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# Science and philosophy of Korea traditional foods (K-food)

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**Abstract**

The foods, diets, lifestyles, and cultures that can be encountered throughout the world are different depending on the environment of each region and each ethnic group. Ethnic food has been developed according to the constraints of the given environment in terms of philosophical, agricultural, and geohistorical conditions. In other words, ethnic food is a product of efforts to cope with and overcome food safety, desirability, and the need for food storage for periods of famine. It would be a tradition and emergence created by accumulated wisdom that actively utilizes the given geographical and natural environment. Since the Ice Age, the development of all ethnic foods on the Earth has been unique in terms of their characteristics, due to the natural agro-ecological background of the region, through the movement and settlement of primitive mankind and wars of the Bronze Age. Therefore, it is impossible to understand the development of a particular ethnic food without understanding its historical background and geographical and agro-ecological characteristics. The same applies to Korean foods, which should be studied from this perspective. Nevertheless, until now, the history of food on the Korean Peninsula has been mainly studied by history scholars who can read Chinese characters rather than by natural scientists, resulting in errors and distortions in our understanding of the identity, history, and originality of Korean food. In this paper, we aim to correct these errors and distortions and to present scientifically validated research and the developmental background of Korean food in terms of its anthropological, historical, geographical, and cultural values, which is essential for K-food (Korean Traditional foods) to be known as a distinctly different world food rather than as a regional variant of Northeast Asian foods. Furthermore, we also aim to provide scientific truths by researching the health functionalities and cultural values of Korean food so that it can develop as a global food worldwide.

**Keywords** Korean traditional foods, K-food, Geo-historical background, yangnyom, kan, jang, Kimchi, Banchan

## Introduction

The global popularity of K-pop music and Korean movies and dramas has increased worldwide interest in Korean culture as a whole. This expanded interest in Korean culture has also increased awareness and interest in Korean ethnic foods (K-foods) since it is an integral component of the Korean lifestyle and culture. However, a full understanding of K-foods requires an appreciation of the historical and spiritual values that inspired its development as well as a comprehension of the geographical and geological characteristics of the Korean Peninsula that influenced the food culture that developed with the transition from hunters and gatherers to a largely agrarian society. Unfortunately, little research is available to reliably describe the historical, geographical, and cultural value of traditional Korean foods. Korean food is sometimes viewed in the context of ancient Chinese documents, including classical literature as a whole, and not

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as a unique regional food. As a result, there is a profound misunderstanding of the identity, historicity, and originality of K-food [1, 2].

Evaluations of the food composition and preparation methods reveal that Korean Food (K-food) is unique compared to other ethnic foods. Kimchi and jang (fermented soybean sauce and paste, kanjang, doenjang, and kochujang) are fermented foods unique to Korea. Although Korean food components such as cabbages, rice, soy, and fish are common throughout Asia, the early Korean population developed their characteristic foods in relative isolation from other regions of Asia due to the oceans and rugged mountains surrounding the country. Therefore, we must be very careful when discussing the culture and history of Korean food through Chinese books or even books written in Chinese characters that have been published in Korea. In particular, there are only a few books written in Chinese characters by men in Korea that our mothers and grandmothers learned for practical use in making food, and many of the books written referring to Chinese books contain contents based on Chinese food. Nevertheless, since Korea is a very discriminatory nation in terms of food, culture and language from China, if someone who has learned difficult Chinese characters talks about Korean food, they tend to be believed as truth without scientific examination and become an established concept and fixed concept. For this reason, numerous mistakes and distortions about K-food are accepted as factual by ordinary citizens. A common distortion and error explaining the history of kimchi in Korea is a variant of the Chinese dish "*PaoChayi*(泡菜)," thus reducing the history of kimchi to hundreds of years or less [2–4]. This misconception is repeatedly spread in the popular media, causing it to be considered factual by a poorly informed population. In addition, Chinese and Western Sinocentrism and Eurocentrism scholars assert that China and Europe were cultural and economic epicenters from which culture and trade spread to other parts of the world. That viewpoint has led to the belief that the original name of "*dakdoritang*," which is the traditional Korean food with a deep-rooted cultural history of hundreds of years, should be called "*dakbokkeumtang* (distorted name)" despite a lack of evidence that it originated in Japan [5].

Many scholars, especially Hanja (ancient Korean writing using Chinese characters), have argued that the development of Korean food has been due to wars, exchanges, documents, and imitations from other countries, resulting in the development of ethnic food. However, as mentioned above, Korea has historically been geographically isolated, even into Stone Age. Furthermore, it was also so historically resistant to outside influences and interactions that it was commonly called the "Hermit Kingdom." Although all ethnic foods are partially the result of mutual interactions with outside influences, the greater influence is the availability of regional foods such as wild plants and animals, natural materials that can be used to manufacture utensils, and conditions that affect food storage methods. For example, in tropical jungles, many wild plants and herbs are developed for seasonings to preserve foods, but fermented foods are difficult to develop. In grasslands where herbivorous animals can be raised, meat and dairy products became common foods, and products such as smoked meats, cheese, and fermented foods became staples. In regions where wheat was a major food crop, they have preserved characteristics of wheat dishes by directly putting salt into wheat flour to keep its texture and taste, thereby developing various forms of a single dish. The main reason why salt is added directly to wheat flour when making bread or noodles is to help form gluten so that the dough has functionality such as elasticity and extensibility in addition to the taste. Regions that cultivate rice as a main ingredient, like China, Southeast Asia, and Korea, have developed rice as a staple food. Unlike nations with wheat as a staple food, they did not directly put salt into the rice; in Korea, salt was added to enhance the taste of *tteok* (Korean rice cakes).

China has a long history of using lard (oil from swine) and fish oil in food preparation. Because the cooking temperature with oil is high (200–400 °C), many aromatic substances are produced, which enhances the flavor [5]. This is why Chinese food is called the "flavorful taste of fire." Furthermore, water vaporizes at 100 °C, so foods prepared at high temperatures have a low moisture activity, improving storage time. Therefore, oil extraction is a common first step in butchering pigs and processing pepper seeds in China. In contrast, in Korea, the blood was first drained when butchering pigs, and powder was made from peppers, but oil was never extracted. These differences in processing are fundamental differences between Korean and Chinese food processing that greatly influences the final products.

Another distinctive feature of Korean cuisine is the unique presentation of *bap* (boiled rice) and *banchan* (side dishes) [6] (Fig. 1). That is, while most ethnic cuisines focus on "what to eat?," Korean cuisine is a culture of "with what to eat *bap*?." Korean ancestors always pondered how to have *bap* deliciously as the main staple grain and enhance its taste (*mat,* 맛) by adding condiments from plants collected from the fields and mountains [6, 7]. We call this *banchan* culture, and it is a food culture that does not exist in any other country in the world. Usually, they scoop up a spoon of *bap* with a spoon, put it in their mouth, and pick up one of the *banchans* with chopsticks to eat. Sometimes, they scoop *kuk*

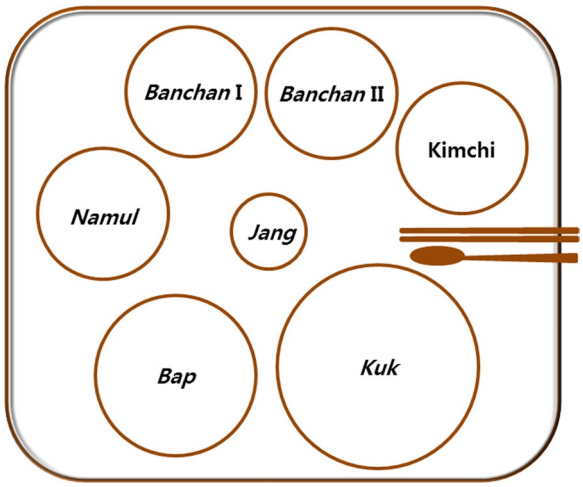


**Fig. 1** Typical structure of the traditional Korean *bap-sang* (see Fig. 4.1 in reference 7). *Bap* (boiled rice) is served alongside *kuk* in a bowl, which assists in the swallowing and digestion of the food. In the *bap-sang*, *banchan* is comprised of one type of kimchi, one *namul*, one vegetable dish (*Banchan* I), and one high protein dish (*Banchan* II), usually made from fish or meat as *chim* (찜) or *gui* (구이). *jang*, or salted dishes such as *jangat-ji* and *jeotgal*, are used to season food and stimulate one's appetite. A variety of *bap-sang* can be constructed using diverse ingredients and cooking methods depending on the season, region, and one's preference. Overlapping ingredients and methods allow for well-balanced flavors and nutrients

(looks like soup) with a spoon so that the *kuk* helps *bap* go down the throat well. The *kuk* is carefully cooked to maximize the flavor and taste and eaten with a spoonful of *bap* and a spoonful of *kuk*. However, Westerners sometimes don't understand this *kuk* culture and mistakenly think *kuk* be eaten before the *bap*, like a soup. Thus the *kuk* should be very tasty. To make it so, we adjust the *kan* with salt or jang to make it feel good and comfortable. We called this delicious state of *kuk 'kan* is right' [5] and taste *'siwonhan-mat'* [8]. However, some scholars in Korea say that *kuk* is salty even though the *kuk* is accompanying food to have *bap* deliciously, not to have calorie intake, without distinguishing *kuk* from Western soup [9]. Not only do we have a different ethnic root than China, but we also do not have oil or sugar as elements to make food delicious agriculturally.

The Manchurian region, including the Korean Peninsula, is not a tropical area where fruits such as bananas are abundant. It does not have extensive flatlands and plains where grains are planted as main crops, and livestock farming is possible. However, due to the geographical conditions of many grasses and herbs growing in the mountains and fields and fish and seaweed harvested from the sea. As a result of the geographical constraints, the ancient Koreans had to find a way to make delicious *banchan* and meals with these ingredients. For this reason, fermented foods of Korea, such as kimchi and jang, are developed as condiments to make *banchans* tasty, rather than relying solely on dishes. As with all vegetables and herbs, they have less flavor when they do not contain salt, fat, or protein. The essence of Korean cuisine lies in the spirit and wisdom of Korean ancestors on how to eat these tasteless vegetables deliciously, which can be said to be the soul of Korean food.

In this paper, we will discuss the origin and development process of traditional Korean food under various historical and geographical difficulties from the perspective of Korean origin, migration, settlement, agronomical and food science backgrounds, as well as from scientific and cultural backgrounds for sustainable growth that can lead to healthy Korean food.

## World ethnic food generation and direction of development

As mentioned in Korean jang's paper on the special issue [10], all ethnic groups develop in a general direction to resolve three fundamental food issues common to all mankind (Fig. 2). First, how can we survive our lives by eating foodstuffs without getting sick or dying? Therefore, we investigate how to develop foodstuffs that can safely satisfy our hunger. Second, how can we eat more deliciously? Humanity's first survival task was to eat safely, but once this is solved, they want to eat deliciously. Gourmets' concern about how to eat the same foods more deliciously is a human instinct passed down from ancient times to the present. Third, how can we safely eat leftovers later? Foodstuff is not always available. In particular, foods with a short shelf life, such as rice, hunted meat, fruits, and vegetables, are rapidly spoiled by microorganisms. Thus, it was not easy to save even a little bit for the next time. Any region or nation in the world develops food after confronting these concerns, and food development is the process of solving these three concerns. At this time, food is made according to the conditions and environment of the region, so each region has its own characteristics, and this is ethnic food (Fig. 2).

## The discovery of fire, the invention of earthenware, and ethnic foods

The discovery of fire before the Paleolithic era solved most of the first problems of food safety and also solved second tasks by improving taste: how to enjoy a meal without an upset stomach. Eating uncooked rice, beans, vegetables, or meat can cause stomach upset and is sometimes life-threatening. Cooking on fire made it safe to eat, and the taste also improved. Heating or boiling the foods with fire sterilizes microorganisms,

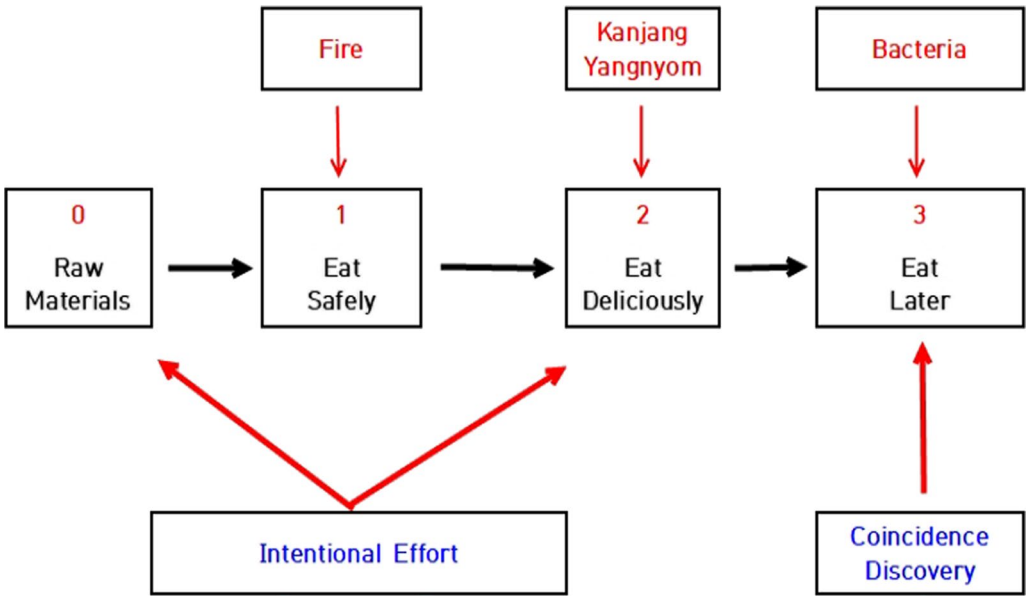


**Fig. 2** The development direction of world ethnic foods. First, how can we survive our lives by eating foodstuffs without getting sick or dying? Second, how can we eat more deliciously? Third, how can we safely eat leftovers later? Any region or nation in the world develops food after going through these concerns, and food development is the process of solving these three concerns

making food intake safer. In addition, as the protein is denatured by heat, the taste improves, and digestion and absorption are improved by facilitating the action of digestive enzymes.

Upon the discovery of fire, the people of the Korean Peninsula were able to store grains, cook food, and ferment food using earthenware vessels [11]. The earthenware vessels found in Korea during the ancient times were of primitive patternless pottery, which was mostly different from that of China. From this alone, we can tell that the food culture of ancient times in Korea was independently formed from that of China. In any case, with the discovery of fire and earthenware vessels, it became possible to cook food, store grains, and ferment food and condiments such as kimchi, and this was aided by earthenware vessels (see Fig. 2.2 in Ref 11). Earthenware vessels developed due to the discovery of fire were called *dok* (*hangari*, earthenware jars) or *onggi* (in Chinese character) and were used for storing kimchi and jang to ferment them properly. This kind of earthenware vessel had a porous structure, making it highly permeable while not allowing water in but allowing gases such as $CO_2$ to escape during fermentation. Korean ancestors understood this phenomenon as "taking a breath." At the same time, the pressure of the fluids also prevented contamination by putrefactive microbes [12].

## Discovery of iron and Korean culture

The Korean and Chinese peoples are ethnologically different nations. However, the field of research studying Korean food culture has committed a mistake in attempting to find the roots of Korean food culture in Chinese cuisine, even by Korean.

Korea has a culture of agriculture that has lasted for more than five thousand years. Geographically, it is adjacent to China, but uniquely it has continued to develop independently thereby developing and preserving its own culture and history without being culturally absorbed by the country of China. The human species (*Homo sapiens*), originating in Africa, split into many branches; one settled in China and the other in the Korean Peninsula after passing through the Eurasian continent via the Amur River. Today, with the development of DNA analysis technology, the whole genome of ancient humans can be analyzed, which serves as a confirmation [13, 14]. Today's Chinese ethnic groups are very diverse, but the Chinese ethnic group represented by the Han (漢) people set the foundation of their country by establishing the Yellow River Culture (黃河文化) with the Yellow River as its center. On the other hand, the Korean ancestors that founded the Gojoseon Dynasty rooted its history and culture in the Liaohe Culture (遼河文化), which was based on Manchuria (now consisting of parts of China's Liaoning Province, Heilongjiang Province, Jilin Province, and Inner Mongolia Autonomous Region) [14, 15]. It

means that the roots of Korea are clearly different from most of China. A careful study of history through the Three Kingdoms period, represented by Gokuryeo, Baekje, and Silla, to the history of Goryeo and Joseon reveals that Korea has survived by inheriting and maintaining its own unique culture that is distinct from China's. It is also true for food culture.

Liaohe Culture displays totally different characteristics biologically, archaeologically, linguistically, and culturally from the Yellow River culture. The representative unique artifacts and relics of Korean Liaohe Culture are the *Mumun* pottery (patternless pottery) and *ondol* (floor heating system). In terms of language, Korean is classified as Ural-Altaic (Trans-Eurasian), which is completely different from the Chinese language system (India-Europe) [15, 16]. Korean belongs to the same linguistic family as Manchurian (ancient Gokuryeo), Mongolian, Japanese, Hungarian, and Finnish. Koreans also have Mongolian spots, like the Mongolians. Thus, Korea has developed differently geographically, ethnically, and culturally from China. In the same way, Korean food culture also has distinct characteristics which are different from Chinese food culture; autonomous and unique. Despite this, many people who study Korean food culture still misunderstand it as originating from Chinese Yellow River Culture. Why do these mistakes and misconceptions happen?

Written language characters were developed early in the Yellow River Culture, and Chinese characters (漢字) were created, allowing records to be kept since antiquity. Through these records, the history and culture of the time can be understood. On the other hand, the Liaohe Culture was not a culture in which characters had developed. Therefore, to understand the Liaohe Culture, it is necessary to infer the geography, history, language, and cultural life through relics and artifacts rather than written records. However, this task is not easy in Korea. Conversely, it is very easy to tell the history and culture of Korean cuisine by simply referring to Chinese literature and Chinese characters' literature without any scientific examination. As a result, there are many distortions and errors in developing Korean cuisine.

Many people claim that as humans progressed from the Bronze Age to the Iron Age, with the development of transportation such as chariots and with the development of tools such as knives, spears, axes, and bows, wars were frequent, and exchanges were active, thus contributing to the changes in ethnic foods. However, when looking at the modern science of human genome analysis of ethnic groups, it is possible to see in progress of foods and languages that there is little possibility for such claims as introduction theory and imitation theory from other countries, development theory, etc. They conserved their own foods and developed them through concerted efforts.

After the Paleolithic Age and the Neolithic Age, weapons and means of transportation began to develop in the Bronze Age and the Iron Age. It made the scale of the war larger and allowed for more casualties. In fact, genome analysis using ancient DNA reveals that female genetic diversity (X-chromosome) and population size continued to increase over time, while male genetic diversity (Y-chromosome) showed many inflection points [see Fig. 1 in Ref 11]. There is also a point where the genetic diversity and population size of males decline rapidly, corresponding to the Bronze/Iron Age around 5000 years ago [11]. The rapid decline in male genetic diversity and population size cannot occur without male genocide. Meanwhile, the female population has steadily increased over the same period. In addition, the genetic analysis of ancient people revealed that the Korean people, which were considered to be a single race and a single lineage, were gradually genetically mixed [17]. The totality of these results suggests that during the war, the invaders slaughtered men and humiliated women.

Due to this war, almost none of the men survived, and the women suffered maltreatment, yet the ethnic mix did not greatly change the language or food culture, and it has been passed down for thousands of years with its unique language and food. Korean language and food culture were very different from neighboring China. Koreans spoke a Trans-Eurasian language (Ural-Altaic) and used very little oil for cooking. Before Vavilov's results came out [18], Korea's unique culture and language were believed to have been passed down through bloodlines [19]. This was right at least as far back as the Paleolithic and Neolithic periods when farming with hunting began. However, considering the results of ancient genome analysis as mentioned above, Korean people have become genetically diverse to the extent that they cannot be called a single lineage due to numerous wars or foreign invasions, but language, culture, and food have been preserved at the level of a single ethnic group, and were completely different from those of China. It can be seen that culture, language, and food were preserved even though men died and women were humiliated due to numerous wars and invasions between tribes. In many cases, after the Bronze/Iron Age, the invaders would have killed husbands and left young sons. However, it would have been the woman's responsibility to give birth to, raise, and save even the children of the invaders. Therefore, it is believed that the uniqueness of food, culture, and language has been maintained centering on women, even though culture and language may have been passed down by bloodline in the Stone Age [20]. The massacre of men meant that the food supply for the remaining women and their children was very sparse, given that men were primarily responsible for hunting, farming, and providing food for their families.

Therefore, it is a false claim that Korean food came from either China or Japan through men's communication. Wars have not advanced the development of food. On the contrary, wars bring an oppressive dark age for food development. Had mothers' languages not changed after the war, their food would not have changed either. Ethnic foods originate naturally from that nation's unique characteristics and geohistorical background; this is true when searching for the truth.

## How did the Koreans eat something delicious?

The discovery and use of fire and pottery ushered in a new era of food safety. Although there was some progress in food safety in earlier times, the problem of food scarcity remained unsolved and remained a dilemma. Furthermore, natural disasters and wars continued to cause shortages of food resources. Such famine conditions require people to eat mostly indigestible plants, such as grasses and trees, as well as insects and unusual sea creatures, just to survive. Generally, the meat or milk of animals is relatively flavorful. However, grass and tree shoots are usually tasteless, rough, and crude, so people do not want to eat them unless they are short on food. Even if the food shortage problem is solved, just eating grains and rice is bland and is not satisfying or nutritionally balanced. Therefore, making some side dishes improve both the flavor and nutritional content is necessary. For this reason, Korean ancestors, especially women, had to find ways to make the hard-to-eat plant and animal foods palatable so they could survive starvation. They were entrusted with making them as edible and delicious as possible, and the Korean food culture may have developed in the process of resolving these concerns.

The effort to make food delicious was a major task in developing food and the core of food culture. In an environment where livestock and dairy products did not exist, where sugar to provide a sweet taste was unavailable, and where there was no oil to enhance the flavor, the ancient Koreans developed side dishes to add flavor to the boiled rice. This is the core of K-foods, combining side dishes and boiled rice called *banchan* and *bap,* respectively. The preparation of flavorful *banchan* from vegetables, without sugar and oil, was central to the development of K-foods. Although foods in other countries have developed as a result of efforts to make the staple foods delicious, Koreans had to make highly flavorful *banchan* to accompany their staple food, *bap*, to make it flavorful and delicious to eat [21, 22]. As a result, the diversity of Korean foods is linked to the diversity of *banchans*. The use of *banchans* to augment rice is analogous to eating other foods with bread from wheat flour in Western countries. However, they had to develop various kinds of *banchans* using local ingredients, cooking methods, and flavorings. In fact, there are thousands of kinds of *banchans* in Korean food [21, 22]. Thus, Korean cuisine provides a more diverse selection of food ingredients and a greater variety of flavors than any other cuisine worldwide. Koreans can make the ingredients of any cuisine in the world into delicious dishes in various ways. Even things that Western people discard thinking they cannot make them palatable, can be made delicious by using Korean *banchan* dishes. For this reason, while in the USA or China, chicken dishes are simply fried, in Korea, we make various kinds of seasoned fried chicken with *yangnyom* [23], which explains the worldwide popularity of Korean chicken.

## Taste (*mat*) of Korea

Korean foods have a distinct taste from Western cuisine. Generally, the taste of Western cuisine is detected by the tongue. The tastes of Western cuisine are mainly sweet, salty, sour, umami, and bitter. Therefore, they started to search for ingredients that bring out these tastes, beginning with adding salt to dough and ending with sprinkling salt over foods on the table. This method of exploring the flavors and tastes of Western cuisine led to a long and arduous journey of looking for spices that brought out certain flavors after the Middle Ages. It was the impetus behind Columbus' voyage of discovery and the exploration of the Indies. Starting with Central America, Westerners contributed to a large part of food taste history. People like sweet tastes, which are mainly found in sugar in the West. In Korea, sugar is also used to achieve sweet tastes, but on rare occasions, it is produced from honey bees, and sometimes people make a syrup called *jocheong* using hydrolyzed starch for special occasions such as *Seol* (Lunar New Year's Day). Since the discovery of sugarcane in South and Central America after the seventeenth century, the discovery of materials that produce a sweet taste allowed for large-scale cultivation of sugarcane. Since the nineteenth century, sugar has also been produced in large quantities. In this way, Westerners developed their taste preferences based on single flavors centered around salt, pepper, and sugar, and complementary foods that utilized them were developed.

In contrast to the Western pursuit of a single taste by searching for ingredients, Koreans seek to bring out the tasty flavors of *banchan*; with that, they have to eat *bap*. While Westerners often select certain meat parts and discard the remaining animal parts, Korean ancestors were reluctant to discard the innards of animals and extracted the essence from even bone to be used as an aqueous source (broth in *kuk*, *kuk-mul*). The early Koreans mostly ate plants and encountered many cases where they had difficulty making them palatable because of the tastes of certain plants; this is referred to as *'japnae*

(miscellaneous off-flavor)' in Korea. The priority for Koreans was to remove this difficult-to-overcome *japnae* and eat those things that were difficult to eat, such as vegetables, by accentuating the tasty *mat* (tastes and flavors) they liked—this is the development history for Korean food tastes. In fact, it is relatively easy to remove *japnae* and bring out taste by cooking at a high temperature with sugar and oil. However, when we understand that Korean ancestors were able to find a way to make food more flavorful in the absence of sugar and oil from a farming perspective, it is easier for us to understand Korean food.

#### *Kan, Yangnyom, Kukmul* (Broth of Kuk)

Westerners mask the off-flavor of vegetables and meats by adding sugar and making the food flavorful. To remove the *japnae* (miscellaneous off-flavor), the Korean ancestors used a variety of herbs with other ingredients, added doenjang (fermented soy paste), kanjang (fermented soy sauce), or vinegar and boiling into a broth, or they soaked them together to make the *mat* of the kanjang or doenjang permeate into the food. As a result, Korean food can be delicious. Eating this as a *kuk* or *banchan* needs to be permeated in the mouth for it to be delicious. Salt, both East and West, was used as a basic ingredient that played the most important role to be delicious. If it has no taste because of low a salty taste, people say, '*kan* is not right (it's watery and tasteless)'; if the taste is really savory, they say, '*kan* is right (the seasoning is just right and it is delicious)', and if its taste is too salty, like brine after cooking for a long time with a lot of salt and seasoning, they also say '*kan* is not right (the seasoning is not right and it is salty)' [5, 6].

Contrarily, simmering meat for a long time or with special ingredients will extract tasty elements into the *kukmul* (broth of kuk), thus making the *kuk* tastier. Koreans usually enjoy this *kuk* by sipping it or eating spoonfuls while they eat their *bap*. This way of consumption has led to the Korean culinary culture being referred to as "*kukmul* culture". During this time, it was said that if the *kan* is not seasoned properly, it will be tasteless, and if the *kuk* is well-seasoned with ingredients such as salt and meat flavors, then the *kuk* will be tasty because of proper *kan*. In the Korean *kuk-mul* culture, when people talk about the taste of the *kuk,* they prioritize whether the *kan* is adequately seasoned or not, but also appreciate a "*siwonhanmat* (refreshing and comfortable taste in Korean)" that makes a person feel good inside (an English equivalent would be to feel warm inside) when drinking a well-made *kuk* [8, 9]. This refreshing taste is usually perceived not through the taste buds but through a visceral sensation. It is said in contrast with mixtures of various tastes with indistinguishable tastes, a well-made *kuk* has a unique and distinct taste that can be described as "refreshing". Koreans say that the taste of *kuk* is "refreshing" when it has a salty taste that matches the flavor of *bap*, so it is comfortably filling, and one's mood is improved. It may be because when the salt content of the *kuk* is almost the same as the amount of sodium in human bodies (0.9%), it can be said that "the *kan* is correct." When a person is well-made *kuk*, the body has a positive response to the appropriate salt concentration. The person feels refreshed, the food is easily digested, and one's mood is elevated. These mood-enhancing properties of *kuk* are what Koreans consider a delicious taste.

Animals have minerals like sodium, so when boiled, fermented, or roasted, they have their own taste due to the interaction of the minerals with amino acids and peptides produced. However, vegetables do not have minerals like salt, so they are bland with little flavor. Phytochemicals which exist as spices in plants are often bitter, spicy, or pungent substances that protect the plants from being directly eaten by foraging animals. Thus, it is not easy to eat many vegetables or grass directly. Korean food has overcome this difficulty by making vegetables tasty, and this skill has been passed down to today's Korean food. In order to reduce the toxins that are often associated with a bland or bitter taste, boiling vegetables in water usually reduce their quantity. Because it is difficult to maintain the texture of the vegetables, it was necessary to find a way to maintain the unique texture and also make it soft enough to eat.

To eliminate *japnae* and to present an appetizing color, Korea has developed and used a unique sauce called '*yangnyom*' in food systems [6, 23]. *Yangnyom*, which is a uniquely Korean key ingredient for making other ingredients tastier, is prepared by chopping garlic, chili peppers (the chili peppers which are grown in Korea and Manchuria called *kochu*), leek (green onions), and gingers, and adding sesame oil, sesame seeds, *kochu* powder, kanjang, and salt. Color is important in *yangnyom*; most yangnyom combinations are made with *kochu* powder (dried red chili, *Capsicum annuum* powder) or kochujang (fermented *kochu* powder paste), as the most appetizing food color is red. Chili peppers have a long history in Korean food and are used to make red and stimulate appetite [5, 24]. Vegetables are cut and seasoned with *yangnyom* by hand to make them tasty. It provides a good taste if vegetables with soft textures are seasoned with *yangnyom* directly. However, if vegetables with hard textures are first blanched or salted and then seasoned with *yangnyom* by hands, they can have a soft texture and a taste. That is why the taste of Korean food is the 'taste of mother's hands'. If vegetables are boiled at 60–70 °C with *yangnyom* and eaten, they become *namul* [25, 26]. Vegetables were pickled with salt under hypertonic conditions to remove the juice from cell, including sodium ions, to

change the texture of vegetables and prevent the growth of pathogenic microorganisms due to osmotic pressure. The pickled cabbage is seasoned with *yangnyom*, called *geotjeoli*, before fermentation [5, 27]. The cabbage with *yangnyom* does not go rancid during fermentation due to the inability to grow the majority of bacteria except for lactic acid bacteria.

The characteristic taste of Korean food is not one derived from a single ingredient but rather a unique taste expressed through the combination of *kuk-mul*, *yangnyom*, and other ingredients to create a harmonious taste with adjusted *kan*. This Korean taste creates an entirely new *mat* (flavor) by blending together different ingredients, which is commonly referred to as "*kip-eun-mat* (deep flavor)" and is a unique amalgam. In this way, Korean cuisine has developed to create hundreds of tastes (*mats*) based on the sense of taste, thus creating more than 100 expressions of tastes. No other country in the world expresses more than a hundred *mat* [6].

## Agronomic background: origins of rice, beans, peppers, and Chinese cabbage

Korean food has developed due to numerous efforts to make it safe and delicious based on agricultural products from the Korean peninsula and Manchuria. Agriculturally, the development of a region or ethnic group's cuisine depends on what kind of food ingredients grow naturally in that area. Available edible resources vary according to the natural environment in which humans live. In other words, 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. If millet or rice plants had not been present in Korean soil, people would not have thought about eating *bap* for thousands of years, and if beans were not present in Korean land, jang fermentation would not have developed. Thanks to the unique Korean chilies (*kochu,* Korean chili from *Capsicum annuum*, which is a different variety from some of those commonly used South and Central America and Southern Asia today, is not brutally hot), we could make *kochugaru* (chili powder) for *yangnyom* and kochujang. If the *baechu* (napa cabbage) variety hadn't grown in Manchuria and Korea, we would not have considered making kimchi. It is the fundamental philosophy behind the birth of Korean ethnic foods: how we could manage to eat the locally available produce and make it delicious over hundreds of years through intentional efforts (Fig. 2).

Despite this, some food science researchers have abandoned this basic philosophy of food development and have claimed that Korean food was introduced from outside by trusting the wrong documents and reducing the history of kimchi and kochujang to less than several hundred years [1, 2, 28]. In order to rationalize and institutionalize their own claims, they eventually distort the biological, agronomic, geographic, and environmental history of *kochu*, *baechu*, and soybeans grown in the Korean peninsula. Such distortions of Korean history minimize the importance of the ancient cultivation history of rice, *kochu*, *baechu*, and soybeans grown in the Korean peninsula.

### *Rice plant (byeo or narak)*

Tens of millions of years ago, rice first appeared on the Earth, growing in the wild and then diverging into short-grain rice, the Japonica type, and long-grain rice, the Indica type, million years ago by evolution. It is highly likely that humans mainly spread rice since animals would be unlikely to spread it because seeds are easily digested in the intestines. Though it is possible that the wind spread rice before humans appeared on the Earth, the possibility of it being spread so widely country-by-country and continent-by-continent is limited, and it was likely spread widely in response to human needs. In other words, the history of the spread of rice is similar to the history of cultivation.

It is conjectured that rice cultivation began at least 20,000 years ago. Previously, it was thought that rice cultivation originated in the Assam region of India, spreading to Myanmar, Thailand, Laos, and Yunnan, China [29]. However, many now believe that rice cultivation began in Hunan, as rice grains were found in China's Yangtze River [30]. It can be seen that rice was found in Songori, Chungju, Korea, about 15,000 years ago [29]. However, it has yet to be discovered exactly where and how the rice Koreans eat was first cultivated and spread to Korea. It is also not certain whether only short-grain rice (*Oryza sativa coreaca*) was spread or both short-grain rice and long-grain rice were spread, and then only the Japonica type (short-grain) was chosen and passed down. Nevertheless, southern regions near the Yangtze River are generally dominated by long-grain Indica-type rice, whereas the northern regions grow short-grain Japonica-type rice. It is highly likely that these two types of rice were spread together, and then one was chosen for cultivation in the Paleolithic or Neolithic periods based on the preference of how to eat them. Therefore, even though rice has been a staple across many countries for thousands of years, each has its own unique ethnic foods.

### *Soybeans*

Soybeans have existed for millions of years before humans appeared on Earth. However, each soybean species grows only in a specific area because soybeans cannot be transplanted without human intervention. Soy seeds are a food that birds like, and once they eat them,

they get digested in their bellies. They can fly far, but they can't spread the seeds. That is why certain areas can only be the origin of wild varieties of pulses (beans) when humans first discovered them. In fact, there are various kinds of pulses on Earth, such as soybeans (*Glycine* spp) in Manchuria, lentils in India, chickpeas in Egypt, and Mesopotamian beans. Through analyzing the genome, it is estimated that soybeans have been growing on Earth, particularly in the Korean Peninsula, for ten million years before humans started cultivating them about one million years ago [31–34]. Nevertheless, since pulses are not grains and eating them raw may cause food poisoning due to the presence of trypsin inhibitors, they were not widely spread. It was not until 2,000 years ago that bean products, such as primitive cheongkukjang, were introduced into China [35, 36].

Tracing the origin of such rarely propagated crops has been accomplished through biological analysis based on documentary analysis since long ago [32, 36]. As a biological approach, the distribution of wild species is used as an essential indicator for deducing the birthplace of crops in botany [19]. Academia defines the place where wild, intermediate, and cultivated soybeans grow in one place as the plant's place of origin, and the Korean Peninsula and Manchuria correspond to this [30, 32, 37]. Second, it can sometimes be identified through literature records. It was recorded in the ancient Chinese books and many reports [29, 38, 39] from Shan-rong, a Northeast barbarian in Manchuria known as the territory of Gojoseon, an ancient Korean state, that soybeans were introduced into China and spread to other regions. It suggests that Gokuryeo was the origin of soybeans, where soybeans were produced and consumed the most, or that processed soybean products of exceptional quality were produced [38]. Third, carbonized soybean, a relic of soybeans, have been frequently excavated from the Neolithic Age to the Bronze Age sites on the Korean Peninsula [40]. Even soybean relics, which are estimated to have been around the third-century AD, have been found, and it is presumed to be *meju* (dried soybean brick made by crushing after boiling) (see Fig. 3) because it was in the form of a dough made by crushing soybeans containing moisture. This suggests that soybeans were cultivated and became common food for Koreans [41]. Recent developments in genetic engineering technology have scientifically confirmed such claims. With the recent development of life science technology, it has become possible to identify the soybean origin through genome analysis. Korean soybeans were found to be located in the early part of the evolutionary tree [34]. It showed that soybeans were native to Manchuria and the Korean Peninsula.

From the above, since Manchuria and the Korean Peninsula were the origins of soybeans, soybeans are relatively abundant in Korea, and Koreans have been able to develop soybean-based foods such as tofu, doenjang, kanjang, cheongkukjang since ancient times. Even though the origin of the beans is not China but Manchuria (in Korea in ancient times), some people claim that cheongkukjang (豉) originated in China and also that it was exported to Korea from China because it appears in some Chinese documents (張華, 博物誌 (Bakmulji), BC 232–300)[35]. It is, however, an incorrect claim since it is made without sufficiently reading ancient texts and understanding the agricultural background behind them [42].

#### *Kochu (chili pepper, chili)*

Chili peppers are members of the *Capsicum* genus and belong to the eggplant family (*Solanaceae*), and it was evolved to Capsicum from other Solanacea such as eggplants and tomatoes etc. in 19.6 million years [43]. It has been widely believed that all Capsicum species are tropical plants native to the equatorial regions of North and South America and Christopher Columbus brought to West at the end of the fifteenth century [28, 44, 45]. However, this belief is largely erroneous from a modern scientific perspectives: It is not correct that only Central America is a native place of chili peppers for varieties, and it is true that Columbus brought some chili peppers to West, but not all of Asian pepper chilies. Some chili pepper species, such as Naga jolokia in Asia, especially in India, are not found in Latin America, which means Naga jolokia could not be originated from Latin America. It is Indian own chili species.

The belief has persisted largely due to the fact that chili peppers were brought to the West from Central America during the time of Columbus, without a good understanding of the diversity and evolutionary process of chili pepper varieties, as well as their culinary and agricultural characteristics [46]. This belief is based on chili pepper is originated from the equatorial regions of North and South America and man is the only carrier to transplantation of chili. These claims have continued to be cited unconsciously without scientific validation [44], which does not contribute to scientific progress as scientists should not rely solely on references without direct scientific validation. Tripodi et al. [46] tried to find the evidence of migration through the Eurasia route but couldn't rule out the possibility of some pepper varieties being introduced to Asia via a pre-Columbian transpacific trade route before Columbus. Therefore, the spread of chili peppers should not be based on blind claims, but on a detailed study of their characteristics, varieties,

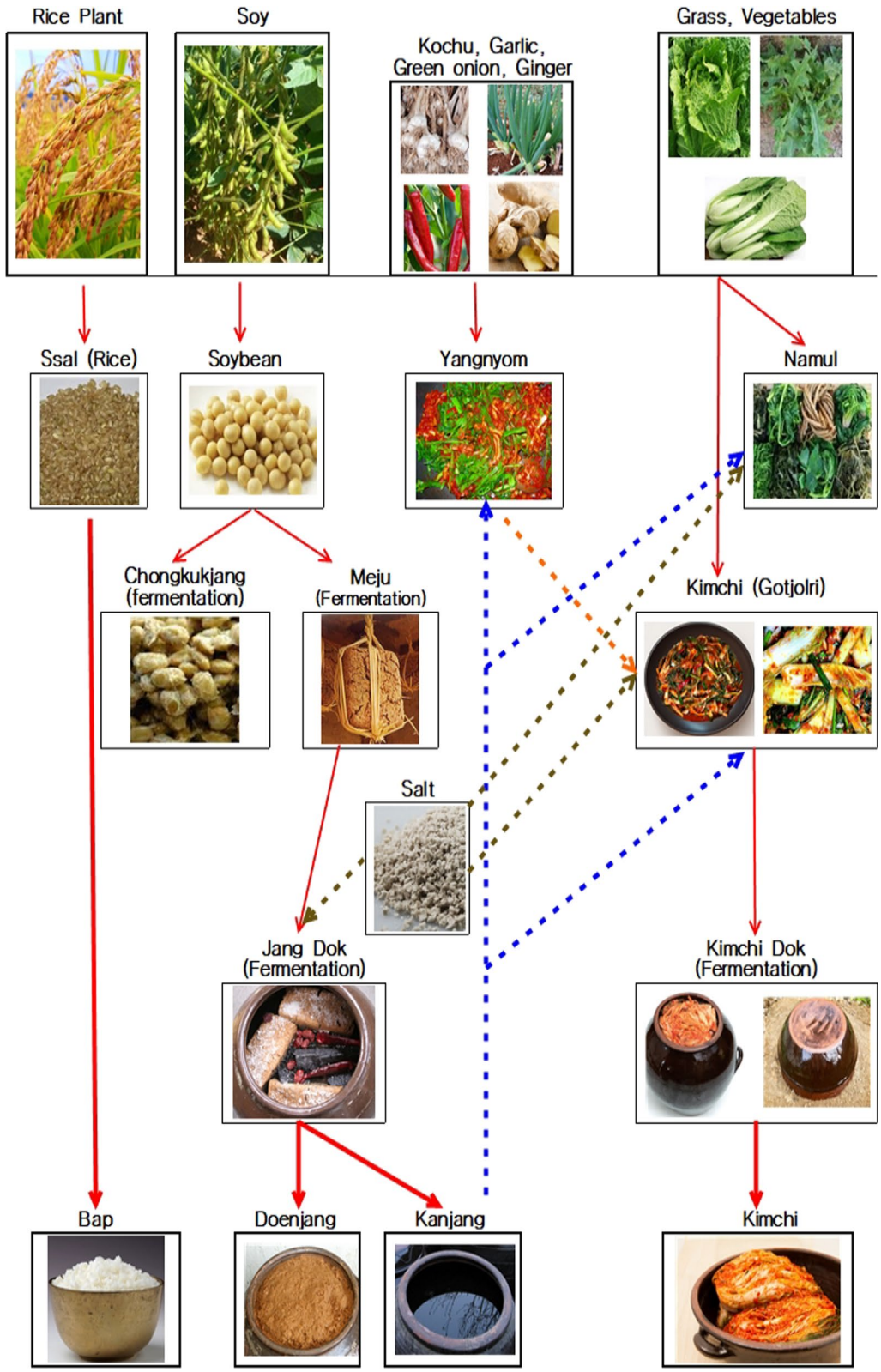


**Fig. 3** Scientific diagram for creating the *yangnyom*, *jang*, and kimchi according to food development philosophy. A key factor is how to adjust *kan* for delicious eating. *Jang* is made from soybean after making *meju* by soaking in a salt solution in *Jang-dok* (Earthenware pottery). Rubbing off and mixing vegetables with *yangnyom* can be eaten, and even a few days later, these vegetables can still be eaten. It is called kimchi

agricultural features, and literary evidence [42, 47]. Because people tend to assume that chili peppers were carried by humans, such arguments have arisen.

Unlike mammals, birds lack capsaicin receptors (TRPV1) responsible for perceiving capsaicin, a compound found in chili peppers, so they can eat chili peppers without feeling the burning sensation [48]. Biologically speaking, the embryo of chili peppers does not decompose even when a bird eats them because the seeds are encased in a protective shell. Thus, chili peppers that spread to each continent evolved according to local conditions and adapted to the wild over millions of years. When birds fly across continents and excrete the seeds, chili peppers can grow from those seeds. Thus men is not a only carrier to transmission of chili. Although Columbus was seeking a route to India for pepper, the discovery of the spice route to the West Indies (Central America) led to some chili varieties being transported to Europe instead [45]. Claims are made that chilies spread to Asia through India within just over a hundred years since Columbus brought them from Central and South America at the end of the fifteenth century, and that they were brought to Korea through Japan during the Japanese Invasion of Korea in 1592 [28], were plausible until genetic engineering techniques were developed. However, these claims have been widely accepted as fact and have resulted in numerous distortions in the history of food culture, hindering the development of Korean culinary culture [1, 2].

On Earth, there are hundreds of varieties of chili peppers [44, 49]. In Asia, there are dozens of varieties, and in Central and South America, there are even more diverse varieties. Even Africa has its own unique varieties. If the Colombians had not brought dozens of chili pepper varieties with them and adapted them to the local climate, dozens of different varieties that evolved in Asia hundreds of years ago would not have existed. This is because it is physically impossible to bring a large number of varieties, and agricultural science was not developed enough to grow each different chili varieties in appropriate climate environments. Otherwise, if the Colombians had brought only a few chili pepper varieties and had them evolve into dozens of varieties according to the local climate in Asia within a few hundred years, it would be both agronomically and genetically incorrect, as genetic evolution takes millions of years, not just a few hundred years. Therefore, while it is possible for the Colombians to have brought a few chili peppers from Central and South America, it is incorrect to say that the chili peppers in Asia evolved from those in Central and South America from an agronomic and genetic perspective.

The diversity of red pepper chili varieties is due to the fact that peppers are easily hybridized [45], and new varieties are constantly being developed with recent agricultural techniques. This is because it is an event that occurs within a varieties, namely within *Capsicum annuum, Capsicum baccatum, Capsicum chinense* and others, not in inter-varieties. Korean chili peppers from Central and South America and India are already the result of evolution that took place millions of years ago between species, and it is easy to determine exactly when it occurred [43, 49]. According to the genome analysis results we presented, *Capsicum annuum* and *Capsicum bocatuum* diverged at least 2 million years ago. While artificial modification to create hybrids with new varieties can occur within a few years, evolution occurs over millions of years, not hundreds of years.

With the progress of life sciences, it has become possible to analyze the origins of chili peppers on Earth and how various cultivars evolved, as well as how they spread in different forms across the planet. Genetic analysis reveals that chili peppers first appeared on Earth about 19 million years ago, and in the Korean Peninsula, there were currently mild varieties and two slightly spicy varieties that evolved about 500,000 years ago (Fig. 4, and also refer to Fig. 1 in reference [43]). Further research is needed to determine whether these two varieties evolved in the Korean Peninsula or elsewhere and were later introduced. Chili peppers were spread to different continents by birds several million years ago, long before humans appeared on Earth [43], compared to rice and soybeans, which were spread only by humans [33, 34]. Chili peppers that spread to each continent by birds evolved according to local conditions and adapted to the wild over millions of years. People began cultivating chili peppers for their needs thousands of years ago by developing food suitable for each cultivar. Therefore, it is impossible to accurately determine where chili peppers originated from, as they were already widely spread before humans appeared on Earth [24, 42].

Some people say Korea cannot be a native country because there are no chili pepper that can grow in Korea in the wild, it is right, nobody says Korea is native country of chili. It is unscientific to say that peppers that have already spread widely before humans appear on Earth are native to certain areas. In addition, some people say that it is a wild species because red pepper trees grow wild in tropical regions such as Central and South America and India, which is wrong. Chili peppers are perennial and grow into wood by lignification, but because of frost in temperate regions, they cannot grow as perennial, grow as annual, and grow anew every year by fallen seeds in prehistorical age.

From an agricultural standpoint, a dish that incorporates different types of chili peppers from around the world preserves the unique chili pepper varieties of the

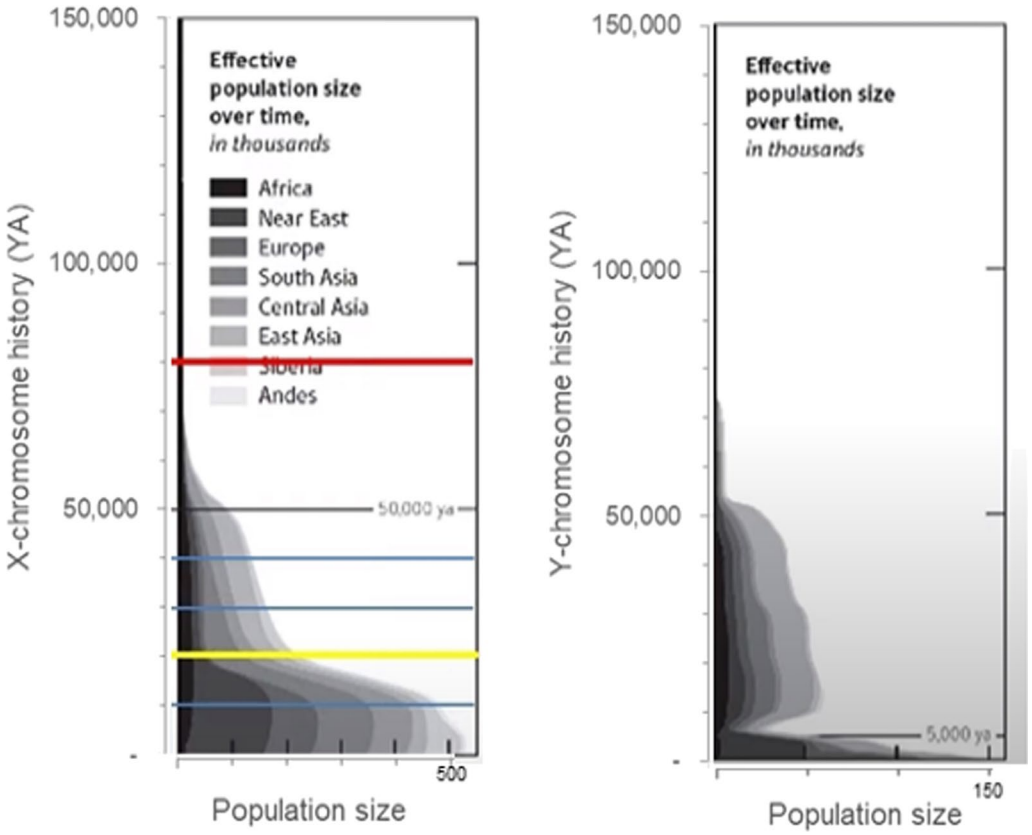


**Fig. 4** Changes in X-chromosome (female) and Y-Chromosome (male) genetic diversity(also refer to Fig. 1 in reference [43]). The genetic diversity of men and women investigated through ancient genome analysis was shown over time by analyzing the genomes from human fossil (adapted from Bhak JH. Origin and Migration of Koreans—Genomic analysis of ancient and modern humans. 2020 [cited 2023 Jan 18]; Available from: http://hongikf.org/sub/sub10_03.php?mNum=3&sNum=2&boardid=speciallecture4&mode=view&idx=2&p_idx=28Bhak). Female genetic diversity continues to increase over time, while male genetic diversity fluctuates, showing a significant decline around 5000 years ago

region and gives the dish a distinctive flavor. This means that dishes such as kimchi and kochujang were made possible due to the presence of sweet and less-spicy Korean chili peppers (*kochu*). They could not have been created if only Mixican, Indian (蕃椒), Vietnamese and South Asian (蠻椒), and Chinese and Chuan chilies (川椒) were available, as these are strongly hot and spicy. Recently, agricultural technique to cultivate many varieties of chili peppers with varying levels of pungency. Therefore, any claim that chilies from Central/South America were brought to India, then to Korea, and were used to make kimchi and kochujang is completely ludicrous from a food science, scientific, agricultural and biological standpoint [5, 24, 42]. Bell peppers and paprika were developed in Hungary in the 1920s to create a very mild variety with no capsaicin content at all. However, most pepper varieties exported from the South Asia including India had high level of pungency.

Even in ancient literature including Chinese literature, there is overwhelming evidence that our chili peppers existed, in terms of chili, *kochu* powder, kimchi and kochujang, so the evidence that our chili peppers were in the Korean Peninsula is overwhelming [42, 47]. All of this is possible because chili pepper varieties appeared on Earth about ten million years ago and spread worldwide through birds before humans appeared on Earth, and each different country or region has its own different chili peppers growing. In 2010, it was reported that *kochu* seeds were found in the internal organs of a mummified woman from the early Joseon Dynasty, dating back to the beginning of the fifteenth century [personal communication with Cha SC from Seorabeol Cultural Heritage Institute, 2021].

#### *Baechu (napa cabbage)*

Kimchi is not made only with cabbage. Nevertheless, there have been attempts to distort the history of our kimchi by claiming that it has not been long since the cabbage came in [1, 2]. Those who distort the history of Korean cuisine by accepting incorrect preconceptions also distort the history of nappa cabbage (Chinese cabbage) in the Korean peninsula [1, 2, 50]. Although

Chinese cabbage has a long history in China, some have claimed that it was introduced to the Korean peninsula 100 years ago, which is obviously a false claim by those who wish to reduce the history of kimchi in Korea to less than 100 years. In fact, it is known that Chinese cabbage originated from main central China, not northern China, including Manchuria (old Gojoseon area territory). Even without a textual analysis, it makes sense that the Korean peninsula was not very far away, that there had been constant exchanges since the Gokuryeo period, and that Koreans were interested in eating fresh vegetables and had condiments such as *yangnyom* and kanjang. However, the claim [1, 2] that *geolku-baechu* (a type of savoy napa cabbage) was introduced 100 years has no factual support from either a historical or agricultural perspective.

From a food science perspective, it is not just the savoy cabbage used for making kimchi. People have been using spring napa cabbage or winter radish leaves from spring to autumn to make kimchi with *yangnyom* and to store it through the winter. In early winter, many neighbors gather to make kimchi, called *kimjang* culture [51, 52]. For *kimjang* (making kimchi), early in autumn, cabbage grew enough to fulfill inside (yellow soft color) by tying outside of them with a straw, which produced a tightly-packed savoy cabbage, which produced a tightly-packed savoy cabbage, preferred for making *kimjang* kimchi. This process of tying the cabbage with a straw to create a tightly-packed inside cabbage dates back hundreds of years. When the autumn cabbage is tied with a straw, it remains green outside but is full of yellow stuffing inside, which is typical of savoy cabbage (*gyeolgu-baechu*).

A review of historical documents reveals that there are numerous records documents documenting the established use of savoy cabbages in Korea 100 years ago [42]. As mentioned earlier, 'sung(菘) [cabbage]' is represented in Honmonjahwoe (訓蒙字會 by Choe Sejin), and 'sung' [cabbage], 'autumn cabbage[秋菘]', and 'cabbage vegetables [菘菜]' are present in numerous documents such as Tongguk-yisangkukjip (東國李相國集, by Yi Kyubo) (1241), Tongmunsun (東文選, by Seo Keojung) (1478), Sakajip (poem, 四佳集, by Seo Keojung) (1488), Jeompiljaejip (佔畢齋集, by Kim Jongjik) (1497), and Maewoltangjip (梅月堂集, by Kim Siseup) (1583). Relying on just these documents provides convincing evidence of a long history of cabbages in Korea. Furthermore, Kim, Jong-duk already acknowledged that there had been cabbages in Korea for a long time [53]. In addition, another character created to represent the Korean word *'baechu* [cabbage]' in Chinese characters, *'baekchae* (白菜)', can be found in Yongjaechongwha (慵齋叢話, by Sung Hyen) (1525), Haetongjaprok (海東雜錄, by Kwon Byeol) (1670), and Sagajip.

Records from Sakajip clearly show that the use of *gyeolgu-baechu* had already established by the fifteenth century. It was characterized by bluish-green and yellowish-white colors, distinctively different colors on the outside and inside leaves. Chongjeonkwanjonseo (靑莊館全書, by Lee Dokmu) (1795) also mentions '*yeonhada* (soft with light green) as the color of *gyeolgu-baechu*'s inside leaves[菘心]. Tasan-shimun-jip (茶山詩文集, Tasan Poetry, and Prose Collection, by Jeong Yakyong) (1865) also mentions the inside leaves of cabbage. All of these references indicate that *gyeolgu-baechu* has a long history in Korea. They confirm that *gyeolgu-baechu*, with its distinctively different colors with green on the outside and yellow on the outside inside, was already in use before the 15 century. To represent kimchi made of *gyeolgu-baechu*, expressions such as '*sungjo* (菘菹)', '*sungje* (菘薤)', and '*chimsungchae* (沈菘菜)' were used. In Yeonhaeng-ilgi (燕行日記, a travel journal by Kim Chang-up) (1712), there is a record of eating rice with *sungjo* (kimchi made of *gyeolgubaechu*). Tasan (Jeong Yakyong) also mentions eating cold noodles with *sungjo*. In Sakajip, there is a record about making kimchi and preserving it in *hangari* (*ongki*, earthenware vessel). This kind of kimchi is called *sungje*. Therefore, the extensive historical documentation of the historical use of kimchi disproves the idea that Korean radish kimchi only dates back a hundred years and that *kimjang* kimchi only dates back a few hundred years [1, 54].

## How can food be preserved for later use? Birth of Jang and Kimchi

Food shortages and famines have plagued mankind throughout recorded history. Accordingly, it was to develop methods to preserve food so that excess food could be stored for later use. Preserving foods in a manner that maintained or improved the flavor was a major step in developing ethnic foods (Fig. 2). Of course, the efforts of Korean ancestors to store grains and crops before they were made into food was a different task. In Korea, physical methods such as *gotgan* (storage house protecting against animals), *hangari*, and *dok* (*hangari*, and *dok* are earthenware, pots, or jars) to store grains were the first step. However, thousands of years ago, the issue of being able to eat the same food again later remained unresolved and was an unavoidable area.

Nevertheless, this problem was solved by accumulating experience and knowledge through a succession of both intentional efforts and fortuitous discoveries that culminated in the distinctive Korean food. The driving force behind the development of Korean food was the search for a solution to "How can we eat the food we ate before, even later?." After much effort, jang and kimchi were discovered by chance as serendipity (Fig. 3).

When times were tough, and food shortages were prevalent, it was heartbreaking to throw away leftover food or *banchans*. In Western countries with high latitudes, there were frequent migrations of people, and cattle husbandry was developed, which resulted in the accidental discovery of fermented dairy products. They put some sour milk into a vessel and ate it, but couldn't finish it all and left some. After a few days had passed, there was much curd forming, and the appearance was bad, but they ate it and experienced no ill effects. Therefore, that was the precursor to fermented dairy products of the West today—cheese and yogurt. In the same way, in Korea, where plants grow well due to the temperate latitude, vegetables seasoned with *yangnyoms* were sometimes left over. When the Korean ancestors ate them a few days later, there was no illness, and the edibility was actually improved—that was kimchi. Basically, the early Koreans started using *yangnyom* to improve their taste, but it evolved into fermented kimchi. Of course, since making kimchi helps to preserve the vegetables, it can be stored much longer than ordinary vegetables. In summer, in order to store kimchi, they would put it in a deep well to maintain low temperatures. Before starting the winter, they made kimjang in buried earthenware pots (*dok* or *ongki*) to maintain temperatures so that it wouldn't freeze. Fermentation could occur, making it delicious, and they could store it through the winter [12]. It wasn't until the late twentieth century, when microbiology science had developed, that the role of microbes involved in fermentation was discovered.

As wisdom and knowledge accumulated over time, the Korean ancestors started pickling and storing kimchi to eat later, something that would have been impossible before the establishment of the *ongki* culture [11]. Pickling and eating vegetables with *yangnyom* became a priority, and kimchi would be eaten later. Pickling kimchi and other vegetables for storage during the winter months was something that would only be discovered hundreds of years later with the invention of *ongki* (earthenware jar) as a *kimjang-dok* or stone jar. Around those times, using this *ongki* or *dok, seokjo* (石槽, stone jar) (Fig. 5a) and *seok-ong* (石瓮, stone pot) (Fig. 5b) were used for making kimchi. A *seokjo,* made by carving a large stone squarely, was used to wash or pickle cabbages with salt, and *seok-ong* made seokjo by carving the stone roundly. *Seok-ong* was buried in the ground to be used for fermentation like a kimchi *dok*. The *seokjo* (stone jar) and *seok-ong* (stone pot) were placed in the Beopjusa Temple in Songnisan mountain, which was founded during the Silla Dynasty (AD 57–935) (Fig. 5). In addition, many other relics support the *kimjang*, and many ancient documents also support this content [42].

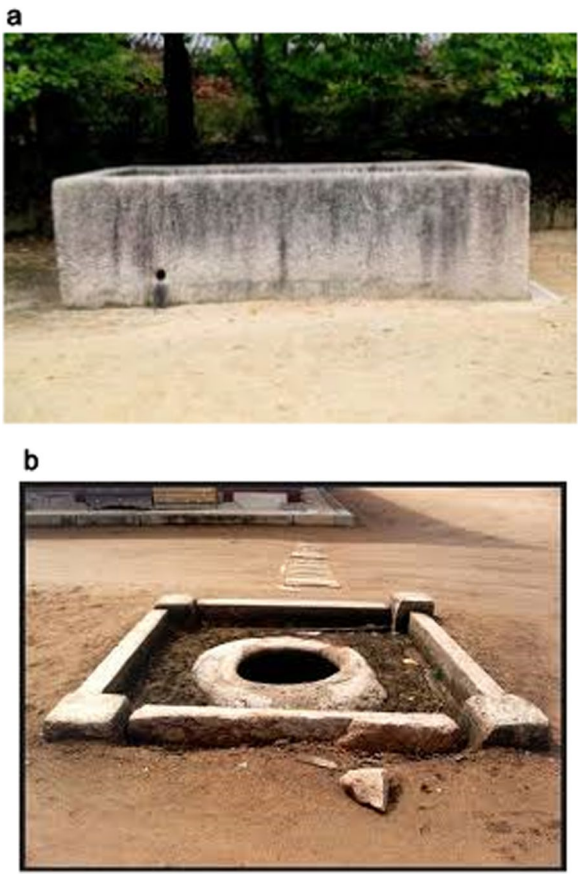


**Fig. 5** The *seokjo* (石槽, stone jar) and the *seok-ong* (石瓮, stone pot) in Beopjusa Temple in Songnisan Mountain, which was founded during the Silla Dynasty (AD 57–935). **a** The *seokjo* that the large stone was carved squarely was used to wash or pickle cabbages with salt. **b** The *seok-ong*, which the stone was carved roundly and buried in the ground, was used for fermentation as a kimchi *dok* (adopted from Professor Kong MS)

Compared to kimchi, the discovery of jang involved a relatively complex process and required more time to evolve. So what do we know about the origins of jang [10]? Similarly, Korean ancestors expended great efforts to develop methods of making delicious jang and to learn how to store it for later consumption. Firstly, it was necessary to store beans well away from animals, but basically, it was possible to eat them by boiling the beans every time. However, if you boil beans once and keep them, they will soon get spoiled. However, in winter, it is possible to keep boiled beans in a room for a few days and make delicious cheongkukjang with a small amount of unfavorable smells. Of course, it was desirable to store cheongkukjang longer for future use, but how could that be accomplished? This problem was solved through great efforts and developed into meju (dried, boiled soybeans)

by drying under the eaves of the thatched-roof house. If we unintentionally leave boiled beans aside, the dry parts will not get spoiled, even if we eat them later. From this process, we learned that if the beans are dried on the ground, they will quickly get spoiled and cannot be eaten, but if they are dried on a rice straw mat or sackcloth where the wind blows well, the boiled beans will dry better and last longer [10].

No matter what kind of food it is, "the longer it has been dried, the longer it lasts, but it is not easy to make it appetizing." In making beans into *meju* so that they can be eaten later, Koreans found a way to eat it deliciously. It is the birth of a unique jang. Like other animals, humans instinctively search for salt (water) to meet the physiological requirement for sodium. They instinctively knew that salt makes food tastier. Korean ancestors found a way to make the *meju* delicious by using salt in solution, which led to the birth of jang [55]. They might have attempted various things, such as tasting the salt directly or grinding it until soft; however, they discovered that making a salt-water solution and mixing it with *meju* resulted in making the beans soft and flavorful. Even in this case, the *meju* would not be soft enough to eat right away, so they had to wait a long time by putting it in a *dok* (pot) and waiting until it became softer and edible. During this waiting period, proteins in the beans are broken down by microbes such as *Bacillus subtilis,* producing tasty peptides and amino acids. Other metabolic substances also developed in the pot, resulting in deep fermentation.

The result of these strenuous efforts and a long wait is Korea's sauces, jang [10]. The liquid and solids were easily separated by putting it in brine using sieves. The solids remaining on the bottom were called doenjang (soybean paste) because it was "*doen*" (thick). The liquid on top was naturally called kanjang (aqueous soy sauce) because it was much more delicious than just salt for seasoning [6]. Thus, unique Korean sauces of doenjang, kanjang, and salt were born since pathogenic bacteria could not survive due to the salt content and were able to be stored for a long time. Kochujang (chili paste) also became part of the strenuous effort to make food more delicious with rice and other dishes thousands of years ago. First, rice malt was made into powder, milled sticky rice *bap* was added, and then the most flavorful and colorful *kochu* powder (red pepper powder) was mixed in and waited for a long time in *jang-dok* (earthenware jars).

### Fermentation: gift of blessing for those who worked hard and waited

The main force driving the development of Korean food was resolving the problem of "How can we have food we ate even later?." In order to solve this problem, kimchi and jang were discovered through numerous efforts and waitings. Kimchi and jang fortuitously discovered accidentally were regarded as a gift from heaven to Korea, although perfecting the production methods took much effort. It is only natural that they saw and just thought kimchi and jang as blessings from heaven only to Korea since there was a lack of scientific knowledge about fermentation [56]. They did not even know the basic concept of microorganisms or fermentation. Of course, it is undoubtedly clear that fermented foods such as Western cheese and yogurt are also considered blessings to them. In Korea, this fermentation is an efficient and refreshing way of solving all three problems of food development at once, which is how to make it tasty and edible later.

In Korean cuisine, jang and *yangnyom* are the cornerstones of making all dishes delicious and flavorful. Vegetables such as garlic, leek, *kochu*, and ginger are mixed with jang and salt to make a *yangnyom*, which is then used to make kimchi.

#### *Kimchi*

It is by chance that kimchi became the foundation of fermented plant science. Korean ancestors developed fermentation processes and microbiology techniques without even knowing the concepts and existence of fermentative microorganisms in order to survive. This fundamental principle was the founding concept from which Korean food development took place. Nowadays, it is almost impossible for Koreans to eat *bap* (cooked rice) without kimchi. As kimchi ferments, organic acids, including lactic acid, are formed, which contribute an appropriate sourness to make the food taste good. At the same time, organic acids also prevent the growth of microbes that cause spoilage [57]. The red color of *kochu* stimulates salivation and causes hiccups, but it has been revealed that capsaicin, a red component, has an antibacterial action and plays a decisive role by promoting the growth of only lactic acid bacteria that are necessary for lactic acid fermentation and preventing other spoilage bacteria from growing through destroying their cell membranes and allowing kimchi to be enjoyed later [58]. At the same time, lactic acid bacteria produce bacteriocins such as nisin and pediocin, which destroy the cell membranes of spoilage bacteria, thereby preventing spoilage [59]. All of this science is contained in kimchi fermentation.

This is the same as milk fermentation, cheese and yogurt, in the West. Milk mainly contains lactose, which prevents pathogenic bacteria from growing and only lactic acid bacteria grow, resulting in fermentation. If milk sugar is mostly composed of glucose, many pathogenic bacteria grow and decay easily, but it is composed of lactose, so only babies who has lactase enzyme or lactic acid bacteria in intestine can drink safely and do not get sick.

#### *Jang*

Korean ancestors worked hard to avoid making any mistakes when fermenting jang. They took baths on the day of making jang to rid the body of evil spirits (*son*) and made to ensure that their efforts would be blessed. Because of this gift of jang, they were able to enjoy bland-tasting vegetables and grains by making them highly flavorful [56]. They also ate vegetables raw or blanching vegetables as a *namul* to reduce their strong flavor with the help of jang. Raw vegetables do not have much *mat* (flavor), so Korean women found various ways to make them tastier using jang [25]. There are Korean proverbs that say: "If you want to know whether the food of one's house is savory or not, namely to know the *mat* (taste) of one's family, check the jang *mat* of the house, first," and "A good agricultural annual harvest depends on the taste of the jang that is soaked in the first lunar January of the year." With great effort and care, they mixed ingredients with jang to create intense flavors, fragrances, tastes, and colors to make a delicious *yangnyom*. The ingredients used as flavoring spices were garlic, leek, *kochu* powder, coarse salt, and sesame oil [6, 23]. The red color from red chili pepper was used as a visual stimulant to initiate salivation, stimulate appetite, and enhance a person's senses to sensitize the taste buds. Thus, they used jang, coloring, aroma, and flavorings to make the dishes more appealing to the senses when serving them together with vegetables and grains while eating *bap*.

In Korea, the representative fermented foods are kimchi, jang, alcohol and vinegar, and *jeotgal*. Of course, in the Western world, yogurt and cheese are representative fermented foods instead of vegetable fermentation. Korea is unique among countries with fermented foods for having plant-originated fermentation culture without alcohol or vinegar. However, it has been only a few hundred years since Koreans began to understand the essence of fermentation. Especially it was not until the twentieth century that it was known that microbes were involved in fermentation. In Korea, mothers were said to be like a gift from the heavens when they prepared and waited with much devotion, just as waiting for their daughter's wedding day [56].

## Origin of Korean diet and foods

The essence of Korean food that is represented by its unique fermented foods is known as the *'Bap-sang* Culture', as shown in Fig. 1. *Bap-sang* (sang means table), is a portable eating table that is usually carried into the room after setting the *bap-sang* in the kitchen. In terms of the Korean diet and Korean foods, as mentioned in the previous papers [21, 60], this *bap-sang* culture is referred to as the 'Korean diet', a system where *bap* together with *kuk* is selected from the *bap-sang* with chopsticks.

The dishes that are mostly eaten as *banchans* have been modified and classified as 'Korean food'.

### Origin of the Korean diet

The origin of Korean food and Korean *mats*, especially kimchi and jang and *yangnyom*, can best be understood through the developmental history of its cuisine. The main cultural characteristic of Korean food, as has been mentioned before, is not "what to eat" but rather "how to eat" or "with what-to-eat *bap*" [5]. *Banchan* dishes were developed to add flavor and enable people to enjoy the *bap*, and *kuk* was developed to help the *bap* go down smoothly and comfortably. Sometimes they put *bap* in the *kuk* and eat it. So this is called *kuk-bap*. Some people in summer, eat *bap* by putting into cold water. Thus, some people describe this as a '*banchan* culture' or '*kuk-mul* culture'.. Hundreds of *banchans* that make the *bap* enjoyable have been developed, and jang, made by fermenting beans, was developed to make the *banchan* dishes even tastier. Furthermore, *yangnyom,* which makes food even more flavorful or tastier, was developed, and kimchi, which was created by fermenting vegetables with these *yangnyom* as the base, could be born. In other words, taste and *mat* were created with jang and *yangnyom*.

The basic principles of Korean cuisine also dictated that the serving style of Korean food be different from other countries. For this reason, a unique *bap-sang* culture and chopstick culture (Fig. 1, from Fig. 4.1 of ref 6) have been developed, which cannot be found in any other country in the world. *Bap* and *kuk* are eaten with spoons, whereas chopsticks are used to pick out various *banchans*. In Western culture, which is based on the concept of 'what to eat', forks and knives are necessary for eating a single dish or cutting meat, but chopsticks are not needed for picking out foods from multiple plates.

*Bap-sang* describes a way of eating *bap* in which the family gathers in a room carrying the *bap-sang* from the kitchen, unlike a fixed table in a particular place [7]. The food is always served on the *bap-sang* with *bap* at the center, followed by *kuk* on the right side, kimchi and jang always served, and one or two *banchans* (Fig. 1). Sometimes even *jeotgal*, a fermented fish product, is placed on the *bapsang,* but yangnyom was rarely served on *bap-sang* because it is itself not a dish. Occasionally, new single-dish foods like *bibimbap* were created and served on the *bap-sang* [22].

### Rebirth of Korean foods

The *bap-sang* culture has been passed down until today. However, during harsh times such as the Japanese occupation period and the even harsher Korean War, some of the *banchan* dishes were turned into single-bowl or one-dish meals. Present-day Korean traditional foods

often refer to dishes served in a single bowl or one-dish food such as *seolleongtang*, *naengmyon, kukbap, kuksu, sundae-(kuk), tteokbokki*, *bulgogi,* and *kimbap*, etc. Nevertheless, they have a long story as *banchan* dishes and *kuk* bowls on the *bap-sang*; however, they do not have a long history as a single dish—traditional Korean foods (K-foods). They are an evolved version of the traditional Korean style of eating in which main *banchan* dishes replaced *bap* as the focal point. This modern development is associated with the commercialization of Korean cuisine. Until the Korean War, most Korean restaurants, eateries, and women's houses would serve K-diet meals in a home-cooked style. Even today, many restaurants remain true to the traditional style, and they are renowned in the local area. There are still many remaining in the Cholla Province area in particular.

The Korean War broke out in 1950 and was a time of great suffering for Koreans. Numerous sacrifices were made, and many people had to leave their homes and migrate. Especially many people in the North left their homes with nothing and moved to the South for freedom. Most of these migrants settled in Seoul with no connections or relatives and had to find ways to survive. Of course, people living in rural areas of South Korea also migrated to Seoul to make a living. With insufficient money to even start a business and no special skills, all they had was their strong body to do hard work and their knowledge of how to make food taste good, as passed down from their mothers.

Under these conditions, there were no opportunities for the people who had overcome the mountain of death in North Korea. There was nothing they could not do. They had to somehow make money to feed and educate their children. Therefore, North Korean people, especially women, started to make what they used to eat as *banchan* at home and sell it as *banchan* dishes. At first, they started selling it out on the alleies around their homes, and if they earned some money, they got a small store on the corner of the street or market and sold food there. To have a menu with just as few dishes as possible, and what they could do was make single-bowl meals based on home-cooked *banchans* and sell them. Although Korean food is based on *kuk-mul* culture, single-bowl meal, rather than one-dish food, was sold. Inexpensive wheat flour from the USA, replaced the more expensive rice with flour, which has greatly contributed to the development of *pajeon, tteokbokki,* and *kuksu*.

Furthermore, people who came to Seoul from the country, especially men, had to work long hours, and there were many times when they missed the food that their hometown mother made. *Bap* with rice can be cooked easily, but preparing *banchans* in the city has always been a problem. In contrast to the countryside, there was no *teotbat* (small garden spaces for a vegetable-growing field near the house), so the displaced people from the countryside did not have easy access to the ingredients for traditional *banchans*. Therefore, it took more work to have traditional food than they had at home before the war. After the war, it became common for people who left their hometowns to meet with their old friends, drink alcohol as *makgeolli* or *soju* with one or two side dishes, and reminisce about their hometowns. Koreans always want side dishes called *anju* (same as *banchan* for *bap*) even when drinking alcohol from hundreds of years ago, which is rare in other countries. For this reason, one-dish foods such as *pajeon,* though not a feast, were recognized as soul food and were very popular, especially in rainy days [6]. At that time, *sundae-kuk, kuk-bap, seolleongtang, gomtang, guksu, tteokbokki, naengmyeon*, etc., were mainly sold [7]. After the Korean War, the traditional Korean meal quickly transitioned to single commercialized products; today, various restaurants have developed in Korea. The success of these people was also copied by South Korean immigrants who opened various restaurants with their hometown local dishes as the theme in the 1980s.

Since the 1990s, there has been an increasingly popular trend of 'fusion *Hanjeongsik*' (course serving with K-foods), which changed the Korean food service system into a Western-style one by serving *banchan* dishes one by one. However, the essence of eating with *bap* as the most basic food in Korean cuisine was abandoned, and it has mostly disappeared these days due to a lack of traditionalism and tasteless dishes. In traditional Korean restaurants, *banchan* dishes are made to eat with *bap*, so the *banchan* should taste good when eaten together with the *bap*. That is, they have to have a nice balance of salt and *kan* in order to be tasty when having *bap* with *banchan* together. This means that in Korean *bap-sang*, *banchan* should be slightly salty because it contributes flavor to *bap*. If the *kan* is not right due to low salt, it does not make the *bap* more palatable. However, at *Hanjeongsik* restaurants, since *banchan* was transformed into a standalone dish, the *Hanjeongsik* meal itself must be delicious with only a little salt. However, many who prepare *Hanjeongsik* have been misled by the incorrect perception that Korean food is too salty and spicy and have started applying Western systems to Korean foods. They failed to introduce traditional *kan* and *yangnyom* concepts to upscale Korean cuisine. Due to their aversion to salt, they made tasteless dishes of unknown origin or usually covered up the tastelessness by adding excessive sugar, and has been rejected by many consumers. Compared to other countries, Korean food is by no means too salty or spicy and has no sugar. The Korean diet we know today has undergone changes and modifications reflecting Koreans' modern lives and culture.

#### Myth of Korean foods: craze for spicy mat (flavors)

Many foreign people have a misconception that K-food is extremely spicy and fiery. Indeed, Korean food does have a lot of *kochu* powder in the *yangnyom*, but not foreign hot chili pepper powder. The pepper used in traditional Korean food is relatively mild. The Scoville Heat Unit (SHU), which is a measure of the hotness of spices, is rather low in the Korean varieties of chili (*Capsicum annuum*) at about 600–1000, compared to 10,000 to 100,000 in some of the chili peppers used in Central and South America, Southeast Asia, or India [42, 47]. Korean chili is known as mild yet sweet chili and is rich in vitamins. Albert Szent-Györgyi, Nobel Prize Laureate in 1937, identified Hungarian paprika, genetically very similar to Korean *kochu*, as a rich source of vitamin C. When Korean chili is used to kimchi or kochujang, it is not spicy. On the other hand, unlike Korean *kochu*, another chili called *ttaengcho* (SHU is around 3,000) which is different species of chili pepper, was crushed and put into *kuk* without making chili powder. The reason why Korean food was perceived to be fiery was because of a certain Korean ramen company. The CEO's last name had the meaning of 'fiery' (*mepda*, 辛) in Chinese character, which started the marketing of spicy *mat*. Nowadays, there is a craze for spicy dishes such as spicy fried chicken and spicy *nakji* (octopus) or squid *bokkeum* (stir-frying). Since foreign spicy chillis are imported in large quantities at lower prices than expensive Korean *kochu* (Korean chili) powder, some restaurants use these cheaper ones, instilling the wrong perception that Korean food is spicy. Foreigners who do not understand this come to believe that Korean food is very spicy. In reality, authentic Korean food is never hot because chili pepper varieties cultivated in Korea are not hot.

Some people who research or study Korean food claim that there are three types of Korean food, *kungjung* (royal court) cuisine, *jongka* (aristocrat) cuisine, and general cuisine [61, 62]. However, this is a very arrogant and exaggerated claim made by those who do not know the roots or philosophy of Korean food. The historical and geographical conditions under which Korean women developed Korean food only permitted one pathway of development. That is to say, there could not be a separate dish with similar ingredients and cooking methods to the ones from China. In short, royal court cuisine and *jongka* cuisine are not Korean food; they are based on Chinese food. Every country has only one unique food. This is because the *yangban* (Korean aristocrats) considered Korean food to be countryside poor peasant food. During the Joseon period, when Confucianism was nationally respected, *yangban* thought it was nonsense for commoners to put traditional Korean food on ceremonies or sacrificial offerings at the palace or rituals. Our ancestors, especially men, were interested in these rituals, and because they thought Chinese food was good as a food for ancestral rites, male literati were interested in publishing Chinese food books in Chinese characters without even translating them. Such books as Hong Manseon's "Sanlimgyeongje (山林經濟)" [63] were published by copying Chinese 'Qiminyaosu (齊民要術)' [39] and Geogapilyong (居家必用) [64], and the subsequent book supplemented it with several Korean foods was "Additional Version of Sanlimgyeongje (增補山林經濟)" [65]. They prepared *kungjung* and *jongka* cuisines without using much frying oil because of its unavailability in Korea as well as they did not use *kochu* powder because China doesn't use chili powder. Chinese food without using *yangnyom* or frying oil should be tasteless. However, they valued formality based on the Confucian Chinese books, regardless of taste. Thus, the foods prepared in the palace and *yangban* house for ceremonies and rituals were bland and flavorless. Therefore, in such circumstances, *jeonbuchi* (*jeonbuchi* as *pajeon* is not fried meals, but is made by heating with the help of small amount of perilla oil, like as pancake) is credited for creating dishes similar to Chinese food for ritual or ceremonial food with limited oil. *Jeonbuchi* is known as Korean traditional sacrificial food, but now that is not the case [66].

## Values of Korean foods

Korean traditional cuisine, starting with various *banchans* and fermentation, is based on the agro-ecological characteristics of Korea and has been developed from the wisdom and spirit of Korean ancestors. At the same time, Korean food has been revealed as very healthy with diverse dishes. For this reason, the great potential for the sustainable growth of K-food popularity for personalized nutrition [67].

### Spirits of Korean foods

The essence of Korean food encompasses the necessity for survival and the desire for sensory pleasure of eating as constrained by the local environment. However, at a deeper level, it also embraces the spiritual values of the Korean people. Accordingly, three fundamental values were embedded in the Korean food culture as it developed over the millennia. The first is *han* and *jung* (grief and affection, 恨 and 情), the second is respect and looking out for others, and the third is balance and harmony.

#### *Han and jung (Grief and affection,* 恨 *and* 情*)*

Long ago in Korea, prior to urbanization, the morning greeting was *'Jinji deshutsoyo?* (진지 드셨어요?) (Have you eaten?)', which is different from the Western 'good morning'. That is evidence of a time when meals weren't easy to come by. From the Bronze Age to the Korean

War in the twentieth century, Korean ancestors, especially mothers, had to carry an inexpressible sadness and resentment (恨, *han*) in their hearts. As mentioned earlier, just like with the genome analysis of humanity, Korean people were subjected to many wars, large and small. Even when men were drafted, and women were humiliated, newborn babies still came into this world. So in such a situation, it must have taken an enormous instinctive power of mothers who remained behind to take care of their children and family and survive without being starved or deprived. Even under these circumstances, instead of carrying hatred, Korean mothers accepted the pain as a *han* (恨) they had to endure as women and lived a difficult life full of humility.

Koreans referred to this world as a world of much *han*. Even though they had to confront their hardships with great wisdom and hard work to make their food delicious, they also shared the food with each other. As the people who survived embraced the same resentment, they raised their children with love, shared the same heart, shared the food, and lived together while sharing their emotions or affections (情, *jung*) [10, 56]. The biggest expression of *jung* (情) is serving food. It is said that Korean food culture and the harmony therein lies in the wisdom accumulated through countless efforts by Korean ancestors to provide for their children in such difficult and harsh conditions. Not only in Korea but also in other countries throughout the world, similar situations in the history of arduous struggles of life must have led to the birth of ethnic foods through great effort.

#### *Respect and consideration*

When preparing a meal in Korea, it is common to put elders or visitors first and select foods to prepare in accordance with their preferences. All family members sit around the table (*bap-sang*) and eat together. Sometimes, a separate meal is served for elders out of respect. When seated around the *bapsang*, other family members wait for elders to pick up their spoons first before beginning to eat. These dining customs, a common part of Korean food culture, were borne out of broader cultural norms of mutual respect and looking out for one another. Korea has a long history as an agrarian society. Although it was not always easy to obtain a full meal, providing hospitality to others through a meal was a way of showing care and respect. In the old days, it was even customary to look out for travelers staying at *sarangbang* in a house by offering them a meal. These cultural traditions are still alive in some rural restaurants in Cholla Province, where travelers are served a full traditional meal.

Unlike Western culture, where foods are served as a single dish, Korean cuisine has a *banchan* culture. Therefore, the final selection of what to eat takes place at the *bap-sang* when the chopsticks are picked up. In Western culture, the selection is already made when the food is made at home or ordered in a restaurant. However, in Korean cuisine, even after receiving a few dishes on the table (*bap-sang*), one needs to think about what to eat and can pick it up with chopsticks. For this reason, Korean cuisine has placed importance on the tastes of consumers and prepared dishes and *banchans* accordingly. Because of this culture, even without sharing the *bap* and *kuk*, *banchan* and *chigae* (similar to stew) are shared together with chopsticks and spoons. The influence of this cultural heritage can be seen in restaurants. When eating in Western restaurants, westerners tend to order a single dish for each person with an individual menu plate, whereas Koreans will order several dishes with one menu plate to share while chatting. In the end, it can be said that this tradition of sharing dishes with one another has its roots in the culture of mutual respect and care found in Korean society based on *jung* (情). This tradition led to the customs of offering and sharing *banchan* dishes with one's dining companions and respecting and looking out for other people. Eventually, this sharing culture created broader social norms of caring for and giving way to others. Even now, a group of four customers at a Korean restaurant will typically only be given a single menu plate [6]. Preparing a K-diet is an elaborate task requiring much respect and consideration [6, 22].

#### *Balance and harmony*

One main difference between Korean food and Western food is that the question is not 'What shall we eat?' but 'With what shall we eat *bap*?', the foundational staple food of every meal. Selecting *banchans* to pair with *bap* was of vital importance when Koreans in ancient times planned what to serve at a meal. One of the most important considerations was balance and harmony [5]. People put great effort into achieving a balance between nutrition and health, vegetables, meat, and even the colors of *banchan*. Sometimes color is more critical for food to be appetizing. Ordinary Korean women would naturally seek balance and harmony when preparing meals, even if they had no knowledge of this theory or science. Careful consideration was given to balance and harmony to promote health depending on who would be eating the meal [5, 6].

Because Korean food culture developed from the country's agrarian history, nature is an integral part of the food culture. Therefore, Korean food differs by season, and Koreans developed cultural traditions of praying to nature during natural disasters such as poor harvests while thanking nature for bumper crops. Seasonal foods and foods based on the 24 divisions of the farming seasons were shown in the lunar calendar and demonstrated

the way in which Korean food seeks harmony and balance with nature, in addition to Koreans seeking the proper season for sowing and harvesting. In fact, the diversity of Korean food is an important contribution to the harmony and balance of Korean food. While pursuing harmony and balance, Korean food also guarantees the right to choose from among the harmonized *banchans* with chopsticks. Therefore, Korea developed a different 'chopsticks culture' from China or Japan.

In China, chopsticks are mainly used for picking up food from far away on a plate, so they are long and thick. In Japan, chopsticks are primarily used for picking up rice from a rice bowl, holding with hands, and eating it directly, so they are short and thin. However, in Korea, chopsticks are mainly used for picking up *banchans*, so they are shorter and less thick than those in China, and longer and less thin than those in Japan [68]. In Korea, because rice is traditionally cooked Japonica-style, it is eaten with spoons, but nowadays, it is often eaten with chopsticks as well. However, unlike in Japan, it is not common to hold the rice bowl in one hand and put it directly into the mouth with chopsticks. This chopstick culture is a symbolic part of Korean food culture, in which each person can choose from various *banchans* presented on one *bap-sang*.

#### Healthy Korean foods

With the late twentieth century urbanization and industrialization of Korea, the way people greet each other changed from 'Have you eaten *bap*' to '*Annyeonghaseyo?* (안녕하세요?) (How are you? or Have you been safe?)', that is, from asking about food to any incidents or accidents. After the Korean War, rapid urbanization increased various disasters and accidents, so the primary concern was "not have you eaten but are you ok"; keeping family and colleagues safe and healthy was the primary concern, including healthy diets. This sentiment was not only unique to the late twentieth century but also was a feeling that Koreans had held long before.

Koreans have always placed great importance on peace and health in their hearts, and this feeling significantly contributed to the development of their food. Korean ancestors had a strong interest in healthy food, believing that eating well was essential for good health, and they even used food for the prevention and treatment of diseases [69]. It highlights how much attention Koreans pay to health and how much they care about the healthiness of food.

Research suggests that the health benefits of Korean food are due to the diversity of ingredients and cooking methods used in Korean cuisine [23, 70]. Furthermore, there have been many studies demonstrating the healthfulness of Korean food using both animal and human experiments [71]. Many healthful substances have been identified in Korean food, and a lot of research is still in progress [72]. However, the answer to why Korean food is healthy can be easily found in a rather philosophical approach. In short, Korean cuisine uses little sugar and fat, which is detrimental to the body, and replaces them with other, more healthful ingredients. Thus Korean food is considered healthy food. Many cultures highly appreciate sugars for their sweet taste and for masking bad flavors, but too much can lead to obesity and metabolic diseases. Fats can contribute great flavor when used in frying and can help preserve the foods by decreasing water activity. However, when exposed to high temperatures, they can produce harmful substances such as carcinogens and oxidative substances. It is very well known that these substances can be detrimental to human health. If oils were used to make Korean food, they should have been taken in adequate amounts from soybean. Although Korea is the origin of beans from which oil can be extracted, we have never done so. The beans were primarily used for making bean sprouts, tofu, and soy sauce. Of course, this means that oil was not necessary for Korean cuisine in contrast to Chinese cuisine.

Another reason Korean food is healthful is that traditional Korean food preparation utilizes many ingredients that are rich in important phytonutrients as well as vitamins and minerals. At the same time, jang used for seasoning contains isoflavones, amino acids, and peptides, and kimchi has a large number of fibrous substances, various fermented metabolites, and various lactic acid bacteria, which are known to be beneficial probiotics. *Yangnyom* contains phytochemicals, including spicy substances that are good for health. Of course, even if the ingredients are good, if they are cooked at high temperatures or fried, harmful substances such as benzopyrene and polyaromatic hydrocarbon, heterocyclic amines, etc., which are carcinogens, will be produced. However, in Korea, all dishes are cooked at temperatures below 100 °C without using oil. On the contrary, they are blanched at 70–80 °C or lower temperatures [28]. That is why Korean cuisine is said to come from the 'taste of the hand (mother's *son-mat*)'. We can therefore say that there are very few if any, hazardous substances in Korean food. The core of Korean cuisine is jang, *yangnyom*, and kimchi, which contains many beans, vegetables full of phytochemicals and proteins, garlic, chili peppers, wild garlic, leek, and ginger. Many papers have reported that these plant-based ingredients contain vitamins, capsaicin, gingerol, and allicin [23]. Protein deficiencies can be solved by consuming beans containing abundant isoflavones and proteins that can be broken down into peptides and amino acids through fermentation, allowing them to

perform various functions. Vitamin $B_{12}$ is essential for everyone and can be found in animal proteins but not beans. A study of elderly Koreans who often ate doenjang, kanjang, kochujang, and cheongkukjang, as well as seaweed, found that there was no deficiency in Vitamin $B_{12}$ [73]. There is much interest in the reasons and causes of this phenomenon.

Thirdly, the traditional Korean diet is nutritionally balanced; the harmony of ingredients and balance of phytochemicals makes scientific sense today. Because Korea's agriculture and food culture is rooted in the belief that seasonal foods are the healthiest and most natural foods; therefore, Korean food is healthful in both biological and cultural terms. We can't be healthy if we limit our diet to a few favorite foods, even if they are healthy foods. However, because Korean food is composed of harmonizing various ingredients with diverse colors and diverse *banchans*, such as seasonal dishes, vegetables, kimchi, and diverse *mat* and colors, etc., eating various foods without favoring one food is a healthy diet. Although researchers have supported the health benefits of the Korean diet, more resources are needed to elucidate further the elements of balanced and healthy meals in the Korean diet [6].

### Sustainability of Korean foods

In the future, with the development of economics and transportation, the world will become closer through interdependent globalization, and there will be more opportunities for the people of different countries to interact and have cultural exchanges. Food safety technology will make foods everywhere safe to eat, and it will be a time when people can heartily enjoy eating any food from any country in the world. People will pursue health and happiness as the world gets closer and internationalizes. In this regard, interest in ethnic foods from countries around the world is increasing, and people are eager to learn more about the history and cultural background of each nation's cuisine. People are increasingly learning about the historical roots as well as science and philosophy that were key elements in the development of ethnic cuisines. Korean cuisine is one of the oldest and was developed wisely by taking into account the geographic characteristics of agricultural science. Culturally unique dishes such as *bap-sang* and chopsticks, as well as fermented foods, were created by no other country in the world. In the future cultural and geohistorical values of ethnic foods will be highly valued, and K-food will develop into a food people around the world will appreciate.

Moreover, Korean cuisine has developed into a fermented food-based cuisine due to the geographical features of the Korean Peninsula, preserving its plant-based ingredients with various *yangnyom,* thereby ensuring its diversity. Also, due to the variety of phytochemicals in plant-based ingredients, various functionalities are scientifically assured, making it a very suitable and healthful food. In addition, it is beneficial from the perspective of climate change and environmental protection, such as reducing carbon emissions compared to animal-based ingredients, which will enable us to achieve sustainable growth in the farm industry.

With the advancement of genetic analysis and other life science technologies, we can now predict the health and diseases of humen accurately and identify precisely what foods to eat to prevent diseases and live a healthier life using a personalized nutritional approach [67]. It is very important to have a variety of foods because if we eat the same foods every day, we will become bored and eventually unable to eat them. For personalized foods, the most important thing is to have a variety of food with functionalities, tastes, and flavors; among all the foods in the world, Korean food has the highest diversity in functionality and flavor (*mat*). With the rapid development of artificial intelligence technology leading to a "super connection" with people worldwide, systems providing personal customized food will soon be developed to match their habits, lifestyle, health, and preferences [74, 75]. Korean culture (K-culture) is already recognized for its excellence and the originality of its content worldwide. Along with dramas, movies, and K-pop, K-food will obtain worldwide appreciation for a long time.

## Conclusion

In the current era of globalization and international engagement, many non-Koreans are highly interested in the Korean diet because of its history, cultural roots, and purported health benefits. This paper explored the nature of the Korean diet in terms of science, history, culture, and health. Korean cuisine has developed in response to the three primary forces that have driven the development of all of the ethnic foods around the world: 1) ensuring survival by providing safe and nutritious food, 2) making food more delicious, and 3) developing methods to preserve food for later or future use. Every world region has gone through this process of developing food to suit its conditions and environment, thereby creating its unique ethnic cuisine. The discovery of fire was a breakthrough in safely solving the problem of food. The discovery of earthenware resulting from the discovery of fire allowed us to find a way to eat food deliciously and eventually found fermentation that could be eaten later. Without the availability of sugar or oil, Korean ancestors had to work hard to make food appetizing, which led to the development of jang and *yangnyom*.

Korean cuisine is renowned for its diverse cooking methods, which have been used to address three main concerns: safety, taste, and preservation. Fermentation is the most diverse method for accomplishing all of the concerns and is achieved through the use of seasonings such as jang (doenjang, kanjang), *yangnyom*, and salt. Jang is made from fermented soybeans, while *yangnyom* is a mixture of garlic, *kochu* powder, leek, scallions, Korean chili peppers (*kochu*), ginger, and vinegar combined with jang and salt. Kimchi is also a popular fermented food in Korea, made by seasoning vegetables such as napa cabbage with *yangnyom*, salt, and other fermented ingredients to improve the *mat* (taste) and preserve them for longer periods. Kimchi developed by realizing that vegetables can be eaten without causing illness, even after a few days, and can be enjoyable deliciously. At that time, ancestors did not know the concept of microorganisms or fermentation. However, they learned about fermentation through the wisdom of their ancestors, who had learned by many trial-and-error efforts and passed it on to future generations.

The K-diet is a unique combination of *bap*, *kuk*, and *banchan* served on a *bapsang* table. Kimchi is always included, and the diet is characterized by its high consumption of vegetables (*namul*), moderate to high consumption of legumes and fish, and low consumption of red meat. *Banchan* is typically seasoned with various jangs, *yangnyom,* and medicinal herbs.

*Han* (恨) and *jung* (情), or respect and consideration, are the guiding principles of the K-diet, which focuses on balance and healthfulness. Korean food has been defined based on ingredients, seasonings, traditional cooking methods, technology, and fundamental principles and knowledge. However, there is a need to establish a definition of Korean food that centers around the core principles of cooking, the traditional fermentation process, and the modern scientific, philosophical, and cultural aspects of K-foods. The unique expressions of the Korean taste are *kan*, the right taste (*barokeu-mat*), and *siwonhan-mat*, typical of delicious Korean dishes.

The advancement of artificial intelligence technology has enabled a super connection between people worldwide and diverse food preferences. Korean foods, with a variety of dishes, can make it possible to provide personalized diets precisely tailored to individual habits, lifestyles, health needs, and food preferences. A variety of foods and various functionalities, as well as different flavors, make Korean cuisine ideally suited to personalized nutrition. Thus, diversity is essential for the development of future personalized food.

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**Author contributions**
Chung, Park and Jim conceptualized the study. Kim and Park were data analysis, and helped in manuscript. Kwon were the principal writers of this manuscript.

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**Availability of data and materials**
The data and materials related to this study are available upon request.

## Declarations

**Ethics approval and consent to participate**
Not applicable.

**Consent for publication**
All the authors have read and approved the content of this manuscript for a publication.

**Competing interests**
The authors declared no competing interests.

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