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ARTICLE

The Ratios of Pre-emulsified Duck Skin for Optimized Processing of Restructured Ham

Jae-Yun Shim[1], Tae-Kyung Kim[2], Young-Boong Kim[2], Ki-Hong Jeon[2], Kwang-Il Ahn[1], Hyun-Dong Paik[1]*, and Yun-Sang Choi[2]*

[1]Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 05029, Korea
[2]Food Processing Research Center, Korean Food Research Institute, Wanju 55365, Korea

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***Corresponding author :** Yun-Sang Choi
Food Processing Research Center, Korean Food Research Institute, Wanju 55365, Korea
Tel: +82-63-219-9387
Fax: +82-63-219-9076
E-mail: kcys0517@kfri.re.kr

Hyun-Dong Paik
Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 05029, Korea
Tel: +82-2-2049-6011
Fax:+82-2-455-3082
E-mail: hdpaik@konkuk.ac.kr

Abstract The purpose of this study was to investigate the quality of duck ham formulated with duck skin through the pre-emulsification process. The experiments to investigate the quality characteristics of duck ham were carried out to measure proximate composition, cooking loss, emulsion stability, pH, color, texture profile analysis, apparent viscosity, and sensory characteristics. Duck ham was prepared with various ratios of duck skin in pre-emulsion as follows: Control (duct skin 30%), T1 (duck skin 20% + pre-emulsified duck skin 10%), T2 (duck skin 15% + pre-emulsified duck skin 15%), T3 (duck skin 10% + pre-emulsified duck skin 20%), and T4 (pre-emulsified duck skin 30%). As the ratio of duck skin to pre-emulsified skin changed, the quality of duck ham in terms of moisture content, fat content, cooking loss, emulsion stability, lightness, textural analysis, apparent viscosity, and overall acceptability changed. The moisture content of T2 was the highest ($p<0.05$) and that of the control and T4 was the lowest ($p<0.05$). The fat content of control was higher than all treatments ($p<0.05$). T2 had the lowest values in cooking loss, total expressible fluid, fat separation, hardness, springiness, and gumminess ($p<0.05$). The score of overall acceptability of all treatments with pre-emulsified skin was higher than control ($p<0.05$). Therefore, the pre-emulsification process can improve the quality characteristics of duck ham and 1:1 ratio of duck skin and pre-emulsified skin was the proper ratio to improve the quality characteristics of duck ham.

Keywords duck breast, duck ham, duck skin, pre-emulsification process

Introduction

Economic growth has increased meat consumption and meat production around the world (Salter, 2017). Meat is not only a major source of protein, but is also rich in micronutrients, such as vitamins and minerals (Choi et al., 2013). To manufacture a meat product, a variety of livestock are raised (Ramadhan et al., 2012). Among these livestock, duck meat is not only a popular food source in Asia but duck meat is also a rich source of unsaturated fatty acids such as linoleic acid, linolenic acid, arachidonic acid, and docosa hexaenoic acid (DHA) (Kang et al., 2014). However, duck meat and other edible parts including duck skin are not commonly used in meat products compared to other meats (Ramadhan et al., 2012; Robinson et al., 2014). Therefore, the development of new products and improvement of duck meat processing needs to be conducted to use beneficial ingredients in duck and activate duck meat market.

There are many methods to improve the quality characteristics of meat products, such as adding ingredients or mechanical processing. When manufacturing a meat product, some ingredients such as phosphate, carrageenan, konjac, and alginate are added. The incorporation of fat sometimes has been processed with pre-emulsification prior to mixing to improve its emulsion stability, water-holding capacity, and reduce cooking loss in meat products (Santhi et al., 2017; Zayas, 1985). The fat plays an important role in emulsion stability, cooking loss, flavor, and texture. Previous studies about stable emulsion systems of meat products have reported using various methods for manufacturing of processed meat. For example, smaller fat particle size can easily be surrounded by salt-solubilized proteins (Hoogenkamp, 2011). Beriain et al. (2011) also reported that pre-emulsion using sodium alginate improved the quality characteristics of low-fat sausage. Therefore, the pre-emulsion process can increase the water-holding capacity and uniform distribution of fat in meat products. According to Kim et al. (2017), who used duck skin as a fat ingredient such as pork back fat in general meat products, emulsion stability and cooking loss decreased as the ratio of duck skin increased. If duck skin goes through a pre-emulsified process using alginate, the fat in duck ham can be distributed uniformly in meat system and the quality characteristics of duck ham might be improved.

Therefore, the purpose of this study was to investigate the effect of pre-emulsified duck skin on the quality characteristics of duck hams and to determine its appropriate proportion in the duck ham.

Materials and Methods

Restructured duck 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 after 48 h post-mortem. The duck breast and skin were ground through an 8-mm plate of a meat chopper (PA-82, Mainca, Spain). Composition analysis of restructured ham was conducted according to a previous study that determined the appropriate composition of duck breast and skin. In this study, duck skin was pre-emulsified with alginate (sodium alginate 100%, ESfood, Korea) to improve the quality of duck ham. For manufacturing pre-emulsified skin, duck skin was cut in ice water containing 1% alginate by a silent cutter (Cutter Nr-963009, Hermann Scharfen GmbH & Co, Germany). The five different duck meat batters and their compositions are given in Table 1. Treatments were assigned as follows: different ratio of duck skin and duck skin curd by treatments (Control, ratio of duck skin to pre-emulsified skin = 30:0; T1, ratio of duck skin to pre-emulsified skin = 20:10; T2, ratio of duck skin to pre-emulsified skin = 15:15; T3, ratio of duck skin to pre-emulsified skin = 10:20; T4, ratio of duck skin to pre-emulsified skin = 0:30). Duck meat, duck skin and pre-emulsified skin were mixed with various additives for 10 min at a temperature below 10°C. After mixing, each duck meat batter was stuffed into a 100-mm cellulose casing. The stuffed duck meat batter was heated for 30 min at 75°C in a water bath, and then cooled at room temperature (25°C) for 1 h. Each duck meat batter mixture was produced in triplicate.

Table 1. Duck ham formulations with different ratios of pre-emulsified skin (Unit %)

Ingredients	Treatments				
	Control	T1	T2	T3	T4
Duck breast	70	70	70	70	70
Duck skin	30	20	15	10	0
Pre-emulsified skin	0	10	15	20	30
Subtotal	100	100	100	100	100
Ice water	15	15	15	15	15
Salt	1.5	1.5	1.5	1.5	1.5
Alginate	1.0	1.0	1.0	1.0	1.0
Sodium nitrite	0.02	0.02	0.02	0.02	0.02
Ascorbic acid	0.06	0.06	0.06	0.06	0.06
Sodium triphosphate	0.3	0.3	0.3	0.3	0.3
Sugar	1.5	1.5	1.5	1.5	1.5
Spice	1.2	1.2	1.2	1.2	1.2
MSG	0.1	0.1	0.1	0.1	0.1
Red colorant	0.02	0.02	0.02	0.02	0.02
Lactic acid mixture	0.2	0.2	0.2	0.2	0.2
Total	120.9	120.9	120.9	120.9	120.9

Proximate composition

The moisture, protein, and fat contents of cooked samples were determined using the methods given by AOAC (2000). The weight loss of samples dried for 12 h at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Korea) was used to determine their moisture content (950.46B). A solvent extraction system (Soxtec® Avanti 2050 Auto System, Foss Tecator AB, Sweden) was used to determine the fat content (960.69). The protein content of cooked samples measured by the Kjeldahl method (981.10) using the Kjeltec auto sampler system (Kjeltec® 2300Analyzer Unit, Foss Tecator AB, Sweden). The ash content was measured by AOAC method 920.153.

Cooking loss

The duck ham batters were stuffed into a conical tube, centrifuged for 5 min at 500 × *g*, and heated at 75°C for 30 min in water bath. Cooked samples were cooled at 25°C for 1 h. After cooling, the weight loss of the cooked samples was measured, and the difference in their weight was used as cooking loss and cooking loss was presented as a percentage (Choi et al., 2016).

Emulsion stability

The emulsion stability of duck ham was determined by the method of Bloukas and Honikel (1992) with minor modifications. After stuffing 25 g duck ham batter in a graduated glass tube, it was heated at 75°C for 30 min. After cooling at room temperature (25°C) for 4 h, the total expressible fluid and fat separated from the duck ham were measured at the bottom of a graduated glass cylinder (Choi et al., 2009).

Apparent viscosity

The apparent viscosity of duck ham batter was measured using a rheometer (Brookfiled DV3THB, Brookfield Engineering Laboratories, USA). Five milliliters of the meat batter were stuffed into the metal cup, and the SC4-29 standard spindle was used to measure the apparent viscosity of the meat batter (Choi et al., 2011). The test speed was 10 rpm for 60 s. The unit of apparent viscosity was presented as Pa·s.

pH

The pH of cooked samples was determined using a pH meter (340, Mettler-Toledo GmbH, Switzerland) calibrated using buffer solution at pH 4, 7, and 10. When measuring the pH of samples, a homogenate of 5 g of sample and 20 mL of distilled water was prepared.

Color

The color values (CIE L*-value, CIE a*-value, and CIE b*-value) of the stuffed cooked samples were measured using a colorimeter (Minolta Chroma meter CR-400, Minolta Ltd., Japan; illuminate C, calibrated with a white plate, L* = +97.83, a* = -0.43, and b* = +1.98). Each CIE L*-value, CIE a*-value, and CIE b*-value was the mean intensity of the lightness, redness, and yellowness, respectively.

Texture profile analysis

Texture profile analysis (TPA) was carried out at room temperature using a texture analyzer (TA-XT2*i*, Stable Micro Systems Ltd., England). The central portion (2.5 cm × 2.5 cm × 2.5 cm) of the cooked duck hams was used for performing the TPA (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, and force 5.0 g) and each sample was analyzed 10 times. Hardness (kg), springiness, cohesiveness, gumminess (kg), and chewiness (kg) were determined, as described by Bourne et al. (1978).

Sensory evaluation

A trained twenty-member panel from the Food Processing Research Center at Korea Food Research Institute (KFRI) in Korea was used to estimate the sensory evaluation of each cooked duck hams. The sensory evaluation criteria included appearance, color, flavor, tenderness, juiciness, and overall acceptability. After the center portions of cooled samples were cut into 2.5 × 2.5 × 2.5 cm, the 2 samples were served to panelists at two sessions. Panelists tasted the samples twice for more than 30 s, and cleansed their palates between the samples using warm water. According to the method of Choi et al. (2009), each item was evaluated using a "9-point" hedonic scale (1 = very undesirable, 9 = very desirable).

Statistical analyses

All tests were performed at least three times for each experimental condition, and the mean values and standard variation values were reported. The statistical analyses of all data were performed by SPSS Ver. 20.0 (SPSS Inc., USA). The one-way ANOVA (analysis of variance) and Duncan's multiple range tests were used to find the differences among treatments ($p<0.05$).

Results and Discussion

Proximate composition

The proximate compositions of duck ham with pre-emulsified skin are presented in Table 2. The moisture contents of treatments significantly increased with an increase in the use of pre-emulsion up to 15% ($p<0.05$). T2, which used duck skin and pre-emulsion at the same level, had the highest moisture content ($p<0.05$). In contrast, the control, which was composed of 30% duck skin, and T4, which was composed of 30% pre-emulsion, had the lowest moisture contents ($p<0.05$). In general, fat through the pre-emulsification process affected the emulsion stability and water-holding capacity of meat products due to the uniform distribution of fat particles (Zayas, 1985). Although the pre-emulsified process may positively affect the moisture content of duck ham, adding an excessive level of skin inhibited the gelling capacity of pre-emulsion using alginate in this study. The fat content of control was higher than all treatments with pre-emulsified skin ($p<0.05$). There were no significant differences between the control and treatments ($p>0.05$) for protein and ash contents. This is probably due to the same composition of ingredients, such as duck breast, duck skin, and alginate. According to Choi et al. (2009), the proximate composition of the protein, fat, and ash of meat products was affected by the ingredients added, and there was no difference in the ingredients used in this study.

Table 2. Proximate composition of duck ham with pre-emulsified skin (Unit %)

Treatments[1)]	Moisture	Protein	Fat	Ash
Control	63.88 ± 0.22^{c}	14.60 ± 0.91	10.82 ± 0.98^{a}	2.38 ± 0.11
T1	66.05 ± 0.61^{b}	15.53 ± 0.62	9.16 ± 0.90^{b}	2.29 ± 0.26
T2	68.89 ± 0.97^{a}	16.08 ± 0.83	9.38 ± 0.74^{b}	2.51 ± 0.12
T3	66.25 ± 1.10^{b}	15.83 ± 0.99	9.43 ± 0.83^{b}	2.44 ± 0.14
T4	63.95 ± 1.39^{c}	16.14 ± 0.87	9.82 ± 0.51^{b}	2.64 ± 0.15

All values are means ± SD of three replicates.

[a-c] Values with different superscripts within a column differ significantly at $p<0.05$.

[1)]Control: duck skin 30%, T1: duck skin 20% + pre-emulsified skin 10%, T2: duck skin 15% + pre-emulsified skin 15%, T3: duck skin 10% + pre-emulsified skin 20%, T4: pre-emulsified skin 30%.

Cooking loss and emulsion stability

When heating the meat products, their proteins were denatured by the heat, decreasing the water-holding capacity and emulsion stability. This resulted in water and fat loss in the meat product (Choi et al., 2009). Therefore, cooking loss indicated how much water and fat molecules protein can hold in meat products. The cooking loss in duck ham with pre-emulsified skin is presented in Table 3. The cooking loss of the treatments was significantly affected by the addition level of the pre-emulsion ($p<0.05$) and all treatment had lower value in cooking loss than the control ($p<0.05$). In addition, cooking loss of T4 was higher than that observed in other treatments ($p<0.05$), cooking loss of T4 was lower than that of control ($p<0.05$). T2 showed the lowest cooking loss ($p<0.05$). Andersson et al. (2000) observed the fat loss of emulsion sausage containing the emulsified fat, was lower than that of a beef burger composed of loosely connected fat. Pintado et al. (2016) reported that frankfurters composed of the pre-emulsified fat with alginate had lower cooking loss compared to frankfurters that were not composed of emulsion gels.

The emulsion stability for duck ham with different ratios of pre-emulsified skin are shown in Table 3. The tendency of the total expressible fluid separation of duck ham was similar to cooking loss. The control sample showed the highest value in total expressible fluid separation (p<0.05). T2, which was composed of 15% duck skin and 15% pre-emulsion, showed the lowest (p<0.05) values in total expressible fluid and fat separation. The decline in the values may be due to the stability of emulsion gels (Pintado et al., 2016). The emulsion stability of meat products can be an important indicator in the quality properties of duck ham. The increase in the moisture content and decrease in the total expressible fluid separation and cooking loss indicated that the pre-emulsion can hold water and fat components in duck ham. T4 had lower emulsion stability than the other treatments (p<0.05). This lower emulsion stability may be due to the limited water and fat holding capacity of alginate (Beriain et al., 2011; Pintado et al., 2016).

Table 3. Cooking loss and emulsion stability of duck ham with pre-emulsified skin (Unit %)

Treatments[1)]	Cooking loss	Emulsion stability	
		Total expressible fluid separation	Fat separation
Control	24.75 ± 0.27[a]	16.05 ± 0.45[a]	6.39 ± 0.01[a]
T1	15.95 ± 1.62[c]	10.66 ± 0.61[c]	3.46 ± 1.01[b]
T2	10.60 ± 0.69[d]	7.66 ± 0.46[d]	1.73 ± 0.23[c]
T3	14.74 ± 0.94[c]	10.66 ± 0.61[c]	3.33 ± 0.83[b]
T4	19.10 ± 0.63[b]	12.31 ± 1.21[b]	6.79 ± 0.39[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)]Control: duck skin 30%, T1: duck skin 20% + pre-emulsified skin 10%, T2: duck skin 15% + pre-emulsified skin 15%, T3: duck skin 10% + pre-emulsified skin 20%, T4: pre-emulsified skin 30%.

Apparent viscosity

Apparent viscosity changes in the duck ham batter with different levels of pre-emulsified skin are shown in Fig. 1. Apparent viscosity of meat products is related to the interaction between molecular and quality characteristics of the meat products, such as the moisture, protein and fat content, emulsion stability, and water-holding capacity (Balejko et al., 2012; Hamm, 1975). The rheological features of all duck ham samples showed a thixotropic behavior, which is

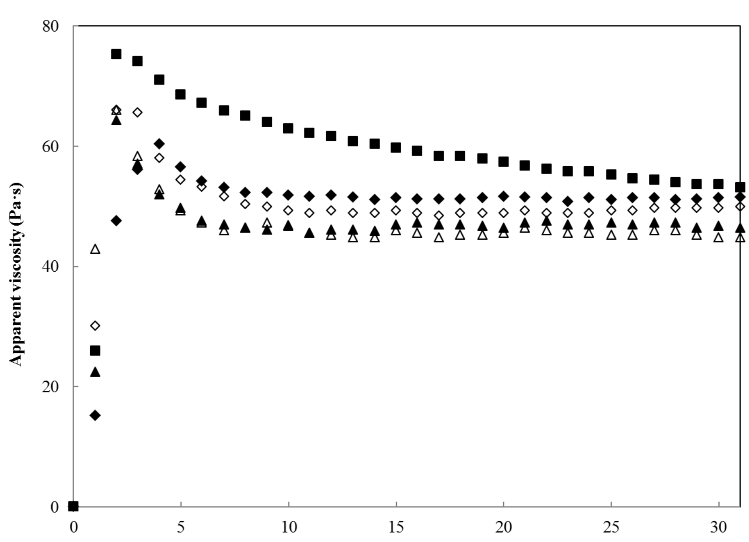

Fig. 1. **Apparent viscosity of duck ham batter with pre-emulsified skin.** (◆) Control: duck skin 30%, (▲) T1: duck skin 20% + pre-emulsified skin 10%, (◇) T2: duck skin 15% + pre-emulsified skin 15%, (△) T3: duck skin 10% + pre-emulsified skin 20%, (■) T4: pre-emulsified skin 30%.

time-dependent (Hsia et al., 1992). The apparent viscosity of all duck ham treatments decreased with time, and T4 had the highest maximum apparent viscosity ($p<0.05$). This result indicated that the pre-emulsified skin affected the apparent viscosity, and it increased the amount of fat particles that can emulsify with water and salt-solubilized proteins (Zayas, 1985). According to Choi et al. (2009), the apparent viscosity of meat batter had a high correlation with emulsion stability. The apparent viscosity of T4 was the highest at all time points ($p<0.05$).

pH and instrumental color

The pH values of duck hams with different ratios of pre-emulsified skin are presented in Table 4. The pH values were not significantly different ($p>0.05$) among control and all treatments. In general, the pH values of meat products are affected by various ingredients, such as protein, water, fat, and some additives (Choi et al., 2009). According to Kim et al. (2017), the pH of duck ham was affected by the level of duck skin, which had a pH value higher than that of duck breast meat. There was no difference in the ingredients used in this study; only the processing method was different. Therefore, a similar trend in pH values was expected. Furthermore, meat at pH 6.5 had higher emulsion stability than that at pH 5.5 (Santhi et al., 2017). The duck hams that had a high pH of 6.37–6.39 may have led to good emulsion stability.

Table 4. pH and CIE L*, a*, and b* of duck ham with pre-emulsified skin

Treatments[1)]	pH	CIE L*-value	CIE a*-value	CIE b*-value
Control	6.38 ± 0.02	58.36 ± 1.74[b]	15.57 ± 0.48	12.27 ± 0.59
T1	6.39 ± 0.02	58.50 ± 1.59[b]	15.62 ± 1.03	12.20 ± 0.84
T2	6.38 ± 0.01	58.41 ± 1.87[ab]	15.63 ± 1.04	12.28 ± 0.43
T3	6.38 ± 0.01	59.37 ± 1.35[a]	15.53 ± 0.86	12.24 ± 1.04
T4	6.37 ± 0.01	59.47 ± 1.28[a]	15.69 ± 1.11	12.64 ± 0.93

All values are means ± SD of three replicates.
[a,b] Values with different superscripts within a column differ significantly at $p<0.05$.
[1)]Control: duck skin 30%, T1: duck skin 20% + pre-emulsified skin 10%, T2: duck skin 15% + pre-emulsified skin 15%, T3: duck skin 10% + pre-emulsified skin 20%, T4: pre-emulsified skin 30%.

Table 4 shows the color values of duck hams with different ratios of pre-emulsified skin. While T3 and T4 had the highest lightness (CIE L*-value) ($p<0.05$), the control and T1 had the lowest lightness ($p<0.05$). T2 had no significant difference in lightness compared to the control and other treatments ($p>0.05$). Bishop et al. (1993) reported that pre-emulsified fat increased the lightness of the meat product due to the uniform distribution of emulsified fat. Therefore, uniform distribution of duck skin affected the lightness of the duck ham. In this study, the lightness of treatments was increased with the increasing level of pre-emulsion. The redness (CIE a*-values) and yellowness (CIE b*-values) of samples were not different from each other among the treatments ($p>0.05$). According to Kang et al. (2014), duck skin had no effect on the redness and yellowness of duck sausage. Kim et al. (2017) also reported similar results that showed no difference, regardless of duck skin content, which is consistent with our results.

Texture profile analysis (TPA)

The texture profile analyses of duck ham mixed with pre-emulsified skin are shown in Table 5. The hardness, springiness, cohesiveness, gumminess, and chewiness of treatments with pre-emulsified skin were lower than those of the control ($p<0.05$), and T2 showed the lowest hardness, springiness, and gumminess ($p<0.05$). Moisture content of duck hams seems to have affected the texture attributes. Thus this is can be explained that as moisture content increased, the hardness of duck ham decreased, which was in agreement with earlier findings by Bishop et al. (1993). According to Herrero et al. (2008), who compared the tensile properties of cooked meat products and determined the correlation between texture profile analyses and the moisture content, the hardness of a cooked meat product was affected by its moisture content, regardless of the types of meat product. The moisture content of duck ham was affected by the pre-emulsion processing method that can increase the water-holding capacity of the meat product (Santhi et al., 2017). According to Afoakwa et al. (2008), furthermore, emulsion composed the smaller fat particle size, that had the lower hardness and this trend was observed in this study. Thus, adding pre-emulsified duck skin has to be controlled to prepare duck ham with a proper texture.

Table 5. Textural attributes of duck ham with pre-emulsified skin

Treatments[1)]	Hardness (kg)	Springiness	Cohesiveness	Gumminess (kg)	Chewiness (kg)
Control	1.40 ± 0.18^{a}	0.77 ± 0.06^{a}	0.61 ± 0.05^{a}	0.86 ± 0.15^{a}	0.66 ± 0.12^{a}
T1	0.61 ± 0.05^{b}	0.57 ± 0.06^{b}	0.44 ± 0.04^{b}	0.27 ± 0.04^{b}	0.15 ± 0.04^{b}
T2	0.27 ± 0.11^{d}	0.43 ± 0.05^{c}	0.37 ± 0.05^{c}	0.10 ± 0.05^{c}	0.04 ± 0.02^{c}
T3	0.43 ± 0.09^{c}	0.56 ± 0.06^{b}	0.44 ± 0.03^{b}	0.19 ± 0.04^{b}	0.11 ± 0.03^{bc}
T4	0.47 ± 0.08^{c}	0.55 ± 0.04^{b}	0.41 ± 0.04^{bc}	0.19 ± 0.02^{b}	0.10 ± 0.02^{bc}

All values are means ± SD of three replicates.
[a-d] Values with different superscripts within a column differ significantly at $p<0.05$.
[1)]Control: duck skin 30%, T1: duck skin 20% + pre-emulsified skin 10%, T2: duck skin 15% + pre-emulsified skin 15%, T3: duck skin 10% + pre-emulsified skin 20%, T4: pre-emulsified skin 30%.

Sensory analysis

Sensory analyses of duck ham formulated with various amounts of pre-emulsified skin are shown in Table 6. The sensory scores for appearance, flavor, tenderness, and overall acceptability of treatments were higher than those of the control ($p<0.05$), and the control had the lowest scores in all sensory items ($p<0.05$) except for color. There were no significant difference between treatments ($p>0.05$) for appearance. The scores for appearance of all treatments except T4 were higher than that of control ($p<0.05$). T4 had lower ratings for flavor, tenderness and overall acceptability among the treatments ($p<0.05$). T2 and T3 had the highest value in tenderness. Kim et al. (2014) found that addition of the proper level of pre-emulsion was critical to sensory properties. They also reported that treatments produced with fat alone, without pre-emulsion, had the lowest scores in overall acceptability. A previous study that investigated sausages made with olive oil emulsified alginate showed no significant difference in appearance and had higher scores for taste (Beriain et al., 2011).

Table 6. Sensory characteristics of duck ham with pre-emulsified skin

Treatments[1)]	Appearance	Color	Flavor	Tenderness	Juiciness	Overall acceptability
Control	5.27 ± 1.04^{b}	7.72 ± 0.76	4.88 ± 0.83^{c}	4.38 ± 1.69^{c}	4.52 ± 0.92^{b}	4.88 ± 0.83^{c}
T1	6.88 ± 0.95^{a}	7.53 ± 0.93	6.63 ± 0.52^{a}	6.62 ± 0.56^{b}	6.13 ± 0.83^{a}	6.38 ± 0.52^{ab}
T2	7.24 ± 0.99^{a}	7.54 ± 0.98	7.04 ± 0.28^{a}	7.65 ± 0.54^{a}	6.74 ± 1.05^{a}	7.03 ± 0.91^{a}
T3	6.76 ± 1.04^{a}	7.78 ± 0.46	7.13 ± 0.83^{a}	7.03 ± 0.47^{ab}	5.76 ± 1.06^{a}	6.14 ± 1.02^{ab}
T4	6.03 ± 0.93^{ab}	7.75 ± 0.46	6.02 ± 0.17^{b}	6.64 ± 0.62^{b}	6.03 ± 0.93^{a}	5.77 ± 1.04^{bc}

All values are means ± SD of three replicates.
Appearance, 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-c] Values with different superscripts within a column differ significantly at $p<0.05$.
[1)]Control: duck skin 30%, T1: duck skin 20% + pre-emulsified skin 10%, T2: duck skin 15% + pre-emulsified skin 15%, T3: duck skin 10% + pre-emulsified skin 20%, T4: pre-emulsified skin 30%.

Conclusion

The different levels of pre-emulsified skin affected the quality characteristics of duck ham such as moisture content, fat content, cooking loss, total expressible fluid separation, lightness, textural attributes, and overall acceptability. The addition of proper level of pre-emulsion is a major part of improving the quality characteristics of duck ham. The proper ratio of duck skin and pre-emulsified skin was founded to be 1:1 (15%:15%) with the lowest cooking loss, effective emulsion stability, and the highest scores for overall acceptability. Therefore, pre-emulsion can improve the quality characteristics of duck ham when mixed at a 1:1 ratio of duck skin and pre-emulsion.

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