UNIVERSITÀ DEGLI STUDI DI PADOVA

Department of Agronomy Animal Food Natural Resources and Environment

Second Cycle Degree (MSc) in Italian Food and Wine

Korean Fermented Foods and Mediterranean Diet: a review of the literature

Supervisor: Prof.ssa Stefania Maggi
Co-Supervisor: Dott.ssa Marianna Noale

Submitted by:
Beatrice Bedin
Student n. 2053022

ANNO ACCADEMICO: 2022/2023

Table of contents

Abstract

Mediterranean diet is a well-known healthy diet based on a food pyramid constituted by seven steps (from the bottom to the top, step one water, step two fruits, vegetables, cereals, olive oil, step three nuts, seeds, herbs, wine, step four dairy, step five fish, eggs, white meat, legumes, step six red meat and processed meat, and step seven sweets) that incorporate lifestyle and cultural elements that makes it unique. Korean diet, instead, is a less known healthy diet characterized by a high consumption of plant-derived products and moderate intake of animal-derived food. It consists of grains (mainly rice), seaweed, fish, vegetables, and meat in moderation, therefore it has high carbohydrate and low-fat contents. Korean diet is based on the huge consumption of fermented foods such as Gangjang, Doenjang, Cheonggukjang, Gochujang, Jeotgal, and Kimchi. Fermented foods are worldwide recognized as health promoter for their ability in prevent and ameliorate chronic diseases such as obesity, cardiovascular diseases, diabetes, cancer, metabolic syndrome, neurodegenerative diseases, hypertension, and osteoporosis while having antioxidant and anti-inflammatory properties. In this context, my thesis reports a review of the literature on Korean fermented foods and analyzes the possible positive effect of a combination between Korean fermented foods and Mediterranean diet. Findings of this work underline the fundamental health benefits of Korean fermented food that, from the point of view of the enhancement of health benefits and sensorial characteristics, could indeed be an important addition to Mediterranean diet. Further research, however, is needed to evaluate the acceptability of Korean fermented foods among Mediterranean's inhabitants and producers.

I. Aim.

During the last century the relation between diet and health have become more and more recognized in the scientific community. Several are the research carried on with the intent of investigate this correlation and find the perfect combination. Studies conducted all around the world evaluated the health benefits of specific diets, foods, molecules, or combination of diet and lifestyle. The effect of the diet on health are significant and the transition to a healthier dietary pattern can potentially reduce several chronic diseases such as cardiovascular diseases, obesity, diabetes, and others. Concurrently, an increasing interest in healthier nutrition choices and lifestyles arose among consumers creating a global trend. In this context, Mediterranean diet has been extensively researched and nowadays it is one of the best-known healthy dietary patterns worldwide. Besides Mediterranean diet, in the last few decades the interest in the health benefits of Korean diet has greatly increased due to the high average life expectancy and low chronic diseases prevalence in South Korea. This interest has been translated in an increased number of papers about these topics that related the high consumption of fermented food in the Korean diet to the prevention of several chronic diseases.

In this context, my thesis aims to provide a review of the current research on Korean fermented food health benefits, with a particular interest in the evaluation of the positive effects of a combination between Mediterranean diet and Korean fermented foods.

II. Introduction

1. Mediterranean Diet

The Mediterranean diet is rather difficult to define due to different reasons. Partially because it is characteristic of different countries of the Mediterranean basin and, consequently, all of them contributed to the development of the diet with different ingredients and recipes, making the diet rather complex. Mediterranean diet in fact is common in Crete, Greece, Southern Italy, Spain, Lebanon, Portugal, Morocco, and many other countries in the Mediterranean area. Nevertheless, variations in the recipes and ingredients are easily noticeable. For example, the consumption of meat is not the same in all the countries: in Arabic countries, goat meat and poultry are commonly used whereas in northern countries red meat is preferred; pasta and rice are widely spread in Europe and Italy but are basically absent in Arabic countries; wine is considered a staple food in northern Mediterranean countries, on the contrary, it is banned for religious means in Arabic Mediterranean countries. (Bach-Faig et al., 2011)

Another point that makes it difficult to define Mediterranean diet is related to the Mediterranean diet adherence scores. It is in fact possible to find different definitions and disparities in the literature in the criteria used to assess adherence to this dietary pattern. As an example, in the review 'Evolution of MediterraneanDiets and Cuisine: Concepts and Definitions' Sue Radd-Vagenas et al. state that, during their research, they identified more than 30 Mediterranean diet index scores which had different parameters anddifferent definitions of what truly is the Mediterranean Diet.

Finally, another cause of variation is the evolution through the years of the diet. In fact, from a historical point of view, the Mediterranean diet can be divided into ancient, 'traditional', and modern (Sue Radd-Vagenas et al., 2017). The ancient Mediterranean diet originated in the Mediterranean basin in antiquity and is a mixture of different ancient civilizations' cultures, religions, economies, and agricultural production. One of the first records about the Mediterranean diet is in the writings of Plato (5^{th} to 4^{th} century BC) where it is stated that the diet consisted of milk, honey, fruits,legumes, water, cereals, and moderate consumption of wine, meat, and sweets. Romans added to this first combination of ingredients oil and bread, whereas Arabic/Islamic culture contributed to the improvement of the dietary pattern with vegetables, almonds, citrus, spices, other variety of grains, and new cooking methods. At the end of the Early Middle Ages, in Europe, two dietary patterns were the most popular. The first was derived from Roman culture and was based on cereals, olive oil, and wine production. The second came from Celtic-Germanic culture and was basedon beer production, pig rearing, and hunting and fishing in wild forests. During the Middle Ages, the two diets merged.

The discovery of the Americas was the conclusive influence that enriched the ancient diet with potatoes, chili, alien legumes, corn, capsicum, and, more importantly, tomato (Sue Radd-Vagenas et al., 2017).

In contrast with this first definition, in the literature, the 'traditional' Mediterranean diet refers to the dietary pattern common in the late 1950s and early 1960s in the Mediterranean areas dedicated to olive growing such as Greece, Crete, and Southern Italy countryside villages. The Seven Countries Study of 1950s (Keys et al., 1986) defined the diet as a plant-based dietary pattern characterized by high consumption of plant foods, moderate consumption of fish and wine, and low consumption of dairy, meat, animal fats, eggs, added salt, and added sugar (Bach-Faig et al., 2011). It refers to a period where ultra-processed foods were not present, and people personally produced the food they then consumed. From the Seven Countries Study onward several studies have proved the correlation between 'traditional' Mediterranean Diet and health benefits, proving that the 'traditional' Mediterranean Diet can be used for the prevention of different diseases. Considering this, since 1995 the 'traditional' Mediterranean Diet have been promoted in its pyramid representation that highlight both the different food groups and the suggested frequency of their consumption (Bach-Faig et al., 2011).

The final evolution of 'traditional' Mediterranean Diet can be called Modern Mediterranean Diet and it embodies some variations that have different means. Some of them are performed by researchers to evaluate different combination of ingredients and their correlation with risk of disease such as reducing the total fat, increasing polyphenol, increase mixed nuts, or change the amount of meat. Other variations, such as the decreasing use of herbs and spices or the increasing use of animal fat such as butter, follow the evolution of the diet of people currently living in the Mediterranean countries due to globalization (Sue Radd-Vagenas et al., 2017).

1.1 Geography and Climate of the Mediterranean Area

The countries in which the Mediterranean Diet arose are the ones lapped by the Mediterranean Sea as it can be seen in Figure II.1.. The Mediterranean Sea is an almost completely closed sea connected with the Atlantic Ocean via the narrow straits of Gibraltar, surrounded by lands on the north (Europe), south (North Africa), and east (Anatolia). The Mediterranean Sea is about 2.5 million km^2 with an average depth of 1500 m. Its extent is about 3700 km in longitude and 1600 km in latitude making its size significant. The Sea is an important source of moisture and heat for the nearby countries and their cultivations. (Lionello et al., 2012)

Figure II.1. The Mediterranean Sea and region. (Sikalidis et al., 2021)

This area has been inhabited since ancient times due to its peculiar climatic, geographic, and soil conditions. In fact, they are unusual and they are present just in five regions of the world (Cowling et al., 1996). These conditions favored the development of typical crops such as cork, tangerines, olives, grapes, and oranges as well as an exceptionally high number of endemic plants. Going more in detail, summers are dry and hot whereas winters are mild and rainy. During the wet winters, iron is released from clays and carbonates and piles up on the soil giving the terrain its peculiar red color and favorable characteristics. Nonetheless, the morphology of the region and its position create complex climatic conditions and a huge variability among countries. In fact, the region is located between the subtropical zone and the temperate zone (Lionello et al., 2012). These unique conditions led to the development and cultivation of a huge variety of crops and wild herbs that contributed to the enrichment of the diet of the inhabitants.

1.2 The Food Pyramid

In 2010 the Mediterranean Diet have been recognized by UNESCO as an Intangible Cultural Heritage of Humanity becoming the only dietary pattern in the world protected by UNESCO (Sue Radd-Vagenas et al., 2017). Consequently, scientists decided to present an update of the 1995 pyramid that would embody new recommendations based on the new lifestyle of worldwide population, hoping to make the adherence to the healthy dietary pattern easier. By making the diet easier to follow, scientists hoped to see a higher compliance among people and consequently an increase of the healthiness of the world population. The new pyramid is the result of a dialogue between different scientific representative, and it is based on the latest research on health, nutrition, and epidemiological studies done on the ‘traditional’ Mediterranean Diet. Moreover, it takes into consideration the socio-economic, geographical, and cultural context of all the different countries of the Mediterranean area to be easily adapted to the specificity of all the countries (Bach-Faig et al., 2011). In the new pyramid, all food groups are included, together with the relative consumption frequency and proportions. A variety of cooking techniques are allowed as well as a variety of foods, amplifying the intake of all the different nutrients and minimizing the possibility of lack of nutrients.

The steps of the new food pyramid are illustrate in Figure II.2. and described in the next sections.

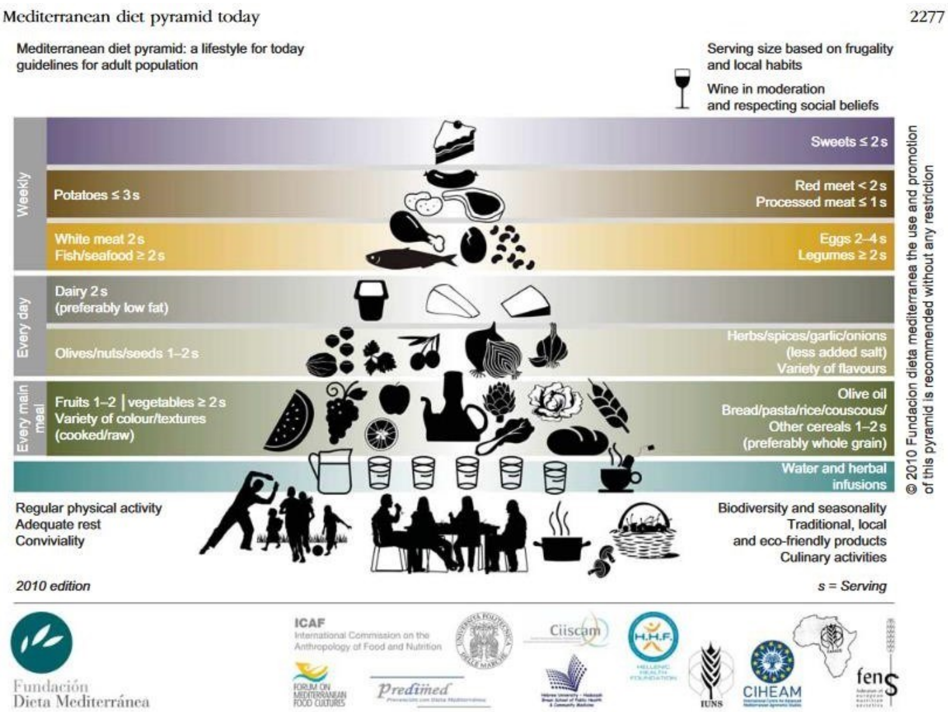

Figure II.2. Mediterranean diet pyramid (Bach-Faig et al., 2011)

1.2.1 Water – the first step of the food pyramid

At the base of the dietary pattern is the consumption of water. Water is considered the basis of a healthy body because most of the human body functions depends on the water equilibrium. Therefore, water intake must be 1-2 liter per day. This value is based on the personal needs that can vary based on age, weather conditions, and physical activity (Bach-Faig et al., 2011). Hydration is maintained with tap or bottled water, sugar free herbal infusions, tea, coffee, and low-sodium and low-fat broths. While maintaining the hydration, the consumption of these broths and tea help increase the antioxidant capacity of the diet. (Sue Radd-Vagenas et al., 2017)

1.2.2 Fruits, vegetables, cereals, olive oil – the second step of the food pyramid

The Mediterranean diet could be considered a vegetarian diet as plant-based ingredients have a prominent place in the dietary pattern. In fact, if we observe the food pyramid, plant-based ingredients represent the second and third step from the bottom, the bigger steps after water. The second step comprehends fruits, vegetables, bread, pasta, olive oil, rice, couscous, other cereals, and potatoes. This means that the previously mentioned ingredients are consumed daily and in every main meal.

The suggested consumption of fruits and vegetables is in proportion of 1-2 portions of daily fruits and ≥ 2 portions of daily vegetables. Fruit and vegetables are sources of vitamins and minerals while at the same time being rich in fiber and water that help with the digestion, satiety, and general well-being (Bach-Faig et al., 2011). Moreover, it is suggested to eat a variety of color and texture of fruit and vegetables to ensure the intake of a variety of protective compounds such as antioxidants. Fruits are consumed fresh or dry as part of breakfast, snack during the day, or dessert. Vegetables are widely use with a peculiar attention to the seasonality of the products. Paired with seasonality, local fruit and vegetables are also preferred by Mediterranean area inhabitants. The diet is rich in salads, cooked vegetables, and soups that are consumed all year round together with legumes. Additionally, wild greens were frequently used in the past, and are still relatively present even nowadays, as source of vitamins, minerals, and antioxidants, and gives to the dishes a regional flavor as wild greens are different in every countries. (Sue Radd-Vagenas et al., 2017)

Another fundamental plant-based ingredient in the Mediterranean diet is cereals. A variety of cereals are used based on the country (as said before, there is a huge variability among countries) but the most successful is durum wheat as it is used in all the Mediterranean countries. Other common cereals are rice, barley, spelt, and oat. Whole grains are optimal sources of dietary fibers, vitamins, magnesium, iron, and phytonutrients such as phytase, phenolic acid, and lignans so they are preferred. (Sue Radd-Vagenas et al., 2017) Cereal-derived products are the main energy source of the Mediterranean population accounting for the 60-70% of the daily needs of energy. The most important and widespread cereal as previously mentioned is durum wheat with which Mediterranean populations produce among others couscous, pasta, and bread. Bread has a strong importance as it accompany basically every meal including dessert. Traditionally, it is made with stone ground whole-meal flour and sourdough as the basic ingredients, and can be added with other cereals, seeds, milk, dried fruits, etc.Bread recipes in the Mediterranean population heritage are countless. Similarly, pasta represent another milestone of the Mediterranean diet that nowadays is known all around the world. Pasta is an important source of carbohydrates such as starch and proteins. The consumption of pasta increases the Glycemic Index, so it is important to pair pasta with vegetables, legumes, meat, cheese, or fish to balance the blood sugar concentration.

Just as important in this dietary pattern is olive oil with extra virgin olive oil as the most abundantly used daily and in every meal. In fact, extra virgin olive oil is used as a seasoning for fresh or boiled vegetables in the proportion of one tablespoon per person, but also as a cooking oil to fry or stir-fry vegetables since it has a high resistance to the heat of the cooking process. (Bach-Faig et al., 2011) It is the only food fat extracted from a fruit and it is the main source of dietary lipid such as monounsaturated oleic acid and polyunsaturated fatty acids. It is also a source of polyphenols with a strong antioxidant capacity. Some recent studies showed that the polyphenols contained in the olive oil can be absorbed by the vegetables fried in it and therefore increase the polyphenol content of vegetables themselves. (Ramírez-Anaya et al., 2015) Its biochemical characteristics and high use are considered the main reason of the healthiness of the Mediterranean Diet.

1.2.3 Nuts, seeds, herbs, wine – the third step of the food pyramid

The importance of plant-based ingredients for the Mediterranean diet is easily noticeable as they represent also the third step of the food pyramid. This step comprehends: olives, nuts, seeds, herbs, spices, onions, garlic, and legumes. The diet provides a daily consumption of these products with 1- 2 daily portions of olives, seeds, and nuts.

Onion and garlic are used raw as added ingredients of some dishes such as salads or as soffritto in cooked dishes. Soffritto is made by slowly cooking onions, garlic, and sometimes spices in olive oil. (Poli, 2013) Generally, soffritto is used as the base of numerous pasta sauces such as tomato sauce, or as the base for stir-frying vegetables.

Spices, herbs, onions, and garlic are often used with extra virgin olive oil to season different dishes such as salads, soups, dishes with meat, pasta, etc. Other seasonings that are frequently used are vinegar and lemon juice. By using a combination of these seasoning ingredients, it is possible to enhance the flavor of the dishes while reducing the amount of salt. (Bach-Faig et al., 2011) Moreover, some seasoning such as vinegar and lemon juice can help lower the Glycemic Index and therefore are preferred in dishes rich in carbohydrates. (Sue Radd-Vagenas et al., 2017) Herbs and spices are also good sources of antioxidant compounds and micronutrients, and traditionally were used as medicine. Oregano is the most used herb, but other popular ones are mint, rosemary, wild fennel, and dill. Moreover, their presence in Mediterranean dishes help create the identity of the country and of the population by giving the specificity that is known all around the world. (Sue Radd-Vagenas et al., 2017)

Seeds, olives, and nuts are widely consumed and are important sources of proteins, vitamins, minerals, fibers, essential amino acids, monounsaturated fatty acids (MUFA), and polyunsaturated fatty acid (PUFA). Their consumption is recommended as a healthy snack choice in the proportion of one handful per day. (Bach-Faig et al., 2011) By combining nuts and seeds with honey, grape juice syrup, and dried fruits ancient Mediterranean inhabitants made nutritive sweets to be eaten during special occasions or served to guests. The main Mediterranean nuts are pistachios, almonds, walnuts, hazelnuts, and pinenuts. Among these, walnuts are the one with the highest content of alpha linoleic acid and phenolic compounds. (Sue Radd-Vagenas et al., 2017)

Additionally, wine and other fermented beverages are also part of this step of the pyramid. The consumption of a moderate amount of wine during meals is recommended both for men and women in the proportion of one glass for women and two glasses for men per day. In fact, some studies have found a protective effect of wine on coronary heart diseases (French Paradox). (Ferrières, 2004)

1.2.4 Dairy – the fourth step of the food pyramid

In the fourth step of the pyramid, we found the first animal derived food: dairy products. The consumption of dairy products in the Mediterranean diet is moderate, 2 servings per day and, to decrease the amount of saturated fat, the low-fat version is preferred. Dairy products such as cheese, yogurt, and other fermented dairy products (e.g., feta) are the main one and are good source of calcium that is fundamental for the health of bones. (Bach-Faig et al., 2011) Traditionally, dairy product came from sheep and goats and therefore were rich in A2 beta-casein. Nowadays, most of the milk come from cows that supply a combination of A1 and A2 beta-casein. (Sue Radd-Vagenas et al., 2017)

1.2.5 Fish, eggs, white meat, legumes – the fifth step of the food pyramid

The fifth step of the pyramid is dedicated to animal-origin protein source products such as fish, eggs, white meat, and legumes. Even if the plant-origin proteins are preferred in this dietary pattern, a weekly consumption of animal-origin proteins are recommended to minimize the lack of this essential nutrient.

Specifically, fish and eggs are optimal sources of high-quality protein therefore the recommended consumption is 2 or more servings of fish and 2-4 servings of eggs per week. Traditionally, eggs are used as they are cooked in different ways but also as a baking ingredient. Fish and shellfish are also a good source of healthy lipids such as omega-3 fatty acids (polyunsaturated fatty acid). White meat is preferred to red meat since it does not contain high level of saturated fat while remain a good source of lean protein. It is recommended in 2 servings per week. (Bach-Faig et al., 2011)

Legumes such as lupins, broad beans, white beans, chickpeas, and lentils are traditionally consumed added to cereals in the recommended amount of more than 2 serving per week. They are plant-origin protein and lipid sources, therefore they can be a meat alternative and traditionally they were the pillars of the diet when the meat was not common as it is in more recent times. (Sue Radd-Vagenas et al., 2017)

Finally, potatoes are included in the weekly consumption as they are frequently present in traditional recipes together with meat and fish. 3 or less serving per week of fresh potatoes are suggested due to their high Glycemic Index so their consumption must be moderated. (Bach-Faig et al., 2011)

1.2.6 Red meat and processed meat – the sixth step of the food pyramid

The last step of the weekly prescription is taken by red meat and processed meat. The consumption of this food category in high quantities is not suggested because studies have associated the consumption of red and processed meat to different chronic diseases such as cancer and coronary heart disease. Therefore, the Mediterranean Diet suggest the consumption of small quantities of red meat, preferably lean red meat, in a low consumption frequency of less than 2 servings per week. (Bach-Faig et al., 2011) Traditionally, the red meat came from small size animals like goats and sheep that pasture freely, therefore, their meat was an additional source of omega-3 fatty acids. (Sue Radd-Vagenas et al., 2017)

1.2.7 Sweets – the seventh step of the food pyramid

The last step of the pyramid is for all the foods that are rich in sugar and unhealthy fats and, consequently, they should be consumed in small amounts. Sweetened fruit juice, soft drinks, sugar, pastries, and candies are part of this step and they must be consumed just occasionally for example for special occasions.

1.3 Cultural Aspects of the Mediterranean Diet

The 2010 version of the food pyramid of Mediterranean Diet also incorporate lifestyle and cultural elements that are protected by UNESCO. The Mediterranean diet in fact is, as Sue Radd-Vagenas et al. state in the article of 2017 ‘Evolution of Mediterranean diets and cuisine: concepts and definition.’,“much more than just a diet pattern that can be described by consideration of its foods and/or nutrients”. In the Candidature Dossier submitted to UNESCO the Mediterranean diet is described as “a social practice based on the set of skills, knowledge, practices and traditions ranging from the landscape to the cuisine, which in the Mediterranean basin concern the crops, harvesting, fishing, conservation, processing, preparation and, particularly, consumption”. (Nic Craith et al., 2018)

The key idea is that, in order to gain all the health benefits of the Mediterranean Diet, cleaner healthy habits are not enough whereas a healthier lifestyle is required. These cultural elements are represented outside of the pyramid at is base because they represent a foundational integration of the pyramid itself.

The cultural aspects of the new food pyramid (2010) are described below.

1.3.1 Seasonality

Among the cultural aspects of the Mediterranean Diet, seasonality takes a relevant place since the beginning. The 'traditional' Mediterranean meals in fact were made with local food and this shaped the dietary pattern up to nowadays. The influence of seasons on dishes promoted the development of countless recipes and cooking technique based on the availability of the ingredients. Moreover, by following the natural cycle of crops, the diet of population of the Mediterranean area faced a huge variability that increase the phytonutrients intakes and the nutritional value of the diet. In fact, seasonal and fresh foods have a high concentration of protective nutrients. (Bach-Faig et al., 2011) Finally, seasonality fostered the development of a variety of flavors strongly tied with the usage of seasonal herbs or spices. (Sue Radd-Vagenas et al., 2017)

1.3.2 Traditional, local, eco-friendly, and biodiverse products

While foster different cooking methods, the Mediterranean Diet maintain the traditional knowledge and practices developed through the centuries. Different recipes, cooking methods, wild herbs knowledge, preservation techniques, and general knowledge about cuisine have been transmitted from generation to generation (Contreras & Armaiz, 2014) and helped shape the Intangible Cultural Heritage of the Mediterranean Diet.

The Mediterranean Diet is considered a sustainable dietary pattern because it contributes to the preservation of the biodiversity of the Mediterranean area. (Myers et al., 2000) In fact, the pattern suggests a variety of ingredients, from vegetables to herbs, from fruit to legumes, and a variety of colors within the same food category. These characteristics make the Mediterranean diet sustainable also from the point of view of nutrition, taste, and appearance. Additionally, the diet recommends the consumption of eco-friendly foods that in the literature are associated to a higher nutritional value. (Lairon, 2010) By promoting a low consumption of animal-origin products it contributes to the reduction of the land, water, and energy usage. (Gussow, 1995) Moreover, Mediterranean diet promote the use of local products, decreasing the pollution produced during transportation and help the preservation of the environment. (*Sustainable Diets and Biodiversity - Directions and Solutions for Policy, Research and Action*, n.d.) In addition to this, the consumption of local foods encourage farmers to diversify their production and therefore improve the local economy. (Burlingame & Dernini, 2011) Traditionally, people personally cultivated most of the ingredients used while cooking in home gardens located near the houses.

1.3.3 Slow cooking methods and home-made dishes

Part of the tradition of Mediterranean Diet is also the domestic cooking. Traditionally, women of the family oversaw the cooking while men oversaw the manual labor in crops. Women were the custody of the recipes, cooking techniques, and other culinary tradition and passed their knowhow from one generation to the other. The new food pyramid through the culinary activities promotion want to enhance the importance of home-made dishes as some studies have shown an increased intake of vegetables and fruit. (Monsivais et al., 2014) In addition to this, the most traditional cooking techniques used in the Mediterranean basin are boiling and stewing that demand slow cooking with low temperature and high moisture. These cooking techniques are known for being less harsh on foods compared to more faster cooking methods and therefore they promote the bioavailability of phytonutrients. (Sue Radd-Vagenas et al., 2017)

1.3.4 Socialization and culinary activities – conviviality

Conviviality is another key concept of the cultural aspects of the Mediterranean Diet. Meals in the Mediterranean Diet are not just a mechanical action of intaking foods but embody a social value. Mediterranean's populations devote an important part of their daily time to meals. Meals become an instrument used to mark time during the day. Meals are consumed by dining companions all together sitting around the table while talking to each other and therefore eating become a way to strengthen the communication and sociability of the community. (Sukkar, 2011) Pleasure is associated with the consumption of meals, and this reflects on the health status of all dinning companions. (Medina, 1996)

Finally, the meals preparation often embodies a variety of culinary activities such as making crafts, cooking, organizing the domestic space, etc. that promote the sociality between different members of the family while creating a cultural identity different from country to country. (Bach-Faig et al., 2011)

1.3.5 Physical activity and adequate rest

Part of the philosophy of the Mediterranean diet is a regular and moderate physical activity quantified in at least 30 minute per day. Any kind of physical activity is suggested with a preference for outdoor activities done with a companion to strengthening the sociality. (Thompson Coon et al., 2011) The physical practice helps to maintain a healthy body weight and balance the daily energy intake. (Organization, 2003) In Mediterranean Diet just as important as physical activity is the resting during the day. Night sleep is valued as well as s short nap after eating. Napping is encouraged because studies have shown an improvement in the cognitive functionality in people with a napping habit.

(Ficca et al., 2010)

1.3.6 Moderation

This last cultural aspect of the Mediterranean Diet is easily noticeable by looking at the food pyramid. Often in the pyramid near to the food category the number of serving per day or week are specified. Moreover, the graphical representation with steps of different size specifies the right proportion between different foods. For example, the steps dedicated to plant-origin foods are bigger compared with the one dedicated to red meat. Therefore, the size of plant-origin ingredients in a meal must be larger than the one with red meat.

The key point of the dietary pattern is to adapt the energy intake with the lifestyle of the specific person, based on working habits, religion, countries differences, etc. This aspect of the diet is as important as the previous because the portion size can influence the prevalence of obesity. (Bach-Faig et al., 2011)

2. Korean diet (K-diet)

The interest in Korean food raised over the past few decades encouraged by the phenomenon known as "Hallyu" which means "Korean Wave" in Korean. The word "Korean wave" express the increase in popularity of Korean culture that occurred from the 1990s onwards. It is related to different aspects of Korean culture such as music (K-pop), cinema, TV shows (K-dramas), comics (manhwa), video games, fashion, language, and food. A 2013 survey on non-Koreans experiencing "Korean Wave", found that the most popular "Korean Wave Contents" were K-pop (35.2%) and TV Dramas (31.0%). The article continues by saying that movies were preferred in the Americas (3.63±0.83 points out of 5 points) and Asia (3.63±1.09 points out of 5 points), whereas K-pop was preferred in Asia (3.68±1.12 points out of 5 points) and games were preferred in Europe (2.50±1.56 points out of 5 points). (B.-K. Shin et al., 2014) Additionally, this research explained that among "Korean Wave Cultural Contents", movies and K-pop affected the 'Purchasing intention of Korean products', and TV Dramas, movies, and K-pop affected the 'Purchasing intention of Korean Food' suggesting a correlation between Korean Cultural Content and the increasing popularity of Korean Food. Several studies have suggested the same correlation. Some examples are the survey of Thanabordeekij et al. (*The Impact of the Korean Wave on Korean Food Consumption of Thai Consumers | Journal of ASEAN PLUS Studies*, n.d.) and the survey of (Jeon, 2019) (*A Study on the Relationship between the Korean Wave, Preference and Recognition of Korean Cuisine among Chinese).*

Another important driver that helped increase the popularity of Korean Food worldwide is the belief in the healthiness of the Korean Diet. This belief has been proven true in the last decades by gradually increasing research on the Korean Traditional Diet, its components, and its health benefit. In general, the healthiness of the diet is related to the high use of soybeans, the wide use of herbs, the high daily intake of vegetables, and the moderate amount of meat (Pettid, 2008). On top of that, Korean Cuisine is rich in fermented food and the daily per capita intake of total fermented food revolves between 100 and 200 g/day in the past nineteen years (S. Y. Kim et al., 2020). This value can be considered rather high if compared with the Japanese daily intake of 3.6 g/day of the Japanese National Health and Nutrition Survey of 2014 (Furuta et al., 2018). Paired with the increasing awareness of the importance of fermented foods for a healthy life, its present popularity is not surprising.

2.1 Climate and Geography of Korea

Noticeable is the influence of geographic and climatic conditions of the Korean peninsula on Korean cuisine. Through the centuries, the peculiar geographic and climatic conditions enriched Korean cuisine with a variety of products coming from mountains, sea, and plain.

The Korean peninsula's size is not large, but it is characterized by a variety of environments. Geographically, it is surrounded by the ocean on the East, South, and West and it is protected by mountains in the North (S. H. Kim et al., 2016). The general terrain is mountainous, with 70% of the peninsula covered with mountains that contribute as a source of food like wild plants and herbs. Moreover, it includes 6 rivers over 400 kilometers in length where eel, carp, and catfish can be caught. Limited pasture lands led to a preference for small-scale stock farming of cattle, pigs, and chickens. The ocean surrounding the peninsula presents a huge variability in depth and consequentially in fish production. On the west, the Yellow Sea is rich in yellow mud that reduces the depth of the Sea to 44 meters, while increasing the marine life such as porpoises, croaker, Spanish mackerel, and Pacific erring. In the Yellow Sea are also harvested a variety of shellfish such as clams, oysters, abalone, and sea snails. Moreover, the western coast is characterized by huge tidal flats from which Koreans harvest tiny and salty shrimp that are used to season numerous foods (Kim Woong Seo, n.d.). Quite the opposite is the East Sea with an average depth of 1,361 meters and over 3,700 meters at its deepest point (Pettid, 2008). This depth creates the best environment for other marine species such as squid, yellowtail, whales, dolphin, and different types of mackerel. On the South, the East China Sea presents a huge number of islands where the harvest includes anchovies, hairtail, shark, mackerel, squid, flounder, octopus, mullet, and shellfish. From the ocean, Koreans also harvest a high number of seaweeds used for daily food preparation.

From the climatic point of view, generally, summer is usually long, hot, and humid, winter is cold and harsh whereas spring and autumn are dry and clear. The season with the highest annual precipitation is summer granting Korea one of the best weathers to produce rice. However, due to the position of the peninsula in a transitional zone between north-east Asia and the western Pacific Ocean and due to the mountainous terrain, there is a huge local variability. In particular, the west of the peninsula has a more continental whether compared with the east coast due to the protection of the T'aebaek Mountain Range. These peculiar climatic conditions created the need to preserve all year round the food produced during the more dry and clear seasons such as vegetables, fish, and grains, and Koreans supplied this need by primarily taking advantage of fermentation (S. H. Kim et al., 2016), paired with boiling, blanching, seasoning, and pickling.

Korean peninsula's peculiar borders (high mountains at the north and ocean all around) geographically isolated the country leading to the development of a distinct Korean diet with well-defined processing, preserving, and cooking methods (S. H. Kim et al., 2016). Compared with near Japanese and Chinese diets, differences are easily noticeable for example in the use of seasoning. In Korean food seasoning is done with garlic, green onions, red pepper, and ginger, and medicinal herbs are used instead of black peppers. Moreover, the mountainous terrain created internal compartmentalization that promoted the development of local recipes, processing, and cooking methods.

2.2 General Aspects of Korean Diet – Dietary Components

As S. H. Kim et al. state in the article 'Korean diet: Characteristics and Historical Background', K-diet and K-food are two separate concepts. The concept of the K-diet is used to represent traditional Korean food culture, cooking methods, and dietary habits and patterns. The definition of traditional Korean food instead is: "Food made with raw materials or ingredients that have been traditionally used in Korea, or with similar ingredients, use authentic or other similar cooking methods, have historical and cultural characteristics, and have developed and been passed on through people's lives." (H. Chung, 2015)

The main characteristics of the Korean diet are listed and described in the next sections.

2.2.1 A Variety of Recipes with Rice and Grains

The importance of grains in the Korean diet can be dated back to the early kingdom of Goryeo (37 BCE- 668 AD) and Tamna (?–1404 AD) as, in their myths, grains are used as valuable gifts, giving political and social significance to this element. In the foundation myth of the Goryeo Kingdom, the founder of the Kingdom received from his mother some barley seeds as a gift for the establishment of the realm (Yi Kyubo, 'Tongmyong-wang p'yon' ('The lay of King Tongmyong'), in Tongguk Yi Sangguk chip [The Collected Works of Minister Yi of the Eastern Country [i.e., Korea]]') (Seoul, 1982), 3, pp. 1-9). The three princesses that married the three founding deities of the Tamna Kingdom bring with them the seeds of five grains and began farming for the first time (Bruneton, 2020). Among grains, steamed rice is the one that usually accompanies every Korean meal. However, other grains such as millet, wheat, buckwheat, barley, and sorghum are frequently used as well. Rice is not indigenous to the Korean peninsula but became the supreme staple food during the Three Kingdoms period (1st century BCE-7 century AD) and became a tax during the Greater Silla period (668-935 AD). Interesting from the etymology point of view is the usage of the character 'rice plant' as one of the characters used to say 'taxes' in Korean. At present times, rice is eaten plain but also combined with other ingredients to prepare well-known and appreciated dishes such as kukbap a combination of rice and soup, and bibimbap where rice is mixed with vegetables and meat. Numerous are also filtered and unfiltered wines produced from rice. Moreover, peculiar are the by-products of cooking rice such as nurungji, the thin layer of roasted rice that is formed during the cooking on the bottom of the pot and eaten as a snack, or sungnyung, which add water to the roasted crust of rice to produce a drink similar to a soup or a tea enjoyed at the end of the meal. Finally, rice flour is also used to produce more than two hundred types of rice cake (tteok) that present different shapes, peculiar cooking methods, and dedicated recipes. (Pettid, 2008) The production of rice was dominant in the South of the peninsula whereas in the North wheat and buckwheat production were the most popular. These two grains are used to produce noodles since the Goryeo dynasty (37 BCE- 668 AD). However, due to the scarcity of production, noodles were eaten just on special occasions such as birthdays celebrations, and weddings. Typical even nowadays is naengmyeon, a buckwheat noodles soup served cold with ice cubes on hot summer days (Pettid, 2008).

2.2.2 Fermented Foods

Fermented foods are one of the most known peculiarities of the Korean diet. Fermentation developed in the peninsula as a preservation method and supported Korean cuisine until the present day. It is widely used to preserve catch and harvest and enrich the food's flavors. My thesis will go more in-depth on this topic in the next chapters (see Introduction 3. Fermented Foods in Mediterranean and Korean Diets).

2.2.3 High Vegetable Intake

Korea has a flourishing agricultural environment that shaped the K-diet as a high vegetable intake diet. Vegetables are widely used in the preparation of Korean dishes and can be cultivated in fields or harvested in the wild mountains with herbs. Koreans refer to both vegetables and herbs as namul.

Namul enriches the diet with fiber and vitamins. The huge use of wild herbs and wild vegetables in the Korean diet has more than one possible explanation. Partially is the result of the past harsh conditions during the several wars, that force inhabitants to find food in the wild; partially is a heritage from the Buddhist Goryeo Dynasty (37 BCE- 668 AD) that imposed a vegetarian diet; partially is a result of the geographical and climatic environments of the peninsula (Pettid, 2008). The most widely used are lettuce, peppers, carrots, cucumbers, and spinach. Both wild and cultivated vegetables are consumed raw with sauces, added raw or dry to kuk, fermented, used as banchan, bleached, and seasoned. The preparation method is used to classify namul in:

- cooked vegetables (sukch'ae), divided into parboiled and seasoned vegetables such as bean sprouts, spinach, and artemisia, and pan-fried vegetables such as eggplant, bellflower, mushrooms, and fernbrake.
- raw vegetables (saengcha'e), divided into vegetables that are suitable to do ssam means wrapping rice or meat in vegetables before eating it such as lettuce or steamed pumpkin leaves, and raw vegetables seasoned with various condiments and then eaten.
- vegetables fried with meat (chapch'ae), divided into a mix of different kinds of vegetables stir-fried with various meat, and vegetables mixed with meat and noodles.

A traditional custom establishes the use of three or more types of namul in the same dish to allow a variety of tastes. Moreover, traditionally they always add namul that has different colors to create a visually appealing contrast. For example, 'three-color' namul and 'five-color' namul are quite common. Scientifically, this custom allows the intake of different kinds of nutritional compounds such as vitamins or phenols that are needed by the body and present in various amounts in vegetables of different colors.

In addition to namul, different types of seaweed such as laver, green algae, kelp, Hizikia fusiformis, and Capsosiphon fulvescens are frequently used in Korean dishes with higher consumption in oceanic areas.

As mentioned before, wild vegetables and herbs harvested in the mountains are widely used in the Korean diet. Among them are herbs with curative or preventive properties such as ginger, green onion, red pepper, and garlic (*Cancer Chemoprevention with Dietary Phytochemicals | Nature Reviews Cancer*, n.d.). These herbs are usually mixed in various amounts to prepare a seasoning called yangnyeom used as dressing for vegetables, legumes, and meat. This seasoning not only enhances the flavor of the meal but also the health benefits (Hu J (許浚). Donguibogam (東醫寶鑑). Seoul (Korea): 1610). In addition, "seasonal herbs" such as tree sap and motherwort are widely used to fight against the summer heat (H.-K. Chung et al., 2016).

2.2.4 Legumes as Protein Source, Low Consumption of Red Meat

Koreans' main protein sources are legumes such as mung beans, red beans, cowpea, peanuts, walnuts, ginkgo nuts, and in particular soybeans (S. H. Kim et al., 2016). Soybeans are extremely rich in essential amino acids and contain 38-45% of proteins (Pettid, 2008). Soybeans and their by-products are widely used in Korean recipes. For example, they are used whole as the main ingredient in seasoning such as fermented soy sauce (kanjang) and fermented soybean paste (doenjang). Moreover, they can be dried and ground to use the powder sprinkled over various desserts such as ice cream, rice cakes, milkshakes, shaved ice, smoothies, bread, and pasties or as breading for fried chicken. Soybeans sprout (kongnamul), instead, are added to soup or stew or eaten as a side dish. Lastly, soybeans also contain 20% of oil that is extracted and used as cooking oil (Pettid, 2008). In contrast with other soybeans products which had a place in the K-diet since the Earliest Kingdom's time, tofu become a common food during the Joseon dynasty (1392 AD- 1897 AD) as the literary collection of Yi Saek (1328-1396) proves.

Among beans, also red adzuki beans are popular in Korean dishes, and their popularity relay on their good taste and color. The red color is known in South Korea for keeping away poisonous influences. Red adzuki beans are often used mixed with rice or in tteok, and porridge (Pettid, 2008).

Alongside legumes, in oceanic areas and areas near rivers, grilled, boiled, and marinated fishes are considered an important protein source. In the past, due to scarcity, meat consumption was limited to specific celebrations or special occasions, and often the only available meat in the agricultural environment was chicken. Nowadays, meat consumption increased due to globalization and new rearing techniques and so a variety of meats have been integrated into the Korean diet. However, meat-based dishes still have a secondary role in a Korean meal and will be supplied to the guests in small amounts regardless of meat availability. (Pettid, 2008). Nevertheless, a brief paragraph on meat-based foods must be mentioned. The most common meat in Korea is beef and it is prepared in various ways such as drying, boiling in soups, or roasting. An example of drying beef is yukpo, strips of dried meat developed as a preserving method for beef. Beef is also added to stews and soups to enhance the flavor. Finally, some examples of roasting beef are thinly sliced rib-eye marinated in soy sauce (bulgogi) and beef ribs (galbi) seasoned with soy sauce, sesame oil, and garlic. The second most common meat in the peninsula is pig meat. Also in this case, pig meat is frequently added to stews and soups or roasted. One of the most internationally famous Korean dishes is roasted pork belly (samgyeopsal). Finally, chicken is the third most common meat consumed in Korea since the pre-modern time. Chicken is served in soups, steamed with vegetables, and roasted. Moreover, rather important is the use of eggs in the preparation of different types of dishes.

2.2.5 The Role of Fish

Contrary to meat, fish is usually present in every Korean meal. This habit date back to the early twelfth century when meat was reserved for upper-status groups while commoners ate the more readily available seafood (Jing & Vermeersch, 2016).

As previously reported in Introduction II. - 2.1 Climate and Geography of Korea, the Korean peninsula is rich both in freshwater fish and saltwater fish. Fish is prepared by following a variety of cooking techniques and recipes. Octopus, sea cucumber, squid, shellfish, and other seafood are often eaten raw (hoe). According to the recipes of a common side dish for drinking spirits, raw fish is thinly sliced and dipped in red chili paste (gochujang) or fermented soy sauce (kanjang). Raw fish is also added to cold soups or enjoyed mixed with vegetables and rice. Similarly, grilled fish is commonly served as a side dish. Whole or filets of Pacific herring, croaker, mackerel, and hairtail are grilled after sprinkling them with salt and served as a complement to the meal. Another common way to enjoy fish is by drying it whole and serving it as a side dish or adding it to soups. This custom was developed to preserve, store, and transport fish to be sold in less coastal regions more easily. Examples of dry fish include croaker, yellow corvina, and anchovies.

Alongside fish, shellfish such as abalone, clams, and oysters are common in the Korean diet. Soup recipes often require them as basic ingredients, but they are also eaten raw with Chinese cabbage kimchi as they help preserve vegetables. A common use of raw shellfish is also mixing them with rice before cooking. Prominent is also the use of shrimp. As for fish, a wide range of cooking techniques are used to prepare all sizes of shrimp such as grilling whole, serving them as a side dish by drying them and mixing them with vegetables, and salty seasoning them before adding them to kimchi.

2.2.6 Sesame and Perilla Oil as Cooking Oils

Due to its geography and climatic conditions, the Korean peninsula was never the ideal place to produce a huge amount of animal-based and vegetable cooking oil. This is the reason why in the K-diet the main oils are sesame and perilla oil. Sesame oil enriches the flavor of kuk, namul, and bibimbap, while perilla oil was traditionally used for pan-frying.

The lack of production of animal-based and vegetable cooking oils also negatively influenced the development of deep-frying techniques in favor of cooking methods such as pan-frying or stir-frying that do not need a huge amount of cooking oil. This is one of the main differences between Korean and Chinese cuisine (S. H. Kim et al., 2016).

2.3 Cultural Aspects of Korean Diet

2.3.1 The Importance of Seasonality

The Korean peninsula's climatic conditions with four distinct seasons favored the development of a cuisine based on fresh ingredients. During the four seasons, harvest and catch face a huge variability leading to the development of equally diverse recipes. Some dishes of the Korean tradition are eaten just on specific periods or days of the year following the availability of the ingredients, others present variations on the recipes based on the presence or absence of the ingredients throughout the year. To give an example, kimchi is made fresh all year round, except in winter, by using different varieties of cabbage based on the season. Moreover, Korean attach to foods a cultural meaning that is clear in seasonal foods, intimately bonded with rituality and with pre-modern beliefs about healthiness and disease prevention. In fact, usually, seasonal foods are also called healthy food (補身食 品) because Koreans believe that the best food is made of seasonal ingredients (S. H. Kim et al., 2016). An example of this is the saying 'yi yeol chi yeol', 'relieving the heat with heat', for which two main explanations can be found. The first explanation is linked to Eastern medicine. Koreans believe that the lethargy and the loss of appetite that we face during summer are caused by the concentration of blood near the skin that happens during summer days to help cool down the body. This causes a bad circulation of the blood in the body: the blood reaches the stomach and muscles in a lower amount compared to their needs. To fight against this situation, it is customary in Korea to eat hot food to warm the body from the stomach on out and help the normal circulation of the blood. The second explanation of this idiom can be found in the philosophical idea of ki, the vital energy of the body. To be in a healthy state, the ki must be in balance with the temperature of the environment. It is believed that one's ki is cold in the summer and hot in the winter. Therefore, to tend to the equilibrium of the ki, in the summer it is needed to eat hot and spicy foods. These beliefs make it rather clear why during summertime is common to find Koreans eating chicken ginseng soup (samgyetang) and spicy soups (H.-K. Chung et al., 2016).

2.3.2 Local Variability

The Korean peninsula's geographic conditions increased the isolation of the county from other nearby countries, but also the isolation among inhabitants of different regions of the peninsula. It was rather hard for farmers to move through the mountainous territory. This promoted the development of a huge number of regional recipes. Therefore, in the plains is noticeable a prominent development of recipes based on grains such as bibimbap (*Cancer Chemoprevention with Dietary Phytochemicals | Nature Reviews Cancer*, n.d.), while seafood where the main ingredient of oceanic regions (S. H. Kim & Jang, 2015). Moreover, in mountainous regions, namul was the most widespread ingredient and led to the development of a variety of vegetable dishes, whereas in regions near rivers freshwater fish or claims were mainly used. Alongside differences in the main ingredients used to prepare the dishes, also the food preparation techniques and the seasoning vary based on the region. For example, the southern seasonings are usually saltier and spicier compared to northern seasonings to relieve the summer heat, whereas in the northern regions, the number of side dishes is higher, and portions are bigger to fight the cold with the right amount of energy. Another example of local variability is kimchi recipes. In fact, each region of Korea has developed a different recipe: in Jeolla-do for example they use Korean lettuce, kat-kimchi instead is mainly produced in Chollanam-do, and again bossam kimchi is famous in Kaesung in North Korea, whereas Kaktuki kimchi is the preferred in Kongju (H.-K. Chung et al., 2016). Even nowadays is rather common, while traveling along the peninsula, to experience these differences and to perceive the inhabitant' pride in their local dishes.

2.3.3 Home-cooked Meals jipbap (집밥)

Korean meals usually were cooked by mothers using natural ingredients therefore, even nowadays, Koreans believe that food represents mothers' love. Usually when served with home-cooked meals Koreans will say that the food has "엄마손맛" which means "the taste of mother's love". Home-cooked meals are more valuable compared with the ones served at restaurants because they represent the dedication and the consideration the cooker has for the eater and are a communication tool between family members and relatives. Moreover, home-cooked meals are considered healthier by many Koreans (S. H. Kim et al., 2016).

2.3.4 East Asian Cosmology: Yin-yang and Five Phases Theories

The connection between food and medicine dates to pre-modern Korea. The book of 1613 Dongui Bogam 'Exemplar of Eastern [i.e., Korean] Medicine' by the royal physician Heo Jun states that the physician should use diet before medicine to cure a patient. At that time, it was clear that, for a healthy body, food must be matching with the body type. They believed that not all foods are suitable for everyone instead the food that we eat should match the properties of one's bodies. Therefore, they believed that an illness arises when an imbalance of the properties of the body occurs, and that this disequilibrium can be solved with the right diet. The boy type was determined by following the yin-yang and the Five Phases theories.

For the yin-yang theories, all things in the universe are made of different combinations of two opposite forces. Yin is the negative, cold, dark, female, and earth force, while yang is the positive, hot, male, heaven force. From the food point of view, meat and eggs are considered yin foods, whereas beans, vegetables, oil, and fruits are considered yang foods. Moreover, the two forces are associated with a specific organ of the body. What was believed is that the ideal situation was a balance between the two forces. Therefore, it was needed to eat a mix of foods from one and the other category to aim for perfect harmony. For this reason, Korean dishes and meals are often composed of a combination of ingredients from the two categories.

Yin-yang theory is completed by the Five Phases theory. This theory further classifies the energy of the universe into five stages of transformation. All things in the universe present these transformation stages that regulate and 'give birth' to the next and previous phases. For the earth for example the stages are wood, fire, earth, metal, and water; for human beings, the stages are birth, growth, maturation, death, and rebirth. Every element of the universe is constantly moving through these phases and so it is the energy. Moreover, similarly to yin and yang forces, every phase is associated with a specific organ, a season of the year, times of the day, color, taste, emotions, etc. (see Table II.1.). Therefore, when planning a meal or a dish it is important to have all Five Phases represented. This theory also explains why often Korean dishes embody vegetables of different colors.

PHASE	YIN	YANG	EMOTION	COLOUR	TASTE
WOOD	Liver	Gall Bladder	Rage	Blue/green	Sour
FIRE	Heart	Small Intestine	Happiness	Red	Bitter
EARTH	Spleen	Stomach	Contemplation	Yellow	Sweet
METAL	Lungs	Large Intestine	Sorrow	White	Spicy
WATER	Kidneys	Bladder	Fear	Black	Salty

Table II.1. Five Phases Theory (Pettid, 2008)

2.4 Daily Table Arrangement

A traditional Korean meal (bapsang) embodies four basic components that are rice, broth or stew, side dishes, and sauces. These four components are served all at once and are meant to be consumed at the same time as it is illustrated in Figure II.3.

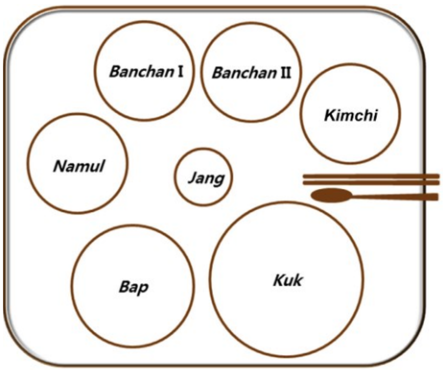

Figure II.3. Daily table arrangement. (S. H. Kim et al., 2016)

2.4.1 Rice

The main energy source in the Korean diet is grains such as steamed rice, boiled barley, and multigrain rice (Kwon et al., 2015). The rice used is a medium grain variety that, if well cooked, is slightly sticky. Rice is traditionally cooked in an iron pot called 'sot'. Often, as a heritage of less flourishing days, it is mixed with other grains like barley, millet, or brow rice and served as multigrain rice. Pretty famous is the five-grain rice (ogokbap) that is served as one of the first moon of the lunar year dishes (Pettid, 2008). Sometimes rice is mixed with legumes such as black beans. Mixing rice with other grains or legumes increase the nutritional value of plain rice and makes white rice healthier by being a protein and fiber source. Rice constitutes the base of every Korean meal, and its importance can be easily seen in that the Korean word used for cooked rice, bap, is also used to describe a generic full meal (S. H. Kim et al., 2016).

2.4.2 Broth or Stew (kuk or chigae)

Rice is served together with broth/soups (kuk) or stew (chigae) dishes that contain vegetables, meat, fish, and shellfish. A liquid component is needed to support the digestive system and, at the same time, to help people chew and swallow the rice. Koreans have the custom to take some rice with a spoon, immerse it in the broth, and then put it in their mouth.

Soups (kuk) are classified into four categories.

- Soups flavored with fermented soy sauce (kanjang).

Usually, these soups are clear soups with boiled meat, fresh or dried seafood, or vegetables. The most famous ones are seaweed soup (miyeok kuk), daikon radish soup (mu kuk), and dried pollock soup (bugeo kuk).

- Soups flavored with fermented soybean paste (doenjang).

Seafood such as shrimp, dried anchovies, and clams are added as basic ingredients of these soups together with red chili paste (gochujang) to make the soup spicy. Some examples are spicy croaker soup (meuntang), shepherd's purse soup (naengi doenjang kuk), and Chinese cabbage-heart soup (baechu kuk).

- Soups made by boiling cattle bones or cartilage.

Known as gom kuk, they are milky-white soups derived from the boiling of various cow bones for long periods to extract fat, potassium, and marrow. Sometimes they also use cattle intestines and head and the only seasoning used is salt. The most common are beef rib soup (galbi tang), beef bone soup (seolleongtang), and oxtail soup (kkori gomtang).

- Cold soups.

Generally called naeng kuk, are usually eaten during summer to soothe the heat of summer months and lightly seasoned with soy sauce and sesame oil. The preferred ones are cucumber cold soup (oi naeng kuk), cold seaweed soup (naeng miyeok kuk), and ginseng chicken soup (samgyetang) (Pettid, 2008).

Compared with soup (kuk), stew (chigae) is thicker and is cooked and served in the same glazed earthenware pot called ttukbaegi. The use of this unique vessel allows the stew to keep cooking even after being served to the guest because it retains the heat much better compared with metal pots. The main idea behind this dish is to put together whatever ingredients are available so the number of possible stews is unlimited. From the tradition, are to be mentioned doenjang chigae, a stew made with fermented soybean paste that represents the basis of any Korean home even today. The combination of ingredients inside the stew varies based on seasonality and preference but usually vegetables, seafood, and tofu are often added to complete the dish. Another popular stew is the kimchi chigae made with sour kimchi combined with pork and tofu.

2.4.3 Side Dishes (banchan)

The third element of a Korean meal is banchan. Banchan has two roles in the construction of the traditional Korean meal: enriching the flavor and increasing the nutritional quality. Usually, banchan are made with seasoned vegetables (namul), fish, legumes, and roasted meat. Banchan's seasonings vary from the easier vinegar or garlic and chili powder mix to more complex sauces such as fermented soy sauce (kanjang), fermented soybean paste (doenjang), red chili paste (gochujang), and fermented fish sauce (jeotkal). The number of banchan served during the meal is used to classify meals itself. Traditionally there are three-, five-, seven-, nine- or twelve-dish meals (Pettid, 2008). Among these, kimchi is the most widespread and is always present as a side dish (Allen & Freer, 1908).

2.4.4 Seasoning and Sauce (yangnyeom and jang)

As importantly, seasonings (yangnyeom) represent the fourth basic component of a Korean meal. Korean seasonings can be roughly divided into two main categories:

- Soybean-derived seasonings (-jang)
- Not soybean-derived seasonings

Fermented soy sauce (kanjang), fermented soybean paste (doenjang), and red chili paste (gochujang) belong to the first category. The suffix -jang means soybean sauce; kanjang refers to a 'salty' soybean sauce while doenjang refers to a 'thick' soybean sauce and gochujang to a 'spicy' soybean sauce. To prepare all of them, it is necessary to produce the basic ingredient soybean malt (meju) by boiling and fermenting whole soybeans. Soybean malt is then soaked in earthenware pots to produce soybean sauce (jang), which will be used to make fermented soybean paste (doenjang) or fermented soy sauce (kanjang). These seasoning ingredients were, and sometimes still are, stored in large quantities in earthenware jars in a dedicated terrace near the kitchen called jangdokdae and used all year round.

Among not soybean-derived seasonings essential are fresh vegetables, such as garlic and chili peppers. The value of garlic for Koreans is evident since the Tan'gun myth of the Gojoseon (?−108 BC), the first kingdom of the Korean peninsula (*Memorabilia of the Three Kingdoms*, 1983). In the foundation myth of the kingdom, the son of God comes to the world and conceived the future founder of Gojoseon, Tan'gun, with a bear transformed into a woman. The bear to maintain human features must eat mug wort and garlic for one hundred years. This myth implies that garlic had a religious or medicinal value. Moreover, evidence from the Three Kingdoms period reports wide cultivation of garlic in the peninsula since that time.

Chili peppers are a relatively new ingredient for the K-diet because it was introduced in Korea in the early seventeenth century via Japan, but since then they became a crucial ingredient for seasoning Korean dishes. Their usage was greatly encouraged by their bright red color. Koreans, as previously mentioned, believe that the red color helps elude bad luck and harmful spirits, and adding chili peppers to their dish became a protective move.

In addition to vegetables, also seafood is used as seasoning. Flesh and/or innards of fish such as corvine, cod, anchovies, herring, and shellfish are salted and fermented to use as side dishes or seasonings. Some examples are jeotkal and jeot. Jeotkal together with black pepper is also used to preserve food.

Fairly important are also sesame oil and perilla oil, the two main cooking oil in the K-diet. In addition to their pan-frying role, they are also used to prepare sauces and dipping sauces. Sesame oil has a characteristic scent that enhances the taste of food and usually is used to season meat and vegetable-based side dishes on the North of the peninsula meanwhile, perilla oil has a delicate scent and is often used to season vegetable-based side dishes or as a dipping sauce for meats in the South.

Lastly, other basic seasonings such as sesame, pepper, ginger, mustard, salt, green onion, vinegar, and sugar are to be mentioned. The combination between the main seasonings described above and the other basic seasoning just mentioned creates a wide range of flavor nuances (Pettid, 2008).

In Korean cuisine, sauce and condiments embody numerous roles. The main role, as stated before, is related to enhancing the flavor of the meal in so far that the peculiar taste of Korean dishes is mostly a result of the combination of seasoning ingredients. Korean food presents a large range of flavors that fluctuates from the very elegant taste of vegetables to harsher flavor granted by seasoning such as garlic, fermented soybean paste (doenjang), fermented soy sauce (kanjang), and red chili paste (gochujang). A second role intimately related to the main one is the stimulation of the appetite (Hwang et al., 2005). Condiments can also be additional protein sources because, as described above, they are often made from soybeans, and they can increase the health benefit of the food due to the presence of capsaicin. Capsaicin, in fact, contains a lot of vitamin C and has antioxidant properties known for slowing down the aging process (H.-K. Chung et al., 2016).

3. Fermented Foods in Mediterranean and Korean Diets

The dawn of fermented foods is believed occurred independently at nearly the same time in every continent (Tamang et al., 2020). Most probably it dates before the existence of written evidence. In fact, Neolithic proof of winemaking has been found in Asia, in the Middle East, and in the Far East. Archeologists have found proof of the production of a Chinese fermented beverage at 7000 BC (McGovern et al., 2004), and proof of winemaking in Iran at 6000 BC (McGovern et al., 1997) and Egypt at 3000 BC (Cavalieri et al., 2003). Nevertheless, the first written record of beer production (through the alcoholic fermentation of barley) and wine production (through the alcoholic fermentation of grapes) dates back around 5000 years (Borgstrom, 1968). At a later time, it is believed that the fermentation of grapes attained Mediterranean regions and the world (Legras et al., 2007). Pretorius in his article titled 'Tailoring wine yeast for the new millennium: novel approaches to the ancient art of Winemaking' states that evidence of winemaking in the Mediterranean area has been found in Greece (2000 BC), Italy (1000 BC), Northern Europe (100 AD), and America (1500 AD) (Pretorius, 2000).

Just the opposite is the origin of milk fermentation. In fact, scientists believe that milk fermentation developed in places in the world where pastoral agricultural practices and animal farming were prevalent as a means of preservation. Therefore, cultured milk, fermented dairy products, and cheese developed mainly in Europe, India, and the Middle East, whereas in countries such as Kores, Japan, and China, where goat, sheep, and cows rearing was limited, the fermentation of fish, vegetables, grains, and soybeans was more common (Tamang et al., 2020). Lactic acid bacteria were used to increase the shelf-life of milk by converting lactose into galactose, glucose, and lactic acid (Campbell-Platt, 1994). The most common milk was cow milk, but also sheep and buffalo milk were used based on the availability of the animals. In Europe and in the Middle East, more than

1000 different cheeses were produced through fermentation (Campbell-Platt, 1987). Yeast instead was used to produce bread from wheat or rye since the Roman era. Records show that more than 250 types of bread were common in Ancient Rome (Pederson, 1971).

As stated in Table II.2, fermented foods are common in the culinary tradition of numerous populations of the world. In South America for example dairy products and beverages are often fermented, whereas fish and legumes are fermented in large quantities in Asia. In India, instead, cereal and legumes are the ingredients that are mainly fermented. It is believed that a proportion of around one-third of the world population's food intake is represented by fermented foods (Campbell-Platt, 1994). Presumably, their origin was a result of a mistake during the transportation or storage of some food product that caused spoilage of the fresh raw material (Tamang et al., 2020). Nevertheless, the potential of fermentation was clear since the start as countless trials were carried on learning how and why the fermentation happened and how to take advantage of it. In fact, it has been used as a low-energy preservation method since ancient times (Bernini, n.d.) alongside salting and drying (Bamforth & Cook, 2019). Originally, fermentation started as a natural process based on autochthonous microorganisms selected by the natural availability of nutrients and environmental conditions such as pH, temperature, water activity, and oxygen. Nowadays, the production process and the microbial cultures are controlled and carefully selected to obtain the best results from the product and the safety perspective. Fermentation is not just a preservation technique anymore. It is used to make deliberate changes to food to enhance taste, nutritional value, or digestibility. These changes and the health benefits that seem to be linked to fermented foods make them particularly appreciated by consumers even in recent years (Bamforth & Cook, 2019).

Fermented Food and Main Constituents	Country
Yogurt—milk, *L. bulgaricus*, *S. thermophilus*	Greece, Turkey
Kefir—milk, kefir grains, *Saccharomyces cerevisiae* and *L. plantarum*	Russia
Sauerkraut—green cabbage, *L. plantarum*	Germany
Kimchi—cabbage, *Leuconostoc mesenteroides*	South Korea
Cortido—cabbage, onions, carrots	El Salvador
Sourdough—flour, water, *L. reuteri*, *Saccharomyces cerevisiae*	Egypt
Kvass—beverage from black or rye bread, *Lactobacillus*	Russia
Kombucha—black, green, white, pekoe, oolong, or darjeeling tea, water, sugar, *Gluconacetobacter* and *Zygosaccharomyces*	Russia and China
Pulque—beverage from agave plant sap, *Zymomonas mobilis*	Mexico
Kaffir beer—beverage from kaffir maize, *Lactobacillus* sp.	South Africa
Ogi—cereal, *Lactobacillus* sp., *Saccharomyces* sp., *Candida* sp.	Africa
Igunaq—fermented walrus	Canada
Miso—soybeans, *Aspergillus oryzae*, Zygosaccharomyces, *Pediococcus* sp.	Japan
Tepa—Stinkhead fermented fish	USA
Dosa—fermented rice batter and lentils, *L. plantarum*	India
Cheddar and stilton cheeses—*Penicillium roqueforti*, *Yarrowia lipolytica*, *Debaryomyces hansenii*, *Trichosporon ovoides*	United Kingdom
Surströmming—fermented herring, brine, *Haloanaerobium praevalens*, *Haloanaerobium alcaliphilum*	Sweden
Crème fraîche—soured dessert cream, *L. cremoris*, *L. lactis*	France
Fermented sausage—Lactobacillus, Pediococcus, or Micrococcus	Greece and Italy
Wine—various organisms particularly *Saccharomyces cerevisiae*	Georgia

Table II.2. Fermented Foods and their Hailing from Countries (Chilton et al., 2015)

As reported by Bamforth & Cook in the book 'Food, fermentation, and Microorganisms' of 2019, Campbell-Platt's definition of fermented food is: 'those foods which have been subjected to the action of microorganisms or enzymes so that desirable biochemical changes cause significant modification to the food.' (Campbell-Platt, 1994) More specifically, fermentation is the process used by microorganisms to produce energy. It is mainly an anaerobic process that, by transforming sugars in other compounds, supplies the microbial cell with the energy needed to carry on all the life processes. Humans have found a way to use this natural process for their own benefit. In fact, byproducts of fermentation are often a waste for microorganisms but useful for human beings. The degradation of molecules during fermentation is not complete therefore the food maintains a good nutritional value or even sees an increase of it due to an increased number of vitamins and antioxidants produced during fermentation or the transformation of inedible compounds into edible compounds. (Chilton et al., 2015) With regard to the preservation ability of fermented foods, the keys are in the conversion of carbohydrates and other molecules, which are spoilage microorganism's prime source of food, in microbial useless compounds and the development of unfavorable conditions for spoilage microbial growth such as high alcohol, anaerobiosis, and low pH (Bamforth & Cook, 2019).

Fermentation can be a way to distinguish cultural differences between world communities. Going more into the details, the main differences are on the way to start the fermentation and the microorganism used. Traditionally, fermented food relied on spontaneous fermentation or on the back-slopping, whereas nowadays industrial fermentation with started cultures is available for some food such as wine, meat, and dairy. Nevertheless, most of the traditional fermented food and alcoholic beverages are still fermented by following the traditional fermentation without the addition of a started culture (Tamang et al., 2020). Bacteria and yeast are the primary microorganisms used by humans in the fermentation of food. The former is used for lactic acid fermentation exploiting their ability to produce lactate from sugars and so decreasing the pH and, as a result, favor the preservation of food. The group of bacteria that can do this kind of fermentation are called Lactic Acid Bacteria (LAB) and the main ones in this category are *Lactobacillus, Enterococcus, Streptococcus, Bifidobacterium and Lactococcus* (Masood et al., 2011). They are used to produce an important number of traditional dishes such as kimchi, kefir, yogurt, sauerkraut, cured fish, and pickled vegetables. The latter is used for alcoholic fermentation that, by using pyruvate, produces ethanol and carbon dioxide. The most famous yeast used both for bread making and alcohol production in beer and wine is *Saccharomyces cerevisiae*. (Chilton et al., 2015)

3.1 Fermented Foods of Mediterranean Diet

By looking at the historical evolution of fermented foods reported in the previous section it is easily noticeable that fermented foods are used by the Mediterranean inhabitants since ancient times. We should also note that lacto-fermented ones are the only processed food that are highly recommended in the food pyramid (NAUREEN et al., 2022) and therefore the most common fermented foods used in this dietary pattern. The reason behind this recommendation lies not only on historical causes but also on their health-promoting properties. In fact, food that have been fermented by lactic acid bacteria present a higher concentration of compounds that interact with the gut microbiota and consequently increase the healthiness. (NAUREEN et al., 2022)

3.1.1 Milk-derived foods

Milk is the main ingredient used to produce lacto-fermented foods. It is an important component of the Mediterranean Diet since ancient times as it was mentioned in the writings of Plato (5th to 4th century BC) as one of the main components. It is a nutrient-rich food as it is a good source of vitamins, minerals, high quality proteins, and amino acids (Smith et al., 2022). Despite this, the same compounds that make milk highly nutritional are also the cause of its fast decay. Due to its nutritional characteristics, human beings have hugely relied on milk throughout all their evolution and the concern on how to preserve it and its nutrients arose soon. The solution was the exploit of fermentation. (Tamang et al., 2020) At first, it was a spontaneous fermentation that evolved through the years in induced fermentation carried on by starter culture. In both cases, lactose is converted in lactic acid and many other useful compounds such as vitamins, minerals, bioactive compounds, essential amino acids, and exopolysaccharides by LAB species. (NAUREEN et al., 2022)

Moreover, besides lactose, LAB modify also other milk compounds making them more available and therefore increasing the quality of the final product.

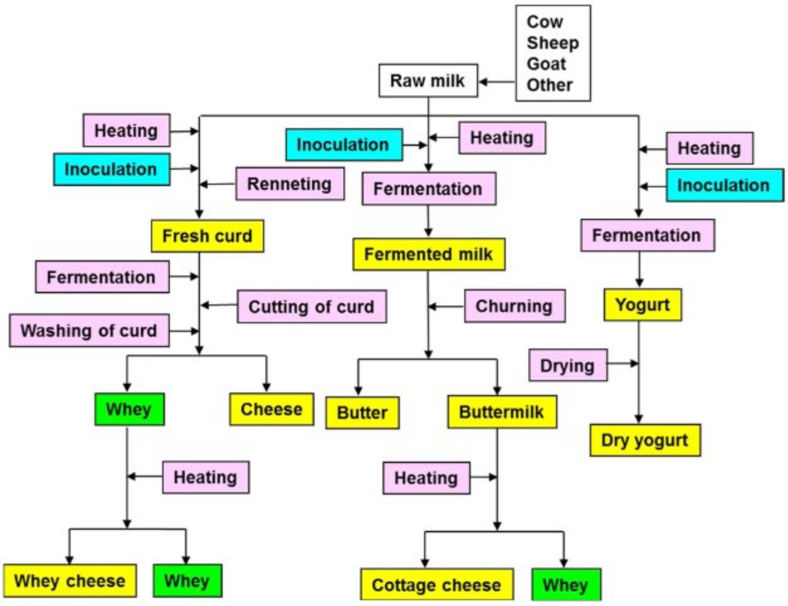

Figure II.4. Generalized flow chart for manufacture of fermented dairy products. (Tamang et al., 2020)

Cow's milk is the most common basis used to produce dairy fermented food worldwide. However, in Mediterranean countries a tradition of small ruminant farming (sheep and goats) resists along with buffalo farming. The milk composition of domesticated animals differs in numerous parameter such as total solid, protein, lactose, and fat content and this reflects on the characteristics of the final fermented product. (Tamang et al., 2020) This and the huge variety of production techniques that involve milk and fermentation results in a wide number of dairy fermented food, as we can see in Figure II.4. As an example, Tamang et al. report that: 'There are a large number of varieties of traditional and commercial fermented milk products with more than 400 generic names worldwide. There are at least another 1,000 varieties of cheese and cheese-like products that also exist.'

In the next sections, I will describe the most common ones in the Mediterranean Area.

3.1.1.1 Yogurt

Prior to 1970, yogurt and yogurt-related products were prepared and consumed just in Europe, Balkans, India and Middle East. (Tamang et al., 2020) The first record of a yogurt-like food can be found in ancient sacred books of the Hindus (Rig Veda and Upanishad) in India and dates about 6000 to 4000 BCE. Nowadays, instead, yogurt and yogurt-related products are the most common fermented milks produced from the inoculum of a started culture. For commercial products the use of commercial culture is highly spread, but for traditional products the culture is usually derived from back-slopping. Back-slopping consists in the addition of small quantity of fermented products into fresh ingredient. By letting this mixture at room temperature, the fermentation will start, and, after a few cycles, a stable microbial community will be formed. (Wirawati et al., 2019)

Yogurt is a semisolid food made through a heating process followed by the action of microorganism. Traditionally the production of yogurt starts with the boiling of milk. This is an important step because it removes all the unwanted microorganism and inactivates the toxins making milk a perfect substrate for the inoculum. Milk is then cooled down and inoculated with LAB microorganism such as *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* in a 3:1 mixture. (Bamforth & Cook, 2019) To promote the action of LAB microorganism, the temperature of the milk must be maintained near 40-45°C because they are moderate thermophiles. (Lick et al., 2001) Therefore, warm ambient are preferred and achieved by exploiting direct sunlight exposure or the warmth of the cooking areas. Nowadays, temperature-controlled incubators are widely used to for this purpose. (Tamang et al., 2020) Moreover, the formulation of yogurt nowadays is enriched with a range of components such as nuts, grains, and fruits. (Bamforth & Cook, 2019)

According to its consistency, yogurt can be classified as drinkable yogurt and spoonable yogurt. Some examples are briefly described below and in Table II.3.

- *Drinkable yogurt*

Traditionally, drinkable yogurts are made by spontaneous fermentation, buttermilk, or back-slopping.

'Raib' or 'rayeb' is a common Moroccan yogurt produced by spontaneous fermentation of goat, buffalo, cow, ewe, or camel milk or a mixture of the mentioned milk. *Streptococcus termophilus, Lactococci, leuconostocs,* and *Lactobacillus* are the microorganisms that are mainly responsible of the fermentation of this milk. By using a spontaneous fermentation, the aromatic profile is enriched and peculiar, different from the industrial product of the same type.

Buttermilk is common in different countries of the Southern Mediterranean area with different names and slightly different production techniques. In Morocco and Algeria, it is called 'lben', in Tunisia 'leben', and in Egypt it can be found with the name 'iraqi' or 'laban khad'. The production start with the natural fermentation of milk at room temperature for 24 to 72 hours until coagulation. Then, the naturally fermented milk is churned to separate two fractions, nonbutter and butter. In this case the microorganisms that are traditionally used are from *Streptococcus termophilus, Lactococci, leuconostocs,* and *Lactobacillus plantarum* species. (Mefleh et al., 2022) These microorganisms enrich the aroma compounds with acetoin, butanoic acid, and hexanoic acid that give a typical fresh and sour taste to the final product. Buttermilk is famous also in Bulgaria where it exploits *L. delbrueckii* subsp. *bulgaricus* ability to produce up to 4% of lactic acid, making Bulgarian buttermilk significantly more acidic that yogurt.

Lebanon and Egypt share a similar spoonable yogurt called respectively 'laban' and 'laban zabady' obtained by back-slopping fermentation. Even in this case, goat, sheep, cow, camel, or buffalo milk can be used and the microorganism that are traditionally used are *Streptococcus termophilus, Lactococci, leuconostocs*, and *Lactobacillus*. 'laban zabady' is the most famous Egyptian fermented milk. Traditionally, Egyptians follow the back-slopping methods by adding to raw buffalo's milk, or to a combination of cow's and buffalo's milk, a portion of 'laban zabady' from the production of the previous day. (Elbaradei et al., 2008) It is characterized by 1% of titratable acidity and a pH of 4.0, lower cholesterol, protein, and fat content compared to milk, in contrast with a higher content of minerals and vitamins compared to milk.

- *Spoonable yogurt*

'Labneh' or 'shaneenah' is a common sour and creamy spoonable yogurt traditional of Lebanon, Jordan, Syria, and Egypt. 'Laban' or 'zabady' are drained using a cheesecloth at room temperature to obtain the solid texture of the spoonable yogurt. 'Labneh' contain double the quantity of proteins compared to 'laban' and a higher content of probiotic microorganisms compared to yogurt. Moreover, it has a low pH of 4.5 that increase the shelf life to 7-10 days.

In the same countries, another fermented dairy product is often consumed: 'kishk'. It is produced by mixing cereal such as wheat, bulgur, or barley with fermented milk ('laban' or buttermilk) in a ratio of 1:1-1:4 and 3% of salt. The fermentation is carried on at room temperature for 2 to 7 days and every day a part of fermented milk is added to maintain the fermentation active. When the fermentation ends, the paste obtained is kneaded in balls that can be consumed fresh or preserved in glass jars with olive oil or dried and grounded to obtain kishk flour. (Mefleh et al., 2022)

Types	Products	Common Name	Description	Main Starters
Drinkable	Spontaneously Fermented Milk	Raib/Laban Rayeb	Raib is a spontaneously fermented milk.	*Streptococcus termophilus*, *Lactococci*, *leuconostocs*, and *Lactobacillus*
	Buttermilk	Lben in Morocco and Algeria, leben in Tunisia, Iraqi and Laban khad in Egypt	Lben is a buttermilk resulting from the churning of naturally fermented milk	*Lactococcus lactis* ssp. *lactis*, *Lactococcus lactis* ssp. *lactis* biovar *diacetylactis*, *Lactococcus lactis* ssp. *cremoris*, and *Lactobacillus plantarum*
	Back-slopping fermented milk	Laban, Laban Zabady	Laban is fermented using old (previous) fermentate	*Streptococcus termophilus*, *Leuconostoc lactis*, and *Lactobacillus acidophilis*
Spoonable	Fresh/Dried Fermented milk and Cereals	Kishk, keshek, kushk, Kishk Matrouh	Kishk is made with fermented milk and cereals	*Streptococcus termophilus* and *Lactobacillus acidophilis*
	Concentrated Fermented Milk	Labneh, Labaneh, shaneenah, Anbaris,	Labneh is made by draining Laban or Laban Zabady until reaching a creamy texture	*Streptococcus termophilus*, *Leuconostoc lactis*, and *Lactobacillus acidophilis*

Table II.3. Main features of traditionally fermented dairy milks of Southern Mediterranean countries. (Mefleh et al., 2022)

Interesting is the development of yogurt-related product in all the Mediterranean basin. By changing the milk type and/or microorganism species Mediterranean populations have obtained products with strong peculiar characteristics that contribute to the development of their tradition. Some examples are listed below.

'Ricotta' is a typical Italian food product obtained from whey. During the production of 'ricotta', skimmed whole milk or cream are added to the whey together with salt and Streptococcus thermophilus and L. bulgaricus. The mixture is than heated to allow the coagulation and the curd is collected.

'Kefir' is a particularly characteristic self-carbonated beverage as it is acidic, slightly effervescent, viscous, and mildly alcoholic. Originated in the Balkan-Caucasian region, it is produced through the fermentation of autochthonous yeasts and bacteria present in grains of kefir. (Ahmed et al., 2013) Kefir grains are a matrix of polysaccharides and proteins where microorganism such as lactic acid bacteria, yeast, and acetic acid bacteria coexists. By adding grains to a substrate (such as milk) the fermentation will start. (Tamang et al., 2020) The presence of yeast in the culture will enrich the final product with alcohol and carbon dioxide. (Bamforth & Cook, 2019)

Another Eastern European product derived from the fermentation of milk is 'koumis'. In this case mare's milk is used as substrate for yeast and bacteria. Mare's milk present a higher fat and lower protein content compared to cow's milk so 'koumis' taste result more smooth and rich compared to yogurt or other similar products. (Tamang et al., 2020)

3.1.1.2 Cheese

Mediterranean basin and the Middle East were the first countries to start the domestication of animals and consequently milk was an important ingredient for their diet. The perishability of the milk fuel the development of preservation techniques and cheese is one of them. Mediterranean inhabitants have a profound tradition of cheesemaking that enriched the diet with numerous cheeses used as a long shelf life energy and nutrients source. (Mefleh et al., 2022) For many centuries, cheese was mainly consumed in Europe and North America. There is evidence of cheesemaking with sheep and cow milk in ancient Mesopotamia (c. 7000 B.C.E.), cheese remnants in an ancient Egyptian tomb (c. 3000 B.C.E.), and cheese trade in ancient Rome and Greece. Some records found in Kujawy state that cheese was produced and consumed in Poland before 5500 BCE. (Salque et al., 2013) From East to West of the Mediterranean area, different tradition on cheesemaking have developed, reflecting the human history of all the different countries and zone. Even little variation in type of milk, technologies, and microbes used in the production led to the development of a different final product and consequently led to the extraordinary portfolio of cheeses that are still currently produce in the Mediterranean basin. (Tamang et al., 2020) Undoubtedly, the development of all this abundance of cheeses originate part from errors, part from art and skills of the cheesemaker, and part from luck. (Hutkins, 2008) Nowadays, the cheese industry is the largest among all fermented foods.

Cheese is a highly nutritional food produced from milk from cow, goat, sheep, buffalo, or a blend of these milks. Compared with milk, it contains more milk solids and less water, therefore it can be considered a concentration process that increase the nutritional value while decreasing microbial and enzymatic activity (due to the lack of water). (Hutkins, 2008) It can be made by following different techniques and with different ingredients, producing a high variability among taste, texture, and shape of final product. Generally, cheese is produced by coagulation of caseins, milk proteins, using bacterial culture, enzymes, and stabilizers, but the production steps may vary based on the cheese type. (Farkye, 2004) In particular, three main coagulation techniques are present: acid coagulation, acid plus heat coagulation, and enzymatic coagulation via rennet. The latest is the more common and use lactic acid bacteria (LAB) as the microbial culture. Different strains of LAB can be using during cheesemaking, and the peculiar characteristic of each strain will modify the final aroma, texture, and taste of cheeses. For example, some strains produce lactic acid at various temperature, some other just at specific temperature or in different amount; some of them can produce carbon dioxide and diacetyl in higher amount compare with other strain. Cheesemaker must choose the strain that will allow the production of the anticipated characteristics. During the production of cheese, the most critical points are maintaining the right moisture content and the right pH, therefore the production of acid and the expulsion of whey are the two main steps that must be carefully controlled during the cheesemaking. Whey in fact contains both buffers that regulate the changing of pH and the substrate that is transformed in acid. (Bamforth & Cook, 2019) The removal of water is the main difference between cheese and buttermilk, sour cream, yogurt, or other fermented dairy products. At the end of the production, some cheeses are consumed fresh, other are matured for a variable period that go from three weeks to more than two years. During the ripening period, cheese will continue to change due to bacteria and mold activity on lipids and proteins. Consequently, compared with the fresh made cheese, the ripened cheese will have hugely different organoleptic characteristics. In Figure II.5 some of these biochemical changes of lipids and proteins are illustrated. Moreover, the longer the ripening period, the lower will be the moisture content of the cheeses. Additionally, some cheeses, such as ‘gorgonzola’ and ‘roquefort’, are further fermented by adding mold during the ripening stage. This technique enriches the organoleptic profile of the mentioned cheeses.

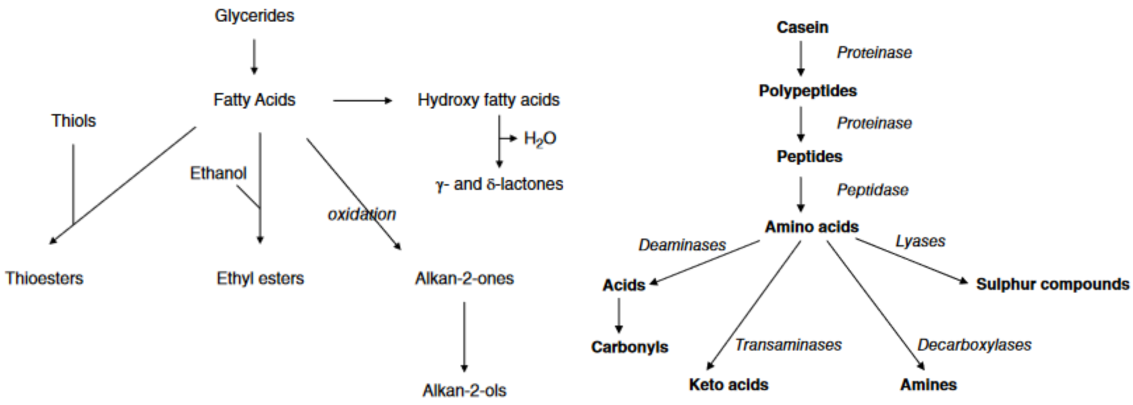

Figure II.5. Reaction of lipids and proteins involved in the development of cheese flavor. (Bamforth & Cook, 2019)

Hundreds of different varieties of cheeses are present worldwide, the majority of which are distributed between the Mediterranean area and Europe. Cheeses can be classified by following different means: country of origin, firmness, composition, maturation agents, production process, moisture content, cooking temperature, extent of aging and maturation techniques. A general overview is given in Table II.4 whereas in Table II.5 Southern Mediterranean cheese and their characteristics are illustrated. Moreover, a brief description of the main cheeses based on their firmness is present after the two tables.

Firmness and subdivision	Moisture (%)	Examples
Soft	50–80	
Unripened/low fat		Cottage
Unripened/high fat		Cream, Neufchâtel
Unripened stretched curd		Mozzarella
Ripened through external mould growth		Brie Camembert
Ripened by bacterial fermentation		Kochkäse Caciotta (from goat's or sheep's milk)
Salt-cured or pickled		Feta
Surface-ripened		Liederkranz
Semi-soft	39–50	
Ripened through internal mould growth		Blue Gorgonzola Roquefort (sheep's milk)
Surface-ripened by bacteria and yeast		Limburger Oka Trappist
Chiefly ripened through internal bacterial fermentation but perhaps also surface growth		Bel Paese Munster
Ripened internally by bacterial fermentation		Provolone
Ripened internally by bacterial fermentation, also CO_2 generation to produce 'eyes' (holes)		Edam Gouda
Hard	<39	
Ripened internally by bacterial fermentation		Caciocavallo Cheddar
Ripened internally by bacterial fermentation, also with 'eye' production		Emmental (a.k.a. Swiss) Gruyere
Ripened by internal mould growth		Stilton
Very Hard Cheese	<34	Parmesan Romano
Whey cheese	60	
By heat/acid denaturation of whey protein		Ricotta

Table II.4. Some types of cheese (Bamforth & Cook, 2019)

Types	Products	Description	Starter Culture
Soft	Chnina	Fresh cheese with short shelf life	Back-slopping fermentation
	Testouri	Fresh and brined cheese	Rennet
	Rigouta	Fresh cheese with short shelf life	Spontaneous fermentation of whey
	Jben	Fresh, white cheese, slightly salty and sour	Spontaneous fermentation, plant coagulating enzymes and/or rennet
	Chefchaouen	Fresh cheese	Rennet
	Arish, kariesh	Fresh light cheese	Natural acid coagulation
	Madghissa	Processed cheese with yellow color, and elastic texture	Back-slopping using fresh Klila
	Domiati	Ripened and light-brown cheese	Spontaneous fermentation
	Mish	Ripened and/or fresh cheese	back-slopping using fresh Karish or old Mish
	Bouhezza	Ripened and spreadable cheese flavors are slightly salty, spicy, and acidic	Spontaneous fermentation
Semihard	Halloumi	Semihard to hard white brined cheese	Rennet
	Akkawi	White brined cheese	Rennet
	Nabulsi	White brined cheese	Rennet
	Mshalshe	Stretched-curd brined cheese	Rennet
	Darfiyeh	Dried and ripened cheese	Spontaneous fermentation
	Shankleesh	Fresh and/or dry aged cheese	Spontaneous fermentation
Hard	Klila	Fresh and/or dry white cheese	Spontaneous fermentation
	Takkamart	Dry brown cheese	Abomasum
	Aoules	Dry cheese	Spontaneous fermentation
	Taklilt	Dry cheese	Spontaneous fermentation
	Roumy, Rumi, Ras	Hard aged cheese	Spontaneous fermentation

Table II.5. Traditional cheeses of Southern Mediterranean area. (Mefleh et al., 2022)

- *Soft Cheeses*

'Mozzarella' is a common Italian soft cheese that belong to the pasta-filata cheese variety. It originated in Battipaglia and traditionally is made with buffalo milk. Buffalo milk is whiter compared with cow milk and this characteristic is highly appreciated in the production of 'mozzarella'. The cheese must in fact be white, soft, lightly salted, and must have a unique property of stretchability. (Jana & Mandal, 2011)

Traditional of Tunisia is 'Testouri', a white cheese made from goat and sheep milk obtained in this case from a rennet coagulation. The presence of *E. faecalis* OB14 and OB15 give a probiotic effect at this cheese. Another Tunisian fresh soft cheese is the 'rigouta' made through spontaneous fermentation at room temperature of whey for 1-2 days. The main actor in the 'rigouta' fermentation are Lactococcus lactis and Enterococcus faecalisare. The industrial version of this cheese is similar to the Italian 'Ricotta'. (Mefleh et al., 2022)

In Greece 'feta' is the most common soft cheese. It is a white cheese produced from sheep milk or from a mixture of sheep and goat milk that have a particular storing time in brine. This ripening period in brine give the peculiar characteristic to the cheese: a salty, acidic taste with pleasant sensory properties. 'Feta' is produced and consumed in Greece since the Homer time, and it is still very appreciated in his origin country with an annual per capita consumption of more than 12 kilograms. Moreover, even if this cheese was common only in the Balkan region until the 20th century, nowadays is known and exported worldwide. (Anifantakis & Moatsou, 2006)

'Jben', 'djben', or 'jebena balady' is traditionally produced in Lebanon and Egypt by spontaneous fermentation of sheep or goat milk. A peculiarity is the addition of plant extracts, spices, and herbs such as garlic and thyme to the cheese to give the peculiar flavor. (Mefleh et al., 2022)

- *Semihard Cheeses*

In Lebanon, Syria, and Jordan 'haloumi' is a common semihard cheese produced by coagulation of ovine milk with rennet. A peculiar characteristic of this cheese is the texture that is elastic and compact when fresh, whereas when heated it has good melting and stretching properties. These properties make 'haloumi' a versatile cheese that can be consumed fresh, fried, or grilled. (Mefleh et al., 2022)

'Provolone' is an Italian semihard cheese typical of the Basilicata region. It is a drawn-curd cheese made from whole pasteurized cow milk that present a firm paste and a different taste based on the cheesemaking techniques. 'Provolone' is therefore produced in two types: 'dolce' (sweet) and 'piccante' (sharp). Southern consumers prefer 'piccante' due to its stronger flavor, whereas in the northern regions the ‘dolce’ is usually preferred. (Favati et al., 2007)

- *Hard Cheeses*

Italy has two products that belong to the hard cheeses category: ‘Grana Padano’ and ‘Parmigiano Reggiano’. Both are characterized by a long maturation period that can exceed two years and characterize the cheeses flavor. These two cheeses in fact need the biochemical changes that happens during maturation to enrich them of taste, texture, and flavor. Additionally, they are produced from raw milk with the addition of ‘sieroinnesto naturale’ daily prepared by the cheesemaker. The starting point of the production of ‘sieroinnesto naturale’ is the collection of a portion of cooked and unacidified whey from the cheese vat at the end of the curd heating step. The unacidified whey is then left to cool for 18-24 hours until a pH of 3.3-3.6 is reached. This step reduces the microbial diversity and select the heat-tolerant, aciduric, and thermophilic LAB species and strains that will be fundamental in the production of the cheese. ‘Sieroinnesto naturale’ has different functions that help in the production of cheese: it favors the activity of the rennet’s chymosin by acting on the acidity of the milk, it activates the lactic fermentation in a stronger way counteracting the development of harmful bacteria, and it enrich the mixture with useful enzymes that support the formation of the typical organoleptic characteristics of the cheese. (Giraffa, 2021)

3.1.2 Table olives

Fermented vegetables are hugely consumed in different countries of the world as side dishes or ingredients for numerous dishes. Among fermented vegetables, table olives are the most common and the oldest in the Mediterranean area and in particular Italy, Egypt, Turkey, Spain, Portugal, and Algeria are the main producers. The preservation of olives through fermentation dates back to the first century CE as some records state that it was common among Romans. (Sealey & Tyers, 1989) In 2010, olives have been added to the Food Pyramid of the Mediterranean diet due to their high content of dietary fibers, antioxidants, fatty acids, and bioactive compounds.

Olive’s production process described in Table II.6, is complex as it is craft-based, and it follows the traditional processes. Therefore, some unpredictable alterations due to spoilage microorganisms may occur. Clearly, to follow the safety rules and the trading standards, the traditional methods have been adapted with the introduction of starter cultures, but in some area the traditional methods still exist. In Sicily, a traditional processing method called Castelvetrano system is still applied as it was. Table olives produced by following this production technique can only be of Nocellara del Belice variety and must have 19 mm in diameter. The chosen olives are placed in a 1.8%-2.5% sodium hydroxide (NaOH) solution for one hour. Then, 5-8 kilograms of salt are added to create a brine in which olives will stay for 10 to 15 days. (Perpetuini et al., 2020)

Preparation Method	Process
Treated olives	It is applied to green olives, olives turning color, or black olives. Olive debittering is achieved through an alkaline treatment (lye 2.5%–3% w/v). Olives are then placed in brine (NaCl 10%–11% w/v) where the fermentation takes place and lasts 3–7 months. Fermentation is driven by lactic acid bacteria.
Natural olives	It is applied to green olives, olives turning color. or black olives. Olives are placed directly in brine. With a salt concentration of about 6%–10% (w/v). Oleuropein is removed through the enzymatic activities (mainly β-glucosidase and esterase) of indigenous microorganisms. The fermentation process can last 8–12 months and it is mainly driven by yeasts and lactic acid bacteria.
Dehydrated and/or shriveled olives	It is applied to green olives, olives turning color, or black olives. Olives are subjected or not to a mild alkaline treatment, preserved in brine, or partially dehydrated in dry salt and/or by heating.
Olives darkened by oxidation	It is applied to green olives or olives turning color. Olives are preserved in brine, fermented or not, and darkened by oxidation in an alkaline medium. They are stored in hermetically sealed containers and subjected to heat sterilization.
Specialties	Olives prepared in a different way than those above following traditional recipes.

Table II.6. Olive processing methods according to the International Olive Oil Council (IOOC) (Perpetuini et al., 2020)

Generally, fermented olives are made from alkaline-treated raw olives or brine-treated raw olives. Olive tree' fruit to produce table olives must follow standards about volume, flash-to-stone ration, shape, taste, and firmness. Moreover, it must have a fine flesh and an easy detachment of flesh from the stone. (Perpetuini et al., 2020) Worldwide the production techniques may vary giving the final product peculiar characteristics that are considered traditional of the origin country. In the Mediterranean basin there are two main styles: Spanish-style green olives and Greek-style natural black olives. (Tamang et al., 2020) Both relay on spontaneous fermentation of autochthonous or indigenous microorganism, with yeast such as *Saccharomyces cerevisiae, Wickerhamomyces anomalus, Candida boidinii*, etc. and LAB such as *Lactobacillus plantarum* or *Lactobacillus pentosus* as the primary microorganism. (NAUREEN et al., 2022)

LAB play the crucial role of converting sugars into lactic acid, acetic acid, and carbon dioxide and therefore they induce an acidification of the brine that will prevent the development of pathogens and spoilage microorganism. (Perpetuini et al., 2020) Additionally, LAB enzyme β-glucosidase catalyzes the degradation in glucose and aglycone of oleuropein. Likewise, aglycone is converted by an esterase in non-bitter compounds such as hydroxytyrosol and elenolic acid. This enzymatic activity is fundamental in the production of table olives because olive tree's fruit cannot be eaten directly from the tree due to its high bitterness caused by oleuropein. Along with fermentation, other steps of the production of olives such as alkaline treatment, salting, and acidification may help remove the bitterness and therefore increase the culinary value of the product. Moreover, the fermentation of oleuropein increases also the nutritional value in terms of fatty acids, antioxidants, dietary fibers, and bioactive compounds. (NAUREEN et al., 2022)

Concerning yeast, they play three roles that are fundamental for the organoleptic profile of table olives. First, they produce volatile compounds (such as ethyl acetate, alcohols, and acetaldehyde) and other compounds that enhance the aroma and the taste of the final product. Second, they release nutritive compounds (such as vitamins, purines, and amino acids) that are used by LAB enhancing the growth and the activity of this microorganisms. Third, they are equipped with lipase and esterase therefore they take part in the microbiological enzymatic activity. Lipase change the free fatty acids composition of olives, whereas esterase produce esters from free fatty acids and therefore improves the table olives taste. (Perpetuini et al., 2020)

Eventually, fermentation improves texture, ensure consumer safety, and adds flavor. (NAUREEN et al., 2022)

3.1.3 Bread and Sourdough bread

Bread has a central role on the Mediterranean diet giving that the suggested consumption places it in the second step of the Food Pyramid. Moreover, cereal-derived foods such as bread account for the 60-70% of the daily need of energy. It may have been one of the first processed foods and it is certainly the first to be produced on large scale. Its origins are not sure because it is believed that is has been produced and consumed even before the birth of writing. Fact is that some artifacts and writing from the Middle East place the origin of bread-making in the eightieth century BCE, however it is possible that it was produced even some thousands of years before. (Hutkins, 2008) Babylonian sources report that they produced a precursor of bread from the gruel obtained from mixing milk or water with a ground grain such as barley. The mixture was then air-dried or baked on hot ashes or hot stone. Other records, prove that Egyptian were producing leavened bread with a rather sophisticated bread manufacturing industry in 3000 BCE, while sourdough can be dated back to 450 BCE. (Bamforth & Cook, 2019) Additionally, during the Roman era, bakers were widely respected and had an elevated status because bread was considered a staple food and provided free or subsidized to the population. Leavening probably have been incidentally made for the first time when gruel became contaminated with wild yeast and bacteria, producing a spongy dough that after baking became a light, aromatic, and airy product. At first bread was probably flat with little to no leavening, like the modern naan or tortilla, due to the use of barley that do not allow a good leavening. Through the years, alongside the development of suitable wheat varieties such as emmer and Kamut, humans understood how to exploit leavening in the best way possible. (Hutkins, 2008)

The fermentation process of bread is not complex and requires few ingredients such as grain (wheat is preferred), salt, water, and a leavening agent. The main production steps of bread are reported in

Figure II.6, even if some variation are possible based on the recipes. Briefly, they are raw material preparation, dough fermentation and kneading, processing of the dough, baking, slicing and/or packaging. (Bamforth & Cook, 2019)

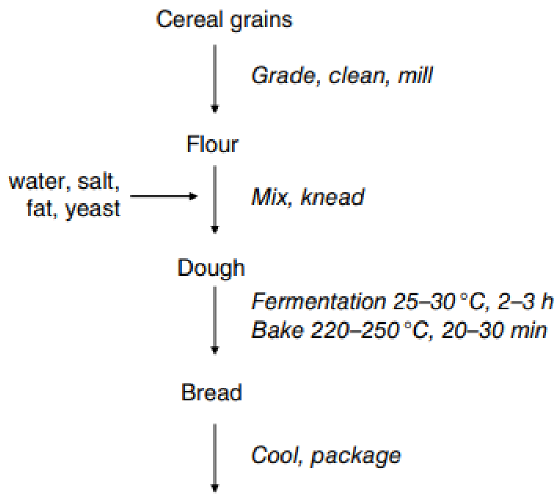

Figure II.6. Bread Making (Hutkins, 2008)

The key component in the production of bread is gluten, a protein complex that account for bread elasticity and structure and is fundamental for the leavening process. Gluten, in fact, retain the carbon dioxide produced during fermentation affecting the loaf volume and the dough expansion. Compared with other grains such as barley, oats, rye, corn, miller, or sorghum that are poor of gluten, wheat flour is rich on this protein complex and therefore it is preferred in the production of bread. Protein content is the main parameter that is used to classify wheat flour. Generally, about 8-15% of wheat flour consist of protein. The best flours for bread have a protein content of more than 11%. Flour proteins are from different families but the most numerous are gliadin and glutenin with a total amount of 85% of the total protein content in flour. With the addition of water these two protein families will form gluten. The remaining 15% of the total protein content consists of albumins and globulins. (Hutkins, 2008)

The yeast used for producing bread is *Saccharomyces cerevisiae*, a yeast widely used also in the production of fermented beverage like wine or beer. Nevertheless, strains used for each of these products are not the same and they are selected based on the expected final product characteristics. For example, the yeast selection for bread making is based on the evaluation of three main parameters such as the yeast ability of producing carbon dioxide (because carbon dioxide is responsible for leavening), the ability of yeast to produce good bread flavor, and the stability of yeast during storage. (Bamforth & Cook, 2019) The fermentation that is used during the production of bread have a different mean compared to other fermentation such as dairy, vegetables, or wine fermentation. In most of other food fermentation, the purpose is to extend the shelf-life of perishable raw materials, but bread is much more perishable than its raw materials. The purpose of bread fermentation is converting grain such as wheat into more functional and edible form. Moreover, in contrast with lactic acid or alcoholic fermentation, the primary fermentation end products of bread fermentation do not remain in the food product. (Hutkins, 2008) The growth of yeast starts as soon as yeast is mixed with flour, water, and other ingredients. At first, a lag phase usually occurs, the duration of which may vary based on fermentable sugar content and yeast ability to start the growth. *Saccharomyces cerevisiae* can use glucose by following either an anaerobic or an aerobic pathway because it has a facultative metabolism. The latter pathway produces much more ATP per glucose and cell mass compared to the anaerobic pathway. Nevertheless, yeast metabolize carbohydrates mainly by the glycolytic fermentative pathway and the initial oxidative metabolism of carbohydrates occurs only briefly or not at all. This choice has different explanations and all of them combined contribute to favor the anaerobic pathway. The first reason must be found on the presence of glucose that inhibits the synthesis of TCA cycle enzymes, making impossible to continue with the cycle. Secondly, the fermentative pathway that produce ethanol is a reduction reaction that generates oxidized NAD which is needed to maintain active the glycolysis. Finally, the dough environment, despite the incorporation of oxygen, quickly become anaerobic due to the production of carbon dioxide. (Hutkins, 2008)

- *Sourdough bread*

Leavening using sourdough process is one of the oldest biotechnological processes in the production of foods derived from cereals. Historically in fact, doughs were naturally fermented by microorganisms present in the air or on surface and therefore a mixture of yeast and bacteria were present and participate in the fermentation as it happens in the sourdough fermentation. (Hutkins, 2008)

The production start with the preparation of a mixture of water and flour that is then fermented with lactic acid bacteria (LAB) and yeast. (Chavan & Chavan, 2011) It is a traditional process that improve bread quality while differentiating the production of rye and wheat bread. A well know example of a baked product that use sourdough is Panettone, an Italian bakery product that is consumed during winter holidays. Sourdough main characteristics derives from its microflora. In fact, LAB and yeast involved in the sourdough fermentation are usually heterofermentative strains that produce acetic acid and lactic acid causing a pleasant acidic, sour-tasting bread. To specify, part of the acidification of bread must be ascribed to the dissolved of carbon dioxide, but the most of it derives from LAB activity. The mechanisms occurring in the sourdough are complex and can be influenced by different components such as flour characteristics or process parameters. Therefore, the sourdough must be processed with a particular care. (Chavan & Chavan, 2011)

Moreover, as reported in Table II.7, LAB and yeast strain hugely varies from one sourdough starter to the other, amplifying the variability among sourdough bread. (Hutkins, 2008)

Bacteria	Yeast	Property
Lactobacillus alimentarius	*Saccharomyces exiguus*[2]	Preservation
Lactobacillus brevis	*Saccharomyces cerevisiae*	Production of anti-fungal agents
Lactobacillus casei	*Candida milleri*	Flavor
Lactobacillus curvatus	*Candida humilis*	Reduced staling rate
Lactobacillus delbrueckii	*Issatchenkia orientalis*	Increased loaf volume
Lactobacillus fermentum		Lower glycemic index
Lactobacillus hilgardii		Increased gluten tolerance
Lactobacillus pentosus		Increased mineral availability
Lactobacillus plantarum		Improved texture
Lactobacillus pontis		
Lactobacillus panis		
Lactobacillus reuteri		
Lactobacillus sanfranciscensis		
Pediococcus acidilactici		

Table II.7. Microorganism isolated in sourdough and their functional advantages. (Hutkins, 2008)

At first, the main function of sourdough fermentation was to produce a more gaseous dough and therefore a more aerated bread. Nowadays, sourdough breads have gained popularity because it improves the flavor and the quality of the bread. (Chavan & Chavan, 2011) As reported in Table II.7, the most important benefit of sourdough fermentation is the enhancing of the preservation of the bread due to the low pH derived from the production of organic acids by LAB. Besides that, sourdough culture can help compensate the complication that belongs to the production of bread from rye flour. Rye is commonly used to produce bread but present several properties that can be challenging in the production of bread. First, it contains high concentration of pentosans (four to five more than in wheat) that may interfere with the gluten formation, producing a non-elastic dough that retain carbon dioxide in a poorly way. Secondly, rye proteins do not form a viscoelastic dough and therefore the bread will be less voluminous and denser. Finally, rye flour is richer in α-amylase compared to wheat flour and this results in an excessive starch hydrolysis and therefore an even worst volume and poor texture. Sourdough cultures can compensate for these complications. First, it decreases the pH, making pentosans more soluble and swelling and leading them to assume the gluten role to form a gluten-like network that improves gas retention and dough elasticity. Additionally, a low pH inactivates the α-amylase avoiding an excessive hydrolysis of starch, even dough sourdough microorganisms are stimulated by the availability of fermentable sugars derived from the action of α-amylase on starch therefore α-amylase activity become a positive aspect. Moreover, LAB can ferment pentoses released from pentosans in acetic acid. Finally, the acidic conditions that is create as a consequence of yeast and LAB activity promote the water-binding capacity of starch granules decreasing the bread staling. (Hutkins, 2008)

3.1.4 Wine

Culturally and economically, ethanol-containing beverages are the most important fermented food products as their consumption is globally associated with social practices such as entertainment, religions, customs, and rituals. Alcoholic products are enjoyed and produced on every continent and can be obtained by using different ingredients that contains fermentable carbohydrates such as potatoes, cereals, and fruit. Wine produced from grapes, in particular, is intimately linked with the Mediterranean area history and culture. (Tamang et al., 2020)

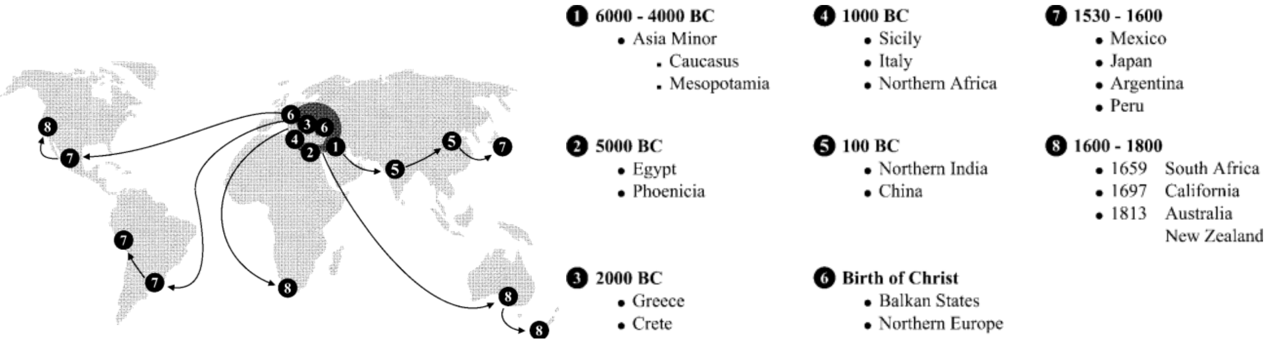

Figure II.7. The early spreading and world distribution of the vine and winemaking technology. (Pretorius, 2000)

Records report evidence of viticulture and winemaking through the history of human population are countless. Some of them and the world distribution of vine and winemaking technology are reported in Figure II.7. Images of wine and winemaking have been found on the walls of the older ancient caves discovered. In Asia, Middle East, and Far East records proves that it was common during the Neolithic period. Moreover, they prove that the production was in large-scale and with a high level of sophistication. This suggest that inhabitants of the regions dedicated years to the experimentation in vine cultivation and winemaking technology. (Cavalieri et al., 2003) Other findings of large-scale wine production come from Zagros Mountains and are dated to 5400 BCE. In support of the early cultivation of vine, chemical evidence of *Vitis vinifera* has been found in the Neolithic village of Shulaveris-Gora in Georgia dating back to the early sixth millennium BCE. Archeological evidence discovered in Iran date winemaking in the area around 6000 BCE. The sequencing of *Saccharomyces cerevisiae* DNA extracted from wine jars from Egypt indicate that Egyptians were using this yeast for wine fermentation in 3150 BCE. (Legras et al., 2007) Wine is mentioned more than 100 times in Bible where it is reported that Noah planted the very first vine. From these regions, winemaking spread to the Mediterranean basin. (Legras et al., 2007) In fact, Greek and Roman mythology is crowded of references to wine. Wine due to its analgesic, disinfectant, mind-altering, and preservative properties rapidly became the most common medicine and drug of antiquity.

(Cavalieri et al., 2003) Wine it is also the first fermented food that have been studied as the early microbiology and chemists were willing to understanding how the winemaking process worked even before the discovery of the existence of microorganisms. (Hutkins, 2008) Nowadays, it is considered one of the best examples of "value-adding" process as it dramatically increases the value of the grapes.

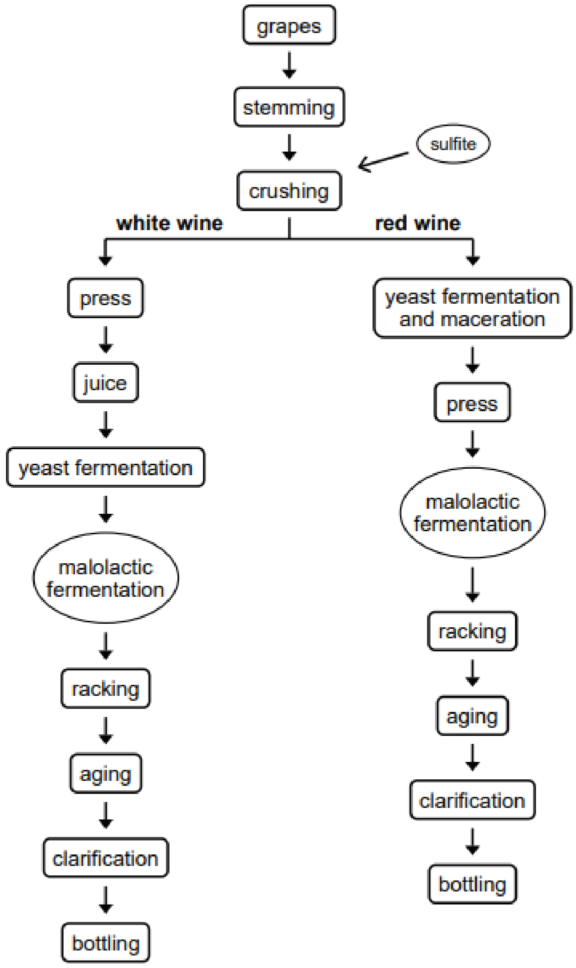

Figure II.8. Flow chart of wine manufacture. (Hutkins, 2008)

In Figure II.8 it is reported the general flow chart of wine making. Steps of the process can change based on the expected final characteristics and production region. The key aspect of the production of high-quality wine, however, always relies on the grapes itself and therefore on viticulture techniques. If the raw ingredient is not of excellent quality, it would be impossible to obtain an excellent final product therefore most wineries tend to put an extraordinary care in the growing of the grapes. Even if wine is widely consumed on every continent, the production of excellent wine is limited to the temperate climate's regions near the sea between the latitudes 40-50° in northern hemisphere of the equator and 30-40° south of the equator. (Bamforth & Cook, 2019) In these areas, it is hot or warm during the day, but it is cool during the night, there is no summer rain, and no to little risk of frost damage making them the ideal region to growing vine from the point of view of the climatic conditions. This is the reason why Italy, France, and Spain are the largest producers of wine and account for more than half of the global production. (Hutkins, 2008) Together with climate, soil nutrients, diseases, depth of the soil, vineyard management practices, moisture content, and ability of the soil to retain and drain water are other limiting parameters that influence the growth of vine. "Terroir" is a key concept when talking about high-quality wines. The "terroir" can be defined as a well-defined area, where the natural, physical, and chemical conditions, combined with the geographical area and the climate of the region, allow the production of a specific wine, identifiable through the unique characteristics of its territoriality. The interaction between multiple environmental and agronomic factors, such as soil nutrient composition, position and topography of the vineyard, climate, cultivar, watering conditions, sunlight exposure, vine density, training and pruning practices, farmers knowhow and consumers preferences create the high-quality of the wine. The unicity of the wine is linked to and derives from all the factor stated above and therefore it is impossible to replicate a particular wine in another region. (Hutkins, 2008)

Wine grapes all belong to the genus *Vitis* with *Vitis vinifera* as the most important and common specie. As reported in Table II.8, within the specie, there are several cultivars (Sauvignon, Cabernet, Mission, Gamay, Gewurztraminer, Sangiovese, Grenache, etc.) that can present different adaptation to climate or soil, different metabolism, pigmentation, and chemical composition making them able to grow at different conditions. (Hutkins, 2008) For example, 2-methoxy-3-isobutylpyrazine can be found in Cabernet Sauvignon, but in Lambrusca methyl anthranilate is more common, and damascenone in Chardonnay. Terpenes such as linalool and geraniol instead are characteristic of Muscats, while terpenols can be found in White Riesling. This chemical variability in grapes reflects on the variability of wine sensorial characteristics and helps shape the different wines. (Bamforth & Cook, 2019) Due to this the matching of grape cultivar, location, and wine type become fundamental. Additionally, of particular importance is also the time of harvesting because it is a determinant of sweetness/acid balance of grapes. Acidity in fact is gradually lost during the maturation of grapes due to the respiratory removal of malic acid. Therefore, harvesting time must be closely evaluate considering the expected wine characteristics.

Varietal	Comments
a) White cultivars	
Sauvignon Blanc	Bordeaux. Green pepper and herbaceous notes
Muscat	Italy. Raisin notes. Prone to oxidation, so often made into dessert wines
Chardonnay	Widespread use globally; use in champagne production. Wines have apple, melon, peach notes
Chenin Blanc	France. Apple, grass, honey
Gewurtztramminer	Cooler European regions. Lychee characters
Riesling	German. Rose and pine notes
Pinot Grigio	France. Citrus, pear
b) Red cultivars	
Cabernet Sauvignon	Bordeaux. Tannic. Blackcurrant, bell pepper, vanilla
Nebbiolo	Italy. Raspberry, cherry, mint, tobacco
Pinot noir	France. Beet, cherry, roses, plum
Grenache	Spain. Raspberry, spice.
Syrah	France. (n.b. Shiraz in Spain). Tannic, peppery aromas.
Merlot	France. Black cherry, plum, chocolate
Zinfandel	California (originally Croatia). Also used for light blush wines. Raspberry, spice, pepper, licorice

Table II.8. Some varieties of grape. (Bamforth & Cook, 2019)

After the harvest, the winemaking process in the winery start. Winemaking process is founded on the harmony between traditional manufacturing practices, biochemistry, and modern microbiology. Therefore, as Hutkins state in the book 'Microbiology and Technology of Fermented Foods', winemaking can be considered "an example of an ancient technology that has adopted twenty-first century science." It may look like a rather simple process because the steps are straightforward. Nevertheless, to produce a high-quality wine, there is a huge difference between the belief and the reality as each of the pre-fermentation, fermentation, and post-fermentation steps must be carefully followed. (Pretorius, 2000) The general steps are harvesting, grape processing (destemming, crushing, draining and pressing), fermentation, clarification, filtration, stabilization, ageing, and packaging. In this paper I will focus on the fermentation step.

After the pre-fermentation steps, the grape juice prior to fermentation contains water, fructose and glucose in equal quantities, organic acids such as tartaric acid, amino acids and ammonia, small amounts of vitamins, several phenolic compounds, and potassium. (Bamforth & Cook, 2019) This is the environment in which microorganism will be inoculated to carry on the fermentation. *Saccharomyces cerevisiae* is the main yeast exploited in the production of wine. Its main role is to converts simple sugars of grape juice into carbon dioxide, ethanol, and other metabolites without the production of off flavors. (Pretorius, 2000) In the production of red wines, grapes are fermented in presence of skins and seeds to allowing the maceration and consequently the extraction of tannins, phenolic compounds, and pigments from seeds and skin to give color and aroma to the wine. In the production of white wines, instead, skins and seeds are removed right before the fermentation as the color must be maintained clear. (Hutkins, 2008) Traditionally, the fermentation of grape juice was done in open barrels, but nowadays stainless-steel tanks are preferred because they are easier to sanitize and clean. To allow the fermentation, the mass temperature is adjusted based on the wine typology. To maintain unaltered the varietal aroma, the fermentation temperature of 10-15°C is preferred for white wines, whereas for red wines secondary and tertiary aromas are preferred so a temperature of 20-30°C is maintained. In all cases, fermentation is complete by 20-30 days and its progression is daily checked by the winemaker. (Pretorius, 2000) After the fermentation, yeasts are removed or maintained based on the final expected characteristics of the wine because the release of chemical substances from yeast will modify the flavor.

In some red wines, in addition to the yeast fermentation, a malolactic fermentation by native or added lactic acid bacteria such as *Leuconostoc* (heterofermentative), *Oenococcus* (heterofermentative), *Pediococcus* (homofermentative), and *Lactobacillus* is promoted. Chemically, a malolactic enzyme decarboxylates malic acid in lactic acid by using NAD and manganese. Usually this fermentation is done on acidic grapes that are grown in cooler climate because bacteria degrade malic acid in lactic acid causing an increase of the pH and a decrease of the total acidity. (Bamforth & Cook, 2019) It is instead considered a spoilage activity in low-acidic grapes because some acidity is desired in these wines. Moreover, malolactic fermentation can also promote flavor stability and balance, therefore it is promoted in wines that need a flavor adjustment. Finally, this fermentation produce diacetyl from citrate that can be desirable in some wines. (Hutkins, 2008)

Even if most wineries use starter culture as inoculum, some wineries produce natural wines from spontaneous fermentation. The outcome of a natural fermentation is difficult to predict as the population of microorganism on grapes skin is not consistent in every harvest. Moreover, during the evolution of the fermentation the variation of the juice or must conditions such as ethanol content, nutrients availability, high osmotic pressure, organic acid amount, sulfites addition, and carbon dioxide content can modify the dominant population. Initially, during a spontaneous fermentation, the genus *Saccharomyces* (the best one in converting sugars in ethanol) represent just 10% of all the yeast population as the dominant genus is *Kloeckera apiculate.* This genus produces up to 6% of ethanol from glucose and fructose but it has a low ethanol tolerance, therefore at 3-4% of ethanol it is inhibited and do not ferment anymore. As the concentration of ethanol increase, the *Kloeckera apiculata* population rapidly decrease and the more ethanol-tolerant *Saccharomyces* spp. arise. The amount of *Saccharomyces* spp, in particular of *Saccharomyces cerevisiae,* in the must cannot be predict, therefore a stuck in the fermentation is quite common in the natural fermentation of wine. (Pretorius, 2000) In Table II.9 are reported the advantages and disadvantages of both natural and starter culture-mediate fermentation.

Starter cultures	Natural
Cleaner flavor	More complex flavor
Greater consistency	Unique qualities
Faster	Slower
Low frequency of stuck fermentations	Greater frequency of stuck fermentations
Can customize strains	Cannot customize
Immune to killer yeasts	May be sensitive to killer yeasts

Table II.9. Starter cultures versus natural fermentation for wine-making. (Hutkins, 2008)

3.1.5 Vinegar

The origin of vinegar is intimately bonded to the development of winemaking techniques. The first vinegar, in fact, derived from the spontaneous souring of fresh produced wine, as the name *vin aigre* in French can suggest. Vinegar at first was considered an unpalatable sour liquid derived from a spoilage mechanism that could not be drunk and was decreasing the value of wine. In reality, it has some crucial characteristics that make it one of the most used fermented foods in the world whether as food or medicine. Vinegar can be produced from different alcohol rich substrates such as wine, beer, cider, other alcohols derived from whey, potatoes, molasses, honey, fruit, and grains. (Bamforth & Cook, 2019) Traditionally, vinegar have been mainly used for its ability to preserve perishable non-fermented foods namely vegetables and meats. Other roles as a food are the direct consumption in a diluted form and the usage as a flavoring agent or acidulent. Moreover, vinegar has been used as a cleaning agent and topical disinfectant due to its anti-microbial activity, and as a demineralizing agent. (Tamang et al., 2020)

The first record of the consumption of vinegar is in the New Testament Bible where it was given to Jesus during the crucifixion. For Greek and Romans, drinking diluted vinegar was a custom linked to its therapeutic effect. (Hutkins, 2008) Hippocrates understood the medical value of this product that have been used both as internal and as topical treatment also through all the Middle Ages. (Bamforth & Cook, 2019) Nowadays, vinegar is commonly used in food industry in several processed foods such as mayonnaise, bakery products, canned foods, salad dressing, pickled foods, marinades, etc. and in almost every cuisine around the world. (Hutkins, 2008)

For this production, a mix of different species and genera belonging to acetic acid bacteria are used as started culture or as wild cultures. *Acetobacter, Gluconobacter, Gluconoacetobacter,* and *Acidomonas* are the four genera that represent the acetic acid bacteria. They are gram negative, can be motile or non-motile, have an ellipsoidal shape that can be single or in chain, and they are obligate aerobes. Species belonging to *Acetobacter, Gluconobacter,* and *Gluconoacetobacter* are responsible of the production of vinegar, mainly *Acetobacter aceti, Acetobacter pasteurianus, Gluconacetobacter xylinus, Gluconobacter oxydans,* and *Gluconoacetobacter europaeus*. Every species and/or strain will have a different ability in converting ethanol in acetic acid and will have distinct biochemical and physiological properties that will lead to quantitative and qualitative variation in taste, flavor, texture, etc. As for wine, choosing the right strain is a key point to produce the expected product characteristics. (Hutkins, 2008)

The production of vinegar consists in two separated processes. (Bamforth & Cook, 2019) The first step is performed by yeast and is an alcoholic fermentation in anaerobic conditions that produce the substrate needed in the second step: an ethanolic substrate. These ethanolic substrates do not need to be of the highest quality because an oxidation will later further modify them, but at the same time vinegar flavor and aroma will derive from the starting material so a poorly made wine will lead to a flavor-lacking vinegar. The second step is an aerobic acetogenic fermentation and it is carried out by acetic acid bacteria that convert ethanol in acetic acid through oxidation. This oxidation is defined as an incomplete oxidation because the organic substrate (ethanol in this case) is not totally oxidized in water and carbon dioxide but only up to acetic acid. The presence of oxygen is a critical point as the oxidation of ethanol in acetic acid is possible just in presence of oxygen. Therefore, it is important to allow air or oxygen to enter the fermentation system in high quantities after the yeast fermentation. (Hutkins, 2008) The acetogenic fermentation is paired with secondary fermentation that are important for the aromatic profile of vinegar and produce mainly ethyl acetate, acetaldehyde, other esters, and higher alcohols. (Bamforth & Cook, 2019)

- *Balsamic vinegar*

A gourmet version of the table vinegar is the balsamic vinegar produced in Modena and protected with the PDO as Aceto Balsamico Tradizionale di Modena DOP. It is a popular and pricey balsamic vinegar that can costs more than 150€ for a bottle of 90 milliliters. This vinegar embodies several peculiar characteristics that explain its popularity and high price. First, the organoleptic characteristics are elaborated and distinctive as it has a strong and complex aroma, a sour and sweet flavor, and a dark brown color. These characteristics derived from the second key point that is the production method. The production method is very different from the traditional ones and consists of a sequence of steps that requires a lot of time. The substrate used for the fermentation is musts obtained from specific grapes varieties namely Trebbiano, Lambrusco, and Sauvignon. Musts are then concentrated two-fold to obtain a syrup-like texture. This step is done by raising the temperature of the musts to near boiling followed by a long simmering that can take as long as two to three days. The final syrup-like solution must contain between 20% and 24% of sugar and it is the substrate to which the inoculum will be inoculated. The inoculum is called ‘mother culture’ and comes from a previous batch. It is a wild culture that contains various osmophilic yeasts, mainly *Saccharomyces* and *Zygosaccharomyces*, and acetic acid bacteria *Gluconobacter*. After the addition of the ‘mother culture’, the mixture is transferred in premium quality wooden barrels where nearly at the same time an alcoholic fermentation and an acetic acid fermentation occur. Finally, the last distinctive trait of the production of balsamic vinegar is the aging period. Aging is carried on in sets of five or seven barrels made from different woods and present several peculiar steps illustrated in Figure II.9. The product is periodically transferred from barrel to barrel via decantation, but just about half of the volume from the previous barrel is moved to the next one. Barrels are usually located in places that are exposed both to very cool temperatures and very warm temperatures as cool temperatures promote the sedimentation and thus the clarity of the product, whereas warm temperatures stimulate fermentation. Going back to enrich the first key point, the rich aromatic characteristics of balsamic vinegar are derived from the specific grape constituents, the volatile and non-volatile compounds that come from the extraction from different types of barrel’s wood, and microorganism metabolism namely esters and acids. Aging period is very long as to achieve the Protected Designation of Origin (PDO) the vinegar must be aged for at least twelve years. Some balsamic vinegar reaches twenty-five to fifty years of aging. Moreover, just around 12,000 liters of authentic balsamic vinegar Aceto Balsamico Tradizionale di Modena DOP enter the market per year. All the detail about the production reported above are adapted from the product specifications (disciplinare di produzione) of Aceto Balsamico Tradizionale di Modena DOP.

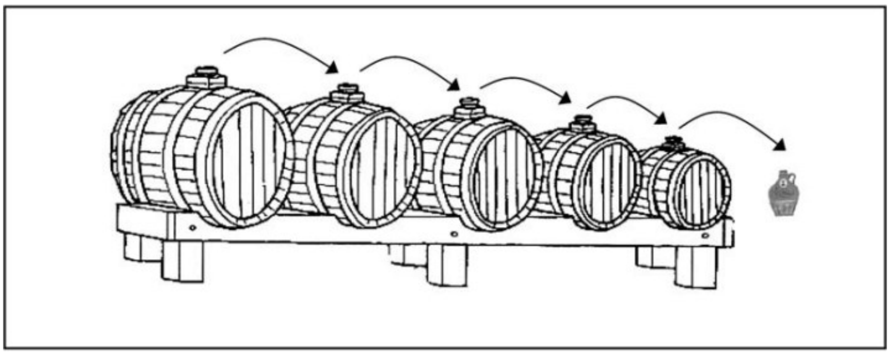

Figure II.9. Sequential barrel formation used during manufacture and aging of balsamic vinegar. (Hutkins, 2008)

3.2 Korean Fermented Foods

Although Western and Eastern fermented foods share some characteristics, such as the enhanced functional properties, use of local products, and preservation means, how the fermentation is carried on and what main ingredients are fermented dramatically differ. (‘Fermentation of Foods in the Orient’, 2006) Fermented foods that evolved in Asia are often based on grains or rice, vegetables, fish, and soybeans. In fact, in Asian countries like Korea, in contrast with Western countries, animal agriculture was limited, therefore fermented dairy products are not common like they are in the Mediterranean area. (Tamang et al., 2020) On the contrary, vegetables and fish were common and needed a preservation technique that allowed the consumption of them during the harsh wintertime.

Moreover, fermentation substrate in Western countries usually consists in simple sugar whereas in Korea starch and polysaccharides are mainly used. Finally, for the most part Western fermentation use anaerobic condition and starter culture, while Asian fermentation relies on aerobic fermentation carried on by microorganisms naturally presents on the ingredients. ('Fermentation of Foods in the Orient', 2006)

Fermentation was used as a preservation method for vegetables since the tribal Kingdom period (1st century BC - 7 century AD) as reports from the Goryeo dynasty proves. Besides its preservative role, fermentation is also used to enrich the aroma profile of fish and vegetables providing new savory, sour, and sweet flavors to boiled rice that is consumed as staple food in all Korean dishes but has no particular taste. (D. H. Shin, 2011) Through the years, fermented foods became so popular that nowadays it is very difficult to find a Korean dish that, directly or indirectly, do not use a fermentation technique. It can be argued that fermented food represent the uniqueness of Korean foods and that Korean food culture is based on fermented foods. (D. H. Shin, 2011)

3.2.1 Soybean sauces (Jang)

Soybeans are the primary legumes used to produce fermented foods in Asian countries. Their origin is believed to be between Manchuria and Korean peninsula where the ancient Dongyi tribes were living. Even at present time several wild species of soybeans can be found in this area. Archeological findings estimate that the cultivation of soybeans started about 4,000 years ago. In different historic sites in the Korean Peninsula carbonized soybeans dated to the Bronze Age were found. (D. H. Shin, 2011)

Several varieties of soybeans are cultivated in Korea and classified based on the purpose. In fact, soybeans are widely used in the Korean cuisine in several preparation. They are used to produce fermented sauces and paste but also as sprouts, boiled with rice, used to produce tofu, soymilk, oil, or rice cakes. Among these, 43 varieties are used to produce fermented sauces and pastes. (D. H. Shin, 2011) Soybeans and fish are the two main protein sources of the Korean diet. Soybeans, in fact, contain 30-50% of protein, of which about 63 ~90% are glycinin, including globulin, and about 17% are phaseolin and legumelin. These are water insoluble proteins that dissolved in a salt solution do not represent a specific taste. However, if fermented the obtained amino acids and peptides have a characteristic savory taste that make them perfect for the seasoning of foods. (D. Shin & Jeong, 2015)

Koreans mastered the process of fermenting soybeans since ancient times driven by the necessity to preserve soybeans for longer time. For this purpose, Koreans developed a variety of sauces and pastes that could be eaten later and can be used for enhancing the flavor of boiled rice. (Tamang et al., 2020) Nowadays fermented soybeans sauces and pastes are required by almost all Korean food and are the basis for create the flavor of two of the main Korean dishes: kuk and chigae . (H.-K. Chung et al., 2016) Soybeans fermentation can be divided into three general category that consists of those fermented by filamentous fungi, those fermented by yeasts, and the ones fermented by lactic acid bacteria. In Korea, usually soybeans are fermented by a mixture of fungi and lactic acid bacteria, mainly *Bacillus sp*. (Tamang et al., 2020)

Fermented soybeans products are numerous. The most common are graphically described in Figure II.10 and in the next sections.

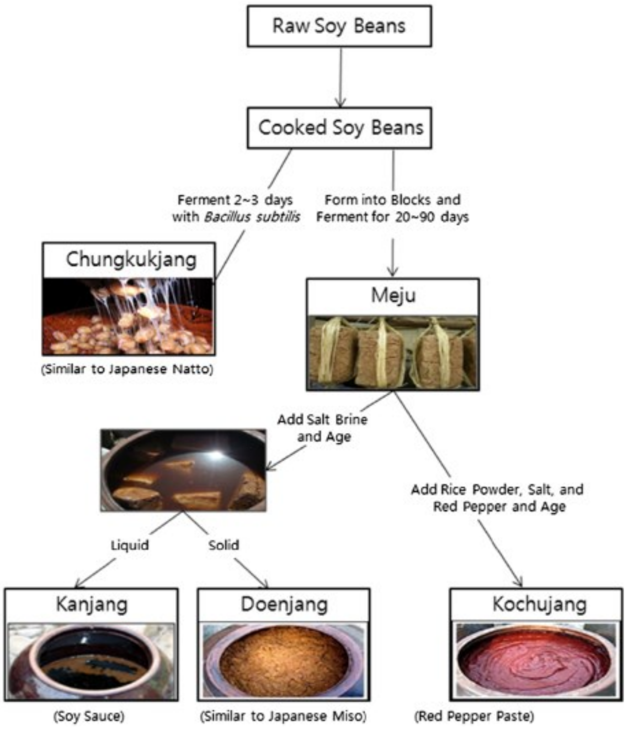

Figure II.10. The preparation of Korean fermented products from soybeans. (D. Shin & Jeong, 2015)

3.2.1.1 Gangjang (soy sauce)

An old Korean saying state that we should “use the Gangjang made when the mother was pregnant with a child for the child's wedding”. It is in fact believed that the older the Gangjang the better the taste and the aroma. The world best Gangjang have been aged for more than 60 years and is dark black and solid. (H.-K. Chung et al., 2016) Gangjang main ingredients are peptides, amino acids, alcohol, and carbohydrates.

Gangjang can be further classified as traditional soy sauce and improved soy sauce (commercial soy sauce) based on the production process.

To produce traditional soybean sauce, housewives prepare a fermented soybean lump called meju that is handed down to following generations. To produce meju, soybeans are carefully washed then boiled with water for 3-4 hours until they are fully cooked but not overcooked. Cooked soybeans are mashed and shaped by hands in a cubic form (15x15x20 centimeters) to be fermented for 4-5 days at room temperature until the surface is dry. Then the fermentation goes on for additional 1-2 months at 25-30°C. The ammino acids produced during fermentation react with saccharides already present in soybeans and produce malanoidine that is a brown substance that gives the distinctive color to Gangjang. During the maturation, meju is slowly dried and bacteria and molds naturally arise to ferment. Maturation and fermentation go on simultaneously through winter. To produce Gangjang, meju is soaked in brine (18-19Be') by following the ration meju:salt:water of 1:1:3. To prevent the production of germs and bad smells, red peppers and charcoal are added to the brine. The soaking period last for about 60-80 days in a sunny place covered with a lid that occasionally is open for letting the sun light enter the jar. Finally, after 2-3 months meju is removed from the brine using a filtering patch or mesh. The liquid part will become Gangjang, the solid part will become Doenjang. (D. H. Shin, 2011)

3.2.1.2 Doenjang (fermented soybean paste)

Similarly to Gangjang, Doenjang is further classified into traditional soybean paste and improved soybean paste (commercial soybean paste). To produce the traditional doenjang, after the separation of the liquid and the solid part by the above-mentioned process, the solid part is mixed with meju flours, soybean sauce, and rice or barley according to family preferences. This mixture is then sorted in jar or pottery and aged for 3-6 months. (D. H. Shin, 2011)

As seen, fermentation in traditional process use a spontaneous fermentation that is barely controlled. On the contrary, to produce the improved Gangjang and Doenjang, bacteria and fermentation are fully controlled. Usually in industrial method, *Aspergillus oryzae* is used to carry on the fermentation. (D. Shin & Jeong, 2015)

3.2.1.3 Gochujang (fermented red pepper soybean paste)

Likewise Gangjang and Doenjang, Gochujang is additionally classified in traditional red pepper soybean paste and improved red pepper soybean paste (commercial red pepper soybean paste). Moreover, the process that allows the production of this fermented red pepper soybean paste is similar to the above-described ones but in this case a different meju is used. For the traditional process, the first step is the meju preparation. Soybeans are mixed with grains, usually rice, with a ratio of 6:4 soybeans to rice. The mixture is cooked and then mashed. The mashed mixture is then shaped as a donut shape and is fermented by molds and bacteria for 2-3 months. The fermentation of Gochujang meju is carried on mainly by *Aspergillus* and *Bacillus subtilis* that through protease and amylase create the peculiar taste. After this period, mejus are dried and powdered for storing.

Next, Gochujang powder is mixed with red pepper flours, digested rice syrup, and Gangjang to create the paste that go through fermentation for 3-6 months. Since Gochujang uses a variety of ingredients, the microorganism that carry on the fermentation are more complex compared to the ones used to produce Gangjang and Doenjang. Moreover, Gochujang contain capsaicin derived from red pepper addition, making this paste even important from the health point of view than the other fermented products. (D. Shin & Jeong, 2015) Another Gochujang peculiarity relies on the taste. In fact, Gochujang taste is a mixture between a spicy taste caused by the red pepper, a savory taste due to amino acids, nucleic acids, and peptides formed due to fermentation, a sweet taste created by sugars derived from starch hydrolysis, and a salty taste caused by the addition on salt.

3.2.1.4 Cheonggukjang (fermented soybean paste by Bacillus)

Cheonggukjang is the fermented product that need the lower amount of fermenting time as 2-4 days are enough because it is fermented at high temperatures. (D. Shin & Jeong, 2015)

The first step in the production of Cheonggukjang is the soaking of soybeans in water. The soaking period length varies based on the season: 24-30 hours in winter at 0-5°C, 16-24 hours in spring and fall at 10-16°C, and 10-16 hours in summer at 18-25°C. Soaked soybeans are then cooked for 5-6 hours until soybeans are completely cooked but not overcooked. The mass is then moved to jars where the fermentation will take place and carried on for 30-35 hours at 40-45°C. In this case, meju is not produced as boiled soybeans are directly fermented. Microorganisms involved in the fermentation are thermophilic bacteria as the fermentation of Cheonggukjang happen at high temperatures. The result will be a sticky and viscous material, made of glutamate and fructose, that produce a unique smell. The main specie used is *Bacillus sp*. that produces trimethyl pyrazin and tetra methyl pyrazin that, combined with 3-methyl-1-butanol already present in soybeans, produce the peculiar smell. The fermented mass is finally mashed and seasoned with salt and garlic. (D. H. Shin, 2011)

3.2.2 Vegetables (kimchi)

As an old Korean saying goes ‘kimchi is half of the food provision’. This saying summarizes the importance kimchi holds for Koreans. In fact, Kimchi is considered a staple food that accompanies and enrich every meal and without which the meal will not be considered complete. It also embodies a leading principle of Korean food: the aesthetic of mixing. In fact, it is made through the spontaneous fermentation of vegetable such as cabbage, radish, spring onions, etc. mixed with several seasonings among which jeotgal, salt, and Korean red pepper are the most important. (H.-K. Chung et al., 2016) As other fermentation techniques, the development of kimchi derived from a preservation need as vegetables contain a lot of water and therefore, they were difficult to store over long winters.

One of the first record, reports that kimchi was a favorite food in Korea during the tribal Kingdom Period (?-7 AD). During the Goryeo kingdom (37 BC–668 AD) a variety of vegetables such as leek, cucumber, bamboo shoot, eggplant, dropwort, and radish were used to produce kimchi. Findings dated back to the Joseon dynasty (1392 AD - 1897 AD) indicate that during that period 150 varieties of kimchi were already present. Moreover, some records dated before the seventeenth century state that kimchi was a 'golden-yellow vegetable' because it was seasoned with garlic, Chinese peppercorns, and ginger as chili peppers was not yet introduced in the Korean peninsula. (Pettid, 2008)

Nowadays, more than two hundred types of kimchi are known. Several elements contributed to the development of hundreds of different types of kimchi. First, approximately all vegetables and wild vegetables that distinguish the Korean diet are used to make kimchi. Therefore, a huge variability derives from the regional availability of vegetables. (H.-K. Chung et al., 2016) Second, seasoning ingredients can vary both in typology and amount based on the local availability. The most common seasoning includes salt, seafood, chili powder, and jeotgal (fermented fish). Finally, climatic conditions influence the ingredients used to produce kimchi and the taste. For example, kimchi produced in the northern regions is less salty and spicy that the one produced in the south. Moreover, the fermenting and flavoring agents in the northern regions are usually shrimp and yellow corvine jeot, whereas on the south anchovy jeot is preferred. (Pettid, 2008)

The fermentation is a lactic acid fermentation carried on by LAB, mainly *Lactobacillus* spp*.,* *Leuconostoc* spp*.,* *Pediococcus* spp., and *Weissella* spp. The production of lactic acid and acetic acid lowers the pH protecting the substrate (kimchi) from spoilage microorganisms. Moreover, secondary metabolisms of LAB forms bioactive compounds, namely antioxidants and peptides. (Patra et al., 2016) The addition of Korean red pepper to kimchi not only enriches its flavor and taste but also inhibits the growth of spoilage microorganisms. This entail the possibility to use less salt (usually used to decrease the water activity) and increase the shelf-life of the product. (H.-K. Chung et al., 2016)

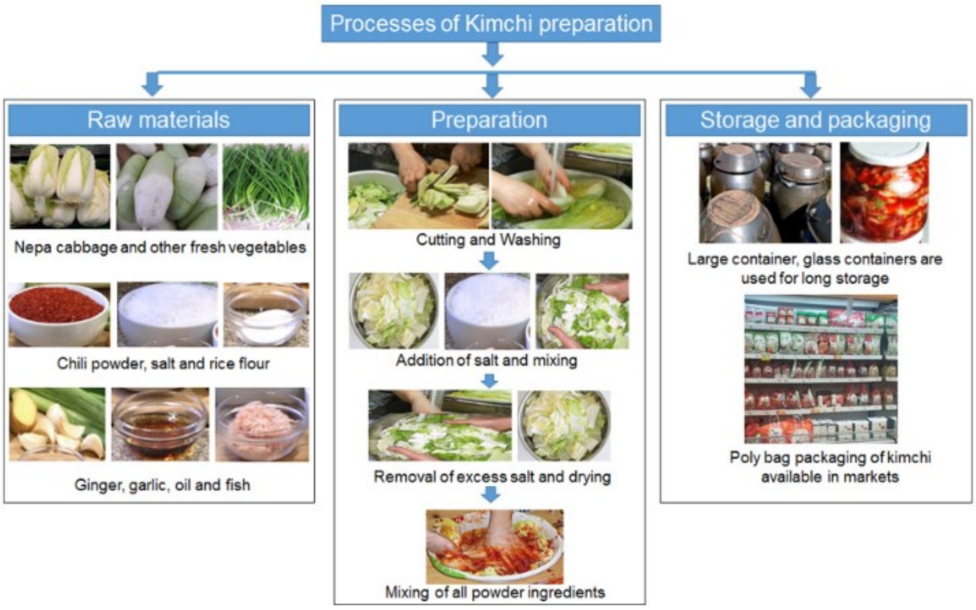

Figure II.11. A schematic representation of the traditional process for kimchi preparation. (Patra et al., 2016)

Traditionally, kimchi is prepared in late autumn after the harvest of vegetables in a process called kimjang as illustrated in Figure II.11, and then stored and consumed through all winter months. (Surya & Lee, 2022) As several kimchi exist, several are the recipes to produce them. The raw materials are classified in four groups: main raw materials, spices, seasonings, and additional materials. Chinese cabbage is the major ingredients, but, as said before, a lot of different vegetables can be used. The spices commonly used are cinnamon, red pepper, black pepper, ginger, mustard, garlic, and onion. For seasonings, usually salt, jeotgal, sesame seed, soybean sauces, and corn syrup are used. Finally the additional materials group gather the most different ingredients such as mushrooms, vegetables, fruits, seafood, cereals, meat, and many more based on local variability. (Patra et al., 2016) Some of these recipes are briefly described below.

Figure II.12 explains briefly the steps needed to prepare the most common kimchi, Chinese cabbage kimchi. Chinese cabbage is soaked in brine for ten to twelve hours while seasoning ingredients, namely ginger, sliced radish, mustard leaf, garlic, salt, green onion, jeot, and chili pepper powder, are prepared. Every household inherit from the womenfolk a different recipe that can contain variations on the ingredients such as the addition of oyster, shrimp, shiitake mushroom, or raw fish. After ten to twelve hours, the cabbage is washed in water and drained before coating it manually with the seasoning. The cabbage is then placed in earthenware jars for the fermentation that must be carried on at a temperature of 5°C. Traditionally, earthenware jars were buried to the neck in the ground, but nowadays special refrigerator are used. (‘Fermented Vegetables’, 2006)

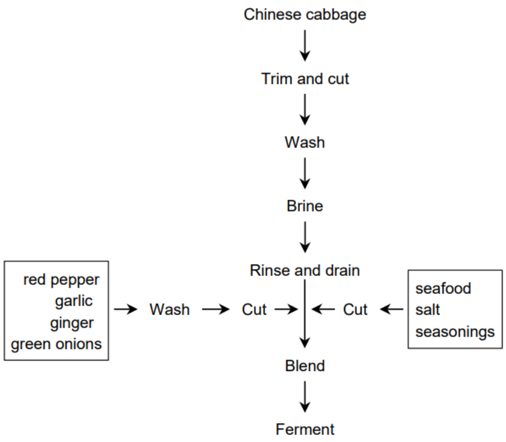

Figure II.12. Chinese Cabbage Kimchi flow chart. ('Fermented Vegetables', 2006)

Kkakdugi is made from daikon. The radish is cut in small cubes and then salted, fermented, and seasoned with shrimp jeot, ginger, green onion, garlic, and chili pepper powder. Some kimchi like Posam kimchi were reserved for the Royal Table and made with salted cabbaged that before fermentation was sliced into portion of four centimeters and wrapped around various seasonings. Pa kimchi instead is made with green onions or scallions fermented in anchovy jeot, while Chonggak kimchi is made with radish seasoned with ginger, chili pepper powder, and garlic. (Pettid, 2008)

3.2.3 Fish and seafood (jeotgal)

Fish fermentation is a traditional technology widely used in the Korean peninsula. The origin of jeotgal in Korea dates to the Goryeo kingdom (37 BC–668 AD) as the Chinese character for jeotgal is present in the Cheminyosul written by Ka in CE 532 and refers to a fish food product preserved salted and wrapped in lotus leaves. Other literary works mention jeotgal as part of the royal life during Silla kingdom (57 BCE – 935 CE) where it is specified that the Korean fermented fish products were different from the ones that could be found in China at that time. Jeotgal continues to be mentioned in numerous writings belonging also to the next dynasty, Joseon dynasty (1392 AD - 1897 AD) where it was offered during ancestral rites or ceremonies accompanied by kimchi. From the seventeenth century, books containing jeotgal recipes were published also for common people. The jeotgal consumed in royal palace historically was made both with fish and meat, as the meat consumption was reserved for the royal family. (Koo et al., 2016) For common people, instead, jeotgal was mainly produced with fish and was the main protein source together with soybeans. Currently, jeotgal refer only to fermented fish products. (Koo et al., 2016) The origin of fish fermentation lies on the positive spoilage of salted fish. Ancient populations were used to preserve fish by immediately salting it after the catch. Salt decreases water activity and therefore protects against spoilage microorganism and pathogens. Nevertheless, some beneficial microorganisms were still able to grow and ferment in the fish without leading to health issues. (Koo et al., 2016) Jeotgal is the product of a spontaneous fermentation carried on by halophilic or halotolerant microorganism coming from the environment where jeotgal is produced and from the ingredients used to produce it. Microbial communities are complex, as reported in in Table II.10, and differ because ingredients and fermentation techniques may vary. All microorganism have yet to be isolated but the most common are *Bacillus, Lactobacillus, Brevibacterium, Pediococcus, Micrococcus, Pseudomonas, Leuconostoc,* and *Halobacterium*. (Koo et al., 2016) Usually, there is a high prevalence of lactic acid bacteria that increase the probiotic potential of jeotgal. Moreover, it is a high sodium environment that inhibit the growth of most of spoilage and pathogen microorganisms. During the fermentation, proteins, lipids, carbohydrates, and organic acids are broken down into volatile and non-volatile aroma compounds that enhance the flavor and makes jeotgal one of the best seasonings in Korea. (Koo et al., 2016)

Jeotgal is an umbrella term that is used to refer to whole fermented fish, fish sauce, and fish paste. It can be made with a variety of fish and seafoods, by using the whole meat and/or internal organs, and it is commonly used as side-dishes or flavor-enhancing seasoning as a substitute of salt or soy sauce. (Tamang et al., 2020) In particular, it is a fundamental ingredient when making kimchi as it is used both as a fermenting and a flavoring agent. Moreover, fermented fish sauce is used as a dipping sauce for broiled pig's feet and blood/noodle sausage.

The modern classification of jeotgal divides more than 150 types of jeotgal by following three different features: main ingredients, processing methods (seasonings), and region.

Type of main ingredients	Food products (main ingredients)
Whole fish & shellfish	
Fish	Order Clupeiformes: *myeolchijeot* (anchovy), *baendaengijeot* (herring), *jeoneojeot* (gizzard shad), *jeongeorijeot* (sardine), *junchijeot* (Chinese herring), *euneojeot* (*Coilia nasus*), *yeobsakjeot* (gizzard shad), *duiporijeot* (herring) Order Perciformes: *kalchijeot* (cutlass fish), *chokijeot* (croaker), *whangseokeojeot* (yellow corvina), *godeungeo jeot* (mackerel), *kanari jeot* (sand eel), *mineo jeot* (croacker), *nungsungeo jeot* (convict grouper), *domi jeot* (sea bream), *maegari jeot* (horse mackerel), *byungeo jeot* (pomfret) Others: *bollackjeot* (rockfish), *kajamijeot* (flatfish), *kongchi jeot* (saury), *taegu jeot* (cod), *baemjangeo jeot* (eel), *dongtae jeot* (frozen pollock), *bangeo jeot* (icefish)
Crustaceans	Shrimps: *saeujeot* (small shrimp), *gonjangijjeot* (mysidacea), *kaetgajae jeot* (squilla), *daeha jeot* (jumbo shrimp) Crabs: *tulge jeot* (hairy crab), *bangke jeot* (3-spined shore crab), *kotge jang* (blue crab), *dolge jang* (stone crab), *chamge jeot* (Chinese mitten crab)
Mollusks	Class Cephalopoda: *ojingeojeot* (squid), *koltukijeot* (small squid), *nakji jeot* (small octopus), *hanchi jeot* (cuttlefish) Class Bivalvia: *kuljeot* (oyster), *eorikul jeot* (oyster with hot pepper), *bajirak jeot* (clam), *dongjuk jeot* (surf clam), *daehap jeot* (clam), *matjeot* (razor clam), *moshijogae jeot* (short-necked clam), *baekhap jeot* (large clam), *pijogae jeot* (ark clam), *honghap jeot* (mussel) Others: *obunjaki jeot* (supertexta), *sora jeot* (conch)
Internal parts of seafood	
Gills (*agami*)	*Taegu-agami jeot* (cod), *mineo-agami jeot* (croaker), *myeongtae-agami jeot* (pollack), *jogi-agami jeot* (yellow corvina)
Intestine	*Chang-nan jeot* (pollack), *haesam-changja jeot* (sea cucumber), *kodeungeo-changja jeot* (mackerel), *kalchi-sok jeot* (cutlass fish), *chuneobam jeot* (gizzard shad), *jogi-sok jeot* (yellow corvina), *chunboknae-jang jeot* (abalone), *baemjangeo-chang jeot* (eel)
Roe (*al*)	*Myeong-ran jeot* (pollack), *gealjeot* (crab), *godeungeo-al jeot* (mackerel), *taegu-al jeot* (cod), *saeu-al jeot* (small shrimp), *sungke-al jeot* (sea urchin), *sungeo-al jeot* (mullet), *yuneo-al jeot* (salmon)

Table II.10. Classification of jeotgal by main ingredients. (Koo et al., 2016)

The classification by main ingredients divides jeotgal in:

- Whole fish

To produce jeotgal, any fresh fish, mollusks, or crustaceans can be use whole. Each jeotgal thus produced will be named after the main fish ingredient followed by jeot. The most common whole fish jeotgal in Korea are myeolchi-jeot, produced from anchovy, and saeujeot, made from shrimps. Anchovies are grown in the south coast of Korea and harvested in spring or autumn. Fishes are previously washed and drained, then layered alternately with 20-30% w/w refined salt. The fermentation last 2-3 months based on the temperature and the salt concentration. Myeolchi-jeot is one of the most important seasoning ingredients of kimchi. For the latter one instead, shrimps are catch from the Yellow Sea, in the west and southwest coasts, and washed with sea water. Then shrimps are salted with a higher concentration of salt compared with anchovy jeotgal due to the presence of shells, 35-40% in summer and 30% in winter. Moreover, the fermentation is longer, 4-5 months, at a constant temperature of 13-20°C. Saeujeot is the most common substitute of salt in the Korean cuisine, and it is usually appreciated as a dipping sauce while eating meat products because it eases the digestion. (Koo et al., 2016)

- Other parts or intestines

Gills, intestines, and roe can be used to produce jeotgal, but some different rules must be followed. For example, the infusion of salt into gills is slower that in whole fish, therefore 15-20% of refined salt must be used and the fermentation must be carried on for up to 3 months. Additionally, when removing roe and intestines, it is important to remove the whole part without any cut in order to provide the right texture and flavor.

The classification by processing methods is reported in Table II.11 and divides jeotgal in:

- Basic jeotgal

The most traditional jeotgal are prepared by simply adding salt and letting them ferment for a certain period that varies based on the main fish ingredient. During the development of the Korean civilization, however, other seasoning ingredients have been used in addition to salt.

- Seasoned jeotgal

Nowadays jeotgal is seasoned with a variety of ingredients among which the most common are red peppers, soy sauce, malted rice, spices, and cooked grains. The amount and type of seasonings vary based on expected taste but also based on the main ingredient characteristics. For example, oysters that contain a lot of glycogen are easy to ferment, therefore only 10% of salt is needed and only 1 week of fermentation is required. Most mollusks, including octopuses and squids, are instead processed by removing bones and internal organs and then seasoned with garlic, ginger, red pepper, syrup, and other varieties of seasoning to reach the unique chewy texture that characterizes this jeotgal.

Type	Main ingredients	Spices
Jeotgal	Fish, shellfish, intestine	Salt
Seasoned *jeotgal*	Fish, shellfish, intestine	Salt, seasoning (hot pepper, garlic, ginger, green onions)
Aekjeot	Fish, crustaceans, residual products	Salt
Sikhae	Fish, mollusks, roe	Salt, cooked grains, seasoning, malt, radish

Table II.11. Classification of jeotgal by processing methods. (Koo et al., 2016)

A particular example of jeotgal is hongeo. Hongeo is a special jeotgal that it is produced from skate, and it is considered as a main dish rather than a side-dish or a seasoning agent. Skate in fact is a highly nutritional fish that have low fat content, high protein, aspartic acid (9.59%), glutamic acid (14.7%) and essential fatty acid such as linolenic acid, linoleic acid, and arachidonic acid (22.8%). It also contains 100 times more urea that humans. During fermentation, urea is converted in ammonia to control the osmotic pressure, and this high ammonia content gives hongeo its characteristic taste and a pungent odor.

Other peculiar jeotgal are aekjeot and sikhae. Aekjeot is a fermented fish sauce that can be done by using any kind of fish or seafood, whole or just some parts of them. It is produced by following the processing techniques used to produce jeotgal, but the fermentation period is longer and reach 6-7 months, so the final product is more liquid. Sikhae instead is a cured fermented fish that is produce by adding cooked grains to the salting/seasoning mixture before fermentation. Different grains can be used such as rice, flour, millet, glutinous rice. As the main ingredient for sikhae it is possible to use fresh fish or directly jeotgal. (Koo et al., 2016)

III. Methodology.

To write this thesis, an electronic literature search was conducted using different online databases and journals such as among other Embase, Medline, Scopus, Google Scholar, Frontiers, MDPI Journals, Korea Science, Wiley Online Library, PubMed, CNR Clinical Nutrition Research, Food and Nutrition Journal, Mary Ann Liebert, Inc. Database, Springer Link, DBpia database, European Journal of Clinical Research, Microbiology and Biotechnology Letters (MBL), Journal of Dairy Science and Biotechnology, ScienceDirect, Journal of the Korean Society of Food Science and Nutrition, J-STAGE, Nutrition Research and Practice, BioMed, and Nature.

To complete the research books such as 'Microbiology and Technology of Fermented Foods', 'Food, Fermentation, and Micro-organisms', 'Applications of Biotechnology to Fermented Foods: Report of an Ad Hoc Panel of the Board on Science and Technology for International Development', 'Microbiology of Fermented Foods and Beverages', 'How Fermented Foods Feed a Healthy Gut Microbiota: A Nutrition Continuum', 'Korean Cuisine: An Illustrated History', and 'Soybean and Nutrition' have been used (see References).

During the research on the health benefits of Korean fermented foods, the range of publications years 2000-2023 was considered.

IV. Results and Discussion.

Korean ancestors mastered the fermentation technique to create more tasteful foods that were easier to preserve for a long time but also exploited them to treat several illnesses. The use of fermented food as a medical remedy, in fact, dates to the development of fermentation in Korea, at least 5000 years ago, as it is reported in several historical records. Ancient Korean populations were unaware of the chemical, biochemical, and microbiological activity connecting fermentation with its health benefits. However, recent scientifical reports agreed with the ancient reports exposing the chemical patterns behind the health benefits of Korean fermented foods. These health benefits arise from the synergy between raw material characteristics, the bioactive substances produced during fermentation, and the beneficial microorganisms in the final product. Microorganisms used during fermentation, in fact, not only decompose or synthesize new substances that are absorbed and exploited by human bodies but also act as probiotics after entering the human body. A schematic view of the fermentation process and its products is reported in Figure IV.1.

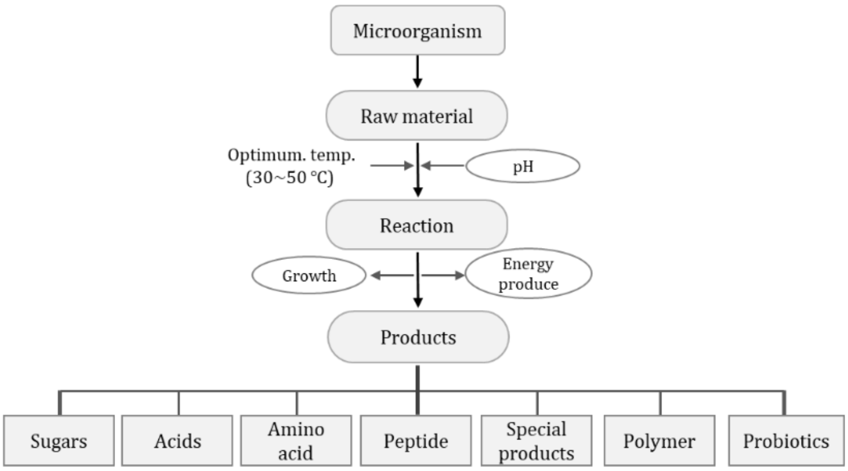

Figure IV.1. General fermentation process and its products. (S.-J. Jung et al., 2022)

Korean fermented foods are claimed to be very beneficial due to their nutritional and health-beneficial properties. These claims have been consistently supported by both preclinical and clinical research as it will be described in the next section. In summary, Korean fermented foods can be used to reduce and prevent chronic metabolic diseases by acting on the mechanism behind memory degeneration, obesity, high blood pressure, diabetes, and immune regulation, and they reduce the risk of cardiovascular diseases. (S.-J. Jung et al., 2022) In particular, a total of 149 studies from 1995 to 2017 confirmed the health effects of kimchi and kimchi-derived lactic acid bacteria, namely anti-mutagenic, antioxidant, anti-hypertensive, and anti-inflammatory activities, lipid-inhibiting effects, immune enhancement, protective effects on the skin, improvement of obesity and blood glucose levels, and finally preventive effects on cancer development. Regarding soybeans sauces (Jang), about 159 studies from 1995 to 2017 assessed the health functionality of Jang such as immune enhancement, anti-inflammatory, antioxidant, intestinal inflammation, anti-thrombotic, and anti-hypertension effects together with effects on blood pressure, diabetes, obesity, and cancer. (Moon & Cha, 2023)

Another crucial point in favor of their health claims is what is called the Korean paradox. Traditional fermented foods involve the usage of a high quantity of salt, globally known to be strictly related to cardiovascular diseases. The WHO suggests a daily sodium intake of fewer than 2,000 mg corresponding to 5 g of salt, however, the daily consumption of salt in Korea in 2021 was higher than the WHO suggested amount as it was around 3,220 mg. (Korea Disease Control and Prevention Agency. Korea National Health and Nutrition Examination Survey: Food intake.) Therefore, what was expected was a higher prevalence of cardiovascular diseases among Koreans and a high death rate. However, Korean fermented foods contain phytochemicals, lactic acid bacteria, potassium, and bioactive compounds derived from fermentation that protects consumers from cardiovascular diseases. This is called Korean paradox. Several studies, reported in the next section, proved the Korean paradox through the administration of high-salt content Korean fermented foods to evaluate the effect on blood pressure: Korean fermented food consumption did not cause an increase in blood pressure. Koreans indeed live a slimmer and longer life despite the high intake of salt. (S. H. Kim et al., 2016)

In the next section, an overview of the health benefits of Korean fermented foods on different diseases will be provided.

1. *Evidence of the Health Benefits of Korean Fermented Foods.*

1.1 Soybeans fermented sauces.

Soybeans are hugely used worldwide mainly to produce seed oil as the content of oil in the seed is around 20%. Due to their high content of proteins, however, soybeans are also a fundamental source of proteins. Soybean seeds, in fact, contain around 40% of proteins. Additionally, the quality of amino acids that form soybean proteins is similar to animal proteins, except for sulfur amino acids (cysteine and methionine), therefore they can be used as a replacement for meat. These two characteristics, make soybeans the best vegetable protein source. (Banaszkiewicz, 2011) In addition to this, soybeans also contain around 35% of carbohydrates, around 20% of which is dietary fiber, around 5% of minerals, and several vitamins in varying amounts such as vitamin E, pantothenic acid, biotin, niacin, thiamin, etc. With fermentation, soybeans change their physical and chemical properties including flavor, color, and bioactive compounds (mainly isoflavonoids and peptides) improving the functional and nutritional properties of the raw material. (Hassan, 2013)

Koreans' soybeans consumption is around 20-80 g per day mainly consumed as soy milk, tofu, fermented soybeans, soybean sprouts, and toasted soy protein flours. This led to a daily intake of 8-50 g of soy proteins and 25-100 mg of total isoflavones. Whereas the consumption of soybeans in Western countries is lower and does not exceed 1-3 g per day with a preference for breakfast cereals, soy burgers, and soy drinks. (Hassan, 2013) Nevertheless, in October 1999 the American Food and Drug Administration suggested a consumption of 25 g of soy proteins in a low-fat and low-cholesterol diet as scientific evidence had proven the health claim that soy may help lower the risk of heart diseases.

1.1.1 Gangjang (soy sauce)

During the production of Gangjang, fermentation modifies the compounds present in soybeans and produces new molecules. At the end of the maturation period, Gangjang is made mainly of 50-70% of water, 15-20% of salt, peptides, amino acids, free sugars, carbohydrates, isoflavones, organic acids, and alcohol. (D. Shin & Jeong, 2015)

Several studies have shown a relationship between Gangjang and numerous health benefits such as the prevention of hypertension and cancer, and antithrombotic, antioxidant, anti-inflammatory, and antibacterial activity. The studies have been in vivo or in vitro.

Hypertension:

A study published in 2017 conducted on Sprague-Dawley rats evaluated the possible different effects on the blood pressure of same concentration (8% NaCl) of Gangjang and table salt. During the 9 weeks of the trial, scientists measured serum chemistry, systolic blood pressure, renal gene expressions, and sodium Na^+ and potassium K^+ ions concentrations. Concerning serum chemistry, two parameters were measured, renin and aldosterone, that regulate blood pressure through the renin-angiotensin-aldosterone system (RAAS). In the Gangjang group, both parameters decreased. Further analysis demonstrated that the mRNA expression of mineralocorticoid receptors, renin, and angiotensin II type I receptor in the Gangjang group was significantly lower compared to the other groups. Additionally, genes for Na+ transporter in the kidney cortex (such as carbonic anhydrases II (CAII), Na+/H+ exchanger 3 (NHE3), Na+/K+ ATPaseα1 (NKAα1), and Na+/HCO3- co-exchanger (NBC)) were at the lowest level in rats fed with Gangjang. These findings explain why Na+ concentration in urine was lower in the NaCl group and higher in the Gangjang group. The combination of all the previous findings confirmed the measurement of systolic blood pressure of rats that increased more in the group of rats supplied with NaCl compared to the group fed with Gangjang. Mun et al. concluded that Gangjang may affect the RAAS in a different way compared to table salt and have a lower negative effect on the kidney, therefore, despite the high content of salt, it may have an anti-hypertensive effect. (Mun et al., 2017)

Colitis.

Song et al. in a study published in 2014 investigated the preventive effect of Gangjang on dextran sulfate sodium-induced colitis in mice. The results of this study were an increased colon length, a suppression of the weight loss caused by the induced colitis, and a decreased colon weight/length ratio. Additionally, edema, loss of crypts, and mucosal damage were prevented in mice fed with Gangjang. Serum levels of tumor necrosis factor-α (TNF-α), interleukin (IL)-6 and IL-17α, and interferon-γ (IFN-γ) decreased in animals belonging to the fermented soy sauce group. Moreover, the inhibition of mRNA expression of these cytokines and the ones of inducible nitric oxide synthase (iNOS) and cyclooxygenase-2 (COX-2) in colon mucosa was found with histological observations. By reducing serum levels of proinflammatory cytokines and inhibiting their mRNA expression in the colon tissue the Gangjang exert an anti-colitic effect. (J.-L. Song et al., 2014)

Cancer.

The same authors of the previews cited article further analyzed the data with an in vitro analysis and published an article in 2018 in which they evaluated the anti-cancer activity of Gangjang. The findings of the first study (Gangjang decreases serum and mRNA levels of tumor necrosis factor-α, interferon-γ, interleukin (IL)-6, and IL-17α as well as reducing mRNA levels of inducible nitric oxide synthase and cyclooxygenase-2 in colon mucosa) not only had an anti-colitic effect but also led to a decrease in the induced colorectal carcinogenesis. Moreover, Gangjang increased the expression of a tumor suppressor gene called p53. (J.-L. Song et al., 2018)

Antithrombotic.

Fibrinolysis is an enzymatic process that is fundamental to preventing unnecessary accumulation of fibrin within a vessel and allowing the removal of thrombi. In an in vitro study published in 2011, researchers found this peculiar enzymatic activity in some strains of bacteria present in Gangjang. During the study, they extracted from the sauce the bacterial strains that exhibit the best fibrinolytic activity. Through gene sequencing of the most fibrinolytic strain, they discovered that it was a *Bacillus licheniformis*. (Baek et al., 2011)

Antioxidant.

In 2003 Lee et al. conducted an in vivo and in vitro study to evaluate the antioxidant capacity of Gangjang concerning the antioxidant capacity of melanoidin. During the in vitro study, Gangjang and melanoidin have shown a higher antioxidant activity compared with the control group. Additionally, Gangjang antioxidant activity resulted stronger than melanoidin antioxidant activity. Moreover, the DPPH free radical scavenging activity resulted stronger in Gangjang. The in vivo study confirmed the findings of the in vitro study. Scientists added to the diet of male Wister rats, fed with high polyunsaturated fatty acids oil, 10% of Gangjang, or 10% glucose-lysine melanoidin for 5 weeks. They evaluated lipid peroxidation by measuring lipid peroxide with TBARS and by measuring the membrane phospholipid PCOOH content in the liver and plasma using the CL (chemiluminescence)-HPLC method. Both Gangjang and melanoidin exert an inhibition of the peroxidation of lipids, but in rats fed with Gangjang, the inhibition was stronger. The results of this study suggest that water-soluble peptides and low-molecular-weight proteins produced from soybeans during fermentation display an antioxidant activity that is stronger than melanoidin. (이상조 et al., 2003)

During the fermentation, the fungi derived from the Meju and the enzymes produced by Bacillus degrade soybean proteins by producing amino acids. These amino acids react with carbohydrates through the Maillard reaction and produce melanoidins. (D. Shin & Jeong, 2015) Melanoidins give the characteristics of color to the sauce, but they also have antioxidant properties due to their ability to scavenge oxygen radicals, bond with positively charged electrophilic species, and form inactive complexes through metal chelation. (Pastoriza & Rufián-Henares, 2014)

Immune/Anti-inflammatory.

In a study published in 2014, researchers tried to identify new bioactive ingredients in Gangjang by focusing on the polysaccharide fraction. Carbohydrates are known as structural components and energy sources, however, in the last decades, several studies suggested an additional anticancer activity through the induction of an immune response. The 2014 study compared the intestinal immune-modulating activities of a Gangjang produced by following a traditional process and a commercial one. It was conducted both in vitro, in a culture supernatant of Peyer's patch cells, and in vivo, on mice. During the in vitro testing, bot Gangjang showed an increased production of interleukine-6 (IL-6), which was stronger in the traditionally made Gangjang, while the bone marrow cell proliferation activity was measured with a fluorometric method and was higher in the traditional Gangjang. To further investigate the effect on the intestinal immune system, an in vivo trial was conducted by feeding four groups of mice with both fermented sauces in various quantities. The in vivo confirmed the in vitro findings. In fact, the IgA production by Peyer's patch cells and their excretion in mice stools were higher in mice fed with Gangjang sauces compared to the control group, with a higher effectiveness in the traditionally made Gangjang. Additionally, in mice fed with traditional Gangjang, IL-6 production and amount in mouse sera were higher. These findings suggest that polysaccharides from Korean traditional Gangjang have intestinal immune-stimulating activities. (M.-S. Lee & Shin, 2014)

Antibacterial.

In volume 3 of the Journal of Life Science of 2003 was published a study that evaluated the potential antibacterial effects of Gangjang on oral disease-causing bacteria. An in vitro trial was conducted to select and identify bacteria that could inhibit the growth of *Streptococcus sanguis, S. salivarius*, and *S. mutans* which are the main microorganisms that cause oral diseases. Through paper disc culture, pairing culture, and dual culture methods they isolated 25 strains from Gangjang, among which two strains were exhibiting an antibacterial effect. The two stains were analyzed by following the bacterial classification of 'Bergey's manual of systematic bacteriology' and resulted be respectively *Bacillus racemilacticus* and *Bacillus amyloliquefacien.* ('Isolation and Identification of the Antagonistic Microorganisms Against Streptococcus Spp. Causing Dental Caries in Korean Soy Sauce', 2003)

1.1.2 Doenjang (fermented soybean paste)

Cancer.

Several studies conducted during the last decades have suggested that numerous are the reasons for the anticancer effects of Doenjang. First, the presence of vitamin E, linoleic acid, trypsin inhibitor, and isoflavone in its composition seems to enhance the anti-tumor activity. (D. Shin & Jeong, 2015)

In 2006 researchers of the Department of Food Science and Nutrition of Pusan National University investigated the effects of Doenjang on solid tumor formation and lung metastasis. In particular, they were interested in the effects of fermentation time on the anti-cancer activity of Doenjang. Therefore, they fed sarcoma-180–injected mice and colon 26-M3.1 cells-injected mice with Doenjang that had 3, 6, and 24 months of fermentation respectively. The results showed that Doenjang aged for two years had a higher antimutagenic activity compared with the ones fermented for 3 and 6 months. The article in fact states that the Doenjang fermented for 24 months caused a two- to three-fold increase in antitumor effects on sarcoma-180–injected mice and antimetastatic effects in colon 26-M 3.1 cells in mice compared with the 3 or 6 months old. 24 months old Doenjang also increased splenic natural killer (NK) cell activity, increased hepatic glutathione S-transferase (GST) activities, and decreased the formation of tumors, suggesting that a longer fermentation could be beneficial from the antimetastatic and antitumor effects point of view. (K.-O. Jung et al., 2006)

Hypertension.

Likewise Gangjang, Doenjang salt content is relatively high. Nevertheless, a recent in vitro study from 2020 showed that Doenjang has an anti-hypertensive effect confirming the findings of a previous in vivo study. The effect derived from the reduction of blood pressure caused by the Doenjang regulation of the renin-angiotensin system (RAS) to improve lipid metabolism in adipose tissue. Moreover, Doenjang also decreases ACE and angiotensin II receptor 2 levels which concur to the reduction of blood pressure. (Woo et al., 2020)

A previous in vivo study was conducted on Sprague-Dawley rats fed with a high-salt diet in which Doenjang and table salt were administered at the same 8% NaCl concentration. The hypothesis was a possible reduction of the blood pressure caused by Doenjang. The results showed that blood pressure was indeed significantly lower in rats fed with Doenjang compared with the ones fed with a high table salt diet. Additionally, sodium and potassium quantity in urine and feces was higher in the Doenjang group, highlighting a greater excretion compared to high table salt-fed mice. Finally, renin and aldosterone levels in serum decreased compared to the high salt intake, while the expression in the kidney cortex of the angiotensin-converting enzyme (ACE), the Ang II type 1 (AT1) receptor, and mineralocorticoid receptor (MR) were partially inhibited. All the findings reported above suggest that the consumption of Doenjang is not a direct cause of hypertension. (Mun et al., 2019)

Obesity.

Several different studies from 2012 proved a correlation between Doenjang consumption and obesity. In Kwak et al. in vivo study, they compared the effects on obesity of fermented soybean paste and non-fermented steamed soybeans in rats. Male Sprague–Dawley rats were feed ad libitum for 8 weeks divided into groups with high fat, high fat + steamed soybeans, and high fat + Doenjang diets. Liver, epididymal fat pad, and body weight together with hepatic triglyceride and cholesterol levels were evaluated. Hepatic triglyceride, cholesterol, and body weight were significantly lower in the soy and Doenjang groups compared with the group fed a high-fat diet, but they were similar among themselves. Doenjang however significantly decreased epididymal adipocyte size and visceral fat weight due to elevate carnitine palmitoyl transferase (CPT)-1 activity and lower fatty acid synthase (FAS) activity in liver tissue. Additionally, serum leptin level and atherogenic index resulted lowered in rats fed with Doenjang compared to the other diets. Scientists related these findings to the Doenjang high content of aglycone isoflavones. Glycosylated isoflavonoids such as daidzin and genistin present in soybeans are converted during fermentation in their aglycone form, genistein, and daidzein. Both these aglycones regulate the enzyme of fatty acid oxidation, while genistein mediates the expression of genes involved in cholesterol metabolism. When the aglycone form of isoflavone increases, the polyglycolic acid (PGA) also increases and, consequently, GABA concentration increases in serum and brain. GABA, among other functions, stimulates the production of human growth hormone from the anterior pituitary. Human growth hormone prevents the creation of fat cells. GABA is also an actor in the suppression of high blood pressure by decreasing cholesterol and blood triglycerides. (H. Lee et al., 2010) In conclusion, Doenjang seems more effective in preventing obesity compared with soybeans. (Kwak et al., 2012)

In Cha et al. randomized controlled trial (RCT) the correlation between obesity and Doenjang consumption has been tested on 51 overweight adults for 12 weeks. The study hypothesized that Doenjang consumption modified body composition and reduced body weight in overweight adults. This hypothesis is similar to the one tested in animal studies that already proved the beneficial effects of Doenjang on cholesterol metabolism and body fat and weight. However, the Doenjang quantity used during animal trials were significantly higher than any hypothetical dose suitable for human diets. Therefore, the study of Cha et al. was specifically designed to evaluate the effect of a feasible supplementation of Doenjang in a human diet. During the 12 weeks, 9.9 g dry/day of Doenjang was supplemented to participants and abdominal fat distribution, blood components, and anthropometric parameters were measured. The results confirmed the in vitro study conducted early that same year as it showed a decrease in body fat mass (both percentage and kilograms), a reduction of the body weight, and a significant reduction in visceral fat in participants with the Doenjang supplementation. (Cha et al., 2012)

Youn-Soo Cha with another team of researchers in 2014 further studied the anti-obesity and antioxidant activities of Doenjang. During a 12 weeks double-blind randomized clinical trial, overweight Koreas with the PPAR-γ2 C1431T polymorphism were supplemented with 9.8 g/day of Doenjang. Before and after the trial, scientists measured abdominal fat distribution and PPAR-γ2 polymorphisms along with anthropometric and metabolic parameters. In the Doenjang group insulin, plasma-free fatty acid, and homeostatic model assessment insulin resistance (HOMA-IR) levels were significantly increased. Additionally, radical clearance capacity (ORAC and DNA tail length) was activated in the same group, while visceral fat area (VFA) was significantly decreased. Moreover, subjects fed with Doenjang tended to have a low intake of dietary sodium and carbohydrate. The finding suggests that Doenjang consumption decreased visceral fat accumulation and aging. (Cha et al., 2014)

Antioxidant/anti-inflammation.

In 2015 the inhibitory effects of Doenjang on oxidative stress and inflammation were studied in the adipose tissue (considered a major source of inflammation) of mice fed with a high-fat diet. The trial lasted 11 weeks and included 4 different diets: a low-fat diet, a high-fat diet, a high-fat containing

Doenjang diet, and a high-fat containing steamed soybean diet. Mice fed with Doenjang presented lower adipose tissue and body weights, associated with a reduced incidence of crown-like structure in the adipose tissue. Moreover, the oxidative stress markers, macrophage markers, fibrosis markers, and pro-inflammatory adipokines mRNA levels were significantly reduced. Doenjang also induced the gene expression of anti-inflammatory adipokine. Results related to Doenjang were targeting more effectively the anti-inflammatory effects and anti-oxidative stress compared to the group of mice fed with a steamed soybean diet. This suggests that the bioactive compounds produced during the fermentation and aging of soybeans may be responsible for the antioxidant and anti-inflammatory ability of Doenjang. (Nam et al., 2015)

Cognitive function.

A recent in vivo study dated 2019 conducted by Ko et al. on mice investigated the protective effect of Doenjang against neuroinflammation and neurodegeneration. The evaluation of these activities was done on the cortex and hippocampus of mice fed with a high-fat diet, low-fat diet, high-fat containing Doenjang diet, and high-fat containing steamed soybeans diet for 11 weeks. Mice fed with Doenjang presented a diminished loss of hippocampal neurons, while neurotrophic factor mRNA levels and cell proliferation were higher compared to other diets. Additionally, Doenjang regulated gene expression involved in β-amyloid peptide (Aβ) production and degradation and therefore reduced Aβ levels. Furthermore, oxidative metabolites content and mRNA levels of neuroinflammation-related genes and of oxidative stress genes were lower in the group with the Doenjang added diet. (Ko et al., 2019)

1.1.3 Gochujang (fermented red pepper soybean paste)

Historically, Gochujang medicinal effects are mentioned in five different records from the Joseon dynasty: Hyangyak-jipsongbang (鄉藥集成方, 1443), Euibangyuchi (醫方 類聚, 1445), Siknyo-chanyo (食療纂要, 1460), Uirimchwalyo (醫林撮要), and Sauigyeongheombang (四醫經驗方). The reports state that Gochujang was used to promote appetite and help digestion, used to relieve vomiting and diarrhea, and restore strength from an overall sense of energy deprivation. Moreover, if dunked as tea it was considered a back pain remedy. Nowadays, scientific reports agreed and proved the claimed health benefits of Gochujang, ascribing these benefits mainly to the spicy compounds and the fermentation byproducts. (D. Shin & Jeong, 2015)

Generally, Gochujang is made of 45% water, 44% carbohydrates, 5% protein, and 1% fat. In every 100g of Gochujang, there are 178 kcal, 822 mg of potassium, and 408 mg of vitamin A, even if different recipes exist and likewise different concentration amounts. (S.-H. Kim et al., 2016) A high share of Gochujang, 25%, consists of red pepper powder that is rich in capsaicinoids such as capsaicin and dihydrocapsaicin. 100g of Gochujang, in fact, contains 5mg of capsaicin. (Ham et al., 2012) Other bioactive compounds that can be found in red pepper powder are carotenoids, flavonoids, and vitamin C. (Shaha et al., 2013) Another important ingredient of Gochujang is meju powder. Meju powder constitutes the 5% of Gochujang and it is rich in isoflavonoids such as daidzin and genistin that come from soybeans and will become daidzein and genistein during fermentation. Daidzein and genistein are more easily absorbed by the organism therefore the fermentation increases the bioavailability of isoflavone. (H. W. Shin et al., 2016)

Metabolic syndrome.

Several studies proved the ability of capsaicin to ameliorate metabolic syndrome. Capsaicin act on different mechanisms for example it stimulates hormone-sensitive lipase and consequent lipolysis through TRPV1, a member of the transient potential family of receptors, (Chen et al., 2015), and increases diet-induced thermogenesis by upregulating uncoupling protein 2 expression, (M. Lee et al., 2011) (McCarty et al., 2015) increases the expression of carnitine palmitoyl transferase 1 α, which is the rate-limiting enzyme for β-oxidation, and results in the facilitation of fatty acid oxidation, (M. Lee et al., 2011) and consequently increase the energy expenditure. Moreover, capsaicin decreases blood glucose and insulin level by increasing insulin sensitivity, (Ahuja et al., 2006) (Weerapan Khovidhunkit, 2009) and activate AMP-activated protein kinase, which regulates glucose uptake and fatty acid oxidation. (Joo et al., 2010) (Kang et al., 2011) (S.-H. Kim et al., 2013) All the previous mechanisms led to an increase in energy expenditure through thermogenesis and fatty acid oxidation, a regulation of blood glucose and lipid levels that ameliorates metabolic syndrome.

Cancer.

A 2009 in vitro study conducted to evaluate the antioxidant and anti-cancer activities of Gochujang tested three different Gochujang extracts using MTT assay, a colorimetric assay for assessing cell metabolic activity, on cell proliferation of colon cancer cell (HCT116), lung cancer cell (NCI-H460), and stomach cancer cell (MKN 45). All three extracts exhibited anti-proliferative activity against all three tumors, with a stronger inhibition on stomach cancer cells. (H.-S. Song et al., 2008)

Obesity.

Several are the evidence that correlates the consumption of Gochujang to the amelioration of obesity. Likewise, the mechanisms through which Gochujang exerts its anti-obesity effects vary.

With a randomized controlled trial (RCT) Cha et al. in 2013 supplemented overweight adults with 30-32 g/day of Gochujang to investigate the changes in the body composition and blood lipid profile after 12 weeks. Parameters like serum lipid profiles, anthropometric parameters, and abdominal fat distribution were measured with computerized tomography, while atherosclerosis indices were additionally calculated by considering the ratio between lipid profiles in blood. The results showed a reduction of visceral fat, and a decrease in serum triglycerides and apolipoprotein B (that constitute lipoproteins) concentration. (Cha et al., 2013)

An in vivo study in 2016 evaluated the anti-obesity effects by feeding rats with different kinds of Gochujang. Diets added with Gochujang caused an improved lipid profile with a reduction in triglyceride levels both in serum and liver, a reduction of body weight gains and epididymal fat weight in mice, and a decrease in obesity gene expression, with a higher reduction in fermented with Meju Gochujang. Scientists correlate these results with the inhibition in epididymal adipose tissue of lipoprotein lipase, lipogenic enzymes fatty acid synthase, and malic enzyme paired with the hepatic inhibition of glucose-6-phosphate dehydrogenase. They also concluded that molecules such as capsaicin and genistein contribute to the anti-obesity activities of Gochujang. (H. W. Shin et al., 2016)

To further prove the preventive effects of Gochujang on obesity, a recent study on overweight and obese adults was conducted. In this study, researchers administered three diets consisting of traditional or commercial Gochujang. Waist circumference and visceral fat decreased significantly in the group fed with Gochujang with a high quantity of beneficial microbes, likewise, triglyceride levels, total cholesterol, high-density lipoprotein cholesterol, and low-density lipoprotein cholesterol consequently improving the lipid profile. (A. L. Han et al., 2022)

Diabetes.

In 2009, an in vivo study was conducted in 90% of pancreatectomized diabetic rats to investigate the ability of Gochujang in modulating energy and glucose metabolism. In particular, scientists wanted to examine if Gochujang affected insulin secretion from β-cells and/or peripheral insulin resistance. Findings report a decrease in visceral fat, serum leptin levels, and body weight. Moreover, mice fed with Gochujang presented a stronger phosphorylation of signal transducer and activator of adenosine monophosphate kinase, associated with a decreased expression of phosphoenolpyruvate carboxykinase that led to an enhancement of hepatic insulin sensitivity and consequently to an improved glucose tolerance. Additionally, Gochujang supplementation decreased the glucose output and the triacylglycerol accumulation in the liver and increased the storage of glycogen. All the previous findings, allow scientists to understand that the anti-diabetes activity of Gochujang on glucose homeostasis is done by reducing the insulin resistance. (Kwon et al., 2009)

Atherosclerosis.

A randomized controlled trial (RCT) of 2015 evaluated the anti-atherosclerosis effects of Gochujang in subjects with hyperlipidemia. Other previous studies had already tested the anti-atherosclerosis effects of traditional Gochujang, but in the Lim et al. study they used a commercial Gochujang made with *Aspergillus oryzae* and evaluated if the cholesterol-lowering effects were still present. The results confirmed the hypothesis as total cholesterol and LDL-C cholesterol levels significantly decreased. Therefore, commercially produced Gochujang that used *Aspergillus oryzae* for the fermentation has a significant hypocholesterolemia effect and can be used to control blood cholesterol levels in atherosclerotic subjects. (J.-H. Lim et al., 2015)

1.1.4 Cheonggukjang (fermented soybean paste by Bacillus)

During the fermentation process used to produce Cheonggukjang, proteins contained in soybeans are degraded by the microbial enzymes, and flavonoid glycosides are converted into aglycones by hydrolysis. The result is the production of free amino acids along with related peptides. (N. Y. Kim et al., 2008) Additionally, fermentation produces dietary fiber, poly-glutamic acid, saponins, phosphatide, and phenolic acid. Moreover, it increases the amount of other functional molecules such as Vitamin B1, B2, and retinol. (Sung et al., 2005) Cheonggukjang, therefore, is rich in proteins, vitamins, minerals, immunostimulant, antimicrobial, anti-inflammatory, antioxidant, and neuroprotective substances that are the origin of all its beneficial effects on human health. (Patra et al., 2016)

Digestibility.

Fermentation makes soybeans more digestible compared with the non-fermented version. In fact, the digestibility of Cheonggukjang is 95% whereas traditional steamed soybeans have a digestibility of 65%. (D. Shin & Jeong, 2015)

A recent randomized controlled trial (RCT) of 2020, supposed that fermentation could modify soybean isoflavones bioavailability and therefore enhance the absorption of phenolic compounds. The study was conducted on healthy adults fed with fermented soybeans (Cheonggukjang) or non-fermented soybeans. In soybeans two forms of isoflavones can be found: aglycone and glucosides. The microbial fermentation decreases the glucosides form by removing sugar from the molecule and increasing the aglycone form which is more digestible. During the study, they tracked isoflavone metabolites in food, plasma, and urine and noticed an increase in the serum isoflavone's absorption derived from the increased bioavailability. (H.-H. Jang et al., 2020)

Bone.

In 2015 Jung and Choi conducted an in vivo study on rats to evaluate the effects of Cheonggukjang on bone mineral density and content. The study lasts for 9 weeks during which rats were fed with general Cheonggukjang or Rubus-Coreanus (bokbunja (Korean: 복분자), Korean blackberry) added Cheonggukjang, a quality of Cheonggukjang that is even richer in phytochemicals. Results highlighted an increase in the spine bone mineral content and weight, and, likewise, an increase in the content and weight of minerals in femur. Spine and femur peak bone mass of growing rats benefited from the Cheonggukjang consumption. This study suggests a possible use of Cheonggukjang in the treatment and prevention of osteoporosis. (Y.-J. Jung & Choi, 2015)

Atherosclerosis.

Radnaabazar et al. in 2011 extracted a recombinant Cheonggukjang kinase 3-5 from Cheonggukjang and overexpressed it in a strain of *Bacillus licheniformis* that usually does not have a fibrinolytic activity. The aim was to understand the mechanism behind the fibrinolytic activity of Cheonggukjang kinase 3-5. They confirmed the antiplatelet and antithrombotic activity of Cheonggukjang kinase 3-5 and found out that it is a plasmin-like protease that directly lyses fibrin and platelet-rich clots without activating plasminogen. Moreover, Cheonggukjang kinase 3-5 decreased the collagen-induced platelet aggregation if put in a plasma rich in platelet. This inhibition was stronger as the concentration of enzyme increased and was completely inhibited with a concentration of enzyme of 1.5 mg/ml. Furthermore, the injection of Cheonggukjang kinase 3-5 protected mice from death by pulmonary embolism with a survival rate of 100% in rats fed with 520 mg/kg of Cheonggukjang kinase 3-5. All the findings reported above suggest that Cheonggukjang kinase 3-5 could be used to treat atherosclerosis, heart failure, and stroke. (Radnaabazar et al., 2011)

In the same year, Shin et al. investigated the changes in plasma lipid profile and blood glucose concentration during fasting derived from the consumption of Cheonggukjang. Abnormalities of lipid metabolism are one of the risk factors for atherosclerosis, therefore investigating plasma lipid profile becomes a central point. Subjects with impaired fasting glucose received a daily dose of Cheonggukjang or red ginseng Cheonggukjang (or starch for the control group) for 8 weeks. After the trial period, total cholesterol, LDL-cholesterol, and erythrocyte thiobarbituric acid-reactive substances in the plasma of subject feed with Cheonggukjang or red ginseng Cheonggukjang were significantly reduced underlining an improvement of lipid profile. Likewise, the atherogenic indices (ratio between apolipoprotein B and apolipoprotein A-1) were reduced, while the concentration of fasting blood glucose was significantly lowered compared with the initial value. (S.-K. Shin et al., 2011)

The ability of Cheonggukjang to change lipid profiles was further investigated in 2016 with a randomized controlled trial (RCT) on overweight and obese subjects. After the two intervention periods of 12 weeks respectively, lipid profile, anthropometric measures, and atherogenic indices were determined. High-sensitivity C-reactive protein and lipid profile were improved, while waist circumference, waist-to-hip ratio, lean body mass, and percentage of body fat were improved in the group with the Cheonggukjang diet compared with the placebo group. Moreover, the ratio between apolipoprotein B and apolipoprotein A-1 (atherogenic indices) decreased below 0.55. Risk factors for cardiovascular disease and body composition may be improved by Cheonggukjang consumption by overweight and obese adults. (Byun et al., 2016)

Obesity.

Findings of the previously mentioned study by Byun et al. of 2016 suggest that Cheonggukjang consumption improve also the obesity index. (Byun et al., 2016)

In the same year, another study confirmed the anti-obesity effects of Cheonggukjang by feeding obese mice with a high-fat diet added with Cheonggukjang. For 13 weeks diet-induced obese male C57BL/6J mice consumed a diet with 30% Cheonggukjang fermented with Bacillus licheniformis-67. At the end of the trial, body weight and epididymal fat pad weight, as well as blood glucose, leptin level, lipid profile, and insulin, were lower in the mice fed with Cheonggukjang. Moreover, the expression of genes correlated with the catabolism of lipids was significantly increased. These findings suggest that Cheonggukjang consumption can help prevent obesity by acting on obesity-related parameters. (J.-H. Choi et al., 2016)

Diabetes.

Findings of the previously mentioned study by Shin et al. of 2011 suggest that Cheonggukjang consumption decreases the fasting glucose level and therefore can be beneficial in the prevention or treatment of diabetes. (S.-K. Shin et al., 2011)

An in vivo study carried on in 2015 by Yang investigated the effects of Cheonggukjang powder on inflammation and blood glucose level. The trial was carried on in both non-diabetic and diabetic rats for 7 weeks to evaluate the differences between the groups. Three different Cheonggukjang diets were administered to the rat and the glycemic control was evaluated. Leptin and adiponectin levels were significantly lower in mice fed with Cheonggukjang, as well as the free fatty acids, insulin levels, and insulin secretory proving that Cheonggukjang help regulate them. (Yang, 2015)

1.2. Kimchi (fermented vegetables)

The health benefits of kimchi are derived from the high nutritive value of raw material and the microbiota that carry on the fermentation. Several studies, in fact, correlated the compounds that can be found in *Brassicaceae*, namely dietary fibers, amino acids, vitamins, minerals, polyphenols, carotenoids, and glucosinolates, with health benefits. In particular, Chinese cabbage (*Brassica rapa* L. *pekinensis*) contains lutein, β-carotene, 34 amino mainly acids γ-aminobutyric acid, threonine, alanine, arginine, asparagine, glutamic acid and serine, vitamins A and C, and 10 minerals among which magnesium, calcium, sodium, and potassium in higher amounts, making Chinese cabbage a high nutritive food. Kimchi also contains radish and onion which are source of flavonoids (quercetin glucosides), black and red peppers that contain piperine and capsaicin, garlic which is rich in organosulfur compounds, and ginger which is known for its biological activities. Moreover, the kimchi fermentation process and its microorganisms have been studied since 1939 when the first strains of LAB were isolated and since then many other microorganisms were isolated, characterized, and related with different health benefits. (Patra et al., 2016) In Figure IV.2 the neutracutical potential of Kimchi are visually described.

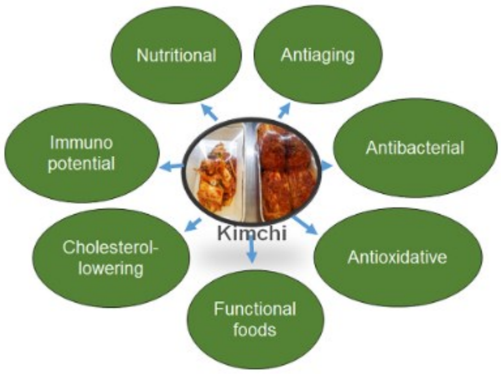

Figure IV.2. Nutraceutical potential of Kimchi. (Patra et al., 2016)

Antioxidant.

An in vitro study conducted in 2013, isolated a *Lactobacillus sakei* from kimchi and evaluated its functional characteristics. Among these, they also evaluated the antioxidant activity of cultural supernatants through DPPH and ABTS radical assay stating that it was approximately 53.8%. Moreover, β-galactosidase activities were 0.243 units/mL at pH 7.0 and 0.387 units/mL at pH 4.1, respectively. Finally, *Lactobacillus sakei* depleted nitrite concentration by 94.75%, suggesting that kimchi have antioxidant properties due to the presence of *Lactobacillus sakei*. (D.-S. Kim et al., 2013)

Anti-bacterial.

An in vivo study carried on by Hur et al. evaluated the consumption of *Lactobacillus plantarum* concerning its anti-bacterial properties. The effectiveness has been evaluated based on the production of tumor necrosis factor-α, interleukin-6, and nitric oxide by RAW264.7 macrophage cells. RAW264.7 macrophage cells were stimulated with four LAB extracted from kimchi and two strains of bifidobacterial. *Lactobacillus plantarum* was the most effective therefore it plays an important role in the anti-bacterial activity of kimchi. (Hur et al., 2004)

A recent study of 2019 confirmed the 2004 study. They isolated strains of LAB in kimchi based on their caseinolytic activity to evaluate a possible usage of these strains as a starter with probiotic activity. At first, thirty-two strains were isolated but just two were selected and identified. Among them, *Lactobacillus plantarum* was the final choice based on its biochemical characteristics. During the study, researchers saw that L. plantarum formed a clear zone of 8-13 mm from the five pathogens used in the study, exhibiting an antibacterial activity that suggests a possibility in use it as a probiotic. (Y.-S. Lim et al., 2019)

Diabetes.

A recent study conducted in vitro studied the β-glucuronidase activity of lactic acid bacteria isolated from kimchi. β-glucuronidase is an important lysosomal enzyme involved in the degradation of glucuronate-containing glycosaminoglycan and therefore participates in the catalyzation of the breakdown of carbohydrates. Among 156 strains isolated and tested, fifty-five used as carbon source glucuronic acid and presented a higher β-glucuronidase activity inside the cell compared to the extracellular activities. (I.-U. Shin et al., 2019)

Serum lipids and blood glucose.

The aim of the study done by Choi et al. in 2013 was to investigate if the content of lipids in serum is influenced by the amount of kimchi consumed. In a randomized controlled trial (RCT), 100 volunteers were administered with a low kimchi diet (50 g/day) and a high kimchi diet (210 g/day) for 7 days. Parameters such as total glucose, total cholesterol, fasting blood glucose, and low-density lipoprotein were significantly decreased in both groups, with a bigger decrease in the group feed with a high kimchi diet. In particular, fasting blood glucose and total cholesterol in serum are the parameters that were more influenced by the dose of kimchi consumed. (I. H. Choi et al., 2013)

Intestinal microbiota/Irritable IBM.

A randomized controlled trial (RCT) conducted in 2016 investigated the changes in the intestinal microbiota of adults due to the consumption of kimchi. Participants were divided into two groups to which a low kimchi diet and high kimchi diet (150 g/day) were administered for 7 days. Feces samples of the participants were collected to analyze the intestinal microbiota. Findings showed a diminishing in the number of pathogenic microorganisms and a double increase of kimchi-dominant fermented microorganisms. These results suggest that not only kimchi modify the intestinal microbiota but also that kimchi microorganisms are healthy symbiotic. (Jy & Ey, 2016)

A recent study was implemented to confirm the beneficial effects of kimchi on irritable bowel syndrome (IBS). The findings of the study indeed confirmed this hypothesis further stating that it reduces serum inflammatory cytokine, dangerous fecal enzyme, and increases dietary fiber. These results were obtained by feeding individuals three types of kimchi (210 g/d) for 12 weeks and by analyzing feces, serum, and microbiota. (H.-Y. Kim et al., 2022)

Metabolic parameters.

A study of 2011 investigated the correlation between metabolic parameters and fermented kimchi hypothesizing that it will have more beneficial effects compared to the fresh version. Metabolic parameters are related to metabolic syndrome and cardiovascular disease risks. The trial was carried out on overweight and obese subjects for two periods of 4 weeks each with 2 weeks of washout period during which they consumed either fermented or fresh kimchi (300 g/day). Results detected a decrease in body mass index, body weight, and body fat in both groups with an additional significant decrease in the fasting blood glucose and waist-hip ratio in the fermented kimchi group. Moreover, differences in percent body fat, fasting glucose, total cholesterol, diastolic blood pressure, and systolic blood pressure were significantly wider in the group feed with fermented kimchi. These results suggest that fermentation affect the beneficial effects of kimchi. (E. K. Kim et al., 2011)

In 2013 An et al. investigated the possibility to use kimchi to prevent diabetes. Therefore, they hypothesized that fermented kimchi could have a positive effect on the glucose metabolism of patients with prediabetes. They tested the hypothesis in a randomized controlled trial (RCT) for 8 + 8 weeks during which subjects were fed with fresh and fermented kimchi respectively. Waist circumference, body mass index, and body weight decreased after the consumption of both fresh and fermented kimchi. However, insulin sensitivity and insulin resistance increased and decreased respectively just in the fermented group. Moreover, decreases of systolic and diastolic blood pressure were measured just in the fermented group. Finally, in both groups the glucose tolerance was improved with a more remarkable improvement in the fermented group (9.5% in the fresh group and 33% in the fermented group). (An et al., 2013)

The study of 2015 was designed to understand the molecular mechanisms behind the anti-obesity activity of kimchi through the evaluation of the association between gut microbiota and the human genome after the consumption of kimchi. Through a randomized controlled trial (RCT) obese subjects received fresh or fermented kimchi (180 g/day) for 8 weeks after which blood and fecal samples were collected and compared with the initial ones. The analyses of the samples revealed that both fresh and fermented kimchi exerted effects on obesity-related parameters such as among other body weight, waist circumference, BMI, body fat, fasting blood sugar, cholesterol, and insulin, but fermented kimchi gave more evident changes compared with fresh kimchi. Fermented kimchi intake, moreover, produced beneficial effects on blood gene expression and gut microbial population with a decrease in genus Blautia (a genus correlated with an increase in obesity) and an increase in *Prevotella* and *Bacteroides* (that are negatively correlated with obesity). (K. Han et al., 2015)

Kim and Park in 2018 further investigate the relationship between kimchi and metabolic parameters considering colon health. The results are in line with the previous study's findings. The consumption of 210 g/day of kimchi increased dietary fiber levels and adiponectin levels, reduced body fat, triglycerides, interleukin (IL)-6, and total cholesterol. Fecal samples analysis detected a decrease in β-glucosidase, β-glucuronidase, and pH in addition to an increase in the *Bacteroidetes* and a decrease in the *Firmicutes.* Moreover, Clostridium sp. and E. coli counts were lower than the initial counts. Findings suggest that kimchi modifies in a positive way colon health and metabolic parameters. (H.-Y. Kim & Park, 2018)

Hypertension.

In 2014 the association between kimchi and hypertension was evaluated on the data from the Korean National Health and Nutrition Examination Survey conducted from 2007 to 2012. A total of 20,114 Korean adults' data was included, and nutrient, daily energy, and kimchi intake were evaluated. Even if participants with the higher consumption of kimchi were also the ones with the higher BMI, blood pressure, consumption of calories, and sodium intake, and the ones with an older age, statistically there was not a higher prevalence of hypertension. Scientists concluded that the high potassium intake, derived from the consumption of kimchi, may help decrease the effect of salt intake on blood pressure. (H. J. Song & Lee, 2014)

1.3. Jeotgal (fermented fish and seafood)

Jeotgal is a low-calorie food, rich in essential amino acids, such as lysine and threonine. The fermentation process enhances the production of functional byproducts from phytochemicals already present in the raw materials. This action improves Jeotgal's health benefits. For example, its free amino acid content (lysine, glutamic acid, methionine, alanine, aspartic acid, and leucine) doubles after 72 days of fermentation. (Seung-Yong & Eung-Ho, 1976) Moreover, glucose and vitamins, mainly vitamin B, increase during the fermentation. Due to the presence of natural glutamic acid, alanine, and glycine it has also an umami taste. (J.-S. Kim & Kim, 2014) Due to the high content of protease, Jeotgal is known to increase appetite, protect the liver, and help the digestion of meat. Therefore, it is usually consumed as a side dish when meat is eaten. (Koo et al., 2016)

Probiotic properties.

The fermentation of Jeotgal is carried on mainly by lactic acid bacteria, which are the most used microorganisms as probiotics. Therefore, Jeotgal is considered a potential probiotic and has been studied in several trials to investigate this hypothesis. The findings suggest that LAB extracted from Jeotgal exert antimicrobial activity on pathogens, can resist at low pH, can adhere to intestinal surfaces, and have anti-cholesterol properties strongly suggesting that Jeotgal LAB can indeed be beneficial as probiotics. (N.-E. Song et al., 2021) ('Some Probiotic Properties of Some Lactic Acid Bacteria and Yeasts Isolated from Jeot-gal.', 2003) (K. W. Lee et al., 2014) (N.-K. Lee et al., 2006)

Anti-mutagenic and anti-cancer activity.

The high presence of garlic, bioactive grains, and hot pepper in Jeotgal have been correlated with an inhibitory effect on mutagenicity of human colon and carcinoma cells already back in the nineties with two main studies conducted in Korea and Japan by respectively Park et al. and Fukushima et al.. (K.-Y. Park et al., 1991) (Fukushima et al., 1997)

In 2000 the Korean Society of Food Science and Nutrition published an article in its journal in which the anti-mutation activity of anchovy jeotgal was shown. Anchovy jeotgal is one of the most important ingredients in Korean cuisine as it is one of the main ingredients of kimchi. The study conducted by Lee et al. claimed that the anti-mutant effect of anchovy jeotgal depended on the length of the fermentation period. In fact, the results on anchovies fermented for 6 and 12 months showed 26.6% and 43.4% of antimutant activity, respectively. (H.-J. Lee et al., 2000)

Following the 2000 study, other researcher teams in 2001 and 2003 conducted studies on Jeotgal anti-cancer abilities and the enhancement of the soybeans' anti-cancer abilities after fermentation and connected them to glutamic acid and lysin content. (H. Lim et al., 2001) (S. Kim, 2003)

Antioxidant.

In 2006 Kim et al. analyzed in vitro the changes in the antioxidant activity of yellow corvina Jeotgal during fermentation. Maturation lasted for 240 days during which different parameters were analyzed at various time intervals including brown color intensity, peroxide values, acids values, reducing sugar, thiobarbituric acid (TBA) values, electron donating ability, and reducing power. Moreover, the antioxidative activities were evaluated on tile linoleic acid emulsion system. Peroxide values, electron donating ability and reducing power, and brown color intensity gradually increased with time, whereas reducing sugars amount decreased with time. The antioxidant effect was the highest in salted fish aged 240 days as it showed a prooxidant effect. As a result, the radical scavenging action by DPPH increased as the aging period increased. The results suggest that the Millard reaction products released during the fermentation period influence the antioxidant activity of Jeotgal. (김지상 et al., 2006)

Immune.

Park et al. in 2017 conducted an in vivo trial with oral administration on lactobacilli isolated from Jeotgal to evaluate their action on atopic dermatitis in mice. In particular, the lactobacilli isolated in Jeotgal were identified as *Lactobacillus plantarum*. During the trial, histological analysis, ear swelling, serum immunoglobulin E levels (IgE), cytokine production by CD4+ T cells from lymph nodes, and interleukin (IL)-12 production in mice were evaluated. The administration of *Lactobacillus plantarum* inhibited the ear swelling, suppressed the serum IgE levels, and decreased the production of IL-4. At the same time, interferon (IFN)-γ and IL-12 production were increased. These findings support the hypothesis that lactobacilli of Jeotgal may suppress the development of skin inflammation due to atopic dermatitis. (M.-S. Park et al., 2017)

Cognitive.

An in vivo study carried out in 2014 by Heo et al. investigated the effects of low salt jeotgal on learning and memory impairments in scopolamine-induced dementia rats. The effectiveness of the treatment with Jeotgal has been tested with behavioral procedures typically used with rodents such as passive avoidance test and Morris water maze test. In both cases, scopolamine-induced memory deficits were significantly reduced with a consequent significant amelioration of the formation of long- and short-term memory. Behavioral experiments were confirmed by the increase of the acetylcholine content, and the reduction of the inhibitory effect on acetylcholinesterase activity. These findings suggest that through the regulation of the cholinergic enzymes, Jeotgal enhances the cognitive functions. (Heo et al., 2014)

Obesity.

A strain of *Lactobacillus plantarum* isolated in flounder sikhae (Jeotgal) and administered to male C57BL/6J mice for 12 weeks exerted anti-obesity activities. A study from Park et al. published in 2014 showed that after 12 weeks mice supplemented with *L. plantarum* had a lower body weight and a significant reduction of the epididymal fat and back fat. Moreover, they measured insulin, triglyceride, and leptin levels in serum and liver and observe a significant reduction. Differences have also been found in the hepatic mRNA expression of lipid metabolism-related genes. The expression of peroxisome proliferator-activated receptor alpha (PPARα) and carnitine palmitoyltransferase I (CPT-I) were significantly increased, whereas the level of acetyl-coenzyme A carboxylase (ACC), sterol regulatory element-binding protein 1 (SREBP-1) and liver X receptor alpha (LXRα) were significantly decreased in rats fed with the high-fat & *L. plantarum* diet. Additionally, the diet added with *L. plantarum* inhibits the genes regulated by peroxisome proliferator-activated receptor gamma (PPARγ) by decreasing the expression of PPARγ itself in the epididymal adipose tissue. These findings suggest an anti-obesity effect of *L. plantarum.* (J.-E. Park et al., 2014)

Thrombosis.

A recent study isolated a *Bacillus velezensis* strain with a strong fibrinolytic activity from sea squirt Jeotgal. Laboratories analysis through electrophoresis and fibrin zymography made it possible to select the proteins that were exerting the major fibrinolytic activity. The gene associated with this protein was cloned and overexpressed in heterologous hosts (*B. subtilis* and *E. coli*) to evaluate the effectiveness of the protein fibrinolysis resulting in a strong α-fibrinogenase and moderate β-fibrinogenase activity. (Yao et al., 2019)

2. Future research - Mediterranean inhabitants' acceptance: sensorial characteristics and fermentation.

Taking into consideration all the observations listed in 'Result and Discussion - 1. Evidence of the Health Benefits of Korean Fermented Foods.', it can be stated that the addition of fermented food in a Mediterranean diet pattern could be beneficial from the health point of view, inasmuch it will boost the health benefits of the Mediterranean diet itself. However, other factors must be taken into consideration while evaluating the feasibility of the addition of Korean fermented foods in the Mediterranean diet.

For example, a general comparison between Korean and Mediterranean diets could help highlight the current similarities and distinctiveness that could become the basis of a merge between the two diet patterns. When comparing the Korean diet and the Mediterranean diet from the point of view of the intake of food and nutrients, the two diet shows similar qualities. Both generally involve a high consumption of plant food such as vegetables, legumes, seeds, cereals, etc. with a preference towards whole grains, low consumption of red and processed meat with legumes and fish as their main protein source, a high consumption of fish, and a low amount of fat derived from animal sources. Clearly, the two diets also present several differences mainly related to cooking methods or availability of raw materials, and both have beneficial and critical points. The Mediterranean diet has a high-fat ratio compared to the Korean diet as olive oil is frequently used. Additionally, the Mediterranean population consumes a higher amount of saturated fat due to the higher intake of animal-derived product compared with Koreans. Koreans' intake of vegetables, seafood, and fish in fact is higher compared with Mediterranean inhabitants, and, even if the consumption of meat is low in the Mediterranean diet, in the Korean diet the meat consumption is even lower. Nevertheless, the Korean diet has a high-carbohydrate ratio since rice is a staple food that accompanies every Korean meal. Furthermore, although both diets suggest a high consumption of vegetables, in the Mediterranean diet vegetables are consumed fresh or cooked whereas in the Korean diet the most common way of preparing them is through fermentation (even if other preparation methods are also present as stated in the Introduction). (Moon & Cha, 2023) Talking about fermentation, the technique is known and widespread in both diets but, while Koreans use mainly vegetables or soybeans (kimchi, jang) as raw materials for fermentation, the Mediterranean population more widely use milk (yogurt, cheese).

Another important factor to take into consideration is related to the peculiar taste of Korean fermented foods. The addition of Korean fermented food could add new sensorial characteristics, such as spiciness, saltiness, sourness, and umami taste to Mediterranean dishes. Nevertheless, Korean fermented foods have a strong flavor that could be despised from the Westerns palates. The Westerns organoleptic acceptance of Korean fermented foods has been tested on Americans in a few studies that took into consideration kimchi, the most known Korean fermented food. The results of the studies present a huge variability because people perceive taste in different ways. For example, a study reported that half of the participants reported that kimchi tasted good due to the spicy and hot taste, whereas the other half of the participants did not like it because it was too spicy. (J.-S. Han et al., 2009) However, a following study reports that subjects of the trial moderately liked kimchi with a preference toward the higher fermented kimchi compared to the freshly made kimchi because it had a stronger taste. Moreover, in the same study American panel seems to like kimchi more than the Korean panel (probably due to development in Koreans of more specific sensory standards due to the frequent consumption). (S.-H. Jang et al., 2016) In general, the studies showed different degrees of acceptance based on personal taste preference and habits: subjects that had a regular spicy-food consumption, subjects that already had tasted kimchi before, and subjects that had an interest in Korean culture were more likely to enjoy and like kimchi. (S.-H. Jang et al., 2016) (H.-J. Park et al., 2020) Further studies are needed to assess the acceptability of Mediterranean inhabitants.

Finally, concerns on the acceptability of the fermentation as a production technique could arise. However, it must be taken into consideration that fermentation techniques are known in the Mediterranean basin since Ancient Times, as extensively reported in the 'Introduction - 3.1

Fermented Foods of Mediterranean Diet'. Moreover, lactic acid bacteria are the main actors of fermentation in both Korean fermented foods and Mediterranean fermented foods. Therefore, the availability of microorganisms should not be a problem, while the knowhow on fermentation is already present in the basin. Clearly, Korean and Mediterranean fermentation techniques are not identical. Nevertheless, their merging will require only an adaptation of an already known manufacturing technique. The main difference between the two fermentation techniques lies in the raw ingredients used during the fermentation and their availability in Mediterranean countries. In particular, some concerns related to Kimchi ingredients may arise. However, increasing interest and demand for nutritious, diversified, and exotic vegetables have been reported in Europe leading to the possible expansion of the European market for Asian vegetables. In particular, the increasing attention on the prevention and cure of diet-related chronic diseases among European populations may encourage the import of Korean vegetables that possess health benefits such as Korean cabbage or Korean ginseng sprout, and consequently the export of their fermented versions as recipes or final product. (Hong & Gruda, 2020) Given the above, the introduction of Korean fermentation technique in the Mediterranean basin seems not to be an issue. However, further research is needed.

V. Conclusion.

The literature review done during the development of this thesis highlighted the importance of Korean fermented foods in the prevention and treatment of chronic diseases such as obesity, cardiovascular diseases, diabetes, cancer, metabolic syndrome, neurodegenerative diseases, hypertension, and osteoporosis while having antioxidant and anti-inflammatory properties.

From the point of view of the enhancement of health benefits and sensorial characteristics, the addition of Korean fermented foods to the Mediterranean diet could indeed be beneficial. In fact, both Korean and Mediterranean diets seem to exert prevention activities on the chronic diseases listed above. The combination of them could lead to a booster of the beneficial effect. Moreover, Korean fermented foods have a peculiar taste that is not widely present among the Mediterranean dishes. Therefore, they could represent a sensorial novelty while amplifying the health benefits of the healthy Mediterranean diet.

Both Korean and Mediterranean diets use fermentation techniques since Ancient Times and relies on lactic acid bacteria to carry on the fermentation. Therefore, Mediterranean's inhabitants and producers are already aware and familiar with this production technique. This could have a positive effect in the introduction of Korean fermented foods in Mediterranean countries. However, raw materials differ so it could be difficult to acquire the ingredients needed to produce Korean-style fermented food in Europe. Actually, the most recent market analysis underlines an increasing in the import of Asian ingredients in Europe and a higher interest among Europeans for healthy Asian vegetables. Consequently, in the next few years the availability of Korean staple ingredients or ready-to-eat Korean fermented foods could increase.

Theoretical basis is promising, however further practical research is needed to evaluate the acceptability of Korean fermented foods among Mediterranean's inhabitants and producers. Major concerns are related to the taste of Korean fermented foods that could be considered too strong or too far from the Mediterranean dishes. In this sense, studies conducted so far gave mixed results and have been conducted on Americans.

Moreover, no research has been conducted directly on a Mediterranean diet sample added with Korean fermented foods. Therefore, the theoretical claims of this thesis must be practical tested and verified with further in vitro and in vivo trials.

VI. References.

Ahmed, Z., Wang, Y., Ahmad, A., Khan, S. T., Nisa, M., Ahmad, H., & Afreen, A. (2013). Kefir and Health: A Contemporary Perspective. *Critical Reviews in Food Science and Nutrition*, *53*(5), 422–434. https://doi.org/10.1080/10408398.2010.540360

Ahuja, K. D., Robertson, I. K., Geraghty, D. P., & Ball, M. J. (2006). Effects of chili consumption on postprandial glucose, insulin, and energy metabolism. *The American Journal of Clinical Nutrition*, *84*(1), 63–69.

Allen, H. N., & Freer, C. L. (1908). *Things Korean: A collection of sketches and anecdotes, missionary and diplomatic*. F. H. Revell Company. https://doi.org/10.5479/sil.50029.39088016500589

An, S.-Y., Lee, M. S., Jeon, J. Y., Ha, E. S., Kim, T. H., Yoon, J. Y., Ok, C.-O., Lee, H.-K., Hwang, W.-S., Choe, S. J., Han, S. J., Kim, H. J., Kim, D. J., & Lee, K.-W. (2013). Beneficial Effects of Fresh and Fermented Kimchi in Prediabetic Individuals. *Annals of Nutrition and Metabolism*, *63*(1–2), 111–119. https://doi.org/10.1159/000353583

Anifantakis, E. M., & Moatsou, G. (2006). Feta and Other Balkan Cheeses. In *Brined Cheeses* (pp. 43–76). John Wiley & Sons, Ltd. https://doi.org/10.1002/9780470995860.ch2

Bach-Faig, A., Berry, E. M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F. X., Battino, M., Belahsen, R., Miranda, G., & Serra-Majem, L. (2011). Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*, *14*(12A), 2274–2284. https://doi.org/10.1017/S1368980011002515

Baek, S.-Y., Yun, H.-J., Park, H.-D., & Yeo, S.-H. (2011). Isolation and Optimized Culture Conditions of Fibrinolytic Enzyme Producing Strain Isolated from Korean Traditional Soybean Sauce. *Microbiology and Biotechnology Letters*, *39*(4), 330–336.

Bamforth, C., & Cook, D. (2019). *Food, Fermentation, and Micro-organisms*. https://doi.org/10.1002/9781119557456

Banaszkiewicz, T. (2011). Nutritional value of soybean meal. *Soybean and Nutrition*, *12*, 1–20.

Bernini, V. (n.d.). *New Insights into Food Fermentation*.

Borgstrom, G. (1968). *Principles of food science. 2. Food microbiology and biochemistry.*

Bruneton, Y. (2020). Koryŏsa 高麗史 고려사: L'histoire officielle du Koryŏ. In N. Kouamé, É. P. Meyer, & A. Viguier (Eds.), *Encyclopédie des historiographies: Afriques, Amériques, Asies: Volume 1: Sources et genres historiques (Tome 1 et Tome 2)* (pp. 973–988). Presses de l'Inalco. https://doi.org/10.4000/books.pressesinalco.26386

Burlingame, B., & Dernini, S. (2011). Sustainable diets: The Mediterranean diet as an example. *Public Health Nutrition*, *14*(12A), 2285–2287. https://doi.org/10.1017/S1368980011002527

Byun, M.-S., Yu, O.-K., Cha, Y.-S., & Park, T.-S. (2016). Korean traditional Chungkookjang improves body composition, lipid profiles and atherogenic indices in overweight/obese subjects: A double-blind, randomized, crossover, placebo-controlled clinical trial. *European Journal of Clinical Nutrition*, *70*(10), Article 10. https://doi.org/10.1038/ejcn.2016.77

Campbell-Platt, G. (1987). Fermented foods of the world. A dictionary and guide. *Fermented Foods of the World. A Dictionary and Guide.* https://www.cabdirect.org/cabdirect/abstract/19870422617

Campbell-Platt, G. (1994). Fermented foods—A world perspective. *Food Research International*, *27*(3), 253–257. https://doi.org/10.1016/0963-9969(94)90093-0

Cancer chemoprevention with dietary phytochemicals | Nature Reviews Cancer. (n.d.). Retrieved 28 June 2023, from https://www.nature.com/articles/nrc1189

Cavalieri, D., McGovern, P. E., Hartl, D. L., Mortimer, R., & Polsinelli, M. (2003). Evidence for S. cerevisiae Fermentation in Ancient Wine. *Journal of Molecular Evolution*, *57*(1), S226–S232. https://doi.org/10.1007/s00239-003-0031-2

Cha, Y.-S., Kim, S.-R., Yang, J.-A., Back, H.-I., Kim, M.-G., Jung, S.-J., Song, W. O., & Chae, S.-W. (2013). Kochujang, fermented soybean-based red pepper paste, decreases visceral fat and improves blood lipid profiles in overweight adults. *Nutrition & Metabolism*, *10*(1), 24. https://doi.org/10.1186/1743-7075-10-24

Cha, Y.-S., Park, Y., Lee, M., Chae, S.-W., Park, K., Kim, Y., & Lee, H.-S. (2014). Doenjang, a Korean Fermented Soy Food, Exerts Antiobesity and Antioxidative Activities in Overweight Subjects with the PPAR-γ2 C1431T Polymorphism: 12-Week, Double-Blind Randomized Clinical Trial. *Journal of Medicinal Food*, *17*(1), 119–127. https://doi.org/10.1089/jmf.2013.2877

Cha, Y.-S., Yang, J.-A., Back, H.-I., Kim, S.-R., Kim, M.-G., Jung, S.-J., Song, W. O., & Chae, S.-W. (2012). Visceral fat and body weight are reduced in overweight adults by the supplementation of Doenjang, a fermented soybean paste. *Nutrition Research and Practice*, *6*(6), 520–526. https://doi.org/10.4162/nrp.2012.6.6.520

Chavan, R. S., & Chavan, S. R. (2011). Sourdough Technology—A Traditional Way for Wholesome Foods: A Review. *Comprehensive Reviews in Food Science and Food Safety*, *10*(3), 169–182. https://doi.org/10.1111/j.1541-4337.2011.00148.x

Chen, J., Li, L., Li, Y., Liang, X., Sun, Q., Yu, H., Zhong, J., Ni, Y., Chen, J., & Zhao, Z. (2015). Activation of TRPV1 channel by dietary capsaicin improves visceral fat remodeling through connexin43-mediated Ca2+ influx. *Cardiovascular Diabetology*, *14*(1), 1–14.

Chilton, S. N., Burton, J. P., & Reid, G. (2015). Inclusion of Fermented Foods in Food Guides around the World. *Nutrients*, *7*(1), Article 1. https://doi.org/10.3390/nu7010390

Choi, I. H., Noh, J. S., Han, J.-S., Kim, H. J., Han, E.-S., & Song, Y. O. (2013). Kimchi, a Fermented Vegetable, Improves Serum Lipid Profiles in Healthy Young Adults: Randomized Clinical Trial. *Journal of Medicinal Food*, *16*(3), 223–229. https://doi.org/10.1089/jmf.2012.2563

Choi, J.-H., Pichiah, P. B. T., Kim, M.-J., & Cha, Y.-S. (2016). *Cheonggukjang*, a soybean paste fermented with *B. licheniformis*-67 prevents weight gain and improves glycemic control in high fat diet induced obese mice. *Journal of Clinical Biochemistry and Nutrition*, *59*(1), 31–38. https://doi.org/10.3164/jcbn.15-30

Chung, H. (2015). The Meaning and Symbolism of Korean Food Culture. *Asia Review*, *5*(1), 97–121.

Chung, H.-K., Yang, H. J., Shin, D., & Chung, K. R. (2016). Aesthetics of Korean foods: The symbol of Korean culture. *Journal of Ethnic Foods*, *3*(3), 178–188. https://doi.org/10.1016/j.jef.2016.09.001

Contreras, J., & Armaiz, M. (2014). Alimentación y cultura. Perspectivas antropológicas. *Investigaciones Sociales*, *11*, 387–392. https://doi.org/10.15381/is.v11i19.8073

Cowling, R. M., Rundel, P. W., Lamont, B. B., Kalin Arroyo, M., & Arianoutsou, M. (1996). Plant diversity in mediterranean-climate regions. *Trends in Ecology & Evolution*, *11*(9), 362–366. https://doi.org/10.1016/0169-5347(96)10044-6

Elbaradei, G., Delacroixbuchet, A., & Ogier, J. (2008). Bacterial biodiversity of traditional Zabady fermented milk. *International Journal of Food Microbiology*, *121*(3), 295–301. https://doi.org/10.1016/j.ijfoodmicro.2007.11.014

Farkye, N. Y. (2004). Cheese technology. *International Journal of Dairy Technology*, *57*(2–3), 91–98. https://doi.org/10.1111/j.1471-0307.2004.00146.x

Favati, F., Galgano, F., & Pace, A. M. (2007). Shelf-life evaluation of portioned Provolone cheese packaged in protective atmosphere. *LWT - Food Science and Technology*, *40*(3), 480–488. https://doi.org/10.1016/j.lwt.2005.12.001

Fermentation of Foods in the Orient. (2006). In *Microbiology and Technology of Fermented Foods* (pp. 419–455). John Wiley & Sons, Ltd. https://doi.org/10.1002/9780470277515.ch12

Fermented Vegetables. (2006). In *Microbiology and Technology of Fermented Foods* (pp. 233–259). John Wiley & Sons, Ltd. https://doi.org/10.1002/9780470277515.ch7

Ferrières, J. (2004). The French paradox: Lessons for other countries. *Heart*, *90*(1), 107–111.

Ficca, G., Axelsson, J., Mollicone, D. J., Muto, V., & Vitiello, M. V. (2010). Naps, cognition and performance. *Sleep Medicine Reviews*, *14*(4), 249–258. https://doi.org/10.1016/j.smrv.2009.09.005

Fukushima, S., Takada, N., Hori, T., & Wanibuchi, H. (1997). Cancer prevention by organosulfur compounds from garlic and onion. *Journal of Cellular Biochemistry*, *67*(S27), 100–105. https://doi.org/10.1002/(SICI)1097-4644(1997)27+<100::AID-JCB16>3.0.CO;2-R

Furuta, M., Takeuchi, K., Shimazaki, Y., Takeshita, T., Shibata, Y., Hata, J., Yoshida, D., Park, D.-Y., Ninomiya, T., & Yamashita, Y. (2018). Comparison of the periodontal condition in Korean and Japanese adults: A cross-sectional study. *BMJ Open*, *8*, bmjopen-2018. https://doi.org/10.1136/bmjopen-2018-024332

Giraffa, G. (2021). The Microbiota of Grana Padano Cheese. A Review. *Foods*, *10*(11), Article 11. https://doi.org/10.3390/foods10112632

Gussow, J. D. (1995). Mediterranean diets: Are they environmentally responsible? *The American Journal of Clinical Nutrition*, *61*(6 Suppl), 1383S-1389S. https://doi.org/10.1093/ajcn/61.6.1383S

Ham, H., Sung, M., Kim, Y., Choi, Y., Jeong, H.-S., & Lee, J. (2012). *Determination of Capsaicinoids in Selected Commercial Pepper Powders and Pepper-Containing Products Using HPLC and Method Validation*. *41*(6), 870–874.

Han, A. L., Jeong, S.-J., Ryu, M.-S., Yang, H.-J., Jeong, D.-Y., Park, D.-S., & Lee, H. K. (2022). Anti-Obesity Effects of Traditional and Commercial Kochujang in Overweight and Obese Adults: A Randomized Controlled Trial. *Nutrients*, *14*(14), Article 14. https://doi.org/10.3390/nu14142783

Han, J.-S., Han, G.-P., Lee, J.-S., & Kim, Y.-J. (2009). A Survey on Americans' Area Perceptions for Korean Commercial Kimchi. *Journal of the East Asian Society of Dietary Life*, *19*(5), 681–689.

Han, K., Bose, S., Wang, J., Kim, B.-S., Kim, M. J., Kim, E.-J., & Kim, H. (2015). Contrasting effects of fresh and fermented kimchi consumption on gut microbiota composition and gene expression related to metabolic syndrome in obese Korean women. *Molecular Nutrition & Food Research*, *59*(5), 1004–1008. https://doi.org/10.1002/mnfr.201400780

Hassan, S. M. (2013). Soybean, Nutrition and Health. In *Soybean—Bio-Active Compounds*. IntechOpen. https://doi.org/10.5772/54545

Heo, J.-S., Kim, J.-B., Cho, S.-Y., Sohn, K.-H., & Choi, J.-W. (2014). Low-salt Todarodes pacificus Jeotgal improves the Learning and Memory Impairments in Scopolamine-induced Dementia Rats. *Korean Journal of Fisheries and Aquatic Sciences*, *47*(3), 195–203. https://doi.org/10.5657/KFAS.2014.0195

Hong, J., & Gruda, N. S. (2020). The Potential of Introduction of Asian Vegetables in Europe. *Horticulturae*, *6*(3), Article 3. https://doi.org/10.3390/horticulturae6030038

Hur, H. J., Lee, K. W., & Lee, H. J. (2004). Production of nitric oxide, tumor necrosis factor-α and interleukin-6 by RAW264.7 macrophage cells treated with lactic acid bacteria isolated from kimchi. *BioFactors*, *21*(1–4), 123–125. https://doi.org/10.1002/biof.552210124

Hutkins, R. W. (2008). *Microbiology and Technology of Fermented Foods*. John Wiley & Sons.

Hwang, H. S., Han, B. R., Han, B. J., & Chung, L. N. (2005). Korean traditional food. *Seoul (Korea): Kyomunsa*, 16–29.

Isolation and Identification of the Antagonistic Microorganisms Against Streptococous spp. Causing Dental Caries in Korean Soy Sauce. (2003). *Journal of Life Science*, *13*(4), 535–540.

Jana, A. H., & Mandal, P. K. (2011). Manufacturing and quality of mozzarella cheese: A review. *International Journal of Dairy Science*, *6*(4), 199–226.

Jang, H.-H., Noh, H., Kim, H.-W., Cho, S.-Y., Kim, H.-J., Lee, S.-H., Lee, S.-H., Gunter, M. J., Ferrari, P., Scalbert, A., Freisling, H., Kim, J.-B., Choe, J.-S., & Kwon, O. (2020). Metabolic tracking of isoflavones in soybean products and biosamples from healthy adults after fermented soybean consumption. *Food Chemistry*, *330*, 127317. https://doi.org/10.1016/j.foodchem.2020.127317

Jang, S.-H., Kim, M.-J., Lim, J., & Hong, J.-H. (2016). Cross-Cultural Comparison of Consumer Acceptability of Kimchi with Different Degree of Fermentation. *Journal of Sensory Studies*, *31*(2), 124–134. https://doi.org/10.1111/joss.12198

Jeon, D. H. (2019). A Study on the Relationship between the Korean Wave, Preference and Recognition of Korean Cuisine among Chinese. *Journal of the Korean Society of Food Culture*, *34*(3), 268–276. https://doi.org/10.7318/KJFC/2019.34.3.268

Jing, X., & Vermeersch, S. (2016). *A Chinese Traveler in Medieval Korea: Xu Jing's Illustrated Account of the Xuanhe Embassy to Koryŏ*. University of Hawai'i Press. https://www.jstor.org/stable/j.ctvvn5hv

Joo, J. I., Kim, D. H., Choi, J.-W., & Yun, J. W. (2010). Proteomic analysis for antiobesity potential of capsaicin on white adipose tissue in rats fed with a high fat diet. *Journal of Proteome Research*, *9*(6), 2977–2987.

Jung, K.-O., Park, S.-Y., & Park, K.-Y. (2006). Longer aging time increases the anticancer and antimetastatic properties of doenjang. *Nutrition*, *22*(5), 539–545. https://doi.org/10.1016/j.nut.2005.11.007

Jung, S.-J., Chae, S.-W., & Shin, D.-H. (2022). Fermented Foods of Korea and Their Functionalities. *Fermentation*, *8*(11), Article 11. https://doi.org/10.3390/fermentation8110645

Jung, Y.-J., & Choi, M.-J. (2015). Effects of Rubus coreanus-Cheonggukjang on Bone Mineral Density and Bone Mineral Content in Growing Rats. *Preventive Nutrition and Food Science*, *20*(4), 260–265.

Jy, K., & Ey, C. (2016). Changes in Korean Adult Females' Intestinal Microbiota Resulting from Kimchi Intake. *Journal of Nutrition & Food Sciences*, *06*(02). https://doi.org/10.4172/2155-9600.1000486

Kang, J.-H., Tsuyoshi, G., Le Ngoc, H., Kim, H.-M., Tu, T. H., Noh, H.-J., Kim, C.-S., Choe, S.-Y., Kawada, T., & Yoo, H. (2011). Dietary capsaicin attenuates metabolic dysregulation in genetically obese diabetic mice. *Journal of Medicinal Food*, *14*(3), 310–315.

Keys, A., Menotti, A., Karvonen, M. J., Aravanis, C., Blackburn, H., Buzina, R., Djordjevic, B. S., Dontas, A. S., Fidanza, F., & Keys, M. H. (1986). The diet and 15-year death rate in the seven countries study. *American Journal of Epidemiology*, *124*(6), 903–915. https://doi.org/10.1093/oxfordjournals.aje.a114480

Kim, D.-S., Cho, H.-W., Kim, D.-H., & Oh, K.-H. (2013). Functional Characterization of Lactobacillus sakei JK-17 Isolated from Long-term Fermented Kimchi, Muk Eun Ji. *KSBB Journal*, *28*(1), 18–23. https://doi.org/10.7841/ksbbj.2013.28.1.18

Kim, E. K., An, S.-Y., Lee, M.-S., Kim, T. H., Lee, H.-K., Hwang, W. S., Choe, S. J., Kim, T.-Y., Han, S. J., Kim, H. J., Kim, D. J., & Lee, K.-W. (2011). Fermented kimchi reduces body weight and improves metabolic parameters in overweight and obese patients. *Nutrition Research*, *31*(6), 436–443. https://doi.org/10.1016/j.nutres.2011.05.011

Kim, H.-Y., Park, E.-S., Choi, Y. S., Park, S. J., Kim, J. H., Chang, H. K., & Park, K.-Y. (2022). Kimchi improves irritable bowel syndrome: Results of a randomized, double-blind placebo-controlled study. *Food & Nutrition Research*. https://doi.org/10.29219/fnr.v66.8268

Kim, H.-Y., & Park, K.-Y. (2018). Clinical trials of kimchi intakes on the regulation of metabolic parameters and colon health in healthy Korean young adults. *Journal of Functional Foods*, *47*, 325–333. https://doi.org/10.1016/j.jff.2018.05.052

Kim, J.-S., & Kim, K. H. (2014). Processing and Characterization of Salt-Fermented Fish (Jeotgal) Using Seafood By-products in Korea. In S.-K. Kim (Ed.), *Seafood Processing By-Products: Trends and Applications* (pp. 63–99). Springer New York. https://doi.org/10.1007/978-1-4614-9590-1_5

Kim, N. Y., Song, E. J., Kwon, D. Y., Kim, H. P., & Heo, M. Y. (2008). Antioxidant and antigenotoxic activities of Korean fermented soybean. *Food and Chemical Toxicology: An International Journal Published for the British Industrial Biological Research Association*, *46*(3), 1184–1189. https://doi.org/10.1016/j.fct.2007.12.003

Kim, S. (2003). The functionality of anchovy sauce. *Food Industry and Nutrition*, *8*, 9–17.

Kim, S. H., & Jang, D. J. (2015). Fabulous Korean ethnic foods; namdo. Korea Food Research Institute. *Seoul (Korea): Elsevier*.

Kim, S. H., Kim, M. S., Lee, M. S., Park, Y. S., Lee, H. J., Kang, S., Lee, H. S., Lee, K.-E., Yang, H. J., Kim, M. J., Lee, Y.-E., & Kwon, D. Y. (2016). Korean diet: Characteristics and historical background. *Journal of Ethnic Foods*, *3*(1), 26–31. https://doi.org/10.1016/j.jef.2016.03.002

Kim, S. Y., Freeland-Graves, J. H., & Kim, H. J. (2020). Nineteen-year trends in fermented food consumption and sodium intake from fermented foods for Korean adults from 1998 to 2016. *Public Health Nutrition*, *23*(3), 515–524. https://doi.org/10.1017/S1368980019002994

Kim, S.-H., Chung, K. R., Yang, H.-J., & Kwon, D. Y. (2016). Sunchang gochujang (Korean red chili paste): The unfolding of authenticity. *Journal of Ethnic Foods*, *3*(3), 201–208. https://doi.org/10.1016/j.jef.2016.09.002

Kim, S.-H., Hwang, J.-T., Park, H. S., Kwon, D. Y., & Kim, M.-S. (2013). Capsaicin stimulates glucose uptake in C2C12 muscle cells via the reactive oxygen species (ROS)/AMPK/p38 MAPK pathway. *Biochemical and Biophysical Research Communications*, *439*(1), 66–70.

Kim Woong Seo. (n.d.). *Korean Waters Abound with Marine Life*.

Ko, J. W., Chung, Y.-S., Kwak, C. S., & Kwon, Y. H. (2019). Doenjang, A Korean Traditional Fermented Soybean Paste, Ameliorates Neuroinflammation and Neurodegeneration in Mice Fed a High-Fat Diet. *Nutrients*, *11*(8), Article 8. https://doi.org/10.3390/nu11081702

Koo, O. K., Lee, S. J., Chung, K. R., Jang, D. J., Yang, H. J., & Kwon, D. Y. (2016). Korean traditional fermented fish products: Jeotgal. *Journal of Ethnic Foods*, *3*(2), 107–116. https://doi.org/10.1016/j.jef.2016.06.004

Kwak, C. S., Park, S. C., & Song, K. Y. (2012). Doenjang, a Fermented Soybean Paste, Decreased Visceral Fat Accumulation and Adipocyte Size in Rats Fed with High Fat Diet More Effectively Than Nonfermented Soybeans. *Journal of Medicinal Food*, *15*(1), 1–9. https://doi.org/10.1089/jmf.2010.1224

Kwon, D. Y., Chung, K. R., Yang, H.-J., & Jang, D.-J. (2015). Gochujang (Korean red pepper paste): A Korean ethnic sauce, its role and history. *Journal of Ethnic Foods*, *2*(1), 29–35. https://doi.org/10.1016/j.jef.2015.02.006

Kwon, D. Y., Hong, S. M., Ahn, I. S., Kim, Y. S., Shin, D. W., & Park, S. (2009). Kochujang, a Korean fermented red pepper plus soybean paste, improves glucose homeostasis in 90% pancreatectomized diabetic rats. *Nutrition*, *25*(7), 790–799. https://doi.org/10.1016/j.nut.2008.12.006

Lairon, D. (2010). Nutritional quality and safety of organic food. A review. *Agronomy for Sustainable Development*, *30*(1), 33–41. https://doi.org/10.1051/agro/2009019

Lee, H., Chang, M.-J., & Kim, S.-H. (2010). Effects of poly-γ-glutamic acid on serum and brain concentrations of glutamate and GABA in diet-induced obese rats. *Nutrition Research and Practice*, *4*(1), 23–29. https://doi.org/10.4162/nrp.2010.4.1.23

Lee, H.-J., Jung, K.-O., Jeon, S.-H., Park, K.-Y., & Lee, W.-H. (2000). Effects of salt and fermented anchovy extract on the somatic mutagenicity in Drosophila wing spot test system. *JOURNAL-KOREAN SOCIETY OF FOOD SCIENCE AND NUTRITION*, *29*(6), 1139–1144.

Lee, K. W., Park, J. Y., Sa, H. D., Jeong, J. H., Jin, D. E., Heo, H. J., & Kim, J. H. (2014). Probiotic properties of Pediococcus strains isolated from jeotgals, salted and fermented Korean sea-food. *Anaerobe*, *28*, 199–206. https://doi.org/10.1016/j.anaerobe.2014.06.013

Lee, M., Kim, C., Kim, I., & Kim, Y. (2011). Effects of capsaicin on lipid catabolism in 3T3-L1 adipocytes. *Phytotherapy Research*, *25*(6), 935–939.

Lee, M.-S., & Shin, K.-S. (2014). Intestinal Immune-Modulating Activities of Polysaccharides Isolated from Commercial and Traditional Korean Soy Sauces. *Journal of the Korean Society of Food Science and Nutrition*, *43*(1), 9–15. https://doi.org/10.3746/jkfn.2014.43.1.009

Lee, N.-K., Kim, H.-W., Chang, H.-I., Yun, C.-W., Kim, S.-W., Kang, C.-W., & Paik, H.-D. (2006). Probiotic properties of Lactobacillus plantarum NK181 lsolated from jeotgal, a Korean fermented food. *Food Science and Biotechnology*, *15*(2), 227–231.

Legras, J.-L., Merdinoglu, D., Cornuet, J.-M., & Karst, F. (2007). Bread, beer and wine: Saccharomyces cerevisiae diversity reflects human history. *Molecular Ecology*, *16*(10), 2091–2102. https://doi.org/10.1111/j.1365-294X.2007.03266.x

Lick, S., Drescher, K., & Heller, K. J. (2001). Survival of Lactobacillus delbrueckii subsp. Bulgaricus and Streptococcus thermophilus in the terminal ileum of fistulated Göttingen minipigs. *Applied and Environmental Microbiology*, *67*(9), 4137–4143. https://doi.org/10.1128/AEM.67.9.4137-4143.2001

Lim, H., Kim, S., Yoo, E., Kang, D., Choi, M., & Song, S. (2001). Anticancer effect of extracts from the marine and salted fish products. *Korean J Life Sci*, *11*, 48–53.

Lim, J.-H., Jung, E.-S., Choi, E.-K., Jeong, D.-Y., Jo, S.-W., Jin, J.-H., Lee, J.-M., Park, B.-H., & Chae, S.-W. (2015). Supplementation with Aspergillus oryzae-fermented kochujang lowers serum cholesterol in subjects with hyperlipidemia. *Clinical Nutrition*, *34*(3), 383–387. https://doi.org/10.1016/j.clnu.2014.05.013

Lim, Y.-S., Kim, J., & Kang, H. (2019). Isolation and Identification of Lactic Acid Bacteria with Probiotic Activities from Kimchi and Their Fermentation Properties in Milk. *Journal of Dairy Science and Biotechnology*, *37*(2), 115–128. https://doi.org/10.22424/jmsb.2019.37.2.115

Lionello, P., Abrantes, F., Congedi, L., Dulac, F., Gacic, M., Gomis, D., Goodess, C., Hoff, H., Kutiel, H., Luterbacher, J., Planton, S., Reale, M., Schröder, K., Vittoria Struglia, M., Toreti, A., Tsimplis, M., Ulbrich, U., & Xoplaki, E. (2012). Introduction: Mediterranean Climate—Background Information. In P. Lionello (Ed.), *The Climate of the Mediterranean Region* (pp. xxxv–xc). Elsevier. https://doi.org/10.1016/B978-0-12-416042-2.00012-4

Masood, M. I., Qadir, M. I., Shirazi, J. H., & Khan, I. U. (2011). Beneficial effects of lactic acid bacteria on human beings. *Critical Reviews in Microbiology*, *37*(1), 91–98. https://doi.org/10.3109/1040841X.2010.536522

McCarty, M. F., DiNicolantonio, J. J., & O'Keefe, J. H. (2015). Capsaicin may have important potential for promoting vascular and metabolic health. *Open Heart*, *2*(1), e000262.

McGovern, P. E., Hartung, U., Badler, V. R., Glusker, D. L., & Exner, L. J. (1997). The beginnings of winemaking and viniculture in the ancient Near East and Egypt. *Expedition*, *39*(1), 3–21.

McGovern, P. E., Zhang, J., Tang, J., Zhang, Z., Hall, G. R., Moreau, R. A., Nuñez, A., Butrym, E. D., Richards, M. P., Wang, C., Cheng, G., Zhao, Z., & Wang, C. (2004). Fermented beverages of pre- and proto-historic China. *Proceedings of the National Academy of Sciences*, *101*(51), 17593–17598. https://doi.org/10.1073/pnas.0407921102

Medina, F. X. (1996). Alimentación, dieta y comportamientos alimentarios en el contexto mediterráneo. *La alimentación mediterránea : historia, cultura, nutrición, 1996, ISBN 84-7426-287-9, págs. 21-46*, 21–46. https://dialnet.unirioja.es/servlet/articulo?codigo=1018653

Mefleh, M., Darwish, A. M. G., Mudgil, P., Maqsood, S., & Boukid, F. (2022). Traditional Fermented Dairy Products in Southern Mediterranean Countries: From Tradition to Innovation. *Fermentation*, *8*(12), Article 12. https://doi.org/10.3390/fermentation8120743

Memorabilia of the Three Kingdoms. (1983). Ŭryu Munhwasa. https://books.google.it/books?id=0UxVPwAACAAJ

Monsivais, P., Aggarwal, A., & Drewnowski, A. (2014). Time Spent on Home Food Preparation and Indicators of Healthy Eating. *American Journal of Preventive Medicine*, *47*(6), 796–802. https://doi.org/10.1016/j.amepre.2014.07.033

Moon, H.-J., & Cha, Y.-S. (2023). Sustainability of K-Food: Focused on the change in the health values of K-Food. *Journal of Ethnic Foods*, *10*(1), 23. https://doi.org/10.1186/s42779-023-00184-5

Mun, E.-G., Park, J. E., & Cha, Y.-S. (2019). Effects of Doenjang, a Traditional Korean Soybean Paste, with High-Salt Diet on Blood Pressure in Sprague-Dawley Rats. *Nutrients*, *11*(11), 2745. https://doi.org/10.3390/nu11112745

Mun, E.-G., Sohn, H.-S., Kim, M.-S., & Cha, Y.-S. (2017). Antihypertensive effect of Ganjang (traditional Korean soy sauce) on Sprague-Dawley Rats. *Nutrition Research and Practice*, *11*(5), 388–395. https://doi.org/10.4162/nrp.2017.11.5.388

Myers, N., Mittermeier, R. A., Mittermeier, C. G., da Fonseca, G. A., & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature*, *403*(6772), 853–858. https://doi.org/10.1038/35002501

Nam, Y. R., Won, S. B., Chung, Y.-S., Kwak, C. S., & Kwon, Y. H. (2015). Inhibitory effects of Doenjang, Korean traditional fermented soybean paste, on oxidative stress and inflammation in adipose tissue of mice fed a high-fat diet. *Nutrition Research and Practice*, *9*(3), 235–241. https://doi.org/10.4162/nrp.2015.9.3.235

NAUREEN, Z., BONETTI, G., MEDORI, M. C., AQUILANTI, B., VELLUTI, V., MATERA, G., IACONELLI, A., & BERTELLI, M. (2022). Foods of the Mediterranean diet: Lacto-fermented food, the food pyramid and food combinations. *Journal of Preventive Medicine and Hygiene*, *63*(2 Suppl 3), E28–E35. https://doi.org/10.15167/2421-4248/jpmh2022.63.2S3.2744

Nic Craith, M., Kockel, U., & Lloyd, K. (2018). The Convention for the Safeguarding of the Intangible Cultural Heritage. In N. Akagawa & L. Smith (Eds.), *Safeguarding Intangible Heritage* (1st ed., pp. 118–132). Routledge. https://doi.org/10.4324/9780429507137-9

Organization, W. H. (2003). *Diet, nutrition and the prevention of chronic diseases: Report of a joint WHO/FAO expert consultation, Geneva, 28 January—1 February 2002* (p. 149 p.). World Health Organization.

Park, H.-J., Ko, J.-M., Lim, J., & Hong, J.-H. (2020). American consumers' perception and acceptance of an ethnic food with strong flavor: A case study of Kimchi with varying levels of red pepper and fish sauce. *Journal of the Science of Food and Agriculture*, *100*(6), 2348–2357. https://doi.org/10.1002/jsfa.10106

Park, J.-E., Oh, S.-H., & Cha, Y.-S. (2014). *Lactobacillus plantarum* LG42 isolated from gajami sik-hae decreases body and fat pad weights in diet-induced obese mice. *Journal of Applied Microbiology*, *116*(1), 145–156. https://doi.org/10.1111/jam.12354

Park, K.-Y., Kim, S.-H., Suh, M.-J., & Chung, H.-Y. (1991). Inhibitory effects of garlic on the mutagenicity in Salmonella assay system and on the growth of HT-29 human colon carcinoma cells. *Korean Journal of Food Science and Technology*, *23*(3), 370–374.

Park, M.-S., Song, N.-E., Baik, S.-H., Pae, H.-O., & Park, S. H. (2017). Oral administration of lactobacilli isolated from Jeotgal, a salted fermented seafood, inhibits the development of 2,4-dinitrofluorobenzene-induced atopic dermatitis in mice. *Experimental and Therapeutic Medicine*, *14*(1), 635–641. https://doi.org/10.3892/etm.2017.4536

Pastoriza, S., & Rufián-Henares, J. A. (2014). Contribution of melanoidins to the antioxidant capacity of the Spanish diet. *Food Chemistry*, *164*, 438–445. https://doi.org/10.1016/j.foodchem.2014.04.118

Patra, J. K., Das, G., Paramithiotis, S., & Shin, H.-S. (2016). Kimchi and Other Widely Consumed Traditional Fermented Foods of Korea: A Review. *Frontiers in Microbiology*, *7*. https://www.frontiersin.org/articles/10.3389/fmicb.2016.01493

Pederson, C. S. (1971). Microbiology of food fermentations. *Microbiology of Food Fermentations.* https://www.cabdirect.org/cabdirect/abstract/19720401914

Perpetuini, G., Prete, R., Garcia-Gonzalez, N., Khairul Alam, M., & Corsetti, A. (2020). Table Olives More than a Fermented Food. *Foods*, *9*(2), Article 2. https://doi.org/10.3390/foods9020178

Pettid, M. J. (2008). *Korean Cuisine: An Illustrated History*.

Poli, A. (2013). *DIETA MEDITERRAnEA E PREVEnzIOnE CARDIOVASCOLARE: un InTERESSAnTE STuDIO DI InTERVEnTO COnTROLLATO*.

Pretorius, I. S. (2000). Tailoring wine yeast for the new millennium: Novel approaches to the ancient art of winemaking. *Yeast*, *16*(8), 675–729. https://doi.org/10.1002/1097-0061(20000615)16:8<675::AID-YEA585>3.0.CO;2-B

Radnaabazar, C., Park, C. M., Kim, J. H., Cha, J., & Song, Y.-S. (2011). Fibrinolytic and Antiplatelet Aggregation Properties of a Recombinant Cheonggukjang Kinase. *Journal of Medicinal Food*, *14*(6), 625–629. https://doi.org/10.1089/jmf.2010.1233

Ramírez-Anaya, J. D. P., Samaniego-Sánchez, C., Castañeda-Saucedo, M. C., Villalón-Mir, M., & de la Serrana, H. L.-G. (2015). Phenols and the antioxidant capacity of Mediterranean vegetables prepared with extra virgin olive oil using different domestic cooking techniques. *Food Chemistry*, *188*, 430–438. https://doi.org/10.1016/j.foodchem.2015.04.124

Salque, M., Bogucki, P. I., Pyzel, J., Sobkowiak-Tabaka, I., Grygiel, R., Szmyt, M., & Evershed, R. P. (2013). Earliest evidence for cheese making in the sixth millennium bc in northern Europe. *Nature*, *493*(7433), 522–525. https://doi.org/10.1038/nature11698

Sealey, P. R., & Tyers, P. A. (1989). Olives from Roman Spain: A Unique Amphora find in British Waters. *The Antiquaries Journal*, *69*(1), 53–72. https://doi.org/10.1017/S0003581500043419

Seung-Yong, C., & Eung-Ho, L. E. E. (1976). THE TASTE COMPOUNDS FERMENTED ACETES CHINENSIS. *Korean Journal of Fisheries and Aquatic Sciences*, *9*(2), 79–110.

Shaha, R. K., Rahman, S., & Asrul, A. (2013). Bioactive compounds in chilli peppers (Capsicum annuum L.) at various ripening (green, yellow and red) stages. *Annals of Biological Research*, *4*(8), 27–34.

Shin, B.-K., Oh, M.-H., Shin, T.-S., Kim, Y.-S., You, S.-M., Roh, G.-Y., & Jung, K.-W. (2014). The Impact of Korean Wave Cultural Contents on the Purchase of Han-Sik (Korean food) and Korean Product—Based on the Survey of Asia (Japan, China), Americas and Europe -. *Journal of the Korean Society of Food Culture*, *29*(3), 250–258. https://doi.org/10.7318/KJFC/2014.29.3.250

Shin, D. H. (2011). Utilization of Soybean as Food Stuffs in Korea. In *Soybean and Nutrition*. IntechOpen. https://doi.org/10.5772/21966

Shin, D., & Jeong, D. (2015). Korean traditional fermented soybean products: Jang. *Journal of Ethnic Foods*, *2*(1), 2–7. https://doi.org/10.1016/j.jef.2015.02.002

Shin, H. W., Jang, E. S., Moon, B. S., Lee, J. J., Lee, D. E., Lee, C. H., & Shin, C. S. (2016). Anti-obesity effects of gochujang products prepared using rice koji and soybean meju in rats. *Journal of Food Science and Technology*, *53*(2), 1004–1013. https://doi.org/10.1007/s13197-015-2162-z

Shin, I.-U., Kwun, S.-Y., Park, E.-H., Yi, J.-H., & Kim, M.-D. (2019). *Exploration of β-Glucuronidase Activity of Lactic Acid Bacteria Isolated from Kimchi*. *47*(3), 434–440. https://doi.org/10.4014/mbl.1901.01002

Shin, S.-K., Kwon, J.-H., Jeong, Y.-J., Jeon, S.-M., Choi, J.-Y., & Choi, M.-S. (2011). Supplementation of Cheonggukjang and Red Ginseng Cheonggukjang Can Improve Plasma Lipid Profile and Fasting Blood Glucose Concentration in Subjects with Impaired Fasting Glucose. *Journal of Medicinal Food*, *14*(1–2), 108–113. https://doi.org/10.1089/jmf.2009.1366

Sikalidis, A. K., Kelleher, A. H., & Kristo, A. S. (2021). Mediterranean Diet. *Encyclopedia*, *1*(2), Article 2. https://doi.org/10.3390/encyclopedia1020031

Smith, N. W., Fletcher, A. J., Hill, J. P., & McNabb, W. C. (2022). Modeling the Contribution of Milk to Global Nutrition. *Frontiers in Nutrition*, *8*. https://www.frontiersin.org/articles/10.3389/fnut.2021.716100

Some Probiotic Properties of Some Lactic Acid Bacteria and Yeasts Isolated from Jeot-gal. (2003). *Microbiology and Biotechnology Letters*, *31*(3), 297–300.

Song, H. J., & Lee, H.-J. (2014). Consumption of kimchi, a salt fermented vegetable, is not associated with hypertension prevalence. *Journal of Ethnic Foods*, *1*(1), 8–12. https://doi.org/10.1016/j.jef.2014.11.004

Song, H.-S., Kim, Y.-M., & Lee, K.-T. (2008). Antioxidant and Anticancer Activities of Traditional Kochujang Added with Garlic Porridge. *Journal of Life Science*, *18*(8), 1140–1146. https://doi.org/10.5352/JLS.2008.18.8.1140

Song, J.-L., Choi, J.-H., Seo, J.-H., Lim, Y.-I., & Park, K.-Y. (2014). Anti-colitic effects of kanjangs (fermented soy sauce and sesame sauce) in dextran sulfate sodium-induced colitis in mice. *Journal of Medicinal Food*, *17*(9), 1027–1035. https://doi.org/10.1089/jmf.2013.3119

Song, J.-L., Choi, J.-H., Seo, J.-H., & Park, K.-Y. (2018). Fermented Ganjangs (Soy Sauce and Sesame Sauce) Attenuates Colonic Carcinogenesis in Azoxymethane/Dextran Sodium Sulfate-Treated C57BL/6J Mice. *Journal of Medicinal Food*, *21*(9), 905–914. https://doi.org/10.1089/jmf.2017.4111

Song, N.-E., Kim, N.-J., Kim, Y.-H., & Baik, S.-H. (2021). Probiotic Properties of Lactic Acid Bacteria with High Conjugated Linoleic Acid Converting Activity Isolated from Jeot-Gal, High-Salt Fermented Seafood. *Microorganisms*, *9*(11), Article 11. https://doi.org/10.3390/microorganisms9112247

Sue Radd-Vagenas, Antigone Kouris-Blazos, Maria Fiatarone Singh, & Victoria M Flood. (2017). Evolution of Mediterranean diets and cuisine: Concepts and definitions. *Asia Pacific Journal of Clinical Nutrition*, *26*(5). https://doi.org/10.6133/apjcn.082016.06

Sukkar, S. (2011). Mediterranean diet? No, thanks: Mediterranean lifestyle! *Mediterranean Journal of Nutrition and Metabolism*, *4*, 79–81. https://doi.org/10.1007/s12349-011-0070-y

Sung, M.-H., Park, C., Kim, C.-J., Poo, H., Soda, K., & Ashiuchi, M. (2005). Natural and edible biopolymer poly-gamma-glutamic acid: Synthesis, production, and applications. *Chemical Record (New York, N.Y.)*, *5*(6), 352–366. https://doi.org/10.1002/tcr.20061

Surya, R., & Lee, A. G.-Y. (2022). Exploring the philosophical values of kimchi and kimjang culture. *Journal of Ethnic Foods*, *9*(1), 20. https://doi.org/10.1186/s42779-022-00136-5

Sustainable diets and Biodiversity—Directions and solutions for policy, research and action. (n.d.).

Tamang, J. P., Cotter, P. D., Endo, A., Han, N. S., Kort, R., Liu, S. Q., Mayo, B., Westerik, N., & Hutkins, R. (2020). Fermented foods in a global age: East meets West. *Comprehensive Reviews in Food Science and Food Safety*, *19*(1), 184–217. https://doi.org/10.1111/1541-4337.12520

The Impact of the Korean Wave on Korean Food Consumption of Thai Consumers | Journal of ASEAN PLUS Studies. (n.d.). Retrieved 13 June 2023, from https://so06.tci-thaijo.org/index.php/aseanplus/article/view/260696

Thompson Coon, J., Boddy, K., Stein, K., Whear, R., Barton, J., & Depledge, M. H. (2011). Does Participating in Physical Activity in Outdoor Natural Environments Have a Greater Effect on Physical and Mental Wellbeing than Physical Activity Indoors? A Systematic Review. *Environmental Science & Technology*, *45*(5), 1761–1772. https://doi.org/10.1021/es102947t

Weerapan Khovidhunkit, M. (2009). Pharmacokinetic and the effect of capsaicin in Capsicum frutescens on decreasing plasma glucose level. *J Med Assoc Thai*, *92*(1), 108–113.

Wirawati, C. U., Sudarwanto, M. B., Lukman, D. W., Wientarsih, I., & Srihanto, E. A. (2019). Diversity of lactic acid bacteria in dadih produced by either back-slopping or spontaneous fermentation from two different regions of West Sumatra, Indonesia. *Veterinary World*, *12*(6), 823–829. https://doi.org/10.14202/vetworld.2019.823-829

Woo, H., Park, J. E., & Cha, Y.-S. (2020). Korean Traditional Fermented Soybean Paste (Doenjang) Regulate Renin-Angiotensin System (RAS) in 3T3-L1 Adipocytes. *Current Developments in Nutrition*, *4*, nzaa052_060. https://doi.org/10.1093/cdn/nzaa052_060

Yang, K.-M. (2015). The Effects of Chungkukjang Powder Supplements on the Regulation of Blood Glucose and Inflammation in Diabetic Rats. *Korean journal of food and cookery science*, *31*(2), 118–127. https://doi.org/10.9724/kfcs.2015.31.2.118

Yao, Z., Kim, J. A., & Kim, J. H. (2019). Characterization of a Fibrinolytic Enzyme Secreted by Bacillus velezensis BS2 Isolated from Sea Squirt Jeotgal. *Journal of Microbiology and Biotechnology*, *29*(3), 347–356. https://doi.org/10.4014/jmb.1810.10053

김지상, 문갑순, 이경희, & 이영순. (2006). 황석어(Collichthys nireatus Jordan et starks) 젓갈의 숙성과정 중 품질변화와 항산화작용에 관한 연구. 한국식품영양과학회지, *35*(2), 171–176.

이상조, 류승희, 이영순, 송영선, & 문갑순. (2003). 고도불포화지방산 함량이 높은 유지를 섭취시킨 흰쥐에서 양조간장과 멜라노이딘의 지질산화 억제효과. 한국식품영양과학회지, *32*(6), 913–920.