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ARTICLE

Assessment of Dipping Treatment with Various Lactic Acid or Sodium Benzoate Concentrations to Extend the Shelf-life of Spent Hen Breast Meats

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Abstract

This study was conducted to investigate the effect of immersion treatment using lactic acid (LA) and sodium benzoate (SB) on the physicochemical quality and freshness of spent hen breast meats. A total of 135 spent hen breast meats were subjected to 9 different treatments using various concentrations of LA and/or SB in sterile DW. The 9 treatment groups were as follows: Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB, respectively. All groups were kept at 4°C for 15 d. The microbial counts in the control group gradually increased during storage, but those for the treated groups were significantly lower than the control or were not detected. The pH values of the control were significantly higher than those of the treated groups ($p<0.05$). In the color measurements, the lightness (L*) and yellowness (b*) values increased during storage and the redness (a*) values decreased ($p<0.05$). The K-value and volatile basic nitrogen of the treated groups were significantly lower than those of the control group ($p<0.05$). Overall, the combined results of this study indicate that LA and SB could be used as favorable preservatives for spent hen breast meats to extend their shelf-life during refrigerated storage.

Key words: spent hen, lactic acid, sodium benzoate, shelf-life, freshness

Introduction

Laying hens are raised until approximately 70 wk of age in order to obtain eggs. A substantial proportion of these hens are referred to and marketed as spent hen meat. Spent hens meat is known to be very tough and this toughness prevents it from being consumed and sold as food in markets. On the other hand, consumers in certain regions of the world, such as Vietnam and East-south Asian countries, are willing to purchase more tough poultry meats. Thus, methods to improve the bacterial safety and refrigerated shelf life of spent hen meat over a relative long exportation are very important not only for foreign consumers but also for Korean spent hen processors.

Poultry meat is more susceptible to lipid and protein oxidation during storage compared to other meats. This is because microorganisms can penetrate poultry meat easily due to the indigestion of muscle and the distinct slaughter processes used for poultry. Meat such as pork and beef acquire improved meat quality by aging; however, this is not the case for chicken because it has a lower degree of rigor mortis, which impacts the quality of meat such as tenderness (Lee *et al*., 1994).

The type of muscle fiber and component ratio of chicken, which has more white muscle than pork and beef, can affect the oxidation of lipids and postmortem metabolic rate. These facts are also dependent on storage time (Brooke and Kaiser, 1970). For this reason, poultry products can only be stored for a short time before the quality of the meat deteriorates (Park *et al*., 1997). Therefore, inhibiting microbial growth and retarding lipid and protein oxidation during storage and retail display is essential to maintain the quality and safety of poultry meat (Vaithiyanathan, 2011).

Several studies have been suggested that microbial

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growth and lipid oxidation in chicken meats can be effectively inhibited using lactic acid (LA) and sodium benzoate (SB). Undissociated LA and acetic acid have been shown to inhibit the growth of microorganism (Colberg and Izat, 1988; Marcel *et al*., 1988; Mossel and Drake, 1990; Mountney and O'Malley, 1965; Stern *et al*., 1985). Marcel *et al*., (1988) reported that decontamination of broiler carcasses with 1-2% LA before chilling improved the microbial safety and extended the refrigerated shelf life. Izat *et al*. (1989) also found that organic acid acids such as LA could be used to increase the shelf life of processed broilers. However, the organic acid concentrations needed to decontaminate poultry carcasses generally lead to unfavorable sensory changes.

Since the maximal antimicrobial activity of SB is accomplished in low-pH environments, its usage as a preservative is limited to high-acid foods such as apple cider, soft drinks, and tomato ketchup (Jay, 1992). SB has been shown to control yeast and some bacteria as well as to inhibit the growth and mycotoxin production by molds (Parish and Carroll, 1988; Roland and Beuchat, 1984; Valcarcel *et al*., 1986).

However, previous studies observed that treatment to extend shelf-life poultry have been mostly conducted to eliminate pathogens on poultry carcasses. Therefore, the aim of this study was to examine the effects of LA and SB on spent hen breast meat in regards to improving shelf-life especially using K-value and volatile basic nitrogen (VBN), which could be used as physicochemical indicator on poultry. The effects various levels of LA and SB were evaluated to investigate optimum concentration by examining changes in total bacterial count (TBC), pH, color, K-value and VBN.

Materials and Methods

Samples and allocation to treatments

Fresh spent hen breast meats were obtained from a commercial slaughter house. A total of 135 spent hen breast meats were subjected to 9 different treatments with various levels of LA and/or SB in sterile DW. The 9 treatment groups were as follows: Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB, respectively. After preservative treatment, samples were individually vacuum-packaged in PE/PP/nylon bags using a vacuum packer (FJ-500XL, Fujee Tech, Korea). All samples were kept at 4°C for 15 d (1, 3, 5, 9 and 15 d).

Total bacterial count evaluation

After preservative treatments, samples were removed from the vacuum packaging using a sterile scalpel. Sample (5 g) were placed in 50 mL of 0.1% peptone water in a sterile stomacher bag and homogenized using a Stomacher (Stomacher400 Circulator, UK) for 2 min. The samples were then serial diluted with peptone water for microbial count. Plate count agar (PCA, Difco, USA) was used to obtain the total bacterial count and experiments were performed in triplicate. The plates were incubated at 37°C for 48 h. Total bacterial count was reported as the mean of three determinations and expressed as CFU/g.

pH evaluation

The pH of the samples was determined by blending 5 g of samples with 20 mL distilled water at 2,000 g for 2 min in a homogenizer (Model AM-7, Japan). The pH values were measured using a digital pH meter (pH meter F-51, Japan) that had been calibrated at pH 4.0 and 7.0.

Color evaluation

Color measurements were taken using a color meter (Chromameter, CR210, Minolta, Japan; illuminate C, calibrated with white standard plate L* = +97.83, a* = -0.43, b* = +1.98). The measuring area was 8 mm in diameter measuring area and the illumination area was 50 nm in diameter. Color values (CIE L^*, CIE a^* and CIE b^*) were measured on the surface of the samples and measurements were acquired in triplicate for each sample.

K-value evaluation

The K value, which is a relative ratio of ATP and ATP-related compounds, can be used as a freshness indicator. To calculate the K value, 200 mg of samples and 600 μL of perchloric acid were placed in a test tube in order to precipitate the protein. The solution was then neutralized with 50 μL KOH. The K-value was calculated with a freshness checker (Freshness checker system HF-1000, Huetech, Korea) using the following formula, as described by Saito *et al*. (1959).

$$\text{K-value (\%)} = \frac{{}^{1)}\text{HxR} + {}^{2)}\text{Hx}}{{}^{3)}\text{ATP} + {}^{4)}\text{ADP} + {}^{5)}\text{AMP} + {}^{6)}\text{IMP} + \text{HxR} + \text{Hx}} \times 100$$

Where, $^{1)}$HxR: hypoxanthine, $^{2)}$Hx: inosine, $^{3)}$ATP: adenosine triphosphate, $^{4)}$ADP: adenosine diphosphate, $^{5)}$AMP: adenosine monophosphate, $^{6)}$IMP: inosine monophosphate, * The lower the K-value, the fresher the meat.

VBN (volatile basic nitrogen) evaluation

Volatile basic nitrogen (mg%) tests were performed to determine the extent of protein deterioration during refrigerated storage. VBN was measured by the modified micro diffusion assay according to the method described by Pearson (1968). Each meat sample (3 g) was homogenized for 1 min with 3 mL distilled water and 6 mL TCA (10%), and then centrifuged at 2,090×g for 15 min.

The supernatant was filtered using filter paper (No.4 Whatman), and the filtrate was placed in a test tube up to a final volume of 30 mL with 5% TCA. 0.01 N boric acid, which is a VBN absorber, was placed in the inner section of a Conway micro-diffusion cell (Sibata Ltd., Japan). One milliliter of the sample solution and 1 mL of saturated K_2CO_3 was placed into the outer section of the same cell and the lid was immediately closed. A 5% TCA solution was used as a blank. The cell was incubated at 37°C for 120 min, and then titrated against 0.02 N sulfuric acid. The concentration of VBN was calculated as ammonia equivalent using the following equation.

VBN (mg %)
= (a-b) × (f × 0.02 × N × 14.007 × 100 × 100)/S

Where, a=titer for sample, b=titer for blank, f=factor of reagent, N=normality, S=sample weight (g)

Statistical analysis

All statistical analyses were performed using the GLM procedure in the SAS software (SAS, 2002). A software program using Duncan's multiple range test to compare treatment means was applied. A $p<0.05$ was considered statistically significant. All data were expressed as mean ± SD.

Results and Discussion

Total bacterial counts

The total bacterial counts on spent hen breast meats that had been treated with various levels of LA and/or SB during refrigerated storage are shown in Table 1. During storage, the total bacterial counts in the control group linearly increased, whereas bacterial counts in the treated groups were not detected. The total bacterial counts of 1% or 2% LA-treated meats increased from 3.5×10^1 to 5.6×10^2 CFU/g at 15 d of cold storage. The combination of LA and SB treatment produced stronger effects on lowering the bacterial counts when compared with the LA alone. Hwang and Beuchat (1995) found that treatment with 0.5% LA and 0.05% SB retarded the growth of psychrophilic bacteria in chicken wings. LA is one of the most widely studied organic acids used by the meat process industry. The antimicrobial effect of organic acids such as LA is due to their ability to lower the pH below the growth range of bacterial cells. The acidification of cytoplasm by LA reduces the initial bacterial counts and thus causes a delay in the start of their growth (Booth, 1985). Since microbial contamination is promoted by physicochemical contamination, the initial microbial counts play an important role in determining the shelf-life of poultry meat (Cunningham, 1982).

Table 1. Total bacterial counts (TBC) of spent hen breast meats treated with LA and/or SB during refrigerated storage (Unit : CFU/g)

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	7.5×10^1	8.7×10^2	1.4×10^3	2.3×10^3	4.8×10^3
T1	ND[2)]	ND	ND	ND	5.6×10^2
T2	ND	ND	ND	ND	3.5×10^1
T3	ND	ND	ND	ND	ND
T4	ND	ND	ND	ND	ND
T5	ND	ND	ND	ND	ND
T6	ND	ND	ND	ND	ND
T7	ND	ND	ND	ND	ND
T8	ND	ND	ND	ND	ND

[1)]Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB

[2)]ND: Not detected

pH

The changes in the pH values of spent hen breast meats that had been treated with various levels of LA and/or SB during refrigerated storage are presented in Table 2 and 3. The pH values of the control were significantly higher than those of the treated groups ($p<0.05$) and the pH values were maximal after 5 d of storage.

In this study, the pH values of spent hen breast meats treated with various levels of LA and/or SB ranged from 4.07 to 5.40 ($p<0.05$).

Proteolysis takes place after postmortem by autolytic enzymes or microbial growth in the meat, which cause decomposition of the proteins. Thus, the pH value is increased due to an increase in the number of basic compounds (Bartholomew and Blumer, 1977; Lee *et al*., 1994). The control had the highest initial pH values and the 4% LA-treated meats (T3) had the lowest with a difference of about 2.0 ($p<0.05$). The pH values were significantly affected by the level of LA. The pH was shown to

Table 2. Changes in pH values of spent hen breast meats treated with LA and/or SB during refrigerated storage

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	6.07±0.07[2)Abc]	6.02±0.03[Ac]	6.12±0.06[Aa]	6.13±0.04[Aa]	6.11±0.06[Aab]
T1	5.40±0.13[Ba]	5.16±0.11[Bbc]	5.10±0.15[Bc]	5.19±0.09[Bbc]	5.27±0.08[Bb]
T2	4.56±0.11[Cc]	4.82±0.20[Ca]	4.77±0.11[Cab]	4.66±0.04[Cbc]	4.69±0.02[Cbc]
T3	4.07±0.07[Dc]	4.49±0.25[Da]	4.26±0.04[Db]	4.34±0.20[Db]	4.29±0.02[Db]

[A-D]Means with the different superscript in the same column are significantly different (p<0.05).
[a-c]Means with the different superscript in the same row are significantly different (p<0.05).
[1)]Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA
[2)]Means±SD

Table 3. Changes in pH values of spent hen breast meats treated with LA and/or SB during refrigerated storage

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	6.07±0.07[2)Abc]	6.02±0.03[Ac]	6.12±0.06[Aa]	6.13±0.04[Aa]	6.11±0.06[Aab]
T4	5.11±0.1[Ba]	5.20±0.22[Ba]	5.10±0.11[Ba]	5.11±0.02[Ba]	5.20±0.03[Ba]
T5	4.64±0.16[Ccd]	4.90±0.19[Cab]	4.54±0.13[Dd]	4.75±0.15[Cbc]	4.99±0.23[Ca]
T6	4.76±0.27[Ca]	4.74±0.17[Da]	4.71±0.14[Ca]	4.67±0.07[Da]	4.60±0.10[Ca]
T7	4.79±0.09[Ca]	4.57±0.16[Eb]	4.59±0.04[Db]	4.44±0.05[Ec]	4.54±0.03[Db]
T8	4.37±0.20[Da]	4.36±0.03[Fab]	4.28±0.01[Ebc]	4.18±0.05[Fd]	4.23±0.03[Ecd]

[A-F]Means with the different superscript in the same column are significantly different (p<0.05).
[a-d]Means with the different superscript in the same row are significantly different (p<0.05).
[1)]Control, sterile DW without LA or SB; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB
[2)]Means±SD

decrease linearly with an increase in LA concentration (p<0.05).

Color

Table 4 and 5 show the color values of the spent hen breast meats treated with various levels of LA and SB during refrigerated storage. The CIE L^*, a^* and b^* values of the control were significantly different from the treated meats (p<0.05). The CIE L* value, which is a measure of lightness, was the highest for 2% LA and 0.1% SB-treated

Table 4. Changes in Color values of spent hen breast meats treated with LA and/or SB during refrigerated storage

Group[1)]		Storage period (d)				
		1	3	5	9	15
Control	L^*	53.87±1.99[2)Ca]	50.23±4.39[Cbc]	54.26±2.99[Ca]	49.52±3.02[Cc]	53.39±4.23[Cab]
	a^*	3.15±1.04[Aa]	3.04±1.31[Aa]	2.53±0.92[Aab]	1.98±1.05[Ab]	0.23±0.41[Bc]
	b^*	3.83±1.09[Cc]	4.17±1.08[Cc]	6.06±1.04[Bb]	6.91±1.41[Cab]	8.07±1.75[Ba]
T1	L^*	59.78±2.87[Ba]	59.17±2.52[Ba]	61.88±2.28[Ba]	59.91±2.90[Ba]	50.38±3.32[Ca]
	a^*	2.50±1.02[Aa]	1.95±0.81[Aab]	1.96±0.84[Aab]	1.70±0.92[Bab]	1.00±1.52[Aab]
	b^*	3.98±1.94[Cd]	5.95±2.10[Bc]	7.67±1.45[Bb]	9.09±1.18[Bb]	10.65±1.07[Aa]
T2	L^*	65.09±2.50[Ab]	64.80±2.73[Bb]	66.90±1.83[Aab]	68.31±2.97[Aa]	69.02±2.87[Aa]
	a^*	2.23±1.38[Aa]	0.29±1.02[Bb]	0.18±1.29[Bb]	-1.44±1.11[Cc]	-1.93±1.12[Cc]
	b^*	7.46±1.58[Ac]	9.00±1.43[Ab]	10.46±1.96[Aab]	11.64±1.51[Aa]	12.02±1.26[Aa]
T3	L^*	63.08±2.15[Aa]	60.08±4.23[Aa]	59.69±2.83[Ba]	60.55±3.97[Ba]	60.69±3.35[Ba]
	a^*	0.74±0.63[Ba]	0.42±0.30[Ba]	-1.48±3.00[Cb]	-2.69±0.28[Db]	-2.17±2.08[Cb]
	b^*	5.50±0.86[Bc]	5.92±1.13[Bbc]	7.37±1.81[Ba]	7.24±1.51[Ca]	7.48±1.56[Ba]

[A-D]Means with the different superscript in the same column are significantly different (p<0.05).
[a-c]Means with the different superscript in the same row are significantly different (p<0.05).
[1)]Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA
[2)]Means ± SD

Table 5. Changes in Color values of spent hen breast meats treated with LA and/or SB during refrigerated storage

Group[1)]		Storage period (d)				
		1	3	5	9	15
Control	L*	53.87±1.99[2)Ca]	50.23±4.39[Cbc]	54.26±2.99[Ba]	49.52±3.02[Cc]	53.39±4.23[Cab]
	a*	3.15±1.04[Aa]	3.04±1.31[Aa]	2.53±0.92[Aab]	1.98±1.05[Ab]	0.23±0.41[Ac]
	b*	3.83±1.09[Cc]	4.17±1.08[Cc]	6.06±1.04[Cb]	6.91±1.41[Cab]	8.07±1.75[Ca]
T4	L*	62.59±4.87[Bab]	62.61±5.35[Bab]	66.74±2.28[Aa]	63.35±4.92[Bab]	60.04±5.10[Bb]
	a*	3.35±1.02[Aa]	2.39±1.23[Aab]	1.96±1.53[Aab]	1.82±1.86[Aab]	0.85±2.18[Ab]
	b*	5.42±1.05[Bd]	6.94±0.87[Bc]	8.52±1.54[Bb]	9.11±0.62[Bb]	10.42±1.29[Ba]
T5	L*	66.49±2.41[Ac]	67.31±2.46[Abc]	69.25±1.66[Aab]	70.69±2.49[Aa]	70.47±2.12[Aa]
	a*	1.78±1.22[Ba]	0.67±0.85[BCb]	0.32±0.67[Bb]	-0.98±0.65[Bc]	-1.61±1.23[Bc]
	b*	5.58±1.17[Bd]	7.86±1.23[ABc]	9.73±1.67[ABb]	11.28±1.70[Aa]	12.71±2.09[Aa]
T6	L*	65.77±1.56[ABb]	64.87±2.50[ABb]	66.49±2.03[Aab]	68.91±2.77[Aa]	66.56±2.72[Aab]
	a*	1.91±0.88[Ba]	0.85±0.30[Bb]	0.68±0.76[Bb]	-0.66±0.90[Bc]	-1.67±1.23[Bd]
	b*	7.22±1.35[Ac]	8.73±1.15[Ab]	9.46±1.58[ABb]	11.88±0.81[Aa]	11.30±1.80[ABa]
T7	L*	65.04±3.93[ABa]	65.65±4.90[ABa]	65.62±6.08[Aa]	68.99±4.79[Aa]	67.68±4.30[Aa]
	a*	1.77±0.89[Ba]	0.53±0.59[BCb]	0.66±0.98[Bb]	-1.09±0.73[Bc]	-1.66±0.44[Bc]
	b*	6.06±1.95[ABc]	7.89±1.76[ABb]	10.16±0.51[Aa]	11.00±1.56[Aa]	11.20±1.76[ABa]
T8	L*	64.81±2.95[ABa]	65.38±4.36[ABa]	68.51±3.20[Aa]	66.88±3.94[ABa]	66.56±3.63[Aa]
	a*	1.78±0.66[Ba]	-0.16±0.85[Cb]	-0.18±1.29[Bb]	-1.70±1.05[Bc]	-2.26±0.68[Bc]
	b*	6.16±1.04[ABc]	8.69±0.50[Ab]	9.57±0.97[ABb]	11.00±1.09[Aa]	11.20±0.99[ABa]

[A-C]Means with the different superscript in the same column are significantly different($p<0.05$).
[a-d]Means with the different superscript in the same row are significantly different($p<0.05$).
[1)]Control, sterile DW without LA or SB; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB
[2)]Means ± SD

meats at 1 day of refrigerated storage. The CIE L* value of control was significantly lower than those of all treated groups ($p<0.05$). The CIE a* value is a measure of redness and the value of the control was higher than those of all treated groups at 1 day of refrigerated storage. Especially, the CIE a* value of the 4% LA-treated meats was the lowest ($p<0.05$). In the case of the CIE b* value, which is a measure of yellowness, the value of the control was lower than those of all treated groups and the CIE b* values of the 2% LA-treated meats was the lowest ($p<0.05$).

The yellowness of spent hen breast meats increased during refrigerated storage, whereas the redness value significantly decreased ($p<0.05$). The CIE L*, a* and b* values at subsequent refrigerated storage were appeared almost the same pattern as those of at 1 d of refrigerated storage. The color in retail displays is one of the most important factors influencing consumer acceptability and preference (Mitsumoto *et al*., 2005). A marked variation of colors was observed in spent hens breast meats treated with various levels of LA and SB in present study.

K-value

The K-value is the relative ratio of the total amount ATP and ATP-related compounds; HxR (hypoxanthine) + Hx (inosine) and is presented as percentage (K-value: %). Generally, a high K-value is indicative of spoiled food. In a previous study on the energy metabolism of chicken, Terasaki *et al*. (1965) suggested that chicken as well as fish are decomposed into ATP, ADP, AMP, IMP, HXR, and HX . Thus, the K-value can be used as an indicator of the freshness of chicken.

The K-value of control was significantly higher than those of all treated groups at 15 d of refrigerated storage, as shown in Table 6 and 7. K-value significantly increased from 24.0 to 63.0% in the control ($p<0.05$) and the difference was about 40% ($p<0.05$). The smallest change in the K-value was observed for the 2% LA and 0.4% SB-treated meats, which increased from 29.1 to 47.4% ($p<0.05$). In addition, all treated groups had lower K-values than the control group, which indicates that the treatments with LA and/or SB resulted in a longer shelf-life of breast meats ($p<0.05$). When compared the T2 with T7 groups, which were treated equal concentrations of LA (2%), the T7, which was also treated with 0.4% SB, had a lower K-value than the T2 group at 15 d. This result suggests that among the groups treated 2% LA, combina-

Table 6. Changes in K-values of spent hen breast meats treated with LA and/or SB during refrigerated storage (Unit : %)

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	24.0±2.10[2)ABe]	33.4±2.20[Ad]	46.0±0.00[Ac]	55.1±0.35[Ab]	63.0±3.70[Aa]
T1	24.9±0.15[ABc]	34.0±5.50[Ab]	38.0±1.45[Bb]	43.5±5.55[Bb]	50.2±7.15[Ba]
T2	26.3±2.70[Ad]	24.6±3.60[Bd]	35.8±4.10[Bc]	44.5±2.30[Bb]	56.5±2.05[ABa]
T3	22.7±0.90[Bd]	25.1±1.15[Bd]	27.9±2.50[Cc]	44.5±0.55[Bb]	54.4±0.90[Ba]

[A-C]Means with the different superscript in the same column are significantly different (p<0.05).
[a-e]Means with the different superscript in the same row are significantly different (p<0.05).
[1)]Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA
[2)]Means±SD

Table 7. Changes in K-values of spent hen breast meats treated with LA and/or SB during refrigerated storage (Unit : %)

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	24.0±2.10[2)Ce]	33.4±2.20[Ad]	46.0±0.00[Ac]	55.1±0.35[Ab]	63.0±3.70[Aa]
T4	28.0±2.60[BCc]	23.8±4.80[Bc]	42.8±1.20[Bb]	47.1±0.50[Bb]	54.4±4.75[Ba]
T5	27.2±3.60[BCc]	35.9±2.30[Ac]	43.3±0.80[Bb]	43.4±0.00[Cb]	55.5±0.95[Ba]
T6	33.1±0.10[Ac]	31.3±3.30[Ac]	41.4±0.95[BCb]	41.5±1.70[Cb]	55.2±2.85[Ba]
T7	29.1±3.90[ABc]	32.5±0.95[Ac]	40.1±0.10[Cb]	46.0±2.45[Bab]	47.4±5.80[Ca]
T8	29.8±1.65[ABd]	33.7±0.45[Ac]	36.0±2.45[Dc]	45.8±0.70[Bb]	58.3±0.50[ABa]

[A-D]Means with the different superscript in the same column are significantly different (p<0.05).
[a-e]Means with the different superscript in the same row are significantly different (p<0.05).
[1)]Control, sterile DW without LA or SB; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB
[2)]Means±SD

tion of 2% LA and 0.4% SB was the most effective in extending the shelf-life. According to the CFR, sodium benzoate can be used as an antimicrobial agent in food products at appropriate levels not exceeding good manufacturing practice. Thus, low levels of SB may be recommended to extend the shelf life of chicken if used in combination with LA.

VBN (volatile basic nitrogen)

The changes in the VBN values of spent hen breast meats treated with various levels of LA and/or SB during refrigerated storage are presented in Table 8 and 9. The VBN content in the control was significantly higher than those of all treated groups during all storage time (p<0.05). The groups treated with a relative higher LA had lower VBN values (p<0.05). At 15 day of storage, the VBN values of groups with LA combination with SB were lowed to approximately the same level as the 4% LA treated groups. This occurred because LA and SB inhibited proteolysis by microorganism and enzymes in the meats. Among the treated groups, the low VBN value was observed in the 2% LA and 0.4% SB-treated group after 5 d (p<0.05).

The extent of protein decomposition was assessed by

Table 8. Changes in VBN (Volatile Basic Nitrogen) of spent hen breast meats treated with LA and/or SB during refrigerated storage (Unit : mg%)

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	8.87±0.56[2)Ad]	11.65±0.11[Ac]	12.05±0.97[Ac]	19.05±2.24[Ab]	29.97±1.91[Aa]
T1	7.62±0.56[Bb]	8.68±0.84[Bb]	10.65±0.56[Ab]	14.43±1.24[Ba]	16.25±3.07[Ba]
T2	6.60±0.56[Bb]	6.04± 0.36[Cb]	7.00±1.75[Bb]	5.60±0.00[Cb]	11.77±1.68[Ca]
T3	4.65±0.56[Cb]	4.88±0.40[Db]	5.51±1.03[Bab]	7.70±2.16[Ca]	6.16±0.56[Dab]

[A-D]Means with the different superscript in the same column are significantly different (p<0.05).
[a-d]Means with the different superscript in the same row are significantly different (p<0.05).
[1)]Control, sterile DW without LA or SB; T1, 1% LA; T2, 2% LA; T3, 4% LA
[2)]Means±SD

Table 9. Changes in VBN (Volatile Basic Nitrogen) of spent hen breast meats treated with LA and/or SB during refrigerated storage
(Unit : mg%)

Group[1)]	Storage period (d)				
	1	3	5	9	15
Control	8.87±0.56[2)Ad]	11.65±0.11[Ac]	12.05±0.97[Ac]	19.05±2.24[Ab]	29.97±1.91[Aa]
T4	7.56±0.56[Bc]	10.09±0.00[ABb]	11.35±1.03[Ab]	14.71±1.16[Ba]	14.76±1.85[Ba]
T5	5.45±0.56[Cc]	8.40±1.68[BCb]	6.16±1.02[Bbc]	13.07±1.16[Ba]	6.54±2.12[Cbc]
T6	5.65±0.56[Ccd]	5.06±0.59[Dd]	11.77±0.56[Aa]	6.58±0.71[Cc]	8.69±0.85[Cb]
T7	5.31±0.55[Cb]	7.84±0.00[Ca]	3.36±0.00[Cc]	5.88±1.40[Cb]	6.16±0.56[Cb]
T8	5.54±0.56[Cb]	8.40±1.68[BCa]	5.60±0.56[Bb]	6.80±0.07[Cab]	7.10±2.12[Cab]

[A-D] Means with the different superscript in the same column are significantly different ($p<0.05$).
[a-d] Means with the different superscript in the same row are significantly different ($p<0.05$).
[1)] Control, sterile DW without LA or SB; T4, 1% LA and 0.1% SB; T5, 2% LA and 0.1% SB; T6 2% LA and 0.2% SB; T7, 2% LA and 0.4% SB; T8, 4% LA and 0.2% SB
[2)] Means±SD

measuring low molecule weight inorganic nitrogen, which originates from protein. The VBN content has been widely accepted as deterioration indicator of meat during storage, which is increased due to proteolysis by microorganisms and enzymes in meats during storage (Field and Chang, 1969; Jo *et al*., 2004). In this study, the VBN values of control and treated groups were linearly increased with elapse of storage time. Yang *et al*. (2009) reported that the VBN values of chicken breast meat in vacuum packed reached up to 25 mg% after 10 d when stored at 4.0°C. The LA and SB treatments were effective in reducing the VBN values during all storage time ($p<0.05$).

The results of this study indicated that LA and SB had effect to extend their shelf-life during refrigerated storage. This study may provide a basis for more detailed studies to be conducted on improving the storage stability of spent hen meats. Further study is required to clarify the dipping treatments of LA and SB on sensory characteristics of chicken meats.

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