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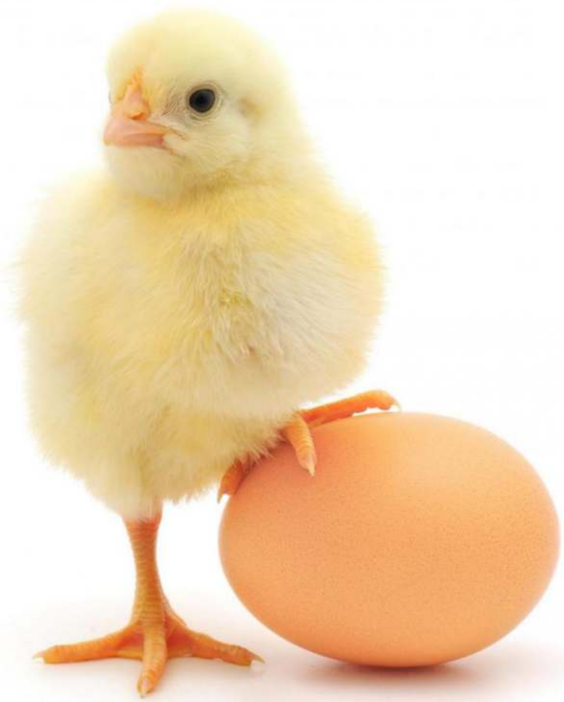

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Amino Acid and Fatty Acid Profiles of Peking and Muscovy Duck Meat

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Abstract: The amino acid and fatty acid profiles of the breasts and thighs of Peking and Muscovy ducks were analyzed in this study. Amino acid profiles were performed in duplicate and fatty acid profiles were performed in triplicate. The chemical score, amino acid score and essential amino acid index were calculated from the amino acid profiles, whereas the SFA, MUFA, PUFA, ω3, ω6 and ω6:ω3 ratio were calculated from the fatty acid profiles. In general lysine and methionine were the highest EAA found in Pecking and Muscovy ducks, whereas their methionine contents were relatively higher than in other poultry meat. Muscovy meat possesses a higher ($p<0.05$) chemical and amino acid score compared to Peking duck meat. No significant difference ($p>0.05$) in the EAA index was observed between different body parts and different species. The concentration of the fatty acid C18:1ω9 was the highest observed in both Peking and Muscovy duck species. The SFA of Muscovy breast was significantly higher ($p<0.05$) than that of Peking breast. The MUFA of Muscovy was significantly higher ($p<0.05$) than that of Peking duck, both in breast and thigh cuts; moreover, the MUFA of Muscovy thigh was significantly higher ($p<0.05$) compared to that of Muscovy breast. The PUFA of Muscovy breast was significantly lower than that of Peking breast. Both Peking and Muscovy ducks meats show high protein quality and are good sources of fatty acids for human consumption.

Key words: Duck, breast, thigh, protein quality, fatty acid

INTRODUCTION

In Southeast Asia, duck meat is the second most consumed poultry meat after chicken meat. Generally, duck meat products are prepared using different techniques known as *gulai itiak lado mudo* (Indonesia), *itek tim* (Malaysia), *bún măng vit* (Vietnam), *kaeng phet ped yang* (Thailand) and *yā fán* (Singapore). Roasted ducks are also commonly consumed by Chinese communities in Malaysia and Singapore. However, the consumption of duck meat is considered very limited for several reasons, including a lack of duck farmers, the limited development of duck meat products and little promotion of ducks meat for human consumption. Statistically, the per capita consumption of duck meat in Malaysia from 1996-2004 (0.88, 1.08, 1.25, 1.40, 1.38, 1.43, 1.53, 1.70, 1.71 kg, respectively) was lower compared to that of chicken (28.35, 31.25, 28.51, 28.08, 28.58, 28.57, 33.75, 33.52, 35.72 kg, respectively) (Department Veterinary Service of Malaysia, 2008). It is estimated that the consumption of duck meat in other Southeast Asia countries is not much different from that reported here for Malaysia. To promote duck meat consumption, nutritional composition data, such as amino acid and fatty acid profiles, are very important for food industries and consumers in considering the use of duck meat as an alternative source of protein.

The quality of protein in processed foods is commonly determined by their amino acid composition. It is widely known that high amino acid content, as well as essential amino acids, are found in high-protein foods (Kim *et al*., 2009). Protein quality is an important aspect of human food intake. Furthermore, differences in the types and percentages of essential amino acids in food could influence the value of protein consumed (Tuan *et al*., 1999). Because some essential amino acids cannot be synthesized by the human body, they need to be obtained directly from food. In addition, the type of (E)AAs in food varies, causing a variation in digestion quality and, ultimately, differences in protein value among food sources (Schaafsma, 2000). Sample parameters used to determine protein quality include chemical score, amino acid score and EAA index.

To support human health, meat products should be processed from meat with high amounts of MUFAs by controlling animal diets or by processing from meat with other components containing high percentages of

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MUFAs. Moreover, cases of cardiovascular disorders can be avoided by reducing the consumption of SFA sources or by increasing the amount of PUFAs in food sources (Salma *et al*., 2007). In recent years, efforts made toward healthier meat production have aimed at the production of higher ratios of PUFAs to SFAs in meat. Additionally, the balance of omega 6 (ω6) and 3 (ω3) fatty acids in PUFAs should also be a focus in producing healthier meat products and this balance can be manipulated by controlling animal diets (Wood *et al*., 2003).

The determination of duck meat quality depends on its amino acid and fatty acid profiles. Comprehensive data for the consumer and industry on the use of duck meat as potential alternative food source have been provided by this research.

MATERIALS AND METHODS

Duck meat: Peking (*Anas Platyrhyncos)* and Muscovy ducks (*Chairina moschatta)*, aged 16 weeks, were supplied by a local farmer from Southern Malaysia. Carcasses were separated from breast and thigh cuts, which were then frozen in a blast freezer (Rhinox, Italy) at -20°C for 30 min. Cuts remained stored in a freezer at -18°C (Pensonic, Malaysia). The samples were then freeze-dried (Labconco, Missouri) at -46°C for 3 days. The breast and thigh samples were then analyzed in duplicate for amino acid determination and in triplicate for fatty acid analyses.

Amino acid analysis: The amino acid compositions of duck breasts and thighs were determined by hydrolysis with 6N HCl at 110°C for 24 h and derivatized with AccQ reagent (6-aminoquinolyl-N-hydroxysuccinimdyl carbamite) before chromatographic separation using an AccQ Tag™ reverse-phase (3.9 x 150 mm) analytical column (Waters®). Amino acid analyses were performed using a high-pressure liquid chromatography (HPLC) system, which consisted of Waters 1525 Binary HPLC Pump, 717 Plus autosampler (Waters®) and Waters 2475 Multi λ Fluorescence detector (wavelength excitation 250 nm, emission 395 nm). As an internal standard for quantitative determination, α-amino butyric acid (AABA) was used. Acetronitrile and AccQ.Tag™ were used as eluents. Chromatographic peaks were integrated, identified and quantified with Breeze™ software version 3.20 by comparing with known standards (Amino acid standard H, Pierce, Rockford, Illinois, USA). Methionine and cysteine were determined by the same method of acid hydrolysis after treating with performic acid oxidation. Tryptophan was not analyzed in this study.

Chemical score, amino acid score and EAA index: Chemical scoring was performed by comparing the essential amino acid content and amino acids of egg as a standard (Acton and Rudd, 1987). The Essential Amino Acid (EAA) contents of egg, according to an FAO report (1970), have been reported (per 100 g protein) as follows: lysine 6.98 g, methionine + cysteine 5.79 g, isoleucine 6.29 g, leucine 8.82 g, valine 6.85 g, phenylalanine + tyrosine 9.89 g and tryptophan 1.49 g. In this case, the calculation of tryptophan content was not conducted.

The amino acid score was determined by comparing the essential amino acid contents of the samples to the amino acid contents suggested for humans (Sawar and McDonough, 1990). The amino acid content recommended for children aged 2-5 years is used to calculate amino acid score of the samples (FAO/WHO/UNU, 1985). The essential amino acid contents were determined (per 100 g protein) to be as follows: histidine 1.9 g, lysine 5.8 g, methionine + cysteine 2.5 g, threonine 3.4 g, isoleucine 2.8 g, leucine 6.6 g, valine 3.5 g, phenylalanine + tyrosine 6.3 g and tryptophan 1.1 g. Again, the calculation of tryptophan was not involved.

The essential amino acid index was obtained from chemical score data. The score, which was obtained for every amino acid, was then converted to a log 10 scale. Then, the averages of the scores were converted to an antilog scale to obtain the amino acid index score (Acton and Rudd, 1987).

Fatty acid analysis: Fatty acid analyses were carried out according to Indarti *et al*. (2005). Fatty Acid Methyl Esters (FAME) were synthesized by a direct or one-step extraction-transesterification method. Briefly, 0.1-g samples were mixed with 2 ml of a mixture of methanol and sulfuric acid (85:15, v/v) and 2 ml of chloroform. Samples were heated to 100°C for 30 min and cooled to room temperature in a desiccator. Then, 1 ml of distilled water was added to the mixture, which was then thoroughly vortexed for 1 min. The mixture was allowed to separate and the organic phase containing FAME was then transferred and dried with anhydrous Na_2SO_4. Samples were stored in a freezer (-20°C) while awaiting Gas Chromatography (GC) analysis.

Fatty Acid Methyl Esters (FAME) were separated and quantified using a gas chromatography system (Automatic System XL, Perkin Elmer, Norwalk, Connecticut, USA) equipped with a flame ionization detector and a 30-m x 0.25-mm fused silica capillary column (Omegawax 250, Supelco, Bellefont, USA). Helium was used as the carrier gas and hydrogen and compressed air were used for Flame Ionization Detection (FID). The oven temperature was programmed to rise from 50-220°C at a rate of 4°C min^{-1} and then held at 220°C for 35 min. The injector and detector temperatures were set to 250°C and 260°C, respectively. Individual fatty acids were identified by comparison to known standards (Supelco 37 Component FAME Mix;

Supleco) and the areas beneath the identified chromatographic peaks were calculated by integration.

SFA, MUFA, PUFA, ω3, ω6 and ω6: ω3 Determinations: The SFA, MUFA, PUFA, ω3, ω6 and ω6: ω3 ratios were calculated from the fatty acid compositions determined in this study.

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

RESULTS AND DISCUSSION

Amino acid composition: The total essential amino acid content of Peking duck thighs is significantly higher ($p<0.05$) than that of Peking duck breast cuts. However, the non-essential amino acid content of Peking duck breasts is higher ($p<0.05$) than that of Peking duck thighs. The total essential and non-essential amino acid contents of Muscovy duck meat were not significantly different ($p>0.05$). In addition, no significant differences ($p>0.05$) were found in comparing similar cuts from the two different species (Peking duck and Muscovy duck). In general, glutamic acid, aspartic acid, lysine and methionine were present at significant levels, with highest concentrations present in the breasts and thighs of Peking and Muscovy duck. This trend is also similar to that observed in chicken and ostrich (Table 1). The percentage of cysteine found in Peking duck was higher than that found in Cherry Valley duck and chicken, whereas the concentration of methionine in both the Peking and Muscovy species was higher compared to that in Cherry Valley duck, chicken and ostrich meat.

High amounts of glutamic acid, aspartic acid and lysine were found not only in duck meat but also in chicken meat, as reported by Wattanachant *et al.* (2004). These authors reported that the muscles of chicken meat were very high in glutamic acid, arginine, leucine, aspartic acid and lysine, but they reported no differences in amino acid compositions between broiler and indigenous chicken muscles.

Analyses of the amino acid compositions of some red meats showed that glutamic acid was present at the highest concentration in camel meat (Dawood and Alhankal, 1995) and buffalo meat (Ziauddin *et al.*, 1994). The results from those studies found that the glutamic acid contents of camel and buffalo were 16.35-17.25 (g/16 g N) and 12.32-12.69 (g/100 g protein), respectively. Aspartic acid was found to be the second-most concentrated amino acid in duck and other poultry; the reports also showed high levels of aspartic acid for camel (aspartic acid was the second-most concentrated amino acid) and buffalo (aspartic acid was the third-most concentrated amino acid). The afore mentioned study reported that the aspartic acid contents in camel

Table 1: Amino acid composition (g/100 g protein) of peking and muscovy duck meat compared to cherry valley duck, chicken and ostrich meat

Type of amino acid	Peking duck		Muscovy duck		Cherry valley duck[1]	Chicken[2]		Ostrich[3]
	Breast	Thigh	Breast	Thigh		Breast	Thigh	
Essential								
Cystine	$2.65^{aA}\pm0.18$	$2.07^{aA}\pm0.45$	$0.07^{aB}\pm0.05$	$0.08^{aB}\pm0.03$	1.54	0.70	0.76	N.A
Histidine	$3.23^{aA}\pm0.35$	$2.79^{aA}\pm0.27$	$2.96^{aA}\pm0.22$	$2.74^{aA}\pm0.29$	1.20	4.28	3.42	2.03
Isoleucine	$7.61^{aA}\pm0.28$	$7.85^{aA}\pm0.18$	$3.44^{aB}\pm0.08$	$3.26^{aB}\pm0.16$	2.30	4.34	4.15	4.71
Leucine	$2.79^{aB}\pm0.08$	$2.82^{aB}\pm0.04$	$7.63^{aA}\pm0.20$	$7.24^{aA}\pm0.16$	3.82	8.25	7.85	7.78
Lysine	$9.21^{aA}\pm0.38$	$9.12^{aA}\pm0.26$	$9.41^{aA}\pm0.00$	$8.23^{aA}\pm0.56$	2.89	8.31	8.15	8.48
Methionine	$7.09^{aA}\pm1.76$	$10.12^{aA}\pm1.63$	$6.15^{aA}\pm0.74$	$12.06^{aA}\pm2.65$	2.19	3.25	3.25	2.82
Phenylalanine	$3.22^{aB}\pm0.09$	$3.27^{aA}\pm0.01$	$3.90^{aA}\pm0.05$	$3.72^{aA}\pm0.30$	2.84	4.03	4.00	4.48
Threonine	$4.65^{aA}\pm0.15$	$4.70^{aA}\pm0.06$	$4.96^{aA}\pm0.14$	$4.30^{aA}\pm0.84$	15.10	4.77	5.02	3.90
Tyrosine	$1.84^{aB}\pm0.12$	$1.85^{aB}\pm0.11$	$3.70^{aA}\pm0.09$	$3.85^{aA}\pm0.03$	3.79	3.95	4.02	3.13
Valine	$4.58^{aA}\pm0.13$	$4.57^{aA}\pm0.06$	$3.49^{aB}\pm0.12$	$3.21^{aB}\pm0.12$	4.73	4.69	4.38	5.00
Total	$46.87^{bA}\pm0.39$	$49.16^{aA}\pm0.36$	$45.71^{aA}\pm01.15$	$48.69^{aA}\pm0.31$	40.40	46.57	45.00	42.33
Non essential								
Arginine	$7.07^{aA}\pm0.21$	$6.40^{aB}\pm0.30$	$7.28^{aA}\pm0.13$	$8.40^{aA}\pm0.55$	6.35	6.54	6.32	6.89
Alanine	$6.21^{aB}\pm0.49$	$6.02^{aA}\pm0.08$	$6.62^{aA}\pm0.07$	$5.85^{bA}\pm0.15$	15.80	5.78	5.68	5.46
Aspartic acid	$9.57^{aA}\pm0.38$	$9.55^{aA}\pm0.38$	$10.01^{aA}\pm0.30$	$8.69^{aA}\pm0.68$	7.57	9.80	9.63	9.78
Glutamic acid	$15.21^{aA}\pm0.18$	$14.96^{aA}\pm0.18$	$15.62^{aA}\pm0.45$	$13.71^{bB}\pm0.00$	15.60	14.91	15.27	15.89
Glycine	$6.26^{aA}\pm0.62$	$5.53^{aA}\pm0.33$	$5.57^{aA}\pm0.02$	$5.68^{aA}\pm0.57$	7.61	4.56	5.13	4.22
Proline	$4.23^{aA}\pm0.08$	$3.94^{aA}\pm0.05$	$4.31^{aA}\pm0.05$	$4.29^{aA}\pm0.03$	-	4.05	4.33	N.A
Serine	$4.56^{aA}\pm0.16$	$4.44^{aA}\pm0.30$	$4.87^{aA}\pm0.16$	$4.67^{aA}\pm0.69$	7.69	4.93	5.40	3.02
Total	$53.11^{aA}\pm0.38$	$50.84^{bA}\pm0.37$	$54.28^{aA}\pm1.15$	$51.29^{aA}\pm0.23$	60.62	50.57	51.76	45.26^{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 letter in the breast and thigh part of different duck are significantly different ($p<0.05$).

[1]Liu *et al.* (2007).

[2]Hamm (1981).

[3]Sales and Hayes (1996)

(g/16 g N) and buffalo were 8.63-9.33 and 7.50-7.74 (g/100 g protein), respectively. In contrast, the researchers found lower methionine contents in camel (2.16-2.59 g/16 g N) and buffalo (4.43-4.59 g/100 g protein) compared to the ducks analyzed in this study. The cysteine content of buffalo was 0.94-1.59 g/100 g protein, which represents a lower percentage than that found in Peking duck but a higher percentage than that of Muscovy duck.

Chemical score, amino acid score and EAA index: The chemical score of Peking duck breast showed no significant difference ($p>0.05$) compared to that of the thigh; a similar trend was observed in Muscovy duck breast compared to the thigh ($p>0.05$). Furthermore, the chemical score of Muscovy duck meat was significantly higher ($p<0.05$) than that of Peking duck meat in comparing similar cuts. The chemical scores of Peking and Muscovy duck meat were lower than that of chicken meat. However, Peking duck meat exhibited a lower chemical score than did Cherry Valley duck meat; this result was in contrast to the higher score reported for Muscovy duck with respect to the Cherry Valley species (Table 2). Compared to the chemical score of ostrich meat, that of Muscovy duck breast was observed to be higher, whereas Muscovy duck thighs and both the breasts and thighs of Peking duck showed lower chemical scores.

The amino acid score is an index of the effectiveness of nitrogen in food, where protein nitrogen should meet the amino acid requirements of the body (WHO, 2007). With respect to the chemical score, the amino acid score of Peking duck breast was not significantly different ($p>0.05$) from that of the thigh; a similar trend was observed in Muscovy duck breast compared to thigh meat ($p>0.05$). Furthermore, the amino acid score of Muscovy duck meat was significantly higher ($p<0.05$) than that of Peking duck meat when comparing similar cuts. The amino acid scores of Peking duck were lower than those of Cherry Valley duck, chicken and ostrich, whereas the scores for Muscovy duck were lower than those of chicken and ostrich but higher than those of Cherry valley duck.

The EAA indices of Peking and Muscovy duck breasts were not significantly different ($p>0.05$) than those of the thighs; similarly, the EAA indices of similar Peking and Muscovy duck parts showed no significant differences ($p>0.05$). The EAA indices of Peking and Muscovy thigh meat were higher than those of Cherry Valley duck, chicken and ostrich meat. The EAA indices of Peking and Muscovy breast meat were slightly lower than those of chicken breast but higher than those Cherry Valley duck, chicken thigh and ostrich meat.

In general, Muscovy meat showed higher protein quality than Peking duck meat. As noted by Jansen (1984), protein quality is related to protein efficiency in the human digestive system. Protein efficiency plays an important role in determining the level of protein required for consumption or the type of protein source required for various individuals. By measuring protein efficiency, we can obtain information related to the suitable level of a certain food source required for digestion.

Fatty acid composition: C18:1ω9, C16:0, C16:4ω3 and C18:2ω6 were the four most concentrated fatty acids found in the breasts and thighs of Peking ducks. In Muscovy duck, C18:1ω9, C16:0, C18:2ω6 and C18:0 were observed to be the four most concentrated fatty acids in Muscovy breast and thigh meat. Other fatty acids were found in smaller amounts in these duck meats. Some fatty acids were not found in the two different species of duck studied, whereas others were found in different parts of the same duck.

The concentration of C18:1ω9 in Peking duck meat was significantly lower ($p<0.05$) than in Muscovy duck meat. In addition, the concentration of C18:2ω6 in Peking duck thigh was significantly higher ($p<0.05$) than in Muscovy duck thigh. Then, the concentration of C16:4ω3 in Peking duck breast was significantly higher ($p<0.05$) than that in Muscovy duck breast. The percentage of C20:4ω6 found in Peking and Muscovy duck was higher than that found in chicken (1.35) and quail (2.78) (Soares *et al.*, 2009; Boni *et al.*, 2010).

The differences in the fatty acid profiles of the duck species studied may depend on the duck breed and the feed they consumed. This is similar to the report of Beckerbauer *et al.* (2001), who noted that the differences in the fatty acid compositions of poultry meat are influenced by the source of dietary lipids source used for daily feed consumption. Similarly, Cobos *et al.* (2000) noted that grains, aquatic plants and aquatic animals found in damp paddy field ecosystems are the most important food sources for ducks and affect the fatty acid composition of ducks.

In addition, fatty acid content varies with muscle type (Jakobsen, 1999). Correspondingly, other authors have noted in greater detail that the differences in fatty acid composition are related to the differences in muscle fiber type, where white muscles generally contain a lower percentage of phospholipids and PUFAs compared to red muscles (Wood *et al.*, 2003).

SFA, MUFA, PUFA, ω3, ω6 and ω6: ω3 ratio: The concentration of SFAs in Peking duck breast are significantly lower ($p<0.05$) than in Muscovy duck breast and no significant differences were observed in the SFA concentrations in thigh cuts ($p>0.05$). Additionally, there were no significant differences ($p<0.05$) in the SFA concentrations between the breasts and thighs of similar duck species. The higher concentration of SFA in Muscovy duck breast meat is similar to the SFA concentration in wild duck reported by Cobos *et al.*

Table 2: Chemical score and amino acid score of peking and muscovy duck meat compared to cherry valley duck, chicken and ostrich meat

Type of amino acid	Peking duck		Muscovy duck		Cherry valley duck[1]	Chicken[2]		Ostrich[3]
	Breast	Thigh	Breast	Thigh		Breast	Thigh	
Chemical score								
Lysine	132.00 (100)^{aA}±5.57	130.73 (100)^{aA}±5.98	134.80 (100)^{aA} ±0.00	117.91 (100)^{aA}±8.10	41.40	119.05 (100)	116.76	121.49 (100)
Methionine + sistine	168.24 (100)^{aA}±14.78	210.55 (100)^{aA}±16.98	107.51 (100)^{aB}±11.85	209.76 (100)^{aA}±46.29	64.42	68.22	69.26	48.71
Treonine	90.83^{aA}±4.14	91.81^{aA}±0.14	96.94^{aA}±2.90	83.98^{aA}±16.57	294.92 (100)	93.16	98.05	76.17
Isoleucine	120.99 (100)^{aA} ±6.30	124.77 (100) ^{aA}±4.95	54.63^{aB}±1.24	51.83^{aB}±2.47	36.57	69.00	65.98	74.88
Leucine	31.63^{aB}±1.28	32.03^{aB}±1.04	86.56^{aA}±2.33	82.13^{aA}±1.84	43.31	93.54	89.00	88.21
Valine	66.86^{aA}±2.68	66.67^{aA}±1.96	50.97^{aB}±1.76	46.84^{aB}±1.86	69.05	68.47	63.94	72.99
Phenylalanine + tyrosine	51.23^{aB}±2.79	51.78^{aB}±0.43	76.80^{aA}±1.36	76.60^{aA}±3.36	67.04	80.69	81.09	76.95
Result	31.63^{aB}±1.28	32.03^{aB}±1.04	50.97^{aA}±1.76	46.84^{aA}±1.86	36.57	68.22	63.94	48.71
Amino acid score								
Histidine	170.00 (100)^{aA} ±23.82	146.69 (100)^{aA}±14.89	155.92 (100)^{aA} ±11.54	144.25 (100)^{aA}±14.89	63.16	225.26 (100)	180.00 (100)	106.84 (100)
Lysine	158.86 (100)^{aA}±6.71	157.32 (100)^{aA}±7.19	162.23 (100)^{aA}±0.00	141.90 (100)^{aA} ±9.75	49.83	143.28 (100)	140.52 (100)	146.21 (100)
Methionine + cystine	389.64 (100)^{aA}±34.22	487.63 (100)^{aA}±39.32	248.98 (100)^{aB}±27.44	485.80 (100)^{aA}±107.20	149.2 (100)	158.00 (100)	160.40 (100)	112.8 (100)
Treonine	136.77 (100)^{aA}±6.24	138.25 (100)^{aA}±0.21	145.98 (100)^{aA}±4.37	126.46 (100)^{aA}±24.96	444.12 (100)	140.29 (100)	147.65 (100)	114.71 (100)
Isoleucine	271.80 (100)^{aA}±14.14	280.30 (100)^{aA}±11.11	122.73 (100)^{aB}±2.78	116.43 (100)^{aB}±5.56	82.14	155.00 (100)	148.21 (100)	168.21 (100)
Leucine	42.27^{aB}±1.71	42.80^{aB}±1.39	115.68 (100)^{aA}±3.11	109.75 (100)^{aA} ±2.46	57.88	125.00 (100)	118.94 (100)	117.88 (100)
Valine	130.86 (100)^{aA}±5.25	130.48 (100)^{aA}±3.84	99.76^{aB}±3.44	91.68^{aB}±3.64	135.14 (100)	134.00 (100)	125.14 (100)	142.86 (100)
Phenylalanine + tyrosine	80.43^{aB}±4.38	81.28^{aB}±0.67	120.56 (100)^{aA}±2.13	120.25 (100)^{aA} ±5.28	105.24 (100)	126.67 (100)	127.30 (100)	120.79 (100)
Triptophan	-	-	-	-	-	-	-	-
Result	42.27^{aB}±1.71	42.80^{aB}±1.39	99.76^{aA}±3.44	91.68^{aA}±3.64	49.83	100	100	100

[1]Calculated from the amino acid data of Liu *et al.* (2007).
[2]Calculated from the amino acid Hamm (1981).
[3]Calculated from the amino acid Sales and Hayes (1996)

Table 3: EAA index of peking and muscovy duck meat compared to cherry valley duck, chicken and ostrich meat

Type of amino acid	Peking duck		Muscovy duck		Cherry valley duck[1]	Chicken[2]		Ostrich[3]
	Breast	Thigh	Breast	Thigh		Breast	Thigh	
EAA index								
Lysine	2.12^{aB}±0.01	2.12^{aA}±0.02	2.13^{aA}±0.00	2.07^{aA}±0.03	1.62	2.08	2.07	2.09
Methionine + cystine	2.23^{aA}±0.04	2.32^{aA}±0.04	2.03^{aB}±0.04	2.32^{aA}±0.09	1.81	1.83	1.84	1.69
Treonine	1.96^{aA}±0.02	1.96^{aA}±0.00	1.99^{aA}±0.01	1.92^{aA}±0.09	2.47	1.97	1.99	1.88
Isoleusine	2.08^{aA}±0.02	2.10^{aA}±0.02	1.74^{aB}±0.01	1.72^{aB}±0.02	1.56	1.84	1.82	1.87
Leusine	1.50^{aB}±0.01	1.51^{aB}±0.01	1.94^{aA}±0.01	1.92^{aA}±0.01	1.64	1.97	1.95	1.95
Valine	1.83^{aA}±0.02	1.82^{aA}±0.01	1.71^{aB}±0.01	1.67^{aB}±0.01	1.84	1.84	1.81	1.86
Phenylalanine + tyrosine	1.71^{aB}±0.03	1.71^{aB}±0.01	1.89^{aA}±0.01	1.88^{aA}±0.02	1.83	1.91	1.91	1.89
Average	1.917^{a}±0.26	1.935^{a}±0.28	1.916^{a}±0.15	1.929^{a}±0.22	1.823	1.919	1.909	1.889
Result	82.69^{aA}±1.21	86.02^{aA}±0.70	82.5^{aA}±2.71	84.87^{aA}±2.77	66.53	82.93	81.63	77.45

[1]Calculated from the amino acid data of Liu *et al.* (2007).

[2]Calculated from the amino acid Hamm (1981).

[3]Calculated from the amino acid Sales and Hayes (1996)

Table 4: Fatty acid (% of total fatty acid) of Peking and Muscovy duck meat

Fatty acid	Peking duck		Muscovy duck	
	Breast	Thigh	Breast	Thigh
C14:0	2.74^{bA}±0.55	5.26^{aA}±1.28	2.24^{bA}±0.08	2.64^{aB}±0.07
C16:0	24.11^{aA}±3.93	20.32^{aA}±0.83	22.61^{aA}±0.06	21.38^{bA}±0.37
C16:1ω7	0.75^{bB}±0.15	1.80^{aA}±0.38	2.25^{aA}±0.18	2.37^{aA}±0.05
C16:2ω4	0.00^{aA}±0.00	0.39^{aA}±0.17	0.06^{aA}±0.10	0.13^{aA}±0.12
C16:3ω4	1.09^{aA}±0.24	0.38^{bA}±0.27	0.46^{aB}±0.12	0.21^{aA}±0.18
C16:4ω3	16.12^{aA}±2.84	12.33^{aA}±4.26	1.95^{aB}±0.84	7.52^{aA}±6.52
C18:0	0.00^{aB}±0.00	0.00^{aB}±0.00	10.63^{aA}±0.25	3.91^{bA}±6.77
C18:1ω7	2.56^{aA}±0.28	2.36^{aA}±0.39	2.71^{aA}±0.13	2.39^{bA}±0.14
C18:1ω9	26.89^{aB}±3.19	30.36^{aB}±4.34	36.45^{bA}±1.32	40.24^{aA}±1.07
C18:2ω6	13.28^{bA}±0.81	17.04^{aA}±0.31	14.69^{aA}±0.53	12.69^{bB}±0.03
C18:3ω4	0.28^{aA}±0.24	1.23^{aA}±2.13	0.18^{aA}±0.15	0.29^{aA}±0.05
C18:3ω6	0.03^{aA}±0.05	0.54^{aA}±0.47	0.08^{aA}±0.13	0.00^{aA}±0.00
C20:1ω9	0.03^{aA}±0.27	0.15^{aA}±0.13	0.19^{aA}±0.17	0.21^{aA}±0.19
C20:3ω6	0.00^{aA}±0.00	0.17^{aA}±0.19	0.12^{aA}±0.12	0.00^{aA}±0.00
C20:4ω3	0.00^{aA}±0.00	0.12^{aA}±0.11	0.16^{aA}±0.14	0.06^{aA}±0.11
C20:4ω6	9.23^{aA}±1.89	6.16^{aA}±3.65	4.74^{aB}±0.58	4.78^{aA}±0.36
C20:5ω3	0.84^{aA}±0.58	0.00^{aA}±0.00	0.00^{aA}±0.00	0.23^{aA}±0.38
C22:5ω3	0.00^{aA}±0.00	0.37^{aA}±0.23	0.08^{aA}±0.13	0.00^{aA}±0.00
C22:6ω3	1.60^{aA}±0.40	1.03^{aA}±0.47	0.44^{aB}±0.38	0.95^{aA}±0.28

^{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 letter in the breast and thigh part of different duck are significantly different (p<0.05)

Table 5: SFA, MUFA, PUFA, ω3, ω6 and ω6: ω3 ratio of peking and muscovy compared to wild duck, chicken and turkey (% of total fatty acid)

Fatty acid type	Peking duck		Muscovy duck		Wild duck[1]	
	Breast	Thigh	Breast	Thigh	Breast	Leg
SFA	26.85^{aB}±3.38	25.58^{aA}±2.03	35.47^{aA}±0.24	27.93^{aA}±6.69	35.10	31.10
MUFA	30.22^{aB}±2.65	34.67^{aB}±5.16	41.59^{bA}±1.56	45.21^{aA}±1.21	23.70	35.50
PUFA	42.47^{aA}±5.97	39.75^{aA}±7.13	22.94^{aB}±1.33	26.86^{aA}±5.68	41.20	33.40
ω3	18.56^{aA}±3.16	13.85^{aA}±4.92	2.63^{aB}±0.57	8.76^{aA}±5.93	41.30*	4.03*
ω6	22.54^{aA}±1.91	23.90^{aA}±4.11	19.62^{aB}±0.41	17.47^{aA}±0.36	37.10*	30.31*
ω6: ω3	1.22^{aB}±0.03	1.73^{aA}±0.17	7.48^{aA}±0.30	2.00^{aA}±1.26	8.98*	7.52*

*Calculated from available data.

[1]Cobos *et al.* (2000)

(2000). They found that the concentration of SFA (% fatty acid) in breast meat (35.1) and this is higher than that found in wild duck leg meat (31.1). Ahn *et al.* (1995) found that the SFA concentration (% of total lipid) in broiler chicken breast (28. 67) was slightly higher than that in the leg meat (26.38 g).

Generally, SFAs are undesirable in food sources; this is clearly noted in one paper that reports that lifestyle and dietary patterns determine the health of human populations whose inappropriate food selection tends to cause cardiovascular disease. Considering this, humans should be more selective in choosing their food intake and focus has now been placed on the reduction in the consumption of food with high SFA content (Krauss *et al.*, 2000). Furthermore, when the SFA in meat is undesirable, modification in the diet improves the source of other fatty acid types (MUFAs or PUFAs).

The MUFA concentration in Peking duck is significantly lower ($p<0.05$) than that in Muscovy duck. No significant differences between the MUFA concentrations in breast and thigh cuts of Peking duck were observed. However, the MUFA concentration in Muscovy duck breast was significantly lower ($p<0.05$) than that in Muscovy thigh meat. A similar trend was also observed in other research on duck meat. The total concentration of MUFA in wild ducks was reported by Cobos *et al.* (2000). They found that the MUFA concentration (% fatty acid) in wild duck breast (23.7) was lower than that in wild duck leg meat (35.5). A similar result was also reported for chicken by Leonel *et al.* (2007), who found that the MUFA concentration (g/100 g meat) in broiler chicken breast (30.47) was also lower than that in thigh meat (32.63). Moreover, the higher PUFA concentration observed in Peking duck breast ($p<0.05$) compared to Muscovy duck breast. No significant difference ($p>0.05$) in the concentration of PUFA between breast and thigh in similar species. This is different to that reported for broiler chicken (Suksombat *et al.*, 2007), where the PUFA concentration (g/100 g of fatty acid) in chicken breast (27.11) was higher than that in chicken thigh meat (25.39).

No significant difference ($p>0.05$) in the $\omega3$ concentration between the breast and thigh meat of similar species was observed. However, the $\omega3$ concentration in the breast meat of Peking duck was significantly higher ($p<0.05$) than that of the breast meats of Muscovy duck. Omega-3 plays an important role in human health, especially in the food intake of young people, for supporting their nutritional growth and older people as well (Simopoulos, 1991). Generally, $\omega3$ content of meat is low, which does not make meat a good source of $\omega3$. Efforts to increase the $\omega3$ content in meats with different feed treatments followed by further storage treatment to maintain their stability have been undertaken by some researchers to provide healthier meat (Ahn *et al.*, 1995). No significant difference ($p>0.05$) in the $\omega6$ content of different cuts of the Peking and Muscovy ducks were observed. However, the $\omega6$ concentration in Peking duck breast was observed to be significantly higher ($p<0.05$) than that in Muscovy duck breast, although no significant difference was observed in the $\omega6$ concentration between the thigh meat of the two species.

The $\omega6{:}\omega3$ ratio in Peking duck breast is significantly lower ($p<0.05$) compared to that in Muscovy duck breast; no significant difference in this ratio was observed between the thigh meats of Peking and Muscovy ducks. In addition, no significant difference was observed in the $\omega6{:}\omega3$ ratio between the thighs and breasts of ducks of the same species. Linolenic acid ($\omega3$) and linoleic acid ($\omega6$) must be obtained directly from food and the source of these acids will determine the quality of health of the person consuming it (Simopoulos, 1991). However, humans must balance the intake of both $\omega6$ and $\omega3$ fatty acids to maintain their health (Simopoulos, 2000). Duck meat alone, or combined with other foods, can be a source of these omega fatty acids for daily consumption.

Conclusion: Among all of the amino acids, glutamic acid was detected at the highest concentration in both Peking and Muscovy duck; among essential amino acid types, lysine and methionine generally showed the highest concentrations. These results are comparable to those reported previously for other meats. The concentration of methionine in duck meat is relatively high compared to the concentration in chicken and ostrich. The quality of the amino acids in duck meat varies due to the essential amino acid content in the meat. Fatty acid compositional analysis found C18:1ω9 to be the highest-concentration fatty acid found in both Peking and Muscovy duck. The concentration of C20:4ω6 in duck meat is relatively high compared to the concentrations reported in other studies for chicken and quail meat. MUFA was the highest-concentration fatty acid found in Muscovy duck, whereas PUFA was the highest-concentration fatty acid in Peking duck.

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REFERENCES

Acton, J.C. and C.L. Rudd, 1987. Protein Quality Method for Seafood. In: Seafood Quality Determination (pp: 453-473). Kramer D.E. and Liston J. (Eds.). Elsevier, Amsterdam.

Ahn, D.U. F.H. Wolfe and J.S. Sim, 1995. Dietary ω-linolenic acid and mixed tocopherols and packaging influences on lipid stability in broiler chicken breast and leg muscle. J. Food Sci., 60: 1013-1018.

Beckerbauer, L.M., R. Thiel-Cooper, D.U. Ahn, J.L. Sell, F.C. Parrish Jr. and D.C. Beitz, 2001. Influence of two dietary fats on the composition of emu oil and meat. Poultry Sci., 80: 187-194.

Boni, I., H. Nurul and I. Noryati, 2010. Comparison of meat quality characteristics between young and spent quails. Int. Food Res. J., 17: 661-666.

Cobos, A., A. Veiga and O. Diaz, 2000. Chemical and fatty acid composition of meat and liver of wild ducks (*Anas platyrhynchos*). Food Chem., 68: 77-79.

Dawood, A. and M.A. Alhankal, 1995. Nutrient composition of Najdi camel meat. Meat Sci., 39: 71-78.

Department Veterinary Service of Malaysia, 2008. Poultry Population and Percapita Consumption of Livestock Products. http://agrolink.moa.my/jph (Accessed November 2008).

FAO, 1970. Amino Acid Content of Foods and Biological Data on Proteins. FAO Nutritional Studies No. 24. Food Policy and Food Science Service, Nutritional Division, FAO, Rome.

FAO/WHO/UNU, 1985. Energy and Protein Requirements. Report of a Joint FAO/WHO/UNU Expert Consultation. Technical Report Series no. 724. World Health Organization, Geneva.

Hamm, D., 1981. Amino acid composition of breast and thigh meat from broilers produced in four locations of the United States. J. Food Sci., 46: 1122-1124.

Indarti, E., M.I.A. Majid, R. Hasyim and A. Chong, 2005. Direct FAME synthesis for rapid total lipid analysis from fish oil and cod liver oil. J. Food Composition Anal., 18: 161-170.

Jakobsen, K., 1999. Dietary modifications of animal fats: Status and future perspectives. Fett/Lipid, 101: S475-483.

Jansen, G.R., 1984. Background paper 1: Assessment of the need for regulating the protein quality of meat and poultry products. The Am. J. Clin. Nutr., 40: 685-703.

Kim, B.H., H.S. Lee, Y.A. Jang, J.Y. Lee, Y.J. Cho and C.-I. Kim, 2009. Development of amino acid composition database for Korean foods. J. Food Composition Anal., 22: 44-52.

Krauss, R.M., R.H. Eckel, B. Howard, L.J. Appel, S.R. Daniels, R.J. Deckelbaum, J.W. Erdman, P. Kris-Etherton, I.J. Goldberg, T.A. Kotchen, A.H. Lichtenstein, W.E. Mitch, R. Mullis, K. Robinson, J. Wylie-Rosett, S. St Jeor, J. Suttie, D.L. Tribble and T.L. Bazzarre, 2000. Revision 2000: A statement for healthcare professionals from the nutrition committee of the American hearth association. Circulation, 102: 2284-2299.

Leonel, F.R., A. Oba, E.R.L. Pelicano, N.M.B.L. Zeola, M.M. Boiago, A.M. Scatolini, T.M.A. Lima, P.A. Souza and H.B.A. Souza, 2007. Performance, carcass yield and qualitative characteristics of breast and leg muscles of broilers fed diets supplemented with vitamin E at different ages. Braz. J. Poult. Sci., 9: 91-97.

Liu, Y., X.-I. Xu and G.-H. Zhou, 2007. Changes in taste compounds of duck during processing. Food Chem., 102: 22-26.

Sales, J. and J.P. Hayes, 1996. Proximate, amino acid and mineral composition of ostrich meat. Food Chem., 56: 167-170.

Salma, U., A.G. Miah, T. Maki, M. Nishimura and H. Tsujii, 2007. Effect of dietary rhodobacter capsulatus on cholesterol concentration and fatty acid composition in broiler meat. Poult. Sci., 86: 1920-1926.

Sawar, G. and F.E. Mcdonough, 1990. Review of protein quality evaluation methods. J. Assoc. Off. Anal. Chem., 73: 347-356.

Schaafsma, G., 2000. The protein digestibility-corrected amino acid score. The J. Nutr., 130: 1865S-1867S.

Simopoulos, A.P., 1991. Omega-3 fatty acids in health and disease and in growth and development. The Am. J. Clin. Nutr., 54: 438-463.

Simopoulos, A.P., 2000. Human requirement for n-3 polyunsaturated fatty acids. Poult. Sci., 79: 961-970.

Soares, A.L., D.F. Marchi, M. Matsushita, P.D. Guarnieri, A.A. Droval, E.I. Ida and M. Shimokomaki, 2009. Lipid oxidation and fatty acid profile related to broiler breast meat color abnormalities. Braz. Arch. Biol. Technol., 52: 1513-1518.

Suksombat, W., T. Boonmee and P. Lounglawan, 2007. Effects of various levels of conjugated linoleic acid supplementation on fatty acid content and carcass composition of broilers. Poult. Sci., 86: 318-324.

Tuan, Y.-H., R.D. Phillips and C.R. Dove, 1999. Predicting integrated protein nutritional quality part 2: Integrated protein nutritional quality predicted from amino acid availability corrected amino acid score (AACAAS). Nutr. Res., 19: 1807-1816.

Wattanachant, S., S. Benjakul and D.A. Ledward, 2004. Composition, color and texture of thai indigenous and broiler chicken muscles. Poult. Sci., 83: 123-128.

WHO, 2007. Protein and Amino Acid Requirements in Human Nutrition. Report of a Joint WHO/FAO/UNU Expert Consultation. Geneva, Switzerland: United Nations University.

Wood, J.D., R.I. Richardson, G.R. Nute, A.V. Fisher, M.M. Campo, E. Kasapidou, P.R. Sheard and M. Enser, 2003. Effects of fatty acids on meat quality: A review. Meat Sci., 66: 21-32.

Ziauddin, K.S., N.S. Mahendrakar, D.N. Rao, B.S. Ramesh and B.L. Amla, 1994. Observations on some chemical and physical characteristics of buffalo meat. Meat Sci., 37: 103-113.