Effect of orifice size on quality characteristics of burger made from spent laying duck meat

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Abstract. An experiment was carried out to investigate the influence of orifice size (4.5, 6, 8 and 10 mm) on the quality characteristics and acceptability of duck burger made from spent laying Khaki Campbell duck meat. Large orifice size resulted in lower fat and protein content compared to small orifice size. Hardness value also decreased significantly (p < 0.05). However, there was no significant difference (p > 0.05) in the diameter of shrinkage, cooking loss and colour of the burger. However, the hardness value decreased significantly with an increase in orifice size. The sensory evaluation showed no significant difference (p > 0.05) within the samples, but the overall acceptability score for burger prepared using 10 mm grind size was higher compared to those prepared at 4.5, 6 and 8 mm orifice sizes. Hence the 10 mm grind size was adopted as the optimum orifice size for spent laying Khaki Campbell duck burger.

Keywords: Grinding, duck meat, orifice size, burger quality, spent laying duck

1. Introduction
Duck meat production has increased in last two decades and in 2008 to 2018, world duck meat has seen an increase of 3.6 million tonnes to 4.4 million tonnes and the output grew at an annual average rate of 3.4 %. Currently, duck meat production has been dominated by Asia and accounted for 80 % of the total duck meat produced worldwide [1]. In Asia, duck is the most widely produced poultry meat in the world after chicken and turkey, and Malaysia is the fifth largest producer of duck meat after China, France, Myanmar and Vietnam [1]. Additionally, most of the local breeds are use for egg production and meat by-products [2]. Some studies have reported that washing duck meats with solutions such as sodium bicarbonate, sodium chloride, sodium phosphate buffer, tap water, etc., can improve its functional properties [3,4,5]. By-products of duck meat industry such as duck feet and duck skin have also been shown to be potential materials for alternative gelatin production [6,7,8,9,10].

The consumption of duck meat has been dominated by the Chinese in Malaysia and duck meat is mostly found in Chinese markets. The duck meats are available only in particular forms such as roasted duck and smoked duck [11]. In fast food industry, products from duck meat based is not easy to find. Usually, fast food such as burger, meatballs, sausages and nuggets are made from fish meat based,
chicken meat based and beef meat based. For this reason, mechanically deboned meat from spent laying duck meat could be used in fast food products to form variety of products [12].

Previous study of the production of burger from duck meat found that patties made from duck meat had lower emulsion stability and cooking yield compared with chicken patties [13]. It has also been reported that duck meat had higher cooking loss, darker colour and more rapid decline of shear force during storage compared to chicken meat [14]. In this study, the spent laying duck meat were ground with meat grinder of different orifice size (4.5, 6, 8 and 10 mm) and evaluated for their chemical, physical and sensory properties after being used for burgers. The analysis conducted in this study was chemical analysis including moisture, fat and protein content. Other analyses done were texture, colour, sensory evaluation, diameter shrinkage and cooking loss.

2. Materials and methods

2.1 Material

Frozen Khaki Campbell duck meat with Halal Certificate was obtained from local supplier at Changkat Jering, Perak, Malaysia. Fine salt (Tesco Brand of Nago Food Industries Sdn Bhd), vegetable shortening (Nona brands Malaysia Sbn Bhd), tapioca flour (Cap Kapal ABC), and Prai coarse sugar (Malayan Sugar MFG Sdn Bhd) were obtained from a supermarket (Tesco) in Sungai Dua, Penang. Konjac powder, soy protein isolate and condiment powder (consisting of garlic, onion and black pepper) were obtained from Sim Company Sdn Bhd, Penang.

2.2 Grinding of meat into different orifice sizes

The frozen deboned duck meat was thawed inside a chiller at 5-7°C for 24 hours before burger production. Then, the duck meat was grind by using meat grinder with four different orifice size of 4.5, 6, 8 and 10 mm (model EVE/ALL-12, Rheninghaus Srl, Torino, Italy).

2.3 Burger preparation

Ingredients for the formulation of duck burger were Duck meat (75%), Tapioca flour (5%), Konjac powder (1%), Vegetable shortening (2.5%), Soy protein isolate (5%), Salt (1.5%), Sugar (0.5%), Condiment powder (3%) and Ice flakes (9%). The duck burgers were prepared according to the method of [15] and [16]. Konjac powder and salt were mixed up together with the minced meat manually for 3 minutes until a meat batter was formed. Vegetable shortening, ice flakes, soy protein isolates, tapioca starch, sugar and condiment powder were blended together by using mixer (Blixer, Robot Coupe USA Inc.) for one minute. Next, the meat batter was mixed with the blended ingredients using the mixer for 5 minutes to ensure that all the ingredients were thoroughly mixed. Finally, the patties (55 g of the final meat batter) were formed by using a burger press (Fimar S.p.a., Rimini, Italy). All the procedures were done under controlled temperature below 4°C to avoid microbial contamination. Molded burgers were frosted in a blast freezer for 3 hours at -18°C and finally stored in a commercial freezer. To get an accurate result, the experiments were conducted twice and the analyses were triplicated for each sample.

2.4 Cooking of burger

The burger was cooked (griddled) on a hot plate (Tefal Plancha, Groupe SEB, Canohes, France) for 8 min at medium heat (level 3 out of 5). Each side of burger was cooked 4 minutes and flipped for another 4 minutes until a well-cooked burger obtained [17].

2.5 Chemical composition

The moisture, protein and fat content of duck burgers were determined according to standard AOAC method [18]. Moisture content was determined by drying 10g samples in drying oven at 100-105°C overnight until constant weight was achieved. Then the dried sample was used for determination of crude fat by Soxhlet method. Meanwhile, determination of crude protein was done by Kjeldahl method
to obtain nitrogen content which was multiplied by 6.25 (a constant for conversion of free nitrogen content to crude protein).

2.6 Colour analysis
The colour surface for raw and cooked patties were measured by using colorimeter Minolta Spectrophotometer (Model CM-3500D with Spectramagic software, Japan). The colorimeter was calibrated by using zero calibration box (CM-A100), followed by white calibration plate (CM-A120). Target mask was used where the sample was placed onto the calibration glass on the optical centre and covered with a black container. The parameters determined were L*, a* and b*. L* stands for lightness (L*=100 is the lightest and L*=0 is the darkest). a* represents the redness (red +60 to green -60) and b* refers to the yellowness (yellow +60 to -60).

2.7 Texture Profile Analysis (TPA)
Texture profile analysis of cooked duck burger were measured by using Texture Analyzer TA-XT2 (Stable Micro Systems, Surrey, UK) [19]. The sample was cut into cubic size (2 x 2 x 0.5 cm) after cooking and subjected to a texture profile analyzer. Before analysis, the texture analyzer was equipped with 30 kg load cell and calibrated with 5 kg cylindrical probe. The samples were compressed to 70% of their original height using P75 probe type. The parameters measured included hardness, chewiness, cohesiveness, cohesiveness, springiness and gumminess. Hardness indicates the highest peak force obtained on first compression. Cohesiveness refers to the ratio of positive force area on the curve during second pressing to that of the first pressing. Gumminess is a product of hardness and cohesiveness, while chewiness was calculated as the product of gumminess and springiness. Lastly, springiness is defined as the recovery of the food height between the end of first compression cycle and the start of second cycle [20,21].

2.8 Diameter shrinkage
The diameter of burger was measured before being cooked. Diameter shrinkage was calculated by the difference in diameter (cm) between uncooked and cooked burger divided by the diameter (cm) of uncooked burger [17].

2.9 Cooking loss
The burger was weighed before being cooked. All the burgers were cooked for 8 min. Percentage cooking loss was determined by using weight differences between burger before and after cooking divided by the weight of uncooked burger [17].

2.10 Sensory evaluation
Sensory evaluation was performed with hedonic test [22]. The samples were evaluated by using 7 point hedonic scale. Thirty untrained panelists consisting of students from School of Industrial Technology evaluated the samples by using 7 point hedonic scale. The burgers were cut into 8 pieces and all four samples were presented all at once for each phase. The samples were coded with 3-digit random numbers and evaluated for its colour, hardness, chewiness, flavour, juiciness and overall acceptability. The ratings for the samples were ranged from dislike very much (1) to like very much (7).

2.11 Statistical analysis
This study was carried out in two batches with all measurements done in triplicates. Therefore, values given in the tables and figures are the means of sextuplicate. Statistical analysis was done using SPSS software version 17.0. Significant differences among means were evaluated by one way ANOVA test at 5% level of probability (p<0.05). The results were expressed as mean value ± standard deviation.
3. Result and discussion

3.1 Chemical composition

The chemical composition of raw duck meat and duck burger made from orifice size 4.5 and 10 mm were analyzed and presented in table 1. The moisture content varied from 66.87 - 69.94%. As compared to raw meat from Khaki Campbell, the moisture content was 65.71. Significant differences (p < 0.05) were observed for moisture between the samples. It was clear that the differences in orifice size affected the moisture content of the burgers. The large orifice size showed the highest percentage of moisture, which means that 10 mm orifice size squeeze meat less and release low amount of water. The moisture content from the study were not significantly different (P >0.05) with 3, 4 and 6 mm orifice size with value between 61.21 – 61.63% [23].

| Table 1. Chemical composition for samples with different orifice size. |
|---------------------------------------------------------------|
| Sample | Moisture (%) | Fat (%) | Protein (%) |
|--------|--------------|---------|-------------|
| 4.5 mm | 66.80 ± 0.80b | 4.87 ± 0.27a | 18.25 ± 1.69a |
| 10 mm  | 69.94 ± 0.37a | 4.74 ± 0.40a | 15.71 ± 1.32b |

Mean values ± standard deviation (n=6). Means within columns followed by different letter indicate significant difference (P<0.05).

Fat contents ranged from 4.74-4.87%. According to Malaysian Food Regulation, fat content in processed meat products should not exceed 30% [24]. Hence, the duck burgers made from different orifice size followed the regulation in terms of fat content. Fat, as a meat component, contributes the flavour, juiciness, texture and appearance to meat and increase the feeling of satiety [25]. There was no significant difference (p >0.05) in fat content as the orifice size increased. The fat content is said to decrease by mechanical action of grinding process. However, the grinding process did not affect the fat content of the duck meat mince. When compared with raw meat without applying grinding process, the fat content was 7.15%. Burger with fat content of 10% or below is a low-fat burger [17,23,26]. So, the burgers made from 4.5 to 10 mm orifice size are considered as low fat burgers.

According to the results of this study, the protein content ranged from 15.71 – 18.25%. A significant (p <0.05) decreased for large size in protein content is related to the increase in moisture content. Duck burger with small orifice size (4.5 mm) had higher protein content than the burger with large orifice size (10 mm). Compared with raw meat Khaki Campbell without any treatment, the protein content was slightly higher which is 19.80%. In addition, the grinding process significantly lowered the protein content and was significant for larger orifice size. Based on food regulation of Malaysia, processed meat products shall contain not less than 10.625% protein content [24]. So, the burgers with different orifice sizes had sufficient protein content and complied with the Malaysian Food regulation 1985. The protein content in this study was not as low as that for duck burger reported previously by Ramadhan [16].

3.2 Colour analysis

Colour of burger plays a crucial role in determining the freshness of meat products and acceptability by consumers. It is also important to determine the colour of cooked burger to meet consumer perception. Colour properties of uncooked and cooked duck burgers are shown in figure 1. – 3. The analysis for colour (L*) is showed in figure 1. Trend for uncooked burger at 6 – 10 mm decreased, meanwhile 4.5 mm showed lower L* than other samples. L* values for the raw burgers were in the order of 6mm > 8mm > 10mm > 4.5mm. After cooking, there was no significant difference (P>0.05) at different orifice size. Orifice size did not affect the L* of the cooked burgers. The value of L* for the cooked burgers were in order of 8mm > 6mm > 4.5mm > 10mm. However, the L* value for cooked burger was much higher than that reported by Ramadhan [16], which was 30.64. L* might be affected by the raw material used. In the present study, whole duck meat was used to make duck burger. Different level of hemoglobin (compound that has an obvious effect on colour characteristic) is due to differences in animal species and anatomical location of muscle [27].
Figure 1. L* values for different orifice size of uncooked and cooked duck burgers. Error bars indicate the mean values ± standard deviations of average readings from the duck burger samples. Means with different letters show significant difference (P < 0.05) from other bars.

Figure 2 shows the redness (a*) value for uncooked and cooked duck burgers. As can be seen from the figure, a* of burger was higher when passed through small orifice than large orifice. It is related with protein content. Higher protein content means a lot of protein component (heme protein, hemoglobin) is retained after grinding. The lower redness could be due to a greater reduction of the native heme protein [28]. The trend of the result for cooked burger was also similar. In contrast, Ramadhan [16] reported high a* values for duck burger after cooking which was 7.96. Meanwhile, the result from Ramadhan [29] using chicken burger showed an increased from 0.97-5.89 before cooking to 2.55-9.07 after cooking. This might be due to higher red muscle fibre in duck meat compared to chicken [30].

According to figure 3, there was no significant different (p >0.05) in term of yellowness (b*) between the uncooked and cooked duck burgers. Orifice size did not affect the yellowness of the burgers. The b* value for uncooked duck burger was higher compared to the a* value in figure 2. On the other hand, after the burgers were cooked, the b* values were higher than a* values, which means that duck meat burgers tended to be yellow and blue colour. During cooking, heme protein becomes denatured and colour alteration occurs in meat, iron will be oxidized into ferric and heme pigment remains intact [31].
3.3 Texture profile analysis

Texture profile analysis of duck meat burger was analyzed by using a texture analyzer. This analysis was performed for the textural properties of cooked duck burger. The result for texture profile analysis is shown in Table 2.

| Sample | Hardness (kg) | Cohesiveness (mm/mm) | Springiness (mm/mm) | Gumminess (kg) | Chewiness (kg/mm) |
|--------|---------------|-----------------------|---------------------|----------------|-------------------|
| 4.5 mm | 17.96 ± 2.74a | 0.42 ± 0.02a          | 0.87 ± 0.22a        | 7.49 ± 1.14a   | 7.24 ± 1.23a      |
| 6 mm   | 16.41 ± 1.02a | 0.38 ± 0.04b          | 0.97 ± 0.03a        | 6.24 ± 1.60ab  | 6.09 ± 1.65a      |
| 8 mm   | 16.37 ± 2.69a | 0.38 ± 0.02b          | 0.94 ± 0.05a        | 6.62 ± 1.39ab  | 5.92 ± 0.94a      |
| 10 mm  | 13.25 ± 1.47b | 0.38 ± 0.02b          | 0.86 ± 0.05a        | 5.02 ± 0.83b   | 4.32 ± 0.66b      |

Mean values ± standard deviation (n=6). Means within columns followed by different letter indicate significant difference (p < 0.05).

Generally, orifice size had no significance effect (p < 0.05) on springiness of the samples which means that it can maintain the food height after the first compression better. However, the duck burger from 4.5mm was highest in hardness, cohesiveness, gumminess and chewiness compared to other samples. Meanwhile, the 6mm duck burger had higher springiness than the other samples. According to the result, there was a reduction trend in terms of hardness of the burger as the orifice size becomes larger. This is due to the moisture content of the burger. Texture of the burger is contributed by the moisture. The higher the moisture, the softer the texture. The results shown in Table 2 are in contradiction to the work of previous report that found hardness value for unwashed duck burger to be 5.92 kg [16]. This contradiction is due to the differences in animal species and age. Spent duck meat contains more connective tissue and makes meat tougher. Besides the quality of raw material used, the addition of several ingredients also affected the texture of the burgers. The addition of whey protein concentrate at certain concentration is capable of increasing the hardness and chewiness value of burgers [32].

Another source of game meat that is processed into burger is ostrich which had lower hardness values of 3.21-11.36 kg [33]. Other than that, fish burger had less hardness, but was more cohesive, chewy and springy [34]. Meanwhile, beef burger showed higher range of hardness which is 23.28-42.14 kg [31]. Hardness values are commonly associated with the amount of stromal protein in the meat; beef contains around 16-28%, poultry about 10-15% and fish 2-3% [35].
3.4 Diameter shrinkage and cooking loss
Table 3 shows the physical analysis for different orifice size of duck burger. The denaturation of protein in burger resulted in major alterations in structure of burger. The most commonly observed was the decrease in diameter due to shrinkage [36].

Table 3. Diameter Shrinkage and cooking loss for burger samples from different orifice size.

| Sample  | Diameter shrinkage (%) | Cooking loss (%) |
|---------|------------------------|-----------------|
| 4.5 mm  | 10.71 ± 4.73ab         | 10.33 ± 2.54a   |
| 6.0 mm  | 8.56 ± 1.13b           | 10.08 ± 1.98a   |
| 8.0 mm  | 9.20 ± 1.14b           | 9.52 ± 1.27a    |
| 10 mm   | 12.76 ± 2.57a          | 10.45 ± 2.29a   |

Mean values ± standard deviation (n=6). Means within columns followed by different letter indicate significant difference (p<0.05).

The diameter shrinkage ranged from 8-13%, which is similar to shrinkage of commercial burger reported to be 2-10% [29]. According to the table, the larger the orifice size, the larger the diameter shrinkage. The result was supported by cooking loss. The cooking loss ranged from 9-10% and the degree of cooking loss were in range with a study by Ramadhan [29] which reported a range of 5-25%. On the other hand, there were no significant differences (p>0.05) in cooking loss for all the orifice size. Cooking loss is higher for patties with higher fat than those with lower fat [37]. Cooking loss occur during cooking process because of the loss of moisture and fat [38].

Shrinkage is an important parameter because meat burger is usually served in burger buns, and if the burger shrinks excessively, the bun might not fill properly leading to an unappealing product [39]. The retention of size and shape of burger during cooking improved at middle orifice. Higher shrinkage was observed in the 10mm orifice size compared with the other orifice sizes. Shrinkage in patties during heating is caused by muscle protein denaturation and partly from the evaporation of water and drainage of melted fat and juices [36]. These structural alterations influence the texture quality of cooked burger.

3.5 Sensory evaluation
Sensory evaluation scores for duck burger made with different orifice sizes are shown in table 4. As shown in table 4, sensory evaluation for all cooked duck burgers received similar scores and were not significantly different (p>0.05) for all the attributes. A similar finding was reported by Egbert [40] who found that overall palatability of low-fat ground beef product were improved by final grinding through 0.48 cm rather than 0.32 cm plate. However, these findings were contrary to the observation in which the juiciness, texture and overall acceptability of low-fat ground buffalo meat patties prepared at 3 mm were higher compared to those prepared using 4 and 6 mm grind sizes [23]. There were no significant differences (p>0.05) between the samples. Nonetheless, juiciness and overall acceptability were maximum for duck burger at 10 mm orifice size, it was adopted as optimum grind size for further experiment with respect to washing treatment.

Table 4. Sensory evaluation for samples with different orifice size.

| Attributes  | 4.5 mm       | 6 mm        | 8 mm        | 10 mm       |
|------------|--------------|-------------|-------------|-------------|
| Colour     | 4.37 ± 1.47a | 4.70 ± 1.29a| 4.60 ± 1.25a| 4.67 ± 1.21a|
| Odour      | 4.90 ± 1.18a | 4.90 ± 1.12a| 4.73 ± 1.05a| 4.60 ± 1.00a|
| Flavour    | 5.33 ± 1.30a | 5.00 ± 1.26a| 5.17 ± 1.02a| 5.03 ± 1.30a|
| Hardness   | 4.97 ± 1.07a | 5.10 ± 1.06a| 4.83 ± 1.29a| 5.10 ± 1.12a|
| Chewiness  | 5.00 ± 1.07a | 5.33 ± 0.66a| 4.97 ± 1.07a| 5.20 ± 0.96a|
| Juiciness  | 4.70 ± 1.34a | 4.63 ± 1.27a| 4.70 ± 1.39a| 4.93 ± 1.23a|
| Overall    | 5.07 ± 0.91a | 5.17 ± 1.02a| 4.97 ± 1.13a| 5.17 ± 1.05a|

Mean values ± standard deviation (n=6). Means within rows followed by the same letter indicates non-significant difference (P>0.05).
4. Conclusions
Different orifice sizes used to make duck burger from spent laying Khaki Campbell had significantly positive effects on the chemical composition, physical characteristics and sensory attributes. Among all the orifice size, 10 mm showed to be the best to produce preferable duck burger. The 10 mm orifice size resulted in lower fat content and softer textured duck burger. There were no significant differences in terms of colour, diameter shrinkage and cooking loss for all the burger with different orifice sizes. The diameter shrinkage was not in range with commercial burger. As for sensory evaluation, most of the panelists preferred 10 mm orifice size duck burger compared to other sizes.

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