Food Sci. Biotechnol. Vol. 18, No. 5, pp. 1138 ~ 1144 (2009)

Food Science and Biotechnology

Effect of *Doenjang* (Korean Fermented Soybean Paste) on Lipid Oxidation and Cooking Properties of Pork Patties

Hyun-Ju Oh[1] and Chang-Soon Kim*

Department of Food and Nutrition, Changwon National University, Changwon, Gyeongnam 641-773, Korea

[1]Research Institute of Changnyeong Onion Products, Changnyeong, Gyeongnam 635-821, Korea

Abstract This study was carried out to investigate the cooking properties and lipid oxidation stability during storage at 4±1°C when the various levels (5 to 20%) of *doenjang* (Korean fermented soybean paste) were added to pork patties cooked by pan frying (PF) and convection oven (CO). With increasing the addition of *doenjang*, cooking properties of pork patties revealed the improved cooking yield, less diameter reduction, and less thickness increase. Also, the shear force, hardness, and chewiness of pork patties were reduced. The PF cooking method showed better cooking properties than CO. Lipid oxidation expressed by the thiobarbituric acid reactive substances (TBARS) values was significantly reduced by the addition of more than 5% *doenjang* (p<0.05). The TBARS values of cooked pork patties by PF were significantly lower than CO during the 8 days of the storage (p<0.05). The development of warmed-over flavor (WOF) in cooked pork patties was delayed as the amount of the *doenjang* was increased. It was suggested that the addition of *doenjang* and PF favorably affected the cooking properties and stability of lipid oxidation in pork patties.

Key words: pork patty, *doenjang* (Korean fermented soybean paste), cooking property, lipid oxidation, warmed-over flavor (WOF)

Introduction

Lipid oxidation that occurs during the process and storage of meat and meat products is the major cause of deterioration in flavor, color, texture, and nutrition. The processed meat products, especially in case of cooked meat, are much more susceptible to lipid oxidation than whole muscle. This low oxidative stability and the warmed-over flavor (WOF) development are largely due to incorporation of oxygen and release of heme catalysts and degradative enzymes as a result of cellular disruption during the grinding, mixing, and heating process (1-3). The peroxides, radicals, and carbonyl compounds formed by lipid oxidation are directly related to the loss of unsaturated fatty acids, fat soluble vitamins, pigments, and development of off-flavors to cause the quality reduction of meat products, and potentially become the cause of aging, carcinogenesis, and arthrosclerosis in humans (4). The lipid oxidation in pork progresses at a faster speed than in beef and mutton, because pork contains a large amount of unsaturated fatty acids compared with other meat (5).

The synthetic antioxidants, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole, and propyl gallate, have been used widely in suppressing the lipid oxidation of cooked meat by their economical advantages (6,7). However, their use recently comes into dispute due to suspected carcinogenic potentials and the general rejection of synthetic food additives by consumers. Therefore, there is a growing interest in the use of naturally occurring antioxidants such as tocopherol, ascorbic acid, β-carotene, and lecithin. Although the attentions have been given recently for the use of edible plants, especially the herbs including spices (galangal, garlic, and ginger), green tea, rosemary, and sage (6-9), there are many difficulties in the actual application of these substances due to their strong flavor, bitterness, and peculiar color (7). Also, the whey and soy protein hydrolysate (SPH) and peptide such as carnosine have been known to act as natural antioxidants in cooked meats (10,11).

Doenjang (Korean fermented soybean paste) is an important fermented food in Korea. *Doenjang* has been traditionally manufactured from *meju*, which is a fermented block of crushed cooked soybeans. The primary microorganisms involved in *meju* fermentation are *Bacillus subtilis* and molds such *Rizopus*, *Mucor*, and *Aspergillus* species (12).

Oh and Kim (13) reported that the methanol extracts of *doenjang* showed better antioxidant effect than BHT and green tea extracts at the same concentration in the linoleic acid system. Even though Cheigh *et al*. (14) reported the antioxidant effect of *doenjang* in the lipid tissues of beef and fish meat model systems, the usage amount of *doenjang* was 50-100% of the meat. Considering the sensory aspect of the foods, the use of *doenjang* is too high to be applied onto the actual development of pork products.

If non-meat proteins, such as soybean powder, textured soy protein, concentrated soy protein, and isolated soy protein (ISP), are used in the manufacture of sausage (15,16) and pork patty (10), several researchers have reported the improvement of the colloidal properties including water binding capacity, emulsifying activity, and gel forming property which increase the binding capacity of the product to reduce cooking loss and to improve the textural properties of elasticity and tenderness of the products.

*Corresponding author: Tel: +82-55-213-3512; Fax: +82-55-281-7480
E-mail: cskim@changwon.ac.kr
Received February 16, 2009; Revised June 1, 2009; Accepted July 3, 2009

Therefore, the objective of this study was to investigate the cooking properties and lipid oxidation stability during storage at 4±1°C when the various levels (5 to 20%) of *doenjang* were added to pork patties cooked by pan frying (PF) and convection oven (CO).

Materials and Methods

Samples and proximate analysis The fore-shank portion of individual porks was purchased at 24 hr post slaughter from a local supplier. The pork was trimmed of visible fat and was double minced through a 6.9-mm plate in a meat chopper (Model 12-S; Hankook Fujee Industries, Suwon, Korea). The minced pork was stored in polyethylene bags at −80±1°C until further analyses, and thawed at 4±1°C for 24 hr as it is needed. Traditional *doenjang* ripened for 5 months was provided by the Alali Food Company (Daegu, Korea) and used while storing it at −25±1°C after grinding for homogenization in a mixer (Rondo 2500; Tefal, Burgundy, France). Proximate analysis of *doenjang* and pork patties was measured according to the AOAC Official Method (17). The salt concentration of *doenjang* was measured using a salinity meter (TM-30D; Takemura Electric Works, Tokyo, Japan). Proximate compositions of *doenjang* were 47.7% water, 13.9% crude protein, 7.5% crude lipid, 18.3% crude ash, 13.5% salt, and 19.0°Bx.

Preparation of pork patties On the basis of the result of a preliminary experiment, the use of *doenjang* in the preparation of pork patties were adjusted to 5, 10, 15, and 20% of the ground pork (21.0% fat) weight, and the amount of moisture and salt in all treatments were adjusted to maintain the same moisture (67.0%) and salinity (2.0%) in no-*doenjang* treatment (control). For the preparation of pork patties, a certain amount of ground pork was mixed with *doenjang*, salt, and water for 2 min using food processor. The pork patties (approximately 50 g each) were shaped manually in a petri dish (8.5 cm diameter×0.6 cm thickness).

Cooking methods Pan frying (PF); pork patties were cooked for a total of 8 min (1 min each side) to an internal temperature of 75±5°C by using a probe-type thermometer (SK-1250MClla; SATO, Tokyo, Japan) on the frying pan (30 cm diameter, Initiatives, Tefal, Seoul, Korea) preheated to 180°C of surface temperature in a gas range (RGR-R2; Rinnai, Seoul, Korea). Convection oven (CO); samples were placed on tray and cooked at 190°C for 10 min to an internal temperature of 75±5°C by using a probe-type thermometer (SK-1250MClla; SATO) in a preheated convection oven (HEC-404; Hobart, MI, USA). After 30 min cooling at a room temperature, pork patties were overwrapped in a pouch made of oxygen permeable (52.6 $mL/m^2 \cdot 24$ hr) nylon film, and then stored at 4±1°C for 8 days to measure pH, thiobarbituric acid reactive substances (TBARS), and warmed-over flavor (WOF) every 2 day of storage.

Cooking properties After 10 min cooling at a room temperature, the cooking loss, diameter reduction, and thickness increase of cooked patties were calculated by the following equations.

Cooking loss (%)=[{weight of uncooked patty (g)−weight of cooked patty (g)}/weight of uncooked patty (g)]×100

Diameter reduction (%)=[{diameter of uncooked patty (cm)−diameter of cooked patty (cm)}/diameter of uncooked patty (cm)]×100

Thickness increase (%)=[{thickness of cooked patty (cm)−thickness of uncooked patty (cm)}/thickness of uncooked patty (cm)]×100

Measurement of texture After 30 min cooling at room temperature of cooked patties, the Warner Bratzler shear test and texture profile analysis (TPA) were carried out on a texture analyzer (TA-XT2; Stable Micro Systems, Godalming, Surrey, England). Shear force of cooked patties (5.0×5.0 cm) was estimated with a Warner Bratzler blade attached to the texture analyzer. The cross-head speed was 2.0 mm/sec. Maximum power (shear force) required to cut the cooked patty was recorded. The TPA was performed using central cores of 5 pieces of each sample (2.5×2.5 cm), which were compressed twice to 70% of the original height using a plexigrass cylinder probe (P/25L). A cross-head speed of 1.0 mm/sec was used. The following parameters were determined: hardness, springiness, cohesiveness, and chewiness.

Measurement of color Surface color of cooked pork patties was measured using a Minolta colormeter (CM-3500d; Minolta, Tokyo, Japan) and expressed as the L* (lightness), a* (redness), b* (yellowness), and ΔE- (color difference) values of the Hunter color system.

Measurement of pH The pH of pork patties was measured using a pH-meter (Mettler Delta 320; Mettler-Toledo, Columbus, OH, USA) after being mixed with 5 g of sample and 45 mL of distilled water and being homogenized for a min at 26,000×g using the homogenizer (Ultra-Turrax; Ika Werke, Staufen, Germany).

Measurement of lipid oxidation Fat was extracted by using the Folch *et al.* (18) method. Lipid oxidation was measured by the 2-thiobarbituric acid distillation method (19), and expressed as mg of malonaldehyde (MAD)/kg meat.

Determination of warmed-over flavor (WOF) To evaluate the time of WOF development at the cooked pork patties (PF and CO) during the storage at 4±1°C, the samples were collected every 2 day of storage. Unstored fresh pork patties and cooked pork patties at each evaluation were set as the reference, and then the difference of WOF between the stored sample and the reference were evaluated by using the 7-point scale (0, equal to control; 3, beginning to lose acceptability; 6, unacceptable). A trained 10 university students were selected as a sensory panel, and each patty was uniformly cut into 8 pie-shipped wedges for WOF evaluation. Samples were placed in covered glass cup, and then reheated in a microwave oven for 1 min prior to serving. Panelists were presented with 4 samples coded with 3-digit numbers according to a randomized balanced incomplete block design.

Table 1. Color values of cooked pork patties treated with *doenjang* using different cooking methods

Doenjang (%)	Cooking method[1)]	Hunter color value[2)]			
		L*	a*	b*	ΔE
0	PF	63.7±0.14[a3)]	1.2±0.39[i]	17.5±0.48[e]	36.6±0.14[j]
	CO	62.8±0.06[b]	1.5±0.06[h]	17.1±0.12[f]	38.3±0.04[i]
5	PF	58.9±0.21[c]	4.0±0.10[g]	18.2±0.18[c]	42.4±0.11[h]
	CO	56.5±0.24[e]	4.7±0.26[f]	17.9±0.26[d]	44.5±0.35[f]
10	PF	57.2±0.26[d]	5.0±0.19[e]	18.2±0.35[c]	44.1±0.07[g]
	CO	53.3±0.20[h]	5.7±0.29[c]	19.0±0.31[b]	47.9±0.14[c]
15	PF	55.4±0.02[f]	5.1±0.08[e]	19.1±0.12[ab]	46.0±0.07[e]
	CO	53.2±0.16[h]	6.1±0.37[b]	19.3±0.38[ab]	48.2±0.15[b]
20	PF	54.5±0.06[g]	5.3±0.04[d]	19.1±0.05[ab]	46.9±0.04[d]
	CO	52.1±0.07[i]	6.5±0.01[a]	19.3±0.08[a]	49.2±0.03[a]

1)PF=pan frying; CO=convection oven.
2)L*=lightness; a*=redness; b*=yellowness; $\Delta E=\sqrt{\Delta L^2+\Delta a^2+\Delta b^2}$, color difference.
3)Different letters (a-i) within a column are significantly different (p<0.05, n=5).

Statistical analysis All data were analyzed with analysis of variance (ANOVA) using SPSS 12.0 statistical program and the level of significance among samples was tested at p<0.05 with Duncan's multiple range test. Pearson's correlation coefficient was performed to evaluate any relationship between the TBARS value and WOF.

Results and Discussion

Cooking properties of pork patties The Hunter color values of pork patties cooked by 2 different methods (PF and CO) are shown in Table 1. The pork patties cooked by the CO showed lower L* values than those cooked by the PF, while the a*, b*, and ΔE-value were higher. This showed that the CO turned out to be a darker, more surface browning of patties than the PF. As the amount of added *doenjang* increased, the pork patties became darker due to the original brown color of *doenjang* (12).

As shown in Table 2, the moisture content of uncooked pork patties was 67.0% in all treatments, but the fat content significantly decreased as the amount of *doenjang* increased from 0 to 20% (p<0.05). It was due to the low fat content of 7.5% in *doenjang* compared to the 21.0% of that in pork. However, the moisture and fat contents were increased as the amount of the *doenjang* was increased in both cooking treatment. It was due to decrease of cooking loss in *doenjang* added patties. As shown in Table 3, both of cooking methods revealed significant reduction of cooking loss, less diameter reduction, and less thickness increase in *doenjang* added patties indicating the improvement of cooking properties. Our results are in good agreement with the reports of Lee *et al*. (20) who reported the decrease of cooking loss by the addition of ISP on pork patty. Pena-Ramos *et al.* (10) reported the increase of polar amino groups and carboxyl groups through the exposure of peptides in the SPH added pork patties improved the cooking yield by the induction of protein-water binding interactions. Claus and Hunt (21) reported the increase of moisture separation was resulted from the fat separation inside of meat batters. Therefore, various emulsifying substances, such as soy protein, SPH, lecithin, and soy fiber, in *doenjang* (22) must have contributed to increasing the viscosity of pork tissues through the well-binding of water, protein, and fat component, and stabilized the batters to improve the cooking yield by the reduction of dripping during the gelling process at the time of heating (23,24). The cooking loss in PF was lower than CO.

As shown in Table 4, the shear force in PF was lower than CO, and both treatments revealed the significant reduction of shear force with increasing the amount of *doenjang* (p<0.05). This similar tendency was found in the hardness and the chewiness. This might be explained by the presence of SPH rather than soy protein in *doenjang* (12,22) and by increasing the binding capacity and the

Table 2. Moisture and fat contents of uncooked and cooked pork patties treated with *doenjang* using different cooking methods

Doenjang (%)	Cooking method[1)]	Moisture (%)	Fat (%)
0	Uncooked	67.0±0.05[a2)]	19.6±0.04[a]
	PF	55.9±0.23[f]	12.5±0.08[j]
	CO	54.0±0.16[h]	11.8±0.04[l]
5	Uncooked	67.0±0.05[a]	19.4±0.05[b]
	PF	56.8±0.19[e]	13.0±0.04[i]
	CO	54.3±0.23[h]	12.0±0.09[k]
10	Uncooked	67.0±0.05[a]	19.1±0.03[c]
	PF	58.3±0.32[d]	13.8±0.08[h]
	CO	55.0±0.40[g]	12.5±0.06[j]
15	Uncooked	67.0±0.05[a]	18.8±0.04[d]
	PF	60.6±0.42[c]	15.0±0.04[g]
	CO	56.4±0.20[e]	13.1±0.05[i]
20	Uncooked	67.0±0.05[a]	18.6±0.05[e]
	PF	62.4±0.49[b]	16.0±0.05[f]
	CO	58.1±0.06[d]	13.8±0.08[h]

1)PF=pan frying; CO=convection oven.
2)Different letters (a-h) within a column are significantly different (p<0.05, n=3).

Table 3. Cooking properties of cooked pork patties treated with *doenjang* using different cooking methods

Doenjang (%)	Cooking method[1)]	Cooking loss (%)	Diameter reduction (%)	Thickness increase (%)
0	PF	23.9±1.23[c2)]	16.5±1.18[de]	26.7±9.13[ab]
	CO	28.3±1.33[a]	21.9±1.58[a]	30.0±7.45[a]
5	PF	22.4±0.31[d]	14.8±1.05[e]	23.3±9.13[abc]
	CO	26.4±0.24[b]	19.9±1.30[b]	27.3±8.30[ab]
10	PF	19.8±0.44[f]	12.5±0.65[f]	19.0±3.65[bcd]
	CO	24.5±1.08[c]	18.4±1.58[bc]	22.7±8.30[abc]
15	PF	17.1±0.72[g]	11.3±0.64[f]	17.0±1.83[cd]
	CO	22.3±0.65[d]	17.2±1.34[cd]	20.0±3.53[bcd]
20	PF	10.0±0.31[h]	9.9±1.78[g]	12.3±4.19[d]
	CO	21.0±0.73[e]	15.3±1.44[e]	13.3±4.57[d]

[1)]PF=pan frying; CO=convection oven.
[2)]Different letters (a-h) within a column are significantly different (p<0.05, n=5).

Table 4. Texture properties of cooked pork patties treated with *doenjang* using different cooking methods

Doenjang (%)	Cooking method[1)]	Shear force (kg)	Hardness (g)	Springiness	Cohesiveness	Chewiness (g)
0	PF	3.10±0.06[b2)]	846±16.8[c]	0.91±0.01[ef]	0.50±0.01[c]	385±5.51[b]
	CO	3.25±0.04[a]	907±24.1[a]	0.89±0.02[f]	0.50±0.01[c]	409±20.6[a]
5	PF	2.97±0.05[c]	806±12.8[de]	0.92±0.01[bcd]	0.51±0.01[bc]	380±5.03[b]
	CO	3.04±0.05[b]	874±19.6[b]	0.91±0.01[ef]	0.51±0.01[bc]	407±11.0[a]
10	PF	2.64±0.02[e]	783±12.5[ef]	0.94±0.01[bc]	0.52±0.01[bc]	379±16.3[b]
	CO	2.76±0.01[d]	831±10.5[cd]	0.92±0.01[de]	0.52±0.01[bc]	393±6.0[ab]
15	PF	2.33±0.06[g]	771±10.8[f]	0.95±0.01[ab]	0.52±0.01[b]	379±10.8[b]
	CO	2.44±0.02[f]	811±11.6[d]	0.92±0.01[de]	0.52±0.01[ab]	392±5.7[ab]
20	PF	2.01±0.01[i]	731±10.1[g]	0.96±0.01[a]	0.53±0.01[a]	375±11.1[b]
	CO	2.15±0.01[h]	783±11.3[ef]	0.93±0.01[bcd]	0.53±0.01[a]	390±4.6[ab]

[1)]PF=pan frying; CO=convection oven.
[2)]Different letters (a-i) within a column are significantly different (p<0.05, n=3).

emulsifying capacity in pork patties by the digestion of muscular protein through the activation of protease present in *doenjang* (25). Unlike our study, Lee *et al.* (20) reported the increase of hardness, gumminess, and chewiness when ISP was added to the meat products. In case of CO, its relatively longer cooking time compared to PF might cause the increase of shear force, hardness, and chewiness with the increase of cooking loss, diameter reduction, and thickness increase of the patties due to the more release of moisture and fat (26).

pH The pH changes in uncooked and cooked pork patties during storage at 4±1°C are shown in Fig. 1. The pH values of cooked pork patties were higher than those of uncooked pork patties (p<0.05). According to Fogg and Harrison (27), this phenomenon is attributed to the exposure of the basic activation groups of imidazolium such as histidine produced by the denaturation of myofibrillar proteins during the cooking. The pH was higher in *doenjang* treatments than control (0% of *doenjang*) (p<0.05). The pH values of *doenjang* and fresh control meat were 5.76 and 6.07, respectively. The addition of *doenjang* into fresh meat increased the pH of meat probably due to proteinous hydrolysates including peptides and basic amino acids formed by the action of protease present in *doenjang* (28).

TBARS value The changes of TBARS values of uncooked and cooked pork patties during 8 days of refrigeration storage at 4±1°C are shown in Table 5. During the grinding and mixing processes for the patty preparation, incorporation of oxygen, release of free irons, and the addition of salt and water catalyzed lipid oxidation (1). At day 0, the TBARS values of the control were significantly higher than those of the pork patties treated with the *doenjang*, and rapidly increased throughout the storage period (p<0.05). The rate of increase in the TBARS values was reduced significantly with the increase of *doenjang* addition (p<0.05). The pork patties cooked by PF and CO maintained higher TBARS values than the uncooked pork patties. In addition, the TBARS values of the CO were higher than those of PF (p<0.05) although the fat contents of PF were higher than those of CO. In case of the CO treatments, more cooking loss was due to the longer cooking time. This must have stimulated the oxidation by the concentration increase of free irons. Therefore, the lipid oxidation increased (2,29). Tarladgis *et al.* (19) suggested higher than 0.5-1.0 MAD mg/kg meat of TBARS values

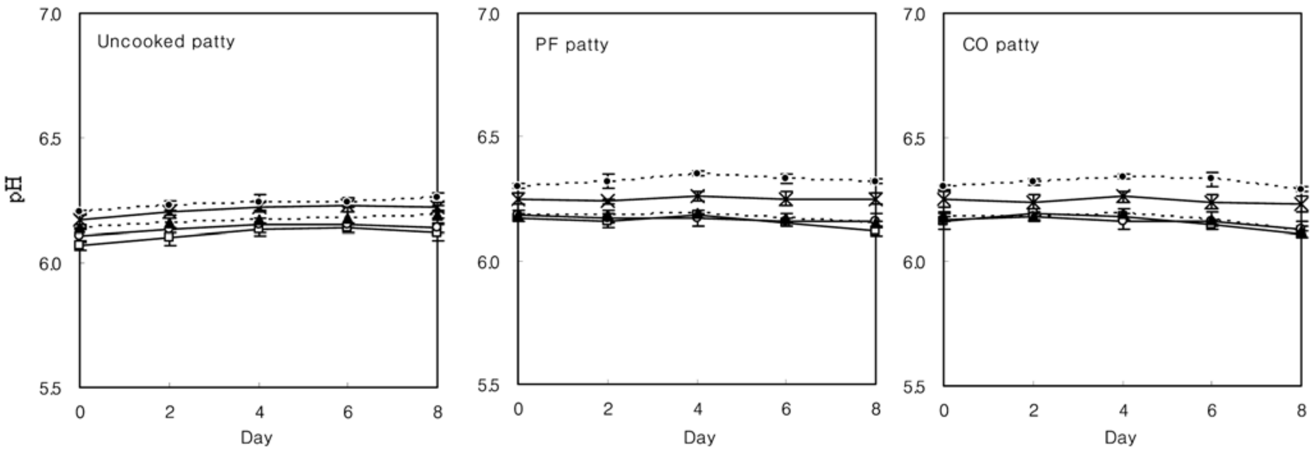

Fig. 1. Changes in pH of uncooked and cooked pork patties treated with *doenjang* using different cooking methods during storage at 4±1°C. PF=pan frying; CO=convection oven. -□- control, -○- *doenjang* 5%, ···▲··· *doenjang* 10%, -×- *doenjang* 15%, ···●··· *doenjang* 20%. Values are mean±SD, *n*=3.

was the threshold values for rancidity perception by consumers. In uncooked pork patties, TBARS value of the control (0% of *doenjang*) were 0.56±0.007 MAD mg/kg at day 2 of the storage, and that of 5% *doenjang*-treated sample was 0.46±0.007 MAD mg/kg at day 8. Thus, the lipid oxidation in 5% of *doenjang* was delayed up to about 6 days compared with control. The addition of more than 10% of *doenjang* didn't show visible increase of TBARS values even by day 8 of the storage. The TBARS values of control in PF and CO were 0.66±0.007 and 0.79±0.002 MAD mg/kg on day 2, respectively. The TBARS values of 5% of *doenjang* in PF and CO were 0.60±0.008 and 0.63±0.007 MAD mg/kg in the 8th day of the storage, respectively. As in the case of uncooked pork patties, the lipid oxidation of cooked patties were delayed up to about 6 days by the addition of 5% of *doenjang*, and the addition of *doenjang* more than 10% resulted in very slow increase of TBARS values. This means that the addition of *doenjang* is very effective in delaying lipid oxidation of both uncooked and cooked pork patties. The lipid oxidation in pork patties is thought to be suppressed not only by the antioxidative products in soybean itself, but also by the increased Maillard reaction products (MRPs), amino acids, peptides, and isoflavones in aglycogne through the fermentation procedure of *doenjang* (12,13).

WOF The changes of the WOF development in pork patties during storage are shown in Table 6. The loss of acceptability of cooked pork patties without *doenjang* started to develop on the 4th day of the storage in control,

Table 5. Changes in thiobarbituric acid reactive substance (TBARS) values of uncooked and cooked pork patties treated with *doenjang* using different cooking methods during storage at 4±1°C (MAD mg/kg)

Doenjang (%)	Cooking method[1)]	Storage period (day)				
		0	2	4	6	8
0	Uncooked	$^{C2)}$0.31±0.005$^{e3)}$	^{C}0.56±0.007^{d}	^{C}0.80±0.008^{c}	^{C}1.15±0.005^{b}	^{C}1.57±0.012^{a}
	PF	^{B}0.37±0.003^{e}	^{B}0.66±0.007^{d}	^{B}0.92±0.003^{c}	^{B}1.29±0.009^{b}	^{B}1.80±0.003^{a}
	CO	^{A}0.44±0.030^{e}	^{A}0.79±0.002^{d}	^{A}1.13±0.005^{c}	^{A}1.45±0.027^{b}	^{A}1.91±0.010^{a}
5	Uncooked	^{F}0.17±0.004^{e}	^{F}0.23±0.003^{d}	^{F}0.33±0.004^{c}	^{F}0.40±0.006^{b}	^{F}0.46±0.007^{a}
	PF	^{E}0.21±0.005^{e}	^{E}0.31±0.011^{d}	^{E}0.44±0.010^{c}	^{E}0.54±0.001^{b}	^{E}0.60±0.008^{a}
	CO	^{D}0.24±0.006^{e}	^{D}0.35±0.003^{d}	^{D}0.48±0.008^{c}	^{D}0.56±0.009^{b}	^{D}0.63±0.007^{a}
10	Uncooked	^{J}0.09±0.004^{e}	^{IJ}0.14±0.002^{d}	^{J}0.15±0.002^{c}	^{J}0.20±0.002^{b}	^{I}0.26±0.004^{a}
	PF	^{GH}0.12±0.002^{e}	^{H}0.15±0.001^{d}	^{H}0.19±0.004^{c}	^{H}0.25±0.004^{b}	^{H}0.31±0.002^{a}
	CO	^{G}0.14±0.007^{e}	^{G}0.18±0.004^{d}	^{G}0.23±0.010^{c}	^{G}0.27±0.001^{b}	^{G}0.33±0.009^{a}
15	Uncooked	^{J}0.09±0.003^{d}	^{M}0.09±0.005^{cd}	^{L}0.10±0.003^{c}	^{K}0.17±0.001^{b}	^{K}0.21±0.008^{a}
	PF	^{HI}0.11±0.003^{d}	^{K}0.12±0.004^{d}	^{I}0.16±0.002^{c}	^{J}0.20±0.006^{b}	^{J}0.23±0.004^{a}
	CO	^{G}0.13±0.004^{d}	^{I}0.14±0.005^{d}	^{H}0.18±0.005^{c}	^{I}0.21±0.005^{b}	^{I}0.25±0.007^{a}
20	Uncooked	^{J}0.08±0.002^{d}	^{M}0.09±0.003^{c}	^{L}0.09±0.005^{c}	^{L}0.14±0.001^{b}	^{M}0.16±0.004^{a}
	PF	^{IJ}0.10±0.004^{e}	^{L}0.11±0.003^{d}	^{K}0.13±0.003^{c}	^{K}0.16±0.002^{b}	^{L}0.19±0.001^{a}
	CO	^{GH}0.12±0.001^{e}	^{J}0.13±0.003^{d}	^{J}0.15±0.005^{c}	^{K}0.18±0.008^{b}	^{J}0.22±0.006^{a}

[1)]PF=pan frying; CO=convection oven.
[2)]Different letters (A-J) within a column are significantly different (p<0.05, n=3).
[3)]Different letters (a-d) within a row are significantly different (p<0.05, n=3).

Table 6. Sensory scores[1)] (difference from day 0 sample) for warmed-over flavor of cooked pork patties treated with *doenjang* using different cooking methods during storage at 4±1°C

Doenjang (%)	Cooking method[2)]	Storage period (day)			
		2	4	6	8
0	PF	$^{AB3)}1.9\pm0.74^{c4)}$	$^{A}3.8\pm0.79^{b}$	$^{A}5.3\pm0.82^{a}$	$^{A}5.8\pm0.42^{a}$
	CO	$^{A}2.2\pm0.63^{c}$	$^{A}3.9\pm0.88^{b}$	$^{A}5.2\pm0.92^{a}$	$^{A}5.7\pm0.48^{a}$
5	PF	$^{BC}1.5\pm0.53^{d}$	$^{B}2.7\pm0.82^{c}$	$^{B}3.7\pm0.82^{b}$	$^{B}4.6\pm0.97^{a}$
	CO	$^{AB}1.8\pm0.63^{d}$	$^{B}2.8\pm0.79^{c}$	$^{B}3.7\pm0.82^{b}$	$^{B}5.0\pm0.82^{a}$
10	PF	$^{AB}1.3\pm0.78^{b}$	$^{C}1.7\pm0.82^{b}$	$^{C}2.7\pm0.48^{a}$	$^{E}2.8\pm0.63^{a}$
	CO	$^{BC}1.6\pm0.52^{c}$	$^{C}1.8\pm0.79^{c}$	$^{C}2.9\pm0.74^{b}$	$^{C}3.6\pm0.70^{a}$
15	PF	$^{CD}1.0\pm0.67^{c}$	$^{C}1.9\pm0.74^{b}$	$^{CD}2.3\pm0.67^{ab}$	$^{E}2.6\pm0.70^{a}$
	CO	$^{BC}1.5\pm0.53^{c}$	$^{BC}2.1\pm0.99^{bc}$	$^{CD}2.5\pm0.53^{ab}$	$^{CD}3.1\pm0.99^{a}$
20	PF	$^{D}0.5\pm0.71^{c}$	$^{C}1.7\pm0.67^{b}$	$^{D}1.9\pm0.74^{ab}$	$^{E}2.4\pm0.52^{a}$
	CO	$^{BC}1.5\pm0.53^{c}$	$^{C}1.9\pm0.74^{bc}$	$^{CD}2.2\pm0.63^{b}$	$^{CD}3.0\pm0.82^{a}$

[1)]0, equal to control; 1, slight difference; 2, more distinct difference but still acceptable; 3, beginning to lose acceptability; 4, more distinct loss of acceptability; 5, very distinct loss of acceptability; 6, unacceptability.
[2)]PF=pan frying; CO=convection oven.
[3)]Different letters (A-D) within a column are significantly different ($p<0.05$, $n=10$).
[4)]Different letters (a-d) within a row are significantly different ($p<0.05$, $n=10$).

the 6th day for pork patties containing 5% of *doenjang*, and the 8th day for pork patties containing more than 10% of *doenjang*. Therefore, these results showed that adding *doenjang* to pork patties delayed WOF development time. The positive correlation coefficients between the values of TBARS and WOF of the patties cooked by PF and CO were obtained to be r=0.80 and r=0.72, respectively ($p<0.05$). These results were similar to the previous study (30).

With increasing the addition of *doenjang*, cooking properties of pork patties revealed the improved cooking yield, less diameter reduction, and less thickness increase. Also, the shear force, hardness, and chewiness of pork patties were reduced. The PF showed better cooking properties than CO. During the storage at 4±1°C of pork patties, lipid oxidation was remarkably reduced by the addition of 5% *doenjang*. The TBARS values of PF were lower than CO. The WOF development was delayed as the amount of the *doenjang* was increased. Thus, the addition of *doenjang* and PF favorably affected the cooking properties and stability of lipid oxidation in pork patties. However, the amount of *doenjang* added to seasoned pork patties might be limited due to the characteristic flavor of *doenjang*. Therefore, in future study, the sensory evaluation is needed whether there is any objectional flavor impact of *doenjang* in pork patties and thus to obtain proper amount of *doenjang* added.

References

1. Dawson LE, Gartner R. Lipid oxidation in mechanically deboned poultry. Food Technol. -Chicago 37: 112-116 (1983)
2. Fernandez-Lopez J, Sevilla L, Sayas BE, Navarro C, Marin F, Perez-Alvarez JA. Evaluation of the antioxidant potential of hyssop (*Hyssopus Officinalis* L.) and rosemary (*Rosmarinus officinalis* L.) extracts in cooked pork meat. J. Food Sci. 68: 660-664 (2003)
3. Rojas MC, Brewer MS. Effect of natural antioxidants on oxidative stability of cooked, refrigerated beef and pork. J. Food Sci. 72: S282-S288 (2007)
4. Jacobsen C. Sensory impact of lipid oxidation in complex food systems. J. Lipid 101: S484-S492 (1999)
5. Jayathilakan K, Sharma GK, Radharkrishna K, Bawa AS. Antioxidant potential of synthetic and natural antioxidants and its effect on warmed-over-flavour in different species of meat. Food Chem. 105: 908-916 (2007)
6. Abd El-Alim SS, Lugasi A, Hovari J, Dworschak E. Culinary herbs inhibit lipid oxidation in raw and cooked minced meat patties during storage. J. Sci. Food Agr. 79: 277-285 (1999)
7. McCarthy TL, Kerry JP, Kerry JF, Lynch PB, Buckley DJ. Evaluation of the antioxidant potential of natural food/plant extracts as compared with synthetic antioxidants and vitamin E in raw and cooked pork patties. Meat Sci. 57: 45-52 (2001)
8. Hahm TS, King DL, Min DB. Food antioxidants. Food Biotechnol. 2: 1-18 (1993)
9. Zhang D, Hamauzu Y. Phenolics, ascorbic acid, carotenoids, and antioxidant activity of broccoli and their changes during conventional and microwave cooking. Food Chem. 88: 503-509 (2004)
10. Pena-Ramos EA, Xiong YL. Whey and soy protein hydrolysates inhibit lipid oxidation in cooked pork patties. Meat Sci. 64: 259-263 (2003)
11. Decker EA, Crum AD. Antioxidant activity of carnosine in cooked ground pork. Meat Sci. 34: 245-253 (1993)
12. Park KY, Jung KO. Fermented soybean products as functional foods: Functional properties of *doenjang* (fermented soybean paste). pp. 555-596. In: Asian Functional Foods. Shi J, Ho C-T, Shahidi F (eds). CRC Press, Inc., Boca Raton, FL, USA (2005)
13. Oh HJ, Kim CS. Study on the antioxidant and nitrite scavenging ability of fermented soybean foods (*cheonggukjang*, *doenjang*). J. Korean Soc. Food Sci. Nutr. 36: 1503-1510 (2007)
14. Cheigh HS, Park KS, Moon GS, Park KY. Antioxidative characteristics of fermented soybean paste and its extracts on the lipid oxidation. J. Korean Soc. Food Sci. Nutr. 19: 163-167 (1990)
15. Chin KB, Keeton JT, Longnecker MT, Lamkey JW. Utilization of soy protein isolate and konjac blends in a low-fat bologna (model system). Meat Sci. 53: 45-57 (1999)
16. Rao LO, Draughon FA, Melton CC. Sensory characters of thuringer sausage extended with textured soy protein. J. Food Sci. 49: 334-336 (1984)
17. AOAC. Official Methods of Analysis of AOAC. 16th ed. Method 967.12, 969.16, 945.46. Association of Official Analytical Chemists, Arlington, VA, USA (1995)
18. Folch I, Lee M, Statnley GHS. A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem.

226: 497-509 (1957)
19. Tarladgis BG, Watts BM, Younathan MT, Dugan L. A distillation method for the quantitative determination malonaldehyde in rancid foods. J. Am. Oil Chem. Soc. 37: 44-48 (1960)
20. Lee YC, Song DS, Yoon SK. Effects of ISP adding methods and freezing rate on quality of pork patties and cutlets. Korean J. Food Sci. Technol. 35: 182-187 (2003)
21. Claus JR, Hunt MC. Low-fat, high added-water bologna formulated with texture-modifying ingredients. J. Food Sci. 56: 643-647 (1991)
22. Oh HY, Kim CS. The effect of commercial *doenjang* (Korean soybean paste) on the sponge cake making. Korean J. Food Cook. Sci. 20: 387-395 (2004)
23. Cofrades S, Guerra M, Carballo J, Fernandez-Martin F, Jimenz-Colmenro F. Plasma protein and soy fiber content effect on bologna sausage properties as influenced by fat level. J. Food Sci. 65: 281-287 (2000)
24. Surh J, Decker EA, Mc-Clements DJ. Properties and stability of oil-in-water emulsion stabilized by fish gelation. Food Hydrocolloid 20: 596-606 (2006)
25. Oh HJ, Moon HK, Kim CS. Development of yeast leavened pan bread using commercial *doenjangs* (Korean soybean pastes): 1. Physicochemical properties of *doenjang* and physical properties of bread added with *doenjang*. J. Korean Soc. Food Sci. Nutr. 32: 1002-1010 (2003)
26. Berry BW, Leddy KF. Effects of the fat level and cooking method on sensory and textural properties of ground beef patties. J. Food Sci. 47: 871-874 (1984)
27. Fogg NE, Harrison DL. Relationships of electrophoretic patterns and selected characteristics of bovine skeketal muscle and internal temperature. J. Food Sci. 40: 28-34 (1975)
28. Park JS, Lee MY, Lee TS. Compositions of sugars and fatty acids in soybean paste (*doenjang*) prepared with different microbial sources. J. Korean Soc. Food Nutr. 24: 917-924 (1995)
29. Buchowski MS, Mahoney AW, Carpenter CE, Comforth DP. Heating and the distribution of total and heme iron between meat and broth. J. Food Sci. 53: 43-49 (1998)
30. Byrne DV, O'Sullivan MG, Bredie WLP, Andersen HJ, Martens M. Descriptive sensory profiling and physical/chemical analyses of warmed-over flavor in pork patties from carriers and non-carriers of the RN^{-}allele. Meat Sci. 63: 211-224 (2003)