. Today, industrially produced fermented foods go through a process of sterilizing raw materials and inoculating selected microorganisms, but in the past, natural fermentation by microorganisms existing in nature took

place. Therefore, if any of the factors, such as quality, hygiene, temperature, moisture content, and salt concentration, are not satisfied, fermentation will not be performed properly. While it is possible to make other foods taste good with a chef's efforts, fermentation cannot be controlled in the same way. When all the ingredients are mixed and fermentation begins, people have to leave everything to the fermenting microorganisms and wait for a long time. Thus, Koreans use the term '부정탄다 (*Bujeongtanda*)' to express poor fermentation, which occurs when *Jangs* are not properly made due to the propagation of putrefactive bacteria [44]. This term is used in folklore to imply that evil spirits have come and caused misfortune. Despite their best efforts, people believed that something bad had come and ruined the *Jang*. Therefore, our ancestors thought that in order to prevent the ruin of *Jang*, they should take measures to prevent the entry of evil spirits or the wrath of evil spirits. Therefore, our ancestors tried to be sincere when making *Jang*. They chose a day when no evil spirits were believed to come (expressed as 'a day without Sohn' in Korean), made *Jang* on that day, and took a bath before making it. It was believed that if sincerity was lacking, evil beings would come and ruin the *Jang*. The words that our ancestors used most often when making *Jang* were 'be sincere' and 'don't let bad luck come' [44]. This thinking may be considered superstitious, but from today's scientific perspective, there is a rational aspect to this sincerity in making *Jang*.

Clean body and mind: hygiene

In the case of *cheongkukjang*, it was important to clean the room and environment before making the *Jang* in order to prevent bad luck and also to prevent the growth of harmful bacteria. This is because *cheongkukjang* is made by fermenting steamed or boiled soybeans in a warm *Ondol* room, which is an ideal environment for bacteria growth [45]. Therefore, by cleaning the environment and preventing the entry and growth of harmful bacteria, the fermentation process can proceed smoothly without any contamination. Similarly, taking a bath and wearing clean clothes before making *Jang* was also part of the folk belief asking for mercy from the gods, but it also contributed to good fermentation by ensuring the hygiene of the cook and preventing contamination of the food. From a scientific perspective, these efforts were rational and beneficial for the fermentation process.

Sincerity in making and drying *meju*: control of water content and starter inoculation

In the old days, people were concerned that if they dried *meju* on the floor, it would be contaminated with bad luck. Therefore, *meju* was dried on clean rice straw to

prevent this. Placing *meju* on top of the straw allowed for proper ventilation through the gaps between the rice straws, resulting in better drying. If *meju* is not dried well, spoilage bacteria will quickly multiply, rendering it unusable. Lightly dried *meju* is tied with straw and hung in the shade under a well-ventilated roof to dry slowly. This process is so elaborate that if *meju* is dried too quickly or too slowly, it cannot ferment properly [22]. If *meju* is dried too quickly in the sun, the fermenting starter bacteria cannot grow properly. Korean ancestors knew nothing about fermentation and microbes, but their method of drying *meju* was suitable for an exquisite control of its moisture content. It has been reported that microorganisms such as *Bacillus subtilis* are primarily involved in the fermentation of *meju*, and these bacteria are present in rice straws [19]. Therefore, when *meju* is tied with rice straw and hung, the bacteria present in the straw naturally transfer to the *meju* and proliferate, playing a similar role to starter inoculation in modern fermentation science.

The day without Sohn: weather and fermentation temperature

Sohn refers to an evil spirit that wanders around and disturbs or harms people. Therefore, a "day without Sohn" means a day when these evil spirits do not roam and do any harm. The selection of such a day was to avoid their interference and obstruction to *Jang*, which originated from folk beliefs at the time. *Jang* is so precious in Koreans' diet that they wanted to make it on a good day if possible. It embodies the sincerity, genuine care, and desire of Koreans to do their best in whatever human beings can do.

The notion of date selection may seem irrational from the point of view of modern science. However, the "days without Sohn" are the days with the last numbers 0 and 9 on the lunar calendar of the month, which are 9, 10, 19, 20, 29, and 30 and are repeated periodically. On these days, the recurring date cycles are believed to contain the concept of seasons reflecting the weather. Temperature is essential for fermenting *Jang*. The specific date may have been chosen to exclude the influence of evil spirits on *Jang*, but it is also believed that it was intended not to miss the right time to make *Jangs* on the days without the calendar.

The use of red pepper and charcoal: from folk beliefs to scientific effects

"*Keumjul*" (禁줄) was tied to the entrance of the *Jang* jar, symbolizing the hope that no misfortune would come to the *Jang*. *Keumjul* is rope made from twisted rice straw and adorned with red pepper, charcoal, and Korean

paper to ward off evil spirits (Enclopedia of Korean Culture, The Academy of Korean Studies). The word "*Keum*" means prohibition or the prevention of entry by evil spirits. The most common use of hanging *Keumjul* is to hang it on the gate when a child is born, which signifies the expulsion of evil spirits. It visually informs people that a newborn baby has been born in that household and also serves to refuse visitors from the outside while it is still hanging. In other words, *Keumjul* plays a role in preventing pathogenic microorganisms from entering the house from outsiders, especially in the days when people were vulnerable to microbial infectious diseases, and there were no antibiotics. Hanging *Keumjul*, which is believed to protect a baby's life, from a jar of *Jang* illustrates the high value that Koreans place on *Jang* in their diet. This practice also reflects the sincere desire for the *Jang* to be well-made.

In addition to being hung over the mouth of the jar, charcoal and red pepper were also placed inside the *Jang* jar. Although these were added as a folk belief at a time when science was not yet fully understood, it has been discovered that red pepper can have an antibacterial effect that inhibits the growth of various bacteria [46]. Surprisingly, it has been found that red pepper does not inhibit the growth of all microorganisms, but rather selectively promotes the growth of lactic acid bacteria, which are necessary for fermentation [47, 48]. The beneficial effect of red pepper on fermentation was discovered during the kimchi fermentation process, and it is believed that red pepper plays a similar role in the fermentation of *Jang*.

Charcoal is known for its ability to act as a filter by absorbing impurities through physical adsorption. Its porous structure provides a large surface area, which enhances its adsorption capacity [49]. Due to this property, it is widely used as an odor deodorant or a natural filter for volatile organic acids (VOCs), which are off-flavor components generated during food fermentation [50]. Although the Korean ancestors may have started applying charcoal to their *Jang* based on their folk beliefs, it has been discovered that adding charcoal can actually improve the taste and flavor of *Jang*, thus making it a custom.

Salinity control using buoyancy of eggs

The concentration of salt is a critical factor in *Jang* fermentation. If the salt concentration is too high, it becomes difficult for bacteria to grow, and if it is too low, rotting bacteria will multiply quickly, leading to spoilage instead of fermentation. However, in the days when there were no scales or salinometers, it was challenging to measure the appropriate salt concentration for a large

amount of food that would last for a year. Korean ancestors developed a method of measuring the salt concentration by floating an egg in the brine used to make *Jang*. Since the buoyancy of the saltwater changes according to its concentration, they adjusted the amount of salt by observing the extent at which the egg floated. Their wisdom in determining the salinity using everyday objects in an era when science was not yet developed is remarkable [44].

Fermentation is a complex process that involves various factors such as temperature, humidity, starter, hygiene, and nutrition working in combination. If any one of these factors is not satisfied, the fermentation process may not proceed successfully. Therefore, Korean ancestors made every effort to ensure that all of these factors were taken into consideration, in order to avoid bad luck. From the modern scientific perspective, their earnest devotion has contributed to the control of hygiene, moisture, microbial contamination, and salt in the fermentation process.

Jang, Korean indigenous culture

The "Chapter of *Dongyi* in the Book recording on Three Kingdoms" (三國志魏志東夷傳, 280 s AD) describes the food, clothing, shelter, and customs of ancient Korean societies, such as *Buyeo*, *Goguryeo*, and *Dongokjeo*, from the viewpoint of the Chinese [see Samkukji-wijidongijeon(三國志魏書東夷傳) in Encyclopedia of Korean Culture, National Folk Museum of Korea]. Due to the lack of records about this period in Korea, the history of Korean society during this time can only be estimated based on what was recorded about Korea by China, its neighboring country. From the record of *Seonjangyang* (善藏釀) in the *Goguryeo* section of *Dongyi*, it can be seen that *Goguryeo* people widely consumed fermented foods, and their fermentation technology was noteworthy even to foreigners [51]. The oldest record of *Jang* among existing records dates back to the 280 s AD. Considering that fermentation technology was already excellent at the time, it can be assumed that fermented foods in Korea were developed even earlier.

In addition, relics presumed to be *meju* have been occasionally discovered on the Korean Peninsula since the third century AD [17]. If such relics were found, it would indicate that fermented soybean products were already common in Korea during that time. *The Chronicles of the Three States* (三國史記, 1145), the oldest extant Korean history, records a list of gifts sent to the queen's house when King Sinmun of *Shilla* proposed marriage to her in 683 AD; “納一吉滄金欽運少女爲夫人, 先差伊滄文穎波珍滄三光定期, 以大阿滄智常納采. 幣帛十五罍, 米·酒·油·蜜·醬·豉·脯·醢一百三十五罍, 租一百五十車” [52]. The list includes rice, alcohol, oil, honey, *Jang* (醬), *cheongkukjang* (豉), *Po* (脯, thinly sliced dried meat or

fish), and *jeotgal* (醃, fermented fish products). The fact that *Jang* and *meju* were included in the list of wedding gifts suggests that they were indispensable and precious foods in the Korean diet at the time.

The Liaohe civilization did not develop a written language and no extant records have been found. Similarly, although Korea had its own language, it did not have its own script to record it, so Koreans had to rely on records about Korea written by the Chinese to learn about their own history and culture. In addition, Koreans have recorded their history and culture in Chinese characters until *Hangeul* was invented and universalized. However, using Chinese characters to express Korean language has its limitations, particularly when it comes to Korean proper nouns. The Korean alphabet, *Hangeul*, is phonetic, while Chinese characters are ideograms. Due to these differences, later generations often made errors when interpreting records written in Chinese characters by interpreting the characters' meanings rather than their sounds. Records should be viewed together with historical, social, and cultural information of that era. Based on them, it is necessary to distinguish and interpret which Chinese characters would have been used as meanings and which Chinese characters would have been borrowed only as sounds. However, there were many cases of mistranslation by interpreting only the characters written in the text without considering social and cultural realities. This is because people sometimes forced interpretations of the meanings of individual ideograms, even when Korean food names were written using Chinese characters only for their sounds.

In particular, it is important to note that during this time period, only men were taught how to read and write Chinese characters, so women were not literate in this regard. Additionally, Confucianism dictated that cooking was a task solely for women, and men were expected to stay out of the kitchen. This means that Korean men who recorded information about food using Chinese characters likely had no experience with cooking. As a result, relying solely on these records to analyze Korean food culture may lead to inaccuracies. It is necessary to consider the history of Korean food culture comprehensively, taking into account factors such as agriculture, geography, and language.

For example, the origin of *cheongkukjang* has been debated as some argue it is of Chinese origin because the name *cheongkukjang* appears in Chinese texts that predate those in Korea. However, in the compendium *Bakmulji* (博物誌) written by Zhang Hua (張華, 232–300 AD) during the Jin dynasty, a method for making *si* (豉) in foreign countries is described, which was passed down from barbarians by Kang Baik (康伯) [51, 53]. This

suggests that not only the recorded part with the Chinese character, but also the context before and after the record should be read together and judged comprehensively. Furthermore, it is reasonable to assume that the fermented soybean food must have originated in the regions where soybeans were abundant and fermentation technology was developed before it became widely consumed.

It is true that many Chinese cultures have influenced Korea due to China's geographical proximity and its advanced Yellow River civilization. Nevertheless, Korea has had a distinct culture from China in terms of language, agriculture, and food. China was based on the Yellow River Civilization, while Korea was based on the Liaohe Civilization, located in Manchuria. By examining excavated artifacts such as earthenware and swords, it is evident that Korean and Chinese artifacts had completely different shapes, indicating that they lived in different cultures [54]. Regarding food culture, ingredients and basic cooking methods differ between China and Korea. Therefore, even if Chinese food was introduced, it could not be adapted as Korean dishes without modifications. Thus, the approach of solely looking for the origins of Korean food in Chinese books or Chinese cuisine should be avoided.

China had an abundance of oil, which made it possible to cook fried food. Deep frying is cooked at a high temperature, which has a sterilizing effect on pathogenic microorganisms and improves taste. Additionally, when food is fried, moisture is evaporated, and the water activity is lowered, which suppresses the growth of microorganisms and enables later consumption. By simply frying food, all three issues of safety, taste, and storage were resolved, so there was little motivation to explore other cooking methods to improve taste. On the other hand, Korea had very limited cooking oil, with sesame and perilla oils being the primary types used. However, these oils were unsuitable for frying due to their low smoke point, and the small amount available was insufficient for frying [8].

While Chinese food is characterized by the fiery taste obtained when cooking at high temperatures in oil, Korean food is characterized by the taste of many motherly touches, as it is seasoned with *Jangs* to add flavor. Because of these differences in ingredients and recipes, Korea has a completely distinct food culture from China. Therefore, simply because a dish is described using Chinese characters, it cannot be concluded that the food originated in China. To find the true identity of Korean food, it is necessary to comprehensively consider factors such as food culture, agricultural background, and historical data.

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References

- Kwon DY, Kim S-H, Chung KR, Daily J, Park S. Science and philosophy of Korea traditional foods (K-food). *J Ethn Foods*. 2023;10:26. <https://doi.org/10.1186/s42779-023-00194-3>
- Baker E, Mustakas G. Heat inactivation of trypsin inhibitor, lipoxigenase and urease in soybeans: effect of acid and base additives. *J Am Oil Chem Soc*. 1973;50:137–41.
- Bhak JH. Origin and Migration of Koreans - Genomic analysis of ancient and modern humans. 2020 [cited 2023 Jan 18]; Available from: http://hongik.org/sub/sub10_03.php?mNum=3&sNum=2&boardid=speciallecture4&mode=view&idx=2&p_idx=28
- Kim J, Jeon S, Choi J-P, Blazyte A, Jeon Y, Kim J-I, et al. The origin and composition of Korean ethnicity analyzed by ancient and present-day genome sequences. *Genome Biol Evol*. 2020;12:553–65.
- Vavilov NI. Origin of cultivated plants. Origin and Geography of Cultivated Plants. 1926.
- Hahn SK. The birthplaces of cultivated plants. Seoul, Korea: Episteme; 2020.
- Statista. Consumption of vegetable oils worldwide from 2013/14 to 2021/2022, by oil type. 2022 [cited 27 Dec 2022]; Available from: <https://www.statista.com/statistics/263937/vegetable-oils-global-consumption/Kim>.
- Kim SH, Kim MS, Lee MS, Park YS, Lee HJ, Kang SA, et al. Korean diet: characteristics and historical background. *J Ethn Foods*. 2016;3:26–31.
- Lim JH. Meat-eating culture in Korea. *Munhwajae: Korean J Cult Herit Stud*. 2000;274–307.
- Korea Soybean Museum Establishment Promotion Committee. Soybean storytelling. Seoul, Korea: Korea Food Security Research Foundation; 2017.
- Moon GS. Sapiens' Table. Paju, Gyeonggi-do: 21st Century Books; 2018.
- Kim MY, Lee S, Van K, Kim T-H, Jeong S-C, Choi I-Y, et al. Whole-genome sequencing and intensive analysis of the undomesticated soybean (*Glycine soja* Sieb. and Zucc.) genome. *Proc Natl Acad Sci*. 2010;107:22032–7.
- Choi DK. The rise of Chinese soy sauce and the spread of soy sauce culture: on the Korean Peninsula soy sauce culture. *J Korean Historical-folklife*. 2020;99–126.
- Lee CH. Korean Food History. Paju-si, Korea: FreeAcademy; 2017.
- Jia S et al. Qiminyao shu (Cheminyosul) (齊民要術, China 532). Edited by Tao Z et al. Shunzhi 3 [1646]. 1646. <https://nrs.lib.harvard.edu/urm-3fnc1:23026996>.
- Lee YH, Park TS. Origin of legumes cultivation in Korean peninsula by viewpoint of excavated grain remains and genetic diversity of legumes. *Korean J Agric History*. 2006;5:1–31.
- Kim M, Ryu A. Fermented soybean and foodways of the three-kingdoms period. *Hanguk Sanggosa Hakbo*. 2018;05:165–87.
- Shin D, Jeong D. Korean traditional fermented soybean products: Jang. *J Ethn Foods*. 2015;2:2–7.
- Kwon G-H, Lee H-A, Park J-Y, Kim JS, Lim J, Park C-S, et al. Development of a RAPD-PCR method for identification of *Bacillus* species isolated from Cheonggukjang. *Int J Food Microbiol*. 2009;129:282–7.
- Messina M. Modern applications for an ancient bean: soybeans and the prevention and treatment of chronic disease. *J Nutr*. 1995;125:567S–569S.
- Jang C-H, Lim J-K, Kim J-H, Park C-S, Kwon D-Y, Kim Y-S, et al. Change of isoflavone content during manufacturing of cheonggukjang, a traditional Korean fermented soyfood. *Food Sci Biotechnol*. 2006;15:643–6.
- Yang HJ, Park S, Pak V, Chung KR, Kwon DY. Fermented soybean products and their bioactive compounds. Soybean and health. 2011:978–53.
- 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.
- Hill TA, Ashrafi H, Reyes-Chin-Wo S, Yao J, Stoffel K, Truco MJ, et al. Characterization of *Capsicum annuum* genetic diversity and population structure based on parallel polymorphism discovery with a 30K unigenic Pepper GeneChip. *PLoS ONE*. 2013;8: e56200.
- Dang YM. Analysis of Capsaicinoids content of Red pepper powder, Gochujang and Kimchi (Master's thesis). Gwangju-si, Korea: Chosun University; 2017.
- Lee SE, Ham H, Kim Y, Sung J, Hwang IG, Yu SM, et al. The content of capsaicinoids in peppers by cultivation region in Korea. *J Korean Soc Food Sci Nutr*. 2013;42:129–33.
- Kim N, Seo D, Cheon W, Choi Y, Lee J, Kim Y. Bioactive nutritional compounds and antioxidant activity of green peppers consumed in Korea. *J Korean Soc Food Sci Nutr*. 2020;49:141–8.
- Ministry of Agriculture Food and Rural Affairs. Title of subordinate document: Spicy! Check with your own eyes. Ministry of Agriculture, Food and Rural Affairs press release. Accessed 3 Jan 2014 Accessed 3 Jan 2014.
- Kim S-H, Kwon DY, Shin D. Namul, the driving force behind health and high vegetable consumption in Korea. *J Ethn Foods*. 2020;7:1–12.
- Han KH, Yim WJ, Kwon C. Euibangyuchi (醫方類聚). Korea; 1445.
- Kwon C, Yu HT, Roh J, Park Y. Hyangyak-jipsongbang (鄉藥集成方). Korea; 1433.
- Kim SH, Chung KR, Yang HJ, Kwon DY. Sunchang gochujang (Korean red chili paste): the unfolding of authenticity. *J Ethn Foods*. 2016;3:201–8.
- OECD. Health at a Glance 2021; 2021.
- Jeong YY. Mokminsimsuh (牧民心書). Korea (Choson Dynasty); 1818.
- Jang DJ, Lee AJ, Kang S-A, Lee SM, Kwon DY. Does siwonhan-mat represent delicious in Korean foods? *J Ethn Foods*. 2016;3:159–62.
- Korea Health Industry Development Institute. National Nutrition Statistics 2020: Food Frequency. 2020.
- Lee YK (李用基). Chosun's incomparable, up-to-date cookbook (朝鮮無雙新式料理製法). Korea; 1924.
- Yu JL. Additional Version of Salimkyongje (增補山林經濟). Korea; 1766. http://kostma.korea.ac.kr/dir/view?uci=RIKS+CRMA+KSM-WZ.0000.0000-2016331.0GURA_591.
- Jo YI, Lee NH, Choi UK. Correlation analysis of long-term aged soy sauce taste components and sensory tests. *Korean J Food Preserv*. 2021;28:900–7.
- Chung H, Sohn KH. The changes of component in traditional Korean soy sauce during ripening period(I). *Korean J Food Cook Sci*. 1994;10:29–34.
- Kim JG. Changes of components affecting organoleptic quality during the ripening of Korean traditional soy sauce-amino nitrogen, amino acids, and color. *Korean J Environ Health*. 2004;30:1.
- Yang SH, Choi MR, Kim JK, Chung YG. Characteristics of the taste in traditional Korean soybean paste. *J Korean Soc Food Sci Nutr*. 1992;21:443–8.
- Kim MJ, Rhee HS. Studies on the changes of taste compounds during soy paste fermentation. *Korean Soc Food Cook Sci*. 1990;6:1–8.
- Kwon DY. Jang and Korean Food Culture. In: Shin D, editor. Overview of Korean Jang (fermented soybean products) Manufacturing. Seoul, Korea: Korea Jang Cooperative; 2022. p. 33–62.
- Park BI, Seok HT, Kim KW. The historical changes of Ondol. *Magazine Soc Air Circ Freezing Eng*. 1995;24:613–27.
- Romero-Luna HE, Colina J, Guzmán-Rodríguez L, Sierra-Carmona CG, Farías-Campomanes ÁM, García-Pinilla S, et al. Capsicum fruits as functional ingredients with antimicrobial activity: an emphasis on mechanisms of action. *J Food Sci Technol*. 2022. <https://doi.org/10.1007/s13197-022-05578-y>.

47. Kang BK, Cho MS, Park DS. Red pepper powder is a crucial factor that influences the ontogeny of *Weissella cibaria* during kimchi fermentation. *Sci Rep*. 2016;6:1–8.
48. Park B, Yang JS, Moon EW, Seo HY, Ha JH. Influence of capsaicinoids content on the microbial community during kimchi fermentation. *J Microbiol Biotechnol*. 2019;28(29):1580–90.
49. Choi SS, Kim KM, Park HS. Utilization of charcoal for food and cosmetic packaging. *Food Sci Ind*. 2012;45:55–60.
50. Jeong S, Yoo SR. Evaluation of deodorization capabilities, morphologies, and thermal stabilities of baking soda, charcoal, coffee, and green tea for kimchi packaging application. *Korean J Packag Sci Tech*. 2020;26:1–9.
51. Kwon DY, Chung KR, Jang D-J. The history and science of Chongkukjang, a Korean fermented soybean product. *J Ethn Foods*. 2019;6:1–17.
52. Kim BS. *Samguk Sagi (三國史記)*. Korea (Goryeo Dynasty); Korea. 1145.
53. Jeong Y, Min KD. The study on the newly found joseon's printed book of bakmulji (博物誌) by Jang H (張華). China; 200s. 2019;59:95–117. <https://doi.org/10.17004/jrcn.2019.59.004>.
54. KOREA.net. Heritage & Relics of Korea, part 1. Ministry of Culture, Sports and Tourism; 2015.

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