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Changes of TBARS, VBN and Pathogens on Vacuum Packed Pork during Storage after Aging with Korean Traditional Sauces

Sung-Sil Moon[1], Sang-Keun Jin*, Il-Suk Kim, Ki-Hoon Park, and Kyung-Hee Hah[2]
Department of Animal Resources Technology, Jinju National University, [1]Sunjin Meat Research Center, [2]National Livestock Research Institute

Abstract

Sixteen semimembranous muscles were removed from sixteen left pig carcasses. They were cut into 7×10×2 cm pieces and mixed randomly. Samples were assigned to four treatments: (T1) soy-based sauce; (T2) Kimchi-based sauce; (T3) pickled shrimp-based sauce; and (T4) onion-based sauce. Each sample was aged in a plastic box at 1℃ for 10 days, then vacuum packed and held at 1°C for 28 days. The lightness and redness values of the aged pork were, in most cases, significantly increased on the surface and in the interior (p<0.05) by day 28 for all treatments , relative to day 1. The thiobarbituric acid reactive substances (TBARS) value significantly (p<0.05) increased for T1 and T4 from day 1 until day 14, but decreased after 14 days of storage (p<0.05). The TBARS value for T3 decreased with storage time (p<0.05), although there was no difference between 14 and 28 days. The total volatile basic nitrogen (VBN) content increased significantly with storage time (p<0.05) for all treatments, with the exception of T2. Total plate counts (TPC) increased significantly (p<0.05) with increasing storage time for all treatments. On day 1, T2 had the highest TPC value (p<0.05), while T4 was lowest (p<0.05). On 28 day, T2 had the lowest TPC value (p<0.05), while T3 was highest (p<0.05). *E. coli* levels showed a significant (p<0.05) decrease with increased storage for T1, T2 and T4. These results indicate that T2 was more effective at inhibiting the growth of *E. coli* than the other pork samples. The levels of *Lactobacillus* spp. increased with storage time for all samples. These results suggest that traditional Korean ingredients could be utilized to extend the shelf-life of aged pork during storage.

Key words : Korean traditional sauces, aged pork, TBARS, *E. coli*, TPC, *Lactobacillus* spp.

INTRODUCTION

Aged meat products are essential components of the diet in a number of developing countries, and are consumed either as main dishes or as condiments (Steinkraus, 1996). They are prepared from both plant and animal materials, using processes in which microorganisms play an active role in the physical, nutritional and organoleptic modification of the starting material (Aidoo, 1994). The microbiological quality and safety are major areas of concern for producers, consumers and public health officials worldwide for fermented meat. During storage for fermented meat, contamination of raw meat and the inherent ability of microorganisms to adapt to their environment may result in production of unsafe meat product (Cowden *et al.*, 1989; Sauer *et al.*, 1997).

Soy protein, *Kimchi*, pickled shrimp and onion made by aging are used for ingredient in Korean traditional side dishes. Soy sauce is well known ingredient to make fermented foods in orient and it has been industrialized and marketed globally (Wood, 1994). *Kimchi* is the most famous fermented food in Korea. Traditional Korean *Kimchi* is made of paprika, garlic, onion and ginger, which are recognized as antioxidants in different food systems (Aguirrezábal *et al.*, 2000; Al-Jalay *et al.*, 1987; Gassmann, 1992; Gerhardt, 1994). The main materials of *Kimchi* such as Chinese cabbage, leek or green onion contain a broad spectrum of phenolic compounds, mainly glucosinolate, tocopherols, and ascorbic acid. Shrimp is a rich source of protein, calcium, vitamins and various extractable compounds and has been used as one of the most popular and important raw materials for many Korean and international

* **Corresponding author** : Sang-Keun Jin, Department of Animal Resources Technology, Jinju National University, Jinju, 660-758, Korea. Tel: 82-55-751-3283, Fax: 82-55-758-1892, E-mail: skjin@jinju.ac.kr

dishes, especially in the production of salt-fermented shrimp (Han, 1997). Onion is source of nitrate as well as a rich source of sulphur volatiles like thiopropanal S-oxide, thiosulphinates and related compounds (zwiebelanes, capaenes) in minor quantities, which participated in the rich flavor (Ferary and Auger, 1996; Mondy *et al.*, 2002). Onion including flavonol glycosides has antioxidant activity (Fattorusso *et al.*, 2001). In previous study, Jin *et al.* (2005) found that pork aged with Korean traditional sauces for 30 days without pre-aging had a significant difference in lipid oxidation, VBN and pathogens between treatments. Hah *et al.* (2005) reported the effect of aged pork with red pepper-based and soybean based sauces on physicochemical properties for storage 28 days. However, little research was carried out about aged pork with Korean traditional sauces.

The objective of this study, therefore, was to investigate the changes of color, TBARS, VBN and pathogens on vacuum packed pork during storage after aging with Korean traditional sauces.

MATERIALS AND METHODS

Separation and Preparation of Muscles

Sixteen *semimembranosus* muscles, which in general contain a lower fat than other muscles, were seemed out from the hindquarter of eight gilts (110±10 kg) at 1 day post-slaughter, and trimmed to remove all sub-cutaneous and inter-muscular fat and epimysial connective tissue. In order to cope with variability in different meat quality from eight gilts, all muscles were cut into 7×10×2 cm pieces and mixed randomly. The mixed samples were also randomly assigned to four treatment groups by different types of sauce: (i) soy-based sauce (T1), (ii) *Kimchi*-based sauce (T2), (iii) pickled shrimp-based sauce (T3), and (iv) onion-based sauce (T4), as shown in Table 1. Assigned samples were mixed with each sauce in the ratio of one to one (w/w), ensuring that each piece was evenly coated. Each batch (around 1 kg) was replicated four times. The coated samples were allowed aged with each sauce in plastic box and held in a chill at 1℃ for 10 days. The aged meats were stored in a chill at 1℃ for 28 days with vacuum package and the experimentation was carried out at 1, 14 and 28 day to investigate meat quality.

Color

The sauce on the surface of all samples was removed by washing with cold water and measured using a Chroma meter (CR-400, Minolta Co., Japan). Before each measurement, the apparatus was standardized against a white tile (L*=89.2, a*=0.92 and b*=0.78). For inner color, samples were cross-sectioned and the color was measured from each for 5 replicates. The color was expressed as a*-value for redness, L*-value for lightness and b*-value for yellowness.

Table 1. The formulation of four different types of sauces to get aged pork

Ingredients	T1 (Soy based sauce)	T2 (*Kimchi* based sauce)	T3 (Pickled shrimp based sauce)	T4 (Onion based sauce)
Pickled shrimp	-	2.5	12	
Garlic	10	-	11	15
Corn syrup	27	33	30	28
Ginger	1	-	3	8
Red pepper	1	-	2	3
Green onion	-	-	9.5	-
Sesame	-	-	0.5	-
Sesame oil	0.5	-	-	-
Red pepper (powder)	-	1	0.5	-
Water	14.5	5.5	31.5	6.2
Onion	10	13	-	20
Salt	-	2	-	2.8
Vinegar	-	-	-	2
Radish	5	-	-	3
Ethyl alcohol	-	3	-	2
Pineapple	10	10	-	10
Kimchi	-	30	-	-
Soy sauce	21	-	-	-
Total	100	100	100	100

Thiobarbituric Acid Reactive Substances (TBARS) and Volatile Basic Nitrogen (VBN)

According to method of Buege and Aust (1978), Five grams of meat was weighed into a 50 mL test tube and homogenized with 15 mL of de-ionized distilled water using the Polytron homogenizer for 10 sec at the highest speed. One mL of meat homogenate was transferred to a disposable test tube (3×100 mm), and butylated hydroxyanisole (50 μL, 10%) and thiobarbituric acid/trichloroacetic acid (TBA/TCA, 2 mL) were added. The mixture was vortexed then incubated in a boiling water bath for 15 min to develop color. The sample was cooled down in cold water for 10 min, vortexed again, and centrifuged for 15 min at 2,000×g. The absorbance of the resulting supernatant solution was determined at 531 nm against a blank, containing 1 mL of DDW and 2 mL of TBA/TCA solution. The amounts of TBARS were expressed as milligrams of malonaldehyde per kilogram of sample. The content of volatile basic nitrogen (VBN) was determined by the micro-diffusion method of Conway (Pharmaceutical Society of Japan, 1980).

Microbiological Analysis

The samples were subjected to microbiological analysis according to standard procedures. Briefly, serial decimal dilutions of the lactic culture suspension were made in 9 mL volumes of sterile 0.1% peptone-water. For meat samples, 25 g portions were blended in 225 mL of 0.1% peptone-water for 1 min in a pre-sterilized blender. Individual serial decimal dilutions were prepared in 9 mL volumes of 0.1% peptone-water, up to 1:106 dilution of the original food sample. The conditions were for total plate count (TPC) on plate count agar (37℃, 48 hr), *Escherichia coli* on MacConkey agar (37℃, 24 hr), *Lactobacilli* spp. on MRS agar (30℃, 48 hr).

Statistical Analysis

All data obtained were expressed as means±standard deviation. Analysis of variance was performed using Turkey's multiple range test to determine the difference in mean values (p<0.05), using SAS package program (1996).

RESULTS AND DISCUSSION

The Surface and Inner Color of Aged Pork

The surface color of aged pork with Korean traditional sauces in vacuum package was shown in Table 2. The lightness value was significantly (p<0.05) increased on 28 day for all treatments, as compared to day 1. It, however, was slightly changed after day 14 for T1 and T3, being from day 1 up to 14 day for T2 and T4. It also was significantly (p<0.05) higher for T4 than for the other treatments on 1 day, being for T2, T3 and T4 than for T1 on 28 day. The redness value was significantly (p<0.05) increased with increased storage

Table 2. Changes of surface color (Hunter L*, a*, b*) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional sauces

Items	Storage days	Treatments[1)			
		T1	T2	T3	T4
L*	1	31.94±1.98^{Cb}	37.29±2.54^{Bb}	37.11±2.29^{Bb}	42.58±1.11^{Ab}
	14	37.49±3.86^{Ba}	35.76±1.01^{Bb}	47.30±2.51^{Aa}	44.40±2.91^{Ab}
	28	36.31±4.30^{Bab}	50.80±0.66^{Aa}	49.25±1.33^{Aa}	50.47±0.87^{Aa}
a*	1	4.42±0.72^{Aa}	5.35±0.97^{Ac}	5.24±0.75^{Aab}	3.22±0.28^{Bb}
	14	5.02±1.02^{ABa}	6.59±0.89^{Ab}	3.77±1.51^{Bb}	4.89±1.65^{ABa}
	28	7.15±1.25^{ABb}	7.80±0.55^{Aa}	6.42±1.23^{Ba}	0.26±0.66^{Cc}
b*	1	7.39±0.70^{Ab}	7.93±1.70^{Ab}	4.99±0.70^{Bb}	4.70±0.69^{Bb}
	14	10.48±1.50^{Aa}	9.46±1.24^{Ab}	8.36±1.98^{Aa}	5.09±1.18^{Bb}
	28	9.11±1.34^{Ba}	12.50±0.81^{Aa}	6.59±1.19^{Cab}	6.65±0.39^{Ca}

[1) Treatments are the same as described in Table 1.

$^{A\sim C}$ Means±SD with different superscripts in the same row significantly differ at p<0.05.

$^{a\sim c}$ Means±SD with different superscripts in the same column significantly differ at p<0.05.

days for all treatments, with the exception of the T4 by onion based sauce in the case of 28 day. The result agrees with the findings of Jin *et al.* (2005), who reported that the lightness and redness of pork seasoned with Korean traditional ingredients were increased with increased storage days. It also was supported by the findings of Fu *et al.* (1992), who found that the redness could be affected by producing peptides and amino acids from the degradation of proteins during aging. There was a little difference between 1 and 14 day for T1 and between storage days for T3 and T4. On 1 and 28 day, T4 had the lowest ($p<0.05$) redness value of all treatments, but no significant difference was found between T1, T2 and T3, with exception of T2 and T3 on 28 day. The yellowness value was higher ($p<0.05$) for T1 and T2 than for T3 and T4 on 1 and 28 day. It was significantly ($p<0.05$) increased with increased storage days for all treatments.

These results may be because the color of aged pork during storage was affected by soaked sauces into pork rather than by pork itself. T1 with the lowest lightness may be due to darker soy-based sauce than the others, while T4 with the highest lightness may be due to whiter onion-based sauce than the others. T2 with a higher redness value than the others may be due to redder *Kimchi*-based sauce, i.e. red pepper, which is major ingredient for *Kimchi* side dishes. The present results agree with the findings of Jin *et al.* (2005), who found that *Kimchi*-based pork stored at 10℃ without aging had a higher redness than soy- and onion-based pork, while soy-based pork had a lower lightness than the other treatments. The yellowness was a significantly ($p<0.05$) higher on day 14 and 28 than day 1 for T1, being on day 28 than day 1 and 14 for T2 and T4. A little difference in the yellowness was found between storage days for T3. On 1 and 28 day, T1 and T2 had significantly ($p<0.05$) higher yellowness values than T3 and T4.

The inner lightness for aged pork on 28 day was significantly ($p<0.05$) higher than that on 1 day for all treatments, with exception of T1 and T4, which had no difference between storage days (Table 3). T3 had the lowest ($p<0.05$) lightness value of all treatments on 1 day, while T4 was lowest ($p<0.05$) on day 28. The redness results showed a significant ($p<0.05$) increase with storage days for all treatments except to T3, which had no difference between 1 and 28 day. On 1 day, there was clearly ($p<0.05$) different in the redness between all treatments, and it showed in order of T3>T2 >T1>T4. On day 28, those of T2 and T3 were highest ($p<0.05$) of all treatments, while T4 was lowest ($p<0.05$). The yellowness did not show a significant increase with storage days for all treatments. When comparing between treatments, T4 had the lowest ($p<0.05$) yellowness on 1 and 28 day of all treatments. The results indicate that the inner color of aged pork would vary depending on sauces for seasoning and the degree of penetrated sauces into meat. This is consistent with

Table 3. Changes of inner color (Hunter L*, a*, b*) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional sauces

Items	Storage days	Treatments[1)]			
		T1	T2	T3	T4
L^*	1	36.36 ± 2.54^{Aa}	38.23 ± 2.44^{Ab}	32.52 ± 2.06^{Bb}	38.74 ± 1.17^{A}
	14	36.61 ± 2.38^{ABa}	35.04 ± 1.72^{Bc}	39.25 ± 2.77^{Aa}	39.73 ± 3.89^{A}
	28	38.75 ± 1.89^{ABa}	40.82 ± 0.73^{Aa}	40.01 ± 3.91^{Aa}	36.28 ± 1.18^{B}
a^*	1	5.38 ± 0.37^{Cab}	6.06 ± 0.56^{Bb}	7.19 ± 0.54^{Aa}	3.98 ± 0.47^{Db}
	14	4.56 ± 1.24^{Bb}	6.52 ± 0.43^{Ab}	5.91 ± 0.37^{Ab}	5.52 ± 0.95^{ABa}
	28	6.47 ± 0.85^{Ba}	7.52 ± 0.59^{Aa}	7.95 ± 0.73^{Aa}	4.92 ± 0.34^{Ca}
b^*	1	4.72 ± 2.86^{A}	4.55 ± 1.18^{A}	4.13 ± 0.69^{Aab}	1.82 ± 0.09^{Bb}
	14	3.85 ± 1.73	3.56 ± 0.60	3.70 ± 0.61^{b}	3.65 ± 1.19^{a}
	28	4.89 ± 0.49^{A}	3.90 ± 0.38^{B}	4.80 ± 0.46^{Aa}	1.71 ± 0.08^{Cb}

[1)] Treatments are the same as described in Table 1.

[A~D] Means±SD with different superscripts in the same row significantly differ at $p<0.05$.

[a~c] Means±SD with different superscripts in the same column significantly differ at $p<0.05$.

Table 4. Changes of TBARS (mg of malonaldehyde/kg) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional sauces

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	0.47±0.07^{Bc}	0.61±0.17^{AB}	0.63±0.12^{ABa}	0.75±0.13^{Ab}
14	1.25±0.05^{Aa}	0.54±0.10^{C}	0.38±0.08^{Cb}	1.03±0.17^{Ba}
28	0.78±0.05^{Ab}	0.41±0.01^{C}	0.35±0.03^{Cb}	0.48±0.03^{Bc}

[1)] Treatments are the same as described in Table 1.

$^{A\sim C}$ Means±SD with different superscripts in the same row significantly differ at $p<0.05$.

$^{a\sim c}$ Means±SD with different superscripts in the same column significantly differ at $p<0.05$.

the findings of Jin *et al.* (2005), who reported that the redness of inner color was lower in *Kimchi*-based pork, and the yellowness was lower in onion-based pork, comparable to the others.

TBARS and VBN

The TBARS results of aged pork with Korean traditional sauces during storage after aging were shown in Table 4. For T1 and T4, the TBARS values were significantly ($p<0.05$) increased from 1 day until 14 day, but decreased ($p<0.05$) after 14 day. For T3, those were significantly ($p<0.05$) decreased with increased storage days, but slightly ($p>0.05$) decreased between 14 and 28 day. The result is inconsistent to the findings of Salgado *et al.* (2005), who found that TBARS of aged meat was increased slowly with increased storage days after aging. The difference may be because in present study, aging was carried out with Korean traditional sauces, including antioxidants. In particular, the TBARS of T3 was significantly ($p<0.05$) decreased with increased storage days. The result may be affected by the sauce made from red pepper, garlic, onion and ginger, which are recognized as antioxidants (Aguirrezábal *et al.*, 2000; Al-Jalay *et al.*, 1987; Gassmann, 1992; Gerhardt, 1994).

On 1 day, the TBARS values were much higher, in the range of 0.47~0.75 mg, comparable to normal meat and meat products in other study (Franco *et al.*, 2002). The difference might be because the process for aging was carried out with Korean traditional sauces. Lee and Kunz (2005) reported that the addition of 5% and 10% of *Kimchi* powder resulted in significant inhibition of lipid oxidation (TBARS) during aging. Chang and Chen (1998) reported that the TBARS of the samples containing high level of red pepper increased at a slower rate than those containing lower level. Nakatani *et al.* (1986, 1989) also found that white pepper and chili pepper had an antioxidant effect. In our study, T1 treated with soy-based sauce, which includes the smallest amount of red pepper and ginger (Table 1), had the highest TBARS value. *Kimchi* traditionally includes red pepper, garlic, onion and ginger. However, TBARS result in the present study showed all treatments as having antioxidant effect, even though its differences existed in aged pork.

The total volatile basic nitrogen (VBN) contents of aged pork with Korean traditional sauces during storage after aging were significantly ($p<0.05$) increased with increased storage days for all treatments, with the exception of T2, which was not significantly different between storage days (Table 5). However, The VBN of T1 showed a big increase on 28 day as compared to 1 day. This result may be due to high formation of gram-negative bacteria by adding high amount of soy sauce through fermentation. When comparing between treatments on 1 and 14 day, which was in the range of 44~65 mg% for 1 day and 63~82 for 14 day, no significant differences were observed. The range of VBN values in the present study showed slightly higher than other studies. On day 28, T1 had a significantly ($p<0.05$) higher VBN value than the others, but there was no significant difference between T2, T3 and T4. The results agree with the findings of Jin *et al.* (2005), who found that the pork seasoned with soy sauce had a higher VBN value at day 28 than pork seasoned with red pepper and soybean paste. They also reported a high range of VBN like the present study, and it could be because fermentation of sauces was carried out earlier than that of meat (Jin *et al.*, 2005). The amount of VBN generally increases during fermentation as the salt concentration (Jo *et*

Table 5. Changes of VBN (mg%) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional sauces

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	64.46± 7.79^{b}	54.00±23.43	46.82± 5.15^{b}	44.42± 3.07^{b}
14	82.10± 0.08^{b}	63.26±12.28	68.27±19.80^{ab}	63.34± 0.73^{ab}
28	169.68±17.50^{Aa}	76.07± 4.13^{B}	84.71± 5.44^{Ba}	74.92±20.61^{Ba}

[1)] Treatments are the same as described in Table 1.
^{A,B} Means±SD with different superscripts in the same row significantly differ at $p<0.05$.
^{a,b} Means±SD with different superscripts in the same column significantly differ at $p<0.05$.

al., 2004), because the formation of gram-negative bacteria like *Pseudomonas* spp. is increased by producing ammonia and amines resulted from the degradation of urea and amino acids (Lefebvre *et al.*, 1994). The proteolytic enzymes brought by meat, especially the cathepsins, have a predominant role in fermented meat. The cathepsins hydrolyse the muscle fibres to release nitrogen compounds.

Microbiological Analysis

Total plate counts (TPC) result showed a significant ($p<0.05$) increase with storage days for all treatments (Table 6). The TPC was in the range of 4.95~5.44 $\log_{10}$ CFU/cm^2 on 1 day, and 6.69~7.64 $\log_{10}$ CFU/cm^2 on 28 day. On 1 day, T2 had the highest ($p<0.05$) TPC value of all treatments, while T4 was lowest ($p<0.05$). On 28 day, interestingly T2 had the lowest ($p<0.05$) TPC value, while T3 was highest ($p<0.05$). This is in agreement with the findings of Jin *et al.* (2005), who found that TPC of pork seasoned with *Kimchi*-based sauce was highest during storage without aging, but that with pickled shrimp based sauce was lowest. The result suggests that *Kimchi*-based sauce could be more effective to inhibit the growth of bacteria during storage after aging. The result was also supported by the findings of Lee and Kunz (2005), who found an antioxidant effect of *Baechu-Kimchi* in fermented sausages.

Contamination can easily result in spoilage or a hazard to the health of the consumer and one of the major pathogen concerns is *Escherichia coli*. The *E. coli* result showed a significant ($p<0.05$) decease with storage days, with the exception of T3, which was significantly ($p<0.05$) higher for 28 day than for day 1. When comparing between treatments, T2, which was treated with *Kimchi* based sauce, was more effective to inhibit the growth of *E. coli* as comparing to other treatments.

The fermentation of meat products is to produce a number of different micro-organism, i.e. a large number of micrococci are always in the raw material, while some, such as lactic acid bacteria, develop during the fermentation stage (Coppola *et al.*, 1997). *Lactobacillus spp.* which is one of lactic acid bacteria, was increased with storage days for all treatments. Its amount was in the range of 5.17~5.38 $\log_{10}$ CFU/cm^2 on day 1, and 6.50~7.24 $\log_{10}$ CFU/cm^2 on 28 day. The increase rate showed T3 to be highest ($p<0.05$), while T2 to be lowest ($p<0.05$). Lactic acid bacteria, including *Pediococcus* spp. and

Table 6. Changes of total plate counts ($\log_{10}$ CFU/cm^2) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	5.26±0.00^{Bb}	5.44±0.01^{Ac}	4.97±0.01^{Cc}	4.95±0.02^{Dc}
14	4.75±0.03^{Dc}	6.03±0.00^{Bb}	6.18±0.01^{Ab}	5.45±0.01^{Cb}
28	6.87±0.00^{Ca}	6.69±0.05^{Da}	7.64±0.02^{Aa}	7.43±0.01^{Ba}

[1)] Treatments are the same as described in Table 1.
$^{A\sim D}$ Means±SD with different superscripts in the same row significantly differ at $p<0.05$.
$^{a\sim c}$ Means±SD with different superscripts in the same column significantly differ at $p<0.05$.

Table 7. Changes of *Escherichia coli* ($log_{10}CFU/cm^2$) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional sauces

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	3.34 ± 0.08^{Aa}	3.31 ± 0.00^{Aa}	2.60 ± 0.52^{Bb}	3.74 ± 0.01^{Aa}
14	2.95 ± 0.00^{Bb}	2.10 ± 0.05^{Db}	3.18 ± 0.04^{Aab}	2.84 ± 0.09^{Cb}
28	2.11 ± 0.03^{Cc}	1.30 ± 0.04^{Dc}	3.42 ± 0.02^{Aa}	2.40 ± 0.04^{Bc}

[1)] Treatments are the same as described in Table 1.
$^{A\sim D}$ Means±SD with different superscripts in the same row significantly differ at $p<0.05$.
$^{a\sim c}$ Means±SD with different superscripts in the same column significantly differ at $p<0.05$.

Table 8. Changes of *Lactobacilli spp.* (log_{10} CFU/cm^2) on vacuum packed pork during storage at 1℃ after aging for 10 days with Korean traditional sauces

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	5.32 ± 0.01^{Bb}	5.38 ± 0.02^{Ac}	5.17 ± 0.01^{Cc}	5.36 ± 0.01^{Ab}
14	4.79 ± 0.01^{Dc}	5.83 ± 0.00^{Bb}	6.20 ± 0.02^{Ab}	5.37 ± 0.03^{Cb}
28	6.94 ± 0.01^{Ba}	6.50 ± 0.02^{Da}	7.24 ± 0.01^{Aa}	6.56 ± 0.02^{Ca}

[1)] Treatments are the same as described in Table 1.
$^{A\sim D}$ Means±SD with different superscripts in the same row significantly differ at $p<0.05$.
$^{a\sim c}$ Means±SD with different superscripts in the same column significantly differ at $p<0.05$.

Lactobacillus spp. ensures a rapid onset of fermentation and discourages growth of undesirable bacteria, such as *L. monocytogenes* (Harris *et al.*, 1989; Rodriguez *et al.*, 1994), due to a release of lactate and a reduction of pH. Bacteriocinogenic lactic acid bacteria have been successfully used for control of *Listeria* in fermented meat products (Berry *et al.*, 1990; Hugas *et al.*, 1995).

In conclusion, the study indicates that Korean traditional sauces could be utilized to extend the shelf life of aged pork by inhibiting lipid oxidation, although its difference exists. The aged pork with *Kimchi*-based sauce, in particular, had the best antioxidant effect and effective to inhibit the growth of total plate bacteria and *E. coli* of all treatments. The amount of *Lactobacillus* spp. one of lactic acid bacteria, which is generated in aging stage, was increased with storage days for all treatments, although pickled shrimp-based sauce had the highest increase.

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