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Changes of Vacuum Packed Pork Quality during Storage after Aging with Korean Traditional Sauces

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Abstract

Sixteen *semimembranosus* muscles were seamed out from sixteen left 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 treatment was aged in plastic box at 1℃ for 10 days. These samples were vacuum-packaged after treatment with sauces and held in a chill at 1℃ for 28 days. The pH of aged pork, in general, was decreased significantly ($p<0.05$) with storage in all treatments. Its falling rate was the slowest in T4 of all treatments, while it was faster in T2 and T3 than in T4. The salinity of aged pork was decreased ($p<0.05$) for T2 with increased storage days, but increased ($p<0.05$) for T1. The salinity showed T2 to be significantly higher ($p<0.05$) than T1 and T4 on 1 day, but to be lower ($p<0.05$) than T1 on 28 day. The saccharinity of T3 was significantly higher ($p<0.05$) on 1 day than those of T1 and T4, but decreased ($p<0.05$) on 14 and 28 day. While saccharinity of T1 was significantly the lowest ($p<0.05$) of all treatments on 1 day and increased ($p<0.05$) with increased storage days. For T1 and T2, the WHC (water holding capacity) results showed higher ($p<0.05$) on 14 day than on 1 and 28 day. On 28 day, the WHC result showed T4 to be the highest ($p<0.05$) of all treatments, but T2 to be the lowest ($p<0.05$). On 28 day, the shear force results showed a big difference ($p<0.05$) among treatments, being in order of T4>T3>T2> T1. Panelists rated T1 as having higher ($p<0.05$) aroma, flavor and overall acceptability than other treatments.

Key words : Korean traditional sauces, aged pork, meat quality, sensory analysis

INTRODUCTION

The demand for convenience meat products like seasoned and fermented meats has increased dramatically in recent years. However, consumers are not only interested in quality products that taste good and are convenient in use but also concerned about the nutritive value, safety and wholesomeness of the meat products they consume. The advent of such health conscious consumers has led to a growing preference for convenient meat products with natural additives from plant. Meat processors have therefore had to develop alternative, natural, functional and cost-effective ingredients from both plant and animal materials that can successfully add into meat to make it healthier while maintaining meat quality.

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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 dishes, especially in the production of salt-fermented shrimp (Han, 1997). Shrimp sauce increases pH and can be used as a tenderizer of meat during storage (Kim *et al.*, 2005) and a food flavorings because crustacean species such as shrimp, crab, lobster, etc., have more than 6,000 volatile flavor compounds comprising of aldehydes, ketones, alcohols, N- and S-containing compounds, furans, etc. (Cha *et al.*, 1993; Kim *et al.*, 1994). Onion (*Allium cepa*) are a source of nitrates as well as a rich source of sulfur volatiles like thiopropanal S-oxide, thiosulfinates and related compounds (zwiebelanes, capaenes) in minor quantities, which participate in the rich flavor (Ferary and Auger, 1996; Mondy *et al.*, 2002). On the other hand, some secondary metabolites are endowed with interesting biological activities. Flavonol glycosides have an inhibitory activity on human platelet aggre-

gation and prevent atherosclerosis and also they have an antioxidant activity (Fattorusso *et al.*, 2001). Soy sauce is a well known ingredient to make fermented foods in orient and it has been industrialized and marketed globally (Wood, 1994). *Kimchi* is one of the most famous fermented foods in Korea. Traditional Korean *Kimchi* is made with paprika, garlic, onion and ginger, which are recognized as antioxidants in different food systems (Aguirrezábal *et al.*, 2000; Al-Jalay *et al.*, 1987; Gassmann *et al.*, 1992; Gerhardt, 1994). As added materials to make *Baechu-kimchi* (Chinese cabbage), leek and green onion contain a broad spectrum of phenolic compounds, mainly of glucosinolate, tocopherols, and ascorbic acid. In previous study, Jin *et al.* (2005) reported that Korean traditional sauces could be utilized for making seasoned pork, not pre-aged pork, without negative effect on meat quality. Hah *et al.* (2005) reported the effect of aged pork with red pepper-based and soybean-based sauces on physicochemical properties for storage 28 day after pre-aging. However, a research was not carried out to investigate the effect of aged pork with Korean traditional sauces associated with meat quality during storage after pre-aging.

The objective of this study, therefore, was to investigate changes of vacuum packed pork quality during storage after aging for 10 days 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 seamed 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 chiller at 1℃ for 10 days. After aging meats, samples were vacuum-packaged and stored in a chiller at 1℃ for 28 days with vacuum package and experiment was carried out at 1, 14 and 28 day to investigate meat quality.

pH, Salinity (%) and Saccharinity (%)

Table 1. The formulation of four different types of sauce 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	-	10
Pineapple	10	10	-	-
Kimchi	-	30	-	-
Soy sauce	21	-	-	-
Total	100	100	100	100

The pH was determined, following grinding and homogenization of 10 g of sample with 90 mL of distilled water for 10 sec at 13,500 rpm, using homogenizer (T25B, IKA Sdn. Bhd., Malaysia) and pH-meter (8603, Metrohm, Swiss). The salinity was determined by salinometer (TM-30D, Takemura, Japan). The saccharinity was determined by saccharimeter (PR-101, ATAGO, Japan).

WHC (Water Holding Capacity) and Shear Force

The WHC was determined by centrifuge method. The chopped meat was put into tubes, heated at 70℃ for 30 min, cooled down to 25℃ for 10 min, centrifuged (1,000 rpm, 10 min at ambient temperature), then the amount of free liquid was measured. Water holding capacity was expressed as percentage (w/w) of sample weight before and after centrifuge. The shear force (g/cm^2) was measured by a cutting test using a rheometer (EZ-test, Shimadze, Japan). The samples were cut into 3 × 3 cm long in a parallel to muscle fibers. The analysis condition was 120 mm/min for chart speed and 10 kg for maximum load, 20 mm/sec for analysis speed, 20 mm for the height of samples and No. 4. adapter was used.

Sensory Analysis

Taste testing was carried out on fermented pork sample of each treatment warmed to room temperature by a panel of ten people experienced in testing aged pork. The samples (four treatments) were grilled to a core temperature of 70℃, and given to the panel members. The panel assessed taste for tenderness, aroma, juiciness, flavor and overall acceptability on a scale of 1 (worst) to 9 (best).

Statistical Analysis

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

RESULTS AND DISCUSSION

pH, Salinity (%) and Saccharinity (%)

The pH of aged pork was, in general, decreased significantly ($p<0.05$) with increased storage days for all treatments (Table 2). The pH values measured were in the range from 5.26 to 5.72 at day 1 and from 4.52 to 5.21 at day 28. Its falling rate of pH was slowest in T4, while it was faster in T2 and T3 than in T4. The result is in agreement with the findings of Jin *et al.* (2005), who found that T4 seasoned with onion-based sauce, without aging, had a slower falling rate of pH than other treatments. They also reported that pork seasoned with onion-based sauce could have lower lactic acid during aging days. A faster fall of pH for T2 and T3 might be occurred because acids were accumulated in meat in the course of aging. The lowest pH value of T2 after 28 day might also be due to an increase of lactic acid bacteria by fermenting of *Kimchi*-based sauce during storage days and of its penetration into meat. Meat pH can be affected by many factors; however, growth of lactic acid bacteria resulting in lactic acid production is the major factor in pH decrease in packaged meats (Gill, 1996). The results indicated the decrease of pH during storage might be affected by accumulation level of lactic acids associated with the types of sauce. Comparing the four treatments, the T3 had the highest ($p<0.05$) pH values of all treatments on 1 and 14 day. The result was supported by the findings of Kim *et al.* (2005), who found that aged sauce of shrimp showed high pH (around 8.0).

The salinity (%) of aged pork was significantly decreased

Table 2. Changes of pH 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	5.26 ± 0.01^{Cb}	5.40 ± 0.02^{Ba}	5.72 ± 0.07^{Aa}	5.31 ± 0.04^{Ca}
14	5.31 ± 0.01^{Ba}	5.23 ± 0.01^{Cb}	5.55 ± 0.04^{Ab}	5.16 ± 0.05^{Cb}
28	4.83 ± 0.02^{Bc}	4.52 ± 0.03^{Cc}	4.84 ± 0.03^{Bc}	5.21 ± 0.02^{Ab}

[1)] Treatments are the same as described in Table 1.
[A~C] Means±SD with different capital letters in the same row significantly differ at $p<0.05$.
[a~c] Means±SD with different small letters in the same column significantly differ at $p<0.05$.

Table 3. Changes of salinity (%) on vacuum packed pork during storage at 1℃ after aging for 10 day with Korean traditional sauces

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	1.22±0.13^{Cb}	1.79±0.07^{Aa}	1.59±0.13^{AB}	1.47±0.22^{BC}
14	1.59±0.12^{Aa}	1.30±0.06^{Bb}	1.54±0.06^{A}	1.55±0.07^{A}
28	1.65±0.07^{Aa}	1.35±0.01^{Bb}	1.43±0.07^{B}	1.38±0.15^{B}

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

($p<0.05$) for T2 until 14 day, but increased ($p<0.05$) for T1, when compared to the sample of 1 day (Table 3). The result might be because salt concentration in aged pork was decreased by moisture extracted from *Kimchi* sauce (T2), and increased by the difference of osmotic pressure between meat surface and inner for T1 during storage. No significant differences between storage days were found for T3 and T4. Comparing the four treatments, the salinity results showed T2 to be significantly higher ($p<0.05$) than T1 and T4 on 1 day, but being to be lower ($p<0.05$) than T1 on 28 day. These results were in agreement with the findings of Jin *et al.* (2005), who found salinity of T1 increased with aging days without aging, while that of T4 was not different over the storage time. There was no significant difference in saccharinity (%) for T2 and T4 by storage days (Table 4). The saccharinity (%) of T1 was significantly lower ($p<0.05$) for 1 day than those for 14 and 28 day of storage, and that of T3 was higher ($p<0.05$) for 1 day than those for 14 and 28 day. On 1 day, T3 had a higher ($p<0.05$) saccharinity (%) than T1 and T4, while being lower ($p<0.05$) than T1 and T4 on 14 day. In our previous study, Jin *et al.* (2005) found that salinity and saccharinity of seasoned pork could be affected by seasoning penetrated into pork during storage. In the present study, the values (%) for salinity and saccharinity showed higher than those of Jin *et al.* (2005). It may be due to a higher penetration rate by aging for 10 days with sauces in the present study.

WHC, Shear Force and Sensory Analysis

The WHC of aged pork was significantly increased ($p<0.05$) from 1 until 14 days storage for T1 and T2, while decreased ($p<0.05$) after 14 days (Table 5). The result was not in agreement with the findings of Jin *et al.* (2005), who reported no significant differences in WHC during storage. The differences might be due to a decreased pH on 28 day compared to 14 day. A further research would probably be needed on WHC of aged pork with sauce during storage. No significant difference between storage days was found in T3 and T4 until 14 day, but T4 had a significantly higher ($p<0.05$) WHC than T3 on 28 day. The result was similar with the findings of Jin *et al.* (2005), who found that the WHC of T3 and T4 were not different in storage time. Comparing the four treatments, there were no significant differences on 1 and 14 day. On 28 day, the WHC showed T4 to be highest ($p<0.05$) of all treatments, but T2 to be lowest ($p<0.05$). This corresponded to the results of pH for treat-

Table 4. Changes of saccharinity (%) on vacuum packed pork during storage at 1℃ after aging for 10 day with Korean traditional sauces

Storage days	Treatments[1)]			
	T1	T2	T3	T4
1	10.54±1.90^{Cb}	14.30±1.46^{AB}	17.13±1.17^{Aa}	13.92±1.44^{B}
14	14.67±2.09^{Aa}	14.19±1.40^{AB}	11.76±0.62^{Bc}	15.51±0.67^{A}
28	16.13±1.41^{a}	14.71±1.25	13.88±0.72^{b}	13.75±1.46

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

Table 5. Changes of WHC (%) 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	74.79±7.13^{b}	77.33±2.17^{b}	81.24±9.95	77.67± 1.31
14	91.68±2.92^{a}	88.10±0.79^{a}	86.58±4.86	86.16±11.92
28	75.51±3.56^{Bb}	69.56±2.20^{Cc}	74.10±1.64^{B}	83.21± 1.56^{A}

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

Table 6. Changes of shear force (g/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	183±39^{B}	169± 16^{Bb}	229±100^{Bc}	397±33^{Aa}
14	172±45^{C}	319±119^{Ba}	462± 35^{Aa}	317±41^{Bb}
28	150±25^{D}	263± 62^{Cab}	329± 15^{Bb}	441±52^{Aa}

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

ments on 28 day (Table 2). Pearson and Young (1989) found that the WHC was closely related to muscle pH, and could be increased by high pH. Oh *et al.* (1986) also reported that salt content included in seasoning could affect on the WHC of meat during storage.

The shear force results showed that types of sauce significantly ($p<0.05$) affected on meat tenderness (Table 6). On 1 day, T4 had a significantly higher ($p<0.05$) shear force value than those for other treatments, although there were no significant differences among T1, T2 and T3 treatments. On 28 day, the shear force results showed a big difference ($p<0.05$) between treatments, being in order of T4>T3>T2>T1. The result indicated that the shear force value of T4 was lower ($p<0.05$) than the others. Kim *et al.* (2005) found that the fermented shrimp gave more tender pork than the control and the saline-treated pork. In general, aging period significantly did not affect on shear force values for T2, T3 and T4. The result was not in agreement with the findings of Jin *et al.* (2005), who reported a significant decrease in shear force during storage days. The difference might be due to a high variation of measurements in this study.

Taste panel aroma results showed no difference between storage days for each treatment (Table 7). There were little difference between treatments, with an exception of T1, which was rated better ($p<0.05$) aroma than other treatments for 1 and 28 day. Regarding flavor ratings, in general, panelists rated T1 as having a higher ($p<0.05$) overall flavor than T2 and T4 for 1 and 14 day, but not for 28 day. There were no significant differences in storage days between all treatments. For juiciness ratings, in general, panelists rated T2 to be juicier ($p<0.05$) than other treatments on 1 and 14 day, but not on day 28, which was of equal juiciness ratings between treatments. Panelists could not differentiate between storage days in each treatment. For overall acceptability, T1 was rated better ($p<0.05$) than the others, while T2 was rated worst ($p<0.05$). No significant difference was found between storage days. The result was in agreement with Jin *et al.* (2005) that overall acceptability was rated seasoned pork with soy-based sauce to be better than the others. Jang and Lee (2005) found that seasoned beef with soy sauce could positively affect on sensory traits during aging.

In conclusion, aged pork with Korean traditional sauces affected on meat quality for storage 28 day after aging, and was affected by the types of sauce as well. Soy sauce

Table 7. Changes of sensory traits 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
Aroma	1	7.0±1.1^{A}	5.5±1.0^{B}	6.0±0.0^{AB}	5.8±1.0^{B}
	14	6.3±1.0	5.5±1.0	5.5±1.0	5.3±1.0
	28	7.0±0.0^{A}	5.3±1.0^{B}	5.8±0.5^{B}	5.0±0.0^{B}
Flavor	1	7.0±0.8^{A}	5.5±1.0^{B}	6.5±0.6^{AB}	5.8±0.5^{B}
	14	7.0±0.0^{A}	5.5±0.6^{B}	5.8±1.0^{B}	6.0±0.8^{AB}
	28	6.3±0.5	5.0±0.8	6.5±0.6	5.8±1.5
Tenderness	1	5.5±0.6^{Bb}	7.3±1.0^{A}	6.8±0.5^{ABa}	6.3±1.0^{AB}
	14	6.8±0.5^{a}	7.5±0.6	6.8±1.0^{a}	6.5±0.6
	28	6.0±0.0^{b}	6.3±1.3	5.5±0.6^{b}	6.5±1.0
Juiciness	1	5.3±0.5^{Bc}	6.8±1.0^{A}	6.5±0.6^{AB}	6.3±1.0^{AB}
	14	7.0±0.0^{ABa}	7.5±0.6^{A}	6.5±1.0^{AB}	6.3±0.5^{B}
	28	6.3±0.5^{Ab}	6.5±1.0^{A}	6.0±0.8^{A}	6.5±1.0^{A}
Overall acceptability	1	6.5±0.6	6.0±0.8	6.8±0.5	6.0±0.0
	14	7.0±0.0^{A}	5.3±1.0^{B}	5.5±1.3^{AB}	5.5±1.3^{AB}
	28	7.0±0.0^{A}	5.0±0.8^{B}	6.5±0.6^{A}	5.8±1.5^{AB}

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

treatment (T1) showed in general to be a higher WHC, higher shear force value for physical traits and rated a better aroma and flavor, and scored a higher overall acceptability for taste panel test.

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