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Effects of Turmeric (*Curcuma longa* L.) on the Physicochemical Characteristics of *Kochujang* during Fermentation

Dong-Han Kim*

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Abstract Physicochemical properties of *kochujang* prepared with different concentration of turmeric were compared. The number of yeast and bacteria in the *kochujang* were low in the group with more than 1% of turmeric while the amylase and protease activity increased in the group with less than 1% of turmeric. The L- and b-values increased as the concentration of turmeric increased, however a-value decreased. The titratable acidity was low in the high percentage of turmeric added group. Oxidation-reduction potential increased in the later stage of fermentation with decrease in Aw. Reducing sugar and alcohol were high in than higher turmeric added group. Amino- and ammonia-type nitrogen were the highest in the 0.5% turmeric added group. The overall acceptability of *kochujang* was significantly more favorable (p <0.05) in the 0.25% turmeric added group than over 1% turmeric added one.

Keywords fermentation · *kochujang* · physicochemical properties · turmeric

Introduction

Kochujang is a traditional fermented food (Lee, 1979) that is made by fermentation of glutinous rice with red pepper powder, *meju* and salt; it has a special flavor and taste with a proper balance of hot taste, sweet taste, and flavor taste. The quality of *kochujang* is characterized by the type of ingredients and the ratio of their mixture (Cho et al., 1981; Kim et al., 2008), microbial strain (Oh et al., 2000), and the concentration of salt (Kim and Yang, 2004). Recently, because consumers desire and pursue convenience and society is becoming a nuclear family society, and because the use of the improved mass-produced *kochujang* with *koji* is replaced with the traditional *kochujang* produced at home using *meju*, the optimum fermentation time (Kwan et al., 1996) and quality index should be established. Studies of *kochujang* have focused mainly on the various starch sources (Moon and Kim, 1988; Shin et al., 1997) used in the preparation of *kochujang*, and followed by the use of fig (Kim and Song, 2002), Japanese apricot (Lee, 2008), and *red koji* (Hyun et al., 2007) as the secondary ingredients for improving the quality or to change the physiochemical properties during the fermentation and aging processes. Also, to improve *kochujang* as a worldwide condiment, lower-salt *kochujang* is advisable to reduce the intake of sodium. However, since salt controls (Oh et al., 2002) the fermentation and aging by the microorganisms, when the concentration of salt is low, it may cause unfavorable fermentation during aging and deterioration during storage. If alcohol with anti-microbial activity (Yamamoto et al., 1984) is used in the preparation of *kochujang*, microorganisms can be effectively controlled during aging and storing and thus lower-salt *kochujang* can be produced. There have been reports of adding spices, such as garlic (Kim and Lee, 2001), mustard and horseradish (Shin et al., 2000; Oh et al., 2006) or adding mixtures of these anti-microbial materials (Kim, 2005; Park and Kim, 2007) during the preparation of *kochujang*.

Turmeric is the root of a rhizomatous herbaceous perennial plant of the ginger family and it is used both as a medicinal plant (Park et al., 2007) and as a spice. It also contains curcumin as its yellow color, and tumerone and dehydrotumerone as essential oils; and its antimutagenic, antioxidant and anti-microbial properties have been reported (Choi, 2009).

In order to prevent microbial proliferation and color change of *kochujang* during fermentation, different amount of turmeric was added and its effect on microorganisms and physicochemical properties of *kochujang* were determined.

D. -H. Kim
Department of Food & Nutrition, Mokpo National University, Muan, Jeonnam 534-729, Republic of Korea

*Corresponding author (D. -H. Kim: dhankim@mokpo.ac.kr)

Materials and Methods

Materials. Glutinous rice, soybean, red pepper powder, malt, sun-dried salt and turmeric powder were purchased at a local market.

Table 1 The mixing ratios of raw materials for the preparation of *kochujang* (Unit: %)

	Glutinous rice	Turmeric	Red pepper	Wheat *koji*	*B. subtilis koji*	Malt	NaCl	Water
Control	20.0	0.0	14.0	11.0	3.0	0.4	9.0	42.6
T-0.25	19.75	0.25	14.0	11.0	3.0	0.4	9.0	42.6
T-0.5	19.5	0.5	14.0	11.0	3.0	0.4	9.0	42.6
T-1	19.0	1.0	14.0	11.0	3.0	0.4	9.0	42.6
T-2	18.0	2.0	14.0	11.0	3.0	0.4	9.0	42.6
T-3	17.0	3.0	14.0	11.0	3.0	0.4	9.0	42.6

[1)]T: Turmeric added *kochujang*

Aspergillus oryzae koji was made with flour and *Bacillus subtilis koji* (Tobagisoonchang, Co., Korea) was made with soybeans.

Kochujang. *Kochujang* was prepared with different ratios of glutinous rice powder (17.0–20.0%), adding malt and water, heating the solutions for the saccharification and then adding turmeric to be 0.0–3.0%, respectively. The rest of the raw materials were added as specified in Table 1, and then the prepared *kochujang* was put in 5 L plastic containers and fermented for 12 weeks at 20°C.

Viable cell count and enzyme activity. *Kochujang* was spread on plates using tryptic soy agar for counting aerobic bacteria, and using APT agar for counting facultative anaerobes and then the spread plate was covered with 1.5% agar to form the second layer; rose bengal agar culture medium was used for yeast and the plates were cultured for 1–3 days at 30°C by the streak plate method (Kim and Yang, 2004) . As for enzyme activities (Park and Kim, 2007), α-amylase activity was measured using a modified Fuwa's blue value method, β-amylase activity using the method of Fuwa et al. and protease activity using the Anson's method in pH 3.0 and 6.0 separately (for convenience, these are called acidic and neutral proteases, respectively).

Chemical analysis and color. As for the general components of *kochujang*; pH, titratable acidity, reducing sugar, alcohol, amino-type nitrogen, and ammonia-type nitrogen were measured based on the official methods of miso analysis (Institute of Miso Technologists, 1968). A Chromameter CR-200 (Minolta, Japan) was used to measure color in L (lightness), a (redness) and b (yellowness) values according to the Hunter scale. Oxidation-reduction potential (ORP) was measured using an ORP-meter (Orion525A+, USA); water activity was measured using a Novasina LabSwift-Aw (CH-8853, Switzerland).

Sensory evaluation. The *kochujang* fermented for 12 weeks, was given to 20 students from the department of Food & Nutrition to evaluate for four items: taste, flavor, color and overall acceptability in 7 levels; then, variance analysis of the results was conducted using the SPSS/PC package 12.0 and statistically processed by Duncan's multiple range test.

Results and Discussion

Microbial flora. As shown in Table 2, the yeast population increased by around 1 log cycle at the 8^{th} week of fermentation, then it decreased thereafter and maintained a level of 10^5 CFU/g. There were no difference among the test groups, although the number of yeast was relatively small in groups of higher turmeric concentration. Compared to the report of Park and Kim (2007) who reported the number of yeast decreased by 2 log cycles when

Table 2 Changes in viable cell counts of microorganism of *kochujang* during fermentation (Unit: log number of CFU/g)

Component	Fermentation time (weeks)	Kochujang					
		Control	T-0.25	T-0.5	T-1	T-2	T-3
Yeast	0	4.79±0.38	4.78±0.38	4.82±0.17	4.78±0.18	4.81±0.31	4.76±0.33
	4	4.87±0.23	4.96±0.29	5.06±0.22	4.99±0.18	4.83±0.23	4.76±0.24
	8	5.82±0.17	5.85±0.27	5.77±0.14	5.61±0.16	5.54±0.11	5.50±0.21
	12	5.60±0.26	5.61±0.33	5.50±0.32	5.23±0.23	5.18±0.26	5.07±0.19
Aerobic bacteria	0	9.44±0.33	9.55±0.30	9.51±0.42	9.57±0.12	9.58±0.21	9.48±0.33
	4	9.41±0.41	9.67±0.30	9.52±0.35	9.49±0.26	9.38±0.23	9.21±0.29
	8	9.88±0.22	9.94±0.33	9.95±0.42	9.71±0.20	9.72±0.41	9.65±0.31
	12	9.77±0.32	9.79±0.22	9.52±0.27	9.49±0.26	9.33±0.45	9.14±0.44
Anaerobic bacteria	0	7.08±0.15	6.98±0.22	7.06±0.18	6.98±0.17	7.12±0.24	7.11±0.31
	4	7.11±0.22	7.14±0.24	7.09±0.21	7.01±0.26	7.05±0.31	7.08±0.46
	8	7.44±0.31	7.52±0.33	7.44±0.31	7.39±0.26	7.26±0.23	7.23±0.37
	12	7.09±0.21	7.19±0.25	6.99±0.21	6.83±0.17	6.66±0.27	6.60±0.34

[1)]T: Turmeric added *kochujang*

[2)]Values are mean ± SD (n =3).

alcohol (4%) or mustard (1%), the anti-microbial activity of turmeric for the yeast was low. In the case of traditional *kochujang* with the addition of fig, the number of yeast increased slightly at the beginning of fermentation and thus was smaller than the 1.9-2.4×10^6 CFU/g reported by Kim and Song (2002). However, an excessive proliferation of yeast produces alcohol during fermentation and makes yeast react with organic acid to be esterified to produce aroma components, it also produces CO_2 gas to cause abnormal formation or rupture in the container during aging and in storage (Kim and Yang, 2004).

Unlike the number of yeast, the number of bacteria did not show any significant change during fermentation, and the numbers of both aerobic bacteria and anaerobic bacteria showed a tendency to increase slightly at the 8th week of fermentation, and decreased thereafter. Also, the number of aerobic bacteria was larger by around 2 log cycles compared to anaerobic bacteria, and the number of bacteria was smaller in groups where more than 1.0% of turmeric was added. This indicates that turmeric suppresses the growth of bacteria. Oh et al. (2006) reported that the number of bacteria in traditional *kochujang* with different concentrations of salt was 10^8 CFU/g and did not show significant differences during fermentation. Their results were similar to this experiment, although there was a difference in the number of bacteria because *Bacillus subtilis koji* was mixed during preparation. Meanwhile, it has been reported that as the turmeric extract increased from 0.25 to 1%, the number of bacteria decreased in *kimchi* (Lee et al.,

Table 3 Changes in amylase activity of *kochujang* during fermentation (Unit: unit/g)

Component	Fermentation time (weeks)	*Kochujang*					
		Control	T-0.25	T-0.5	T-1	T-2	T-3
α-Amylase (×10)	0	1.72±0.29	1.65±0.37	1.68±0.27	1.69±0.40	1.71±0.26	1.68±0.32
	2	1.15±0.29	1.14±0.34	1.17±0.32	1.22±0.40	1.14±0.11	1.13±0.23
	4	1.24±0.38	1.27±0.39	1.29±0.18	1.30±0.30	1.23±0.19	1.17±0.29
	6	1.46±0.24	1.48±0.20	1.57±0.21	1.43±0.17	1.35±0.33	1.31±0.16
	8	1.60±0.09	1.61±0.38	1.63±0.42	1.71±0.30	1.74±0.32	1.72±0.41
	10	2.01±0.11	2.06±0.12	2.35±0.19	2.33±0.08	2.31±0.44	2.22±0.30
	12	1.18±0.32	1.29±0.11	1.32±0.23	1.29±0.21	1.17±0.22	1.16±0.11
β-Amylase (×100)	0	1.36±0.36	1.41±0.31	1.44±0.40	1.46±0.41	1.43±0.35	1.47±0.37
	2	2.26±0.36	2.87±0.28	2.99±0.49	2.95±0.22	3.02±0.44	2.99±0.25
	4	3.37±0.48	3.71±0.57	3.86±0.36	4.76±0.19	4.49±0.20	4.15±0.44
	6	4.39±0.58	4.43±0.46	4.47±0.58	4.83±0.46	4.90±0.15	4.81±0.35
	8	4.73±0.19	4.78±0.36	4.94±0.48	5.17±0.26	5.04±0.35	5.03±0.31
	10	8.28±0.63	8.33±0.54	8.78±0.11	8.76±0.38	8.91±0.52	8.84±0.21
	12	2.79±0.57	2.88±0.49	2.71±0.45	2.36±0.19	2.24±0.45	2.20±0.43

[1)]T: Turmeric added *kochujang*
[2)]Values are mean ± SD (n =3).

Table 4 Changes in protease activity of *kochujang* during fermentation (Unit: unit/g)

Component	Fermentation time (weeks)	Kochujang					
		Control	T-0.25	T-0.5	T-1	T-2	T-3
Acidic protease	0	5.97±0.66	5.82±061	6.13±0.60	6.13±0.53	6.16±0.54	6.05±0.49
	2	2.77±0.64	2.88±0.43	2.90±0.56	2.92±0.38	2.99±0.50	3.13±0.41
	4	2.90±0.54	3.29±0.38	4.08±0.21	4.09±0.19	3.65±0.36	3.32±0.45
	6	2.77±0.55	3.23±0.29	3.15±0.41	3.12±0.48	3.02±0.39	3.05±0.36
	8	2.77±0.52	3.58±0.21	3.40±0.61	3.15±0.49	3.15±0.41	2.92±0.40
	10	4.10±0.55	4.43±0.41	5.66±0.58	5.39±0.62	5.22±0.21	5.03±0.44
	12	5.38±0.65^{b}	6.15±0.40^{ab}	6.57±0.59^{a}	6.55±0.39^{a}	5.28±0.51^{b}	4.91±0.13^{b}
Neutral protease	0	2.90±0.60	2.77±0.55	2.75±0.11	2.72±0.19	2.95±0.21	2.98±0.30
	2	1.38±0.24	1.46±0.23	1.64±0.31	1.76±0.26	1.68±0.36	1.59±0.29
	4	2.62±0.41	2.65±0.51	2.72±0.22	3.02±0.49	2.90±0.28	2.77±0.55
	6	2.39±0.25	2.52±0.11	2.65±0.31	2.65±0.19	2.52±0.26	2.32±0.42
	8	2.14±0.41	2.39±0.32	2.52±0.26	3.02±0.36	3.40±0.25	3.03±0.32
	10	2.57±0.20^{c}	2.39±0.21^{c}	2.72±0.13^{bc}	3.02±0.42^{ab}	3.40±0.52^{a}	3.33±0.20^{ab}
	12	2.65±0.44^{c}	2.77±0.45^{c}	2.85±0.14^{bc}	2.63±0.42^{ab}	2.52±0.31^{a}	2.45±0.23^{ab}

[1)]T: Turmeric added *kochujang*
[2)]Values are mean ± SD (n =3).
[3)]Means with the same letter in row are not significantly different by Duncan's multiple range test (p <0.05).

1997) and the initial stage of decomposition was suppressed in noodles and rice cakes.

Enzyme activity. The enzyme activity of *kochujang* during fermentation is shown in Tables 3 and 4. In the case of amylases, the activity of α-amylase decreased at the 2nd week of fermentation, but slowly increased thereafter, showing the highest activity at the 10th week. In the group with 0.5–1% of turmeric addition, the enzyme activity increased a little but decreased when more turmeric was added. The activity of β-amylase started to increase at the beginning of fermentation, showed the highest activity at the 10th week, and decreased rapidly thereafter. In the group with 1–2% of turmeric addition, the enzyme activity was high in the middle of the fermentation and, decreased in the later period of the fermentation. This result has a similar tendency to the report by Oh et al. (2006), in which the activity of β-amylase in *kochujang* with mustard addition was the highest the 60th day of fermentation, the enzyme activity of β-amylase increased during fermentation, and the enzyme activity was higher in the group where mustard (1.2%) was added compared to groups without mustard.

Unlike the amylase activity, the acidic protease activity decreased rapidly right after the preparation but increased after the 10th week, and the neutral protease activity showed irregular increase and decrease without any significant changes during fermentation. Compared to the neutral protease, the acidic protease showed higher activity. It also showed slightly higher activity when 0.5–1% of turmeric was added, but it decreased when a higher percentage was added. Oh et al. (2006) reported that the *kochujang* with 1.2% mustard had a slightly higher protease activity than that of the control, which is similar to the effects of the addition of turmeric. The result, however, was different from the results of Park and Kim (2007) in which the protease activity was slightly lower when anti-microbial materials were added. The changes in the number of bacteria and the enzyme activity shown in Table 2 were not similar. It was judged that the enzyme activity in *kochujang* would be determined by the types of microorganisms and *koji* during fermentation rather than by the number of bacteria.

Color. Changes in the color of *kochujang*, which is important for consumer preference, were measured using the Hunter chromameter. All of L-values (brightness), a-values (redness) and b-values (yellowness) decreased slowly as the fermentation progressed (Table 5). In the test group, the L-value and b-value increased as the percentage of turmeric increased and the a-value decreased slightly to show a tendency to have a lighter yellow shade compared to the control. These results were similar to the report by Oh et al. (2002) in which all of L-, a- and b-values decreased in *kochujang* made using red *koji* and barley, while being different from the report by Park and Kim (2007) in which a- and b-values increased during fermentation when anti-microbial materials were mixed and added to the *kochujang*. Therefore, the color of *kochujang* was thought to be determined by the red pepper drying methods, the varieties of red pepper, the amount of red pepper powder used and the fermentation condition. Meanwhile, the fermentation of *kochujang* progressed to orange-pink colors in a dominant wavelength range of 594–7 nm and the colors became darker and deeper due to Maillard reactions (Moon and Kim, 1988). The browning progressed also because of biochemical reactions (Kim et al., 2001), such as oxidation and enzymatic reactions.

pH and titratable acidity. The pH during fermentation of *kochujang* decreased slowly as the fermentation progressed to become 4.63–4.78 at the 12th week; the pH was high in the group where the concentration of added turmeric was high (Fig. 1). These results were similar to the report by Park and Kim (2007) in which changes in pH were slight when anti-microbial materials were mixed and added, and the pH after fermentation varied with the types of *kochujang*; the *kochujang* of Kim et al. (2008) which was mixed with *Aspergillus* sp. and *Bacillus subtilis* showed a pH

Table 5 Changes in color values of *kochujang* during fermentation

Fermentation time (weeks)	Hunter color value	*Kochujang*					
		Control	T-0.25	T-0.5	T-1	T-2	T-3
0	L	33.71±0.42[b]	33.52±0.27[b]	34.11±0.63[b]	34.19±0.26[b]	34.94±0.73[b]	35.58±0.76[a]
	a	20.89±0.71	20.84±0.59	20.77±0.69	20.71±0.51	19.78±0.69	19.40±0.60
	b	23.60±0.57[c]	25.36±0.54[b]	25.63±0.67[b]	25.82±0.64[b]	27.11±0.25[a]	28.19±0.59[a]
4	L	31.83±0.22[d]	31.70±0.43[cd]	32.30±0.16[bc]	32.41±0.10[b]	32.77±0.20[b]	33.50±0.32[a]
	a	18.81±0.24[a]	18.65±0.12[a]	18.59±0.11[a]	18.58±0.12[a]	18.00±0.11[b]	18.02±0.19[b]
	b	21.06±0.37[d]	21.27±0.19[d]	22.25±0.34[c]	22.45±0.15[bc]	23.27±0.51[b]	24.73±0.63[a]
8	L	32.01±0.47[d]	32.15±0.34[cd]	32.73±0.67[bc]	33.88±0.82[ab]	33.71±0.59[ab]	34.34±0.62[a]
	a	18.25±0.27[b]	18.34±0.09[a]	17.74±0.07[c]	17.36±0.11[c]	17.80±0.22[c]	16.99±0.09[d]
	b	19.11±0.45[b]	19.64±0.69[b]	19.48±0.24[b]	20.57±0.61[ab]	20.84±0.43[ab]	21.98±0.36[a]
12	L	31.11±0.61[c]	31.88±0.20[bc]	31.89±0.22[bc]	31.62±0.36[bc]	32.16±0.39[b]	32.96±0.18[a]
	a	17.72±0.23[ab]	18.09±0.23[a]	17.88±0.33[ab]	17.57±0.18[b]	17.16±0.14[c]	16.74±0.11[c]
	b	19.85±0.13[d]	20.23±0.12[d]	20.51±0.22[c]	20.88±0.16[c]	22.64±0.28[c]	23.57±0.21[a]

[1)]T: Turmeric added *kochujang*
[2)]Values are mean ± SD (n =3).
[3)]Means with the same letter in row are not significantly different by Duncan's multiple range test (p <0.05).

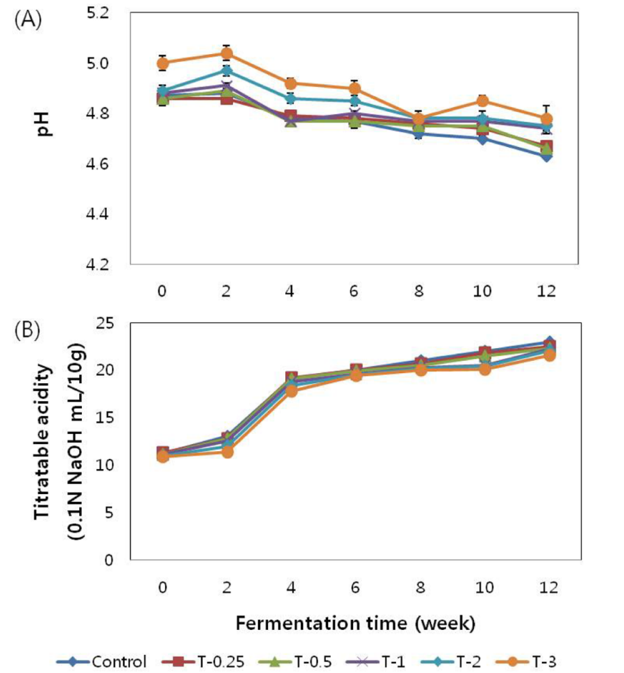

Fig. 1 Changes in pH (A) and titratable acidity (B) of *kochujang* during fermentation

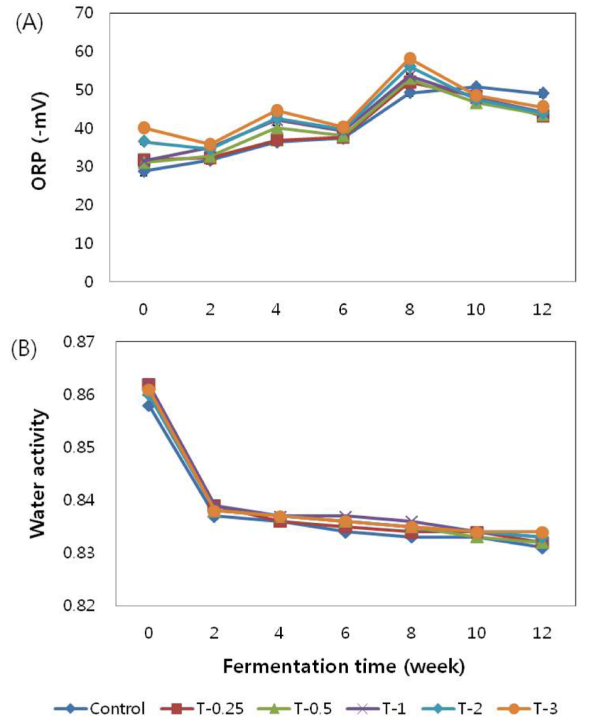

Fig. 2 Changes in oxidation-reduction potential (A) and water activity (B) of *kochujang* during fermentation

of 4.71–4.82 after 100 days of fermentation, and the *kochujang* mixed with fig showed a pH of 4.65–4.67 after 60 days of fermentation (Kim and Song, 2002). The titratable acidity increased as the fermentation progressed and the increase was rapid at the initial stage of fermentation. After 2 weeks of preparation, the increase of the titratable acidity was slight in the group with high concentrations of turmeric. It has been reported (Oh et al., 2000) that the acidity of *kochujang* increased at the beginning of fermentation while changes in acidity were slight in the later stage of fermentation because it changed to an aroma component by esterifying with alcohol generated during the fermentation. This report generally coincided with the results shown in Fig. 4, where the production of alcohol was high at the later stage of fermentation.

ORP and water activity. ORP in *kochujang* had a tendency to decrease until the 6th week of fermentation, and increased thereafter as the fermentation progressed (Fig. 2). Though the ORP was low when the concentration of added turmeric was high at the beginning of preparation, it tended to be high after 10 weeks. Meanwhile, the ORP change was slight during fermentation when anti-microbial materials were added, and it has been reported that ORP of *kochujang* with chitosan addition was lower compared to *kochujang* with alcohol or mustard (Kim and Yang, 2004; Park and Kim, 2007), but higher than −200 mV, a level at which the addition of anti-microbial materials can suppress the growth of aerobic microorganisms (James, 2000). As shown in Fig. 1, the water activity gradually decreased as the fermentation progressed even though the water content was increased, Aw was a little high in the group where the concentration of added turmeric was high. It has been reported that Aw decreased because the raw material components were hydrolyzed as the fermentation progressed and thus the molar fraction of solutes increased (Shin et al., 1997), and that the control had lower Aw than the group where the anti-microbial material was added compared to the moisture content (Kim, 2005). Meanwhile, it was reported (Lee, 2008) that in *kochujang* with added Japanese apricot, the water content was 36.22–38.37%, and thus Aw was 0.61–0.67 and the water content that could control the aging of *kochujang* was below 45%.

Reducing sugar and ethanol. The changes in reducing sugar, which is a necessary for the sweet taste of *kochujang*, gradually increased as fermentation progressed to the level of 18.23–18.80% at the 12th week of fermentation (Fig. 3). The reducing sugar was a little high in the groups where the percentage of added turmeric was high because the usage of reducing sugar was low since the growth of microorganism was suppressed in the experimental groups (Table 2). These results are similar to two reports: [1] the report by Kim and Yang (2004) in which the reducing sugar in *kochujang* with added alcohol and mustard was higher, 17.22% and 15.86%, respectively, after fermentation, compared to 12.33% in the group without additives; and [2] the report by Park and Kim (2007) in which the reducing sugar content was higher, 9.24% when a mixture of alcohol and mustard was added, compared to 6.76% in the control, although the content of reducing sugar varied greatly with the preparation conditions. Alcohol was produced gradually during fermentation although the increase was rapid in the later stage of fermentation. The production of alcohol increased

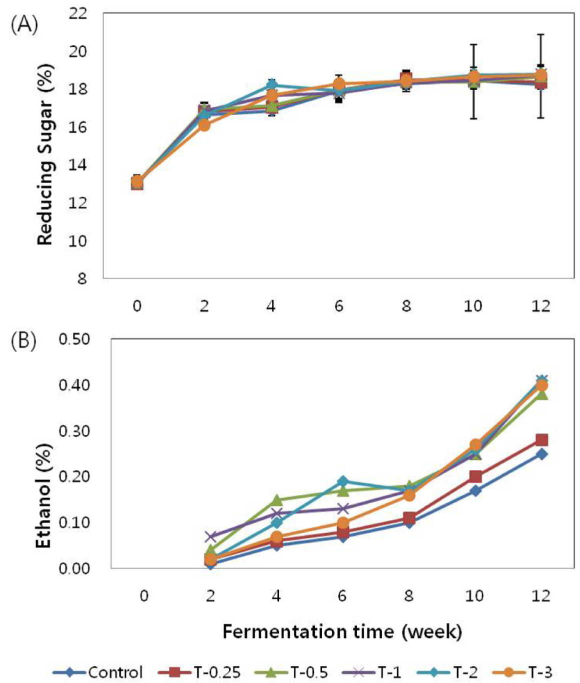

Fig. 3 Changes in reducing sugar (A) and ethanol (B) contents of *kochujang* during fermentation

as the concentration of added turmeric increased. The concentration of alcohol was 0.41% in *kochujang* with 1–2% of added turmeric at week 12 of fermentation while it was lower at higher concentrations of turmeric. However, the production of alcohol did not coincide with the number of yeast in Table 2, and the content of alcohol after fermentation was lower compared to the report by Kim et al. (2008) in which it was 0.75–0.94% at day 100 when different types of *meju* were used, and 1.42% at day 150 for traditional *kochujang* (Kwan et al., 1996).

Nitrogen component. Amino-type nitrogen which is an important taste component of *kochujang* was gradually increased by the hydrolysis of protein as the fermentation progressed to be the highest at the 8th week of fermentation at 0.31–0.36%, and then decreased thereafter (Fig. 4). The amino-type nitrogen was the highest in the group with 0.5% of turmeric addition and it tended to decrease in higher concentrations. These results were higher than 164.20 mg% (Kim et al., 2008) in *kochujang* with different types of *meju* and lower than 340–510 mg% (Shin et al., 2000) when horseradish and mustard were added, which indicates that the amino-type nitrogen content varied with the types of *koji* and mixing ratios. Ammonia-type nitrogen, which can be a reason for unacceptable taste during the fermentation of *kochujang,* increased during the first 10 weeks of fermentation then rapidly decreased. It was also high in the section with 0.5% of added turmeric and decreased in higher concentrations. These were a lower compared to the report by Lee (1979) in which it was 34–41 mg% *in kochujang* added with yeast and 32 mg% (Cho et al., 1981) in traditional *kochujang*.

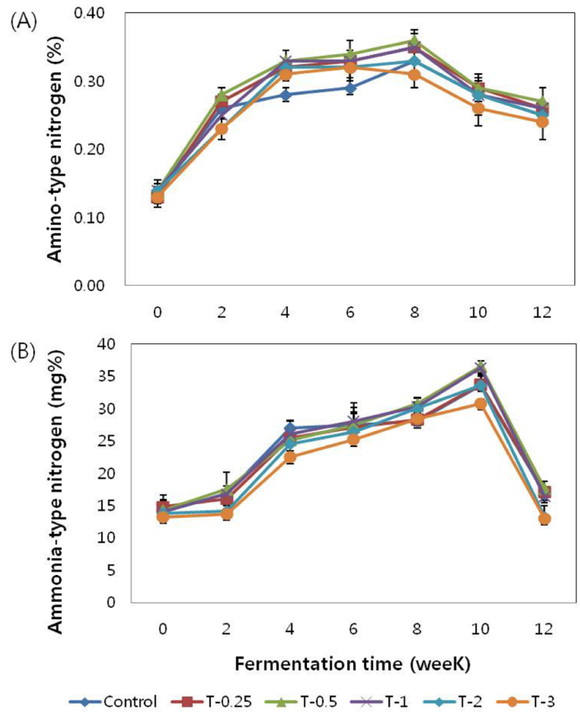

Fig. 4 Changes in amino-type nitrogen (A) and ammonia-type nitrogen (B) contents of *kochujang* during fermentation

Table 6 Result of sensory evaluation of *kochujang* aged for 12 weeks

Kochujang	Taste	Color	Flavor	Overall acceptability
Control	4.20±0.24^{ab}	5.15±0.22^{a}	4.80±0.29^{a}	4.45±0.32^{ab}
T-0.25	4.95±0.28^{a}	5.45±0.21^{a}	4.80±0.24^{a}	5.10±0.31^{a}
T-0.5	4.70±0.33^{a}	4.80±0.26^{a}	4.85±0.21^{a}	5.00±0.26^{ab}
T-1	4.55±0.29^{a}	3.85±0.22^{b}	4.65±0.22^{ab}	4.25±0.25^{bc}
T-2	3.60±0.27^{b}	3.25±0.23^{bc}	4.00±0.23^{bc}	3.60±0.20^{cd}
T-3	2.75±0.27^{c}	2.70±0.23^{c}	3.65±0.33^{c}	3.10±0.25^{d}

1)T: Turmeric added *kochujang*
2) Values are mean ± standard deviation
3)Means with the same letter in column are not significantly different by Duncans multiple range test ($p < 0.05$)

Sensory evaluation. In the sensory evaluation of *kochujang* fermented for 12 weeks, the taste was significantly more satisfactory ($p < 0.05$) in the group with 0.25% turmeric added compared to the group with more than 2% turmeric added one, and the color was significantly more satisfactory compared to the group with more than 1% turmeric added group as shown in Table 6. As for the color, when the added concentration of turmeric increased, the shade of yellow increased to receive unfavorable judgment as shown in Table 5. For the flavor, the group with 0.5% addition received a favorable judgment and the overall acceptability of the group with 0.25% of added turmeric was significantly preferable ($p < 0.05$) than the group with 1% or more added, followed by the group with 0.5% added. Groups with above 0.5% added received unfavorable judgment because of the unique stimulating taste of turmeric. Based on these results, when compared to the report (Kim and Yang, 2004) where for customer preference for *kochujang* with anti-microbial materials added, the group with 4% alcohol addition was higher than the group without any addition. While the group with 1% mustard or 0.7% chitosan added was not favored, adding turmeric in *kochujang* preparation was desirable.

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