pISSN 1225-4339 eISSN 2287-4992
Korean J. Food Nutr. Vol. 29. No. 2, 237~245 (2016)
http://dx.doi.org/10.9799/ksfan.2016.29.2.237

THE KOREAN JOURNAL OF
한국식품영양학회지
FOOD AND NUTRITION

Quality Characteristics of Low-Salt Myungran Jeotkal Fermented by Vegetable-Origin Lactic Acid Bacteria and Salt from Deep Sea Water

†Deuk-Sik Lee*,**

*Dept. of Foodservice & Nutrition, Hanzhong University, Donghae 25800, Korea
**Institute of Life Science, Well-being LS Co., Ltd, Marine Bio, Gangneung 25451, Korea

Abstract

In this study, the physicochemical and sensory characteristics of low-salt Myungran jeotkal (Alaskan pollock roe) were evaluated after fermentation at 4℃ and 20℃ with or without the addition of deep sea water, salt from deep sea water, and vegetable-origin lactic acid bacteria (*Lactobacillus fermentum* JS, LBF). When fermented at 20℃, the addition of LBF to Myungran jeotkal resulted in a slow increase in lactic acid content, followed by an abrupt increase after five days of fermentation. However, when fermented at 4℃, the lactic acid content did not change significantly. Further, when Myungran jeotkal fermented at 4℃, the pH decreased as lactic acid production increased. The salinity of Myungran jeotkal fermented at 4℃ and 20℃ was 7% and was not affected by fermentation period. When fermented at 20℃, volatile basic nitrogen and amino nitrogen contents increased with increasing duration of fermentation. Further, volatile acid content decreased, however, the content of amino nitrogen increased after 11 days of fermentation with LBF and no salt effects were observed. When fermented at 20℃ for 13 days, preference (sensory evaluation) was the highest in all experimental groups after 9 days of fermentation, and then decreased as the fermentation period increased. The free amino acid content was highest (1,648.8 mg/100 g) in Myungran jeotkal when sun-dried salt and LBF were added, 2.3 times higher than in the control.

Key words: deep sea water, fermentation, *Lactobacillus fermentum* JS, Myungran jeotkal, vegetable-origin lactic acid bacteria

Introduction

Jeotkal a traditional from of salted and fermented seafood, has been consumed for thousands of years, as shown in the literatures. There are many different kinds of jeotkals, including, jeotkal fermented with only salt, seasoned raw crab soaked in soy sauce, cereal fermented with low salt, fermented fish with pepper powder, liquid jeotkal obtained by filtering jeotkal juice and jeotkal seasoned with spices. The type and quality of products are numerous and vary according to recipe and shape of the food organism (Kim JW 2008).

The statistical yearbook of agriculture, forestry, and fishery products shows that the production of jeotkal was 39,848 tons in 2003, 35,993 tons in 2004, 32,659 tons in 2005, 37,992 tons in 2006, and 28,641 tons in 2007, indicating a decreasing trend in gross production. Recently, eating habits have been changing and health-oriented food consumption has increased. The decline in jeoktal consumption may be due to concerns about its high salt content, which could lead to health problems. However, the gross production of low-salt Myungran jeotkal (Alaskan pollock roe) was 1,544 tons in 2003 and 2,595 tons in 2007, indicating an increasing consumption.

Han et al. (2005) analyzed the volatile basic nitrogen, amino nitrogen, pH, acidity, bacterial counts, and sensory characteristics of low-salt Myungran jeotkal during storage, at 10℃, to check its shelf life. Lee & Kim (2012) and Won & Kim (2013) investigated the quality characteristics and shelf-life of squid ink of low-salt squid jeotkal at different fermentation temperature and

† Corresponding author: Deuk-Sik Lee, Dept. of Foodservice & Nutrition, Hanzhong University, Donghae 25800, Korea. Tel & Fax: +82-33-520-9252, E-mail: deuk0522@hanmail.net

salt concentrations. Jung et al. (2009b) studied the effects of irradiation on microbiological, physicochemical, and sensory characteristics of Myungran jeotkal and showed that electron beam irradiation may increase the shelf life of Myungran jeotkal.

Deep sea water is sea water collected from sea depths of 200 m and deeper, where sun light does not reach. It contains much greater amounts of nutrients and minerals that are beneficial for health. The contents of calcium, magnesium, and potassium are up to 50 times higher, than that of general water (Kim et al. 2003). Deep sea water is used in alcoholic drinks, soybean curd, Kimchi, cosmetics, and drinking water after purification and salt removal. Therefore, the possibility of industrialization has been studied by many researchers (Moon et al. 2005; Lee et al. 2007; Ham et al. 2008; Jung et al. 2009a).

Lactobacillus fermentum JS (LBF) isolated from fermented soy beans and salted vegetable foods is a beneficial lactic acid bacteria that, inhibits harmful microorganisms in the bowel, and aids peristalsis, effectively preventing intestinal disorders. LBF, a facultative anaerobe, is a gram-positive, catalase-negative, hetero-fermentative, immobile rod type that can transform 50% and more of glucose into lactic acid (Jeong GJ 2005). The LBF (KCCM 10499 strain) used in this experiment is a vegetable-origin lactic acid bacteria, that shows superior acid, bile, salinity, and heat resistance than other lactic acid bacteria. Therefore, LBF can be applied in generally processed foods, to aid in bowel health, because the survival rate of bacteria that reach the bowel in the living state is high after consumption. In addition, growth and attachment to the bowel are superior (Park et al. 2013). Consumption of LBF improves serum lipid metabolism by lowering total cholesterol level and atherosclerosis indices. It also removes odor effectively by empowering autoimmune function, and decreasing intestinal function and anti-oxidative activity.

The objective of the present study was to evaluate the physicochemical and sensory characteristics of Myungran jeotkal by producing low-salt fermented Myungran jeotkal using salt from deep sea water and then fermenting with LBF. The aim to protect the consumer, promote public health, and improve dining culture using scientific evaluating methods. The low-salt fermented Myungran jeotkal produced using salt from deep sea water and LBF was compared with low-salt Myungran jeotkal produced using deep sea salt, produced by evaporation and concentration.

Materials and Methods

1. Materials

Myungran (Alaskan pollock roe) used in the experiment was a Russian frozen product that, was thawed at room temperature, and washed three times with tap water to remove parasites and debris. Deep sea water and salt from deep sea water were obtained from Kangwon Deep Sea Water Co., Ltd. and stored in a cool, dark place. Commercial salt (Daesang Co., Ltd., Korea) was purchased from a local market. LBF powder with a bacterial number of $\times 10^8$ CFU/g or more was obtained from Well-being LS Co., Ltd., Korea.

2. Low-salted Myungran jeotkal

Salt concentration was controlled by soaking in saline solution of 12% for 24 hours to adjust the final salt concentration of Myungran jeotkal to 7%. Myungran jeotkal was produced as described in Table 1, using salt from deep sea water and LBF, and then was fermented at 4℃ and 20℃ by placing in plastic bags for 20 days and 13 days, respectively. The manufacturing

Table 1. Ingredients ratio of low-salt, fermented Myungran jeotkal

	4℃				20℃			
	A	B	C	D	E	F	G	H
Sea salt (g)	223	223	0	0	223	223	0	0
Distilled water (L)	1	1	0	0	1	1	0	0
Deep sea water salt (g)	0	0	165	165	0	0	165	165
Deep sea water (L)	0	0	1	1	0	0	1	1
LBF* (1×10^8 CFU/g) (g)	0	30	0	30	0	30	0	30

A, E: Sea salt + deep sea water salt
B, F: Sea salt + deep sea water salt + LBF
C, G: Deep sea water salt + deep sea water
D, H: Deep sea water salt + deep sea water + LBF
*LBF: *Lactobacillus fermentum* JS.

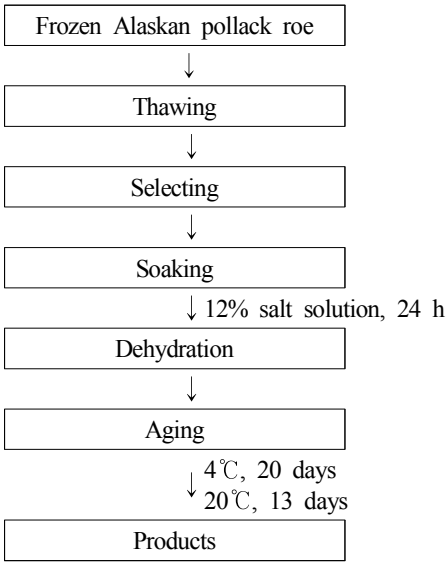

Fig. 1. Flow diagram for processing of low-salted and fermented Myungran (Alaskan pollock roe) jeotkal.

process of low-salt Myungran jeotkal is shown in Fig. 1.

3. pH changes

pH was measured with a pH meter (Orion 520A, USA) after adding 90 mL of distilled water to 10 g of sample and mashing with a homogenizer (Diax 900, Heidolph, Schwabach, Germany).

4. Acidity of organic acid

After adding ten times the volume of distilled water to the sample and homogenizing, the sample was filtered. The content of lactic acid was calculated by titrating 10 mL of filtrate with 0.1 N NaOH. The content of lactic acid was converted using the following equation:

$$\text{Acidity(\%, as lactic acid)} = \frac{\text{mL of 0.1N NaOH} \times 0.009 \times \text{F}}{\text{Weight of sample(g)}} \times 100$$

F: Factor of 0.1 N NaOH

5. Salinity

Salinity of Myungran jeotkal after fermentation was measured, using a salinometer (Atago ES-421, Japan).

6. Volatile basic nitrogen (VBN)

VBN was determined by a micro diffusion method, using a Conway unit (Kim et al. 2000). A 16 mL volume of distilled water and 2 mL of trichloroacetic acid solution were added to 2 g of sample, the sample was homogenized, and then filtered. Vaseline was coated onto the Conway unit, 1 mL of boric acid absorbent was added to the inner chamber, and 1 mL of test sample and 1 mL of saturated calcium carbonate were added to the outer chamber and then lid was closed. The Conway unit was kept at 37℃ for 80 min and then the solution was titrated with 0.01 N HCl until the colors changed to a light pink. VBN was calculated using the following equation:

$$\text{VBN(mg\%)} = \frac{0.1401 \times (\text{A} - \text{B})}{\text{Sample(g)}} \times \text{F} \times 20 \times 100$$

A: Amount of 0.01 N HCl consumed in the experiment (mL)
B: Amount of 0.01 N HCl consumed in blank (mL)
F: Factor of 0.01 N HCl

7. Amino nitrogen (AN)

The analysis of amino nitrogen was performed, using an adaptation of the Formol method (Chae et al. 1999). A 250 mL volume of distilled water was added to 5 g of test sample and stirred for 30 min A, 20 mL volume of this sample solution was adjusted to pH 8.5 by adding 0.1 N NaOH. Subsequently, 20 mL of formaldehyde adjusted to pH 8.5 was added. The solution was titrated with 0.1 N NaOH to pH 8.5. The amino nitrogen content was calculated using the following equation:

$$\text{AN(mg\%)} = \frac{(\text{A} - \text{B}) \times 1.4 \times \text{F} \times 250}{\text{Sample(g)}} \times 100$$

A: Amount of 0.1 N NaOH consumed in the experiment (mL)
B: Amount of 0.1 N NaOH consumed in blank (mL)
F: Factor of 0.1 N NaOH

8. Sensory evaluation

To evaluate the quality of the fermented Myungran jeotkal, 10 panel members performed a 9 point scoring sensory test in terms of color, flavor, taste, texture, and overall acceptance. A 25 g sample of fermented Myungran jeotkal was put in a tray, and randomly assigned a three-digit number before being given to each panel member. Palates were cleansed with orange juice and drinking water after evaluating each sample. Sensory evaluation was graded as best (9 points) and worst (1 point). Flavor evaluation

was graded as weakest (1 point) and strongest (9 points).

9. Free amino acids

Free amino acids were analyzed with an automatic amino acid analyzer (Hitach L-8800 Amino acid Analyzer, Japan). A 30 mL volume of 70% ethyl alcohol was added to 3 g of sample, allowed to extract for 1 h, let stand for 10 min and then centrifuged at 327 g force for 15 min, The supernatant was concentrated under vacuum, dissolved in 20 mL of 0.02 N HCl, filtered, and then analyzed.

10. Statistical analysis

Experimental results were analyzed statistically using the SPSS program (Version 17.0, SPSS, Chicago, IL, USA). Statistical significance of each group average was verified, using one-way ANOVA and Duncan's multiple range tests in $p<0.05$. Data are reported as mean±S.D.

Results and Discussion

1. pH change

The pH change of Myungran jeotkal fermented at 4℃ and 20℃ is shown in Fig. 2. When fermented at 4℃, the starting pH of all samples was between 5.62 and 5.69. When fermented for 20 days, the pH of each sample was between 5.56 and 5.64 and was not affected by fermentation periods. However, when fermented at 20℃, the starting pH of all samples was between 5.72 and 5.79. When Myungran jeotkal was fermented by, adding LBF 5 days and 9 days into the fermentation, the pH dropped significantly. The pH of all Myungran jeotkal samples dropped as fermentation period increased (Fig. 2). Han et al. (2005) measured pH changes while storing Myungran jeotkal at 10℃, and found the starting pH was 6.4, dropped with increasing storage time, reaching pH 6.2 at after 18 days of storage and 6.1 after 20 days of storage, in agreement with the current study. Kim et al. (2003) reported that when pH change was measured, during fermentation at 5℃ under vacuum or at ambient pressure, the pH remained stable for 10 days after fermentation, and was not affected by atmospheric pressure changes. Park et al. (1998) reported that when Changran (Alaskan pollock entrails) jeotkal was stored at 0℃ for 60 days, the pH did not change significantly, which was somewhat different from the result of the present study.

2. Acidity of organic acids

The acidity changes due to organic acids in Myungran jeotkal fermented at 4℃ and 20℃ are shown in Fig. 3. When fermented at 4℃, the starting acidity of organic acid of all Myungran jeotkal samples was between 0.57% and 0.65%. When fermented for 20 days, the acidity of organic acid was between 0.77% and 0.82% and was increased with increase in fermentation periods, but differences among experimental samples were not statistically

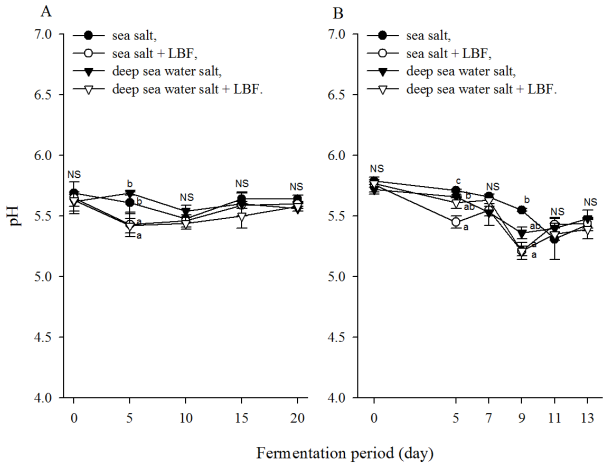

Fig. 2. pH changes of low-salt Myungran jeotkal during fermentation at 4℃ (A) and 20℃ (B). The values are the mean±S.D. of three independent experiments. a~c: Different letters within the same row differ significantly ($p<0.05$). NS: not significant.

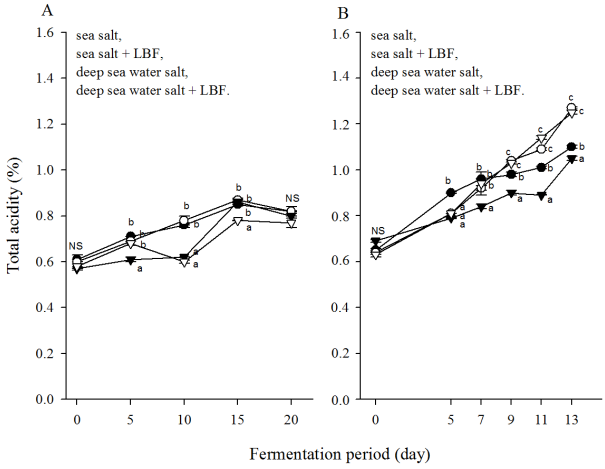

Fig. 3. Total acidity changes of low-salt Myungran jeotkal during fermentation at 4℃ (A) and 20℃ (B). The values are the mean±S.D. of three independent experiments. a~c: Different letters within the same row differ significantly ($p<0.05$). NS: not significant.

significant. When fermented at 20℃, the starting acidity of organic acid of all Myungran jeotkal was between 0.61% and 0.69%. When fermented for 13 days, the acidity of organic acids was between 1.05% and 1.25% and increased with increasing fermenting period. The acidity of organic acids in Myungran jeotkal fermented with LBF in particular was significantly higher, independent of the type of salt used. This result may be because Myungran jeotkal is fermented actively at 20℃ by LBF and more lactic acid is produced at 20℃ than at 4℃. Higher temperature than low temperature is thought to improve fermentation processing due to activation of added LBF. Kim & Hahn (2008) reported that when pH and acidity of soy-sauce Kimchi, soy-sauce Kimchi with added 2% sucrose, and a control, (watery Kimchi with added salt instead of soy-sauce) were measured, fermentation at 20℃, 10℃, and 1℃ resulted in a decrease in pH and an increase in acidity with increasing fermentation period and temperature. The result was in good agreement with the current experimental results.

3. Salinity change

Final salinity of Myungran jeotkal was adjusted below 7%, by soaking in 12% salt water for 24 h. When salinity was measured after, fermenting Myungran jeotkal at 4℃ or 20℃ for 20 days or 13 days, respectively, salinity level remained constant throughout the fementation period (Fig. 4). Park et al. (1998) reported that fermentation of low salt Changran jeotkal 9% salinity, resulted in salinity was levels of 7.9%, 8.2% and 8.2%, at 10, 30 and 60 days of fermentation, respectively, but none of these changes were statistically significant. This again was in good agreement with results of the present study.

4. Volatile basic nitrogen

Changes in volatile basic nitrogen content of Myungran jeotkal fermented at 4℃ and 20℃ are shown in Fig. 5. When fermented at 4℃, the starting content of volatile basic nitrogen of all Myungran jeotkal was below 19 mg% and there were was no significant differences among the groups. When fermented for 20 days, the content of volatile basic nitrogen remained below 21 mg% and was not affected by fermentation duration. However, when fermented at 20℃, the content of volatile basic nitrogen increased in all groups with increasing fermentation period. The content of volatile basic nitrogen was particularly high in Myungran jeotkal with added salt from deep sea water than in other groups, and increased to an initial putrefaction level after 9 days of fermentation. For Myungran jeotkal that contained sun-dried salt or that had salt from deep sea water and LBF added together, the content of volatile basic nitrogen was increased to an initial putrefaction level after 9 days of fermentation. Park et al. (1998) reported that volatile nitrogen, in low salt Changran jeotkal fermenting at 0℃ for 60 days, tended to continuously increase, and was about 4 times higher, at 94.4 mg%, after 60 days of fermentation, compared to the control (23.1 mg%). The volatile basic nitrogen content was increased in low salt Myeolchi-jeot (fermented anchovy) and Joki-jeot (fermented yellow corvenia) (10%

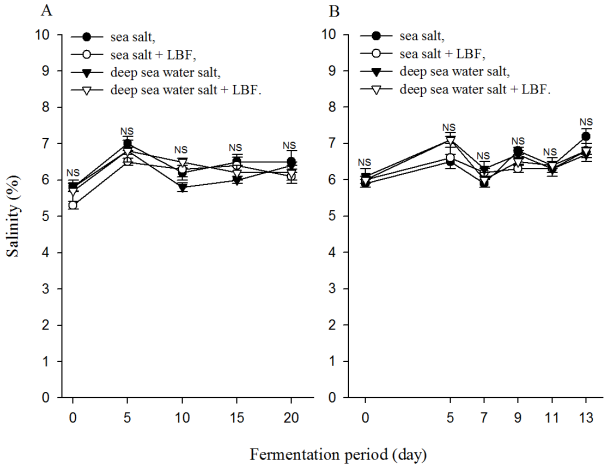

Fig. 4. Salinity changes of low-salt Myungran jeotkal during fermentation at 4℃ (A) and 20℃ (B). The values are the mean±S.D. of three independent experiments. NS: not significant.

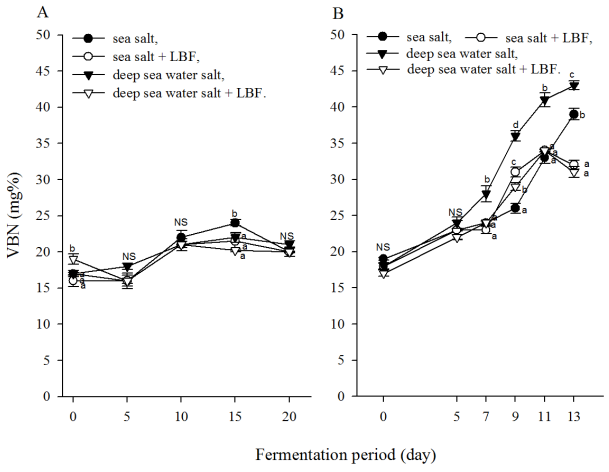

Fig. 5. Changes of volatile base nitrogen of low-salt Myungran jeotkal during fermentation at 4℃ (A) and 20℃ (B). The values are the mean±S.D. of three independent experiments. a~d: Different letters within the same row differ significantly (p<0.05). NS: not significant.

salinity and lower) during fermentation and even in Ohginguh-jeot (fermented squid) and Myeolchi-jeot (fermented anchovy) (20% salinity and higher) (Lee & Choe 1974; Chung & Lee 1976; Cha & Lee 1985).

5. Amino nitrogen

In fermented foods, the amino nitrogen content is used as a fermentation index, and is also considered an important quality index because the amino nitrogen content has a strong relationship with flavor. Myungran jeotkal was fermented at 4℃ and 20℃, adding different ratios of salt, deep sea water, and LBF. The amino nitrogen content changed in each different experimental condition, as shown in Fig. 6. When fermented at 4℃, amino nitrogen content increased with increasing fermentation duration, but the difference was not statistically significant. The amino nitrogen content was not significantly different in any group after 0, 5, 10 and 15 days of fermentation, but was significantly higher in Myungran jeotkal with added LBF after 20 days of fermentation. When fermented at 20℃, the amino nitrogen content increased abruptly with increasing fermenting period. The amino nitrogen content was significantly higher in Myungran jeotkal with added LBF after 5, 11 and 13 days of fermentation than in samples without added LBF, regardless of the type of salt added, and was also about 1.8 times (510 mg%) higher in Myungran jeotkal fermented at 20℃ for 13 days than in Myungran jeotkal fermented at 4℃. The reason may be that LBF takes part in degrading the protein of Myungran jeotkal into amino acids and accelerates the degradation of protein. Park et al. (1998) reported that when the content of amino nitrogen was measured, fermenting low salted Changran jeotkal at 0℃ for 60 days, the content of amino nitrogen tended to be increased continuously, and was about 5 times higher as 190.7 mg% 50 days after fermenting, compared to that of control (36.1 mg%). Lee et al. (2003) reported that the amino nitrogen content was decreased in Changran jeotkal irradiated with gamma rays. Lee et al. (1993) reported that when fermented ascidian was produced, under changing salinity, the amino nitrogen content was lower in the high salt product than in the low-salt product. Kim et al. (2001) reported that the content of amino nitrogen was higher in low-salted fermented oyster.

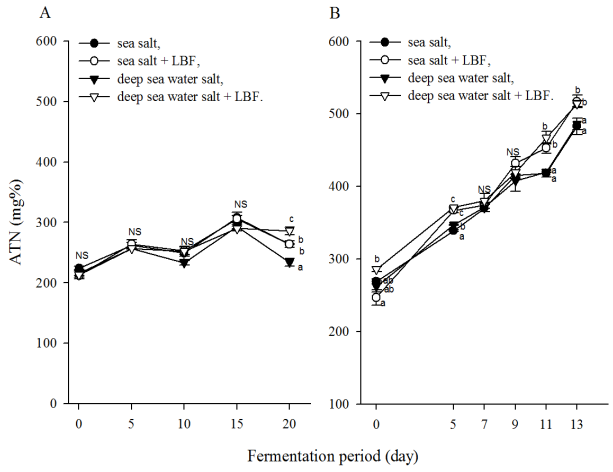

Fig. 6. Changes of amino type nitrogen of low-salt Myungran jeotkal during fermentation at 4℃ (A) and 20℃ (B). The values are the mean±S.D. of three independent experiments. a~c: Different letters within the same row differ significantly (p<0.05). NS: not significant.

6. Sensory evaluation

The sensory quality of jeotkal was evaluated because the sensory element is the most important component in jeotkal quality evaluation. In Myungran jeotkal fermented at 4℃ for 20 days, preference was the highest for Myungran jeotkal with added LBF, and was independent salt type added. The highest value, at 8.2±0.8 points, was found in Myungran jeotkal fermented with sun-dried salt and LBF (Table 2). In the sensory evaluation of Myungran jeotkal fermented at 20℃ for 13 days, preference was the highest for Myungran jeotkal fermented for 9 days, and then decreased after fermentation for 11 and 13 days samples (Table 3). The reason may be that if fermented at 20℃ for 9 days or longer, the sensory quality of jeotkal was decreased by accelerated fermentation. When fermented for 9 days, preference was better in Myungran jeotkal with added LBF than in samples without added LBF, regardless of salt type.

7. Analysis of free amino acids

Free amino acids were measured, in Myungran jeotkal samples in which the content of volatile basic nitrogen was less than the putrefaction level (30 mg%). When the amino nitrogen content was high, the preference scoring was high in the sensory evaluation. When Myungran jeotkal fermented at 20℃ for 9 days was analyzed, the free amino acid content was 717 mg/100 g in the control, and was increased to 1,395.7~1,648.8 mg/100 g in the fermented Myungran jeotkal. Free amino acid levels were highest, at 1,648.8 mg/100 g or 2.3 times that of the control, in Myungran jeotkal to which sun-dried salt and LBF, were added. Preference was also the highest in Myungran jeotkal to which sun-dried salt

Table 2. Sensory evaluation of low-salt Myungran jeotkal during fermentation at 4℃

Fermentation period (day)	Group*	Color**	Odor	Taste	Off-flavor	Texture	Acceptability
5	A	3.2±0.8^{d}	5.7±1.0^{bc}	5.5±0.8^{c}	1.5±0.2^{c}	5.5±0.5^{c}	5.4±0.6^{c}
	B	7.6±0.5^{ab}	7.2±1.1^{a}	7.5±0.9^{a}	3.2±0.4^{a}	7.2±0.7^{a}	7.8±0.7^{a}
	C	6.4±0.9^{c}	6.2±0.8^{ab}	5.7±0.5^{c}	2.2±0.4^{b}	6.2±0.7^{bc}	6.8±0.7^{b}
	D	8.4±0.7^{a}	6.7±0.9^{a}	6.7±0.7^{ab}	3.2±0.3^{a}	6.7±0.7^{ab}	7.4±0.8^{ab}
10	A	4.1±1.0^{c}	5.3±0.5^{b}	6.1±0.5^{a}	3.8±0.4^{b}	6.6±0.8^{a}	6.1±0.8^{a}
	B	6.8±1.1^{a}	6.5±0.6^{a}	6.5±0.6^{a}	3.5±0.4^{b}	5.8±0.8^{ab}	6.6±1.0^{a}
	C	5.5±0.8^{ab}	5.3±0.6^{b}	6.3±0.6^{a}	3.5±0.3^{b}	5.6±1.2^{ab}	6.5±1.0^{a}
	D	4.5±0.8^{c}	5.1±0.7^{b}	6.1±0.7^{a}	4.6±0.5^{a}	5.8±1.0^{ab}	6.1±0.9^{a}
15	A	7.5±0.7^{b}	6.7±1.2^{bc}	7.2±0.9^{bc}	3.5±0.5^{a}	6.7±0.7^{bc}	6.7±0.9^{bc}
	B	8.7±0.5^{a}	8.5±1.0^{a}	8.2±0.7^{a}	1.2±0.3^{c}	8.5±0.6^{a}	8.7±0.9^{a}
	C	6.7±0.9^{bc}	6.7±0.9^{bc}	7.2±0.5^{bc}	3.5±0.4^{a}	6.5±0.6^{bc}	6.7±0.7^{bc}
	D	7.5±0.9^{b}	7.7±0.9^{ab}	7.7±0.5^{ab}	2.5±0.5^{b}	7.7±1.1^{ab}	7.7±0.7^{ab}
20	A	6.4±0.6^{b}	6.6±1.0^{b}	6.8±1.2^{bc}	2.8±0.5^{a}	7.4±1.0^{ab}	6.8±0.6^{bc}
	B	8.4±0.6^{a}	7.8±0.8^{a}	7.8±0.4^{a}	2.8±0.5^{a}	8.2±0.9^{a}	8.2±0.8^{a}
	C	8.0±0.5^{a}	8.1±0.8^{a}	7.2±0.5^{ab}	2.2±0.3^{ab}	7.4±0.4^{ab}	7.8±0.8^{ab}
	D	8.0±0.7^{a}	8.1±0.7^{a}	7.8±1.0^{a}	2.2±0.3^{ab}	7.6±0.5^{ab}	7.8±0.7^{ab}

*Group, A: sea salt, B: sea salt + LBF, C: deep sea water salt, D: deep sea water salt + LBF
**Values with different letters within a column differ significantly (p<0.05).

Table 3. Sensory evaluation of low-salt Myungran jeotkal during fermentation at 20℃

Fermentation period (day)	Group*	Color**	Odor	Taste	Off-flavor	Texture	Acceptability
5	E	4.8±0.7^{bc}	5.2±0.7^{bc}	5.2±0.4^{b}	1.2±0.1^{ab}	5.0±0.9^{ab}	5.8±0.7^{ab}
	F	4.4±0.6^{c}	7.1±0.6^{a}	5.5±0.4^{ab}	1.7±0.2^{a}	5.2±0.9^{ab}	6.4±0.5^{a}
	G	6.8±0.6^{a}	5.7±0.9^{bc}	5.7±0.3^{ab}	1.5±0.3^{a}	5.5±1.1^{ab}	6.0±0.7^{a}
	H	5.6±0.7^{ab}	6.2±1.2^{ab}	6.2±0.6^{a}	1.2±0.2^{ab}	6.0±1.0^{a}	6.6±0.8^{a}
7	E	5.8±0.8^{a}	5.5±0.6^{bc}	5.2±0.5^{b}	1.2±0.3^{ab}	5.3±0.5^{ab}	5.8±0.6^{ab}
	F	4.5±0.8^{bc}	6.3±0.9^{a}	5.5±0.5^{ab}	1.6±0.3^{a}	5.5±0.4^{ab}	6.4±0.6^{a}
	G	5.4±0.9^{a}	5.7±0.9^{ab}	5.7±0.6^{ab}	1.4±0.1^{a}	5.5±0.7^{ab}	6.0±0.9^{a}
	H	5.1±0.7^{ab}	6.2±0.7^{a}	6.2±0.5^{a}	1.5±0.2^{a}	6.5±0.6^{a}	6.6±0.9^{a}
9	E	5.4±0.7^{c}	7.6±0.6^{a}	7.1±0.7^{a}	1.6±0.4^{a}	5.8±0.4^{b}	6.6±0.5^{ab}
	F	6.6±0.5^{b}	6.6±0.7^{ab}	6.8±0.7^{a}	1.4±0.5^{a}	6.1±0.6^{b}	7.2±0.6^{a}
	G	6.6±0.5^{b}	6.6±0.8^{ab}	6.2±0.6^{ab}	1.2±0.5^{ab}	5.8±0.9^{b}	6.8±0.7^{a}
	H	7.4±0.7^{a}	6.6±0.8^{ab}	7.2±0.8^{a}	1.2±0.3^{ab}	7.2±0.8^{a}	7.4±0.5^{a}
11	E	8.0±1.0^{a}	6.4±0.5^{a}	5.8±0.7^{a}	4.4±0.4^{a}	5.6±0.7^{ab}	4.8±1.2^{c}
	F	7.2±0.8^{ab}	6.6±0.4^{a}	6.2±0.8^{a}	2.2±0.4^{b}	6.6±0.7^{a}	6.8±1.0^{a}
	G	7.2±0.8^{ab}	6.0±0.7^{a}	5.6±0.7^{ab}	2.6±0.5^{b}	6.4±0.6^{a}	6.0±1.0^{ab}
	H	5.0±0.6^{c}	6.2±0.7^{a}	6.1±0.8^{a}	2.4±0.2^{b}	6.4±0.6^{a}	5.4±1.1^{bc}
13	E	7.5±0.7^{a}	5.2±1.0^{ab}	7.5±0.8^{a}	3.2±0.5^{a}	5.2±0.8^{ab}	6.5±1.0^{a}
	F	6.2±0.8^{b}	5.5±0.9^{ab}	5.2±1.0^{b}	3.5±0.3^{a}	6.5±0.9^{a}	6.2±0.8^{a}
	G	6.2±0.6^{b}	6.2±0.8^{a}	5.5±1.0^{b}	2.5±0.4^{b}	5.5±1.1^{ab}	6.0±0.9^{a}
	H	6.2±0.6^{b}	6.2±0.8^{a}	5.5±0.8^{b}	2.5±0.2^{b}	5.5±1.0^{ab}	6.1±0.8^{a}

* Group, E: sea salt, F: sea salt + LBF, G: deep sea water salt, H: deep sea water salt + LBF
**Values with different letters within a column differ significantly (p<0.05).

Table 4. Free amino acid content (mg/100 g) of low-salt Myungran jeotkal during the fermentation at 20℃

Amino acid	Group[1)]				
	Control	E	F	G	H
Aspartic acid	48.3	105.4	125.4	105.7	118.1
Threonine*	41.2	81.7	86.3	76.2	83.3
Serine	49.2	94.1	112.1	96.8	105.5
Glutamic acid	105.2	131.4	156.5	0	151.9
Proline	27.2	59.2	68.1	53.9	61.1
Glycine	33.1	45.7	53.9	47.4	51.5
Alanine*	81.2	106.0	124.5	110.7	120.5
Valine*	43.1	97.2	109.7	99.1	107.0
Cysteine	0	2.3	2.6	2.7	2.5
Methionine*	4.1	8.2	35.1	32.9	32.2
Isoleucine*	30.3	82.5	96.1	162.2	94.1
Leucine*	67.9	154.7	186.2	0	182.1
Tyrosine	31.5	82.5	97.4	81.0	85.7
Phenylalanine*	29.6	70.1	78.4	69.1	75.9
Lysine*	65.6	140.5	160.4	142.0	154.4
Histidine*	14.1	26.3	31.8	25.7	29.2
Arginine*	45.5	107.9	124.3	109.9	119.7
Tryptophan*	0	8.2	19.0	15.1	15.6
Total	671.6	1,287.8	1,524.5	1,215.3	1,574.7

*Essential amino acids

1) Group, E: sea salt, F: sea salt + LBF, G: deep sea water salt, H: deep sea water salt + LBF

and LBF or salt from deep sea water and LBF was added (Table 4). The free amino acid content is used as a fermentation index for jeotkal because free amino acids are degraded into amino nitrogen, as the jeotkal is fermented (Yook et al. 2004). Part et al. (1998) reported that fermentation of Changran jeotkal for 50 days, resulted in a free amino acid content about 3 times higher, at 3,061.1 mg%, than in the control, in agreement with the present experimental result. The reason may be that LBF degrades some part of proteins into free amino acids, and taste compounds, thus, addition of LBF added improves the taste and flavor of Myungran jeotkal.

A low-salt Myungran jeotkal prepared in this study showed high preference. Therefore, if Myungran jeotkal is used in the food industry, it is thought to contribute to public health. A low-salt Myungran jeotkal is needed more research on the storage stability.

References

Cha YJ, Lee EH. 1985. Studies on the processing of low salt fermented sea foods; 5. Processing conditions of low salt fermented anchovy and yellow corvenia (in Korean). *Bull Korean Fish Soc* 18:206-213

Chae SK, Kang KS, Ma SJ, Bang KW, Oh MH. 1999. Standard Food Analytics, Gi-Goo-Mun-Hwa-Sa Publishing Co., Ltd., Seoul, Republic of Korea, pp. 299-300

Chung SY, Lee EH. 1976. The taste compounds of fermented *Acetes chinensis* (in Korean). *Bull Korean Fish Soc* 9: 79-110

Ham SS, Kim SH, Yoo SJ, Oh HT, Choi HJ, Chung MJ. 2008. Biological activities of soybean sauce (Kanjang) supplemented with deep sea water and sea tangle. *Korean J Food Preserv* 15:272-279

Han JS, Cho HR, Cho HS. 2005. Study for the establishment of the quality index of low-salted Myungran-jeot. *Korean J Food Cookery Sci* 21:440-446

Jeong GJ. 2005. Picture Book to the Microbiology Ⅱ. Kook-Jae-Pi-Al Publishing Co., Ltd., Seoul, Republic of Korea, pp. 49-55

Jung HK, Jeong YS, Youn KS, Kim DI, Hong JH. 2009a.

Quality characteristics of soybean paste (Doenjang) prepared with *Bacillus subtilis* DH3 expressing high protease levels, and deep sea water. *Korean J Food Preserv* 16:348-354

Jung S, Choe JH, Kim B, Yun H, Kim YJ, Jo C. 2009b. Microbiological, physicochemical, and sensory characteristics of Myungran jeotgal treated by electron beam irradiation. *Korean J Food Preserv* 16:198-203

Kim DS, Lee HO, Rhee SK, Lee S. 2001. The processing of seasoned and fermented oyster and its quality changes during the fermentation. *J Korean Soc Agric Chem Biotechnol* 44: 81-87

Kim EJ, Hahn YS. 2008. Studies on the manufacturing and fermentation characteristics of soy-sauce-Kimchi. *Korean J Food Cookery Sci* 24:517-524

Kim JH, Ryu GH, Ahn HJ, Lee KH, Lee HJ, Byun MW. 2000. Quality evaluation of commercial salted and fermented anchovy sauce. *J Korean Soc Food Sci Nutr* 29:837-842

Kim JW. 2008. Changes in physicochemical quality during the seasoned and fermented alaska pollack roe with vacuum fermentation. MS thesis, Hankyong National Univ. Anseong, Korea

Kim ML, Jeong JS, Lee GD. 2003. Change in growth of alcohol fermentation yeast with addition of deep seawater. *Korean J Food Preser* 10:417-420

Lee JG, Choe WK. 1974. Studies on the variation of microflora during the fermentation of anchovy, *Engraulis japonica* (in Korean). *Bull Korean Fish Soc* 7:105-114

Lee KH, Cho HS, Lee DH, Ryuk JH, Cho YJ, Suh JS, Kim DS. 1993. Utilization of ascidian, *Holocynthia orretzi*, 5. Processing and quality evaluation of fermented ascidian (I). *Korean J Fish Aquat Sci* 26:221-229

Lee KG, Kim SM. 2012. Quality changes in low-salted squid jeot-gal during fermentation and determination of shelf-life. *J Korean Soc Food Sci Nutr* 41:687-694

Lee NY, Jo CU, Lee WD, Kim JH, Byun MW. 2003. Physicochemical characteristics of gamma irradiated Changran jeotkal during storage at 10℃. *Korean J Food Sci Technol* 35:1129-1134

Lee SW, Kim HJ, Moon DS, Kim AR, Jeong IH. 2007. Characteristics of tofu coagulants extracted from sea tangle using treated deep ocean water. *J Korean Fish Soc* 40:113-116

Moon DS, Kim HJ, Shin PK, Jung DH. 2005. Characteristics of chemical contents of horizontal spray salts from deep ocean water. *J Korean Fish Soc* 38:65-69

Park SH, Sim YB, Suh HW, Nam KS, Lee DJ, Choi SY, Lee DS. 2013. Effects of physiological activity on immune function, anti-hyperglycemia and intestinal motility promotion of vegetable *Lactobacillus fermentum*. *Chinese Journal of Microbiology* 25:782-788

Park SM, Park CK, Lee KT, Kim SM. 1998. Changes in taste compound of low salt fermented pollack tripe during controlled freezing point aging. *Korean J Food Sci Technol* 30:49-53

Yook HS, Cha BS, Kim DH, Lee JW, Byun MW. 2004. Genotoxicological safety of gamma-irradiated salted and fermented anchovy sauce. *J Korean Soc Food Sci Nutr* 33:1192-1200

Received 18 March, 2016
Revised 6 April, 2016
Accepted 18 April, 2016