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The role of kimchi in modulating gut microbiota diversity and supporting gastrointestinal health

Gabriela Ragan[1*], Oliwia Cecelska[1], Julia Niedźwiecka[1], Aleksandra Korżel[1], Ewelina Roksana Wojna[1], Jędrzej Mogilany[1], Kamil Źródłowski[1], Karolina Górowska[1], Patrycja Anita Kobrzyńska[2], Natalia Cegielska[1]

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Authors' Affiliation:
[1]Medical University of Lodz, 4 Tadeusza Kościuszki St., 90-419 Łódź, Poland
[2]University Clinical Hospital No. 2 of the Medical University of Lodz, 113 Stefana Żeromskiego St., 90-549 Łódź, Poland

***Corresponding author:**
Gabriela Ragan
Medical University of Lodz, 4 Tadeusza Kościuszki St., 90-419 Łódź, Poland
E-mail: gabirag22@gmail.com

Orcid List

Gabriela Ragan	0009-0002-0869-6543
Oliwia Cecelska	0009-0003-3054-7023
Julia Niedźwiecka	0009-0002-8387-6085
Aleksandra Korżel	0009-0002-5388-9168
Ewelina Roksana Wojna	0009-0006-7049-5477
Jędrzej Mogilany	0009-0001-6471-653X
Kamil Źródłowski	0009-0001-1088-4853
Karolina Górowska	0009-0009-0088-6079
Patrycja Anita Kobrzyńska	0009-0008-0476-5111
Natalia Cegielska	0000-0002-2484-9637

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ABSTRACT

Fermented foods have been an essential part of the human diet for thousands of years. One of the most popular Korean fermented foods is kimchi. It consists of diverse ingredients and is produced via fermentation by Lactic Acid Bacteria (LAB). A cabbage is a key ingredient in kimchi. Kimchi ingredients are divided into essential and optional ingredients. Basic ingredients, including cabbage, garlic, red pepper, and radish, are correlated with the composition of microbial community. Kimchi cabbage parts, leaves and roots, contain different amounts of principal and trace elements. Personal preferences, region of production, and tradition influence the choice of optional ingredients. Various ingredients, parts of vegetables and the abundance of elements positively impact gastrointestinal health and intestinal flora differently. Kimchi's health-improving abilities also depend on appropriate preparation and environmental conditions of fermentation. High temperature (10-15 °C) of fermentation increases the level of the largest genus within the LAB group – *Lactobacillus*. The type of salt which is a crucial kimchi component impacts on bacteria composition. Regular kimchi consumption delivers diverse LAB strains, dietary fibre, vitamins, proteins participating in immunological processes, improves gastrointestinal health state and modifies gut microbiota. It positively impacts on gastrointestinal barrier, mucus secretion, combating with infections and pathogene and overall health. Additionally, it supports cardiovascular health and cholesterol reduction, and it has immunological, anti-inflammatory, antibacterial, antioxidant, anticancer, anti-obesity, and probiotic properties. This review aims to explain how kimchi, through its production, fermentation conditions, LAB, ingredients, and different vegetable parts, beneficially affects gastrointestinal health and gut microbiota.

Keywords: Kimchi, intestinal flora, gastrointestinal health, lactic acid bacteria, fermented food

1. INTRODUCTION

The human diet has included fermented food for thousands of years. Fermentation is a process induced by microorganisms and can be carried out using either plant-based or animal enzymes. It occurs via anaerobic or partially anaerobic decomposition of different substances, mainly carbohydrates, into other compounds. There are two main types of this process: lactic acid fermentation and ethanol fermentation. The products of these processes are alcohols, carbon dioxide, and organic acids. These create an acidic medium that inhibits microbial growth and inactivates some enzymes, making food safer to consume. As a result of these processes, fermentation is well-established in the human diet (Leeuwendaal et al., 2022; Chilton et al., 2015). Many different types of food can undergo fermentation, ranging from meat and fish through legumes, dairy, cereal, to fruit and vegetables. Historically, it was used for preservation and protection against contamination by pathogenic microorganisms. Over the years, the popularity of fermented foods has significantly increased because of the additional benefits they provide, such as improved nutritional quality, unique tastes created by new flavours and textures, environmental benefits like reduced overproduction or food loss, and diverse health benefits across different health areas (Dimidi et al., 2019; Li et al., 2022). Microorganisms in fermented foods can modify the composition of the human gut microbiota (Jahn et al., 2023; Pasolli et al., 2020). There are many ways to improve the condition of our microbiome, including regular consumption of fermented foods. Although many products fall into this category, this review will focus on kimchi. Kimchi is one of the most popular fermented products with a long culinary history in Korea. The typical yearly intake of kimchi per individual in Korea is around 22kg (Chilton et al., 2015). It consists mainly of cabbage, green onion, leaf mustard, and radish. It also contains additional ingredients like garlic, ginger, salt, red pepper, fermented fish, and others (Lee et al., 2021; Song et al., 2021). Kimchi results from spontaneous fermentation by the microorganisms naturally present in cabbage and other kimchi ingredients. It can also be commercially produced by using starter cultures of bacteria (Dimidi et al., 2019).

The fermentation process itself, as well as adding salt, suppresses putrefactive bacteria. Many bacteria are involved in this process; however, it is predominantly carried out by lactic acid bacteria (LAB). LAB and their fermentation byproducts help eliminate putrefactive bacteria and other contaminants (Park et al., 2014). LAB is a large group of homo- and heterolactic acid bacteria, including *Lactobacillus, Streptococcus, Enterococcus, Lactococcus*, and *Bifidobacterium* (Chilton et al., 2015; Masood et al., 2011). LAB fermented foods are considered beneficial for health due to the probiotic properties of LAB and their fermentation metabolites. Kimchi is regarded as a natural functional food because of its high-quality health benefits arising from its contents, including dietary fibres, minerals, vitamins, capsaicin, organic acids, polyphenols, and fermentation byproducts (Castellone et al., 2021). This review focuses on the positive effects of kimchi on gut microbiota. It focuses on how production, fermentation process conditions, LAB, different ingredients, and parts of vegetables positively impact gastrointestinal health and modify intestinal flora.

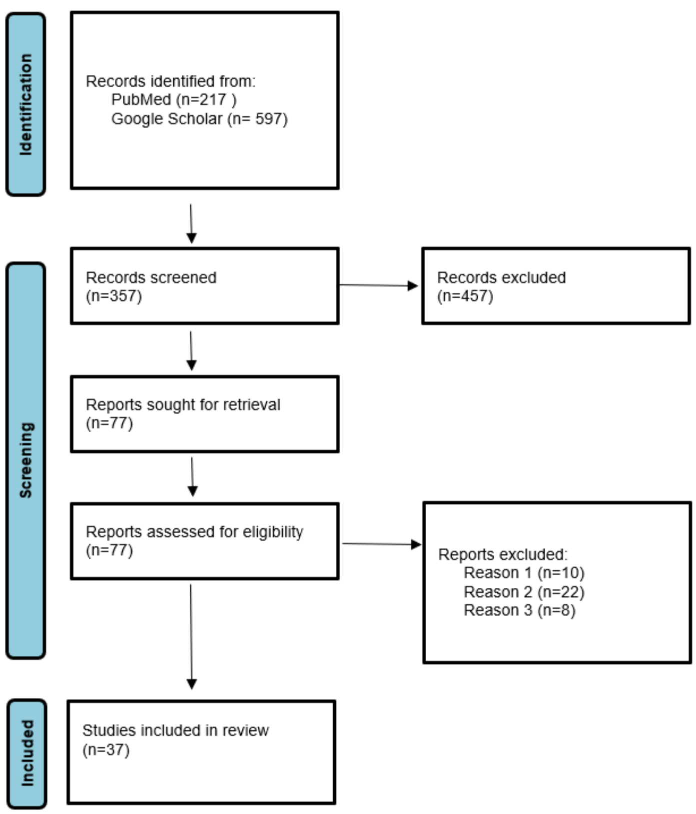

Figure 1: PRISMA flowchart

2. REVIEW METHODS

This review was prepared based on publications available in PubMed and Google Scholar databases. Studies were selected using keywords related to the subject, alone or in different combinations. The search concerned clinical and scientific studies published between 2005 and 2024, with an emphasis on the recent findings. The purpose of this review was to explore how kimchi positively affects the gut microbiome. Particular attention was given to the roles of production methods, fermentation conditions, LAB, diverse ingredients, and various vegetable components in supporting gastrointestinal health and shaping the composition of the intestinal microbiome.

Titles and abstracts were systematically assessed for relevance to the review's objectives, and publications were excluded if they did not match our research scope. The reasons for exclusion targeted non-English publications (reason 1), lack of access to the full text (reason 2), and studies with incomplete or missing informations associated with the theme. (reason 3). The review considered observational studies, randomised controlled trials, systematic reviews, and relevant clinical studies. A Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram was prepared to illustrate the study selection process (Figure 1).

3. RESULTS & DISCUSSION

Kimchi production and fermentation process conditions (temperature and type of salt)

Kimchi preparation has a determined order. At the beginning, vegetables are chopped into thin slices, brined for 5 to 10 hours, washed with water, drained, and mixed with other ingredients and seasonings afterwards. Spontaneous fermentation occurs at low temperatures, which helps different types of LAB to grow. These microorganisms exhibit a psychrophilic or psychrotolerant nature. They can live without much oxygen because their metabolism is facultatively anaerobic. These properties allow them to remain stable in salty and acidic conditions (Jeong et al., 2013; Jung et al., 2024). The kimchi fermentation environment is high-salinity, anaerobic, acidic, with a low pH, cold, and commonly at temperatures around 2-6 °C (Jung et al., 2024; Lee et al., 2021). pH and acidity affect LAB growth and are significant indicators of kimchi maturity (Min et al., 2022).

As fermentation progresses, pH decreases (Lee et al., 2022). Final product, kimchi, contains different microorganisms, including *Leuconostoc mesenteroides*, *Leuconostoc gasicomitatum*, *Weissella confuse*, *Leuconostoc gelidum*, *Weissella koreensis*, *Lactobacillus sakei*, *Lactobacillus plantarum*, *Lactobacillus curvatus*, *Trichosporon domesticum*, *Trichosporon loubieri*, *Saccharomyces unisporus*, and *Pichia kluyveri*. The amounts of *Leuconostoc*, *Weissella*, and *Lactobacillus* range from 10^7 to 10^8 cfu/g (Rezac et al., 2018). However, after fermentation starts, bacterial diversity decreases, and within only three days, *Leuconostoc* becomes dominant, especially *Leuconostoc gasicomitatum* and *Leuconostoc gelidum* (Dimidi et al., 2019). The fermentation process depends on different factors that impact the kimchi taste, texture, fermentation byproducts, health benefits, and bacterial composition. Fermentation temperature significantly impacts the composition and variety of metabolite products in kimchi.

A study by Jung et al., (2024) analysed three different temperature conditions. Researchers prepared kimchi samples and refrigerated them for 4 weeks at 4°C, 10°C, and 15°C, respectively. They followed fermentation by measuring bacterial count and acidity. The analysis used 16S rDNA isolated from the samples. In comparison to low temperature (4 °C), high temperature (10–15 °C) changed gut microbiota diversity. Kimchi prepared at 10°C and 15°C showed a greater diversity of LAB species than that prepared at 4°C. The increase in *Lactiplantibacillus plantarum* and *Latilactobacillus sakei* and the reduction in *Lactococcus lactis* were especially emphasised. At 4°C, *Leuconostoc* fermentation was dominant. Alternative kimchi production initiates a more rapid fermentation at around 20°C, and after a few days, the temperature decreases. It contributes to bacterial proliferation and to an increase in *Lactobacillus*. Fermentation in different temperature conditions and alternative production confirm that increased temperature affects bacterial diversity. Additionally, increasing temperature reduces the sugar content and pH. It leads to the acidification of kimchi (Jung et al., 2024). Higher temperature increases the level of *Lactobacillus*. This genus is the largest genus within the LAB group. It supports gut microbiota and is considered probiotic. *Lactobacillus* helps maintain the durability of the gastrointestinal barrier. Different species promote mucus secretion and, as a result, defences against different pathogens. The level of *L. plantarum* increases in high-temperature conditions of kimchi preparation. It is one of several *Lactobacillus* strains that increase secretory immunoglobulin A (sIgA) levels in the small intestine. sIgA broadens the intestinal barrier by intraepithelial defences against pathogens.

Additionally, *Lactobacillus* stabilises adherent junctions. *L. plantarum* modifies gene expression of tight junction (TJ) and adherent junction proteins. Different *Lactobacillus* strains participate in various defence against bacterial infection (Dempsey and Corr, 2022; Mujagic et al., 2017). The studies in this review suggest that conditions, especially fermentation temperature, have significant implications. They affect microbial composition. Diverse bacterial genera yield varied compounds promoting health and therapeutic purposes. In order that kimchi may deliver plenty of health-improving properties and present proper quality, it has to be prepared with due care and in appropriate conditions, including temperature.

The microbial community in kimchi fermentation also depends on the type of salt used, a crucial ingredient in kimchi production. A study by Lee et al., (2022) investigated this connection and the correlation with the total number of viable bacteria. Moreover, the type of salt affects the type and concentration of metabolites found in fermented kimchi.

Salt is responsible for the appropriate taste and preservation of kimchi. It suppresses the growth of pathogenic microorganisms and impacts the selective growth of salt-resistant LAB. Salt concentration of 2–3% or less is optimal. There are different types of salt used to prepare kimchi. They include solar salt aged for 1 year (SS1), solar salt aged for 3 years (SS3), dehydrated solar salt (DSS), and purified salt (PS). There are some differences between these types. The most commonly used purified salt includes sodium chloride without any additives. In contrast, solar salt contains minerals including magnesium (Mg), calcium (Ca), sulphur (S), potassium (K), iron (Fe), manganese (Mn), and zinc (Zn). In the study, four types of kimchi samples were prepared using each type of salt. All probes, except for salt type, were prepared in the same way and under the same conditions.

Microbial community composition analysis indicates that, initially, all samples, regardless of salt type, share a similar bacterial composition. *Weissella* is dominant during the initial fermentation stages of kimchi supplemented with solar salt. The level of *Weissella* in kimchi supplemented with SS1 was two times higher than in kimchi supplemented with DSS. The level of *Latilactobacillus sakei* was the highest in kimchi supplemented with PS in the late fermentation period. *Latilactobacillus sakei* was dominant while *Leuconostoc* and *Weissella* decreased in all kimchi samples by the end of the fermentation.

The results show that mineral content varies depending on the type of salt. Solar salt had a lower sodium content than purified salt. The content of Mg and Mn was higher in solar salt and DSS than in PS. The levels of Mg and K decreased with the aging period of solar salt. Ca content was high in SS1 and SS3, but higher in SS3. Solar salt significantly improved the quality of kimchi compared to PS. Bacterial quantity was higher in kimchi supplemented with solar salt containing Mg and Ca than in that supplemented with PS (Lee et al., 2022). The results suggest that salt type affects the total number of viable bacteria. *Leuconostoc* and *Weissella* are dominant in kimchi prepared using solar salt, while *Lactobacillus* is dominant in kimchi supplemented with PS and DSS. An appropriate environment provides a diversity of microorganisms and, as a result, can deliver different benefits for human health. They depend on bacterial composition and other mineral properties.

Different ingredients and parts of vegetables

Kimchi consists of diverse ingredients and is fermented. The mixture contains different vegetables, fruits, and seasonings. Fermentation starts due to a multitude of bacteria and microorganisms. Their population consists of diverse species, of which *Leuconostoc*, *Lactobacillus*, *Pseudomonas*, *Pantoea*, *Weissella*, *Trichosporon*, *Saccharomyces unisporusa*, and *Pichia kluyveri* are dominant. The number of bacterial species of *Leuconostoc*, *Weissella*, and *Lactobacillus* in kimchi totals between 10^7 and 10^8 cfu/g. It also contains 10^8 LAB per gram and delivers approximately 10^{10} live microorganisms, assuming that daily consumption totals 100 g per person per day (Rezac et al., 2018). The variety of bacteria depends on different factors, like duration of fermentation or the type and amount of the foods included, although the fermentation process reduces their diversity (Dimidi et al., 2019). Salt is a crucial component, making salted cabbage a primary vegetable in kimchi. It is used at the beginning of the process because, before fermentation, there are preparatory stages that create an appropriate environment for it to begin. Initially, the cabbage is chopped, brined and drained, and other ingredients are added afterwards (Dimidi et al., 2019). Kimchi consists of critical and optional ingredients. Green onion, radish, garlic, ginger, and red pepper are considered essential ingredients. In contrast, optional ingredients depend on personal preferences, region of production, and tradition, and may include sugar, leek, anchovy sauce, rice, and others.

The composition and amounts of these ingredients impact the metabolic profile of kimchi and the bacterial concentration and proportions. The fermentation environment, with all the essential ingredients, supports higher organic acid production, particularly lactic acid. Kimchi prepared without essential ingredients has lower lactic acid content, whereas the inclusion of optional ingredients is associated with higher lactic acid levels (Lee et al., 2024). Essential ingredients mainly influence the composition of the microbial community, while garlic and red pepper are related to the composition of LAB. As a primary inhibitory neurotransmitter in the central nervous system, GABA plays a key role in neurological transmissions and modulates the gut–brain axis response (Duranti et al., 2020). Other additives, like sugar may increase melibiose levels, a non-digestible disaccharide known to stimulate the growth of fecal *Bifidobacteria* (Adamberg et al., 2018). Anchovy sauce is positively correlated to the abundance of *Lactobacillus* and negatively correlated to the abundance of *Citrobacter*. Moreover, it shows a positive correlation with the amounts of amino acids produced, such as methionine, leucine, and glycine. They originate from the enzymatic degradation of fish proteins (Lee et al., 2024).

Amino acids affect the intestinal microbiota. They help to nourish the intestinal flora, and maintain homeostasis, composition and physiological functions of the gut microbiota (Wu et al., 2020; Wang et al., 2019). Various ingredients as crucial basis of food products answer for their nutritional value. The unique taste is available due to diverse seasoning combinations (Lee et al., 2024). Kimchi contains various components and can, as a result, modify the gut microbiota. This is beneficial for overall human health, especially for the gastrointestinal system. Due to the multiple minerals it contains, kimchi has health-promoting properties. The content of nutrient elements is different depending on whether cabbage leaves or roots are used. One study by Hwang et al., (2023) measured the levels of major elements sodium (Na), potassium (K), zinc (Zn), cuprum (Cu), magnesium (Mg), iron (Fe), calcium (Ca), trace elements selenium (Se), beryl (Be), bismuth (Bi), cobalt (Co), lithium (Li), nickel (Ni), gallate (Ga), strontium (Sr), boron (B) and chromium (Cr) of 36 kimchi cabbages.

The analysis method relied on inductively coupled plasma-optical emission spectrometry for the major nutrient elements and following the standards set by the Association of Official Analytical Chemists (AOAC) guidelines (Hwang et al., 2023). They found that the sequence of major elements was, in leaves: K > Ca > Mg > Na > Fe, Zn, Cu, and in roots: K > Ca > Na > Mg > Fe > Zn, Cu. The order of the trace element content was Sr > B > Ni, Cr > Ga, V > Co, Li, Se > Be in roots, and B > Sr > Ni > Se > Cr, Ga > Co, V > Be, Bi in leaves. These results suggest that leaves and roots are rich in K, B, and Be. Concentrations (mg/100 g) of significant elements in kimchi cabbage leaves and roots, reveal that K is the most abundant nutrient element. The content of K in leaves amounts to 332,6 mg/100 g and to 263,9 mg/100 g in roots. Ca and Mg levels are high in both parts; Ca totalled at 50,0 mg/100 g in leaves and 75,1 mg/100 g in roots, while Mg at 18,2 and 31,1 mg/100 g, respectively (Hwang et al., 2023; Castellone et al., 2021). Analysis of trace element concentrations (mg/kg) revealed that in the roots Sr was the most abundant trace element, followed by B. In the leaves, B was the most abundant with Sr in second place (Hwang et al., 2023). The amount of various elements affects the physiological functions of different organs.

They also influence gut microbiota, which, except for digestion, is responsible for homeostasis. Disruption of the gut microbiome balance has been identified as a contributing factor to metabolic disorders such as hypertension, hyperlipidaemia, or diabetes mellitus (Cao et al., 2024). Individual components of kimchi modify microbial composition through distinct mechanisms. One study conducted in murine models suggests a correlation between fecal microbiota composition and function and a high-sodium diet. Kimchi contains sodium and, as a result, may decrease *Lactobacillus* and increase *Lachnospiraceae* and *Ruminococcus*, as well as fecal short-chain fatty acids (SCFAs) concentrations, and promote microbial-dependent intestinal T-helper 17 cells (Wang et al., 2020; Wilck et al., 2017; Bier et al., 2018). *Lachnospiraceae* not only induce positive benefits to intestinal health but can also prevent chemotherapy-induced intestinal damage, senescence-like weakness, and death (Long et al., 2024). *Ruminococcaceae* are positively related to SCFAs production. SCFAs promote increased abundance and diversification of gut microbial communities (Walker et al., 2005). Evidence from mouse models revealed that *Lactobacillus paracasei LS2* derived from kimchi lowered levels of Inflammatory cells, such as macrophages, neutrophils, lymphocytes, and cytokines. Kimchi may have a positive effect on gastrointestinal health because of the ability of *LS2* to reduce the severity of colitis (Park et al., 2017).

Another study investigated the impact of fresh and fermented kimchi on gut microbiota composition in 24 obese Korean women. After eight weeks of the experiment, it was found that, in addition to anti-obesity effects, fermented kimchi increased *Proteobacteria*, *Actinobacteria*, *Bacteroides*, and *Prevotella* levels and decreased *Blautia* levels (Leeuwendaal et al., 2022; Han et al., 2015).

Another piece of evidence for the positive impact of kimchi on microbiota is a population-based study in Chinese adults. The cohort consisted of 2833 (18–80-year-olds, 51,2% female) adults from 12 provinces and three megacities. The study aimed to discover an association between sodium and potassium consumption and gut microbiota composition. Researchers provided observational evidence of that, but they did not observe a clear separation in gut microbiota composition by sodium and potassium intake. However, they found a connection between sodium and potassium consumption and the overall microbiome (Wang et al., 2020).

Potassium, the primary intracellular cation, helps maintain cellular and membrane function (Toft et al., 2024). Ion channels and TJs interact with the mucus layer, mucosal blood flow, permeability, and the microbiota, which is crucial for gastrointestinal mucosal integrity (Deng et al., 2021). Due to K+ channels located on the plasma membranes of small intestine epithelial cells, K+ is significant for intestinal motility. Apart from gastrointestinal benefits of K, the results of the study indicate that K intake above 3500 mg/day (90 mmol/day) is associated with reduced risk of stroke (Toft et al., 2024). The data above suggest that kimchi ingestion is beneficial for the gut microbiota and overall human health. Kimchi is rich in various ingredients that have high levels of vitamins, especially vitamin C, vitamin B complex, minerals, dietary fibre, and β-carotene, which all have different benefits (Patra et al., 2016).

This article found that regular kimchi consumption may have many benefits for our gut and gastrointestinal system. It is essential to care for gut wellbeing as it affects not only digestive processes but also many different health areas. Ingesting kimchi for 8 weeks can modify gene expression, potentially altering metabolic pathways and immunity (Han et al., 2015). Kimchi supports cardiovascular health and cholesterol reduction and has immunological, anti-inflammatory, antibacterial, antioxidant, anticancer, anti-obesity, and probiotic properties (Patra et al., 2016).

Lactic Acid Bacteria (LAB)

LAB produces different fermentation end products. They include lactic acid, acetic acid, ethanol, and carbon dioxide. These products and LAB's probiotic properties make LAB-fermented foods, including kimchi, beneficial in diverse human health areas. LAB and *Bifidobacteriaceae* are classified as well-known probiotics. Due to advances in genetics, other bacteria have been approved as beneficial to host health. The development of microbial culturing techniques, metagenomic and genomic sequencing, and the editing of bacterial genomes contributed to the enhancement. Despite their widespread presence, LAB remain essential in food production and are recognised as safe by various health and food-safety organizations (Castellone et al., 2021). A study carried out on 23 obese women aged 30–60 years old researched the effects of kimchi consumption on the gut microbiota. Twelve of them consumed fresh kimchi, and 11 of them consumed fermented kimchi. The experiment lasted 8 weeks. Frequency and dose of the intervention totalled 60 g, three times per day (Stiemsma et al., 2020). The results showed that consuming fermented kimchi modified the composition of the gut microbiota. Regular consumption delivers numerous beneficial microorganisms to the gastrointestinal tract (Rezac et al., 2018). They observed a significant increase in *Bifidobacteria spp. Abundance*. Another non–randomised study of six people in South Korea compared a consumption of 300 g/day kimchi for four weeks with 60 g/day. The results showed elevated fecal levels of *Lactobacillus* and *Leuconostoc*, accompanied by a reduction in stool pH (Dimidi et al., 2019). Lowering of pH in the intestinal lumen and in the faeces is connected with acid-resistant microbiota. It leads to increased levels of LAB and *Bifidobacteria* and decreased levels of the pathogen (Castellone et al., 2021). Due to its numerous benefits, kimchi has become part of dietary guidelines. It should be introduced to children at a young age and becomes a part of the nutritional habits (Rezac et al., 2018). An absolute beginning of regular kimchi intake can help prevent some degenerative processes and reduce the risk of gastrointestinal diseases like irritable bowel syndrome (IBS), Crohn's disease, and infections (Castellone et al., 2021).

Table 1. Summary of factors associated with kimchi fermentation, microbial composition, and human health.

Aspect	Key findings	Biological/physiological relevance
Fermentation process	Kimchi fermentation is driven mainly by LAB, including *Leuconostoc*, *Lactobacillu*s and *Weissella*	Production of organic acids and bioactive metabolites; stabilization of gut microbial balance
Ingredient composition	Essential ingredients shape Lab composition and metabolite profile	Modulation of LAB dominance; influence on GABA and organic acid production
Bioactive metabolites	Fermentation generates GABA, SCFAs, bacteriocins, peptides and vitamins	Neurotransmission modulation, immune regulation and gut–brain axis support
Human consumption studies	Regular kimchi intake invreases fecal *Lactobacillu*s and *Leuconostoc* and lowers stool pH	Favourable intestinal environment; suppression of pathogenic bacteria
Probiotic effects	Kimchi-derived LAB (e.g. *L. Paracasei LS2*) reduce intestinal inflammation	Improved gut barrier integrity and reduced colitis severity
Mineral content	Kimchi is rich in K, Ca and Mg	Support of epithelial function, intestinal motility, and systemic homeostasis
Metabolic effects	Altered gut microbiota is associated with metabolic disorders	Proper microbiota function supports metabolic and cardiovascular health

During fermentation, different bioactive products are produced. This wide-ranging collection includes vitamins, bioactive peptides, ornithine, GABA, bacteriocins, organic acids like 2-hydroxyisocaproic acid and 3-phenyllactic acid, mannitol, and exopolysaccharides (Castellone et al., 2021; Lee et al., 2021). Kimchi, as a LAB-fermented food, can introduce bioactive compounds (Castellone et al., 2021). Additionally, LAB as probiotics colonise the intestinal mucosa and interact with the mucus layer. The constant presence in the gut enables bacteria to maintain contact with intestinal epithelium. It leads to different interactions like digestion and conversion of fermentation products to active compounds with health-improving abilities and immune system stimulation. That helps the immune response by decreasing autoimmune reactions. Pathogenic microflora is reduced, and beneficial microbial populations are promoted (Castellone et al., 2021). Table 1 presents an overview of the main factors affecting kimchi fermentation, including ingredient composition and processing conditions, and their associated effects on microbial composition and human gastrointestinal health.

4. CONCLUSION

Kimchi is a widespread Korean fermented food. Due to various factors, such as fermentation conditions, LAB strains, and essential and optional ingredients, kimchi offers a wide range of health-promoting properties. Kimchi should be introduced to the daily diet starting from a young age. It delivers vitamins, minerals, dietary fiber, B-carotene, polyphenols, bacteriocins, bioactive peptides, neurotransmitter GABA, organic acids, and many others. Regular consumption has an impact on overall health, especially gastrointestinal health, and modifies gut microbiota. *Leuconostoc*, *Weissella*, and *Lactobacillus* are dominant in the final fermented kimchi. They are responsible for intestinal integrity, including acid-base balance, motility, the stability of intestinal epithelial cell junctions, the proper functioning of ion channels, mucus secretion, preventing pathogenic microbial invasion, and combating infections.

In addition to gastrointestinal benefits, kimchi intake also supports cardiovascular health, reduces cholesterol levels, and has anti-obesity properties. It also significantly influences the immune system by reducing autoimmunity and promoting immune defence through various peptides, immune cells, and cytokines. Various studies demonstrate the health-promoting and therapeutic properties of kimchi. It should be an incentive to introduce kimchi to daily dietary habits and benefit from its health-promoting qualities.

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Author's Contribution:

Conceptualisation: Gabriela Ragan, Oliwia Cecelska
Methodology: Julia Niedźwiecka, Aleksandra Korżel
Analysis: Ewelina Roksana Wojna, Jędrzej Mogilany
Visualization: Kamil Źródłowski, Karolina Górowska, Patrycja Anita Kobrzyńska
Investigation: Patrycja Anita Kobrzyńska, Natalia Cegielska
Supervision: Karolina Górowska, Aleksandra Korżel
Validation: Kamil Źródłowski, Jędrzej Mogilany, Natalia Cegielska
Writing Original Draft: Gabriela Ragan
Writing – Review & Editing: Oliwia Cecelska, Julia Niedźwiecka, Ewelina Roksana Wojna, Karolina Górowska
Project administration: Gabriela Ragan, Oliwia Cecelska

Informed consent

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Data and materials availability

All data associated with this study will be available based on reasonable request to the Corresponding Author.

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