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Physiological Effects of Lactic Acid Bacteria Treated Condiments on Dolsan Leaf Mustard Kimchi

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This study evaluated the changes in the pH, acidity, *lactobacillus* and total bacterial counts, and sensory evaluation of Dolsan leaf mustard Kimchi (DLMK) after incubation for 50 days at 4℃ in the presence of one of three lactic acid bacteria (LAB); *Weissella kimchii* (W.k.), *Leuconostoc gelidum* (L.g.), and *Leuconostoc mesenteroides* (L.m.). The pH ranged from 5.12 to 5.62 and the acidity varied from 0.62% to 3.77% upon the addition of a 2% salt solution to the DLMK prepared using the three LAB. Overall, the LAB counts decreased rapidly from day 10 to day 20 of fermentation, whereas the total bacterial count decreased during the 50 days of fermentation. The pH and acidity in the DLMK ranged from 5.22 to 5.61 and from 0.91% to 4.41%, respectively, in the absence of the 2% salt solution. The LAB count decreased until 20 days and then increased thereafter, whereas the total bacterial count decreased until 20 days and then increased until 50 days. The condiments treated with or without the 2% salt solution showed a gradual decrease in appearance, flavor, salinity, hot taste, and overall acceptability as fermentation time increased. In addition, DPPH radical scavenging activity was high for 2% W. k. and 2% L. m., and ACE inhibitory activity was the highest, at 70.38% in the marinated condiments fermented at 10°C for 8 days. Thus, this condiment production method may be useful for DLMK and other Kimchi types.

Key words : ACE, condiments, Dolsan leaf mustard Kimchi, DPPH, lactic acid bacteria

Introduction

Leaf mustard Kimchi is a type of Korean traditional Kimchi prepared using red pepper powder, fermented shrimp and fermented anchovy as the primary ingredients. It has been consumed as, food since ancient times. Spontaneous fermentation and household methods have been mainly used for the preparation of leaf mustard Kimchi, which contains compounds such as glucosinolates, ascorbic acid, β-carotene, chlorophyll, dietary fiber, and flavonoids [6, 8]. Glucosinolates include at least 120 different aglycons [11]. Many secondary metabolites are currently being isolated from naturally cultivated whole plants using the solvent extraction method [24]. Among these, indole glucosinolates present in vegetables of the genus Brassica have been shown to inhibit carcinogenesis in experimental animals. Some of the main ingredients of leaf mustard Kimchi include garlic, ginger, red pepper powder, fermented shrimp, and fermented anchovy. Garlic is known to reduce blood pressure and exert antioxidant activities, which are helpful in preventing cancer and cardiovascular disease [13, 15, 16, 24, 26]. Ginger is rich in antioxidants that prevent cancers and coronary heart disease and play important role in the preservation of lipid-based foods [17, 18]. Red pepper powder clears the lungs and sinuses, protects the stomach by increasing the flow of digestive juices, triggers the release of endorphins in the brain, induces the secretion of saliva to neutralize cavity-causing acids, and helps protect the body against cancer through its antioxidant activity [1]. Further, the lactic acid bacteria in leaf mustard exhibit antibacterial activities and prevent early stage acidification, thus improving the shelf life of the product. In order to obtain a thorough understanding of the complete ripening process of Kimchi, an evaluation of the microbial compositions during Kimchi fermentation is vital. Several laboratories in Korea have attempted to evaluate and understand the microbial compositions of Kimchi. Evidence suggests that *Leuconostoc* species, including *Leuconostoc mesenteroides*, dominate the early fermentation process. Leaf mustard Kimchi has attracted attention as a functional food with health benefits and disease preventing properties [30]. The sulfur containing materials

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in cruciferous plants is catalyzed by plant and bacterial myrosinase [19]. Song *et al*. [28] reported that the antioxidative activities of crude chlorophylls and carotenoids in leaf mustard Kimchi against the autoxidation of linoleic acid are much higher than those of α-tocopherol. Further, the vitamin C and β-carotene levels in this species are notably higher than those in various other Chinese vegetables [31]. However, the effects of the addition of fermented condiments treated with lactic acid bacteria on leaf mustard Kimchi have not yet been studied. Thus, in this study, we used fermented condiments treated with lactic acid bacteria to prepare leaf mustard Kimchi and investigated the changes in pH, acidity, and other physiological characteristics.

Materials and Methods

Materials

The leaf mustard was obtained from Dolsan, Jeollanamdo, Korea. Other condiments such as garlic, ginger, and red pepper powder were purchased from a local market in Yeosu, Korea. Methanol, ethanol, and ethyl acetate were procured from Duksan Pure Chemical Co. (Korea). MRS broth and tryptone glucose yeast extract (TGY) broth were supplied by Difco Co. (USA). *Weissella kimchii* (W.k.), *Leuconostoc gelidum* (L.g.) and *Leuconostoc mesenteroides* (L.m.) were cultured in our laboratory.

Preparation and fermentation of condiments

Garlic, red pepper powder, ginger, fermented shrimp, fermented anchovy, sesame seeds, sugar and glutinous rice gruel were mixed in a clean plastic barrel. The ratio of the ingredients of the Dolsan leaf mustard Kimchi is shown in Table 1. Lactic acid bacteria were inoculated to facilitate the fermentation of the condiments for 50 days at 4℃.

Table 1. Ratio of condiments used to prepare the Dolsan leaf mustard Kimchi

Condiments	Ratio (g)
Garlic	3.50
Red pepper powder	6.00
Ginger	1.50
Fermented shrimp	5.25
Fermented anchovy	5.25
Sesame seeds	0.50
Sugar	1.40
Glutinous rice gruel	12.00

Measurement of pH and acidity

The pH of the condiments and Kimchi was measured using a pH meter (Orion 520A, Boston, USA). Each condiment (1 g) was added to 50 ml of distilled water. [2]. After vortexing and filtering (Whatman No. 4), 10 ml of the filtrate was added to a flask and treated with drop of phenolphthalein. A 0.1 N sodium hydroxide (NaOH) solution was used to titrate the filtrate until the pH reached 8.3. Total acidity was expressed in percentage as follows:

$$\text{Acidity } (\%) = \frac{\text{X ml for 0.1 N}-\text{NaOH}\times 0.009\times \text{F}}{\text{100 ml}} \times 50 \times 100$$

X: volume of 0.1 N-NaOH solution used for the titration of the filtrate
F: solution factor data
50: 50-fold dilutions
10: 10 ml of filtrate volume

Enumeration of lactic acid bacteria and total bacteria cells

Weissella kimchii (W.k.), *Leuconostoc gelidum* (L.g.) and *Leuconostoc mesenteroides* (L.m.) were cultured in our laboratory. All three types of lactic acid bacteria were sold and used from the microorganism and gene bank. Each of the three type lactic acid bacteria was added to the condiments, diluted with 0.85% (w/v) sterile saline and inoculated on MRS agar solid medium (Difco, USA). The MRS agar plate was duplicated and incubated at 26℃ for 48 hr. The number of lactic acid bacteria (LAB) was counted as colony forming units (CFU/ml). In addition, a TGY agar plate was inoculated in duplicate and incubated at 30℃ for 48 hr [17]. The total cell number was counted and recorded as CFU/ml.

Sensory evaluation

Ten trained panelists, all of whom were graduate students from the Chonnam National University, performed the sensory evaluations. The appearance, flavor, salinity, hot taste and overall acceptability were evaluated using a 5-point scale (1 = weak, 3 = moderate, 5 = strong).

Preparation of the methanol extracts

These condiments samples were freeze dried (LABCONCO Freeze dry system/ Freezone ®4.5). The freeze dried samples were finely ground, and then were extracted by using methanol. Briefly, each sample, weighing about 25 g, was extracted in 250 ml methanol two times (each for 30 min). The extracts were filtrated (Whatman No.4) and con-

centrated in vacuum (Eyela rotary evaporator N-1000; Eyela aspirator A-3S; Eyela digital water bath SB-1000) at 45℃. Finally, the extracts were kept in freezer until tested.

DPPH radical scavenging activity

The free radical scavenging activity of methanol extracts of Dolsan leaf mustard Kimchi's condiments and Kimchi were measured by DPPH (2,2-diphenyl-1-picrylhydrazyl) (Sigma chemical co.) according to the method of Benzie [3]. 5 ml of DPPH was added to 1 ml of sample and left to stand for 30 min. The absorbance of the resulting solution was measured at 525 nm with spectrophotometer (Shimadzu, UV-120A, Kyoto, Japan). Each sample was run four times, and the average was calculated as the % antioxidative activity. Inhibition of free radical DPPH in percent was calculated in following way [29]:

DPPH (%) = (1 - absorbance of the solution with the added sample / absorbance of the solution without sample) ×100

Angiotensin I-converting enzyme (ACE) inhibitory activity

The ACE inhibitory activity was measured according to the methods of Cushman and Cheung [12] with slight a modification. The ACE (peptidyldipeptide hydrolase, EC 3.4.15.1) 0.38 mg was dissolved in 0.1 M sodium borate buffer (pH 8.3) 10 ml Hippuryl-His-Leu (HHL) substrate, which was by mixing the substrate solution to obtain a (25 mM HHL solution). Then, 100 µl of the 25 mM HHL solution was mixed with a 50 µl sample, preincubated at 37℃ for 10 min, and the reaction was initiated by adding 150 µl of ACE dissolved in sodium borate buffer (pH 8.3), followed by further incubation of the mixture at 37℃ for 60 min. The reaction was finally stopped by adding 250 µl of 0.5 N HCl, and the hippuric acid was extracted with 1.5 ml of ethyl acetate. The extracts were centrifuged at 2,500 rpm for 10 min. 0.5 ml of the supernatant was dried in an oven at 140℃ for 10 min, dissolved in 3 ml of 1 M NaCl, and then the absorbance was measured at 228 nm to evaluate the degree of inhibition of the ACE activity.

$$\text{Inhibitory activity } (\%) = \frac{A-B}{A-C} \times 100$$

(A : Absorbance of the group with distilled water instead of sample, B : Absorbance of Sample, C : absorbance of the control solution with 0.5N HCl added to stop the reaction initiated by the ACE enzyme addition)

Statistical analysis

All tests and analyses were repeated at least three times. The results are expressed as mean ± standard deviation (SD). One way analysis of variance (ANOVA) and Duncan's test were used for multiple comparisons using the SPSS version 21.0 (SPSS Institute, Chicago, IL, USA). In all experiments, differences were considered to be statistically significant if $p<0.05$.

Results and Discussion

Changes in pH and acidity during fermentation

More recent works on microbial compositions using commercially available Kimchi or laboratory prepared Kimchi add some more lactic acid bacteria on this bacterial list. Here we will discuss the significance of three lactic acid bacteria adding in leaf mustard Kimchi. In this study, leaf mustard Kimchi's condiments (by adding of three lactic acid bacteria) at various fermentation temperatures were investigated to determine any changes in physiological activity.

The ratio of the condiments in the DLMK is shown in Table 1. Condiments with and without the 2% salt solution were stored at 4℃ for 50 days, their pH and acidity were measured at intervals of 10 days. The pH and acidity of the condiments treated with 2% salt solution and without the 2% salt solution are shown in Table 2. The pH value ranged from 5.09 to 5.62, whereas the acidity ranged from 0.62% to 3.7%. The average pH of the Kimchi condiments was 5.44, the average acidity was 0.86% [7]. The pH value ranged from 5.22 to 5.61, which was the lowest pH range on day 20 of storage. The acidity ranged from 0.89% to 5.36% the highest value reported for the condiments treated with the 2% salt solution. The results of this study are different from those of Choi *et al.* [10] and Yun *et al.* [33] at the pH decreased as the storage period passed, and t is thought that the seasoning composition influenced the pH. The salt solution added condiments showed a decrease in pH in the early stage of storage compared to the non-addition condiments, and a decrease in relatively small pH in the second half of the storage period. In the study of Han *et al.* [14], the initial pH of pickled cabbage was higher than in this study, which is thought to be due to the type and concentration of pickled cabbage used. Also, the initial acidity of condiments reported by Park *et al.* [22], Choi *et al.* [10], and Yun *et al.* [33] was about 0.2%. The higher values observed in our study may be attributed to the differences in the quality of

Table 2. Changes in the pH, acidity, lactic acid bacteria (LAB) and total bacteria (TB) count of the condiments treated with 2% salt solution and without salt solution during fermentation at 4℃

Days	LAB	2% salt solution				Without solution			
		pH	Acidity (%)	LAB (log CFU/ml)	TB (log CFU/ml)	pH	Acidity (%)	LAB (log CFU/ml)	TB (log CFU/ml)
0	A. 2% W. k.	5.12±0.01^{A*}	0.62±0.16^{A}	6.40±0.08^{B}	6.00±0.27^{B}	3.55±1.13^{B}	0.91±0.06^{A}	5.12±0.01^{A}	4.52±0.08^{C}
	B. 3% W. k.	5.32±0.04^{C}	0.97±0.18^{A}	6.50±0.08^{B}	6.30±0.21^{C}	3.55±1.13^{B}	1.03±0.15^{A}	5.32±0.04^{C}	4.13±0.19^{B}
	C. 4% W. k.	5.38±0.05^{B}	1.22±0.24^{B}	6.60±0.05^{C}	6.75±0.07^{D}	3.55±1.13^{B}	1.31±0.17^{B}	5.38±0.05^{C}	4.06±0.12^{A}
	D. 2% L. g.	5.21±0.04^{B}	1.63±0.12^{C}	6.50±0.05^{B}	6.20±0.11^{B}	3.66±1.32^{B}	1.81±0.14^{D}	5.21±0.04^{B}	3.96±0.38^{A}
	E. 3% L. g.	5.23±0.04^{B}	1.38±0.69^{B}	6.40±0.09^{B}	6.01±0.18^{B}	3.11±1.17^{A}	1.45±0.23^{B}	5.23±0.04^{B}	4.02±0.10^{A}
	F. 4% L. g.	5.19±0.05^{A}	1.46±0.15^{C}	6.70±0.08^{C}	6.30±0.39^{C}	3.89±1.05^{C}	1.50±0.23^{B}	5.19±0.05^{B}	3.94±0.70^{A}
	G. 2% L. m.	5.20±0.04^{B}	1.85±0.27^{C}	6.30±0.18^{B}	6.00±0.18^{B}	3.89±1.05^{C}	1.92±0.25^{D}	5.20±0.04^{B}	4.27±0.19^{B}
	H. 3% L. m.	5.32±0.08^{C}	1.51±0.14^{C}	6.70±0.08^{C}	6.75±0.09^{D}	3.89±1.05^{C}	1.62±0.22^{C}	5.32±0.08^{C}	3.97±0.12^{aB}
	I. 4% L. m.	5.31±0.05^{C}	1.46±0.23^{C}	6.30±0.18^{B}	6.30±0.17^{C}	5.38±0.21^{D}	1.53±0.11^{B}	5.09±0.15^{A}	4.06±0.10^{A}
	Control	5.36±0.05^{D}	0.62±0.46^{A}	4.40±0.62^{A}	4.01±0.14^{A}	5.40±0.29^{D}	0.89±0.19^{A}	4.93±0.23^{A}	4.30±0.12^{cC}
10	A. 2% W. k.	5.60±0.02^{B}	1.62±0.11^{C}	6.50±0.05^{C}	5.30±0.4^{B}	5.58±0.03^{B}	1.80±0.24^{B}	5.60±0.02^{C}	4.70±0.17^{C}
	B. 3% W. k.	5.60±0.13^{B}	1.38±0.14^{B}	6.67±0.01^{D}	6.00±0.24^{C}	5.58±0.22^{B}	1.98±0.10^{B}	5.60±0.13^{C}	4.30±0.09^{B}
	C. 4% W. k.	5.60±0.03^{B}	1.25±0.09^{A}	6.81±0.04^{D}	5.71±0.18^{C}	5.51±0.22^{B}	1.81±0.17^{B}	5.60±0.03^{C}	4.38±0.11^{B}
	D. 2% L. g.	5.49±0.08^{A}	1.48±0.14^{B}	6.62±0.07^{D}	6.35±0.14^{D}	5.56±1.50^{B}	1.81±0.17^{B}	5.49±0.08^{B}	4.00±0.21^{A}
	E. 3% L. g.	5.52±0.06^{A}	0.99±0.26^{A}	6.51±0.10^{C}	6.09±0.08^{C}	5.41±0.23^{A}	2.22±0.31^{C}	5.52±0.06^{B}	4.30±0.29^{B}
	F. 4% L. g.	5.45±0.03^{A}	1.27±0.22^{B}	6.62±0.15^{D}	6.38±0.16^{D}	5.40±0.19^{A}	2.42±0.18^{C}	5.45±0.03^{B}	4.00±0.14^{A}
	G. 2% L. m.	5.48±0.04^{A}	1.38±0.30^{bC}	6.00±0.14^{B}	5.90±0.17^{C}	5.53±0.14^{B}	2.22±0.38^{C}	5.48±0.04^{B}	4.60±0.09^{C}
	H. 3% L. m.	5.58±0.04^{B}	1.25±0.06^{A}	6.62±0.15^{D}	6.09±0.10^{C}	5.45±0.24^{A}	1.52±0.25^{A}	5.58±0.04^{C}	4.10±0.13^{A}
	I. 4% L. m.	5.62±0.06^{B}	1.01±0.26^{A}	6.30±0.23^{B}	6.00±0.17^{C}	5.36±0.11^{A}	1.98±0.15^{B}	5.50±0.17^{B}	4.30±0.12^{B}
	Control	5.61±0.04^{B}	1.01±0.27^{A}	4.30±0.27^{A}	4.15±0.14^{A}	5.42±0.31^{A}	2.22±0.32^{C}	5.10±0.28^{A}	4.30±0.15^{B}
20	A. 2% W. k.	5.25±0.03^{B}	1.98±0.12^{C}	5.37±0.22^{cC}	5.80±0.15^{D}	5.33±0.14^{A}	2.50±0.14^{B}	5.25±0.03^{C}	4.00±0.27^{A}
	B. 3% W. k.	5.29±0.02^{B}	1.75±0.19^{B}	5.25±0.04^{dC}	5.00±0.16^{B}	5.52±0.15^{C}	2.12±0.22^{A}	5.29±0.02^{C}	4.00±0.21^{A}
	C. 4% W. k.	5.30±0.01^{B}	1.28±0.04^{A}	5.44±0.06^{bB}	5.55±0.14^{C}	5.45±0.09^{B}	2.99±0.18^{C}	5.30±0.01^{C}	4.00±0.27^{A}
	D. 2% L. g.	5.15±0.05^{A}	1.47±0.15^{A}	5.71±0.09^{aA}	5.87±0.09^{D}	5.45±0.22^{B}	2.51±0.18^{B}	5.15±0.05^{B}	4.27±0.21^{B}
	E. 3% L. g.	5.20±0.03^{A}	1.28±0.15^{A}	5.43±0.05^{aA}	5.40±0.17^{C}	5.35±0.14^{A}	3.00±0.16^{C}	5.20±0.03^{C}	5.00±0.63^{C}
	F. 4% L. g.	5.12±0.07^{A}	1.49±0.23^{A}	5.43±0.11^{cC}	5.31±0.22^{C}	5.41±0.14^{B}	3.23±0.19^{C}	5.12±0.07^{B}	4.00±0.17^{A}
	G. 2% L. m.	5.18±0.05^{A}	1.77±0.26^{B}	5.82±0.20^{cC}	5.00±0.38^{B}	5.43±0.18^{B}	3.48±0.16^{C}	5.18±0.05^{B}	4.28±0.11^{B}
	H. 3% L. m.	5.24±0.05^{B}	1.65±0.24^{B}	5.00±0.18^{cC}	5.50±0.13^{C}	5.43±0.19^{B}	3.63±0.13^{D}	5.24±0.05^{C}	4.08±0.13^{A}
	I. 4% L. m.	5.25±0.05^{B}	1.47±0.23^{A}	5.25±0.22^{cC}	5.60±0.24^{D}	5.25±0.23^{A}	3.71±0.18^{D}	4.70±0.19^{A}	4.00±0.14^{A}
	Control	5.27±0.03^{B}	1.75±0.19^{B}	4.30±0.26^{cB}	4.22±0.10^{A}	5.38±0.12^{A}	4.23±0.26^{E}	5.16±0.23^{B}	4.00±0.27^{A}
30	A. 2% W. k.	5.28±0.02^{C}	1.03±0.11^{A}	5.03±0.42^{C}	4.30±0.22^{A}	5.56±0.20^{B}	2.75±0.15^{B}	5.12±0.01^{B}	4.68±0.16^{B}
	B. 3% W. k.	5.22±0.03^{B}	1.74±0.16^{C}	5.19±0.05^{C}	4.60±0.18^{A}	5.61±0.25^{B}	3.45±0.14^{C}	5.32±0.04^{C}	4.22±0.28^{A}
	C. 4% W. k.	5.25±0.03^{C}	2.02±0.27^{D}	6.03±0.08^{E}	5.51±0.22^{D}	5.52±0.21^{B}	2.41±0.18^{A}	5.38±0.05^{C}	4.38±0.17^{A}
	D. 2% L. g.	5.21±0.05^{B}	1.77±0.20^{C}	5.72±0.08^{D}	5.51±0.43^{D}	5.57±0.23^{B}	2.45±0.22^{A}	5.21±0.04^{aB}	4.70±0.47^{C}
	E. 3% L. g.	5.15±0.05^{B}	1.79±0.17^{C}	4.42±0.16^{B}	5.10±0.28^{C}	5.41±0.22^{A}	2.12±0.17^{A}	5.23±0.04^{B}	4.80±0.12^{C}
	F. 4% L. g.	5.09±0.05^{A}	1.79±0.28^{C}	5.51±0.17^{D}	4.50±0.18^{A}	5.53±0.20^{B}	2.45±0.22^{A}	5.19±0.05^{B}	4.81±0.52^{C}
	G. 2% L. m.	5.12±0.07^{A}	1.99±0.12^{D}	5.41±0.18^{D}	5.30±0.24^{C}	5.55±0.10^{B}	2.81±0.22^{C}	5.20±0.04^{B}	4.38±0.03^{B}
	H. 3% L. m.	5.19±0.05^{B}	1.51±0.08^{B}	4.50±0.13^{B}	4.63±0.23^{B}	5.49±0.24^{A}	2.63±0.22^{B}	5.32±0.08^{C}	4.90±0.15^{aB}
	I. 4% L. m.	5.20±0.07^{B}	1.78±0.20^{C}	5.08±0.16^{C}	4.50±0.13^{A}	5.33±0.31^{A}	2.75±0.17^{B}	5.20±0.29^{B}	4.40±0.10^{B}
	Control	5.22±0.03^{B}	1.75±0.19^{C}	4.10±0.28^{A}	4.68±0.12^{B}	5.48±0.33^{A}	2.63±0.19^{B}	4.90±0.24^{A}	4.30±0.04^{A}
40	A. 2% W. k.	5.19±0.04^{B}	2.50±0.26^{C}	4.96±0.39^{C}	4.30±0.23^{B}	5.30±0.20^{A}	2.73±0.13^{aA}	5.60±0.02^{C}	5.70±0.19^{C}
	B. 3% W. k.	5.18±0.03^{B}	2.50±0.17^{C}	4.57±0.06^{B}	4.03±0.25^{A}	5.61±0.19^{C}	1.98±0.10^{A}	5.60±0.13^{C}	4.98±0.17^{A}
	C. 4% W. k.	5.15±0.04^{B}	2.27±0.08^{C}	4.86±0.05^{C}	4.50±0.15^{C}	5.48±0.13^{A}	3.00±1.75^{B}	5.60±0.03^{C}	5.50±0.11^{B}
	D. 2% L. g.	5.07±0.03^{A}	2.84±0.19^{D}	5.71±0.09^{bE}	4.81±0.23^{C}	5.51±0.21^{B}	4.01±0.26^{C}	5.49±0.08^{B}	5.80±0.38^{C}
	E. 3% L. g.	5.09±0.05^{A}	1.87±0.17^{B}	4.41±0.11^{A}	4.03±0.18^{A}	5.50±0.19^{B}	1.97±0.10^{A}	5.52±0.06^{B}	5.60±0.03^{B}
	F. 4% L. g.	4.97±0.04^{A}	2.33±0.22^{C}	5.10±0.17^{D}	4.03±0.24^{A}	5.51±0.19^{B}	2.51±0.35^{B}	5.45±0.03^{B}	5.90±0.21^{C}
	G. 2% L. m.	5.20±0.07^{C}	2.48±0.33^{C}	4.83±0.06^{C}	4.75±0.18^{C}	5.59±0.08^{C}	3.00±0.27^{aB}	5.48±0.04^{B}	5.60±0.19^{B}
	H. 3% L. m.	5.11±0.10^{B}	1.64±0.28^{A}	5.10±0.17^{D}	4.33±0.21^{B}	5.54±0.28^{B}	3.61±0.16^{C}	5.58±0.04^{C}	5.60±0.31^{B}
	I. 4% L. m.	5.14±0.07^{B}	1.66±0.24^{A}	4.81±0.17^{C}	4.03±0.14^{A}	5.34±0.08^{A}	4.41±0.32^{D}	5.20±0.13^{A}	5.60±0.27^{b}
	Control	5.19±0.04^{B}	1.78±0.16^{B}	4.40±0.27^{A}	5.03±0.14^{D}	5.52±0.26^{C}	4.41±0.31^{D}	5.25±0.36^{A}	5.50±0.14^{B}

Table 2. Continued

Days	LAB	2% salt solution				Without solution			
		pH	Acidity (%)	LAB (log CFU/ml)	TB (log CFU/ml)	pH	Acidity (%)	LAB (log CFU/ml)	TB (log CFU/ml)
50	A. 2% W. k.	5.22±0.03^{C}	1.84±0.10^{B}	4.98±0.43^{C}	4.00±0.22^{A}	5.33±0.19^{A}	2.88±0.10^{A}	5.25±0.03^{B}	6.00±0.29^{D}
	B. 3% W. k.	5.22±0.04^{C}	2.01±0.25^{C}	4.41±0.10^{A}	4.03±0.12^{A}	5.60±0.13^{B}	2.88±0.13^{A}	5.29±0.02^{B}	5.61±0.21^{B}
	C. 4% W. k.	5.20±0.08^{C}	2.21±0.22^{C}	8.98±0.05^{D}	4.00±0.24^{A}	5.51±0.18^{B}	3.93±0.17^{C}	5.30±0.01^{B}	5.50±0.20^{B}
	D. 2% L. g.	5.10±0.06^{A}	1.92±0.24^{B}	5.50±0.09^{C}	4.32±0.22^{B}	5.59±0.14^{B}	3.92±0.24^{C}	5.15±0.05^{A}	5.70±0.41^{C}
	E. 3% L. g.	5.17±0.03^{B}	1.99±0.16^{B}	4.50±0.11^{A}	4.00±0.37^{A}	5.43±0.18^{A}	3.51±0.27^{B}	5.20±0.03^{A}	5.30±0.16^{bA}
	F. 4% L. g.	5.05±0.05^{A}	1.66±0.20^{A}	5.53±0.15^{cC}	4.00±0.18^{A}	5.55±0.17^{B}	2.92±0.26^{A}	5.12±0.07^{A}	5.80±0.30^{C}
	G. 2% L. m.	5.20±0.07^{C}	2.23±0.11^{C}	4.79±0.07^{B}	4.32±0.29^{B}	5.56±0.12^{B}	3.93±0.13^{C}	5.18±0.05^{A}	5.80±0.17^{C}
	H. 3% L. m.	5.16±0.06^{B}	2.26±0.08^{C}	4.70±0.13^{B}	4.00±0.21^{A}	5.52±0.26^{B}	3.93±0.25^{C}	5.24±0.05^{A}	5.79±0.45^{C}
	I. 4% L. m.	5.18±0.05^{B}	1.98±0.13^{B}	4.80±0.18^{B}	4.32±0.21^{B}	5.35±0.31^{A}	4.22±0.31^{D}	5.00±0.21^{A}	5.30±0.18^{A}
	Control	5.23±0.07^{C}	3.77±0.26^{D}	4.78±0.11^{B}	4.97±0.19^{C}	5.50±0.44^{B}	5.36±0.14^{E}	5.23±0.31^{A}	5.50±0.09^{B}

*Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same column (A-E) indicate statistically significant difference by Duncan's multiple range test (p<0.05)

the ingredients used to prepare Kimchi [30].

Changes in lactic acid bacteria and total bacteria counts during fermentation

The condiments treated with or without the 2% salt solution were stored at 4℃ for 50 days then, LAB and total bacteria counts were determined at intervals of 10 days. The counts of LAB and total bacteria in the condiments treated with the 2% salt solution and without 2% salt solution are shown in Table 2. No change was reported in the count of the LAB until day 10, however, the number of LAB decreaed by day 30. The count in the control group was maintained at 4.15-4.78 log CFU/ml during the fermentation period. In comparison with that in Kimchi and pickled cabbage, the condiments tended to show a lower count of LAB during the fermentation period [33]. The total bacteria count also decreased after 10 days, and the control group appeared only on the 10th day. The count of lactic acid bacteria decreased from day 10 to day 20 of fermentation and increased, except in the 2% W. k. group, from day 20 to day 30 of fermentation. Further, except for the 2% L. g., 3% L. g., and 4% L. g. groups, the other groups showed a decrease in the total bacteria count from day 10 to day 20 of fermentation, this number increased from day 20 to day 30. The count of LAB in Kimchi condiments was 5.33-8.25 log CFU/ml and that of total bacteria was 5.87-8.17 log CFU/ml [7]. In the study by Chang *et al*. [5], the LAB counts on the day of purchase of domestic commercial Kimchi from a (side dish shop, medium and small enterprise, large corporation) were found to be 5.32, 4.78, and 6.30 log CFU/ml, respectively, whereas the total bacteria counts 6.48, 5.93, and 6.95 log CFU/ml, respectively. The highest number of bacteria was detected in commercial Kimchi, respectively. In the present study, we found that the average counts of LAB and total bacteria were 5.39 and 4.72 log CFU/ml, respectively, which were lower than those reported for commercial Kimchi. This difference

Table 3. Antioxidant activity and angiotensin I-converting enzyme (ACE) inhibitory activity of methanol extract of Dolsan leaf mustard kimchi condiments sauce

Methanol extracts samples of condiments		DPPH				ACE			
		4℃, 30days	10℃, 8days	20℃, 4days	L-ascorbic acid	4℃, 30days	10℃, 8days	20℃, 4days	0.01% capotopril
0.2 ml	Control	18.11±0.20^{aA*}	20.09±0.24^{bA}	24.16±0.18^{cA}	97.13±0.20	44.33±0.02^{aA}	49.86±0.11^{bA}	43.22±0.05^{aA}	72.19±0.01
	2% W. k.	22.52±0.08^{aB}	24.57±0.14^{bB}	26.59±0.08^{bA}		61.52±0.24^{aD}	70.38±0.11^{cD}	66.24±0.01^{bD}	
	2% L. m.	24.31±0.14^{bB}	20.47±0.21^{aA}	24.81±0.14^{bA}		49.84±0.18^{aB}	65.68±0.15^{c}	56.57±0.04^{bC}	
0.4 ml	Control	34.17±0.06^{aC}	36.75±0.34^{bC}	39.51±0.21^{bB}		52.04±0.32^{bC}	47.22±0.17^{aA}	49.27±0.11^{aB}	
	2% W. k.	38.39±0.11^{aC}	39.08±0.22^{aC}	42.59±0.17^{bC}		53.47±0.21^{aC}	62.57±0.04^{cB}	51.49±0.21^{aB}	
	2% L. m.	36.73±0.23^{aC}	38.57±0.11^{aC}	44.62±0.05^{cCC}		53.78±0.13^{aC}	68.96±0.09^{cC}	59.04±0.09^{bC}	

*Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same row (a-c) and column (A-D) indicate statistically significant difference by Duncan's multiple range test (p<0.05)

Table 4. Sensory evaluation of the Dolsan leaf mustard Kimchi condiments sauce treated with 2% salt solution during fermentation at 4℃

Sensory evaluation		Appearance	Flavor	Salinity	Hot taste	Overall acceptability
4 days	A. 2% W. k.	4.20±1.40^{cC*}	3.89±1.45^{bB}	3.55±1.13^{aB}	3.86±1.07^{bA}	4.25±1.04^{cC}
	B. 3% W. k.	3.67±1.00^{aB}	3.89±1.45^{bB}	3.55±1.13^{aB}	3.86±1.07^{bA}	4.38±1.19^{cC}
	C. 4% W. k.	4.11±1.05^{cC}	3.89±1.45^{bB}	3.55±1.13^{aB}	3.86±1.07^{bA}	3.89±0.99^{bB}
	D. 2% L. g.	3.22±1.09^{aB}	4.20±1.40^{cC}	3.66±1.32^{bB}	4.56±1.33^{dC}	3.25±1.16^{aA}
	E. 3% L. g.	3.44±0.88^{bB}	3.67±1.41^{bA}	3.11±1.17^{aA}	4.38±1.19^{cB}	3.12±0.83^{aA}
	F. 4% L. g.	3.75±1.20^{bB}	3.44±0.88^{aA}	3.89±1.05^{bC}	4.63±1.51^{cC}	3.88±1.55^{bB}
	G. 2% L. m.	4.56±1.33^{dD}	3.44±0.88^{aA}	3.89±1.05^{bC}	4.77±1.56^{dC}	4.13±1.25^{cC}
	H. 3% L. m.	4.11±1.05^{bC}	3.88±1.05^{aB}	3.89±1.05^{aC}	4.75±0.66^{cC}	4.00±1.10^{bC}
	I. 4% L. m.	4.56±1.33^{cD}	4.33±1.41^{cC}	3.66±1.32^{aB}	4.75±0.66^{dC}	4.00±1.10^{bC}
	Control	2.67±1.00^{aA}	4.11±1.05^{cC}	3.11±1.62^{bA}	4.22±1.20^{cB}	3.43±1.13^{bA}
10 days	A. 2% W. k.	3.25±1.09^{bB}	3.00±0.00^{bB}	2.25±0.50^{aB}	2.75±0.50^{aA}	2.50±0.58^{aA}
	B. 3% W. k.	3.50±1.00^{cC}	3.00±0.00^{cB}	1.75±0.50^{aA}	4.25±1.50^{dD}	2.50±0.58^{bA}
	C. 4% W. k.	3.75±1.50^{cC}	2.75±0.50^{aA}	3.00±1.41^{bC}	3.50±1.75^{cC}	2.50±0.58^{aA}
	D. 2% L. g.	3.75±1.50^{bC}	2.75±0.50^{aA}	3.75±1.50^{bD}	3.75±2.22^{bC}	3.50±1.00^{bB}
	E. 3% L. g.	2.75±0.50^{aA}	2.75±0.50^{aA}	2.50±0.55^{aB}	2.75±0.50^{aA}	3.50±1.00^{bB}
	F. 4% L. g.	2.75±0.50^{aA}	2.75±0.50^{aA}	3.25±1.26^{bD}	3.25±1.26^{bB}	3.50±1.00^{bB}
	G. 2% L. m.	2.75±1.50^{aA}	3.50±1.00^{bC}	3.00±1.22^{aC}	3.00±1.41^{aB}	4.50±1.00^{cC}
	H. 3% L. m.	3.75±1.50^{bC}	3.25±1.25^{aB}	3.75±1.50^{b}	3.25±1.26^{aB}	4.50±1.00^{cC}
	I. 4% L. m.	3.25±1.26^{bB}	3.00±0.00^{bB}	2.75±1.50^{aC}	2.50±0.56^{aA}	4.50±1.00^{cC}
	Control	2.75±1.71^{aA}	3.00±1.63^{aB}	2.75±1.51^{aC}	3.00±1.65^{aB}	2.75±1.71^{aA}
20 days	A. 2% W. k.	4.33±1.15^{cC}	3.00±0.00^{aA}	3.00±1.41^{aB}	4.00±1.15^{cC}	3.50±1.00^{bC}
	B. 3% W. k.	4.33±1.15^{dC}	3.33±1.53^{cA}	2.50±0.58^{aA}	3.50±1.00^{cB}	3.00±0.00^{bB}
	C. 4% W. k.	4.00±1.75^{bB}	3.67±1.15^{bB}	3.50±1.73^{bC}	3.25±1.25^{aB}	3.00±0.00^{aB}
	D. 2% L. g.	3.67±1.15^{aA}	4.33±2.31^{bC}	3.50±1.71^{aC}	4.00±1.15^{bC}	4.00±1.15^{b}
	E. 3% L. g.	3.67±1.15^{aA}	3.33±1.53^{bA}	3.00±1.41^{aB}	2.75±0.50^{aA}	2.75±0.50^{aA}
	F. 4% L. g.	4.33±1.15^{cC}	3.67±1.53^{bB}	3.50±2.38^{aC}	4.00±1.15^{cC}	3.25±1.26^{aB}
	G. 2% L. m.	4.33±1.15^{cC}	3.00±0.00^{aA}	3.00±1.41^{aB}	4.00±1.15^{cC}	3.50±1.00^{bC}
	H. 3% L. m.	4.33±1.15^{cC}	3.67±1.15^{bB}	3.50±1.75^{bC}	3.25±1.25^{aB}	3.50±1.00^{bC}
	I. 4% L. m.	4.33±1.15^{cC}	3.67±1.15^{bB}	3.00±1.41^{aB}	3.25±1.25^{aB}	3.75±1.50^{bC}
	Control	4.00±1.75^{cB}	4.33±1.15^{cC}	3.25±1.26^{bB}	2.75±0.50^{aA}	3.00±0.00^{aB}
30 days	A. 2% W. k.	3.50±1.00^{aA}	4.50±1.00^{cC}	3.50±1.00^{aC}	4.00±1.15^{bD}	4.00±1.15^{bD}
	B. 3% W. k.	3.50±1.00^{bA}	4.00±1.15^{cB}	3.00±0.00^{aB}	3.00±0.00^{aB}	3.00±0.00^{aB}
	C. 4% W. k.	3.50±1.00^{bA}	4.00±1.15^{cB}	3.25±1.26^{aB}	3.00±0.00^{aB}	3.00±0.00^{aB}
	D. 2% L. g.	4.00±1.15^{bB}	4.00±1.15^{bB}	3.75±1.50^{aC}	3.75±1.50^{aC}	3.75±1.50^{aC}
	E. 3% L. g.	3.50±1.00^{aA}	4.00±1.15^{bB}	4.25±1.50^{bD}	3.50±1.00^{aC}	3.50±1.00^{aC}
	F. 4% L. g.	3.25±1.25^{bA}	3.50±1.00^{bA}	2.50±0.58^{aA}	2.50±0.58^{aA}	2.50±0.58^{aA}
	G. 2% L. m.	3.50±1.00^{bA}	3.50±1.00^{bA}	3.75±1.50^{bC}	3.25±1.26^{aB}	3.25±1.26^{aB}
	H. 3% L. m.	4.00±1.15^{bB}	3.50±1.00^{aA}	3.25±1.26^{aB}	3.50±1.00^{aC}	3.50±1.00^{aC}
	I. 4% L. m.	3.50±1.00^{aA}	3.25±1.26^{aA}	3.25±1.26^{aB}	3.00±0.00^{aB}	3.00±0.00^{aB}
	Control	3.50±1.00^{cA}	4.50±1.00^{dC}	2.75±0.50^{aA}	3.00±0.00^{bB}	3.00±0.00^{bB}
40 days	A. 2% W. k.	3.40±0.89^{cA}	4.20±1.10^{dD}	2.60±0.55^{aA}	3.00±1.22^{bA}	3.00±1.22^{bA}
	B. 3% W. k.	3.40±0.89^{aA}	3.40±0.89^{aB}	3.80±1.64^{bC}	3.40±0.89^{aA}	3.40±0.89^{aA}
	C. 4% W. k.	3.40±0.89^{cA}	3.00±0.00^{bA}	2.60±0.55^{aA}	3.00±0.00^{bA}	3.00±0.00^{bA}
	D. 2% L. g.	3.40±0.89^{bA}	3.40±0.89^{bB}	3.20±1.10^{aB}	3.00±0.00^{aA}	3.00±0.00^{aA}
	E. 3% L. g.	3.40±0.89^{bA}	3.00±0.00^{aA}	3.00±1.22^{aB}	3.40±0.89^{bA}	3.40±0.89^{bA}
	F. 4% L. g.	3.40±0.89^{cA}	3.40±0.89^{cB}	2.60±0.55^{aA}	3.00±0.00^{bA}	3.00±0.00^{bA}
	G. 2% L. m.	3.40±0.89^{cA}	3.00±0.00^{bA}	2.60±0.55^{aA}	3.40±0.89^{cA}	3.40±0.89^{CA}
	H. 3% L. m.	3.40±0.89^{cA}	3.00±0.00^{bA}	2.40±0.89^{aA}	3.40±0.89^{cA}	3.40±0.89^{cA}
	I. 4% L. m.	3.40±0.89^{aA}	3.80±1.10^{bC}	3.20±1.10^{aB}	3.00±0.00^{aA}	3.00±0.00^{aA}
	Control	3.40±0.89^{aA}	4.50±1.00^{bD}	3.20±1.10^{aB}	3.40±0.89^{aA}	3.40±0.89^{aA}
50 days	A. 2% W. k.	3.00±0.00^{bA}	3.80±1.10^{cB}	2.40±0.55^{aA}	4.00±1.41^{cC}	4.00±1.41^{cC}
	B. 3% W. k.	3.00±0.00^{aA}	3.00±0.00^{aA}	3.80±1.10^{bC}	3.60±1.34^{bC}	3.60±1.34^{bB}
	C. 4% W. k.	3.00±0.00^{aA}	5.00±0.00^{b}	3.00±0.00^{aB}	2.80±0.45^{aA}	2.80±0.45^{aA}
	D. 2% L. g.	3.00±0.00^{aA}	4.00±1.41^{cB}	2.80±0.45^{aA}	2.60±0.55^{aA}	2.60±0.55^{aA}
	E. 3% L. g.	2.80±0.45^{aA}	3.00±0.00^{aA}	2.80±0.45^{aA}	2.80±0.45^{aA}	2.80±0.45^{aA}
	F. 4% L. g.	2.80±0.45^{aA}	2.60±0.55^{aA}	3.40±1.52^{bB}	3.20±1.10^{bB}	3.20±1.10^{bB}
	G. 2% L. m.	3.40±0.89^{bB}	3.80±1.10^{cB}	3.60±1.54^{bC}	2.60±0.55^{aA}	2.60±0.55^{aA}
	H. 3% L. m.	3.00±0.00^{bA}	4.20±1.10^{cC}	2.40±0.55^{aA}	2.40±0.55^{aA}	2.40±0.55^{aA}
	I. 4% L. m.	3.40±0.89^{cB}	2.60±0.55^{aA}	3.00±0.00^{bB}	3.80±1.10^{dC}	3.80±1.10^{dC}
	Control	3.40±0.89^{bB}	4.00±1.41^{cB}	3.00±1.22^{aB}	3.60±1.34^{bC}	3.60±1.34^{bB}

*Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same row (a-d) and column (A-D) indicate statistically significant difference by Duncan's multiple range test (p<0.05).

Table 5. Sensory evaluation of the Dolsan leaf mustard Kimchi condiments sauce without salt solution during fermentation at 4℃

Sensory evaluation		Appearance	Flavor	Salinity	Hot taste	Overall acceptability
4 days	A. 2% W. k.	4.00±0.58^{dC*}	4.11±0.45^{dB}	3.10±0.13^{aA}	3.46±0.07^{bB}	3.67±1.03^{cC}
	B. 3% W. k.	3.41±1.10^{aA}	4.33±1.03^{bC}	3.10±0.13^{aA}	3.46±0.07^{aB}	3.33±0.82^{aB}
	C. 4% W. k.	3.11±0.05^{aA}	4.33±1.03^{bC}	3.10±0.13^{aA}	3.46±0.07^{aB}	3.33±0.82^{aB}
	D. 2% L. g.	3.35±1.53^{aA}	4.32±0.40^{cC}	3.15±1.10^{aA}	3.56±1.03^{bC}	3.50±1.22^{bC}
	E. 3% L. g.	3.21±0.93^{aA}	4.41±1.33^{cC}	3.11±1.17^{aA}	3.68±0.58^{bC}	3.33±0.82^{aB}
	F. 4% L. g.	3.10±1.00^{aA}	3.89±0.88^{bA}	3.18±0.05^{aA}	3.71±1.03^{bC}	2.83±0.41^{aA}
	G. 2% L. m.	3.83±1.03^{bB}	4.33±1.03^{cC}	3.09±1.05^{aA}	3.73±0.56^{bC}	3.67±1.03^{bC}
	H. 3% L. m.	3.43±0.58^{bA}	4.15±1.05^{dB}	3.09±1.05^{aA}	3.75±0.66^{cC}	3.17±0.98^{aB}
	I. 4% L. m.	4.10±1.33^{cC}	4.33±1.03^{cC}	3.16±1.12^{aA}	3.75±0.66^{bC}	3.67±1.03^{bC}
	Control	3.33±1.00^{aA}	4.22±0.05^{bB}	3.01±0.61^{aA}	3.22±1.11^{aA}	3.33±0.82^{aB}
10 days	A. 2% W. k.	3.67±1.03^{bC}	4.33±1.03^{cD}	3.50±1.22^{bC}	4.67±0.52^{cD}	3.00±0.00^{aB}
	B. 3% W. k.	3.33±0.82^{bB}	4.00±1.10^{cC}	3.17±0.98^{bB}	3.33±0.52^{bA}	2.67±0.58^{aA}
	C. 4% W. k.	3.00±0.00^{aA}	4.00±1.10^{cC}	2.83±0.41^{aA}	3.33±0.52^{bA}	4.00±1.73^{cD}
	D. 2% L. g.	3.67±1.03^{bC}	4.00±1.10^{cC}	3.67±1.51^{bC}	3.50±1.22^{bC}	3.00±0.00^{aB}
	E. 3% L. g.	3.00±1.10^{aA}	4.00±1.10^{bC}	3.17±0.98^{aB}	3.17±0.98^{aA}	3.00±1.73^{aB}
	F. 4% L. g.	2.67±0.52^{aA}	3.00±1.10^{bA}	3.00±1.10^{bB}	3.17±0.98^{bA}	2.33±0.58^{aA}
	G. 2% L. m.	3.17±0.98^{aB}	4.00±1.10^{bC}	3.00±1.10^{aB}	3.67±1.51^{bC}	3.00±1.73^{aB}
	H. 3% L. m.	3.67±1.03^{bC}	4.00±1.10^{cC}	2.67±0.52^{aB}	3.67±1.51^{bC}	2.67±0.58^{aA}
	I. 4% L. m.	3.40±0.89^{bB}	3.67±1.03^{cB}	3.33±1.37^{bC}	3.50±1.22^{cC}	2.33±0.58^{aA}
	Control	3.17±0.98^{aB}	4.00±1.10^{cC}	3.00±1.10^{aB}	3.50±1.22^{bC}	3.67±1.15^{bC}
20 days	A. 2% W. k.	3.67±1.15^{bC}	5.00±0.00^{cC}	3.67±1.15^{bC}	3.00±0.00^{aB}	2.67±0.58^{aB}
	B. 3% W. k.	3.67±1.15^{cC}	4.33±1.15^{dB}	3.00±0.00^{bB}	4.00±1.75^{dC}	2.33±0.58^{aA}
	C. 4% W. k.	3.00±0.00^{aA}	3.67±1.15^{bA}	3.00±0.00^{aB}	4.00±1.75^{cC}	3.00±0.00^{aB}
	D. 2% L. g.	3.67±1.15^{bC}	3.67±1.15^{bA}	4.33±1.15^{cD}	3.00±0.00^{bB}	2.33±0.58^{aA}
	E. 3% L. g.	3.33±1.53^{bB}	4.00±1.73^{cB}	3.67±1.15^{cC}	2.33±0.58^{aA}	3.00±0.00^{bB}
	F. 4% L. g.	3.00±0.00^{aA}	3.67±1.15^{bA}	3.67±1.15^{bC}	3.00±0.00^{aB}	3.67±1.15^{bC}
	G. 2% L. m.	3.67±1.15^{bC}	4.33±1.15^{cB}	3.33±1.53^{aB}	4.00±1.75^{cC}	3.33±1.53^{aC}
	H. 3% L. m.	3.67±1.15^{cC}	3.67±1.15^{cA}	2.00±0.00^{aA}	3.00±0.00^{bB}	4.33±1.15^{dD}
	I. 4% L. m.	3.67±1.15^{bC}	3.67±1.15^{bA}	4.00±1.73^{cD}	3.00±0.00^{aB}	3.00±0.00^{aB}
	Control	3.33±1.53^{bB}	4.33±1.15^{cB}	4.00±1.73^{cD}	3.00±0.00^{aB}	2.67±0.58^{aB}
30 days	A. 2% W. k.	5.00±0.00^{dD}	5.00±0.00^{dD}	2.33±0.58^{aA}	2.67±0.56^{bB}	3.33±1.53^{cC}
	B. 3% W. k.	3.67±1.15^{cC}	3.00±0.00^{bA}	2.33±0.58^{aA}	2.33±0.56^{aA}	3.33±1.53^{bC}
	C. 4% W. k.	2.33±0.56^{aA}	5.00±0.00^{cD}	3.00±0.00^{bB}	3.00±0.00^{bB}	2.67±0.58^{aB}
	D. 2% L. g.	3.33±1.53^{bB}	3.67±1.15^{cB}	2.67±0.58^{aB}	2.67±0.56^{aB}	2.67±0.58^{aB}
	E. 3% L. g.	3.00±0.00^{aB}	5.00±0.00^{cD}	3.00±0.00^{bB}	2.67±0.56^{aB}	3.33±1.53^{bC}
	F. 4% L. g.	2.33±0.58^{aA}	4.33±1.15^{cC}	3.67±1.15^{bC}	2.67±0.56^{aB}	2.67±0.58^{aB}
	G. 2% L. m.	5.00±0.00^{dD}	3.67±1.15^{cB}	2.67±0.58^{aB}	2.67±0.56^{aB}	3.33±1.53^{bC}
	H. 3% L. m.	2.33±0.55^{aA}	5.00±0.00^{cD}	2.67±0.58^{aB}	3.33±1.53^{bC}	2.67±0.58^{aB}
	I. 4% L. m.	2.33±0.55^{aA}	3.00±0.00^{bA}	3.00±0.00^{bB}	3.67±1.15^{cC}	2.67±0.58^{aB}
	Control	5.00±0.00^{cD}	3.67±1.15^{bB}	2.67±0.58^{aB}	3.33±1.53^{bC}	2.33±0.58^{aA}
40 days	A. 2% W. k.	3.33±1.53^{bA}	3.67±1.15^{cC}	2.67±0.58^{aA}	3.33±1.53^{bB}	3.33±1.53^{bC}
	B. 3% W. k.	3.33±1.53^{bA}	3.33±1.53^{bB}	3.33±1.53^{bB}	2.67±0.56^{aA}	2.67±0.58^{aB}
	C. 4% W. k.	3.33±1.53^{bA}	2.67±0.58^{aA}	3.33±1.53^{bB}	2.67±0.56^{aA}	3.33±1.53^{bC}
	D. 2% L. g.	3.33±1.53^{bA}	3.00±0.00^{bB}	2.67±0.58^{aA}	2.67±0.56^{aA}	2.33±0.58^{aA}
	E. 3% L. g.	3.33±1.53^{bA}	3.67±1.15^{bC}	3.33±1.53^{bB}	2.67±0.56^{aA}	2.33±0.58^{aA}
	F. 4% L. g.	3.33±1.53^{bA}	3.00±0.00^{bB}	3.33±1.53^{bB}	2.67±0.56^{aA}	3.00±0.00^{bB}
	G. 2% L. m.	3.33±1.53^{bA}	2.67±0.56^{aA}	3.00±0.00^{aA}	3.33±1.53^{bB}	3.00±0.00^{aB}
	H. 3% L. m.	3.33±1.53^{bA}	2.67±0.56^{aA}	2.67±0.58^{aA}	2.67±0.56^{aA}	4.33±1.15^{cD}
	I. 4% L. m.	3.33±1.53^{bA}	2.33±0.56^{aA}	2.67±0.58^{aA}	2.67±0.56^{aA}	2.67±0.58^{aB}
	Control	3.33±1.53^{bA}	2.67±0.56^{aA}	3.00±0.00^{bA}	2.67±0.56^{aA}	3.67±1.15^{cC}
50 days	A. 2% W. k.	4.33±1.15^{cC}	5.00±0.00^{dC}	2.67±0.58^{aA}	3.67±1.15^{bC}	3.67±1.03^{bC}
	B. 3% W. k.	3.67±1.15^{bA}	4.33±1.15^{cB}	3.00±0.00^{aA}	3.00±0.00^{aB}	3.33±0.82^{aB}
	C. 4% W. k.	4.00±1.75^{cB}	4.33±1.15^{cB}	4.33±1.15^{cC}	2.33±0.55^{aA}	3.33±0.82^{bB}
	D. 2% L. g.	3.67±1.15^{bA}	3.67±1.15^{bA}	3.00±0.00^{aA}	3.33±1.53^{aB}	3.50±1.22^{bC}
	E. 3% L. g.	3.67±1.15^{bA}	4.33±1.15^{cB}	3.67±1.15^{bB}	2.33±0.55^{aA}	3.33±0.82^{bB}
	F. 4% L. g.	3.33±1.53^{bA}	4.33±1.15^{cB}	3.33±1.15^{bB}	3.00±0.00^{aB}	2.83±0.41^{aA}
	G. 2% L. m.	5.00±0.00^{dD}	4.33±1.15^{cB}	3.67±1.15^{bB}	3.00±0.00^{aB}	3.67±1.03^{bC}
	H. 3% L. m.	4.00±1.73^{bB}	3.67±1.15^{bA}	3.00±0.00^{aA}	4.33±1.15^{cD}	3.17±0.98^{aA}
	I. 4% L. m.	3.33±1.53^{bA}	4.33±1.15^{cB}	3.00±0.00^{bA}	2.33±0.55^{aA}	3.67±1.03^{cC}
	Control	4.33±1.15^{cC}	3.67±1.15^{bA}	3.67±1.15^{bB}	3.67±1.15^{bC}	3.33±0.82^{aB}

*Data represent the mean ± SD of experiments performed in triplicates. The different lower-case letters (superscript) in the same row (a-d) and column (A-D) indicate statistically significant difference by Duncan's multiple range test (p<0.05).

was considered to be relatively low in terms of the amount of microorganisms owing to the relatively high proportion of antimicrobials added to Kimchi condiments.

Sensory evaluation

The results of the sensory evaluation test every 10 days for the samples stored at 4℃ for 50 days, with or without 2% salt solution treatment are shown in Table 4 and 5. The sensory evaluation scores for the condiments treated with and without the 2% salt solution were high at the beginning of the fermentation, but decreased as the fermentation time increased. Condiments inoculated with LAB had higher scores for appearance, flavor, hot taste, and overall acceptability than those from the control group. As the fermentation process progressed, the flavor and hot taste scores decreased. The improvement in the taste of the product with addition of LAB was also consistent with that previously reported. The addition of LAB is considered to beneficial for the manufacture of Kimchi with excellent sensory qualities to meets consumer preferences [4].

DPPH radical scavenging activity

Reactive oxygen species (ROS) are mostly removed by internal defense mechanisms, but if not removed, they react quickly with biomolecules, causing protein degeneration, lipid peroxidation, and DNA damage. Lipid peroxides that are diffused into cells or moved through the bloodstream promote new radical reactions and causes various diseases [27]. DPPH radical scavenging activity is used as a measure to inhibit lipid oxidation by donating electrons to active radicals, and is also used as a measure of the action of inhibiting aging by active radicals in the human body [9]. The antioxidant activity of methanol extract of DLMK condiments was shown in Table 3 by DPPH radical scavenging method. The antioxidant activity was shown in the samples fermented at 4℃ for 30 days, fermented at 10℃ for 8 days and fermented at 20℃ for 4 days. The higher the concentration of the methanol extract of condiments, the higher the DPPH scavenging activity. Except for L-ascorbic acid, 2% w. k. and 2% L. m. fermented at 20℃ for 4 days showed higher antioxidant effects among 9 samples and the higher concentration showed a higher effect. The antioxidant activity of seasonings fermented at 4℃, 10℃, and 20℃ by adding a starter is thought to be due to the difference in the progression rate of fermentation depending on the temperature, and accordingly, a difference in the rate at which antioxidants are produced.

Angiotensin I-converting enzyme (ACE) inhibitory activity

ACE is an important enzyme in the rennin-angiotensin-aldosterone system, which generates dipeptide (His-Leu) by hydrolyzing the inactive angiotensin-I at the C-terminal, thereby creating angiotensin-II that causes powerful vasoconstriction. Angiotensin II eventually raises the blood pressure and, therefore inhibition of ACE activation is a useful strategy for controlling disorders such as those involving the destruction of blood vessels and stroke [20]. Table 3 showed ACE inhibitory activity of methanol extract of DLMK condiments at various fermentation temperatures. In the methanol extract of seasoning fermented at 10℃ for 8 days, ACE inhibitory activity showed the highest activity (70.38%) than the others. In addition, the results of this study show that the DLMK added with the starter showed higher ACE inhibition activity than the control group [10]. The maximum ACE inhibitory activity was 65.87% when 2% L. m. was added in the methanol extract of Dolsan leaf mustard Kimchi condiments fermented at 4℃, 10℃ and 20℃. Products added with starter indicate that microbial metabolism due to the presence of a large number of cells contributes to the production of substances that exhibit ACE inhibitory activity.

The Conflict of Interest Statement

The authors declare that they have no conflicts of interest with the contents of this article.

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초록 : 돌산갓김치 제조를 위한 유산균 처리한 조미료의 생리적 효과

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본 연구는 *Weissella kimchii* (W.k.), *Leuconostoc gelidum* (L.g.) 및 *Leuconostoc mesenteroides* (L.m)의 3가지 유산균을 각각 첨가한 돌산갓김치의 양념소를 4℃에서 50일 동안 pH, 산도, 유산균 및 총균수, 관능적 특성의 변화를 측정하였다. 3가지 종류의 유산균을 첨가한 돌산갓김치의 양념소에 2% 소금 용액을 첨가한 pH 값의 범위는 5.12~5.62, 산도 값 범위는 0.62~3.77를 나타냈다. 유산균 수의 전체 추세는 발효 10일에서 20일 동안 빠르게 감소하였고, 총균수는 50일 동안 감소하는 것으로 나타났다. 돌산갓김치의 양념소에 2% 소금 용액을 첨가하지 않은 pH값의 범위는 5.22~5.61, 산도 값 범위는 0.91~4.41를 나타냈다. 유산균의 수는 전체적으로 20일까지 감소한 후 증가하였고, 총균수도 20일까지 감소 후 50일까지 증가추세를 나타냈다. 관능적 특성은 2% 소금 용액을 첨가한 양념소와 2% 소금 용액을 첨가하지 않은 양념소는 발효시간이 지날수록 외관, 향, 염도, 매운맛 및 전반적인 기호도는 점점 감소하였다. 또한, DPPH 라디칼 소거활성은 2% w. k.와 2% L. m.에서 높게 나타났고, ACE 억제활성은 10℃에서 8일간 발효된 양념소에서 70.38%로 가장 높게 나타났다. 이러한 양념소 생산은 돌산갓김치 제조 및 다른 김치제조에도 유용하게 사용될 수 있을 것으로 판단된다.