



Effect of the Duck Skin on Quality Characteristics of Duck Hams

Dong-Hyun Kim^{1,2†}, Tae-Kyung Kim^{1†}, Young-Boong Kim¹, Jung-Min Sung¹, Young-Jin Jang¹, Jae-Yun Shim^{2,3}, Sung-Gu Han², and Yun-Sang Choi^{1*}

¹Food Processing Research Center, Korean Food Research Institute, Seongnam 13539, Korea

²Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 05029, Korea

³R&D Center, Farm Duck, Seongnam 13103, Korea

Abstract

This study was conducted to investigate the effect of duck skin on cooking loss, emulsion stability, pH, color, protein solubility, texture profile analysis (TPA), apparent viscosity, and sensory characteristics of press type duck ham with different ratio of duck breast meat and duck skin. Five duck ham formulations were produced with the following compositions: T1 (duck breast 70% + duck skin 30%), T2 (duck breast 60% + duck skin 40%), T3 (duck breast 50% + duck skin 50%), T4 (duck breast 40% + duck skin 60%), and T5 (duck breast 30% + duck skin 70%). The cooking loss and fat separation were lower in T1, and the total expressible fluid separations were lower in T1 and T2 than others. The pH ranged from 6.48 to 6.59, with the highest values in T4 and T5. T5 had the highest CIE L*-value, and T1 and T2 had the highest CIE a*-values; however, CIE b*-values did not differ significantly between the duck ham samples. The protein solubility and TPA (hardness, springiness, cohesiveness, gumminess, and chewiness) were the highest in T1. T1 and T2 had higher scores for color, tenderness, and overall acceptability. T1, T2, and T3 showed significantly higher values, but there were no significant differences for flavor and juiciness. Regarding apparent viscosity properties, T1 and T2 had higher viscosity values than the other formulations. In conclusion, the T1 (duck breast 70% + duck skin 30%) and T2 (duck breast 60% + duck skin 40%) duck hams show the highest quality characteristics.

Keywords duck breast, duck skin, press ham, emulsion stability, quality characteristic

Introduction

Meat is not only a high-quality source of essential proteins, but also contains critical nutrients such as minerals and vitamins. Thus, the development necessity of processed meat products that maintain the nutritional value has been increased and as simple food sources in has been actively examined (Prieto *et al.*, 2009). In addition, Fenger *et al.* (2015) reported that it was necessary to develop new and diverse processed meat products to attract consumers. While various meat products have been developed using pork and beef, fewer studies have attempted to develop products from poultry meats such as chicken and duck meat (Kang *et al.*, 2014).

Among poultry meats, global production and demand for duck meat has consistently increased, and its consumption in Korea doubled from 1.75 kg per person in 2008 to 3.4 kg per person in 2014 (Kang *et al.*, 2014). Compared to other meats,

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†The author contributed equally to this work.

*Corresponding author

Yun-Sang Choi
Food Processing Research Center,
Korea Food Research Institute, Sun-
gnam 13539, Korea
Tel: +82-31-780-9387
Fax: +82-31-780-9076
E-mail: kcys0517@kfri.re.kr

duck meat contains lower levels of cholesterol and saturated fats and higher levels of lecithin and unsaturated fats, including omega 6 fatty acids and oleic acids. It has been reported that duck meat is an alkaline food and a high-quality protein source containing high levels of essential amino acids, as well as peptides with antioxidative effects (Muhlisin *et al.*, 2013; Nuernberg *et al.*, 2011). Previous studies have examined the nutritional characteristics of duck meat (Song *et al.*, 2013), and a comparative study evaluated duck feet gelatin prepared using different extraction methods (Park *et al.*, 2013). In contrast, few studies have evaluated processed meat products prepared using duck meat.

Since the skin of food-source animals contains various functional components including collagen, it is advantageous not only for enhancing added-value as a food material (Weiss *et al.*, 2010), but also for improving texture and increasing weight in meat products (Song *et al.*, 2014). Studies have attempted to improve the texture of semi-dried restructured jerky by the addition of chicken skin (Choi *et al.*, 2016) and the quality of low-fat sausage using a mixture of pork rind and wheat dietary fibers (Choe *et al.*, 2013); however, meat products using duck skin have not been thoroughly investigated. Duck skin contains an antioxidative peptide that reduces free radicals, as well as an inhibitor of an angiotensin-converting enzyme that causes vasoconstriction, thus lowering blood pressure and preventing cardiovascular diseases (Lee *et al.*, 2012). Studies of meat products using duck skin containing high levels of functional components may increase the utilization of duck skin, which is otherwise used in feed or discarded.

Therefore, the present study investigated the quality characteristics of duck hams by varying the ratio between duck breast meat and duck skin to improve the quality of processed duck products and generate fundamental data required for the development of new processed duck products.

Materials and Methods

Duck press ham preparation and processing

Fresh duck breast (moisture content: 73.84%, protein content: 19.87%, fat content: 5.23%) and duck skin (moisture content: 32.17%, protein content: 9.21%, fat content: 58.41%) were purchased from a local processor 48 h post-mortem. The duck breast and duck skin were initially ground through an 8-mm plate. Five different duck meat batters were produced, and the experimental design and compositions are given in Table 1. Duck breast and duck skin in this study was used as meat and fat in general meat products. Duck breast and duck skin were added with different ratio to find the proper compounding ratio. Duck breast was homogenized, ground for 30 s in a silent cutter (Cutter Nr-963009, Hermann Scharfen GmbH & Co., Germany), then chilled in iced water (2°C). Sodium chloride (1.5%), sodium nitrite (0.02%), ascorbic acid (0.06%), sugar (1.7%), and isolated soy protein (1.7%) were added to the meat and mixed for 1 min. Duck skin was added after 3 min. The duck ham batters were homogenized for 5 min. A temperature probe (Kane-May, KM 330, UK) was used to monitor the temperature of the emulsion, which was maintained below 10°C throughout batter preparation. After emulsification, the meat batter was stuffed (Stuffer IS-8, Sirman, Italy) into cellulose casings. The duck meat batters were then heated to 75°C for 30 min in a water bath, and then cooled at room temperature (21°C) for 3 h. This procedure was performed in triplicate for each duck ham.

Proximate composition

The compositional properties of the duck hams were determined using standard AOAC methods (2000). Moisture content (950.46B) was determined by weight loss after 12 h of drying at 105°C in a drying oven (SW-90D,

Table 1. Duck ham formulations with the different ratio of duck breast meat and duck skin (Units: %)

Ingredients	Treatments				
	T1	T2	T3	T4	T5
Duck breast	70	60	50	40	30
Duck skin	30	40	50	60	70
Total	100	100	100	100	100
Ice water	10	10	10	10	10
Salt	1.5	1.5	1.5	1.5	1.5
Sodium nitrite	0.02	0.02	0.02	0.02	0.02
Ascorbic acid	0.06	0.06	0.06	0.06	0.06
Sugar	1.7	1.7	1.7	1.7	1.7
Isolated soy protein	1.7	1.7	1.7	1.7	1.7

Sang Woo Scientific Co., Korea). Fat content (960.69) was determined by the Soxhlet method using a solvent extraction system (Soxtec[®] Avanti 2050 Auto System, Foss Tecator AB, Sweden) and protein content (981.10) was determined by the Kjeldahl method (Kjeltec[®] 2300 Analyzer Unit, Foss Tecator AB, Sweden). Ash was determined according to the AOAC method (920.153).

Cooking loss

The duck hams were stuffed to the initial weight and after heat processing at 75°C for 30 min, cooked samples were cooled to room temperature (21°C) for 3 h. After cooling, the cooked duck ham samples were weighed and the cooking loss was deduced.

Emulsion stability

The samples of duck ham batters were analyzed for emulsion stability using the method of Blouka and Honikel (1992) with the following modifications: total expressible fluid and fat separated at the bottom of each graduated glass tube were measured and calculated (Choi *et al.*, 2007).

pH

The pH value of each sample was measured in a homogenate prepared with 5 g of sample and 20 mL distilled water using a Model 340 pH meter (Mettler-Toledo GmbH, Switzerland).

Color

The color of each sample was determined using a colorimeter (Minolta Chroma meter CR-210, Minolta Ltd., Japan; illuminate C, calibrated with a white plate, $L^* = +97.83$, $a^* = -0.43$, $b^* = +1.98$). CIE L^* -value (lightness), CIE a^* -value (redness), and CIE b^* -value (yellowness) values were recorded.

Protein solubility

The protein solubility was determined using the method of Joo *et al.* (1999). Sarcoplasmic protein solubility and total protein solubility were determined, and myofibrillar protein solubility was obtained by determining the difference between the total and sarcoplasmic protein solubilities.

Texture profile analysis

The texture profile analysis (TPA) was performed at room temperature with a texture analyzer (TA-XT2i, Stable Micro Systems Ltd., England). The duck hams were

stuffed into cellulose casings followed by heating, and the cooked samples were cooled to room temperature (21°C) for 30 h. Duck ham samples were taken from the central portion of each sample. TPA values (pre-test speed 2.0 mm/s, post-test speed 5.0 mm/s, maximum load 2.0 kg, head speed 2.0 mm/s, distance 8.0 mm, force 5.0 g) were obtained. Hardness (kg), springiness, cohesiveness, gumminess (kg), and chewiness (kg) were determined as described by Bourne (1978).

Sensory evaluation

A trained thirty-member panel from the Food Processing Research Center at Korea Food Research Institute in Korea was used to evaluate the duck hams. Each duck ham was evaluated for color, flavor, tenderness, juiciness, and overall acceptability. The duck hams were heated at 75°C for 30 min, cooled to 21°C for 3 h, cut into quarters, and served to the panelists randomly. Panelists were instructed to cleanse their palates between samples using warm water. The qualities of the cooked samples were evaluated using a 9-point descriptive scale (1 = very undesirable, 9 = very desirable). This analysis was conducted using the Hedonic test described by Choi *et al.* (2008).

Apparent viscosity

The apparent viscosity of duck meat batter was measured in triplicate with a rotational viscometer (HAKKE Viscotester[®] 550, Thermo Electron Corporation, Germany) set at 10 rpm. The standard cylinder sensor (SV-2) was positioned in a 25 mL metal cup filled with duck ham batter and allowed to rotate under a constant shear rate (s^{-1}) for 60 s before each reading was taken. Apparent viscosity values in centipoises were obtained.

Statistical analysis

All tests were done at least three times for each experimental condition and mean values were reported. Statistical analysis was performed by using Statistical Analysis System (version 8.0, SAS Institute, USA) to calculate the average and standard deviation. When using Duncan's multiple range test method, the significance test ($p < 0.05$) was carried out through multiple tests.

Results and Discussion

Proximate composition

The proximate compositions of the duck hams formulated with different ratio of duck breast meat and duck

skin are shown in Table 2. The moisture content of duck hams decreased with increasing in the ratio of duck breast meat to duck skin ($p<0.05$), whereas the reverse correlation was observed in the fat content of duck hams ($p<0.05$), owing to the fat in duck skin. The protein and ash contents showed no significant differences between treatments ($p>0.05$). Choi *et al.* (2016) reported that the presence of skin resulted in significant increases in the fat content of meat products, which may be due to the higher fat content of chicken skin. Biswas *et al.* (2007) reported that a significant increase in fat levels of meat may be due to the addition of increased amounts of chicken skin in chicken sausage formulations. These results were consistent with those obtained by Kim *et al.* (2016) for the addition of chicken skin to chicken nuggets. These studies also showed that the moisture content of samples decreased and the fat content increased with an increase in chicken skin levels.

Cooking loss and emulsion stability

The results of cooking loss in the duck hams with different ratio of duck breast meat and duck skin are presented in Table 3. The smallest cooking loss was observed in T1 (12.25, $p<0.05$), while T5 had the highest cooking loss of

16.38% ($p<0.05$). Bhat *et al.* (2013) reported that meat-balls containing higher levels of chicken skin tended to show decrease in cooking yield, while a control sample without chicken skin gave the highest cooking yield after heating. Consistent with the results of this study, chicken nuggets with chicken skin also showed higher cooking loss than those without chicken skin (Kim *et al.*, 2016). These results may be attributable to the elution of fat and water from duck skin, and several studies have reported that cooking loss of meat products increased as skin content increased (Biswas *et al.*, 2007; Fotjik and Mandigo, 1998; Kim *et al.*, 2016).

The results for emulsion stability in duck meat batters are presented in Table 3. The highest level of fat separation in duck ham batters was observed in T4 and T5 with a value of 1.98% respectively, while T1 showed the lowest fat separation level ($p<0.05$; 80%). T4 (9.58%) and T5 (9.82%) also showed significantly higher levels of total fluid separation, whereas T1 (5.52%) and T2 (5.59%) showed lower values ($p<0.05$). This may be due to the high fat content of duck skin (Kang *et al.*, 2014). Crehan *et al.* (2000) reported that emulsified sausage generally exhibited higher levels of fat separation and fluid separation as fat content increased, which was similar to our findings.

Table 2. Proximate composition of duck ham formulations with the different ratio of duck breast meat and duck skin (Units: %)

Treatments ¹⁾	Moisture content	Protein content	Fat content	Ash content
T1	60.68±0.36 ^a	14.15±1.67	17.27±0.79 ^c	2.16±0.12
T2	60.34±0.78 ^a	13.06±0.90	18.62±0.27 ^c	2.20±0.16
T3	60.07±1.26 ^{ab}	13.19±1.27	21.82±0.94 ^{ab}	2.19±0.08
T4	58.67±0.33 ^b	13.81±0.01	23.31±0.23 ^a	2.14±0.08
T5	58.40±0.89 ^b	13.18±1.33	23.67±0.87 ^a	2.34±0.09

All values are means±SD of three replicates.

^{a-c} Values with different superscripts within a column differ significantly at $p<0.05$.

¹⁾T1: duck breast 70% + duck skin 30%, T2: duck breast 60% + duck skin 40%, T3: duck breast 50% + duck skin 50%, T4: duck breast 40% + duck skin 60%, T5: duck breast 30% + duck skin 70%

Table 3. Cooking loss and emulsion stability of duck ham formulations with the different ratio of duck breast meat and duck skin (Units: %)

Treatments ¹⁾	Cooking loss	Emulsion stability	
		Total expressible fluid separation	Fat separation
T1	12.25±0.06 ^c	5.52±1.04 ^b	0.80±0.12 ^b
T2	13.26±0.51 ^{bc}	5.59±1.13 ^b	1.20±0.56 ^{ab}
T3	14.60±0.21 ^b	7.79±1.14 ^{ab}	1.40±0.28 ^{ab}
T4	14.86±0.06 ^b	9.58±0.11 ^a	1.98±0.72 ^a
T5	16.38±1.70 ^a	9.82±0.10 ^a	1.98±0.13 ^a

All values are means±SD of three replicates.

^{a-c} Values with different superscripts within a column differ significantly at $p<0.05$.

¹⁾T1: duck breast 70% + duck skin 30%, T2: duck breast 60% + duck skin 40%, T3: duck breast 50% + duck skin 50%, T4: duck breast 40% + duck skin 60%, T5: duck breast 30% + duck skin 70%

pH and color

Table 4 shows the pH and CIE color values of duck hams depending on the ratio of duck breast meat and duck skin. Duck hams showed increasingly high pH values as the ratio of duck breast meat to duck skin decreased ($p < 0.05$). Duck skin with a high fat content has a higher pH than duck breast meat, which could result in the increased pH of duck ham as duck skin content increased (Kang *et al.*, 2014). According to a report by Lorenzo *et al.* (2011), the pH of dry cured duck sausage increased with the addition of fat, indicating that the high pH values in samples with a higher proportion of duck skin were related to the high fat content in duck skin.

Regarding lightness of duck hams (CIE L*), T5 was significantly lighter than other formulations, and lightness became significantly lower as the ratio of duck breast meat to duck skin increased ($p < 0.05$). Bonifer *et al.* (1996) found that bologna sausages became lighter as the proportion of chicken skin increased. T1 and T2 exhibited significantly higher values of redness (CIE a*), while formulations with lower ratio of duck breast meat to duck skin showed lower values of redness ($p < 0.05$). These results are consistent with those of previous studies showing that the addition of chicken skin to chicken nuggets reduced redness (Kim *et al.*, 2016). There was no significant difference in yellowness (CIE b*) among the different

formulations. Kang *et al.* (2014) reported that the tendency to show yellowness did not occur in duck meat sausage with or without duck skin.

Protein solubility

The solubility of meat proteins is dependent on sarcoplasmic, myofibrillar, and stromal proteins, which can be extracted by changing water, phosphate content, salt concentration, and pH. Myofibrillar proteins are important for improving the texture and emulsifying and water-holding capacity of meat products, and higher protein levels are generally accompanied by improved protein solubility (Choi *et al.*, 2015). The results of protein solubility analysis of duck hams in the study are presented in Table 5. For myofibrillar proteins, T1 and T2 showed the highest values, decreasing with the decreasing ratio of duck breast meat to duck skins resulted in the lowest values in T4 and T5 ($p < 0.05$). Comparison of sarcoplasmic proteins between formulations revealed the highest value in T1 ($p < 0.05$), and the sarcoplasmic protein contents significantly decreased as the ratio of duck breast meat to duck skin decreased ($p < 0.05$). This is probably due to composition dependent effect by different ratio of duck breast meat and skin. Similarly, Chin *et al.* (1998) reported that protein solubility in low-fat sausages was higher than that in the control, which was attributed to the reduced fat content and increased protein levels.

Table 4. pH and CIE L*, a*, and b* of duck ham formulations with the different ratio of duck breast meat and duck skin

Treatments ¹⁾	pH	CIE L*-value	CIE a*-value	CIE b*-value
T1	6.48±0.04 ^b	61.71±1.12 ^c	13.86±0.49 ^a	11.57±0.33
T2	6.53±0.03 ^{ab}	62.09±2.20 ^c	13.18±0.83 ^a	11.44±0.67
T3	6.54±0.01 ^{ab}	66.22±1.21 ^b	11.27±0.90 ^b	11.46±0.65
T4	6.59±0.03 ^a	66.23±2.33 ^b	10.76±1.40 ^b	11.58±0.52
T5	6.59±0.05 ^a	67.82±1.08 ^a	10.07±0.50 ^b	11.52±0.38

All values are means±SD of three replicates.

^{a-c} Values with different superscripts within a column differ significantly at $p < 0.05$.

¹⁾T1: duck breast 70% + duck skin 30%, T2: duck breast 60% + duck skin 40%, T3: duck breast 50% + duck skin 50%, T4: duck breast 40% + duck skin 60%, T5: duck breast 30% + duck skin 70%

Table 5. Protein solubility of duck ham formulations with the different ratio of duck breast meat and duck skin

Treatments ¹⁾	Protein solubility		
	Total protein	Sarcoplasmic protein	Myofibrillar protein
T1	118.65±2.53 ^a	40.05±0.44 ^a	78.60±4.40 ^a
T2	114.30±3.21 ^{ab}	36.75±1.36 ^b	77.55±2.81 ^{ab}
T3	108.35±0.57 ^b	32.30±0.70 ^c	76.05±1.10 ^b
T4	88.45±4.05 ^c	27.30±0.53 ^d	61.15±3.36 ^c
T5	86.70±6.28 ^c	23.65±0.66 ^e	63.05±2.41 ^c

All values are means±SD of three replicates.

^{a-e} Values with different superscripts within a column differ significantly at $p < 0.05$.

¹⁾T1: duck breast 70% + duck skin 30%, T2: duck breast 60% + duck skin 40%, T3: duck breast 50% + duck skin 50%, T4: duck breast 40% + duck skin 60%, T5: duck breast 30% + duck skin 70%

Texture profile analysis

Table 6 presents the texture profiles of the duck hams analyzed in the study, including hardness, springiness, cohesiveness, gumminess, and chewiness. A high content of duck skin affected hardness and springiness, resulting in the highest values for the two parameters in T1 and the lowest values in T5. There were no significant differences in hardness and springiness among T2, T3, T4, and T5 ($p < 0.05$). Gomez and Lorenzo (2013) also reported that as fat content increased in semi-dried sausages, hardness decreased. Although cohesiveness significantly differed depending on proportion of duck breast meat and duck skin, there was consistent tendency. However, gumminess and chewiness significantly increased as duck breast meat content increased ($p < 0.05$). This is in contrast with the work by Garcia *et al.* (2002), who reported no consistent differences in gumminess and chewiness of sausages depending on added fat amount. Because the high fat content of duck skin reduced the emulsifying capacity and protein solubility of duck hams, a higher amount of duck skin may decrease the texture profile.

Sensory analysis

Table 7 shows the sensory characteristics of duck hams manufactured with duck breast meats and duck skins. T1

and T2 showed significantly highest scores for color, whereas T5 had the lowest significant value ($p < 0.05$). Cengiz and Gokoglu (2007) reported that the appearance of the frankfurter-type sausages generally increased in ratings as fat content decreased. There were no significant differences in flavor among the formulations of duck hams, while T1 and T2 exhibited higher tenderness scores than others ($p < 0.05$). Despite significant differences in cooking loss between formulations, no significant difference in juiciness was observed ($p > 0.05$). For overall acceptability, T1, T2, and T3 had significantly the highest scores, while T4 and T5 had the lowest scores. Biswas *et al.* (2007) reported that the texture and overall palatability of chicken sausages significantly decreased as the fat and skin contents of the sausages increased. According to Bonifer *et al.* (1996), the addition of skin to bologna-type sausages decreased textural properties, leading to reduced overall acceptability. Therefore, adding either 70% of duck breast meat and 30% of duck skin or 60% of duck breast meat and 40% of duck skin in duck hams may result in production of duck meat products with excellent quality characteristics.

Apparent viscosity

Changes in viscosity of duck meat batter with the ratio of duck breast meat and duck skin at different times are

Table 6. Textural attributes of duck ham formulations with the different ratio of duck breast meat and duck skin

Treatments ¹⁾	Hardness (kg)	Springiness	Cohesiveness	Gumminess (kg)	Chewiness (kg)
T1	0.28±0.02 ^a	0.97±0.02 ^a	0.44±0.02 ^a	0.27±0.02 ^a	0.26±0.02 ^a
T2	0.21±0.01 ^b	0.93±0.02 ^{ab}	0.42±0.02 ^{ab}	0.20±0.01 ^b	0.19±0.01 ^b
T3	0.21±0.02 ^b	0.94±0.04 ^{ab}	0.42±0.01 ^{ab}	0.20±0.01 ^b	0.19±0.01 ^b
T4	0.18±0.02 ^b	0.90±0.07 ^{ab}	0.39±0.02 ^b	0.17±0.02 ^c	0.15±0.02 ^c
T5	0.12±0.02 ^c	0.84±0.12 ^b	0.40±0.04 ^{ab}	0.10±0.02 ^d	0.09±0.02 ^d

All values are means±SD of three replicates.

^{a-d} Values with different superscripts within a column differ significantly at $p < 0.05$.

¹⁾T1: duck breast 70% + duck skin 30%, T2: duck breast 60% + duck skin 40%, T3: duck breast 50% + duck skin 50%, T4: duck breast 40% + duck skin 60%, T5: duck breast 30% + duck skin 70%

Table 7. Sensory characteristics of duck ham formulations with the different ratio of duck breast meat and duck skin

Treatments ¹⁾	Color	Flavor	Tenderness	Juiciness	Overall acceptability
T1	7.86±0.69 ^a	7.03±0.58	7.02±0.82 ^a	7.21±0.38	7.57±0.53 ^a
T2	7.43±0.53 ^a	6.86±0.90	7.00±0.82 ^a	7.13±0.38	7.43±0.79 ^a
T3	7.14±0.38 ^{ab}	6.71±1.11	5.71±0.95 ^b	7.14±0.90	7.02±0.58 ^a
T4	6.57±0.79 ^b	5.57±1.81	4.57±0.98 ^b	7.12±1.35	5.57±0.79 ^b
T5	6.57±0.79 ^b	5.57±1.81	5.57±1.51 ^b	6.86±1.57	5.86±0.69 ^b

All values are means±SD of three replicates.

Color, flavor, tenderness, juiciness, and overall acceptability of the samples were evaluated using a 9-point descriptive scale (1 = extremely undesirable, 9 = extremely desirable).

^{a,b} Values with different superscripts within a column differ significantly at $p < 0.05$.

¹⁾T1: duck breast 70% + duck skin 30%, T2: duck breast 60% + duck skin 40%, T3: duck breast 50% + duck skin 50%, T4: duck breast 40% + duck skin 60%, T5: duck breast 30% + duck skin 70%

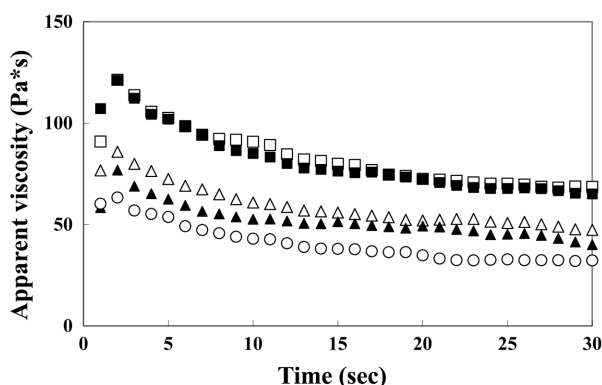


Fig. 1. Changes in apparent viscosity of duck ham formulations with the different ratio of duck breast meat and duck skin. (□) T1: duck breast 70% + duck skin 30%; (■) T2: duck breast 60% + duck skin 40%; (△) T3: duck breast 50% + duck skin 50%; (▲) T4: duck breast 40% + duck skin 60%; (○) T5: duck breast 30% + duck skin 70%.

presented in Fig. 1. Viscosity is affected by physical characteristics including water-holding capacity, protein solubility, and interactions between fats and proteins (Hamm, 1975). Initially, viscosity is high because of the high resistance caused by irregular arrays, and decreases as the molecular array becomes regular over time (Kim *et al.*, 2009). T1 and T2 had the highest viscosity of duck hams, whereas T5 with the highest duck skin content showed the lowest value ($p < 0.05$). Similarly, Hefnawy and Ramadan (2011) reported that emulsions with higher emulsion stabilities showed higher viscosity values, and Grigelmo-Miguel *et al.* (1999) also reported that emulsions with higher meat contents showed higher viscosity than those with higher fat content. Formulations with higher duck breast meat content had higher protein contents, which may have enhanced emulsifying capacity and binding capacity between emulsions, leading to high viscosity values.

Conclusion

This study evaluated the physicochemical and sensory characteristics of duck hams containing the different ratio of duck breast meat and duck skin (30-70%). As the ratio of duck breast meat and duck skin decreased, cooking loss, fat separation, and fluid separation of duck hams significantly increased. In contrast, duck hams had significantly higher values in protein solubility, hardness, springiness, cohesiveness, gumminess, and chewiness as the levels of duck skin decreased and duck breast meat increased. Comparison of sensory characteristics showed that for-

mulations with high duck breast meat content had higher scores for color, texture, and overall taste than those with high levels of duck skin. However, no significant differences were observed in flavor and juiciness of the formulations. Duck hams with proportions of 70% and 60% of duck breast meat had the highest viscosity values and viscosity decreased as duck skin content increased. In conclusion, duck hams containing 30% or 40% duck skin exhibited superior quality characteristics, which positively improved sensory palatability compared to hams with higher levels of duck skin.

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