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Proximate and physicochemical properties of Peking and Muscovy duck breasts and thighs for further processing

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Abstract

The proximate and physicochemical properties of Peking and Muscovy duck breasts and thighs were analyzed in this study. In both the Peking and Muscovy duck, protein content was higher in the breast than in the thigh, whereas fat content was lower in the breast than in the thigh. The breast and thigh exhibited a correlated physicochemical variation. Findings were supported by the data of related studies performed on other poultry meats and provided a reason for different findings in both the breast and thigh. Some estimated modifications or potential applied products were examined for making these parts acceptable. Similar approaches to other poultry meat for further processing at the market scale were also examined. The information in this study is useful for the use of separate breast and thigh parts for developing manufactured duck meat products.

Key words: Peking duck, Muscovy duck, chemical composition, physicochemical properties.

Introduction

In recent time, there are some important factors influencing meat and meat products choice of consumer mainly related to health concern (fat content, production of leaner animals), appearance factors (visible fat), development of low fat meat products (low fat formulation), demographic influences (income, age, ethnicity, convenience, change in distribution, price) and new product development (restructured meat products, low-salt products, vacuum-packaged meat products) [1]. Nutrition value is the basic adjustment factor, but the physicochemical properties of meat, which include pH, water holding capacity, cooking loss, color and texture are also important factors for determining meat quality, the processor decision making and consumer quality traits. However, both price and efficiency are also important for economic competitiveness.

It is not easy to find duck meat and duck meat product in the market. It happens because there are not many modern duck rearing farms and finally it causes the duck meat and meat product just have little expose among society [2]. The total production of poultry in Peninsular Malaysia is growing significantly by the year. A report stated that the total population of ducks was 2,341,762 in 1996, and it increased to 7,478,710 in 2004. Although the total production of duck is still less than chicken production with 75,622,691 in 1996 and 156,634,055 in 2004, ducks exhibit the highest recent production increase: 319% from 1996 to 2004. Total duck consumption also showed a positive correlation with total production, increasing 194% from 1996 to 2004 [3].

Peking duck (*Anas platyrhynchos)* was bred as a broiler species, and it is a popular duck in the world. Muscovy duck (*Chairina moschata*) is the dominant duck used in Southeast Asia, because of its ability to produce more meat than other domesticated ducks. Muscovy ducks are often found on traditional farms in Southeast Asian countries. However, there is a lack of data regarding the properties of Peking and Muscovy duck. This information is necessary to encourage the future of the Peking and Muscovy duck industry.

Providing particular characteristics information of different parts of muscle will support the meat industry to use suitable muscle for producing specific product and also for marketing purposes [4]. During the past decade, restructured meat products have been produced from specific part of meats such as breast and thigh. Breast part is usually used in meat product formulation due to its physical superiority characteristics such as its uniformity, soft texture, and lighter color. Meanwhile, leg meat with it higher fat content will give stronger flavor when this part is cooked, and finally attracts the consumer preferences. The use of leg meat in meat product formulation will minimize the production cost because the sale of fresh leg meat is low related to it higher fat content which is not preferred by the consumer [5]. The differences in muscle characteristics especially the breast and leg part will determine the specific result of further processed meat products [5, 6].

Non-chicken poultry meat has been studied by several researchers; research has been undertaken on ostrich meat [4, 7], quail meat [8] and goose meat [9,10]. However, current data is not available regarding the functionality of duck thigh and breast meat. Complete information about the proximate composition and physicochemical properties of Peking and Muscovy duck meat is not clear. Therefore, strategies for the introduction of this meat must focus on its quality in terms of both its proximate and physicochemical properties. Taking into account the data presented in this research, the utilization of Peking and Muscovy duck meat in prepared ready-to-eat food could be a consideration for both processors and consumers. In sum, the objective of this study was to determine the proximate composition and physicochemical characteristics of Peking and Muscovy duck.

The data related to duck meat nutrient and its physicochemical properties is the fundamental information to help the meat processing industries to consider the using of duck meat in meat products formulation such as in nuggets, meatballs and sausages. Aim of the study was to determine proximate and physicochemical properties of Peking and Muscovy duck breasts and thighs. Application of duck in meat products can minimize the dependence to chicken meat as the dominant consumed poultry meat and duck meat can appear as new potential non-chicken poultry meat product.

Materials and Methods

Materials: Fifteen 16-week-old Peking ducks (*Anas platyrhynchos*) and seven 16-week-old Muscovy ducks (*Chairina moschata*) raised on a traditional farm in the Northern part of Malaysia were slaughtered manually following the Malaysian Standard MS 1500:2004 guidelines [11]. Soon after evisceration (which included removing the skin and organs), the meat was washed with cool water (5°C) and then frozen in a blast freezer (Rinox, Italy) at -20°C/30 min; it remained in storage in a freezer at -18°C (Pensonic, Malaysia) and was used for analysis. Both the breasts and thighs of each duck were analyzed three times.

Analytical methods: Proximate composition such as moisture (AOAC, Method 925.40), protein (AOAC, Method 955.04), fat (AOAC, Method 920.39) and ash (AOAC, Method 932.03) were determined according to AOAC standard method [12].

The pH value was determined by weighing 5 g sample, putting it in a glass beaker and then dissolving with 45 ml aquadest using a homogenizer (IKA® T25 digital Ultra-Turrax, Germany) and then measuring the pH value by using a pH meter (Mettler Toledo Delta 320, Switzerland).

Myoglobin was determined using Krzywicki's procedure. Duck meat samples weighing 2.0 g were mixed into 18 ml of 40 mM phosphate buffer (pH 6.8) and blended at a high speed in a homogenizer (IKA® T25 digital Ultra-Turrax, Germany) for 20 s. The homogenate was poured into 40 ml screw-top centrifuge tubes and put on ice for a period of 2 hours for pigment extraction. The tubes were centrifuged at 5°C for 60 min at 30,000 x g. The supernatant was filtered through a Whatman No. 1 filter paper and kept on ice. The absorbance of the solution was read at 572, 565, 545 and 525 nm in a UV-visible recording spectrophotometer (model UV-160A, Shimadzu, Japan) and three determinations were conducted for each sample solution. Exposure to light was kept minimal throughout the procedure by placing the sample solutions in the dark to minimize the possible pigment oxidation [13].

$$\text{Total myoglobin (mmol/l)} = (-0.166R_1 + 0.086R_2 + 0.088R_3 + 0.099) \times A_{525}$$

where R_1, R_2 and R_3 are absorbance ratios of A_{572}/A_{525}, A_{565}/A_{525} and A_{545}/A_{525}, respectively[13].

Color analysis consisting of lightness (L*), redness (a*) and yellowness (b*) was performed by a reflectance colorimeter (Minolta Spectrophotometer CM-3500d, Japan). The reflectance colorimeter was calibrated using white calibration plate (Minolta, Japan), and soon after that the sample was run for colour analysis[14].

The water holding capacity (WHC) of the meat samples was determined using a modified of Wierbicki's method [15]. A 20 g duck meat sample was homogenized with 40 ml distilled water in a homogenizer (IKA® T25 digital Ultra-Turrax, Germany) for 2 min. A 10 ml aliquot of the homogenate was placed in centrifuge (centrifuge Kubota Model 5100, Japan) at 2000 rpm for 5 min. The volume of the insoluble protein (v ml) was read and WHC was calculated as below [15]:

$$\text{WHC \%} = \frac{V}{10} \times 100$$

Cooking loss was determined as follows: approximately 1 cm x 0.5 cm x 0.5 cm samples were weighed and placed in thin-walled plastic bags in a water-bath at 80°C to reach an internal minimal temperature of 75°C as recommended. The samples were placed in the water-bath for 1 h. Followed by cooling in cold water, and further blotted with tissue paper and weighed. The cooking loss is expressed as a percentage of the initial sample weight [16].

Texture (hardness) measurement was done using a Warner Bratzler instrument (Stable Micro Systems Texture Analyser Model TA-XT plus, UK) with three cores (1.27 cm) with pre test speed 2.0 mm/s, test speed 2.0 mm/s, post test speed 10.0 mm/s, distance 30 mm, trigger type auto-20 g, tare mode auto and data acquisition rate of 200 pps.

Statistical analysis: The data collected was analyzed using the Statistic Package for Social Science (SPSS) version 11.5. The means of the treatments showing significant differences ($P<0.05$) were subjected to t-test.

Results and Discussion

Proximate composition: There were significant differences between the breast and thigh meat of both Peking and Muscovy duck. The moisture and protein contents of Peking duck breast were higher than those of thigh whereas fat content was lower. The protein content of Muscovy duck breast was higher than that of thigh whereas fat content was lower. Comparison between the two species showed that the moisture and ash content of Peking duck were higher than those of Muscovy duck while the protein and fat content of Peking duck were lower than in Muscovy duck. As shown in Table 1, when compared to chicken and ostrich, the moisture of both Peking and Muscovy duck meat was higher but the protein content was lower. The fat content of breast and

Table 1. Proximate composition (%) of Peking and Muscovy duck meat compared to chicken and ostrich meat.

	Peking duck		Muscovy duck		Chicken[20]	Ostrich[21]
	Breast	Thigh	Breast	Thigh		
Moisture	$79.44^{aA}\pm0.36$	$78.26^{bA}\pm0.66$	$77.08^{aB}\pm0.71$	$76.78^{aB}\pm0.73$	74.45	76.27
Protein	$17.47^{aB}\pm0.46$	$17.19^{bB}\pm0.52$	$19.41^{aA}\pm0.69$	$18.41^{bA}\pm0.64$	22.96	21.12
Fat	$1.81^{bB}\pm0.06$	$3.24^{aB}\pm0.12$	$2.32^{bA}\pm0.26$	$3.63^{aA}\pm0.47$	1.25	0.65
Ash	$1.09^{aA}\pm0.06$	$1.08^{aA}\pm0.06$	$0.86^{aB}\pm0.42$	$0.84^{aB}\pm0.49$	1.31	1.07

[ab]Means with different small letters in different parts of Peking and Muscovy ducks meat are significantly different ($P<0.05$).
[AB]Means with different capital letters in the breast and thigh parts of different ducks are significantly different ($P<0.05$).

thigh part of Peking and Muscovy was higher than than that of chicken and ostrich while the ash content of these ducks was lower than in chicken but only Muscovy ducks showed lower ash content compared to ostrich.

In the proximate analysis of poultry meat, it was found that in general the protein in the breast part was higher than the protein in the thigh. In contrast, the fat in breast poultry meat was lower than that in the thigh. Similar results were found in four chicken genotypes (Black-boned, Thai, Breese and Rhode) where the protein in the breast (23.6-24.8%) was higher than in the thigh (20.1-21.7%) whereas fat in the breast (0.51-0.76%) was lower than in the thigh (2.81-6.04%) [17]. Higher protein and lower fat contents in the breast were also reported in turkey meat. The authors noted that the protein content of turkey breast was 24.4% and fat content was 1.21% while in the thigh muscle the content was 21.1% protein and 2.03% fat, respectively [18]. Similar results were also found that the protein in turkey breast (25.0%) was higher than thigh (21.0%) and the fat content in the breast (2.06%) was lower than in the thigh (5.67%) [19].

The different protein composition and the functional properties of breast and thigh are very important to determine the final result in emulsified meat products. Some related studies in other poultry meat have proven the important role of these two qualities. A study reported that the higher the level of the meat protein (10, 11, 12, 13, 14 and 15%), the higher the value of the hardness of emulsified beef meat emulsions both for combination with canola oil (40.2, 49.9, 58.6, 63.1, 66.2, 89.2 N) and for combination with beef fat (29.0, 32.4, 43.5, 50.7, 60.7, 73.6 N) [22]. More specific explanation also showed that the myofibril, sarcoplasmic and connective tissue protein will influence raw and cooked meat products. Important characteristics such as oil binding ability, water holding ability, stability, viscosity, density and other emulsion characteristics are influenced by the rate of solubility and the interaction of myofibrillar proteins of the processed meat products [23]. However, when the protein functionality of meat is low, it needs to be given modified treatment in order to obtain the expected meat product. The cohesiveness of cooked sausages batter prepared from beef meat is mainly influenced by sarcoplasmic proteins [24]. Researchers who focused on the homogenate gelation properties of chicken breast and thigh indicated that the determination of best processing aspects such as formulation, pH, and thermal condition should be done to reach most favourable product quality between chicken light (breast) and dark (thigh or leg) and it might affect the final product [25]. In the connective tissue, with collagen as a dominant composition, previous studies of broilers showed that the collagen content in the breast (3.9 mg/g) is lower than in the thigh (9.3 mg/g) [26] and it may affect the final product when it is produced from different parts of muscles.

Fat with a lower percentage than protein in meat is another important factor in raw materials and cooked meat products. The potential oxidation during storage before processing, during processing and storage time after processing before being consumed should drive consumers and industrial meat processors to pay more attention to the intramuscular fat content of duck meat and other meat types. Some authors noted that after post-mortem, lipid oxidation continuously occur and leads to the lowering of storage quality of meat and processed meat product [27]. Other authors noted that a number of aspects such as fat content and fatty acid profile influences the continuity of lipid oxidation and finally it will minimize the shelf life of meat and meat products [28].

As explained by some authors, high level of unsaturated fatty acids, generally found in poultry meat, is one of primary factors involved in reduction of sensory acceptability of meat over storage period [29]. Breast and thigh part of poultry meat showed different types and percentages of volatile compounds treated during different holding time [30] and this phenomenon may cause the different aroma of breast and thigh used in the processed poultry products. Highest lipid oxidation during storage time results from the highest fat content in burger formulation [31].

Physicochemical properties

pH: As shown in Table 2, there were significant differences in the pH value between the breast and the thigh parts of both Peking and Muscovy duck meats. The pH of Peking duck breast was lower than in the thigh whereas the pH of the breast of Muscovy duck was higher than in the thigh. Comparison between duck species showed that the pH of Peking duck breast was lower than Muscovy duck breast while the pH of Peking duck thigh was higher than that of Muscovy duck thigh. Compared to chicken and turkey, the pH of Peking duck breast and Muscovy duck thigh were relatively similar whereas the pH of Peking duck thigh and Muscovy duck breast were higher than the pH of chicken, ostrich and turkey meat.

There was a significant difference in the pH between the breast and thigh meat of Peking duck meat. When compared with other results, except for the pH of Peking duck thigh, the pH of both ducks was lower than the deboned meat pH of partridge (6.35), quail (6.53), chicken (6.40) and turkey (6.32) [32]. Differences in pH values among different duck parts and poultry meats are related to the varying amounts of the total glycogen of each muscle and animal.

A trend of positive correlation between total glycogen and pH drop was found in chicken where higher glycogen content

Table 2. The pH, color and myoglobin content of Peking and Muscovy duck meat compared to chicken, ostrich and turkey meat.

	Peking duck		Muscovy duck		Chicken [35]	Ostrich [36]	Turkey [37]
	Breast	Thigh	Breast	Thigh			
pH	$5.87^{bB}\pm0.04$	$6.56^{aA}\pm0.05$	$6.01^{aA}\pm0.12$	$5.94^{bB}\pm0.11$	5.81	5.86	5.99
Myoglobin (mMol/L)	$0.0366^{aA}\pm0.02$	$0.0482^{aA}\pm0.01$	$0.0219^{aB}\pm0.01$	$0.0210^{aB}\pm0.01$	-	-	-
L	$38.24^{aB}\pm1.62$	$34.79^{bB}\pm1.77$	$40.53^{bA}\pm1.30$	$42.60^{aA}\pm0.77$	49.62	36.74	54.80
a	$5.42^{aB}\pm1.37$	$5.44^{aB}\pm1.23$	$9.85^{aA}\pm1.53$	$9.25^{aA}\pm1.57$	3.25	22.84	4.45
b	$11.93^{aA}\pm2.28$	$10.95^{aA}\pm0.93$	$11.67^{aA}\pm1.73$	$11.13^{aA}\pm1.87$	4.93	6.57	2.35

^{ab}Means with the different small letters in different parts of Peking and Muscovy duck meats are significantly different (P<0.05).
^{AB}Means with the different big letters in different duck species of breast and thigh parts are significantly different (p<0.05).

(7.9, 6.8 and 6.6 ppm, respectively) contributed to lower pH (5.97, 6.01 and 6.02, respectively), although there was no significant difference in data presented [20]. The lower pH in the breast of Peking duck meat was probably due to the higher glycogen content in the breast. The result was consistent with other reports where the total glycogen content in the breast was higher than the thigh in chickens. It was found that breast parts contain 7.04 mg/g glycogen whereas thigh parts contain 5.38 mg/g glycogen in the muscle [33]. In contrast, the higher pH of the breast of Muscovy duck was estimated to be caused by lower glycogen content in breast. Gröschel-Stewart and Zuber [34] also reported that the glycogen content of breast duck meat was lower than thigh meat. The glycogen level in the breast was 14.81 μmol/g whereas the glycogen level in the thigh was 46.9 μmol/g [34].

The denaturation of meat protein caused a decrease of the WHC function and this led to water loss during raw duck meat storage, processing and storing after duck meat processing. Some authors noted that physical meat quality attributes such as water holding capacity, tenderness and color are significantly affected by denaturation of meat protein [38]. Others noted that the irreversible reduction of protein functionality in meat related to the alteration of WHC and pH where this phenomenon may affect the rate of water lost from the meat including free, immobilized and bound water [39].

Myoglobin: The myoglobin content in Peking duck breast (0.0366 mmol/l) and thigh (0.0482 mmol/l) showed no significant differences. There were also no significant differences found in the myoglobin content in Muscovy duck breast (0.0219 mmol/l) and thigh (0.0210 mmol/l). On the other hand, the myoglobin content of Peking duck breast was significantly higher than in Muscovy duck breast, and similar results are also found in the thighs of both Peking and Muscovy meat.

Myoglobin showed a positive correlation with pH but a negative correlation with the L* value of the meat. Myoglobin content of Peking duck was higher and L* value lower compared to Muscovy duck (Table 2). The colour of fresh meat is mainly determined by myoglobin (Mb) concentration [40]. The lower pH of meat cause the higher L* value of the meat. As an example, the increase of lightness (57.70) in chicken breast meat is caused by low pH (5.72) and the decreasing of lightness (44.88) is caused by high pH (6.27) [41].

When the higher myoglobin becomes a problem in manufactured meat products, the removal of the heme pigment of myoglobin can solve the problem by modifying meat product preparation. Some research has focused on minimizing the heme pigment by using the washing treatment in meat. In studies related to the washing treatment of mechanically deboned chicken meat (MDCM), tap water, 0.1 M NaCl, sodium phosphate and 0.5% $NaHCO_3$ solution were used, and the results proved that 0.1 M NaCl, sodium phosphate and 0.5% $NaHCO_3$ washing solution give lighter color compared to unwashed MDCM or tap water treatment [42].

By increasing use of washed mechanical deboned meat (0, 20 and 40%) in chicken nugget formulation the lightness of raw and cooked nugget increased; the lightness of raw nugget was 66.9, 67.8 and 70.7, respectively, and the lightness of cooked nugget 68.7, 69.1 and 69.5, respectively [43]. A related study in sausage production showed that using of 20, 40 and 60% of spent laying hen breast surimi in formulation increases the lightness of sausage from 88.52, 91.54 and 93.32, respectively. A similar trend was also found when the product was stored continuously for 2 and 4 weeks. The lightness over 2 weeks of storage was 78.07, 80.20, and 82.44, respectively, by the increase of spent laying hen breast surimi percentage in formulation whereas over 4 weeks of storage the lightness was 77.48, 79.54 and 81.45, respectively. Furthermore, from color results it was noted that during surimi preparation, heme pigment and other undesirable substances can be removed by washing with water [44] or chemical treatments.

Color (L, a*, b*):* The L* value of Peking duck breast was significantly higher than that of the thigh whereas the L* value of Muscovy duck breast was significantly lower than that of the thigh. A similar result, which had a lower L* value for the breast part of Muscovy duck was found in broilers where the L* value of breast (49.88) was lower than that of the thigh (50.83) [30]. In comparing duck species, the L* value of Peking duck meat was lower than that of Muscovy duck meat in both the breast and the thigh. As shown in Table 2, the L* value of both Peking and Muscovy parts were lower than in chicken and turkey whereas in ostrich meat higher than the thigh part of Peking duck but lower than breast of Peking and breast and thigh of Muscovy duck. Compared to the results for another study on ostrich meat, the L* value of Peking and Muscovy duck meat was still higher than values for both young (29.42) and old (24.84) ostriches [7]. The a* values of both the breast and thigh parts of Peking and Muscovy ducks were significantly lower than that of Muscovy ducks. When compared to chicken and turkey, the a* value of the breast and thigh parts of Peking and Muscovy ducks was higher but it was lower than for ostrich meat. On the other hand, the b* value of both Peking and Muscovy duck meat was higher than those of chicken, ostrich and turkey meat.

It was estimated that the thigh meat of Peking duck and the breast meat of Muscovy duck have higher heme pigment which had the impact of minimizing the L* value of this part compared to the thigh. Although there was no significant difference in the myoglobin content, the data still gives the tendency for the increase in L* value by the decrease of myoglobin on a smaller scale. However, myoglobin is not the only factor that influences the color because hemoglobin also has a role in this case.

This finding was also supported by the pH of meat which showed that a low pH caused a high lightness value. As the pH lowers, the lightness value will be higher. By decreasing the pH after post-mortem, some of the proteins will denature. This effect will create bigger spaces among the fibrous muscles. Furthermore the water which was bound before will be released. The existence of water out of the fibrous protein will cause the decreasing ability of the meat to adsorb and will bounce back the light. Finally, it minimizes visualization especially in the L* value of the meat. Similar results were obtained where the pH 5.81 had L* value 43.1 followed by pH 5.70 and 5.63 with the L* value of 45.6 and 48.8, respectively [45].

Color, especially the lightness of meat (L* value), was also affected by the moisture content. The higher moisture content in Peking duck breast (79.44%) gave an L* value of 38.24 while the thigh, with a moisture content of 78.26%, gave an L* value of 34.79. This trend was also similar with other results where the lightness of the ground breast meat of broiler chicken was associated with moisture content of the meat. By increase in

Table 3. Water holding capacity, texture and cooking loss of Peking and Muscovy duck and chicken, ostrich and turkey meat.

	Peking duck		Muscovy duck		Chicken [47]	Ostrich [36,48]	Turkey [36,37]
	Breast	Thigh	Breast	Thigh			
WHC (%)	$61.41^{bA}\pm0.46$	$63.17^{aA}\pm0.63$	$49.76^{aB}\pm1.06$	$48.39^{bB}\pm1.11$	-	-	-
Cooking loss (%)	$45.31^{aA}\pm0.50$	$42.06^{bA}\pm0.48$	$37.82^{bB}\pm0.99$	$41.98^{aA}\pm0.97$	15.74	35.80	19.30
Texture (kg)	$2.43^{aB}\pm0.48$	$1.71^{bB}\pm0.45$	$5.17^{aA}\pm1.71$	$3.21^{bA}\pm1.73$	2.89	2.70	2.10

[ab]Means with the different small letters in different parts of Peking and Muscovy duck meats are significantly different ($P<0.05$).
[AB]Means with the different big letters in different duck species of breast and thigh parts are significantly different ($p<0.05$).

moisture content (76.23, 76.35 and 76.72, respectively) of the meat, the color will be lighter (57.83, 62.07 and 64.34, respectively) [46].

WHC: As shown in Table 3, there is a significant difference between the breast and thigh of Peking and Muscovy duck in WHC, cooking loss and texture. The WHC of Peking duck breast was lower than the thigh which is contrary to the result in Muscovy duck where the WHC of the breast was higher than the thigh. Comparison of duck species, the WHC of Peking duck meat is higher than Muscovy duck meat both in breast and thigh parts. Contrary to other results, the results of the breast and thigh of Peking and Muscovy duck meat was different than the results which were found in partridge (39.6%), quail (47.4%), chicken (37.5%) and turkey (38.0%) [32].

Variation factors involved during the whole meat production chain, such as differences in physiological, animal rearing and processing of meat, are responsible for the varied results in water holding capacity [49]. In deeper explanations, other authors explained many factors that contribute to the result of WHC of the meat; both during pre- (growth time, genotype, diet, stresses and stunning methods) and postmortem time duration (chilling, ageing, non-meat ingredient injections and tumbling) [50]. Physically, in the term of WHC, cell structures (intra- and extra-myofibrillar spaces) play their function for storing the water. Water will come out gradually from the myofibril with increasing length of postmortem time [51]. A higher WHC is very important to the food industry, as it can correlate positively to minimize the decrease of the final product weight during storage time.

Cooking loss: The cooking loss of Peking duck breast was higher than that of the thigh whereas the cooking loss of Muscovy duck breast was lower than that of the thigh. Comparison among duck species showed that the cooking loss of Peking duck breast was higher than that of Muscovy duck breast. As shown in Table 3, when compared to other poultry meat, the cooking loss of both Peking and Muscovy duck meat was higher than that of chicken, ostrich and turkey. Other results on ostriches also showed lower cooking losses both in young (31.91%) and old (33.23%) ostriches than in Muscovy duck meat [7]. However, the cooking loss of Peking and Muscovy duck was higher than the cooking loss of partridge (22.3%), quail (24.9%), chicken (25.4%) and turkey (26.1%) [32].

In relation to the results of the water holding capacity in the breast and thigh of Peking and Muscovy duck, cooking loss tends to decrease with the increase of the water holding capacity. A higher pH causes the denaturation of protein and leads to a lower water holding capacity before cooking. Denaturation of protein continued during cooking of duck meat.

Although the WHC of the breast and thigh of Peking duck meat were higher than in Muscovy duck meat, the cooking loss of Peking duck meat showed higher loss than Muscovy duck meat. This could be due to the influence of the total protein content in meat. As shown in Table 3, the total protein content of Peking duck in the breast and thigh parts was lower than the total protein content in the breast and thigh of Muscovy. The lower protein content in Peking duck meat lowers the ability of its protein to bind water during cooking compared to Muscovy duck meat. This phenomenon is also probably due to differences in myofibrillar content. As with WHC, lower cooking loss of meat is beneficial because it will minimize weight loss especially during the processing of manufactured meat products.

Texture: The texture of the breast part is tougher than the thigh of both Peking and Muscovy duck meat. Comparison among duck species showed that Peking duck breast is more tender than Muscovy duck breast and a similar result is also found in the thigh part of Peking and Muscovy duck meat. Compared to other poultry meat, Peking duck meat is tougher than chicken and ostrich but was more tender than turkey while the texture of Muscovy duck meat was tougher than that of chicken, ostrich and turkey meat.

Intramuscular fat of the meat is correlated with the tenderness of the meat besides other aspects [52]. As shown in Table 3, the fat content of the breast part is lower than in the thigh. The total intramuscular fat in Peking duck breast was lower than that of the thigh while the total intramuscular fat in Muscovy duck breast was also lower than in the thigh; this leads to tougher texture in the breast part.

However, other factors also contribute to the texture of different muscles. Although the fat content in Peking duck meat was lower than Muscovy duck meat, the texture of Peking duck meat showed a more tender texture than Muscovy duck meat. It is believed that the muscle fibre of Muscovy duck meat is bigger than Peking duck meat, the texture of Muscovy duck meat is tougher. Meat tenderness (shear force) significantly relates to the average muscle fiber size [53]. Different parts of ostrich muscle (*M. Iliofibularis, M. Gastrocnemius* and *M. Iliotibialis*) on 14-15-month age showed significant differences in tenderness attributes both in Warner Bratzler shear values (1.17, 4.01 and 1.49 kg, respectively) and sensory panel score (5.31, 4.20 and 5.74, respectively) [54]. Different parts of muscles influence the thickness of perimisium that can play a role for the textural attributes of meat [55].

Conclusions

The proximate results showed that the protein content of the breast is higher than in the thigh, whereas the fat content of the breast was lower. The physicochemical results in Peking duck meat showed that breast pH was lower than thigh pH; it correlated positively to create a lower WHC in the breast than in the thigh but correlated negatively to create the higher cooking loss and L* value in the breast than in the thigh. In contrast to Peking duck, the pH and WHC of Muscovy duck breast are higher than in the thigh and negatively correlated to the cooking loss and L* value. On the other hand, the hardness of both Peking and Muscovy duck breast is higher than that of the thigh. The choice of the parts utilized in duck meat products should be made in reference to the functional characteristics of the breast and thigh.

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