Korean J. Food Sci. Ani. Resour.
Vol. 31, No. 2, pp. 183~190(2011)

ARTICLE

Effects of Konjac, Isolated Soy Protein, and Egg Albumin on Quality Properties of Semi-dried Chicken Jerky

Doo-Jeong Han[1], Ji-Hun Choi[2], Yun-Sang Choi[2], Hack-Youn Kim[1], Si-Young Kim[1], Hyun-Wook Kim[1], Hae-Kyung Chung[3], and Cheon-Jei Kim[1,2]*

[1]*Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Korea*
[2]*Research Institute for Meat Science and Culture, Konkuk University, Seoul 143-701, Korea*
[3]*Department of Food Science and Nutrition, Hoseo University, Asan 336-795, Korea*

Abstract

The objective of this study was to examine the effect of adding various humectants (konjac, egg albumin, and isolated soy protein) on the properties of semi-dried chicken jerky. Jerky samples were prepared as follows: control with no humectants and treatments with 0.05, 0.1, and 0.2% of added humectants. Adding the humectants influenced the increase in pH, processing yields, moisture contents, water activity, mechanical tenderness, and sensorial properties (tenderness, juiciness, and overall acceptability) of chicken jerky. Additionally, the konjac treatment most improved the yields, tenderness, and sensorial traits, among the humectant treatments tested. Furthermore, adding 0.1% konjac during jerky manufacture resulted in similar quality properties as adding 0.2% konjac.

Key words: chicken jerky, humectants, konjac, isolated soy protein, egg albumin

Introduction

Intermediate-moisture foods (IMF), such as jerky, represent processed foods that can be stored without refrigeration; however, upon storage these products, can lose moisture and acquire a dry texture rather than the desired moist texture (Hole, 2003). The undesirable ingress or loss of moisture depends on the humidity of the surrounding atmosphere and can be controlled by packaging. In regards to IMF, a high water activity could allow for microbial growth (Hole, 2003). The composition of IMF is controlled by use of humectants, which prevent migration of moisture. Konjac, egg albumin, and isolated soy protein (ISP) are the most commonly used humectants in the manufacturing of meat products.

Konjac (or konjac mannan) is a polysaccharide from the dried tuber of *Amorphophallus konjac*. It is a glucomannan and consists of a main chain of (1, 4)-β-D-mannopyranosyl and D-glucopyranosyl units with (1, 3) linked branches approximately every 10 sugar residues, and the ratio of mannose to glucose is 1.6:1 (Lin and Huang, 2003; Williams and Phillips, 2003). Recently, konjac was approved for use in food and is now finding applications as a thickener and gelling agent, since it forms thermo-reversible gels with xanthan gum and also increases the gel strength, elasticity, and clarity of kappa-carrageenan gels, and the purified konjac flour has been introduced on a relatively small scale into the United States and Europe, both as a food additive and a dietary supplement (Chua *et al*., 2010; Williams and Phillips, 2003). Chin *et al*. (2009) reported that the addition of konjac flour improved gelling properties of the composite gel systems.

Egg albumin is available in different forms for use in processed foods and has many important functional properties, such as foaming and binding ability, emulsifying ability and moisture retention. It has been used in the formulation of normal and low-fat meat products and has proved very effective as binders for meat. However, there is a drawback to its use in processed meats in that it is relatively costly (Jimenez-Colmenero, 2004). Fernandez *et al*. (1998) found that the addition of egg white increased water binding of chicken meat batters, and Pietrasik (2003) reported that the cooking and purge losses and the expressible moisture of beef gels were appreciably affected

*Corresponding author: Cheon-Jei Kim, Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Korea. Tel: 82-2-450-3684, Fax: 82-2-444-6695, E-mail: kimcj@konkuk.ac.kr

by egg albumin addition.

Soy protein products have been used primarily for their functional characteristics. The soy protein polymer chain contains both lipophilic and hydrophilic groups; thus, this protein associates readily with both fat and water. This promotes the formation of stable oil and water emulsions when the protein dispersion is mixed with oil. Especially, isolated soy protein (ISP) aids in the formation of gels, which acts as matrices to retain moisture, fats and solids, and imparts a desirable texture (Jimenez-Colmenero, 2004). Lee *et al*. (2003) reported that the addition of ISP to meat emulsion for pork patties improved cooking loss and juiciness. However, Chin *et al*. (1999) pointed out that the textural properties in a low-fat bologna were less acceptable than the control when more than 2% of the meat protein was replaced with ISP.

Therefore, the objective of this study was to enhance the quality characteristics of semi-dried chicken jerky prepared with various humectants, and to determine whether humectants treatment can be effectively utilized during jerky processing.

Table 1. Curing solution formula for semi-dried chicken jerky

Ingredients	Formulation (% in batch)
Water	9
Soy sauce	8
Salt	0.6
Starch syrup	3.5
Sucrose	1.8
D-sorbitol	5.8
Black pepper powder	0.18
Ginger powder	0.09
Garlic powder	0.18
Onion powder	0.18
Sodium nitrate	0.005
Sodium citrate	0.007
Potassium sorbate	0.09
Sodium erythorbate	0.03
Soup stock powder	0.09
Phosphate	0.1

Control: no humectants, humectants treatments: added 0.05, 0.1, 0.2%, respectively

Materials and Methods

Raw materials and curing solution preparation

A commercial sample of chicken breast meat (*Pectoralis major*; pH: 5.99±0.16, moisture contents: 74.94±0.96%, protein contents: 22.58±0.43%, fat contents: 1.09±0.09%, ash contents: 1.31±0.08%) was purchased from a local market. The meat was trimmed of visible fat before use for jerky processing, and was ground through a grinder with an 8 mm plate (PM-100, Mainca, Barcelona, Spain). The composition (%, w/w) of the curing solution was water (9%), soy sauce (8%), starch syrup (3.5%), sucrose (1.8%), D-sorbitol (5.8%), black pepper powder (0.18%), ginger powder (0.09%), garlic power (0.18%), onion power (0.18%), sodium nitrite (0.005%), sodium citrate (0.007%), potassium sorbate (0.09%), sodium erythorbate (0.03%), and soup stock powder (0.09%). Also, salt (0.6%) and phosphate (0.1%) were incorporated into the binding meat (Choi *et al*., 2008). The pH of curing solutions was 5.45±0.06. Additionally, each humectant added 0.05, 0.1, and 0.2%, after dissolved in water, respectively (Table 1).

Preparation of jerky

The ground chicken breast meat was mixed with curing solution by hand for 3 min. The meat was then continuously tumbled in a tumbler (MGH-20, Vackona, Germany) at 4ºC for 30 min at 25 rpm. Cured meat was stuffed into cellulose casing (Φ - 20 mm), and dried in a convection dry oven (Enex-CO-600, Enex, Korea) for 180 min at 55°C, for 180 min at 65°C, and for 60 min at 75°C (Choi *et al*., 2008).

Moisture contents and water activity

Moisture contents were determined by weight loss after 24 h of drying at 105ºC in a drying oven (SW-90D, Sang Woo Scienctific Co., Korea) as recommended by AOAC (1995). Samples for water activity of each sample was determined in triplicate with a hygrometer (BT-RS1, Rotronic ag., Switzerland).

pH

The pH of samples was determined with a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland). The pH values of jerky were measured by blending a 5 g sample with 20 mL distilled water for 60 s in a homogenizer (Ultra-Turrax T25, Janke & Kunkel, Germany).

Processing yields

Processing yields were determined by calculating the weight differences of jerky before and after drying as follows:

Processing yields (%)

$$= \frac{\text{jerky weight after drying (g)}}{\text{cured meat weight before drying (g)}} \times 100$$

TBA (Thiobarbituric acid) value

Thiobarbituric acid (TBA) values were determined using the distillation method of Tarladgis *et al*. (1960). Results were expressed as mg of malonaldehyde per kg of sample.

Percent metmyoglobin measurements

Metmyoglobin concentration of sample was used a modification of procedures by Krzywicki (1979). Samples were blended with five volumes of cold 0.04 M phosphate buffer at pH 6.8 for 10 s in a homogenizer (Model AM-7, Nihonseiki Kaisha Ltd., Tokyo, Japan). After standing at 1°C for 24 h, the mixtures were centrifuged at 3500 g at 4°C for 30 min. The supernatant was further clarified by filtration through Whatman No. 1 filter paper. The absorbance of filtrate was measured at 525, 572, 700 nm using a spectrophotometer (Libra S22, Young In Scientific Ltd., Seoul, Korea). The percent metmyoglobin was calculated using the following formula:

$$\text{Metmyoglobin (\%)} = [1.395-(A_{572}-A_{700})/(A_{525}-A_{700})] \times 100$$

where A_{λ} = Absorbance at λ nm

Shear force measurement

Shear force values were determined with a Warner-Bratzler shear attachment on a texture analyzer (TA-XT2*i*, Stable Micro System Ltd., Surrey, UK). Test speeds were set at 2.0 mm/s. Data were collected and analyzed from the shear force values to obtain for the maximum force required to shear through each sample.

MFI (Myofibrillar fragmentation index) measurements

Myofibrils were obtained according to the method of Olson *et al*. (1976) using MFI buffer (20 mM K_2HPO_4/KH_2PO_4, pH 7, 100 mM KCl, 1 mM EDTA, 1 mM NaN_3). The myofibrils were suspended in MFI buffer. An aliquot of myofibril suspension was diluted with the MFI buffer to 0.5 mg/mL protein concentration and the absorbance of this suspension was measured at 540 nm. MFI values were recorded as absorbance of units per 0.5 mg/mL myofibril protein concentration multiplied by 200 (Yu *et al*., 2009).

Sensory evaluations

Each jerky sample was subjected to sensory evaluations. The samples were served to 12 panel members with previous experience. Panelists were presented with randomly coded samples. The color (1 = extremely undesirable, 10 = extremely desirable), flavor (1 = extremely undesirable, 10 = extremely desirable), tenderness (1 = extremely tough, 10 = extremely tender), juiciness (1 = extremely dry, 10 = extremely juicy), and overall acceptability (1 = extremely undesirable, 10 = extremely desirable) of the samples were evaluated using a 10-point horizontal scale. Panelists were required to cleanse their palate between samples with water (Choi *et al*., 2008; Keeton, 1983).

Statistical analysis

An analysis of variance were performed on all the variables measured using the General Linear Model (GLM) procedure of the SAS statistical package (SAS Inst., 1999). The Duncan's multiple range test (p<0.05) was used to determine differences among the treatment means.

Results and Discussion

pH and processing yield

The pH and processing yields of the chicken jerky containing humectants is shown in Table 2. The pH of all jerky was between 6.09-6.17, and the samples containing humectant had higher pH values than the control samples, except for treatments with 0.05% konjac and egg albumin. At higher humectants concentrations, the pH values of the semi-dried jerky increased. Similar results were obtained by Song (1997) who found that beef jerky manufactured with glycerol had a slightly higher pH than the control. Lin and Huang (2008) reported that the pH values of gum-containing treatments were higher than the controls, which was attributed to the alkaline-induced gelation of konjac gel. In addition, Ahamed *et al*. (2000) reported that cutlets containing egg white powder had a significantly higher pH compared to the control because of the higher pH of the egg white powder. Furthermore, Chin *et al*. (2000) found that mean pH values of low-fat bologna containing ISP were higher than those of low-fat bologna formulated without ISP.

The processing yields of semi-dried chicken jerky ranged from 46.89 to 49.60%, and the jerky containing humectants had higher yields than the control, except for treatments with 0.05% humectant and 0.1% ISP. In addition, samples prepared with 0.2% konjac had higher process-

Table 2. Comparison on pH, processing yields, water contents, and water activity of semi-dried chicken jerky prepared with various humectants

Treatments		pH	Processing yields (%)	Water contents (%)	Water activity
Control		6.09±0.04^{C}	46.89±0.75^{D}	36.41±0.56^{B}	0.84±0.00^{C}
Konjac	0.05%	6.10±0.04^{BC}	47.01±0.28^{D}	37.22±0.39^{B}	0.84±0.00^{C}
	0.1%	6.14±0.05^{AB}	49.05±0.22^{AB}	39.18±0.20^{A}	0.86±0.01^{A}
	0.2%	6.14±0.06^{AB}	49.60±0.54^{A}	39.20±0.45^{A}	0.86±0.00^{A}
Egg albumin	0.05%	6.10±0.05^{BC}	46.98±0.71^{D}	36.82±0.26^{B}	0.85±0.00^{BC}
	0.1%	6.15±0.04^{AB}	47.81±0.35^{C}	37.23±2.64^{B}	0.85±0.00^{BC}
	0.2%	6.17±0.06^{A}	48.72±0.59^{B}	37.93±2.40^{AB}	0.86±0.01^{AB}
Isolated soy protein	0.05%	6.14±0.05^{AB}	46.95±0.39^{D}	36.47±0.78^{B}	0.85±0.01^{ABC}
	0.1%	6.14±0.04^{AB}	47.39±0.40^{CD}	37.07±0.53^{B}	0.86±0.01^{AB}
	0.2%	6.15±0.06^{AB}	48.57±0.23^{B}	37.90±0.62^{B}	0.86±0.01^{AB}

All values are mean±SD.
$^{A-D}$Means in the same column with different letters are significantly different (p<0.05).

ing yields than other treatments except for jerky prepared with 0.1% konjac; therefore, addition of 0.1% konjac was more effective with regard to product yield enhancement. Choi *et al*. (2008) found that the drying yields of jerky ranged between 48-53% regardless of the pork/beef levels, and Song (1997) reported that humectants treatments resulted in higher product yields than control beef jerky, which may have been due to the humectants having a higher capacity to retain water. Chin *et al*. (1998) reported that the cooking yields of low fat bologna containing konjac blends were higher than low fat bologna not containing the konjac blends (control sample), which indicated that more moisture was being held in the gel matrix when the konjac blends were used. Dawson *et al*. (1990) found that the addition of spray-dried egg white increased the cooking yield for both washed and unwashed mechanically deboned chicken meat gels. Tsao *et al*. (2002) reported that the cooking yields of low-sodium restructured pork sticks was affected by the level of added soy protein, and they concluded that the soy protein may have acted as binders for restructured meat products due to their ability to bind muscle proteins.

Moisture contents and water activity

The moisture contents and water activity of all jerky samples ranged from 36.41-39.20% and 0.84-0.86, and the addition of humectants was positively correlated with moisture contents and water activity (Table 2). Similar results were obtained by Choi *et al*. (2008) who found that semi-dried jerky had moisture contents ranging from 34-37% and water activity ranging from 0.82-0.88. In addition, the chicken jerky containing 0.1 and 0.2% konjac had significantly higher moisture contents than other treatments; however, there were no significant differences in jerky containing 0.1% and 0.2% konjac. The control jerky also had significantly lower water activity than the samples containing 0.1 and 0.2% konjac, 0.2% egg albumin, and 0.1 and 0.2% ISP.

Chin *et al*. (2009) demonstrated that konjac flour improved the water-binding properties in myofibrillar protein mixed gels, and the interaction between konjac flour and the myofibrillar protein appeared to play a role in the improved gelling properties of the composite gel systems. In addition, Xiong *et al*. (2009) reported that the water-holding properties of the grass carp (*Ctenopharyngodon idella*) surimi gels improved with an increase in the konjac glucomannan concentration. Jimenez-Colmenero *et al*. (1996) reported that the addition of egg white had no effect on the water holding capacity (WHC) of bologna sausages. Akesowan (2008) found that increasing the ISP levels resulted in higher moisture contents in pork sausage; however, in this study, the moisture content of ISP treatments was similar to the controls due to the difference in the amounts added.

TBA and metmyoglobin

As shown in Table 3, the semi-dried chicken jerky prepared with 0.2% konjac had lower TBA and metmyoglobin than the control jerky, and there were no differences within the same humectants treatments. Niwa *et al*. (2002) found that *tobiko* (konjac powder) contained natural antioxidants (ex: serotonin, trans-*N*-(p-coumaroyl)serotonin, 3,4-dihydroxybenzaldehyde, and 3,4-dihydroxybenzoic acid), which showed high antioxidative activities. In addition, Huang *et al*. (1998) reported that the TBA values of low-fat Chinese-style sausage decreased with an increase

Table 3. Comparison on TBA, metmyoglobin, shear force, and MFI of semi-dried chicken jerky prepared with various humectants

Treatments		TBA (mg/kg)	Metmyoglobin (%)	Shear force (kg)	MFI
Control		0.22±0.03^{A}	92.39±0.70^{A}	13.14±0.85^{A}	6.15±0.25^{D}
Konjac	0.05%	0.20±0.03^{ABC}	92.19±0.35^{AB}	12.85±1.11^{AB}	7.25±0.34^{C}
	0.1%	0.20±0.02^{BC}	91.73±0.18^{AB}	11.12±0.91^{E}	9.50±0.42^{B}
	0.2%	0.19±0.02^{C}	91.52±0.45^{B}	11.30±0.84^{E}	10.85±0.44^{A}
Egg albumin	0.05%	0.22±0.02^{A}	92.21±0.39^{AB}	12.89±1.05^{AB}	6.95±0.55^{C}
	0.1%	0.21±0.02^{ABC}	91.93±0.26^{AB}	12.15±0.59^{CD}	8.80±0.67^{B}
	0.2%	0.21±0.02^{ABC}	91.73±0.50^{AB}	11.89±0.65^{D}	10.50±0.53^{A}
Isolated soy protein	0.05%	0.22±0.02^{A}	92.35±0.23^{A}	12.84±0.90^{AB}	6.60±0.43^{CD}
	0.1%	0.21±0.03^{ABC}	92.07±0.65^{AB}	12.59±0.82^{ABC}	7.35±0.66^{C}
	0.2%	0.21±0.03^{ABC}	91.83±0.45^{AB}	12.42±0.81^{BCD}	9.25±0.53^{B}

All values are mean±SD.
$^{A-E}$ Means in the same row with different letters are significantly different (p<0.05).

in the amount of added konjac.

Although there were no significant differences among the samples, except the jerky containing 0.1 and 0.2% konjac, the addition of egg albumin and ISP tended to decrease the TBA value and metmyoglobin levels. Sathivel (2005) reported that the TBA value of pink salmon fillets coated with egg albumin were slightly lower than the control non-coated fillet. Manso *et al*. (2002) demonstrated that hydrolysed egg white prevented oxidative stress by increasing plasma radical-scavenging capacity and inhibiting lipid peroxidation, and this antioxidant activity could act together with the ACE-inhibitory activity and vasodilator properties, both of which contribute to the antihypertensive effects of hydrolysed egg white. Wu and Brewer (1994) found that the water extracts of a soy protein isolate had antioxidant effects in ground beef and microsomal lipids based on iron-induced oxidation as measured by TBA. Peòa-Ramos and Xiong (2002) also reported that both hydrolyzed and non-hydrolyzed soy protein isolates decreased TBARS in a liposome-oxidizing system.

Shear force and MFI

Tenderness, which is the most important textural factor of meat and meat products, significantly influences consumer preference (Kim and Lee, 2003), and the application of myofibrillar fragmentation index (MFI), a method for identifying tender meat and meat products, has been shown to be significantly correlated with shear force values (Culler *et al*., 1978; Olson and Parrish, 1977). In this study, the tenderness of semi-dried chicken jerky was assessed by comparing the shear force and MFI of different samples (Table 3). Compared to the control jerky samples, the chicken jerky prepared with 0.1 and 0.2% humectants had significantly lower shear force except for treatments with 0.1% ISP. In addition, samples prepared with humectant also had a higher MFI except for with 0.05% ISP. Therefore, the addition of humectants improved the tenderness in chicken jerky, and konjac treatment was the most effective with regard to enhancing the tenderness of the jerky product. Similar results were reported by Okonkwo *et al*. (1992) who found that the glycerol treated intermediate moisture smoked meats were significantly less tough than the corresponding glycerol-free samples, which was attributed to a moisture loss in the controls.

Hsu and Chung (1999) found that the addition of konjac decreased the hardness in low fat Kung-wan (a Taiwanese emulsified meatball), and Chin *et al*. (1998) reported that as the levels of konjac blends increased from 0.5 to 1.0%, the TPA hardness of low-fat bologna decreased. In addition, Chin *et al*. (2000) demonstrated that the gelation of konjac blends and a soy protein isolate upon cooking contributed to the viscoelastic texture of a low-fat meat gel system. Chen *et al*. (1993) also reported that egg white improved the textural properties of surimi gels. Chung and Lee (1991) pointed out that the compressive force of soy protein isolate-incorporated surimi gels and egg white-incorporated samples was significantly lower than those of the controls, and a similar trend was observed for the penetration force with the exception of egg white-incorporated gels.

Sensory properties

The sensory properties of semi-dried chicken jerky containing humectants are given in Table 4. The semi-dried

Table 4. Comparison on sensorial properties of semi-dried chicken jerky prepared with various humectants

Treatments		Color	Flavor	Tenderness	Juiciness	Overall acceptability
Control		8.78±0.44	8.00±0.50	7.22±0.67^{C}	7.11±0.78^{C}	7.17±0.94^{B}
Konjac	0.05%	8.78±0.44	8.00±0.50	7.56±0.53^{BC}	7.56±0.53^{ABC}	7.78±0.44^{AB}
	0.1%	8.67±0.50	7.78±0.44	7.89±0.33^{AB}	7.89±0.60^{AB}	7.78±0.44^{AB}
	0.2%	8.56±0.53	7.78±0.50	8.22±0.67^{A}	8.00±0.71^{A}	8.11±0.60^{A}
Egg albumin	0.05%	8.78±0.44	7.89±0.33	7.33±0.50^{BC}	7.22±0.67^{BC}	7.56±0.73^{AB}
	0.1%	8.67±0.50	7.78±0.44	7.56±0.53^{BC}	7.44±0.73^{ABC}	7.67±0.71^{AB}
	0.2%	8.33±0.50	7.67±0.50	7.78±0.67^{ABC}	7.67±0.50^{ABC}	7.89±0.33^{AB}
Isolated soy protein	0.05%	8.67±0.50	7.78±0.67	7.33±0.71^{BC}	7.22±0.67^{BC}	7.39±0.70^{AB}
	0.1%	8.56±0.53	7.61±0.49	7.61±0.49^{BC}	7.39±0.70^{ABC}	7.50±0.71^{AB}
	0.2%	8.33±0.71	7.56±0.53	7.78±0.67^{ABC}	7.67±0.87^{ABC}	7.67±0.87^{AB}

All values are mean±SD.
$^{A-C}$Means in the same row with different letters are significantly different (p<0.05).

jerky prepared with 0.1 and 0.2% konjac had significantly higher tenderness and juiciness scores than the control jerky, and the overall acceptability of the jerky containing 0.2% konjac was significantly higher than the controls. Also, there were no differences in the sensorial tenderness property within the same humectants treatments except for samples containing 0.05 and 0.2% konjac. Osburn and Keeton (2004) reported that significant sensory differences were only slightly perceptible at different konjac gel levels in terms of the flavor, taste, and texture of cooked lamb, and Lin and Huang (2003) found that the addition of konjac/gellan gum mixed gel to reduced-fat frankfurters could not only increase the perception that the food was healthy but it also had comparable characteristics as the regular high-fat frankfurters. In addition, no significant difference was observed between the controls and humectant treatments except for the jerky containing konjac, the addition of egg albumin and ISP tended to improve the sensorial tenderness, juiciness, and overall acceptability. Karthikeyan *et al*. (2000) demonstrated that a slow release of moisture in Caprine *keema* (Indian traditional meat product) samples treated with humectants reduced the rapid decline in the juiciness observed for the control.

The study was to examine the effect of adding humectants such as konjac, egg albumin, and isolated soy protein on the properties of semi-dried chicken jerky. The use of humectants enhanced the quality properties of semi-dried chicken jerky, and the addition of 0.1% konjac was the most effective humectants treatment in this study, since it resulted in similar properties as the samples containing 0.2% konjac.

Acknowledgements

This research was supported by Technology Development Program (608001-05-2-SB310) for Agriculture and Forestry, Ministry for Agriculture, Forestry and Fisheries, Republic of Korea. This authors also partially supported by the Brain Korea 21 (BK21) Project from Ministry of Education and Human Resources Development.

References

1. Ahamed, M. E., Anjaneyulu, A. S. R., Sathu, T., Thomas, R., and Kondaiah, N. (2007) Effect of different binders on the quality of enrobed buffalo meat cutlets and their shelf life at refrigeration storage (4±1°C). *Meat Sci*. **75**, 451-459.
2. Akesowan, A. (2008) Effect of soy protein isolate on quality of light pork sausages containing konjac flour. *Afr. J. Biotechnol.* **7**, 4586-4590.
3. AOAC. (1995) Official methods of analysis of AOAC. 16th ed, Association of Official Analytical Chemists, Washington, DC.
4. Chen, J. S., Lee, C. M., and Crapo, C. (1993) Linear programming and response surface methodology to optimize surimi gel texture. *J. Food Sci*. **58**, 535-538.
5. Chin, K. B., Go, M. Y., and Xiong, Y. L. (2009) Konjac flour improved textural and water retention properties of transglutaminase-mediated, heat-induced porcine myofibrillar protein gel: Effect of salt level and transglutaminase incubation. *Meat Sci*. **81**, 565-572.
6. Chin, K. B., Keeton, J. T., Longnecker, M. T., and Lamkey, J. W. (1998) Functional, textural and microstructural properties of low-fat bologna (model system) with a konjac blend. *J. Food Sci*. **63**, 801-807.
7. Chin, K. B., Keeton, J. T., Longnecker, M. T., and Lamkey, J. W. (1999) Utilization of soy protein isolate and konjac blends in a low-fat bologna (model system). *Meat Sci*. **53**,

45-57.
8. Chin, K. B., Keeton, J. T., Miller, R. K., Longnecker, M. T., and Lamkey, J. W. (2000) Evaluation of konjac blends and soy protein isolate as fat replacements in low-fat bologna. *J. Food Sci*. **65**, 756-763.
9. Choi, J. H., Jeong, J. Y., Han, D. J., Choi, Y. S., Kim, H. Y., Lee, M. A., Lee, E. S., Paik, H. D., and Kim, C. J. (2008) Effects of pork/beef levels and various casings on quality properties of semi-dried jerky. *Meat Sci*. **80**, 278-286.
10. Chua, M., Baldwin, T. C., Hocking, T. J., and Chan, K. (2010) Traditional uses and potential health benefits of *Amorphophallus konjac* K. Koch ex N.E.Br. *J. Ethnopharmacol*. **128**, 268-278.
11. Chung, K. H. and Lee, C. M. (1991) Water binding and ingredient dispersion pattern effects on surimi gel texture. *J. Food Sci*. **56**, 1263-1266.
12. Culler, R. D., Parrish, F. C. Jr., Smith, G. C., and Cross, H. R. (1978) Relationship of myofibril fragmentation index to certain chemical, physical and sensory characteristics of bovine longissimus muscle. *J. Food Sci*. **43**, 1117-1180.
13. Dawson, P. L., Sheldon, B. W., and Ball, H. R. Jr. (1990) Effect of washing and adding spray-dried egg white to mechanically deboned chicken meat on the quality of cooked gels. *Poult. Sci*. **69**, 307-312.
14. Fernandez, P., Cofrades, S., Solas, M. T., Carballo, J., and Jiménez-Colmenero, F. (1998) High pressure-cooking of chicken meat batters with starch, egg white, and iota carrageenan. *J. Food Sci*. **63**, 267-271.
15. Hole, M. (2003) Storage stability: Parameters affecting storage stability. In Encyclopedia of Food Sciences and Nutrition. Caballero, B., Trugo, L., & Finglas, P. (ed) Elsevier, Oxford, pp. 5612-5618.
16. Hsu, S. Y. and Chung, H. Y. (1999) Comparisons of 13 edible gum-hydrate fat substitutes for low fat Kung-wan (an emulsified meatball). *J. Food Eng*. **40**, 279-285.
17. Huang, C. C., Su, H. P., and Lin, C. W. (1998) Utilization of konjac in low-fat Chinese-style sausage. *Food Sci.-Taiwan*. **25**, 437-445.
18. Jimenez-Colmenero, F. (2004) Chemistry and physics of comminuted products: Non-meat proteins. In: Encyclopedia of meat sciences. Jensen, W. K., Devine, C., & Dikeman, M. (ed.), Oxford, pp. 271-278.
19. Jimenez-Colmenero, F., Barreto, G., Fernandez, P., and Carballo, J. (1996) Frozen storage of bologna sausages as a function of fat content and of levels of added starch and egg white. *Meat Sci*. **42**, 325-332.
20. Kato, K. and Matsuda, K. (1969) Studies of the chemical structure of konjac mannan: I. Isolation and characterization of oligosaccharides from the partial hydrolyzate of the mannan. *Agr. Biol. Chem*. **33**, 1446-1453.
21. Karthikeyan, J., Kumar, S., Anjaneyulu, A. S. R., and Rao, K. H. (2000) Application of hurdle technology for the development of Caprine *keema* and its stability at ambient temperature. *Meat Sci*. **54**, 9-15.
22. Keeton, J. T. (1983) Effects of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties. *J. Food Sci*. **48**, 878-881.
23. Kim, C. J. and Lee, E. S. (2003) Effects of quality grade on the chemical, physical and sensory characteristics of Hanwoo (Korean native cattle) beef. *Meat Sci*. **63**, 397-405.
24. Krzywicki, K. (1979) Assessment of relative content of myoglobin, oxymyoglobin and metmyoglobin at the surface of beef. *Meat Sci*. **3**, 1-10.
25. Lee, Y. C., Song, D. S., and Yoon, S. K. (2003) Effects of ISP adding methods and freezing rate on quality of pork patties and cutlets. *Korean J. Food Sci. Technol*. **35**, 182-187.
26. Lin, K. W. and Huang, C. Y. (2008) Physicochemical and textural properties of ultrasound-degraded konjac flour and their influences on the quality of low-fat Chinese-style sausage. *Meat Sci*. **79**, 615-622.
27. Lin, K. W. and Huang, H. Y. (2003) Konjac/gellan gum mixed gels improve the quality of reduced-fat frankfurters. *Meat Sci*. **65**, 749-755.
28. Manso, M. A., Miguel, M., Even, J., Hernández, R., Aleixandre, A., and López-Fandiòo, R. (2008) Effect of the long-term intake of an egg white hydrolysate on the oxidative status and blood lipid profile of spontaneously hypertensive rats. *Food Chem*. **109**, 361-367.
29. Niwa, T., Murakami, K., Ohtake, T., Etoh, H., Shimizu, A., Shimizu, Y., Kato, Y., and Tanaka, H. (2002) Peroxynitrite scavenging activities of aromatic compounds isolated from konnyaku, *Amorphophallus konjac* K. Koch. *Biosci. Biotechnol. Biochem*. **66**, 1386-1388.
30. Okonkwo, T. M., Obanu, Z. A., and Ledward, D. A. (1992) The stability of some intermediate moisture smoked meats during storage at 30°C and 38°C. *Meat Sci*. **31**, 245-255.
31. Olson, D. G., Parrish, F. C. Jr., and Stromer, M. H. (1976) Myofibril fragmentation and shear resistance of three bovine muscles during postmortem storage. *J. Food Sci*. **41**, 1036-1041.
32. Olson, D. G. and Parrish, F. C. Jr. (1977) Relationship of myofibril fragmentation index to measures of beefsteak tenderness. *J. Food Sci*. **42**, 506-509.
33. Osburn, W. N. and Keeton, J. T. (2004) Evaluation of low-fat sausage containing desinewed lamb and konjac gel. *Meat Sci*. **68**, 221-233.
34. Peňa-Ramos, E. A. and Xiong, Y. L. (2002) Antioxidant activity of soy protein hydrolysates in a liposomal system. *J. Food Sci*. **67**, 2952-2956.
35. Pietrasik, Z. (2003) Binding and textural properties of beef gels processed with κ–carrageenan, egg albumin and microbial transglutaminase. *Meat Sci*. **63**, 317-324.
36. SAS. (1999) SAS/STAT Software for PC. Release 8.1, SAS Institute Inc., Cary, NC, USA.
37. Sathivel, S. (2005) Chitosan and protein coatings affect yield, moisture loss, and lipid oxidation of pink salmon (Oncorhynchus gorbuscha) fillets during frozen storage. *J. Food Sci*. **70**, 455-459.
38. Song, H. H. (1997) The effects of glycerol, rice syrup and honey on the quality and storage characteristics of beef jerky. *MSc. thesis*, Konkuk Univ., Seoul, Korea.
39. Tarladgis, B. G., Watts, B. M., Younathan, M. T., and Dugan,

L. R. Jr. (1960) A distillation method for the quantitative determination of malonaldehyde in rancid foods. *J. Am. Oil Chem. Soc.* **37**, 44-48.

40. Tsao, C. Y., Kao, Y. C., Hsieh, J. F., and Jiang, S. T. (2002) Use of soy protein and microbial transglutaminase as a binder in low-sodium restructured meats. *J. Food Sci*. **67**, 3502-3506.
41. Tye, R. J. (1991) Konjac flour: properties and applications. *Food Technol*. **45**, 87-92.
42. Gums: Food uses. In: Encyclopedia of Food Sciences and Nutrition. Caballero, B., Trugo, L., & Finglas, P. (ed) Elsevier, Oxford, pp. 3001-3007.
43. Wu, S. Y. and Brewer, M. S. (1994) Soy protein isolate antioxidant effect on lipid peroxidation of ground beef and microsomal lipids. *J. Food Sci*. **59**, 702-706, 738.
44. Xiong, G., Cheng, W., Ye, L., Du, X., Zhou, M., Lin, R., Geng, S., Chen, M., Corke, H., and Cai, Y. Z. (2009) Effects of konjac glucomannan on physicochemical properties of myofibrillar protein and surimi gels from grass carp (*Ctenopharyngodon idella*). *Food Chem*. **116**, 413-418.
45. Yu, L. H., Lee, E. S., Jeong, J. Y., Choi, J. H., and Kim, C. J. (2009) Effects of post-mortem temperature on the physicochemical properties of hot-boned chicken breast muscles. *Korean J. Food Sci. Ani. Resour*. **29**, 55-61.

(Received 2011.1.19/Revised 2011.2.18/Accepted 2011.2.22)