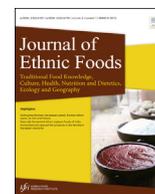




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Review article

Korean traditional fermented soybean products: *Jang*Donghwa Shin ^{a,*}, Doyoun Jeong ^b^a Shindonghwa Food Research Institute, Jeonju, Jeollabuk-do, South Korea^b Institute of Sunchang Fermented Soybean Products, Sunchang, Jeollabuk-do, South Korea

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ABSTRACT

Soybeans are produced in large amounts around the world. In Asian countries, soybeans have been used mostly as a source of food, and in Western countries, they have been used as animal feed and in non-food products. However, since scientific evidence of the dietary benefits of soybeans has been published, the use of soybeans as a food ingredient has increased. In Asia, soybeans have been used in various ways on their own and also combined with fermented products to be used as seasonings or side dishes. According to some sources, the use of soybeans in Korea dates back to B.C. Currently, more research is being conducted on soybeans, and the benefits of fermented soybean products are coming to light.

Fermented products are going beyond the boundaries of their use as mere side dishes, and are seeing significant increases in their use as a functional food. Kanjang (fermented soy sauce), Doenjang (fermented soybean paste), and Gochujang (fermented red pepper paste) are the most well-known fermented products in Korea. These products occupy an important place in people's daily lives as seasonings and are used in many side dishes. It has been proven through clinical studies that these products have many health benefits, such as their ability to fight cancer and diabetes, and to prevent obesity and constipation.

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1. Introduction

In East Asia or Southeast Asia, soybeans have been recognized as a very important food source that has affected dietary life in many ways [1,2]. Starting in the twentieth century, Western countries, including the United States, acknowledged soybeans as feed and as a source of vegetable fat and oil. But since protein and the unique psychological functions of soybeans have been identified, their importance from a dietary perspective is also being emphasized.

Historically, Korea has a deep relationship with the soybean [3], and its usage dates back to 4,000 years ago. The Korean people's preference for soybeans is connected to the fact that the birth place of the soybean is Manchuria [1], and that it has acted as a great source of protein for Koreans since that time.

In Korea, soybeans are boiled and made into fermented products, or used as an ingredient for rice with beans, *Injeolmi* (rice cake crumbs), soy milk, and soybean oil [4]. Fermented soybean products in particular, have become an essential part of the Korean diet, used as seasoning and found in side dishes and soups that are consumed daily. An increased demand for these sauces in Korea in recent times has given rise to greater commercial production and

control over development processes, including the fermentation process. The traditional fermented products have various flavors because different kinds of microorganisms are involved. However, in commercial products, only monomicrobial interception takes place, so the taste is sweet and rather simple. For this reason, there are soy sauce products that cater to the traditional customer base as well products for those looking for more variety to their sauces. This article will analyze the fermentation process used in the creation of a variety of sauces in Korea, including microbial fermentation.

2. Korean fermented soybean products: *Jang*

In the plant, the soybeans contain the most protein, and therefore, different methods of use have evolved. Soybeans can be used in their natural state, or by decomposing the protein into fusible substance, the most widely used method. This means the soybeans can be used as a seasoning or as a nutrient source with added amino acid and peptide.

For more than thousand years, people in Asian countries have let the microorganism in the boiled soybeans increase. They used the essential taste components earned from the breaking down of protein through the enzyme reaction. Some of the soybeans are made into paste and used in soup to be eaten with rice. Ethnic

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groups which consume fermented soybeans are called as “Fermented Soy Jang Culture,” where Jang in Korean means soy fermented sauce or paste [1, see the previous paper by Kwon et al in this issue], and East Asia is categorized in this group. Most of the people living in these areas have implemented fermenting techniques, and according to the region and differences in dietary life, they use the soybeans in liquid, paste, or mixed forms.

The traditional fermented products that use soybeans can be largely categorized into cases where fungi and *Bacillus* sp. are used. Food that uses fungi is widespread in East and Southeast Asian countries such as Korea, Japan and Indonesia. In Indonesia, *Temphe* is unique. *Bacillus* is widely used in fermented foods in many Asian countries such as India, Nepal, and Cambodia. Fermenting with *Bacillus* produces viscous substances, and these products include *Natto* (Japan), *Chongkukjang* (Korea), *Knema* (India, Nepal, Bhutan), *Thua nao* (Thailand), *Pepok* (Myanmar) and *Sieng* (Cambodia, Laos) [5]. Most of these fermented products, soybeans are soaked in water, and then cooled down moderately. They are put in a big basket and fermented for three to five days at around 25–40°C. The kind of soybean that is used differs depending on the country, but *Bacillus* is usually used for fermentation.

Fermented products in Korea that are produced and distributed in Korea are different from other East Asian countries. In Korea, *Meju* (dried soybean block) is used to produce products such as *Kanjang*, *Doenjang* and *Gochuchang* (Fig. 1). Traditionally *Chongkukjang* (also written as *Chungkukjang*) was made by fermenting the cooked but non-crushed soybeans for two or three days in the living room, usually they prepared *Chongkukjang* in autumn and winter after harvesting soybeans. Traditionally making *Meju* for *Kanjang* and *Doenjang*, most often by the women of the household in late fall during the harvest season is hard working. *Doenjang* and *Kanjang* were prepared by three step fermentations: firstly they prepared the *Meju* from cooked beans in late of October or early of November and fermented it for 1 or 2 months like as solid fermentation under the outdoor roof of the Korea traditional house in winter; secondly they aged *Meju* for another 1 or 2 months in large earthenware jars by adding a salt solution as liquid fermentation, and then they decanted the supernatant liquid to prepare *Kanjang* from liquid and *Doenjang* from the remaining soy paste; finally, both liquid and paste were aged for longer periods [4]. *Gochujang* (*Kochujang* in 2, see the previous paper by Kwon et al in this issue) is a unique and representative Korean traditional food for more than a thousand years [6]. *Gochujang* was usually prepared by mixing powdered red peppers, powdered *Meju*, salt, malt-digested rice syrup, and rice flour, and the mixture fermented for more than 6 months (7). For *Meju*, fungi and *Bacillus* sp. are used in the fermentation process and they make the enzymes that are needed. The enzyme breaks down the proteins while maturing and produces different tastes and aromas. *Chongkukjang* only uses *Bacillus* to produce the tastes that are similar to other fermented products. The *Meju* is fermented outdoors during the winter and dried in the sunlight during the spring.

As shown Table 1, the microorganisms involved in the fermentation process include the following variety: *Meju* mold, molds isolated from *Meju*, yeast, and bacteria [8].

3. Manufacturing and functionality of fermented soybean products

3.1. Kanjang

Kanjang is one of the representative fermented products, and it is the most widely known fermented soybean seasoning. The fungi that proliferates from the *Meju* and the enzyme created from *Bacillus* breaks down the soybean protein and produces the amino

acid that creates its savory taste. The amino acid produced during the fermentation process reacts with the saccharides and produces a brown substance called malanoidine by Maillard reaction [9]. As a result, the *Kanjang*'s distinctive color is created. Japan has contributed to the globalization of *Kanjang*, but the use of fermented products was already widespread before modern times and Baekje Kingdom period (Baekje is one Three Kingdom Peninsula, AD 600) [10].

As shown in Fig. 1, *Kanjang* and *Doenjang* are traditionally made through the same process. Normally, fermentation and maturation takes from three months to six months. However in industrial method, *Kanjang* produced with defatted soybean and wheat flour using koji inoculated *Aspergillus oryzae*, and soaked and then matured independently *Doenjang* process. The main ingredients of *Kanjang* are amino acid, peptide, saccharides, and alcohol created during the maturing process, and organic acid, which affects both the taste and the aroma. There are significant differences in the aroma and content between the traditionally made and institutionally made *Kanjang*. The savory flavors of *Kanjang* come from the free amino acid that makes up 50 to 70% of the nitrogenous. Usually the glutamic acid has a significant effect. For *Kanjang*, the effect of antioxidants from the fermentation process is known to prevent cancer [8].

3.2. Doenjang

As described before, traditional *Doenjang* is made with same the process shown in Fig. 1, where the liquid is divided to make *Kanjang*, and the solid is collected. For further fermentation, put more cooked cereals and *Meju* into it and matured for three to six months, *Doenjang* is made. Fungi proliferates in the *Meju*, and the enzymes created from the *Bacillus* play the main role for maturation. The final *Doenjang* product is usually light brown, and served as paste that turns darker over time due to chemical reactions like as Maillard reaction [9]. It is mostly used for soups and sometimes eaten with vegetables.

Koreans eat *Doenjang* in the form of soup every day [11], and the amount consumed daily is about 8.8 grams. When preparing the soup, garlic, onions, and red pepper powders are sometimes added to enhance the *Doenjang* flavor.

3.2.1. The functionality of Doenjang

The soybeans that are used as the ingredient for *Doenjang* have special functional components. They contain isoflavone, which is categorized as phytoestrogen. Here, 12 isomers [10] such as daidzein, genistein, glycitein exist (10), and they all have different functionalities [12].

Generally, the anti-cancer effects of *Doenjang* come from the trypsin inhibitor, isoflavone, vitamin E, and linoleic acid, which is an unsaturated fatty acid that contributes to biological activity [13]. Also, the *Doenjang* extract vitalizes the glutathione S-transferase, which aids in the detoxification of the liver. It also increases the vitalization of natural killer cells [14]. When the maturation period is extended, glycosylated isoflavone converts into genistein, daidzein that are aglycone. The tumor control effect [15,16] being increased can be witnessed (Table 2).

By taking the fermented *Doenjang*, di-peptide as arginine-proline, which have the abilities to produce an ACE (angiotensin converting enzyme) inhibitory effect, is also consumed. They are known to prevent high blood pressure [17]. Other peptide substances have blood pressure depressant abilities [18]. Most notably, *Doenjang* has the ability to control obesity (Table 3), and this effect increases as a result of fermentation [19]. Research has shown that the consumption of *Doenjang* also enhances immune functions [20] and decreases the Ig E-antibodies that are produced from the

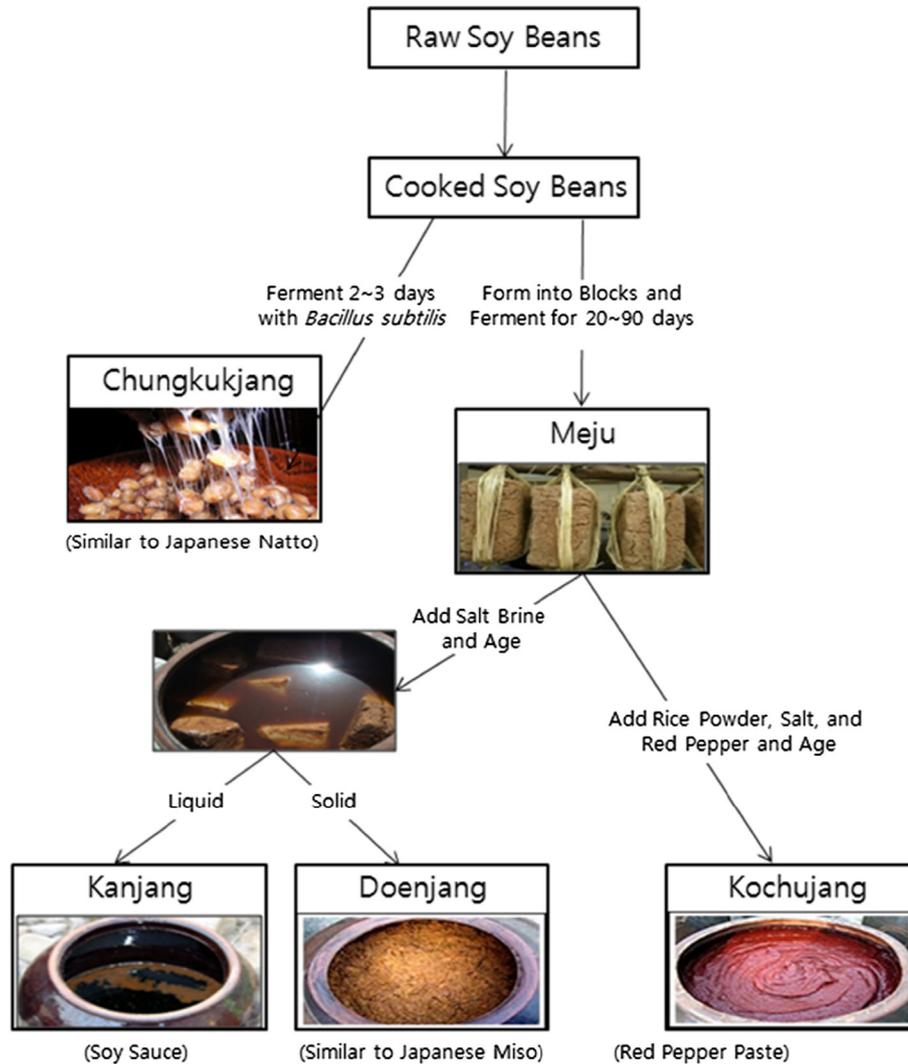


Fig. 1. The preparation of Korean fermented products from soybeans. (quoted from reference [2]).

Table 1
Microorganisms isolated from traditional *Meju* (5).

Microbial Type	Microorganisms
Mold	<i>Aspergillus flavus</i> , <i>A. fumigatus</i> , <i>A. niger</i> , <i>A. oryzae</i> , <i>A. reticus</i> , <i>A. spinosa</i> , <i>A. terreus</i> , <i>A. wentii</i> , <i>Botrytis cinerea</i> , <i>Mucor adundans</i> , <i>M. circinelloides</i> , <i>M. griseocyanus</i> , <i>M. jasseni</i> , <i>M. hiemalis</i> , <i>M. racemosus</i> , <i>Penicillium citrinum</i> , <i>P. griseopurpureum</i> , <i>P. griesotula</i> , <i>P. kaupscinskii</i> , <i>P. lanosum</i> , <i>P. thomii</i> , <i>P. turalense</i> , <i>Rhizopus chinencis</i> , <i>R. nigricans</i> , <i>R. oryzae</i> , <i>R. sotronifer</i>
Yeast	<i>Candida edax</i> , <i>C. incommis</i> , <i>C. utilis</i> , <i>Hansenula anomala</i> , <i>H. senula capsulata</i> , <i>H. senula holstii</i> , <i>Rhodotorula flaca</i> , <i>R. glutinis</i> , <i>Saccharomyces sp.</i> , <i>S. exiguus</i> , <i>S. cerevisiae</i> , <i>S. kluyveri</i> , <i>Zygosaccharomyces japoninus</i> , <i>Z. saccharomyces rouxii</i>
Bacteria	<i>Bacillus citreus</i> , <i>B. circulans</i> , <i>B. licheniformis</i> , <i>B. megaterium</i> , <i>B. mesentericus</i> , <i>B. subtilis</i> , <i>B. pumilis</i> , <i>Lactobacillus sp.</i> , <i>Pedococcus sp.</i> , <i>P. acidilactici</i>

antigen. This also shows the function of improving and preventing allergies [21].

3.3. Gochujang

Gochujang, a spicy paste made primarily from red peppers [7] and soy sauce, is very unique to Korea, and along with rice, has occupied a space in the staple diet of most Koreans for a long time.

Gochujang is made mainly of soybean and consists of 10% to 20% of other ingredients, including spicy red pepper powder and small amounts of rice cereal starches. The fermentation techniques used to make these sauces are unique to Korea and cannot be found anywhere else in the world.

The most distinctive characteristic is use of special Gochujang Meju (different one from Doenjang Meju), which is used as the basic component when making Gochujang. The Gochujang Meju

Table 2
Anti-tumor acting by Doenjang diet.

Sample	Tumor (g)	Inhibition (%)
Sarcoma 180 Cancer Cell(A)+PBS (phosphate buffered saline)	5.8 ± 0.3 ^a	–
A+ Doenjang (3 month)	5.4 ± 0.2 ^a	7
A+ Doenjang (6 month)	4.7 ± 0.3 ^b	19
A+ Doenjang (24 month)	3.6 ± 0.2 ^c	38

※ Shows the significant difference in a-c Duncan's multiple range test ($p < 0.05$).

Table 3
Anti-obesity effects in rats for ingesting different fermented soybean products including Doenjang (ingesting for 30 days).

Attribute	Normal rat	High-fat diet	High-fat diet + Doenjang	High-fat diet + Chongkukjang	High-fat diet + Gochujang	High-fat diet + samjang
Initial weight	143.7 ± 3.9	143.7 ± 3.9	143.8 ± 4.1	143.7 ± 3.9	143.9 ± 4.5	143.7 ± 5.0
Final weight	259.0 ± 16.1 ^{bc}	295.1 ± 11.6 ^a	251.3 ± 22.3 ^c	277.1 ± 13.8 ^{ab}	270.5 ± 5.4 ^{bc}	261.1 ± 17.0 ^{bc}
Weight increment	3.9 ± 0.6 ^b	4.8 ± 0.4 ^a	3.8 ± 0.3 ^b	4.2 ± 0.5 ^b	4.2 ± 0.1 ^b	4.0 ± 0.2 ^b

1. Significant difference in a,b,c,ab,bc Duncan's multiple range test ($p < 0.05$).

2. Values are expressed as means ± SE.

3. Values in each column represent differences between the mean changes and scores of the Doenjang group and those of the placebo group.

4. Values derived from repeated measures analysis (per protocol) after adjusting for age, gender and BMI.

contains soybean and wheat, which are sources of proteins and carbohydrates. The microorganisms proliferated in Meju produce the enzymes that hydrolyze protein and starch. The traditional Gochujang Meju usually takes two to three months for natural fermentation with wild microorganisms. After fermentation, the remaining dried and pulverized substance is used as the main source of Gochujang. Usually, rice is saccharified by malt, and Gochujang Meju powder, powdered red pepper, and Kanjang are all added to make the paste. Next, it goes through fermentation. The fermentation period normally takes three to six months, and during this period, protein and starch is decomposed to produce a umami (savory) and sweet flavor as shown in Fig. 1.

Compared to other fermented products, Gochujang uses a variety of ingredients. Thus, the microbes involved are not simple. Normally, the amount of Bacillus is 10^7 to 10^8 /g, and the altered Bacillus that are detected are *Bacillus velezensis*, *B. amyloliquefaciens*, *B. subtilis* [7]. For halophilisms, *B. licheniformis* and *B. velezensis* are confirmed. As for yeast, *Zygosaccharomyces rouxii* are the main components and *Candida apicola* and *Z. beilli* are also found. Sometimes, halophilism is detected as well. In other research results, *B. licheniformis* and *B. subtilis* were found in traditional Sunchang Gochujang, and the range of the total amount of Bacillus was 6.6 to 8.38 log CFU/g [22]. For fungi, Aspergillus are the microorganisms that can act first, and Penicillium and Rhizopus have worked.

Different functionality of Gochujang has been known through the red pepper's capsaicin and soybean's fermentation product. There have been many studies that show its effects in preventing obesity [23,24]. The spicy flavor of the red pepper and capsaicin stimulate the spinal cord and accelerate the adrenal adrenalin secretion, also expediting metabolism and breaking down body fat [25] (Table 4).

Table 4
Change in body weight, food intake and food efficiency ratio of fat experimental diets after 4 weeks.

Body weight	ND ¹⁾	HFD ²⁾	CK ³⁾	TK I ⁴⁾	TK II ⁵⁾	RPP ⁶⁾
Initial weight (g)	199.9 ± 7.5	198.0 ± 6.4	198.6 ± 7.1	200.7 ± 9.6	199.9 ± 9.7	199.9 ± 2.7
Final weight (g)	338.8 ± 0.5	382.8 ± 1.4 ^a	358.4 ± 4.4 ^{bc}	362.6 ± 2.5 ^b	354.5 ± 0.1 ^c	376.5 ± 5.1 ^a
Weight ain(g/day)	4.4 ± 0.2 ^d	6.4 ± 0.1 ^a	5.7 ± 0.1 ^{bc}	5.8 ± 0.4 ^{bc}	5.6 ± 0.5 ^c	6.2 ± 0.2 ^{3ab}

Significant difference in a,b,c,ab,bc Duncan's multiple range test ($p < 0.05$).

¹⁾ Normal diet (AIN-76TM).

²⁾ High fat diet (contains 20% corn oil in normal diet).

³⁾ Commercial diet : C Co.

⁴⁾ Traditional Gochujang diet I: 0 day fermented Gochujang (Sunchang Gochujang Village).

⁵⁾ Traditional Gochujang diet II: 6 month fermented Gochujang (Sunchang Gochujang Village).

⁶⁾ Red pepper powder (3%) diet (red pepper content of 10% Gochujang added high fat diet).

Some clinical data shows that Gochujang, together with capsaicin and the fermentation product, has a connection to weight loss [26]. In an experiment where Gochujang pills were consumed, the abdominal fat and subcutaneous fat decreased significantly, so a decrease in weight due to the consumption of Gochujang is evident. The total cholesterol (TC) and low density cholesterol (LDL-C) in the blood decreases significantly [27], and the result shows that bad lipids in the blood decrease as do stress levels. Recently, thus, European and other Western countries have shown great interest in Gochujang. Some research has been conducted that focuses on the evaluation of the consumer function Gochujang has for Europeans [28].

3.4. Chongkukjang

Of the fermented products, Chongkukjang has the shortest fermentation period (2–4 days) and is fermented at a high temperature (40 to 43°C).

The history of Chongkukjang production dates back to B.C.E., but the oldest on record, Si(豉), dates back to the period of the Three Kingdoms (C.E. 683). So it can be inferred that even before this time there were fermented products. Chongkukjang has its soybean protein degraded from the protein degradation enzyme, and free amino acid is produced along with related peptides afterward. Because of this, Chongkukjang has its own special characteristic and aroma. It also serves as a great source of nutrients that provide adequate amounts of amino acid in Korean people's diets, where rice constitutes a common and substantial part of most meals. Chongkukjang only takes about 3–4 days to make. It is fermented straight from boiled soybeans, unlike Doenjang and Gochujang, which use fermented Meju. As a result, it requires considerably less time to prepare (Fig. 1).

Table 5
Comparison of nutritional composition in *Chongkukjang*.

	Moisture	Protein	Lipid	Carbohydrate	Retinol (mg)	V-1 (mg)	V-B2 (mg)	niacin (mg)	V-C (mg)
Cooked Soybean	61.7	17.8	7.7	11.2	–	.023	0.10	1.5	1
<i>Chongkukjang</i>	70.7	10.2	8	14.9	16	0.63	0.19	5.1	–

Table 6
Changes of bioactive compounds between soybeans and *Chongkukjang*.

Phytochemical			Steamed soybean	<i>Chongkukjang</i>
Isoflavone	Glucoside	Daidzin	15–57	79–93
		genistin	36–86	87–91
	Aglycone	glycitin	2–6	10–12
		daidzein	0.3–5	4–7
Gamma-PGA	genistein	0.2–5	3–4	
	Glycitein	0.1–0.6	11–13	
Ammonia		–	↑	
Protein absorption (%)		65	95	

For *Chongkukjang*, the strain in the *Bacillus* is directly involved. Traditionally, *Chongkukjang* depended on natural fermentation, and people in the past used rice straws on boiled soybeans, so that *Bacillus* could be inoculated. Nowadays, strains are purely separated from traditional *Chongkukjang* or rice straw, which are used as a starter for the fermentation process. In the past, it was thought that *Bacillus natto Sawmur* was the predominating influence but it was later discovered it was *B. subtilis* [29].

The large amount of viscous substance produced and the distinct aroma are its unique properties. Through the fermentation of the *Chongkukjang*, a considerable amount of functional materials are created and the content increases. When looking at the components, there are dietary fiber, phosphatide, isoflavone, phenolic acid, poly-glutamic acid (PGA), and saponine [30].

The comparisons of the soybean's compositions that are from *Chongkukjang* and boiled soybeans are as shown in Table 5 [31]. Table 5 shows that the amount of retinol, Vitamin B1, B2 increases due to fermentation, and also shows that the amount of functional materials increases significantly while fermenting *Chongkukjang* [20]. Table 6 shows that when the aglycone content of isoflavone increases significantly, the PGA also increases. The digestibility of *Chongkukjang* has improved to 95% from 65% of soybean.

It has been proven the consumption of *Chongkukjang* can lead to a drop in blood pressure and that it can also stop blood clots from forming [32]. The increase of the functional component content suppresses the increase of tumor cells and slows down the increase of carcinogenesis [33]. There are insoluble and water soluble fibers in *Chongkukjang*, which probably increases the viscosity of the content in the intestines and shortens the time that it takes to pass through the intestines by significant [34,35]. Therefore, by consuming *Chongkukjang*, the time it takes to pass through the intestines can be shortened, and people can protect themselves from constipation [36,37].

3.5. Other traditional Korean fermented foods

Korea has a few other kinds of complex fermented dishes. A few of those that use soy sauce are listed below [7].

Eoyukjang: The haunch of cow, chicken, gray mullet, and sea bream are dried and then put into Meju along with abalone, mussel, shrimp, egg, ginger, green onion, and tofu. Using these ingredients, the same steps for making *Kanjang* is followed.

Fermented dried pollack: *Hwangtae* soybean is steamed, and the Meju is shaped like a hilt with bean leaves floating on the top. With this Meju, a fermented product is produced.

Chongyukjang: Fried soybean is boiled and from this a solution is produced. Next, soybean is added to the solution it is boiled with beef, white radish, and red pepper for three to four days.

Juebjang: Meju is made with wheat bran and fried soybeans. Is it then shaped into walnut-sized pieces and steamed with mulberry leaves that float. Cucumbers and eggplants may be added and then fermented together.

4. Discussion

On the Korean peninsula, the history of production of soybeans dates back to B.C.E. Soybeans make great seasoning and used in soups and side dishes. Since the origin of soybean dates back to Manchuria (*Kochosun*), Korean people and soybeans have an inseparable relationship. As a result, Koreans have developed many ways to use soybeans.

Soybeans can be eaten in their natural form, with rice, by boiling the two together, by frying them in *Kangjeong*, or by using them as *Injeolmi* crumbs. Soybeans function as an important source of vegetables during winter, when they are sprouted into bean sprouts. Using another method, boiled soybeans can be used to make Meju. Using Meju, *Kanjang*, *Doenjang*, and *Gochujang* is produced. By exploiting the microorganisms to change the soybean protein, fat, or carbohydrates, into a water-soluble substance, new methods of making new flavors and aromas have been developed. The products created through fermentation have new kinds of bioactive substances that have positive effects on the body. It has been scientifically proven that these products can function to fight off cancer and tumors, as well as prevent blood clots, obesity, diabetes, and constipation.

Looking at these results, the importance of fermented products is clear. More than a seasoning, they have the capacity to function as health aids.

Conflicts of interest

The authors have no conflicts of interest.

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