Pertanika J. Trop. Agric. Sci. 43 (3): 343 - 357 (2020)

PERTANIKA JOURNALS

TROPICAL AGRICULTURAL SCIENCE

Journal homepage: http://www.pertanika.upm.edu.my/

Effects of Age at Slaughter and Sex on Carcass Characteristics and Meat Quality of Betong Chicken

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ABSTRACT

The purpose of this study was to determine the effects of age at slaughter and sex on carcass characteristics and meat quality of Betong chickens that were raised under a semi-free-range system. A total of 360 chickens from Takbai, Narathiwat Province, Thailand were arranged into 3x2 factorial design with 3 levels of age at slaughter (16, 20, 24 weeks) and sex (male and female) in CRD. The experiment consisted of 6 treatments with 3 replications. Ten chickens of each replicate from each treatment group were randomly sampled for carcass yield and meat quality. Results showed that slaughter and carcass weights were significantly higher when the age at slaughter increased ($P<0.01$). Males had heavier slaughter and carcass weights ($P<0.001$) with lower breast percentage than the female chickens in each particular age. Higher yellowness value was significantly illustrated when the age of chickens increased. This color value was higher in both breast and thigh meat of the female chickens ($P<0.05$). Considering texture analysis, the males had significantly higher shear force value than the females ($P<0.05$). This shear value tended to increase when the age of the chicken increased ($P>0.05$). There was no significant difference observed between age at slaughter on chemical composition ($P>0.05$). Nevertheless, the males had less fat content in breast meat and higher collagen content in thigh meat than the female Betong chickens ($P<0.05$). The results show that males should be slaughtered at 20 weeks, while the females

ARTICLE INFO

Article history:
Received: 12 December 2019
Accepted: 27 May 2020
Published: 28 August 2020

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ISSN: 1511-3701
e-ISSN 2231-8542

should be slaughtered when they reach the age of 24 weeks.

Keywords: Age at slaughter, Betong chicken, meat quality, sex

INTRODUCTION

Betong chicken (*Gallus domesticus*) is a native Thai chicken predominantly found in the three provinces located in the Deep South of Thailand, especially in the Betong District, Yala Province, and in the northern part of Hulu Perak, Perak State, Malaysia. Farmers in the Deep South of Thailand commonly raise this chicken indoors until eight weeks into the growth period. Then they are raised under semi-free-range conditions until reaching the market weight of 1,500 to 2,000 g for females or 2,000 to 2,500 g for males (Chanjula et al., 2004; Chatreewong & Waree, 2006; Nualhnuplong et al., 2019b).

From a literature review, some research work on Betong chicken has been reported, for example, phenotypic characteristics and productive performance of this chicken (Chanjula et al., 2004); optimum age and weight of Betong chicken for the market (Chatreewong & Waree, 2006); dietary protein and energy level on growth performance and reproductive system development in the female during growth to pullet period (Buakeeree & Nualhnuplong, 2018); nitrogen-corrected true and apparent metabolizable energy (TMEn and AMEn) of crude glycerin (CG) for Betong chicken (Sopian et al., 2018); and effect of rearing system on meat quality (Nualhnuplong et al., 2019a; Ritchoo et al., 2019). However, less information about the carcass yield and meat quality of Betong chicken has been reported. Thus, this study aimed to provide basic information about the effects of age at slaughter and sex on the carcass yield and meat quality in terms of physical characteristics and chemical composition. Results from this work will be used as reference information for managing Betong chicken production.

MATERIALS AND METHODS

Sample Preparation

A total of 360 male and female Betong chickens were randomly divided into 6 treatment groups. According to the treatment groups, The Betong chickens were arranged as 3 x 2 factorial in a completely randomized design with 3 levels of age at slaughter (16, 20, 24 weeks) and sex (male and female). Each treatment group consisted of 3 replicates (pens) of 20 Betong chickens. The chickens in each treatment were raised in a semi-free-range system. They were raised in the house (5 birds/m^2) with access to grass paddock or backyard or garden (3 birds/m^2). During week 1 to 3 chickens were kept in a house and fed commercial diet containing 21% of crude protein (CP), while they were allowed to walk outdoors and fed 19% CP from week 8 to 24. Nevertheless, cooked rice and corn were mixed with a commercial diet at a ratio of 0.5:0.5:1. Once they reached the target age, chickens were sampled from the flock and transferred to slaughter at a local abattoir. The slaughtering method used in this study

had followed the regulations of the National Bureau of Agricultural Commodity and Food Standards (ACFS) (2007), Ministry of Agriculture and Cooperatives, Thailand. After slaughter, eviscerated carcasses were weighed and immediately stored at chill temperature for about 24 h for further determination.

Sample Collection and Analyses

After 24 h, the eviscerated carcasses were weighed and separated for retail parts, such as breasts, thighs, drumsticks, wings, feet, head, neck, and skeletal. The percentages of the chilled carcasses were expressed as a percentage of live weight, while the retail parts were determined based on chilled carcass weight. For meat quality determination, breast and thigh muscles were sampled for physical and chemical analysis. Ten (10) Betong chickens of each replicates from each treatment group were randomly sampled for the carcass yield and meat quality included physical characteristics and chemical composition of meat. The variables for analysis were the following:

Physical Properties Determination. The pH of breast and thigh muscles was measured by digital pH meter (Seven2Go, Mettler-Toledo, Switzerland) 45 min after slaughter for pH_0 and 24 h after slaughter for pH_{24}. Meat and skin color were measured on the raw muscle and skin with a Konica Minolta colorimeter (Konica Minolta, Japan) after 24 h chill at 4°C. The result was reported on the complete International Commission on Illumination (CIE) system color profile of lightness (L*), redness (a*), and yellowness (b*). The meat samples for drip loss and cooking loss were trimmed to a dimension of 2.0 x 1.0 x 0.5 cm. Each piece was weighed (weight before storage = W1) and put into a sealed plastic bag, with drip loss stored at a chilled temperature (4°C) for 24 h. The sample was then removed from the sealed plastic bag, blotted, and weighed (W2 is the weight after storage); the cooking loss was measured by heating in a water bath at 80°C for 10 min. After cooking, the sample was cooled to room temperature and weighed (W2 is the weight after cooking). Drip loss and cooking loss were calculated as a percentage of weight loss: ((W1- W2)/ W1) x 100. Shear force was measured on cooked meat samples using a Texture Analyzer (TA-XT plus Stable Micro System Texture Analyzer, UK) with a 2 mm/s crosshead speed and a 50-load cell. The score obtained after a Warner-Bratzler blade cut the sample represented the shear force (Dawson et al., 1991).

Chemical Composition Determination. Moisture, crude protein, crude fat, and ash were analyzed according to the Association of Analytical Chemists (AOAC) (2006). Total collagen was determined after acid hydrolysis as described by Palka (1999). Hydroxyproline contents in the hydrolysate were determined by the procedure of Bergman and Loxley (1963) and converted to collagen contents using the factor 7.25, as described by Wattanachant et al. (2004).

Statistical Analysis. The data on carcass percentages and meat quality were analyzed by two-way Analysis of Variance (ANOVA) in a 3 x 2 factorial completely randomized design (3 age levels and 2 sex levels). The significance between means was analyzed using Duncan's Multiple Range Test (DMRT) in the Statistical Analysis System (SAS) (1998).

RESULTS AND DISCUSSION

Effects of Age at Slaughter and Sex on Carcass Characteristics and Retail Cuts of Betong Chicken

The effects of age at slaughter and sex on carcass yield and retail part percentage of Betong chicken are shown in Tables 1 and 2, with a significant interaction effect between age at slaughter and sex on slaughter weight and breast percentage ($P<0.05$) (Figure 1). Figure 1 clearly shows that the slaughter weight of male Betong chickens tended to increase from the age of 16 weeks to 20 weeks and the weight was stable until reaching the age of 24 weeks, while the female chickens in the 16-20 weeks had no significant difference in weight. But slaughter weight tended to be higher when the chicken reached the age of 24 weeks old. Under this condition, both sexes had higher weight at slaughter at 24 weeks than the chicken aged 16 and 20 weeks. The range of slaughter weight obtained in this work was about 1,896-2,051 g in the male and 1,476-1,562 g in female.

When discussing the retail cuts, slaughter age did not show any significant effect on breast meat percentage of the male ($P>0.05$), but breast meat was significantly lower when the slaughter age increased ($P<0.05$). More breast muscle percentage in chicken aged 16 and 20 weeks old, after which it tended to decrease at the age of 24 weeks. Nevertheless, the male had a lower percent breast (18.39-19.10%) than the female (20.15-20.93%).

Table 1

Effects of age at slaughter and sex on carcass yield (g) and carcass percentage (%) of Betong chicken (mean ± SD)

Items		Slaughter weight	Warm carcass weight	Chill carcass weight	Carcass percentage
Age	16	1,689.17^{b}	1,175.73^{b}	1,158.82^{b}	68.50
	20	1,770.17^{a}	1,236.75^{a}	1,217.30^{a}	68.73
	24	1,787.60^{a}	1,275.88^{a}	1,238.98^{a}	69.09
P-value		0.0005	<0.0001	0.0006	0.3746
Sex	Male	1,993.93^{a}	1,401.79^{a}	1,377.31^{a}	69.24^{a}
	Female	1,505.23^{b}	1,045.99^{b}	1,025.51^{b}	68.25^{b}
P-value		<0.0001	<0.0001	<0.0001	0.0040

Table 1 *(Continued)*

Items		Slaughter weight	Warm carcass weight	Chill carcass weight	Carcass percentage
Age	16	1,689.17[b]	1,175.73[b]	1,158.82[b]	68.50
	20	1,770.17[a]	1,236.75[a]	1,217.30[a]	68.73
	24	1,787.60[a]	1,275.88[a]	1,238.98[a]	69.09
P-value		0.0005	<0.0001	0.0006	0.3746
Sex	Male	1,993.93[a]	1,401.79[a]	1,377.31[a]	69.24[a]
	Female	1,505.23[b]	1,045.99[b]	1,025.51[b]	68.25[b]
P-value		<0.0001	<0.0001	<0.0001	0.0040
Interaction between sex x age					
Male	16	1,896.67±118.07[b]	1,326.87±94.95	1,308.83±86.20	69.02±1.92
	20	2,045.16±154.10[a]	1,433.45±112.10	1,412.58±108.23	69.08±1.57
	24	2,051.74±170.58[a]	1,450.50±151.58	1,414.27±148.13	69.64±2.46
Female	16	1,481.67±122.93[d]	1,024.60±107.17	1,008.80±105.66	67.98±2.12
	20	1,476.21±158.96[d]	1,026.48±126.39	1,008.55±109.50	68.35±2.49
	24	1,562.59±118.08[c]	1,094.28±119.97	1,063.69±116.09	68.45±2.78
P-value		0.0020	0.1282	0.0603	0.9610
SEM		27.136	22.566	21.423	0.408

[a,b] Means within the column with different superscripts differ significantly (P<0.05)

Table 2

Effects of age and sex on the retail cut (%) of Betong chicken (mean ± SD)

Items		Breast	Thigh	Drumstick	Wing	Skeletal
Age	16	19.61	18.49	16.30	12.59[a]	30.25[b]
	20	19.60	18.64	16.27	12.28[b]	32.38[a]
	24	19.70	19.12	16.64	12.23[b]	31.64[a]
P-value		0.8949	0.0884	0.0921	0.0359	0.0004
Sex	Male	18.73[b]	19.37[a]	18.03[a]	12.64[a]	30.32[b]
	Female	20.53[a]	18.13[b]	14.88[b]	12.09[b]	32.54[a]
P-value		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Interaction between sex x age						
Male	16	18.39±1.42[c]	18.95±1.49	17.97±0.92	12.75±0.81	29.42±3.12
	20	19.10±1.05[c]	19.21±1.76	17.65±1.06	12.58±0.80	31.30±2.79
	24	18.75±1.15[c]	19.98±1.41	18.47±0.94	12.59±0.82	30.19±2.18

Table 2 *(Continued)*

Items		Breast	Thigh	Drumstick	Wing	Skeletal
	20	20.15±1.11[b]	18.04±0.98	14.79±0.94	11.96±0.78	33.53±2.68
	24	20.47±1.50[ab]	18.29±1.69	14.87±0.76	11.83±0.73	33.04±4.05
P-value		0.0108	0.3511	0.0623	0.2348	0.4369
SEM		0.232	0.296	0.185	0.147	0.537

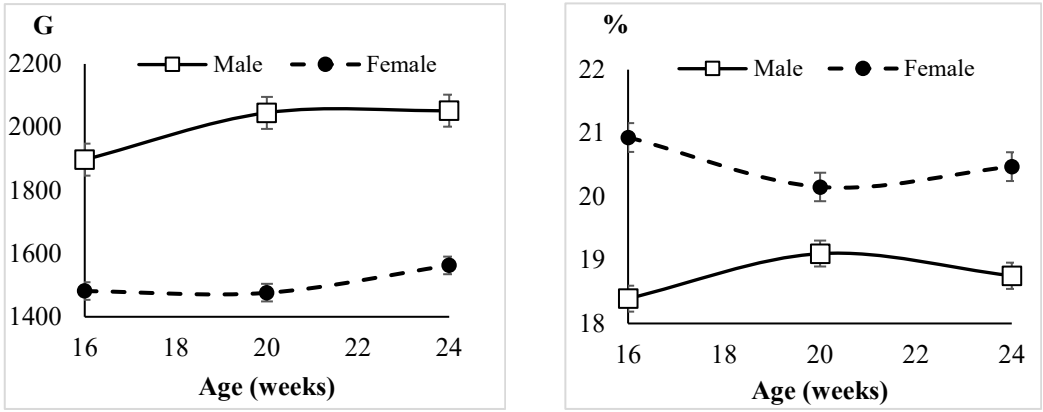

Figure 1. Effect of interaction between age and sex on slaughter weight (left) and breast percentage (right)

Considering the effect of age at slaughter, slaughter weight, warm carcass weight, chilled carcass weight, and skeletal percentage were increased as the age at slaughter increased (P<0.01). The highest slaughter, warm carcass, and chilled carcass weights were observed at 24 weeks of age. According to the finding of Poltowicz and Doktor (2012), carcass percentage of the slow-growing broiler at 84 days was higher than that at 70 and 56 days (P<0.05). However, based on the percent of slaughter weight, chickens at 16 weeks of age had the highest wing percentage, but the lowest skeletal percentage, when compared with chickens at 20 and 24 weeks (P<0.05).

In terms of sex differences, males had significantly higher slaughter, warm carcass, and chilled carcass weights, and higher carcass, thigh, drumstick, and wing percentages than female chickens. Nevertheless, breast and skeletal percentages of the female were significantly higher than those of the male (P<0.01). This result was following Lopez et al. (2011), who reported that male broilers had higher body weight but lower carcass and breast percentages than females (P<0.05).

Effects of Age at Slaughter and Sex on Physical Characteristics of Betong Chicken Meat

The effects of age at slaughter and sex on the physical characteristics of Betong chicken meat are presented in Tables 3, 4, and 5. Age at slaughter had a significant effect on the pH_0 of breast and thigh meat, and pH_{24} of breast meat (P<0.01), with

pH_0 value tending to increase with age at slaughter. However, this work found that sex affected pH_{24} in both breast and thigh meat ($P<0.01$). The males had higher pH_{24} values in breast meat than the females. This was in concordance with the work of Poltowicz and Doktor (2012) who found a lower pH_{24} of broiler meat at 56 days than that of meat from broiler aged 70 and 84 days ($P<0.05$). Similar work was obtained by Atthaporn et al. (2009) who found that high pH_{24} value in Thai native chicken (Kai Nong Dang) when the age of chicken increased. The value of pH in meat was related to the amount of glycogen in the muscle and the stress condition of the animal (Warriss, 2000) which were resulting in the level of lactic acid in the meat. This result was closely associated with the color and water holding capacity of the meat (Warriss, 2000; Wattanachant, 2008).

From the results, significant interaction effects on the shear force value of breast meat, drip loss, and color (particularly lightness (L*) and redness (a*) of thigh meat) were noted among the age at slaughter and sex ($P<0.05$) (Figure 2).

Considering the effect of age at slaughter, this study indicated that the shear force value in male Betong chicken meat tended to be increased when the slaughter age increased. Although this value did not show any significant difference between the age of 16 and 20 weeks, it was significantly higher at the age of 24 weeks old. This work was similar to the work of Atthaporn et al. (2009) who found a higher shear force value of breast and thigh muscle when the age of Thai native chicken increased. A similar result was reported by Poltowicz and Doktor (2012) on a slow-growing broiler. The increasing shear force value when the age of chicken increased is not only related to the increasing of muscle fiber diameter (Atthaporn et al., 2009; Dransfield & Sosnicki, 1999; Wattanachant, 2008) but also associated with a higher intermolecular cross-linking of connective tissue in meat (Castellini et al., 2002; Chen et al., 2013; Dawson et al., 1991; Husak et al., 2008). Sex had a significant effect on the shear force value of both breast and thigh meat ($P<0.05$), with males having higher values than females ($P<0.05$). This work was in agreement with Fanatico et al. (2005), and Chen et al. (2006). This was due to the larger diameter of muscle fiber and more thickness of perimysium (Wattanachant, 2008).

No interaction between age at slaughter and sex on drip and cooking losses of the breast meat (Table 3) was observed, but significantly interaction effect on drip loss of the thigh meat (Table 4). Both sexes had a lower drip loss percentage at the age of 16 weeks, but it significantly increased when the age at slaughter increased ($P<0.01$). This report was in agreement with the work of Li et al. (2020), although earlier researches found no significant differences between male and female chicken meat on water holding capacity (Chen et al., 2006; Fanatico et al., 2005; Kirmizibayrak et al., 2011; Lopez et al., 2011; Uhlirova et al., 2018).

In terms of the color of meat (Table 5), it was found that the female Betong chickens had higher L*, but lower a* than male

Table 3

Effects of age at slaughter and sex on pH value, drip loss, cooking loss and shear force of breast meat Betong chicken (mean ± SD)

Items		pH_0	pH_{24}	Drip loss (%)	Cooking loss (%)	Shear force (kg/cm^3)
Age	16	5.92[b]	5.77[b]	2.09	16.21[b]	3.06
	20	6.10[a]	5.80[ab]	2.09	18.64[a]	3.22
	24	6.10[a]	5.82[a]	1.85	17.47[ab]	3.67
P-value		<0.0001	0.0032	0.3508	0.0010	0.0707
Sex	Male	6.04	5.82[a]	1.88	18.42[a]	3.61[a]
	Female	6.04	5.77[b]	2.14	16.45[b]	3.12[b]
P-value		0.8877	0.0009	0.1000	0.0002	0.0273
Interaction between sex x age						
Male	16	5.94±0.19	5.79±0.06	2.09±0.78	17.61±2.93	2.83±1.13[b]
	20	6.10±0.19	5.82±0.11	1.80±1.04	19.20±3.50	3.44±1.48[ab]
	24	6.10±0.16	5.84±0.08	1.77±1.28	18.41±3.76	4.19±1.74[a]
Female	16	5.91±0.22	5.75±0.08	2.09±0.78	14.81±3.56	2.54±0.35[b]
	20	6.11±0.25	5.77±0.09	2.42±0.58	18.04±3.32	2.99±1.27[b]
	24	6.10±0.29	5.81±0.09	2.33±1.36	16.56±3.86	3.26±1.00[b]
P-value		0.8756	0.6225	0.2356	0.5263	0.0471
SEM		0.040	0.016	0.190	0.639	0.244

[a,b] Means within the column with different superscripts differ significantly (P<0.05)

Table 4

Effects of age at slaughter and sex on pH value, drip loss, cooking loss and shear force of thigh meat Betong chicken (mean ± SD)

Item		pH_0	pH_{24}	Drip loss (%)	Cooking loss (%)	Shear force (kg/cm^3)
Age	16	6.26[b]	6.09	0.71[b]	21.05	3.75
	20	6.42[a]	6.07	1.11[a]	22.30	3.81
	24	6.44[a]	6.05	1.15[a]	20.94	4.18
P-value		<0.0001	0.1184	<0.0001	0.3801	0.0715
Sex	Male	6.37	6.03[b]	0.89[b]	21.22	4.13[a]
	Female	6.37	6.09[a]	1.08[a]	21.65	3.75[b]
P-value		0.8605	0.0066	0.0061	0.6269	0.0209
Interaction between age x sex						
Male	16	6.28±0.24	6.04±0.12	0.77±0.33[c]	21.50±3.92	4.00±0.93
	20	6.38±0.20	6.05±0.06	1.10±0.40[b]	21.60±6.50	3.91±0.94

Table 4 *(Continued)*

Item		pH_0	pH_{24}	Drip loss (%)	Cooking loss (%)	Shear force (kg/cm^3)
	24	6.45±0.25	6.05±0.09	1.00±0.37^{bc}	20.51±7.37	4.42±0.70
Female	16	6.23±0.30	6.14±0.20	0.75±0.38^{c}	20.59±5.80	3.42±1.35
	20	6.47±0.17	6.09±0.06	1.11±0.40^{b}	23.04±6.54	3.69±1.04
	24	6.43±0.19	6.05±0.07	1.40±0.70^{a}	21.35±4.73	3.96±1.01
P-value		0.2785	0.0608	0.0083	0.5202	0.5479
SEM		0.042	0.021	0.085	1.080	0.184

^{a,b} Means within the column with different superscripts differ significantly (P<0.05)

Table 5

Effects of age at slaughter and sex on color meat of breast and thigh meat Betong chicken (mean ± SD)

Items		Breast meat			Thigh meat		
		Lightness (L*)	Redness (a*)	Yellowness (b*)	Lightness (L*)	Redness (a*)	Yellowness (b*)
Age	16	48.52^{a}	1.43	4.90^{b}	49.86^{a}	3.83^{b}	4.82
	20	48.51^{a}	1.54	4.83^{b}	51.30^{a}	4.77^{b}	5.07
	24	45.90^{b}	1.63	5.89^{a}	45.92^{b}	5.89^{a}	5.34
P-value		0.0056	0.3173	0.0112	<0.0001	0.0002	0.7221
Sex	Male	47.43	1.70^{a}	4.51^{b}	46.69^{b}	6.70^{a}	4.52^{b}
	Female	47.96	1.31^{b}	5.87^{a}	51.44^{a}	2.65^{b}	5.67^{a}
P-value		0.4671	0.0005	<0.0001	<0.0001	<0.0001	0.0337
Interaction between age x sex							
Male	16	48.09±4.14	1.53±0.76	4.03±1.59	48.86±6.50^{bc}	5.57±2.91^{b}	4.84±3.56
	20	47.58±6.36	1.74±0.79	4.01±2.38	47.81±5.23^{c}	7.50±3.18^{a}	4.85±3.34
	24	46.43±3.18	1.84±0.87	5.63±2.48	43.01±4.03^{d}	8.02±2.51^{a}	4.81±2.66
Female	16	48.95±4.00	1.33±0.26	5.78±1.71	50.87±4.45^{b}	2.09±2.72^{d}	4.80±1.86
	20	49.43±5.40	1.30±0.26	5.72±2.33	55.03±5.02^{a}	2.85±1.82^{d}	5.28±3.92
	24	45.47±4.32	1.29±0.95	6.12±1.93	48.55±3.45^{bc}	4.01±1.90^{c}	6.52±3.30
P-value		0.2689	0.6728	0.2833	0.0035	0.0235	0.0954
SEM		0.865	0.208	0.382	0.894	0.482	0.590

^{a,b} Means within the column with different superscripts differ significantly (P<0.05)

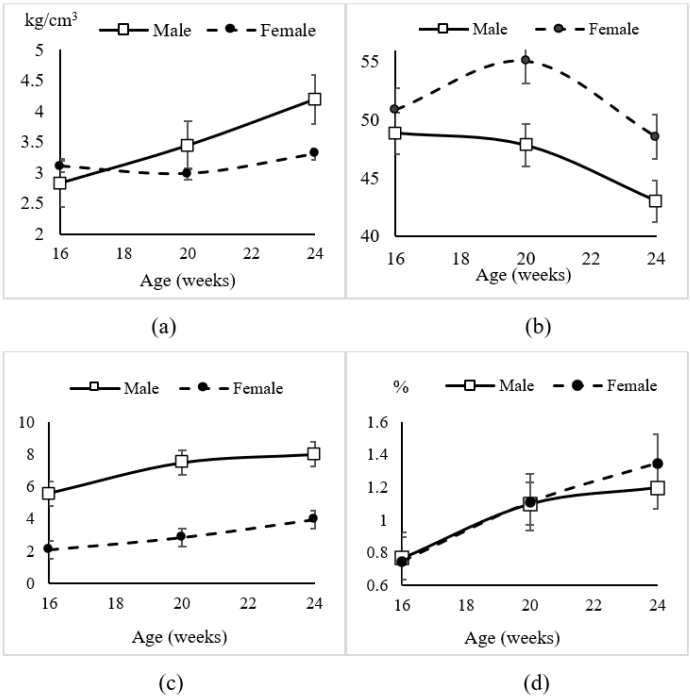

Figure 2. Effect of interaction between age and sex on the shear force of breast meat (kg/cm^3) (a), lightness of thigh meat (b), redness of thigh meat (c), and a drip loss percentage of thigh meat (d)

chickens for 16-24 weeks. The L* of both males and females tended to decrease from the age of 16 weeks to the age of 24 weeks. Nevertheless, redness (a*) of both sexes tended to increase when the age of chicken increased. Although there was no significant effect on the lightness of breast meat of the male and female chickens (P>0.05), males showed higher reddish meat than the female Betong chickens. Likewise, we found that in chicken meat, higher b* was observed in the older Betong chickens. This value could result from xanthophyll in diet and natural carotenoids from plants' free-range. The higher b* value was observed in the breast muscle (P<0.05), while the females had higher b* value than the male chickens. The result of this present study was the following results from Kirmizibayrak et al. (2011) and Uhlirova et al. (2018), that male chicken's meat had a higher a* value than the meat of females. Similar results were reported by Lopez et al. (2011) and Fanatico et al. (2005), who found higher b* values in female chicken meat than in male meat (P<0.05). Higher a* in the male than the female chicken was probably related to the higher activity of the male than the female. However, males had lower L*and b* values than female chickens. Besides, chicken meat color may depend on many factors such as genetic, raising system, type of feed, and age at slaughter (Wattanachant, 2008).

Table 6

Effects of age at slaughter and sex on chemical meat quality of breast and thigh (mean ± SD)

Items		Breast meat				Thigh meat			
		Moisture (%)	Protein (%)	Fat (%)	Collagen (%)	Moisture (%)	Protein (%)	Fat (%)	Collagen (mg/100g)
Age	16	74.34	24.13	0.40	5.34	75.84	20.75	3.12	9.39
	20	74.52	24.09	0.42	6.30	75.90	20.70	3.23	10.18
	24	74.73	24.09	0.44	6.59	75.72	21.09	3.30	12.30
P-value		0.3235	0.9879	0.1376	0.2573	0.6786	0.4564	0.2523	0.1395
Sex	Male	74.96[a]	23.87[b]	0.34[b]	6.86	76.16[a]	20.51[b]	3.15	12.75[a]
	Female	74.12[b]	24.34[a]	0.50[a]	5.52	75.41[b]	21.21[a]	3.32	9.10[b]
P-value		0.0189	0.0347	<0.0001	0.2697	<0.0001	0.0159	0.2126	0.0117
Interaction between age x sex									
Male	16	74.67±0.66	23.82±0.86	0.31±0.03	6.01±0.37	76.33±0.70	20.51±0.91	3.06±0.15	10.57±1.57[b]
	20	74.69±1.02	23.84±0.65	0.35±0.03	6.92±0.80	76.29±0.46	20.36±1.27	3.13±0.00	11.43±1.55[b]
	24	74.54±0.73	23.93±0.90	0.36±0.02	7.39±1.08	75.88±0.64	20.66±0.61	3.25±0.18	16.25±1.70[a]
Female	16	74.03±0.50	24.53±0.92	0.49±0.00	4.90±1.29	75.15±0.68	21.05±0.46	3.16±0.03	8.22±0.38[c]
	20	74.34±1.38	24.32±0.68	0.50±0.03	5.86±1.63	75.47±0.61	21.03±1.48	3.32±0.35	9.34±1.10[b]
	24	73.73±0.70	24.25±0.51	0.52±0.04	5.79±1.14	75.55±0.70	21.53±1.20	3.48±0.37	9.67±1.59[b]
P-value		1.0000	0.74000	0.7051	1.0000	0.1635	0.9455	0.9124	0.0500
SEM		0.167	0.139	0.021	0.219	0.117	0.196	0.219	0.545

[a,b] Means within the column with different superscripts differ significantly (P<0.05)

Effects of Age at Slaughter and Sex on Chemical Composition of Betong Chicken Meat

As seen in Table 6, no significant interaction between age at slaughter and sex on the proximate composition of either breast or thigh meat (P>0.05). However, the highest collagen content was found in thigh meat from 24-week old male Betong chicken while the lowest collagen content was found in 16-week old females. Nevertheless, age at slaughter did not show any significant effect on any parameters (P>0.05), although the collagen content tended to increase as the age at slaughter increased. High collagen content when the age of chicken increased was following shear force value reported in Table 3. In this study, the result of proximate analysis contradicted that of Boni et al. (2010), who found a significantly higher fat content but lower levels of protein, moisture, and ash contents in older quail than in younger quail (P<0.05). However, in this study, the higher collagen content in meat from 24-week-old Betong chicken than in 16-and 20-week old was probably due to the type of collagen content and muscle fiber diameter as described by Wattanachant (2003). This was confirmed by Atthaporn et al. (2009), who found larger fiber diameter and perimysium thickness in Thai native chicken meat (Kai Nok Dang) as the age of the chicken increased. Fat contents tended to increase with age at slaughter in both breast and thigh meats (P>0.05). A high amount of fat deposition when the age of chicken increased was related to the reduction of energy for muscular growth, while high energy feed supplements could lead to more body fat deposition. This was in agreement with the work of Atthaporn et al. (2009), Nikolova et al. (2007), and Zerhdaran et al. (2005).

In terms of sex, the breast and thigh meat of males had higher moisture content but lower protein content than that of females (P<0.05). In addition, the male Betong chickens had lower fat content in breast meat with higher collagen content in thigh meat than the females (P<0.05). This was similar to the work of Corzo et al. (2005) and Nikolova et al. (2007), who studied broilers, and Atthaporn et al. (2009), who studied in Thai native chicken (P<0.05).

CONCLUSION

Based on our findings, a distinctive feature of raising Betong chickens under a semi-free-range system was that the meat was low in fat content. (0.31 to 0.52% in breast and 3.06 to 3.48% in thigh meat). However, because the male Betong chicken grew much faster than the female, raising the male until 24 weeks old would increase the amount of collagen content that results in tougher meat than the female. Also, more reddish meat would be shown when the male was raised until 24 weeks of age. To control the quality of the meat, especially the redness, toughness, and amount of collagen, the male should be raised not more than 20 weeks while the female should be raised until the age of 24 weeks. However, it is recommended that the consumer's preference for Betong chicken meat be explored in further studies.

ACKNOWLEDGEMENTS

The authors would like to thank the Office of the Higher Education Commission (OHEC) and Graduate School, PSU, for financial support. We also would thank the Faculty of Natural Resources, PSU, for facilities support.

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