Meat characteristics from four different cutting parts of Cherry Valley duck

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Abstract. The objective of this study was to investigate the duck meat characteristics in 4 main parts : breast, fillet, leg, and thigh. A total of 30 Cherry Valley ducks were used in this study. They were slaughtered at the age of 42 days. Carcasses were cut and collected the boneless and skinless of breast, fillet, leg, and thigh for measuring meat characteristics. The results showed that fillet and leg had the longest sarcomere length at 6, 12, and 24 hour post mortem ($P<0.05$). The highest pH was from leg and the lowest pH was from breast and fillet ($P<0.01$). The cooking loss percentage of breast was the highest while the lowest was from leg ($P<0.01$). Thigh and leg were tougher than breast and fillet. Shear force value negatively correlated with sarcomere length at 24 hour post mortem and with pH but positively correlated with L* value.

1. Introduction

Cherry Valley duck is a commercial crosses of Pekin ducks and it is one of a major duck crosses that has been used for commercial duck meat production in Thailand. It has high growth rate and reaches a market live weight of 3.45 kg at 42 days of age with a FCR of 1.92 for a medium-sized commercial duck [1]. For supporting duck production, not only the information of growth performance, carcass yield, and cuttability but also the information of duck meat characteristics is required because it is involved in cooking and processing process. In duck meat production industry, the duck carcass is sale both in a whole carcass and in different cutting parts such as breast, thigh, leg, and fillet. Each part of carcass has different meat characteristics in terms of tenderness, color, water holding capacity, and etc. According to different meat characteristics, each duck cutting part will be cooked in the various methods to meet consumer taste choices. Some scientific studies regarding each part of carcass are needed in order to provide reasons for using in how to cook and process which temperature and time are mainly involved. However, the scientific information of duck meat characteristics in each duck carcass cut up are limited. So the objective of this study was to investigate the duck meat characteristics in 4 main parts : breast, fillet, leg, and thigh.

2. Materials and Methods

2.1 Animals

A total of 30 Cherry Velley ducks were used in this study. They were slaughtered at the age of 42 days . All carcasses were kept in ice box during transferring around 2 hours from Duck King slaughter house in Chachangsao province, Thailand to the laboratory at the Department of Agricultural Education, Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang. Carcasses were cut and collected the boneless and skinless of breast, fillet, leg, and thigh at approximately 6 hour post mortem for measuring sarcomere length, pH, color, cooking loss, and shear force.

2.2 Sarcomere length measurement

Sarcomere length was measured according to the method of [2]. At different post mortem time, 10-15 g of fresh muscle sample from each cutting part of duck carcass were immersed in solution A (0.1 M potassium chloride, 0.39 M boric acid, and 5 mM ethylenediaminetetraacetic acid in 2.5% glutaraldehyde) for 2 hours. The samples were then transferred to new vials containing solution B (0.25 M KCl, 0.29 M boric acid, and 5 mM ethylenediamine-tetraacetic acid in 2.5% glutaraldehyde) for 17 to 19 hours. Sarcomere length was measured by light diffraction using a 0.5-mW helium-neon laser (Model No. 31004, REO, USA). The lengths of 30 sarcomeres were measured in 30 myofibrils from each sample.

2.3 pH measurement

The pH at 6 hour post mortem were measured in duplicate directly at each cutting part of the carcass using pH meter equipped with a spear tip glass electrode (Model SG2 - ELK Seven Go™, Mettler Toledo International Inc., China).

2.4 Color measurement

The boneless and skinless of 4 main cutting parts of the carcass were allowed to bloom for 30 min before measuring CIE L*, a*, and b* color values using a Minolta Chromameter CR-300 (Minolta Camera Co., Japan; Illuminant D65).

2.5 Cooking loss and Shear force measurement

Two pieces of approximately 3-cm-thick slices obtained from each cutting part were weighed, placed into high-density polyethylene bag, heat sealed, and then cooked

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in a water bath set at 80°C for 30 min or until internal temperature of meat sample reached 70°C. After cooked samples were cooled down by running tap water to room temperature before weighing then cooking loss percentage was estimated by calculating the difference between before and after cooking weight. As many as possible of 1 x 1 x 3 cm^3 cuts of each cooking loss sample were removed from across the slice parallel to the muscle fiber orientation. Each cut was sheared once perpendicular to the muscle fiber orientation using a Warner-Bratzler shear head attached to a single column materials testing machine (model H1KS, Hounsfield, England) equipped with a 50 kg load cell using 50 mm/min crosshead speed.

2.6 Statistical analysis

Analyses of variance was generated by using the GLM procedure (SAS Inst. Inc., Cary, NC) with cutting parts as the main effect. Least squares means were separated using the probability of difference option (PDIFF), and the results were considered significant difference when P<0.05. The relationships between shear force value and other traits from four parts of duck carcasses were evaluated by Pearson correlation coefficients.

3. Results and Discussion

3.1 Sarcomere length

In this study, sarcomere length from fillet and leg were longer than from breast and thigh at 6, 12, and 24 hour post mortem (Table 1). However, the study of [3] showed that the sarcomere length from breast and leg of Chungdong ori duck were not significant different. [4] reported that the sarcomere length of age 6 week old Cherry Valley duck measured immediately after slaughter was 1.38 μm which was shorter than in this study. Leg and fillet may contain red or slow muscle fiber having slow contraction which causes longer sarcomere length as explained by [5].

Sarcomere is the contractile unit of myofibrils and sarcomere lengths shorten during muscle contraction [6]. The sarcomere length is shorthen by the overlapping of actin filaments in the center of the I-band and myosin filaments close to the Z-disk causing muscle shrinkage which is reducing meat tenderness [7]. The degree of muscle shrinkage depended on the contractile stage during post mortem storage. The highest degree of muscle shrinkage is during rigor mortis which has a crucial influence on meat tenderness. [8] reported that duck pectoralis major muscles showed a resting sarcomere length of 1.92 ± 0.12 μm at 15 min post mortem during storage at 0°C and shrank continuously until 24 hour post mortem. These authors reported that sarcomere lengths for meat stored at 0°C for 2 and 24 hour post mortem were, respectively, 24 and 37% shorter than at 15 min post mortem. As stated by [9] leg muscles of chicken such as soleus muscle is red muscle which contents more red type I fiber and breast muscle or pectoralis muscle is white muscle which contents more white type IIB fiber. [4] stated that duck leg has a large ratio of red muscle fiber than breast. Red muscle has more muscle contraction than white muscle [10]. In this study, sarcomere length of leg from 6 hour post mortem to 24 hour post mortem showed more contraction (3.3%) than sarcomere length contraction in breast (2.1%) that was in agreement with [9, 10].

Table 1 Sarcomere length (μm) at different time point of 4 major cutting parts of Cherry Valley ducks

Trait[1]	n	LSMeans				RMSE	P value
		Breast	Fillet	Leg	Thigh		
SL_{6h}	30	1.90^b	2.07^a	2.09^a	1.92^b	0.28	0.022
SL_{12h}	10	1.73^b	2.00^a	1.96^a	1.85^b	0.19	0.011
SL_{24h}	30	1.86^b	2.04^a	2.02^a	1.94^b	0.28	0.046

[a,b] within a row, least squares means with different superscripts differ ($p < 0.05$)
[1] SL_{6h}, SL_{12h}, SL_{24h} = sarcomere length at 6, 12, and 24 hour post mortem

3.2 pH

The pH of leg was the highest following by thigh, and the lowest pH was from breast and fillet (P<0.01). The locomotive muscles ; leg and thigh had higher pH than supportive muscles; breast and fillet (Table 2). In agreement with [3] that reported duck leg had higher pH than breast, 6.52 and 5.95, respectively. [11] reported that Cherry Berry duck breast has pH values ranging from 6.6 to 6.0 at 15 min post mortem and at 24 hour post mortem, respectively. Type IIB white breast muscle has higher glycogen content thus its pH post mortem declines more than in type I red leg muscle [9]. [12] stated that pH during post mortem storage decreased faster in fast glycolytic muscle (breast) than in slow oxidative muscle (leg).

3.3 Color

The most redness muscle indicated by the highest a* value was fillet, followed by leg, thigh, and breast, respectively (P < 0.01) as shown in Table 2. Breast and thigh had the same b* value which was higher than from leg and fillet (P < 0.01). L* value from fillet and leg were higher than from breast and thigh (P < 0.01). Breast had lower a* value than leg might be explained by breast had less myoglobin than leg so breast color was less redness [9]. However, from [13] showed that breast and leg had the same a* value approximately 13.5 and [14] also reported that a* value of breast and leg were 17.8 and 17.7, respectively. Breast and thigh had the same b* value and were higher than from leg and fillet in the present study. In agreement with [13] reported higher b* value from breast than from leg (9.15 VS 6.86). In addition [14] reported that breast had b* value 1.89 and leg had b* value 1.50. Breast had significantly lower L* value than leg (28.99 VS 30.13) in the current study. In agreement with [14] found lower L* value from breast than from leg, 40.3 and 41.5, respectively. These authors explained that breast had lower L* value than leg which was probably due to the higher fat content in leg than in breast. In contrast, [13] reported that breast had higher L* value than leg (49.53 VS 47.93).

3.4 Cooking loss

Cooking loss of breast was the highest followed by from fillet and thigh (P<0.01) and the lowest cooking loss was from leg (Table 2). Because the lower pH post mortem causes denaturation of muscle protein in breast so breast has lower water holding capacity and increased exudation and cooking loss of meat [12].

3.5 Shear force

In this study, leg and thigh had the highest shear force value followed by breast and the lowest was fillet (P< 0.01). Fillet was more tender than others this might be associated with its longer sarcomere length. [3] reported that leg had higher shear force value than breast which was similar to this study. [12] informed that post mortem acidification kinetic of muscle had strongly influence on meat texture. In the present study, breast and fillet had lower pH so it might be decresed shear force value.

Table 2 pH, color, cooking loss, and shear force of 4 major cutting parts of Cherry Valley ducks (n=30)

Trait	LSMeans				RMSE	P value
	Breast	Fillet	Leg	Thigh		
pH	5.84^{c}	5.85^{c}	6.28^{a}	6.16^{b}	0.23	<.0001
color						
a*	22.13^{c}	25.52^{a}	23.79^{b}	22.39^{bc}	2.72	<.0001
b*	9.85^{a}	7.59^{c}	8.37^{b}	9.27^{a}	1.08	<.0001
L*	28.99^{b}	30.75^{a}	30.13^{a}	28.71^{b}	1.49	<.0001
CL[1] (%)	29.19^{a}	26.69^{b}	23.59^{c}	25.69^{b}	2.98	<.0001
SF[2] (kg)	4.84^{b}	2.57^{c}	5.62^{a}	6.02^{a}	1.18	<.0001

^{a,b,c}within a row, least squares means with different superscripts differ ($p < 0.01$)
[1]CL = cooking loss, SF[2] = shear force

3.6 Correlation

The correlation between shear force value and other study traits as shown in Table 3.

Table 3 Correlation coefficient of parameter studies and shear force value

Trait	Shear force value	
	r	P value
SL_{6h}[1]	-0.17	0.063
SL_{12h}[1]	-0.24	0.138
SL_{24h}[1]	-0.22	0.015
pH	-0.46	<0.0001
a*	-0.12	0.210
b*	0.17	0.059
L*	0.41	<0.0001
% Cooking loss	-0.05	0.556

[1]SL_{6h}, SL_{12h} , SL_{24h} = sarcomere length at 6, 12, and 24 hour post mortem

Shear force value negatively correlated with sarcomere length at 24 hour post mortem (r=-0.22, P=0.015) and had a trend of negative significant correlation with sarcomere length at 6 hour post mortem (r = -0.17, P =0.063). The pH had a negatively significant correlation with shear force value (r=-0.46, P<0.01). For meat color, b* value tend to have a positive correlation with shear force value (r=0.17, P=0.059) while L* positively correlated with shear force value (r=0.41, P<0.01). The shortening of sarcomere was a main contributor to toughess as indicated by a strong negative correlation between shear force and sarcomere length in chicken breast during chilled at −12 °C and 0°C [15].

4. Conclusion

Different cutting parts from duck carcass had different meat characteristics. Sarcomere length from leg and fillet were longer than from breast and thigh. Leg had the highest pH followed by thigh and the lowest pH were from breast and fillet. The most redness part was fillet followed by leg and thigh and the lowest redness part was breast. Breast and thigh were more yellow color than leg and fillet, respectively. Leg and fillet were lighter color than breast and thigh. Breast had the highest cooking loss and the lowest was from leg. Thigh and leg were tougher than breast and fillet, respectively. In conclusion, fillet was the most tender due to its lowest shear force value which might be associated with the longest sarcomere length. In addition, shear force value negatively correlated with sarcomere length at 24 hour post mortem and with pH at 6 hour post mortem while it positively correlated with L* value. From the results, leg and thigh were tougher than breast and fillet so the appropriate method to cook them should be slow cook or long time low temperature cooking.

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