Effect of washing treatment on quality characteristics of burger made from spent laying duck meat

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Abstract. Experiment was carried out to investigate the influence number of washing treatment (without, single and double washing) on the quality characteristics and acceptability of duck burger made from spent laying Khaki Campbell duck meat. The chemical composition of burger at different number of washing treatment was varied in terms of moisture content, fats and protein content. The number washing cycles treatment were found to increase moisture content and reduce fat and protein content significantly. Increase number of washing treatment showed significantly higher (p <0.05) lightness (L*), hardness, diameter shrinkage and cooking loss. As for sensory evaluation, there was no significantly difference (p >0.05) within the sample and control (chicken burger). The spent laying duck Khaki Campbell produced using different number of washing treatment may have a possible use as raw material in restructured meat products such as burger.

Keywords: Washing process, duck meat, restructured product, burger quality, spent laying duck

1. Introduction
Spent laying duck is those that have survive their productive lives at the end of their egg laying cycle. One of its breed is Khaki Campbell that have potential sources of duck mince and value added product such as burger, sausage, nugget and others. By-product of duck processing is also a potential raw material for production of gelatin [1,2,3]. Generally, spent laying duck mostly underutilised and therefore low priced. Since spent layer ducks have lost their commercial values, their meat will be cheap. As a result, meat consumer and manufactures shall benefit from the improvement of efficient and economical technology for processing such worthless meat into value-added meat products that are palatable [4,5]. There are factors contributed to the low level of duck meat consumption such as preference by the society, weakness of market system for selling duck meat products, the inability to slaughter ducks and lack of demand for ducks [6]. Thus, to solve these problems, researchers and government must be focus to promote the duck meat as food choice.

Burger is a flat round cake of minced meat, usually disc-shaped, serving of ground meat or meat alternatives. The meat is compacted and shaped, cooked and typically served in a sandwich. Burger
also can be made from various ingredients, type of meats and formulations. Different types of meats, ingredients and formulations will determine the category of the burger as long as it has similar-shaped meat cakes. The quality of burger also may be varied due to the different of type of meats as well as processing method used [7]. Washing or leaching treatment is an additional step in burger processing. The purpose of this process is to remove undesirable components for example blood, fat, pigments and sacroplasmic protein [8,9,10]. The major objective of washing is to remove water soluble sacroplasmic muscle protein, enzymes such as protease, pigments or blood, lipids and other water soluble components as well leaving myofibrillar to concentrate [4, 11].

Since duck meat is higher in fat and dark colour compared to chicken, whereas the spent layer is tough and dry due to its high connective tissue content and it is less valuable to consumers. Therefore, if the spent layer duck meats can be improved in terms of quality, then underutilized meat could be considered as a source of potential animal protein for processing new products [12]. So, one way of salvaging spent-layer meat might be by washing this meat. This process might increase the functional properties of spent layer duck meats thus produce potential valuable of raw material. In this study, the spent laying duck meat were treated with different number of washing treatment (without washing, single washing and double washing) to evaluate the physico-chemical including diameter shrinkage and cooking loss, moisture, fat and protein content and sensory properties of burger.

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 SdnBhd), vegetable shortening (Nona brands Malaysia Sdn Bhd), tapioca flour (Cap Kapal ABC), Prai coarse sugar (Malayan Sugar MFG Sdn Bhd) obtained from a local supermarket (Tesco) in Sungai Dua, Penang. Meanwhile, konjac powder, soy protein isolate and condiment powder (consisting of garlic, onion and black pepper) obtained from Sim Company Sdn Bhd. Penang.

2.2 Washing treatment
The frozen deboned duck meat was thawed inside chiller at 5-7° for 24 hours before burger production. Then, the duck meat was grind by using meat grinder using size of orifice which 10 mm (model EVE/ALL-12, RheninghausSrl, Torino, Italy). The resulted mince duck meat was applied with 3 type of washing treatments which were unwashed, single washing and double washing. During washing treatment, cold water (4°C) were mixed with ground meat in a ratio of 3:1 (v/w) for 4 minutes. Then, the mixture was allowed to settle for 10 minutes before the topmost layer of the mixture was removed and the residue was filtered through commercial sieve. After that, washed sample was squeezed to remove the remaining water using cloth cotton and screw press.

2.3 Burger preparation
Ingredients of 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 Naveena [13] and Ramadhan [14]. Chicken meat was used as a control by using the same formulation. Konjac powder and salt were mixed up together with the washed 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 was 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 (FimarS.p.a., Rimini, Italy). All the procedures were done under controlled temperature below 4°C to avoid microbial contamination. Molded burgers were frosted into blast freezer for 3 hours at -18°C and stored the burgers into a
freezer at commercial freezer. To get an accurate result, the experiments were conducted 2 times and repetition of analysis (triplicate) for each sample were performed.

2.4 Cooking of burger
The burger was cooked (griddled) on a hot plate (TefalPlancha, Groupe SEB, Canohes, France) for 8 min at medium heat (level 3 out of 5). Each side of burger were cooked 4 minutes and flipped for another 4 minutes until a well-done cooked burger obtained [15].

2.5 Chemical composition
The moisture, protein and fat content of duck burgers were determined according to standard AOAC method [16]. 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 was 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* represent the redness (red +60 to green -60) and b* refer 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) [17]. 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 5kg cylindrical probe. The samples were compressed to 70% of their original height using P75 probe type. The parameters of the burger were included hardness, chewiness, cohesiveness, springiness and gumminess. The highest hardness values were found on first compression. Meanwhile, 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 can be 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 [18,19].

2.8 Diameter shrinkage
The diameter of burger were measured before cooked. Diameter shrinkage was calculated by the difference in diameter (cm) between uncooked and cooked burger divided by the diameter (cm) of uncooked burger [15].

2.9 Cooking loss
The burger were weighed before cooked. All the burger were cooked for 8 min. Percent cooking loss was determined by using weight differences between burger before and after cooking [15].

2.10 Sensory evaluation
Sensory evaluation was performed with hedonic test [20]. The samples were evaluated by using 7 point hedonic scale. Thirty untrained panellists consist of student from School of Industrial Technology were 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. Typically, the samples were coded with 3-digit random numbers and evaluated its colour, hardness, chewiness, flavour, juiciness and overall acceptability. The ratings for the samples were ranging from dislike very much (1) to like very much (7).

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

3. Result and discussion

3.1 Chemical composition
Table 1 showed the chemical composition of duck burger with number of washing treatment. Overall, moisture content was significantly increased by washing treatment and higher compared to the control. The moisture content increased significantly from 70.12 % (p<0.05) for without washing to 74.09 -78.11 % after single and double washing. The increase in moisture content might be correlated with the reduction of protein and fat content. The result correlated with previous reported that the moisture content of washed duck meat ranged from 74.55-83.93 % [21].

| Sample         | Moisture     | Fat         | Protein     |
|----------------|--------------|-------------|-------------|
| Control        | 66.94 ± 1.76a| 2.30 ± 0.19b| 20.29 ± 1.22ac|
| Without Wash   | 70.12 ± 0.56b| 4.49 ± 0.35c| 21.23 ± 2.00c|
| Single Wash    | 74.09 ± 1.08c| 2.56 ± 0.24b| 15.83 ± 1.08b|
| Double Wash    | 78.11 ± 0.29d| 1.80 ± 0.27a| 14.95 ± 0.86a|

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

A significant reduction (p<0.05) in the protein contents of samples was determined as a result of washing. The protein content reduction was likely due to the loss of water-soluble proteins during washing treatment and the higher moisture content of the final products [22]. This data was higher to previous reported that the protein content for unwashed, single and double washing were ranged from 12.97-14.32 % [21]. Most of the proteins eliminated during washing treatment were sacroplasmic proteins, which are water soluble; other eliminated proteins included the heme pigments and blood [23].

Successive washing was also effective in removing fat from the sample. The lowest fat content (1.80%) obtained from the sample washed with double washing. The fat removal in this study was not as high as that for control which used chicken meat. Relative to chicken, duck meat has a higher fat content, and it is rich with intramuscular fat and pigment, likely similar to red meat [24]. Additionally, the effective in fat removal was attributed to the density and polarity differences between ground meat and the washing solutions [25].

3.2 Colour analysis
The colour analysis of uncooked and cooked duck burger with different washing treatment is shown in figure 1 to 3. Compared with the result from effect of different orifice size, it was found that washing improved the L* of the samples. All burger tended to decrease in lightness (L*) and yellowness (b*) and increase in redness (a*) after cooking. This result was similar with previous reported, a lower L* value and b* value and a higher a* value for washed chicken spent meat [26]. The L* values of
uncooked duck burgers ranged from 47.26-50.70 and obviously dropped to a range of 37.98-45.00 after cooking.

![Diagram](image1)

**Figure 1.** L* values for control (chicken) and number of washing treatment for uncooked and cooked duck burgers. Error bars indicate the mean values ± standard deviations of average readings from the samples. Means with different letters show significant difference at (p < 0.05) from other bars.

However, the L* value for control was increasing after cooking from 49.64 to 53.51 due to the greater myoglobin content in the raw material [14]. Based on the trend of the results, it found that number of washing treatment improved the L* of samples. Additionally, the darker colour after cooked could be contributed by the condiments used in the burger formulation (black pepper, onion powder and garlic powder) and gridding practice for cooking.

The value of a* in figure 2 are decreased for uncooked duck burger as increased number of washing treatments. The higher redness in without wash duck burger might be associated to the greater retention of native heme protein [27]. As expected, duck burger contained significantly higher a* compared to chicken burger. The higher a* value in duck burger were related to the higher red muscle fibres in duck compared to chicken [28]. Duckling breast muscle contained approximately 16% white fibre and 84% red fibres compared with 100% of white fibres in chicken breast [29]. Similar trends were also found for cooked duck burger.
Based on the result from figure 3, the b* of uncooked decreased as increase number of washing treatment. The similar results found to cooked samples. The result showed that the washing treatment affected the yellowness of duck burger. The colour of processed meat product is one of the major factor by which consumers judge their acceptability. It also depends on various factors such as the concentration and chemical state of meat pigment, physical properties of meat and presence of non-meat ingredients [30].

Table 2 showed the effects of number of washing treatment on the textural properties of duck burgers. Sample without wash had significantly higher hardness compared to other washing treatments (p
<0.05). However, there was no significant different between control and without wash sample in terms of hardness, cohesiveness, springiness, gumminess and chewiness. Duck burgers with single and double wash were less hard than the control and without wash. This hardness reduction might be attributed to the higher moisture content of the burger after several washing treatment. This texture profile analysis (TPA) showed a decrease in hardness gradually and significantly from 15.11 kg to 8.16 kg for without wash and single wash. However, for duck burger with double wash, the hardness was slightly increased to 10.41 kg.

Table 2. Texture profile analysis for samples with different orifice size.

| Sample          | Hardness (kg)  | Cohesiveness (mm/mm) | Springiness (mm/mm) | Gumminess (kg) | Chewiness (kg/mm^-1) |
|-----------------|----------------|----------------------|---------------------|----------------|----------------------|
| Control         | 14.81 ± 1.44^a| 0.87 ± 0.04^a        | 0.42 ± 0.03^a       | 6.36 ± 0.90^a  | 5.61 ± 0.75^a        |
| Without Wash    | 15.11 ± 0.78^a| 0.82 ± 0.03^a        | 0.41 ± 0.02^ab      | 6.16 ± 0.48^a  | 5.04 ± 0.43^a        |
| Single Wash     | 8.16 ± 0.64^b | 0.71 ± 0.05^b        | 0.34 ± 0.02^c       | 2.33 ± 1.05^b  | 1.96 ± 0.31^b        |
| Double Wash     | 10.41 ± 2.00^c| 0.69 ± 0.06^b        | 0.39 ± 0.04^b       | 4.08 ± 1.08^c  | 2.81 ± 0.83^c        |

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

Previous study reported that hardness from unwashed mechanically deboned duck meat were 23.13 kg [31]. Yang and Froning [25] also reported an increase in hardness from washed mechanically deboned chicken meat compared with unwashed meat. Besides myofibrillar protein, the textural properties are influenced by salt addition and heating temperature during cooking process. Hardness values of all samples were within the range reported for commercial chicken burger (between 8-19 kg).

The springiness values of single and double wash duck burger were lower than those of without wash duck burger, which means that without wash sample maintained the food’s height after the first compression better than single and double wash.

3.4. Diameter shrinkage and cooking loss

Diameter shrinkages and cooking losses of cooked burger are presented in table 3. There was significant difference (p >0.05) observed between the control sample and samples with different washing treatment. The degree of shrinkages for the commercial burger were ranged from about 2-10% [31]. However, without, single and double wash were not within the range of diameter shrinkage and could be reduced the quality of the burger. Burgers are mainly served with burger buns and it should be comparable with the buns size. The reduction in diameter was higher at single and double wash due to the denaturation of meat proteins.

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

| Sample          | Diameter Shrinkage (%) | Cooking Loss (%) |
|-----------------|------------------------|-----------------|
| Control         | 5.63 ± 0.53^a          | 11.73 ± 0.33^a  |
| Without Wash    | 10.28 ± 0.39^b         | 10.25 ± 0.29^b  |
| Single Wash     | 16.84 ± 3.57^c         | 13.45 ± 1.08^c  |
| Double Wash     | 13.32 ± 0.83^d         | 11.02 ± 0.04^d  |

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

The cooking loss values increased with the increased on number of washing treatment. However, double wash showed decreasing trend in cooking loss. Cooking loss was the highest for burger from single wash. Ali (28) also found that higher cooking loss for duck meat compared to the chicken meat. Higher cooking loss in duck meat despite a higher proportion of oxidative fibre may be related to water holding capacity of duck and chicken meat. Duck muscles have comparatively lower water holding capacity than chicken muscle, resulting in greater cooking loss [32].
3.5 Sensory evaluation
Table 4 exhibited the sensory profiles of cooked burger. There were no significant differences between the types of burger in sensory qualities like colour, odour, flavour, hardness, chewiness, juiciness and overall acceptability. In terms of colour, panellist showed a preference for control followed by without, single and double wash. Based on the result, panellist preference for the duck burger was above 4 means that duck burger can be acceptable. The colour of the control was better due to its light colour.

Table 4. Sensory evaluation for samples with different number of washing treatment

| Sample       | Control     | Without wash | Single wash | Double wash |
|--------------|-------------|--------------|-------------|-------------|
| Colour       | 5.00 ± 1.68a | 4.97 ± 1.10a | 4.90 ± 1.24a | 4.70 ± 1.40a |
| Odour        | 5.20 ± 1.16a | 4.80 ± 1.16a | 4.67 ± 1.21a | 4.93 ± 0.98a |
| Flavour      | 5.53 ± 1.14a | 4.77 ± 1.33a | 5.03 ± 1.22ab | 4.80 ± 1.30a |
| Hardness     | 5.37 ± 1.25a | 4.83 ± 1.26a | 5.30 ± 1.18a | 5.27 ± 1.26a |
| Chewiness    | 5.47 ± 1.01a | 5.07 ± 1.01a | 5.50 ± 1.07a | 5.13 ± 1.17a |
| Juiciness    | 5.40 ± 1.07a | 4.63 ± 1.16a | 5.27 ± 0.98a | 5.07 ± 1.20ab |
| Overall      | 5.57 ± 1.07a | 5.03 ± 0.89ab | 5.20 ± 1.13ab | 4.97 ± 1.03a |

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

Odour and flavour showed that no significant difference in preferences found among the samples (p <0.05). Duck burgers with different washing treatment were scored an insignificantly less value in respect of flavour due to the inherent characteristic ducky odour that couldn't be masked by the condiments added [33]. Therefore, overall acceptability differed insignificantly among the four samples providing strong base for the acceptability of the duck meat.

4. Conclusions
As the number of washing treatment increase, moisture content increased whereas the fat and protein content decreased. Washing treatment also increased the lightness of the raw duck burger. All samples including control had significantly different in lightness after cooked. All the textural attributes investigated were influenced by the number of washing treatment. The hardness of duck burger decreased proportionally with the number of washing treatment. However, there were an increase in the diameter shrinkage and cooking loss for burger from second experiment. The effect of number of washing treatment made the duck burger acceptable as similar as control sample as for the result from sensory evaluation was not significantly different between the samples. Furthermore, it can be effectively utilized for the preparation of burger with well acceptability and good quality characteristic. Thus, better economic return to both producers and consumers can be ensured by utilizing spent duck through burger making.

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