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ARTICLE

Antioxidant Properties of Lotus Leaf (*Nelumbo nucifera*) Powder and Barley Leaf (*Hordeum vulgare*) Powder in Raw Minced Pork during Chilled Storage

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Abstract

The effects of additions of lotus leaf (0.1 and 0.5%) and barley leaf powder (0.1 and 0.5%) on the lipid oxidation and microbiological analysis of raw minced pork were investigated after 1, 4, 7, and 10 d at chilled storage. Days of storage caused (p<0.05) decreases in pH values in samples with lotus leaf (LP) and barley leaf powder (BP). L* and a* values decreased, and b* values increased in the treatments with increasing lotus leaf and barley leaf powder contents, respectively. The decrease in a * values was lowest (p<0.05) in the treatment with 0.1% BP. Thiobarbituric acid reaction substance values and free fatty acids in 0.5% LP were lowest (p<0.05) on day 10. Thus, the addition of lotus leaf powder significantly improved lipid oxidative stability in the raw minced pork during chilled storage of 10 d. Furthermore, the raw minced pork treatments with LP and BP presented low peroxide values and total microbes as compared to control (-) (without LP and BP). These results indicate that LP and BP can be incorporated into raw minced pork as natural additives to retard oxidation.

Key words: lotus leaf, barley leaf, lipid oxidation, microbiological analysis, minced pork

Introduction

Minced pork has become an important food due to its convenience. Minced meat is markedly changed by exposing lipid membranes to metal ions. This process makes possible the generation of free radicals and propagation of oxidative reactions by interacting pro-oxidants and unsaturated fatty acids (Asghar *et al*., 1988). Oxidative reactions in meat during processing and storage result in deteriorations of color, sensory quality, and decreased shelf-life. Therefore, it is important for the meat food industry to inhibit lipid oxidation in minced meat.

Antioxidants that have oxidative stability and enhance the quality of meat can be classified into two groups: synthetic antioxidants and natural antioxidants (Huber *et al*., 1995). Synthetic antioxidants such as butylated hydroxytoluene (BHT), butylated hydroxylanisole (BHA), tert-butylhydroquinone (TBHQ), and propyl gallate have been used in raw and precooked meat products as strong oxidative inhibitors. However, negative health effects of synthetic antioxidants have decreased their use (Shahidi *et al*., 1992). For example, high concentrations of BHT can be toxic (De Oliveira *et al*., 2009). These negative effects of synthetic antioxidants have led to interest in natural antioxidants due to their safety (Han and Lee, 2005). Natural antioxidants obtained from natural sources such as seeds, rinds, leaves, nuts of plants, honey, fruits, and vegetables have been studied for their antioxidant activities in meat products (Devatkal and Naveena, 2010; Naveena *et al*., 2008). Several studies have documented the antioxidant effects of grape seed extracts in chicken thigh meat (Brannan, 2008), kinnow rind and pomegranate rind extracts in goat meat patties (Devatkal and Narsaiah, 2010), and green tea leaf extracts in turkey sausages (Bozkurt, 2006). In recent studies, Bastida *et al*. (2009) observed the antioxidant activities of carob fruit extracts in pork meats, and Ganhão *et al.* (2010) reported on antioxidant activities of fruit extracts in burger patties.

Plant extracts containing phenolic compounds retard lipid oxidation in meat products by radical scavenging and metal-chelating activities (Rice-Evans *et al*., 1996).

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Lotus (*Nelumbo nucifera*) leaf has antioxidant compounds such as phenolic acids and flavonoids (Choe *et al*., 2010). Several studies have reported on the antioxidant effects (Choe *et al*., 2010; Lee *et al*., 2006a) and antimicrobial activities (Lee *et al*., 2006b) of lotus leaf extracts. In addition, lotus leaf has been used as a functional food because of its various biologically active components (Lee *et al*., 2006). For example, lotus leaf powder was added to sulgitteok (Yoon, 2007) and fish paste (Shin, 2007).

Interest in the functionality of barley leaf, which contains the natural antioxidant enzyme superoxide dismutase (SOD), vitamin C, vitamin E, β-carotene, and flavonoids, has increased (Arimoto *et al.*, 2000). Lee *et al*. (1994) studied the antioxidant activity of barley leaf extract and Jang *et al*. (2007) reported that barley leaf tea had antioxidant effects due to high DPPH radical scavenging activity.

The objective of this study was to evaluate the effects of lotus leaf powder and barley leaf powder in raw minced pork during chilled storage (4±1°C) for 10 d.

Materials and Methods

Preparation of meat and samples

Fresh pork hams, weighing 6.5-7.0 kg each, were purchased from a pilot plant at Konkuk University, Korea at 48 h postmortem. The pork back fat was also collected from the slaughter house. All subcutaneous and intermuscular fat and visible connective tissues were removed from the fresh ham muscles.

The raw minced pork was prepared by the following formulation and process: 73.5% lean pork meat, 20% pork back fat, 5% ice, and 1.5% salt. The lean pork meat and pork back fat were ground through a 3 mm plate and then the ice and salt were added. The lotus leaf powder and hot-air-dried barley leaf powder was added at levels of 0% (Control (-), 0.1% (LP1 and BP1), and 0.5% (LP2 and BP2), and added 0.01% BHT (Control (+)). These percentages were based on the control formula weight. Samples were hand mixed for 10 min. Then, the raw minced pork meat was anaerobically packed in PE/nylon film bags and stored for maximum of 10 d at 4±1°C.

pH values

The pH values of samples were determined with a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland). The pH of the raw minced pork was measured after blending 5 g of sample with 20 mL of distilled water for 60 s in a homogenizer (Ultra-Turrax SK15, Janke & Kunkel, Germany).

Instrumental color evaluations

The instrumental color analyses of the raw pork patties were conducted as follows. The color measurements were taken with a colorimeter (Chroma meter CR-210, Minolta, Japan; illuminate C, calibrated with a white standard plate CIE L^* = 97.83, CIE a^* = -0.43, CIE b^* = +1.98), consisting of an 8 mm diameter measuring area and a 50 mm diameter illumination area. The color values (CIE L^*, a^*, and b^*) were measured on the sample surfaces and data were taken in triplicate for each sample.

Thiobarbituric acid reaction substance (TBARS) values

Lipid oxidation was assessed in triplicate by the 2-thiobarbituric acid (TBA) method of Tarladgis *et al*. (1960) with minor modifications. Fifty mL of distilled water was added to 10 g sample prior to homogenizing with a homogenizer (AM-7, Nihonseiki Kaisha Ltd., Japan) at 10,000 rpm for 2 min. The cup used for blending was washed with an additional 47.5 mL of distilled water, which was added to the same distillation 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 cooled to room temperature. The absorbance was measured at 538 nm, against a blank prepared with distilled water (5 mL) and TBA-reagent (5 mL), using a UV/VIS spectrophotometer (Libra S22, Biochrom Ltd., England). TBARS values were calculated by multiplying the absorbance by 73%, the recovery of the standard from meat, resulting in a K value of 7.8. The TBA values were calculated as mg malonaldehyde (MA)/kg sample.

TBA (mg MA/sample kg) = OD value × 7.8

Peroxide values (PV) and free fatty acids (FFA)

Lipids from the samples were extracted by the method of Folch (Floch *et al*., 1957) using the chloroform:methanol solvent system (2:1). The lipid extracts were evaporated and concentrated with a rotary evaporator (Rotary evaportater N-1000, EYELA, Japan). The peroxide val-

ues (PV) of the lipids extracted from the samples were determined by AOAC (1999), and calculated as follows: PV (meq/kg) = (S - B) × F × N × 1000/W [S, titration amount of sample; B, titration amount of blank; F, titer of 0.01 N sodium thiosulfate; N, normality of sodium thiosulfate; W, sample weight (g)]. The results are expressed as milliequivalent peroxide O_2/kg meat. The free fatty acids (FFA) values of the extracted lipids were determined by AOCS (1987), and calculated as follows: FFA (%) = (S − B) × N × 28.2/W [S, titration amount of sample; B, titration amount of blank; F, titer of 0.01N KOH; N, normality of KOH; W, sample weight (g)].

Microbiological analysis

A 5 g aliquot of each sample was aseptically transferred into a sterile stomacher bag at each respective sampling interval and 45 mL of sterile distilled water was added. The sample was then evenly mixed in the stomacher (Masticator-Paddle-Blender, IUL Instrument, Spain) for 2 min at normal speed and aliquots were plated out directly at 1:10 dilution in sterile distilled water. After serially diluting each sample in sterile distilled water, 0.1 mL portions were separately plated onto plates. The total bacterial count was determined on plate count agar (PCA, Difco, USA) at 35°C for 48 h. Microbial colonies were counted and expressed as $\log_{10}$ CFU/g pork meat.

Statistical analysis

Analysis of variance was performed on all the variables measured using the General Linear Model (GLM) procedure of the SAS statistical package (SAS Institute, Inc., 1999). Duncan's multiple range test ($p<0.05$) was used to determine the differences between treatment means.

Results and Discussion

pH evaluations

The evaluated pH values in the raw minced pork containing various powders and BHT are presented in Table 1. These values ranged from 5.52-5.70. The additions of the various powders resulted in increased pH on day 1 and 4. Furthermore, a dramatic decrease in pH ($p<0.05$) was observed on storage day 10 in the samples with LP and BP. However, pH values were not affected by storage time as reported by Park and Chin (2007). The pH values of control (+) increased during 10 d. McCarthy *et al.* (2001) demonstrated improvements in the pH values of pork patties with added BHA/BHT, ginseng, and rosemary, and Lo Fiego *et al.* (2004) demonstrated that levels of dietary vitamin C caused increases of pH values.

Instrumental color evaluations

Meat color relies on concentrations of myoglobin and hemoglobin, thus the chemical state of meat. Moreover, levels of added lean meat or fat can affect the color of meat products (Song *et al*., 2002). The color of meat products is an important criterion of judgment for consumer purchases. Georgantelis *et al*. (2007) found that meat color was affected by storage temperature, packing method, muscle type, and the color of additives. There were effects in terms of the color of the raw minced pork by the lotus leaf and barley leaf powders during 1, 4, and 7 d under chilled storage conditions (Table 2). The redness values of control (-) were highest during the 10 d. This agrees with the results of Choe *et al*. (2008) who found that the redness values of pork patties containing a medicinal herb extract mix were lower than those of a control, and Hayes *et al*. (2010) reported that raw minced

Table 1. Effects of lotus leaf and barley leaf powder on pH in raw minced pork during chilled storage for 10 d

Treatment[1)]	Storage time (d)			
	1	4	7	10
Control (-)	5.63±0.01^{Ba}	5.64±0.02^{Da}	5.65±0.01^{BCa}	5.65±0.01^{Ba}
LP1	5.64±0.05^{ABab}	5.67±0.01^{BCa}	5.61±0.02^{Dab}	5.52±0.03^{Db}
LP2	5.65±0.01^{ABa}	5.65±0.02^{CDa}	5.64±0.01^{Ca}	5.48±0.01^{Eb}
BP1	5.63±0.02^{Bb}	5.67±0.02^{Ba}	5.66±0.01^{Ba}	5.59±0.01^{Cc}
BP2	5.68±0.01^{Ab}	5.70±0.01^{Aa}	5.70±0.01^{Aa}	5.59±0.01^{Cc}
Control (+)	5.63±0.01^{Bb}	5.66±0.01^{CDa}	5.66±0.01^{Ba}	5.67±0.01^{Aa}

All values are mean±SD of three replicates.

$^{A-E}$Means within columns with different superscript letters are significantly different ($p<0.05$).

$^{a-c}$Means within rows with different superscript letters are significantly different ($p<0.05$).

[1)]Control (-), Raw minced pork without antioxidant powder; LP1, Raw minced pork with 0.1% lotus leaf powder; LP2, Raw minced pork with 0.5% lotus leaf powder; BP1, Raw minced pork with 0.1% barley leaf powder; BP2, Raw minced pork with 0.5% lotus leaf powder; Control (+), Raw minced pork with 0.01% BHT

Table 2. Effects of lotus leaf and barley leaf powder on instrument color in raw minced pork during chilled storage for 10 d

Treatment[1)]	CIE L^*_{day1}	CIE L^*_{day10}	CIE a^*_{day1}	CIE a^*_{day10}	CIE b^*_{day1}	CIE b^*_{day10}
Control (-)	61.23 ± 0.03^{ABa}	58.12 ± 0.98^{Cb}	13.28 ± 0.28^{Aa}	7.88 ± 0.25^{Ab}	13.61 ± 0.64^{Eb}	15.82 ± 0.16^{Da}
LP1	61.82 ± 0.89^{Aa}	59.51 ± 0.66^{Bb}	10.78 ± 0.86^{Ba}	6.31 ± 0.41^{Bb}	15.11 ± 0.26^{Db}	16.80 ± 0.34^{Ca}
LP2	58.62 ± 0.97^{Ca}	54.25 ± 0.69^{Eb}	6.89 ± 0.66^{Ca}	2.68 ± 0.74^{Db}	17.7 ± 0.22^{Bb}	18.97 ± 0.38^{Ba}
BP1	60.10 ± 0.61^{BCa}	58.07 ± 0.65^{Cb}	6.65 ± 0.08^{Ca}	3.98 ± 0.31^{Cb}	16.02 ± 0.11^{Cb}	17.61 ± 0.17^{Ba}
BP2	56.30 ± 0.80^{Da}	56.12 ± 0.56^{Db}	-1.49 ± 0.11^{Da}	-2.03 ± 0.20^{Eb}	20.3 ± 0.54^{Ab}	21.81 ± 0.08^{Aa}
Control (+)	60.30 ± 0.45^{ABa}	61.94 ± 0.89^{Ab}	11.27 ± 0.35^{Ba}	8.01 ± 0.26^{Ab}	13.41 ± 0.34^{Eb}	14.99 ± 0.18^{Ca}

All values are mean±SD of three replicates.
[A-E]Means within columns with different superscript letters are significantly different ($p<0.05$).
[a-b]Means within rows with different superscript letters are significantly different ($p<0.05$).
[1)]Control (-), Raw minced pork without antioxidant powder; LP1, Raw minced pork with 0.1% lotus leaf powder; LP2, Raw minced pork with 0.5% lotus leaf powder; BP1, Raw minced pork with 0.1% barley leaf powder; BP2, Raw minced pork with 0.5% lotus leaf powder; Control (+), Raw minced pork with 0.01% BHT

beef patties with added sesamol extracts had lower ($p<0.05$) a* values than a control. It was also found that meat samples with added BHT had their highest redness values at 1 and 4 d of storage (Prasetyo *et al*., 2008). The BP2 treatment had the lowest ($p<0.05$) redness values. Also, redness values were significantly lower with a longer storage period. Similarly, it was found that increasing storage time resulted in reduced redness of ground beef (Ismail *et al*., 2008). On the other hand, the treatment of lotus leaf and barley leaf powder appeared to delay discoloration according to a* values relative to control (-). This result indicates that lotus leaf and barley leaf powder may have antioxidant activity by reducing the formation of metmyoglobin.

Lightness significantly decreased ($p<0.05$) with increasing storage time in the raw ground pork except for control (+). Increases in LP and BP content resulted in decreases of L^* and a^* values and increases of b* values in the raw minced pork, respectively. However, previous work determined that L* values rose by adding colorfico to raw chicken patties (Castro *et al.*, 2011). Furthermore, the yellowness of fermented sausage was increased by the addition of hazelnut oil (Yildiz-Turp and Serdaroðlu, 2008).

TBARS values

TBARS values were determined by the production of malondialdehyde in combination with TBARS and detected at 538 nm. The TBARS values demonstrated effects of the lotus leaf and barley leaf powder in the raw minced pork during chilled storage for 10 d (Table 3). The TBARS values of the raw minced pork ranged from 0.16 to 0.60 mg MA/kg of meat. TBARS values significantly increased with increasing storage time. Sohn *et al.* (2009) found that lipid oxidation increased up to 7 d with increasing storage time in ground beef containing α-tocopherol. However, TBARS values were significantly decreased in both raw pork patties with green tea leaf extract and raw ground goat meat with added pomegran-

Table 3. Effects of lotus leaf and barley leaf powder on TBARS values (mg/MA/kg meat) in raw minced pork during chilled storage for 10 d

Treatment[1)]	Storage time (d)			
	1	4	7	10
Control (-)	0.25 ± 0.32^{Ad}	0.38 ± 0.12^{Ac}	0.51 ± 0.39^{Ab}	0.60 ± 0.29^{Aa}
LP1	0.18 ± 0.32^{Dd}	0.20 ± 0.40^{Dc}	0.20 ± 0.32^{Ec}	0.27 ± 0.12^{Eb}
LP2	0.16 ± 0.14^{Ed}	0.18 ± 0.67^{Ec}	0.21 ± 0.18^{Eb}	0.22 ± 0.23^{Fb}
BP1	0.22 ± 0.61^{Ce}	0.30 ± 0.12^{Bd}	0.33 ± 0.17^{Cc}	0.36 ± 0.52^{Cb}
BP2	0.24 ± 0.36^{Be}	0.31 ± 0.08^{Bd}	0.42 ± 0.32^{Bc}	0.43 ± 0.22^{Bc}
Control (+)	0.19 ± 0.27^{De}	0.23 ± 0.36^{Cd}	0.28 ± 0.06^{Dc}	0.31 ± 0.36^{Db}

All values are mean±SD of three replicates.
[A-F]Means within columns with different superscript letters are significantly different ($p<0.05$).
[a-e]Means within rows with different superscript letters are significantly different ($p<0.05$).
[1)]Control (-), Raw minced pork without antioxidant powder; LP1, Raw minced pork with 0.1% lotus leaf powder; LP2, Raw minced pork with 0.5% lotus leaf powder; BP1, Raw minced pork with 0.1% barley leaf powder; BP2, Raw minced pork with 0.5% lotus leaf powder; Control (+), Raw minced pork with 0.01% BHT

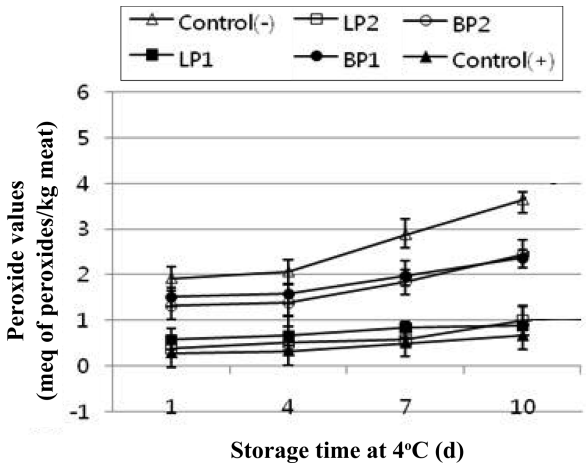

Fig. 1. Effects of lotus leaf and barley leaf powder on peroxide values (meq of peroxides/kg meat) of raw minced pork during chilled storage for 10 d. All values are mean±SD of three replicates.

ate seed powder (Devatkal and Naveena, 2010; Jo *et al*., 2003). In the present study, the TBARS values of control (-) were highest ($p<0.05$) while those of the treatments with LP were lowest ($p<0.05$) during the entire storage period. The treatments with LP resulted in decreased ($p<0.05$) TBARS values as compared to the treatments with BP. The raw minced pork containing added BP had lower TBARS compared to control (-) during storage. In the raw minced pork with LP, lipid oxidation inhibition activity was concentration-dependent, whereas lipid oxidation inhibition activity was not dependent on the concentration of BP in the raw minced pork. The results of this study indicate that the additions of lotus leaf and barley leaf powder had improved effects ($p<0.05$) in terms of inhibiting lipid oxidation in raw minced pork. Hernández-Hernández *et al*. (2009) used rosemary and oregano extracts in order to diminish lipid oxidation in raw pork batters. Greene and Cumuze (1982) found that a TBARS range of 0.6-2.0 mg/kg of meat induced off-flavor according to trained panelists.

PV

PV measure the concentration of hydroperoxides produced at early stages of oxidation. PV ranging from 20 to 40 meq/kg of meat have indicated rancidity of meat products (Economou *et al.*, 1991). The peroxide values of the raw minced pork containing lotus leaf or barley leaf powder are shown in Fig. 1. PV ranged from 0.28 to 3.64 meq of peroxides/kg of raw minced pork at chilled storage for 10 d. Georgantelis (2007) reported that beef burgers had POV of 0.24-2.69 meq of peroxides/kg of fat during 180 d of freezing storage. In the present study, increases in PV depended on increases in the storage time of raw minced pork. After 4 d of chilled storage, PV significantly increased. This may be due to the catalysis of intracellular compounds, in which cell structures were degraded by NaCl and processing. The treatments containing lotus leaf and barley leaf powder represented lower ($p<0.05$) PV than control (-) during the entire storage period. The greatest differences in PV values were found between control (-) and the LP1 raw minced pork, which had the best effect toward lipid oxidation on day 10. A similar consequence was previously shown in liver sausage without/with rosemary extract on day 3 at 4°C (Waszkowiak and Dolata, 2007). The reduction of PV in raw minced pork containing LP and BP may be due to the presence of a number of phenolic compounds.

FFA

FFA in the raw minced pork containing LP and BP ranged from 1.82 to 3.60%. FFA significantly ($p<0.05$) increased with increasing storage days in all treatments (Table 4). Kwak and Kang (2000) reported that free fatty acids increased in Korean beef during storage. Dempster *et al*. (1985) demonstrated that increased FFA resulted from the decomposition of triglycerides and phospholipids in meat products. These changes by action of tissue enzymes can cause quality deterioration of products. There were no significant differences in FFA among all treatments on days 1 and 4. However, the additions of LP and BP to the raw minced pork resulted in slightly lower FFA on day 1 and 4. The LP2 sample indicated antioxidants effectiveness by having the lowest FFA among the entire treatments.

Microbiological analysis

The microbiological analysis results of the raw minced pork containing LP and BP during 10 d of storage are shown in Table 5. No significant differences were found in total bacterial counts of all treatments, except LP2 on day 1. Allen and Cornforth (2010) reported that the total aerobic plate counts of ground beef patties without/with eugenol and rosmarinic acid were not significantly different. The additions of LP and BP to the raw minced pork significantly decreased ($p<0.05$) total bacterial counts after 4 d of storage compared to control (-). At storage day 10, LP1 and LP2 showed significantly inhibited ($p<0.05$) total bacterial counts by log 4.28 CFU/g and log 4.16 CFU/g, respectively, compared to control (-). Previous research has shown that a medicinal herb extract mix

Table 4. Effects of lotus leaf and barley leaf powder on FFA in raw minced pork during chilled storage for 10 d

Treatment[1)]	Storage time (d)			
	1	4	7	10
Control (-)	2.16±0.15^{Ad}	2.29±0.05^{Ac}	2.96±0.08^{Ab}	3.60±0.01^{Aa}
LP1	2.01±0.43^{ABc}	2.06±0.37^{ABbc}	2.41±0.01^{BCc}	2.95±0.04^{Ca}
LP2	1.82±0.20^{Bc}	1.93±0.20^{Bc}	2.25±0.02^{Cb}	2.45±0.02^{Ea}
BP1	2.09±0.20^{ABc}	2.22±0.15^{Ac}	2.58±0.30^{Bb}	2.90±0.16^{CDa}
BP2	2.05±0.03^{ABd}	2.30±0.05^{Ac}	2.88±0.14^{Ab}	3.13±0.20^{Ba}
Control (+)	2.03±0.08^{ABd}	2.20±0.08^{Ac}	2.41±0.19^{BCb}	2.78±0.13^{Da}

All values are mean±SD of three replicates.
$^{A-E}$Means within columns with different superscript letters are significantly different (p<0.05).
$^{a-d}$Means within rows with different superscript letters are significantly different (p<0.05).
[1)]Control (-), Raw minced pork without antioxidant powder; LP1, Raw minced pork with 0.1% lotus leaf powder; LP2, Raw minced pork with 0.5% lotus leaf powder; BP1, Raw minced pork with 0.1% barley leaf powder; BP2, Raw minced pork with 0.5% lotus leaf powder; Control (+), Raw minced pork with 0.01% BHT

Table 5. Effects of lotus leaf and barley leaf powder on total aerobic counts in raw minced pork during chilled storage for 10 d

Treatment[1)]	Storage time (d)			
	1	4	7	10
Control (-)	2.64±0.03^{Ad}	2.89±0.02^{Ac}	4.03±0.03^{Ab}	5.23±0.01^{Aa}
LP1	2.56±0.02^{ABc}	2.79±0.08^{Ab}	3.92±0.011^{Ca}	4.28±0.02^{Da}
LP2	1.89±0.21^{Bd}	2.41±0.01^{Cc}	3.78±0.050^{Db}	4.16±0.01^{Ea}
BP1	2.38±0.10^{Ad}	2.84±0.08^{Ac}	3.98±0.019^{Bb}	4.41±0.08^{Ca}
BP2	2.51±0.12^{Ad}	2.64±0.01^{Bc}	3.96±0.01^{Bb}	4.51±0.05^{Ba}
Control (+)	2.20±0.13^{ABd}	2.38±0.14^{Cc}	3.97±0.04^{Bb}	4.48±0.20^{BCa}

All values are mean±SD of three replicates.
$^{A-E}$Means within columns with different superscript letters are significantly different (p<0.05).
$^{a-d}$Means within rows with different superscript letters are significantly different (p<0.05).
[1)]Control (-), Raw minced pork without antioxidant powder; LP1, Raw minced pork with 0.1% lotus leaf powder; LP2, Raw minced pork with 0.5% lotus leaf powder; BP1, Raw minced pork with 0.1% barley leaf powder; BP2, Raw minced pork with 0.5% lotus leaf powder; Control (+), Raw minced pork with 0.01% BHT

(1%) inhibited microorganism growth in pork patties compared to a control according to a log 1 CFU/g difference at 10 d of chilled storage (Choe *et al*., 2008). The BP2 sample had higher inhibition activity of its microorganism counts than control (+), but the difference was not significant.

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