Korean J. Food Sci. Ani. Resour.
Vol. 31, No. 1, pp. 9~18(2011)

ARTICLE

# Effect of Lotus (*Nelumbo nucifera*) Leaf Powder on the Quality Characteristics of Chicken Patties in Refrigerated Storage

Yun-Sang Choi[1], Ji-Hun Choi[1], Hack-Youn Kim[2], Hyun-Wook Kim[2], Mi-Ai Lee[3], Hai-Jung Chung[4], Sung Ki Lee[5], and Cheon-Jei Kim[1,2]*

[1]*Research Institute for Meat Science and Culture, Konkuk University, Seoul 143-701, Korea*
[2]*Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Korea*
[3]*World Institue of Kimchi, An Annex of Korea Food Research Institute, Seongnam 463-746, Korea*
[4]*Department of Food Science and Nutrition, Daejin University, Pochon 487-711, Korea*
[5]*Department of Animal Products and Food Science, Kangwon National University, Chuncheon 200-701, Korea*

**Abstract**

This study was aimed at comparing the pH, color, thiobarbituric acid (TBA), volatile basic nitrogen (VBN), textural properties, and sensory evaluations of chicken meat patties containing lotus (*Nelumbo nucifera)* leaf powder, and assessing their shelf-life at refrigeration temperature (4±1°C). In the refrigerated storage, the pH, lightness, yellowness, springiness values, and sensory properties scores of the control as well as all the treated samples decreased as the storage increased. The hardness, gumminess, chewiness, TBA, and VBN-values of control and all the samples treated with lotus leaf increased during refrigerated storage. At the end of the storage period (day 28), chicken patties containing lotus leaf powder had lower pH, redness, yellowness, TBA, VBN, hardness, gumminess, and chewiness values than those of control. The results of this study showed that a lotus leaf powder can increase storage stability in chicken meat products.

**Key words:** lotus leaf, chicken patties, shelf-life, thiobarbituric acid, volatile basic nitrogen, sensory evaluation

## Introduction

Chicken meats and products are generally a very popular food commodity around the world, and its consumption has increased over the last decades in many countries (Chouliara *et al*., 2007). Some of the reasons for their popularity are the relatively low cost of production, low fat content, and the high nutritional value of chicken breast meat. Chicken contains relatively high concentrations of polyunsaturated fatty acids. However, a high degree of polyunsaturation accelerates oxidative processes, leading to deterioration in meat flavor, color, and nutritional value (Sayago-Ayerdi *et al*., 2009).

Antioxidants play an important role in the chicken meat industry as inhibitors of oxidative rancidity and improve of shelf-life. Synthetic antioxidants such as BHT (butrylhydroxytoluene), TBHQ (tert-butylhydroquinone) is limited due to their potential carcinogenic effects (Choe *et al*., 2010). Thus, in the processing of chicken meat products, there is increasing need for a natural way to minimize oxidative rancidity and extend shelf-life (Naveena *et al*., 2008).

Lotus (*Nelumbo nucifera* Gaertner, Nelumbonaceas family) leaf contains many components that are beneficial to human health (Ko *et al*., 2006). Lotus, well-known by the term *Indian lotus*, is an aquatic perennial grown (*rhizomes*) throughout Asia, such as in Korea, China, Japan, and India (Choi *et al*., 2009; Park *et al*., 2009a; Yoon and Noh, 2009), and of which all parts, such as flowers, seeds, leaves, stems, and roots are generally consumed. Leaves and petals are especially valuable and economic parts of the plant, it used as food, medicine, and ornamentals (Na *et al*., 2009; Park *et al*., 2009b). Lotus leaf has various biological activities such as sedative action, antipyretic action, antioxidative effects, and amelioration of diabetes and high cholesterol (Park *et al*., 2009a; Park *et al*., 2009c). For these reasons, lotus leaf is a good potential source of functional component, including tartaric acid, citric acid, malic acid, succinic acid, tannin, and alkaloid components on roemerine, nuciferin, armepavine, *N*-nor-nuciferine, and pronuciferine (Choe *et al*.,

*Corresponding author: Cheon-Jei Kim, Research Institute for Meat Science and Culture, Konkuk University, Seoul 143-701, Korea. Tel: 82-2-450-3684, Fax: 82-2-444-6695, E-mail: kimcj@konkuk.ac.kr

2010; Lee *et al*., 2006; Shin and Han, 2006; Yoon and Noh, 2009). The leaves of lotus have therefore already been subjected to numerous biological and pharmacological studies. The leaves have been reported to exhibit antioxidant (Huang *et al*., 2010; Jung *et al*., 2008; Park *et al*., 2007), antihyperlipidemic (Kim *et al*., 2005), and antiobesity effects (Ono *et al*., 2006). However, direct or indirect utilization of the leaves of lotus in meat processing and the potential health benefits that could thereby result are not well understood. Also, consumers have an important in meat products quality as well as the potential health benefits.

Therefore, the objective of this study was to investigate the effects of pH, color, TBA, VBN, textural properties, and sensory evaluations on the chicken patties containing different levels of lotus (*Nelumbo nucifera*) leaf powder.

## Materials and Methods

### Preparation and processing of lotus leaf powder

The lotus (*Nelumbo nucifera* Gaertner, Nelumbonaceas family) leaves were purchased from a market in Gwangjin-gu, Seoul, Korea. It was ground for one minute using a blender (KA-2610, Jworld Tech, Korea) and passed though a 35-mesh sieve (particle size of <0.5 mm). The *Nelumbo nucifera* leaf powder (moisture content: 5.98%, protein content: 21.85%, fat content:1.01%, ash content: 8.67%, and pH: 5.42) was then placed in polyethylene bags, vacuum-packaged using a vacuum packaging system (FJ-500XL, Fujee Tech, Korea) and stored at 4°C until used for product manufacture. The lightness, redness, and yellowness values of *Nelumbo nucifera* leaf powder were measured to be 47.13, -0.60, and 24.81.

### Chicken patties preparation and processing

Fresh chicken breast meat (broilers, *M. pectoralis major*, 5 wk of age, approximately 1.5-2.0 kg live weight) were obtained from a pilot plant at Konkuk University, Chungju, Korea. Pork back fat (moisture 12.59%, fat 86.23%) was also purchased from a local processor at 48 hr postmortem. Chicken breast meat was initially ground through an 8-mm plate and through a 3-mm plate. And then pork back fat was also ground through 8-mm plate and through a 3-mm plate. Each batch of samples consisted of five chicken patties, which differed in composition with respect to lotus leaf powder levels, plus another treatment (T1, T2, and T3) replacing lotus leaf powder with ascorbic acid. Mixed ingredients (1.5% salt, 0.3% sodium tripolyphosphate, 1.5% seasonging, 2.0% D-sorbitol, and 0.15% garlic powder) were added to the chicken breast meat and pork back fat. The meat and additives were mixed for 15 min at 4°C by hand, and the chicken patty mixtures were divided into five equal portions. The first batch was used as a control, which treatment without both lotus leaf powder and ascorbic acid. The second batch was designated as TA, which treatment added 0.05% ascorbic acid. The other batches were supplemented with various levels (T1: 0.1%, T2: 0.2%, and T3: 0.4%) of lotus leaf powder (Table 1). After mixing, the mixture were stored in a cold room (4°C) for 1 d, and then shaped using a household hamburger mold (PM 10/13 Burger press, AB Services Food Machinery, England; diameter: 100 mm, thickness: 23 mm) into meat products that were approximately 100 mm in diameter and 15 mm thickness, with a weight of about 90 g. Chicken patties were placed in polyethylene bags, vacuum-sealed (FJ-500XL, Fujee Tech., Korea), and stored at 4°C until used for experiments. Chicken patty processing was carried out in triplicate for each treatment. The quality and storage stability were determined on 0, 7, 14, 21, and 28 d at 4°C.

### pH

The pH values of meat patties were measured in a homogenate prepared with 5 g of sample and distilled water (20 mL) using a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland). All determinations were performed in triplicate.

### Color measurements

The color of each chicken meat patty was determined

**Table 1. Formulation of chicken patties with various levels of lotus leaf powder** (Units: %)

| Ingredients | Control | Treatments[1] | | | |
|---|---|---|---|---|---|
| | | TA | T1 | T2 | T3 |
| Chicken meat | 70 | 70 | 70 | 70 | 70 |
| Pork fat | 20 | 20 | 20 | 20 | 20 |
| Cold water | 10 | 10 | 10 | 10 | 10 |
| Salt | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Sodium tripolyphosphate | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Seasoning | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| D-sorbitol | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Garlic powder | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Ascorbic acid | | 0.05 | | | |
| Lotus leaf powder | | | 0.1 | 0.2 | 0.4 |

[1]Control, chicken patties without *Nelumbo nucifera* powder; TA, chicken patties with 0.05% ascorbic acid, T1, chicken patties with 0.1% *Nelumbo nucifera* powder; T2, chicken patties with 0.2% *Nelumbo nucifera* powder; T3, chicken patties with 0.4% *Nelumbo nucifera* powder

using a colorimeter (Minolta Chroma Meter CR-210, Minolta Ltd., Japan; illuminate C, calibrated with a white plate, $L^*$=+97.83, $a^*$=-0.43, $b^*$=+1.98). Six measurements for each of five replicates were taken. Lightness (CIE $L^*$-value), redness (CIE $a^*$- value), and yellowness (CIE $b^*$-value) values were recorded.

**Thiobarbituric acid (TBA) value**

Lipid oxidation was assessed in triplicate by the 2-thiobarbituric acid (TBA) method of Tarladgis *et al.* (1960) with minor modifications. A 10 g sample was blended with 50 mL distilled water for 2 min and then transferred to a distillation tube. The cup used for blending was washed with an additional 47.5 mL of distilled water, which was added to the same disitillation flask with 2.5 mL 4 N HCl and a few drops of an antifoam agent, silicone o/w (KMK-73, Shin-Etsu Silicone Co., Ltd., Korea). The mixture was distilled, and 50 mL distillate was collected. Five mL of 0.02 M 2-thiobarbituric acid in 90% acetic acid (TBA reagent) was added to a vial containing 5 mL of the distillate and mixed well. The vials were capped and heated in a boiling water bath for 30 min to develop the chromogen, and then cooled to room temperature. Absorbances were measured using a UV/VIS spectrophotometer (Optizen 2120 UV plus, Mecasys Co. Ltd., Korea) at 538 nm, against a blank prepared with 5 mL distilled water and 5 mL TBA-reagent. Thiobarbituric acid-reactive substances (TBARS) were calculated from a standard curve (8-50 nmol) of malondialdehyde (MA), freshly prepared by acidification of TEP (1,1,3,3-tetraethoxy propane). Reagents were obtained from Sigma (UK). TBA levels were calculated as mg MA/kg samples.

**Volatile basic nitrogen (VBN) value**

Volatile basic nitrogen (mg%) test was performed to determine the extent of protein deterioration during refrigerated storage. VBN was measured by the modified micro diffusion assay according to the method of Pearson (1968).

$$\text{VBN (mg\%)} = \frac{(a-b)\times(f\times 0.02\times N\times 14.007\times 100\times 100)}{S}$$

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

**Texture profile analysis**

Texture measurements in the form of texture profile analysis were performed at room temperature with a texture analyzer (TA-XT2*i*, Stable Micro Systems, England). The chicken meat patty samples were taken from the central portion of each patty. Prior to analysis, samples were allowed to equilibrate to room temperature (20°C, 3 h). The conditions of texture analysis were as follows: spherical prove ø 0.25 mm diameter, pre-test speed 2.0 mm/s, post-test speed 5.0 mm/s, maximum load 2 kg, head speed 2.0 mm/s, distance 8.0 mm, force 5 g. The calculation of TPA values was obtained by graphing a curve using force and time plots. Values for hardness (kg), springiness, cohesiveness, gumminess (kg), and chewiness (kg) were determined by reported methods (Bourne, 1978).

**Sensory evaluation**

Sensory evaluations were performed in triplicate on each sample by sensory panelists. A trained twelve-member panel consisting of researchers from the department of Food Sciences and Biotechnology of Animal Resources at Konkuk University in Korea was used to evaluate the chicken patties. Training of panelists was performed according to a sensory evaluation procedure. Each chicken patty was evaluated in terms of color, flavor, juiciness, tenderness, and overall acceptability. Chicken patties were cooked to a core temperature of 75°C, cooled to 20°C, cut into quarters (size: 5×5×3 cm), and served to the panelists randomly. Each sample was coded with a randomly selected 3-digit number. Sensory evaluations were performed under fluorescent lighting. Panelists were instructed to cleanse their palates between samples using warm water (30°C). The color (1 = extremely undesirable, 6 = slightly desirable, 10 = extremely desirable), flavor (1 = extremely undesirable, 6 = slightly desirable, 10 = extremely desirable), tenderness (1 = extremely tough, 6 = slightly tender, 10 = extremely tender), juiciness (1 = extremely dry, 6 = slightly juicy, 10 = extremely juicy), and overall acceptability (1 = extremely undesirable, 6 = slightly desirable, 10 = extremely desirable) of the cooked samples were evaluated using a 10-point descriptive scale. This analysis was conducted using the hedonic test described by Choi *et al.* (2010).

**Statistical analysis**

Analysis of variance was performed on all the variables measured using the general linear model (GLM) procedure of the SAS statistical package (1999). Duncan's multiple range test ($p$<0.05) was used to determine the significant difference between treatment means.

## Results and Discussion

### Changes of pH and color of chicken meat patties during refrigerated storage

Fig. 1 shows the pH values of uncooked chicken patties with lotus leaf powder during refrigerated storage over 28 d. Initial (day 1) pH values for all lotus leaf treated samples were slightly lower than those for the control containing no added ingredients, but overall the treated samples and control did not significantly differ ($p>0.05$). Similar trends in pH values were observed in studies by Kim and Park (2008) when different amounts of lotus leaf powder were added to cookies. Also, Park *et al*. (2009a) showed that lotus leaf powder addition decreased the pH values of *Jook* (a Korean soup). The addition of lotus leaf powder (pH=5.42) may result in decrease of chicken patty pH and pH of the samples added lotus leaf powder was lower than control at the end of storage. However, in storage period at 4°C, the pH of control and all treated samples were decreased. The pH consistently decreased during refrigerated storage over the course of 28 d, probably due to the lactic acid bacteria (Ahmad and Stivastava, 2007; Liepe and Probic, 1986). Similar trends of pH values were observed in studies by Kim *et al*. (2008a) when different amounts of sweet persimmon powder were added to meat patties during freeze at 30 d. Park and Kim (2007) reported that the pH value of ground pork meat containing paprika decreased from about 6.5 to 5.0. According to Shikama and Sugawara (1978), pH values decrease markedly with increased rate of autoxidation. However, a work of Kim *et al*. (2007) reports that when the effects of glucomannan on the shelf-life of chicken patties is tested, no significant difference in pH values was observed between the control and treated samples through increasing storage periods.

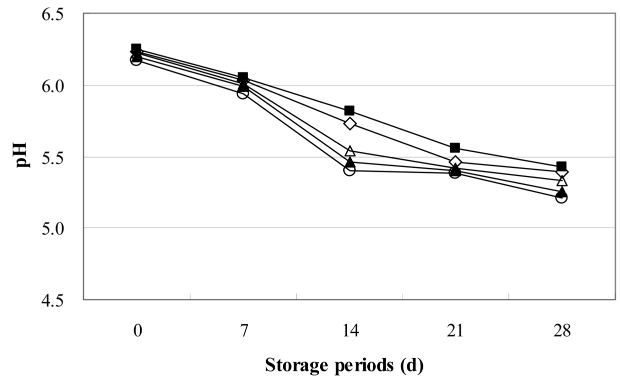


**Fig. 1. pH changes of chicken patty with various levels of lotus leaf powder during 28 d of storage at 4°C.** (◇) Control, chicken patties without *Nelumbo nucifera* powder; (■) TA, chicken patties with 0.05% ascorbic acid, (△) T1, chicken patties with 0.1% *Nelumbo nucifera* powder; (▲) T2, chicken patties with 0.2% *Nelumbo nucifera* powder; (○) T3, chicken patties with 0.4% *Nelumbo nucifera* powder

The color of meat products is one of the important factors by which consumers judge their acceptability (Serrano *et al*., 2006). Discoloring is a major problem for marketing meat products, since it reduces consumer acceptability (Chen and Trout, 1991). The differences in lightness (CIE $L^*$-value), redness (CIE $a^*$-value), and yellowness (CIE $b^*$-value) values of uncooked chicken patties with lotus leaf powder during refrigerated storage were shown to be significant (Table 2). Lotus leaf powder reduced lightness, redness, and yellowness of raw chicken patty at 0 d ($p<0.05$). Also, the treated sample with added ascorbic acid showed the lowest lightness and the highest redness at 0 d. Similar results were obtained by Shin (2007) in quality characteristics of fish paste containing lotus leaf powder. This effect has been attributed to the diluting effect that non-meat ingredients such as lotus leaf have on meat pigment in chicken patties. The period of refrigerated storage affected lightness and yellowness values, which significantly decreased during storage in control and all treated samples ($p<0.05$). On the other hand, redness values of raw patty samples increased as storage progressed ($p<0.05$). These results showed similar trends to those in a study of Kim *et al*. (2008a) in which sweet persimmon powder was added to meat patties storage for improved storage stability. However, there have been different reports on the effects of storage on the color of meat products. While it has been indicated that storage had no significant effect on the redness value of meat products, or that such changes over the storage period were variable (Serrano *et al*., 2006), such changes in color have been reported in association with patterns of change in other color parameters.

### Changes of TBA and VBN values of chicken meat patties during refrigerated storage

The oxidation of lipids leading to rancidity is one of the most important changes during food storage and production (Melton, 1983; Rosmini *et al*., 1996). Ulu (2004) reported that lipid oxidation in products may change the color, aroma, flavor, texture and even the nutritive values of the food. According to Brewer and Wu (1993), oxidation of lipids causes deterioration and decreased shelf life of meat products. The TBA values in uncooked chicken patties with lotus leaf powder during refrigerated storage are shown in Fig. 2. The analysis of variance for these

**Table 2. Color properties of chicken patty with various levels of louts leaf powder during 28 d of storage at 4°C**

| Parameter | Storage periods (d) | Control | Treatments[1)] | | | |
|---|---|---|---|---|---|---|
| | | | TA | T1 | T2 | T3 |
| L*-value | 0 | 68.90±1.34$^{Aa}$ | 65.57±1.34$^{Ba}$ | 68.45±1.13$^{Aa}$ | 67.98±1.02$^{ABa}$ | 67.33±1.41$^{ABa}$ |
| | 7 | 64.95±1.74$^{b}$ | 65.03±1.22$^{ab}$ | 64.93±1.85$^{b}$ | 64.58±1.72$^{b}$ | 65.03±0.98$^{b}$ |
| | 14 | 64.45±1.62$^{b}$ | 64.86±0.78$^{b}$ | 64.52±1.22$^{b}$ | 64.47±1.12$^{b}$ | 64.24±1.02$^{b}$ |
| | 21 | 63.96±0.98$^{c}$ | 64.01±1.08$^{c}$ | 64.32±1.07$^{b}$ | 64.03±1.01$^{bc}$ | 63.99±0.98$^{bc}$ |
| | 28 | 63.57±0.26$^{c}$ | 63.52±1.11$^{c}$ | 63.55±0.89$^{c}$ | 63.19±0.15$^{c}$ | 63.18±0.88$^{c}$ |
| a*-value | 0 | 3.97±0.89$^{Bd}$ | 4.23±0.87$^{Ad}$ | 3.62±0.88$^{Bc}$ | 1.99±0.81$^{Cc}$ | 1.79±0.79$^{Cc}$ |
| | 7 | 4.83±0.49$^{Bc}$ | 5.55±0.98$^{Ac}$ | 4.48±0.79$^{Bb}$ | 3.68±0.71$^{Cb}$ | 3.12±0.89$^{Cb}$ |
| | 14 | 6.01±0.52$^{Ab}$ | 5.67±0.59$^{Bc}$ | 4.92±0.81$^{Cb}$ | 3.78±0.69$^{Db}$ | 3.78±0.93$^{Db}$ |
| | 21 | 6.38±0.45$^{Ab}$ | 6.02±0.68$^{Aab}$ | 5.61±0.71$^{Ba}$ | 4.52±0.75$^{Ca}$ | 4.21±0.83$^{Ca}$ |
| | 28 | 7.00±0.62$^{Aa}$ | 6.67±0.72$^{Aa}$ | 5.93±0.69$^{Ba}$ | 5.00±0.82$^{BCa}$ | 4.83±0.71$^{Ca}$ |
| b*-value | 0 | 36.29±0.35$^{Aa}$ | 34.19±0.48$^{Ba}$ | 33.48±0.59$^{Ba}$ | 30.04±0.65$^{Ca}$ | 29.29±0.63$^{Ca}$ |
| | 7 | 28.59±0.63$^{Bb}$ | 31.92±0.51$^{Aa}$ | 30.96±0.66$^{Ab}$ | 29.52±0.38$^{ABa}$ | 28.01±0.47$^{Ba}$ |
| | 14 | 25.22±0.43$^{Bc}$ | 28.83±0.55$^{Ab}$ | 25.43±0.61$^{Bc}$ | 25.19±0.48$^{Bb}$ | 24.38±0.58$^{Cb}$ |
| | 21 | 20.05±0.52$^{Bd}$ | 26.27±0.42$^{Ac}$ | 21.02±0.62$^{Bd}$ | 19.73±0.52$^{Bc}$ | 19.19±0.48$^{Cc}$ |
| | 28 | 18.18±0.45$^{Be}$ | 20.21±0.34$^{Ad}$ | 17.23±0.58$^{Be}$ | 16.78±0.36$^{BCd}$ | 14.22±0.42$^{Cd}$ |

All values are mean±SD of three replicates.
$^{A-D}$Means within a column with different letters are significantly different ($p$<0.05).
$^{a-e}$Means within a row with different letters are significantly different ($p$<0.05).
[1)]Treatments are the same as in Table 1.

TBA values indicates that the TBA values were significantly affected by both the storage periods (1, 7, 14, 21, and 28 d) and the lotus leaf powder treatments. Initial (day 1) TBA values for control and all treatments did not significantly differ ($p$>0.05), and a steady increase in TBA values was found among all treated samples during storage. During refrigerated storage, the highest TBA value was found in the control. At the end of the storage period (day 28), all treated samples showed significantly lower TBA values than the control ($p$<0.05). These results are similar to those reported by Han *et al*. (2006) for physicochemical and storage characteristics of sausage containing added *mugwort* powder. Fernandez-Lopez *et al*. (2005) studied the effect of rosemary, orange, and lemon extracts applied to beef meatballs. Mansour and Khalil (2000) reported the antioxidant activity of freeze dried extracts from potato peel in ground beef patties. Also, Brannan (2008) found that grape seed reduced the TBA values in chicken patties, and Naveena *et al*. (2008) reported and antioxidant effect of pomegranate rind powder in chicken patties. In general, storage periods have a significant influence on the development of lipid oxidation in meat and meat products (Lee *et al*., 2010), and the greatest advantage in using natural antioxidant material in meat products is restrained potential rancidity development (Hernández-Hernández *et al*., 2009; Intarapichet and Maikhunthod, 2005). Tarladgis *et al*. (1960) indicated that the acceptable limit of TBA values of cooked meat products during storage was 0.5-1.0 mg/kg as detected by a trained panel. Greene and Cumuze (1982) reported that a range of 0.6-2.0 mg/kg was considered to be the detectable minimum level for off-flavor by inexperienced panelists. Kohsaka (1975) studies also suggested a malondialdehyde concentration of 0.5 mg/kg as a threshold value for rancidity perception by consumers.

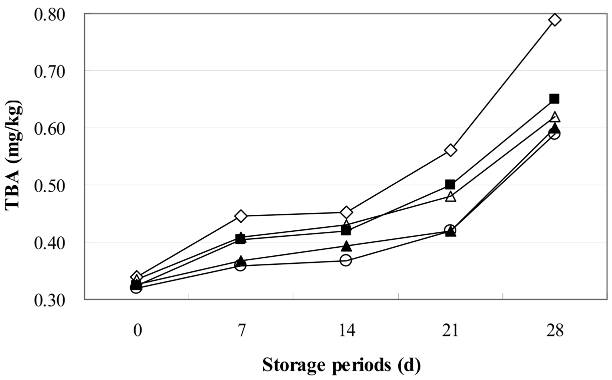


**Fig. 2. TBA values changes of chicken patty with various levels of lotus leaf powder during 28 d of storage at 4°C.** (◇) Control, chicken patties without *Nelumbo nucifera* powder; (■) TA, chicken patties with 0.05% ascorbic acid, (△) T1, chicken patties with 0.1% *Nelumbo nucifera* powder; (▲) T2, chicken patties with 0.2% *Nelumbo nucifera* powder; (○) T3, chicken patties with 0.4% *Nelumbo nucifera* powder

Measurement of VBN, which is the result of the decomposition of protein such as the amino acid decarboxylase activity during storage by microorganisms (Lin and Lin, 2002), can be an important indicator of deterioration in meat products during storage periods (Kim *et al.*, 2008b; Kohsaka, 1975). The influence of added lotus leaf powder on VBN content in chicken meat patties is shown in Fig. 3. The VBN content in chicken meat patties with lotus leaf powder increased during refrigerated storage periods ($p$<0.05). The VBN content in the control was higher than that of the lotus leaf powder treated samples in storage at day 28 ($p$>0.05). However, among the samples treated with lotus leaf powder the VBN content in chicken meat patties was not significantly affected at 28 d of storage ($p$<0.05). This result represents a similar trend to the TBA values in the chicken meat patties. According to Field and Chang (1969), VBN content has been considered as a spoilage indicator, and is increased by proteolysis carried out by microorganisms and enzymes in meat products (Jung *et al.*, 2010).

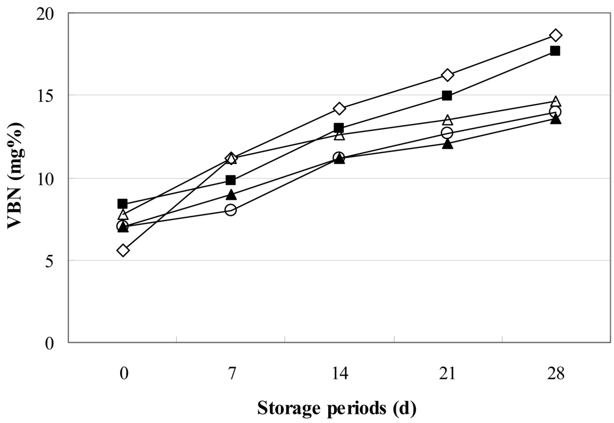


**Fig. 3. VBN values changes of chicken patty with various levels of lotus leaf powder during 28 d of storage at 4°C.** (◇) Control, chicken patties without *Nelumbo nucifera* powder; (■) TA, chicken patties with 0.05% ascorbic acid, (△) T1, chicken patties with 0.1% *Nelumbo nucifera* powder; (▲) T2, chicken patties with 0.2% *Nelumbo nucifera* powder; (○) T3, chicken patties with 0.4% *Nelumbo nucifera* powder

**Table 3. Textural properties of chicken patty with various levels of louts leaf powder during 28 d of storage at 4°C**

| Parameter | Storage periods (d) | Control | Treatments[1)] | | | |
|---|---|---|---|---|---|---|
| | | | TA | T1 | T2 | T3 |
| Hardness (kg) | 0 | 0.95±0.05$^{Ad}$ | 0.76±0.04$^{Bd}$ | 0.81±0.04$^{Bd}$ | 0.75±0.04$^{BCd}$ | 0.71±0.03$^{Cc}$ |
| | 7 | 1.01±0.03$^{Ad}$ | 1.01±0.04$^{Ac}$ | 0.97±0.03$^{ABc}$ | 0.88±0.05$^{Bc}$ | 0.85±0.05$^{Bb}$ |
| | 14 | 1.10±0.05$^{Bc}$ | 1.17±0.05$^{Ab}$ | 1.10±0.05$^{Bb}$ | 0.97±0.04$^{BCc}$ | 0.91±0.03$^{Cb}$ |
| | 21 | 1.27±0.07$^{Ab}$ | 1.20±0.04$^{ABb}$ | 1.14±0.05$^{Bb}$ | 1.12±0.05$^{Bb}$ | 0.99±0.04$^{Ca}$ |
| | 28 | 1.39±0.08$^{Aa}$ | 1.31±0.05$^{ABa}$ | 1.25±0.03$^{Ba}$ | 1.22±0.05$^{Ba}$ | 1.11±0.05$^{Ca}$ |
| Springiness | 0 | 0.91±0.03$^{a}$ | 0.89±0.03$^{a}$ | 0.90±0.03$^{a}$ | 0.92±0.03$^{a}$ | 0.92±0.03$^{a}$ |
| | 7 | 0.90±0.02$^{a}$ | 0.90±0.03$^{a}$ | 0.90±0.03$^{a}$ | 0.91±0.03$^{a}$ | 0.91±0.04$^{a}$ |
| | 14 | 0.89±0.04$^{ab}$ | 0.87±0.02$^{ab}$ | 0.89±0.02$^{a}$ | 0.87±0.03$^{a}$ | 0.88±0.03$^{ab}$ |
| | 21 | 0.86±0.03$^{ab}$ | 0.83±0.04$^{b}$ | 0.85±0.03$^{ab}$ | 0.86±0.04$^{ab}$ | 0.86±0.04$^{b}$ |
| | 28 | 0.84±0.04$^{Bb}$ | 0.79±0.03$^{Bc}$ | 0.83±0.04$^{Ab}$ | 0.83±0.04$^{Ab}$ | 0.84±0.05$^{Ab}$ |
| Cohesiveness | 0 | 0.46±0.03$^{B}$ | 0.51±0.02$^{A}$ | 0.43±0.03$^{B}$ | 0.45±0.03$^{B}$ | 0.46±0.03$^{B}$ |
| | 7 | 0.46±0.03$^{A}$ | 0.43±0.03$^{A}$ | 0.42±0.02$^{AB}$ | 0.40±0.02$^{B}$ | 0.44±0.03$^{A}$ |
| | 14 | 0.45±0.03$^{A}$ | 0.42±0.03$^{B}$ | 0.46±0.03$^{A}$ | 0.44±0.03$^{AB}$ | 0.42±0.02$^{AB}$ |
| | 21 | 0.45±0.04 | 0.45±0.03 | 0.44±0.02 | 0.43±0.03 | 0.44±0.03 |
| | 28 | 0.45±0.04 | 0.46±0.03 | 0.43±0.02 | 0.44±0.03 | 0.43±0.02 |
| Gumminess (kg) | 0 | 0.42±0.03$^{Ad}$ | 0.39±0.03$^{ABc}$ | 0.37±0.02$^{Bc}$ | 0.34±0.02$^{Bc}$ | 0.30±0.03$^{Cc}$ |
| | 7 | 0.51±0.02$^{Ac}$ | 0.44±0.04$^{Bb}$ | 0.46±0.03$^{Bb}$ | 0.38±0.02$^{Cc}$ | 0.33±0.02$^{Cb}$ |
| | 14 | 0.52±0.03$^{Ac}$ | 0.55±0.03$^{Aa}$ | 0.45±0.03$^{Bb}$ | 0.42±0.04$^{Bb}$ | 0.39±0.02$^{Cb}$ |
| | 21 | 0.57±0.02$^{Ab}$ | 0.56±0.03$^{Aa}$ | 0.52±0.03$^{ABa}$ | 0.50±0.03$^{ABa}$ | 0.49±0.04$^{Bab}$ |
| | 28 | 0.60±0.05$^{Aa}$ | 0.58±0.02$^{ABa}$ | 0.55±0.02$^{Ba}$ | 0.52±0.04$^{Ba}$ | 0.50±0.03$^{Ba}$ |
| Chewiness (kg) | 0 | 0.38±0.02$^{Ad}$ | 0.36±0.03$^{ABc}$ | 0.33±0.02$^{Bd}$ | 0.30±0.02$^{Bd}$ | 0.28±0.03$^{Bd}$ |
| | 7 | 0.46±0.02$^{Ac}$ | 0.47±0.03$^{Ab}$ | 0.42±0.03$^{Bc}$ | 0.37±0.03$^{Cc}$ | 0.36±0.03$^{Cc}$ |
| | 14 | 0.53±0.03$^{Ab}$ | 0.55±0.03$^{Aa}$ | 0.45±0.03$^{Bc}$ | 0.39±0.04$^{Cc}$ | 0.38±0.03$^{Cc}$ |
| | 21 | 0.55±0.05$^{Aab}$ | 0.57±0.04$^{Aa}$ | 0.49±0.02$^{Bb}$ | 0.45±0.04$^{Cb}$ | 0.45±0.02$^{Cb}$ |
| | 28 | 0.58±0.05$^{Aa}$ | 0.60±0.05$^{Aa}$ | 0.57±0.04$^{ABa}$ | 0.55±0.03$^{Ba}$ | 0.49±0.03$^{Ca}$ |

All values are mean±SD of three replicates.
$^{A-C}$Means within a column with different letters are significantly different ($p$<0.05).
$^{a-d}$Means within a row with different letters are significantly different ($p$<0.05).
[1)]Treatments are the same as in Table 1.

**Changes in texture profile analysis of chicken meat patties during refrigerated storage**

Changes in textural properties of meat patties with lotus leaf powder-treated samples during refrigerated storage period are shown in Table 3. Generally, there were significant differences in textural attributes among all treated chicken patty samples with different amounts of added lotus leaf powder. Chicken meat patties with added lotus leaf powder showed lower values for hardness, gumminess, and chewiness than a control at 0 d. The springiness of meat patty samples was not significantly different among the control and samples with added lotus leaf powder at 0 d. Refrigerated storage consistently and significantly increased the hardness, gumminess, and chewiness of both the control and samples with added lotus leaf powder through 28 d. Increasing the lotus leaf powder levels from 1 to 3%, the hardness, gumminess, and chewiness of chicken meat patties were significantly decreased ($p<0.05$). However, the springiness of both the control and treated samples decreased during refrigerated storage. Similar trends in hardness were observed in studies by Verma *et al*. (1984) when different amounts of chickpea flour were added to sausage. Das *et al*. (2008) showed that addition of soy paste markedly decreased the hardness of goat meat nuggets. These results agree with Choi *et al*. (2007) who reported similar increased hardness for meat products during storage, and Hoe *et al*. (2006), who indicated similar textural properties for sausages with added tomato powder during storage at 15 d.

**Changes in sensory evaluations of chicken meat patties during refrigerated storage**

The sensory scores in chicken patties with lotus leaf powder stored for 0, 7, 14, 21, and 28 d are shown in Table 4. The chicken meat patties prepared from control and with added ascorbic acid treatment had the highest color scores among all the samples at 0 d ($p<0.05$), but the control and all treated samples did not significantly

**Table 4. Sensory properties of chicken patty with various levels of louts leaf powder during 28 d of storage at 4°C**

| Parameter | Storage periods (d) | Control | Treatments[1)] | | | |
|---|---|---|---|---|---|---|
| | | | TA | T1 | T2 | T3 |
| Color | 0 | $8.01±0.54^{Aa}$ | $8.06±0.68^{Aa}$ | $7.88±0.78^{Ba}$ | $7.79±0.45^{Ba}$ | $7.52±0.90^{Ba}$ |
| | 7 | $7.92±0.48^{a}$ | $7.95±0.48^{ab}$ | $7.75±0.72^{a}$ | $7.71±0.58^{a}$ | $7.50±0.66^{a}$ |
| | 14 | $7.59±0.65^{b}$ | $7.55±0.34^{b}$ | $7.70±0.67^{a}$ | $7.28±0.52^{ab}$ | $7.12±0.77^{ab}$ |
| | 21 | $7.42±0.55^{b}$ | $7.48±0.51^{b}$ | $7.52±0.64^{ab}$ | $7.18±0.36^{ab}$ | $7.08±0.62^{ab}$ |
| | 28 | $7.41±0.58^{b}$ | $7.46±0.64^{b}$ | $7.28±0.48^{b}$ | $7.01±0.85^{b}$ | $6.98±0.35^{b}$ |
| Flavor | 0 | $8.28±0.65^{a}$ | $8.15±0.68^{a}$ | $8.05±0.67^{a}$ | $8.04±0.82^{a}$ | $8.03±0.78^{a}$ |
| | 7 | $7.85±0.73^{ab}$ | $7.76±0.49^{b}$ | $7.87±0.43^{ab}$ | $7.54±0.76^{ab}$ | $7.49±0.82^{ab}$ |
| | 14 | $7.56±0.54^{ab}$ | $7.45±0.53^{b}$ | $7.45±0.56^{b}$ | $7.38±0.55^{ab}$ | $7.29±0.79^{ab}$ |
| | 21 | $7.13±0.39^{bc}$ | $6.78±0.75^{c}$ | $6.78±0.75^{c}$ | $6.77±0.79^{b}$ | $6.68±0.88^{b}$ |
| | 28 | $6.55±0.87^{c}$ | $6.48±0.58^{c}$ | $6.37±0.58^{c}$ | $6.29±0.68^{c}$ | $6.19±0.78^{c}$ |
| Tenderness | 0 | $8.27±0.78^{a}$ | $8.17±0.65^{a}$ | $8.09±0.85^{a}$ | $8.05±0.94^{a}$ | $8.00±0.85^{a}$ |
| | 7 | $7.79±0.93^{ab}$ | $7.87±0.66^{ab}$ | $7.75±0.74^{ab}$ | $7.57±0.82^{ab}$ | $7.43±0.81^{ab}$ |
| | 14 | $7.43±0.55^{bc}$ | $7.44±0.73^{bc}$ | $7.38±0.56^{ab}$ | $7.29±0.49^{b}$ | $7.27±0.65^{ab}$ |
| | 21 | $7.34±0.76^{c}$ | $7.24±0.85^{c}$ | $7.18±0.68^{ab}$ | $6.98±0.76^{c}$ | $7.00±0.52^{ab}$ |
| | 28 | $7.14±0.85^{c}$ | $6.91±0.72^{d}$ | $6.82±0.74^{b}$ | $6.79±0.98^{c}$ | $6.79±0.85^{b}$ |
| Juiciness | 0 | $8.57±1.13^{a}$ | $8.43±0.53^{a}$ | $8.71±0.76^{a}$ | $8.36±0.69^{a}$ | $8.05±0.38^{a}$ |
| | 7 | $7.57±0.79^{ab}$ | $8.14±0.38^{ab}$ | $7.86±0.87^{ab}$ | $7.86±0.69^{ab}$ | $8.00±0.82^{a}$ |
| | 14 | $7.29±0.86^{ab}$ | $7.57±0.76^{b}$ | $7.29±0.91^{ab}$ | $7.14±0.69^{b}$ | $7.57±0.53^{ab}$ |
| | 21 | $7.14±0.66^{ab}$ | $7.43±0.63^{bc}$ | $6.91±0.76^{b}$ | $7.00±0.58^{b}$ | $7.20±0.58^{b}$ |
| | 28 | $6.78±0.51^{b}$ | $6.71±0.76^{c}$ | $6.43±0.53^{c}$ | $6.57±0.53^{c}$ | $6.43±0.55^{c}$ |
| Overall acceptability | 0 | $8.43±0.82^{a}$ | $8.54±0.67^{a}$ | $8.37±0.85^{a}$ | $8.22±0.84^{a}$ | $8.18±0.87^{a}$ |
| | 7 | $8.04±0.69^{a}$ | $8.00±0.82^{a}$ | $8.01±0.85^{a}$ | $7.92±0.79^{ab}$ | $8.00±0.75^{a}$ |
| | 14 | $7.98±1.00^{ab}$ | $7.57±0.53^{ab}$ | $7.57±0.79^{ab}$ | $7.35±0.54^{b}$ | $7.57±0.79^{ab}$ |
| | 21 | $7.32±0.76^{bc}$ | $7.12±0.68^{bc}$ | $6.99±0.72^{b}$ | $6.45±0.69^{c}$ | $6.86±0.65^{bc}$ |
| | 28 | $6.96±0.49^{c}$ | $6.53±0.52^{c}$ | $6.29±0.49^{c}$ | $6.28±0.52^{d}$ | $6.29±0.63^{c}$ |

All values are mean±SD of three replicates.

[A, B]Means within a column with different letters are significantly different ($p<0.05$).

[a-c]Means within a row with different letters are significantly different ($p<0.05$).

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

differ during refrigerated storage. The flavor, tenderness, juiciness, and overall acceptability scores of treated chicken meat patties did not significantly differ from the control, after 0, 7, 14, 21 and 28 d. Sensory properties are the most important factor in the preparation of meat products and in consumer preference (Choi *et al*., 2008, 2010). Similar results were obtained by Park *et al*. (2009c) for quality characteristics of bread made with added lotus leaf powder, and Kim and Park (2008) for sensory properties of cookies prepared with lotus leaf powder.

Generally, sensory properties of foods with added lotus leaf can be a disadvantage with regard to color. However, Yoon and Noh (2009) reported quantitative descriptive analysis scores and preference test scores of lotus leaf *Dasik* (Korean style cake) with added lotus leaf powder showing that 6% lotus leaf powder levels had the greatest overall acceptability score. According to Shin (2007), among all treatments, the flavor, taste, texture, and overall acceptability score of fish paste containing lotus leaf powder were the greatest in samples treated with 0.5% lotus leaf powder. Since the color, flavor, tenderness, juiciness, and overall acceptability scores in the control and all treated samples decreased during refrigerated storage periods ($p<0.05$), all trait parameter scores were the lowest at 28 d. These results agree with Hoe *et al*. (2006), who reported similar sensory characteristics for low-fat emulsion sausage supplemented with tomatoes during refrigerated storage, and with Kim *et al*. (2008b), who evaluated pork patties containing silkworm powder during cold storage. Kim *et al*. (2008a) showed sensory properties of meat patties in freeze storage containing sweet persimmon powder were improved.

The chicken patty made with addition lotus leaf powder had significantly lower TBA and VBN values compared to controls during refrigerated storage. Chicken patties containing lotus leaf powder had similar sensory characteristics to control, except in color score. Thus, results of this study showed that added lotus leaf powder in chicken meat patty formulations can improve shelf-life during refrigerated storage. And the chicken meat patty with lotus leat powder showed sensory properties similar to control chicken meat patties.

## Acknowledgement

This research was supported (608001-05-2-SB310) by Rural Development Administration (Republic of Korea). The authors also were partially supported by the Brain Korean 21 (BK 21) Project from Ministry of Education and Human Resources Development (Republic of Korea).

## References

1. Ahmad, S. and Srivastava, P. K. (2007) Quality and shelf life evaluation of fermented sausages of buffalo meat with different levels of heart and fat. *Meat Sci*. **75**, 603-609.
2. Bourne, M. C. (1978) Texture profile analysis. *Food Technol*. **32**, 62-66.
3. Brannan, R. G. (2008) Effect of grape seed extract on physicochemical properties of ground, salted chicken thigh meat during refrigerated storage at different relative humidity levels. *Food Chem*. **73**, 36-38.
4. Brewer, M. S. and Wu, S. Y. (1993) Display packaging and meat block location effects on colour lipid oxidation on frozen lean ground beef. *J. Food Sci*. **58**, 1219-1223.
5. Chen, C. M. and Trout, G. R. (1991) Color and its stability in restructured beef steaks during frozen storage: Effects of various binders. *J. Food Sci*. **56**, 1461-1464, 1475.
6. Choe, J. H., Jang, A. R., Choi, J. H., Choi, Y. S., Han, D. J., Kim, H. Y., Lee, M. A., Kim, H. W., and Kim, C. J. (2010) Antioxidant activities of lotus leaves (*Nelumbo nucifera*) and barley leaves (*Hordeum vulgare*) extracts. *Food Sci. Biotechnol*. **19**, 831-836.
7. Choi, H. Y., Jung, K. H., and Shin, H. S. (2009) Antioxidant activity of the various extracts from different parts of lotus (*Nelumbo nucifera* Gaertner). *Food Sci. Biotechnol*. **81**, 1051-1054.
8. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Jeong, J. Y., Chung, H. J., and Kim, C. J. (2010) Effects of replacing pork back fat with vegetable oils and rice bran fiber on the quality of reduced-fat frankfurters. *Meat Sci*. **84**, 557-563.
9. Choi, Y. S., Choi, J. H., Han, D. J., Kim, H. Y., Lee, M. A., Kim, H. W., Jeong, J. Y., Paik, H. D., and Kim, C. J. (2008) Effect of adding levels of rice bran fiber on the quality characteristics of ground pork meat product. *Korean J. Food Sci. Ani. Resour*. **28**, 319-326.
10. Chouliara, E., Karatapanis, A., Savvaidis, I. N., and Kontominas, M. G. (2007) Combined effect of oregano essential oil and modified atmosphere packaging on shelf-life extension of fresh chicken breast meat, stored at 4°C. *Food Microbiol.* **24**, 607-617.
11. Das, A. K., Anjaneyulu, A. S. R., Gadekar, Y. P., Singh, R. P., and Pragati, H. (2008) Effect of full-fat soy paste and textured soy granules on quality and shelf-life of goat meat nuggets in frozen storage. *Meat Sci*. **80**, 607-614.
12. Fernandez-Lopez, J., Zhi, N., Aleson-Carbonell, L., Perez-Alvarez, J. A., and Kuri, V. (2005) Antioxidant and antibacterial activities of natural extracts: Application in beef meatballs. *Meat Sci*. **69**, 371-380.
13. Field, R. A. and Chang, Y. D. (1969) Free amino acids in bovine muscle and their relationship to tenderness. *J. Food Sci*. **34**, 329-331.

14. Greene, B. A. and Cumuze, T. H. (1982) Relationship between TBA numbers and inexperienced panelists. Assessments of oxidized flavour in cooked beef. *J. Food Sci*. **47**, 52-58.
15. Han, K. H., Choi, I. S., and Lee, C. H. (2006) The physicochemical and storage characteristics of sausage added *mugwort* powder. *Korean J. Food Sci. Ani. Resour.* **36**, 356-361.
16. Hernández-Hernández, E., Ponce-Alquicira, E., Jaramillo-Flores, M. E., and Legarreta, I. G. (2009) Antioxidant effect rosemary (*Rosmarinus officinalis* L.) and oregano (*Origanum vulgare* L.) extracts on TBARS and colour of model raw pork batters. *Meat Sci*. **81**, 410-417.
17. Hoe, S. K., Park, K. H., Yang, M. R., Jeong, K. J., Kim, D. H., Choi, J. S., Jin, S. K., and Kim, I. S. (2006) Quality characteristics of low-fat emulsified sausage containing tomatoes during cold storage. *Korean J. Food Sci. Ani. Resour*. **26**, 297-305.
18. Huang, B., Ban, X., He, J., Tong, J., Tian, J., and Wang, Y. (2010) Hepatoprotective and antioxidant activity of ethanolic extracts of edible lotus (*Nelumbo nucifera* Gaertn.) leaves. *Food Chem*. **120**, 873-878.
19. Jung, H. A., Jung, Y. J., Yoon, N. Y., Jeong, D. M., Bae, H. J., Kim, D. W., Na, D. H., and Choi, J. S. (2008) Inhibitory effects of *Nelumbo nucifera* leaves on rat lens aldose reductase, advanced glycation endproducts formation, and oxidative stress. *Food Chem Toxicol*. **46**, 3818-3826.
20. Jung, S., Choe, J. H., Kim, B., Yun, H., Kruk, Z. A., and Jo, C. (2010) Effect of dietary mixture of gallic acid and linoleic acid on autioxidative potential and quality of breast meat from broilers. *Meat Sci*. **86**, 520-526.
21. Kim, G. S. and Park, G. S. (2008) Quality characteristics of cookies prepared with lotus leaf powder. *Korean J. Food Cookery Sci*. **24**, 398-404.
22. Kim, I. S., Jin, S. K., and Ha, C. J. (2008a) Improved quality properties of low-fat meat patties containing sweet persimmon powder during freeze storage. *Korean J. Food Sci. Ani. Resour*. **28**, 113-121.
23. Kim, I. S., Jin, S. K., Jo, C. R., Lee, M. H., and Jang, A. R. (2008b) Quality characteristics of pork patties containing silkworm powder and vegetable worm (*Paecilomyces Japonica*) during cold storage. *Korean J. Food Sci. Ani. Resour*. **28**, 521-528.
24. Kim, S. B., Rho, S. B., Rhyu, D. Y., and Kim, D. W. (2005) Effect of *Nelumbo nucifera* leaves on hyperlipidemic and atherosclerotic bio F1B hamster. *Kor. J. Pharmacogn*. **36**, 229-234.
25. Kim, S. J., Choi, W. S., You, S. G., and Min, Y. S. (2007) Effect of glucomannan on quality and shelf-life of low-fat chicken patty. *Korean J. Food Sci. Technol*. **39**, 55-60.
26. Ko, B. S., Jun, D. W., Jang, J. S., Kim, J. H., and Park, S. M. (2006) Effect of Sasa borealis and white lotus roots and leaves on insulin action and secretion *in vitro*. *Korean J. Food Sci. Technol*. **38**, 114-120.
27. Kohsaka, K. (1975) Freshness preservation of food and measurement. *Food Ind*. **18**, 105-108.
28. Lee, K. S., Kim, M. G., and Lee, K. Y. (2006) Antioxidative activity of ethanol extract from lotus (*Nelumbo nucifera*) leaf. *J. Korean Soc. Food Sci. Nutr*. **35**, 182-186.
29. Lee, M. A., Choi, J. H., Choi, Y. S., Han, D. J., Kim, H. Y., Shim, S. Y., Chung, H. K., and Kim, C. J. (2010) The antioxidative properties of mustard leaf (*Brassica juncea*) *kimchi* extracts on refrigerated raw ground pork meat against lipid oxidation. *Meat Sci*. **84**, 498-504.
30. Liepe, H. U. and Probic, B. (1986) Composition and use of sugars in dry sausage manufacture. *Fleischwirtschaft* **66**, 401-402.
31. Lin, K. W. and Lin, S. N. (2002) Effects of sodium lactate and trisodium phosphate on the physicochemical properties and shelf life of low-fat Chinese-style sausage. *Meat Sci*. **60**, 147-154.
32. Mansour, E. H. and Khalil, A. H. (2000) Evaluation of antioxidant activity of some plant extracts and their application to ground beef patties. *Food Chem*. **69**, 135-141.
33. Melton, S. T. (1983) Methodology for following lipid oxidation in muscle foods. *Food Technol*. **37**, 105-116.
34. Na, A. N., Hong-bo, G. U. O., and Wei-dong, K. E. (2009) Genetic variation rhizome lotus (*Nelumbo nucifera* Gaertn. ssp. *nucifera*) germplasms from China assessed by RAPD markers. *Agr. Sci. China* **8**, 31-39.
35. Naveena, B. M., Sen, A. R., Kingsly, R. P., Singh, D. B., and Kondaiah, N. (2008) Antioxidant activity of pomegranate rind powder extract in cooked chicken patties. *Int. J. Food Sci. Technol*. **43**, 1807-1812.
36. Ono, Y., Hattori, E., Fukaya, Y., Imai, S., and Ohizumi, Y. (2006) Anti-obesity effect of *Nelumbo nucifera* leaves extract in mice and rats. *J. Ehtnopharmacol.* **106**, 238-244.
37. Park, B. H., Cho, H. S., Jeon, E. R., and Kim, S. D. (2009a) Quality characteristics of *Jook* prepared with lotus leaf powder. *Korean J. Food Cookery Sci*. **25**, 55-61.
38. Park, B. H., Cho, H. S., Jeon, E. R., Kim, S. D., and Koh, K. M. (2009b) Quality characteristics of soybean curd prepared with lotus leaf powder. *Korean J. Food Cult.* **24**, 315-320.
39. Park, C. H., Hur, J. M., Song, K. S., and Park, J. C. (2007) Phenolic compounds from the leaves of *Nelumbo nucifera* showing DPPH radical scavenging effect. *Kor. J. Pharmacogen*. **38**, 263-269.
40. Park, J. H. and Kim, C. S. (2007) Effect of paprika (*Capsicum annuum L.*) on inhibition of lipid oxidation in lard-pork model system during storage at 4°C. *Food Sci. Biotechnol.* **16,** 753-758.
41. Park, S. H., Chang, K. H., Byun, G. I., and Kang, W. W. (2009c) Quality characteristics of bread made with flour partly substituted by lotus leaf powder. *Korean J. Food Preserv.* **16**, 47-52.
42. Pearson, D. (1968) Assesment of meat freshness in quality control employing chemical techniques. A review. *J. Food Sci*. **19**, 357-363.
43. Rosmini, M. R., Perlo, F., Perez-Alvarez, J. A., Pagan-Moreno, M. J., Gago-Gago, A., Lopez-Santoveoa, F., and Aranda-Catalel, V. (1996) TBA test by an extractive method applied to 'paté'. *Meat Sci*. **42**, 103-110.
44. SAS (1999) SAS/STAT Software for PC. SAS Institute Inc.,

Cary, NC, USA.
45. Sayago-Ayerdi, S. G., Brenes, A., Viveros, A., and Goni, I. (2009) Antioxidative effect of dietary grape pomace concentrate on lipid oxidation of chilled and long-term frozen stored chicken patties. *Meat Sci*. **83**, 528-533.
46. Serrano, A., Cofrades, S., and Jimenez-Colmenero, F. (2006) Characteristics of restructured beef steak with different proportions of walnut during frozen storage. *Meat Sci*. **72**, 108-115.
47. Shikma, K. and Sugawara, Y. (1978) Antioxidation of native oxymyoglobin: Kinetics analysis of the pH-profile. *Eur. J. Biochem.* **91,** 407-413.
48. Shin, M. K. and Han, S. H. (2006) Effect of lotus (*Nelumbo nucifera*) leaf powder on lipid concentrations in rats fed high fat diet rats. *Korean J. Food Cult.* **21**, 202-208.
49. Shin, Y. J. (2007) Quality characteristics of fish paste containing lotus (*Nelumbo nucifera*) leaf powder. *Korean J. Food Cookery Sci*. **23**, 947-953.
50. Tarladgis, B. G., Watts, B. M., Younthan, M. T., and Dugan, L. R. (1960) A distillation method for the quantitative determination of malonaldehyde in rancid foods. *J. Am. Oil Chem. Soc.* **37**, 403-406.
51. Ulu, H. (2004) Evaluation of three 2-thiobarbituric acid methods for the measurement of lipid oxidation in various meat products. *Meat Sci*. **67**, 683-687.
52. Verma, M. M., Ledward, D. A., and Lawrie, R. A. (1984) Utilization of chick pea flour in sausages. *Meat Sci*. **11**, 109-121.
53. Yoon, S. J. and Noh, K. S. (2009) The effect of lotus leaf powder on the quality of *Dasik*. *Korean J. Food Cookery Sci*. **25**, 25-30.

(Received 2010.7.22/Revised 1st 2010.8.27, 2nd 2010.12.7/ Accepted 2010.12.8)