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Taste Supplementation of Low-Salinity Kimchi

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Abstract

The salinity of the brining solution for preparing kimchi imparts saltiness to kimchi, and affects its overall taste. In this study, the changes in the overall taste and quality of kimchi depending on the salinity of the brining solution (6% and 12%) were investigated. The salinity of kimchi brined in 6% NaCl solution was approximately 1.3%, and its umami (2.22±0.22) was lower than that (2.96±0.16) of the conventional kimchi, brined in 12% NaCl solution. In contrast, its bitterness (-3.77±0.05) was higher than that of the conventional kimchi (-4.48±0.12). The sensory evaluation results showed that the overall taste score of the low-salinity kimchi (2.8±0.4) was significantly lower than that of the conventional kimchi (4.5±1.1). To overcome the deterioration in the overall taste, a taste enhancer with a sea tangle extract and anchovy extract was added to the low-salinity kimchi. The overall taste score (4.4±1.2) of the seasoned kimchi, which is the low-salinity kimchi supplemented with the taste enhancer, was comparable to that (4.5±1.1) of the conventional kimchi, while maintaining a salinity of 1.7%. This study demonstrated the benefits of proper taste enhancer for improving the taste of low-salinity kimchi.

Key words: low-salinity kimchi, taste sensing, overall taste, taste enhancer

Introduction

Generally, conventional kimchi, including homemade kimchi, is prepared with Napa cabbage salted in 10-15% brine for 24-48 h to achieve approximately 2.0-3.0% salinity. Currently, commercial kimchi manufacturers have begun to produce low-salinity kimchi, with up to 30% lesser salt content than that of the ordinary product (2-2.5% salinity) in accordance with the low-salt campaign by the Korean government (MFDS, 2016). Such a reduction would bring about changes in the overall taste of kimchi due to probable alteration of brine salinity and fermentation processes.

While the acceptable saltiness of homemade kimchi is 3.04% and that of kimchi prepared by manufacturers is approximately 2.38% (Yi et al., 2009), low-salinity kimchi is produced aiming a salinity level of 1.4-1.5%, which is reduced up to 30% salt content (Kim, 2016).

The quality and taste of kimchi are intricately correlated with salt content and ripening temperature (Park et al., 2002). In particular, salt imparts an umami taste, eliminates bitter taste, and yields lactic acid bacteria for efficient fermentation. Furthermore, the characteristic sour taste resulting from accumulated organic acids, such as lactic acid, affects the taste of kimchi (Mheen and Kwon, 1984).

As lactic acid fermentation in low-salinity kimchi occurs under low-salinity conditions, the dominant species of lactic acid bacteria that manage fermentation may change. Accordingly, the composition of fermentation metabolites that are affected by changes in the intensity of umami and sour taste of low-salinity kimchi can be changed (Jin et al., 2007; Yu & Hwang, 2011). Various substances from ingredients added to buffer saltiness and produce umami also affect the overall taste of low-salinity kimchi (Jang et al., 1991).

Moon et al. (1997) reported many cases of kimchi preparation with 3% as the optimum salinity level; however, there were also some reported cases using approximately 2% for healthy people and approximately 1% for patients (Moon et al., 2014). In addition, some reports defined low-salinity kimchi as kimchi having < 2% salinity, as the necessity of low-salinity kimchi is socially perceived (Cho et al., 2005; Kim, 1985; Kim et al., 1988).

Therefore, it is advisable to use Napa cabbage salted in approximately 5-10% brine to prepare kimchi with less than 2% salinity; however, this type of kimchi is preferred less over conventional kimchi, making a counterplan is a necessity.

Supplementary measures for improving the taste of low-

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salinity kimchi include adding sea tangle extract, anchovy extract, and fruits, such as pear, apple, jujube, and plum extracts.

In the current study, taste and quality factors of low-salinity kimchi prepared with Napa cabbage salted in 6% brine were compared with those of conventional kimchi (2.0-3.0% salinity) prepared with Napa cabbage salted in 12% brine. Furthermore, a taste enhancing mixture was prepared and added to low-salinity kimchi to determine if the mixture is applicable as a taste supplement.

Materials and Methods

Kimchi samples

Conventional and low-salinity kimchi were prepared with Napa cabbage (*Brassica rapa* ssp. pekinensis) according to the procedure shown in Fig. 1 and stored in a refrigerator for further experiments. To prepare samples for taste sensing analysis, kimchi samples (30 g) were blended in 100 mL distilled water with a food mixer (HM-1270 Food mixer, Hanil Electric Inc., Seoul, Korea) and then filtered with sterilized gauze. The filtrate was centrifuged (1,430 × g, 10 min) using a table-top centrifuge (Union 32R, Hanil Scientific Inc., Gimpo, Korea) and the supernatant was collected for taste sensing.

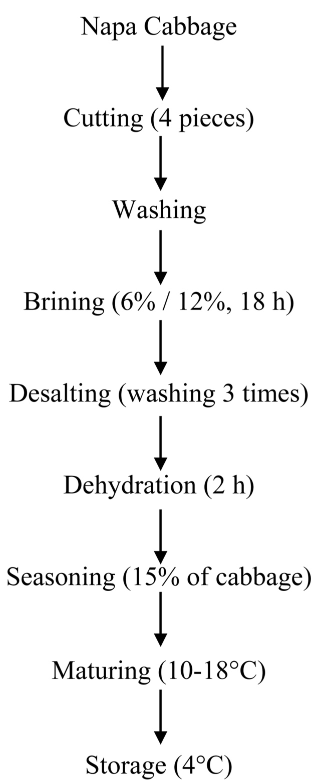

Fig. 1. The procedure of kimchi preparation.

Other analytical reagents used in the experiments were obtained from Sigma-Aldrich (St. Louis, MO, USA).

Cell counts and chemical analysis

Cell counts of lactic acid bacteria in kimchi samples were determined based on inoculation of onto MRS agar and incubation at 30°C for 48 h. The kimchi samples for inoculation were prepared by serial dilution of the supernatant used for taste sensing. The pH and salinity of kimchi samples (25mL of supernatant) were measured using a pH meter (420 Benchtop, Orion Research, Beverly, MA, USA) and a New Salt-Tester (DMT-20-1, 0-5%, Seoul, Korea), respectively. The consumed volume of NaOH (0.1N) was obtained by adding 2-3 drops of 0.1% phenolphthalein into the sample and then titrating it with 0.1 N NaOH until it reached pH 8.3, and the acidity was calculated from the following formula.

$$\text{Acidity (\%)} = \frac{0.1\ \text{NaOH consumed (mL)} \times \text{NaOH factors} \times \text{acid factor} \times \text{dilution rate}}{\text{sample volume (mL)}} \quad (1)$$

Taste sensing analysis

Taste analyses of kimchi samples were conducted using a taste sensing system (TS-5000Z, Insent Inc., Atsugi, Japan) equipped with taste sensors. The taste analysis results are depicted as the mean of the data obtained from technical triplicates for each sample (35 mL). Taste sensing items included umami, richness, bitterness, astringency, saltiness, and sourness.

Sensory evaluation

Sensory evaluation (9-point scale) was performed on 30 student panelists of food science majors, to whom 30 g kimchi samples were presented. Each panelist was asked about the overall taste of the kimchi samples in a blinded analysis. Drinking water and cooked rice were used to wash out the residual taste of the previous sample. Correlation coefficients for the overall taste and taste-sensing items of the kimchi samples were calculated from the data obtained from each conventional kimchi and low-salinity kimchi samples.

Statistical analysis

Data are presented as the mean±standard deviation for triplicate values. Statistical significance was calculated using Student's t-test in SPSS software (Statistical Package for the Social Sciences, Version 21.0, SPSS Inc., Chicago, IL, USA).

Statistical significance was set at $p<0.05$.

Results & Discussion

Table 1 summarized the quality characteristics of conventional kimchi, low-salinity kimchi, and seasoned kimchi. Conventional (normal-salinity) kimchi was prepared with Napa cabbage immersed in 12% saline solution for 18 h, with a salinity of approximately 2.2% in this study. The pH and acidity of the conventional kimchi were 4.33±0.01 and 0.87±0.18 after 2 weeks of storage at 4°C, respectively. The number of lactic acid bacteria was 7.4 log cfu/g, less than that of the low-salinity kimchi prepared with Napa cabbage incubated in 6% saline solution for 18 h (Table 1).

The specifications of low-salinity kimchi have not yet been proposed, however, its salinity is maintained under 2.0% (Kim, 2016). Therefore, most conventional kimchi or homemade kimchi using Napa cabbage immersed in 10-15% saline solution for 15-20 h (Kim, 1997) is expected to exceed 2.0% salinity which is the tentatively proposed salinity level of low-salinity kimchi.

The low-salinity kimchi prepared showed approximately 1.3% salinity. The acidity (1.06±0.13) and pH (3.94±0.01) of low-salinity kimchi after 2 weeks of storage at 4°C were higher and lower, respectively than those (0.87±0.18, 4.33±0.01, respectively) of the conventional kimchi. Thus, lactic acid fermentation seemed more active in low-salinity kimchi than in conventional kimchi (Table 1). The pH (3.94) of the low-salinity kimchi in the current study was lower than that of the low-salinity kimchi A in a previous study (Lee & Chung, 2020) due to the difference in storage days (7 and 14 days, respectively). However, these two have approximately the same salinity.

Sensory scores of the overall taste (2.8±0.4) and salty taste (2.4±1.0) of the low-salinity kimchi were significantly lower than those of the conventional kimchi (4.5±1.1, 6.4±1.4, respectively). Taste sensing analysis also suggested an association between kimchi salinity and its taste characteristics. As expected, the saltiness (3.79±0.28) of the conventional kimchi was significantly higher than that of the low-salinity kimchi (3.11±0.54). Additionally, the umami (2.96±0.16) of the conventional kimchi was higher than that of the low-salinity kimchi (2.22±0.22) and the bitterness (-4.48±0.12) of the conventional kimchi was lower than that of the low-salinity kimchi (-3.77±0.05) (Table 2). Therefore, it is considered that reducing the salinity of the saline solution from 12% to 6% would increase the bitterness of kimchi but would decrease the saltiness and umami of kimchi. Based on the above results, the overall preference for low-salinity kimchi in terms of taste characteristics seems to be inferior to that of conventional kimchi.

Currently, commercial kimchi manufacturers have opted to produce low-salinity kimchi to help maintain physiological fitness in terms of blood pressure and cardiovascular function (MFDS, 2016). However, such a reduction would cause alterations in the taste of kimchi (Jin et al., 2007, Yu & Hwang,

Table 1. Quality characteristics of the seasoned kimchi compared to other kimchi

Items of measurement	Conventional kimchi	Low-salinity kimchi	Seasoned kimchi
Salting concentration of cabbage (%)	12	6	6
Salinity (%)	2.2	1.3	1.7
Acidity	0.87±0.18[a]	1.06±0.13[b]	1.02±0.12[b]
pH	4.33±0.01[a]	3.94±0.01[b]	4.07±0.01[c]
Lactic acid bacteria (log cfu/g)	7.4[a]	7.9[b]	8.0[b]

Means in the same row not sharing a common letter are significantly different ($p<0.05$) by Duncan's multiple test.

Table 2. Taste characteristics of the seasoned kimchi compared to other kimchi

Taste sensing items		Conventional kimchi	Low-salinity kimchi	Seasoned kimchi
Saltiness		3.79±0.28[a]	3.11±0.54[b]	3.53±0.33[a]
Sourness		-7.24±1.68[a]	-6.43±2.27[b]	-7.59±1.79[a]
Umami		2.96±0.16[a]	2.22±0.22[b]	2.54±0.17[a]
Richness		1.94±0.05[a]	2.2±0.1[b]	2.18±0.08[b]
Bitterness		-4.48±0.12[a]	-3.77±0.05[b]	-3.79±0.1[b]
Astringency		-2.57±0.35[a]	-1.62±0.28[b]	-2.5±0.31[a]
Sensory Evaluation (9 points scale)	Salty taste	6.4±1.4[a]	2.4±1.0[b]	4.0±1.3[c]
	Overall taste	4.5±1.1[a]	2.8±0.4[b]	4.4±1.2[a]

Means in the same row not sharing a common letter are significantly different ($p<0.05$) by Duncan's multiple test.

2011), in particular, an increase in undesirable taste, such as bitterness and astringency.

The umami (2.22±0.22) of the low-salinity kimchi was not comparable to that (2.96±0.16) of the conventional kimchi, because components accounting for umami taste were insufficiently extracted from Napa cabbage by osmotic action under low-salinity conditions. Moreover, the bitterness (-3.77 ±0.05) of the low-salinity kimchi was found to be stronger than that of the conventional kimchi (-4.48±0.12). Therefore, it is expected that the overall taste of low-salinity kimchi would be deficient compared to that of conventional kimchi.

A 50% reduction (from 12% to 6% salinity) of saline solution could maintain the salinity of kimchi under 2.0%. However, its overall taste is considered incomparable to conventional kimchi, considering the overall changes in the taste of kimchi conditions on the salinity of the saline solution for immersing Napa cabbage.

In the traditional Korean community, the broth mixture was added to low-salinity kimchi before maturation for taste enhancement purposes. The taste enhancer was prepared from a broth mixed with a sea tangle extract and anchovy extract at a ratio of 1:1. Sea tangle extract (A in Fig. 2) showed stronger umami and weaker saltiness than the anchovy extract (B in Fig. 2). In contrast, the anchovy extract exhibited stronger saltiness and weaker umami. The combination (C in Fig. 2) of the two taste extracts is expected to create a taste-enhancing effect and can compensate for the deficiency in kimchi taste.

This taste enhancer was added to low-salinity kimchi before maturation. The seasoned kimchi with the taste enhancer showed 1.7% salinity despite the addition of the taste enhancer. The seasoned kimchi showed an acidity of 1.02±0.12, a pH of 4.07±0.01, and lactic acid bacteria count of 8.0 log cfu/g after 2 weeks of storage at 4°C, of which salinity was not over the tentative maximum level of low-salinity kimchi (2.0%) (Table 1). However, the saltiness (4.0±1.3) of the seasoned kimchi was different from the conventional kimchi (6.4±1.4) or low-salinity kimchi (2.4±1.0) (Table 2). Furthermore, the overall taste (4.4±1.2) of the seasoned kimchi improved when compared with that (2.8±0.4) of the low-salinity kimchi, but was almost similar to that of conventional kimchi (4.5±1.1) (Table 2). The umami and saltiness of the seasoned kimchi made up for the deficits of the low-salinity kimchi; thus, imparting better overall taste.

Taste sensing analyses were performed to confirm the above results. The saltiness (3.53±0.33) and umami (2.54±0.17) of the seasoned kimchi were slightly increased compared with those of the low-salinity kimchi (3.11±0.54 and 2.22±0.22, respectively). Despite the taste enhancement, the bitterness of the seasoned kimchi was not significantly different from that of the low-salinity kimchi (Fig. 3), and the astringency of the seasoned kimchi was lower than that of the low-salinity kimchi (Fig. 4).

Based on the above results, it was found that low-salinity kimchi is generally preferred less over conventional kimchi. However, the seasoned kimchi prepared by adding the taste enhancer to low-salinity kimchi could alleviate the sensory challenges of low-salinity kimchi, while maintaining low salinity. Therefore, seasoned kimchi supplemented with a

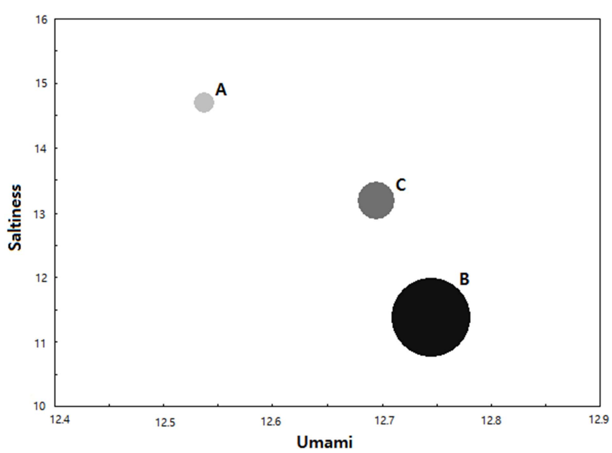

Fig. 2. The bubble chart of taste enhancing extracts. *The size of each bubble is proportional to bitterness. A, anchovy extract; B, sea tangle extract; C, taste enhancer (1:1 mixture of A and B).

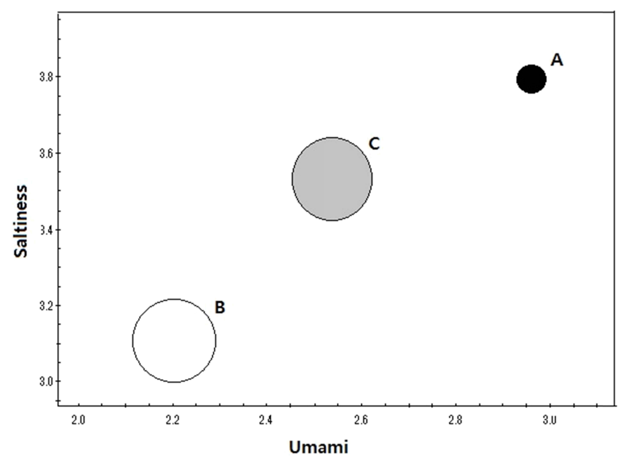

Fig. 3. The bubble chart 1 of the seasoned kimchi compared to other kimchi. *The size of each bubble is proportional to bitterness. A, conventional kimchi; B, low-salinity kimchi; C, seasoned kimchi (low-salinity kimchi added with the taste enhancer).

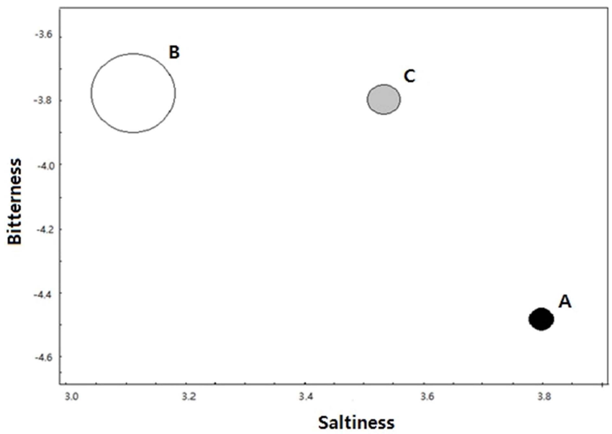

Fig. 4. The bubble chart 2 of the seasoned kimchi compared to other kimchi. *The size of each bubble is proportional to astringency. A, conventional kimchi; B, low-salinity kimchi; C, seasoned kimchi (low-salinity kimchi added with the taste enhancer).

proper taste enhancer could improve the product competency of low-salinity kimchi in emerging markets.

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