Pakistan J. Zool., pp 1-10, 2026. DOI: https://dx.doi.org/10.17582/journal.pjz/20240910074724

Effect of Sex on Meat Quality of Dong'an Chicken (*Gallus gallus*)

Xu Liu[1], Hang Yang[1], Jiayi Cao[1] and Xiangyong Qu[2]*

[1]Hunan Key Laboratory for Conservation and Utilization of Biological Resources in the Nanyue Mountainous Region, College of Life Sciences, Hengyang Normal University, Hengyang, Hunan 421008, China

[2]Hunan Engineering Research Center of Poultry Production Safety, College of Animal Science and Technology, Hunan Agricultural University, Changsha, Hunan 410128, China

Article Information
Received 10 September 2024
Revised 15 October 2024
Accepted 30 October 2024
Available online 23 March 2026 (early access)

Authors' Contribution
XL, HY and JC conceptualized the study design, collected data, and conducted the experiment. XL, JC performed data analysis. XL and HY wrote the first draft of the paper. XQ reviewed and commented on the first draft. All authors reviewed and approved the final manuscript.

Key words
Sex, Breast muscle, Thigh muscle, Meat quality, Free-range, Chicken

ABSTRACT

There is an increasing interest in free-range poultry with the increasing focus on animal welfare. The aim of this study is to examine the effect of sex on physicochemical traits, chemical composition, muscle fibers, mineral, amino acids and fatty acids contents in muscle of free-range Dong'an chicken (DAC). Thirty-two (16 males and 16 females) DACs were raised under the same conditions and slaughtered at 28 weeks of age. Males had a higher ($P < 0.05$) pH_{45min}, redness value, and lower ($P < 0.05$) water loss rate, crude fat, and crude ash when compared with females in breast muscle. Males presented a higher ($P < 0.05$) cooking loss, moisture, muscle fiber density, and amino acid (Gly, Ala, Pro) contents, and lower ($P < 0.05$) yellowness value and crude fat in thigh muscle. The sex of DAC significantly affected ($P < 0.05$) the contents of C14:0, C18:0, C18:1, C20:3n6, and C22:6n. The crude fat and monounsaturated fatty acids contents in breast and thigh muscles of females were higher ($P < 0.05$) than that of males. The male exhibited a higher CL, muscle fiber density, amino acids (Gly, Ala, Pro), and PUFA contents in the thigh muscle, and had a lower WLR, crude fat, and MUFA content in the breast muscle. The results of this study are a valuable contribution to describing the quality and nutritional composition of indigenous breeds of yellow-feathered broilers in free-range system.

INTRODUCTION

With the improvement of people's living standards, consumers are increasingly interested in meat from indigenous and local chicken breedss because of desirable and unique taste, rich flavor, and firm texture (Anyona *et al*., 2023). Moreover, many consumers prefer to purchase free-range products, such as free-range chicken and eggs, *et al*. It is well known that chickens from free-range systems have better meat quality. Moreover, previous studies have showed that free-range systems were more beneficial to animal health and more in line with animal welfare laws (Yamak *et al*., 2016).

Different factors are known to influence meat quality, such as slaughter age, breed, sex, management conditions, and diet composition (Kowalski *et al*., 2024). Research on chickens showed that genotype has a significant effect on the meat quality, fatty acid composition, and consumer preference (Devatkal *et al*., 2019). Beijing-you chickens had a higher water capacity, as well as lower shear forces and IMF content than Cobb 500 broiler, indicating that the local chickens have better meat quality than commercial chickens (Chen *et al*., 2023). Sex is also one of the most important factors in chickens, ducks, geese, quails, and turkeys (Śmiecińska *et al*., 2022; Huang *et al*., 2023). The meat from females showed a significantly higher protein, dry matter, fiber diameter and shear force and a significantly lower fat level than the male group (Cygan-Szczegielniak and Bogucka, 2021).

Dong'an chicken (DAC) is one of the most important and popular local breeds in China, especially in Hunan Province, and it was recorded as the list of national livestock and poultry genetic resources protection in China in 2010 (Peng *et al*., 2018). DAC has the characteristics of coarse feeding tolerance, strong adaptability, good stress resistance, and tender and delicious meat. A growing body of scientific research indicated that the indigenous chicken meat has high nutritional value and desirable sensory

* Corresponding author: quxy99@126.com
0030-9923/2026/0001-0001 $ 9.00/0

properties in free-range systems (Baéza *et al*., 2021). In the future, the genetic diversity of indigenous chickens will be needed to meet production and environmental conditions changes, thereby achieving sustained genetic improvement and promoting rapid adaptation to changing breeding objectives. However, there is limited existing information on sex-related differences in meat composition and quality changes in free-range local chickens. Hence, the objective of this study was to determine the effect of sex on the physicochemical traits, chemical composition, muscle fibers, mineral, amino acids and fatty acids composition of the free-range local chickens.

MATERIALS AND METHODS

Animals, experimental design and sample collection

The experiment was conducted in the Dong'an chicken Technology Company Limited, Yongzhou, Hunan, China. From March to September. A total of 90 one-day-old DACs (half males and half females) were kept indoors until 10 weeks of age, and from week 11 until slaughter they were divided into 2 groups, according to the sex, and reared under organic conditions. Indoor and outdoor area per bird was 0.5 m^2 and 5 m^2, respectively. The outdoor access from the pens was provided after 11 weeks of age during daylight hours (from 8:00 am to 5:00 pm), and those chickens were exposed to natural environment (the average temperature was 20-25 ℃). Birds were confined to indoor pens at night. Feed and water were available *ad libitum*. The birds were fed commercial complete chicken diets: starter (0-9 weeks), grower (10-20 weeks), and finisher (21-28 weeks). The composition of diets fed to DACs different feeding periods is presented in Table I.

On the last day of rearing, thirty-two (16 males and 16 females) DACs with similar body weight were fed for 28 weeks. They were slaughtered by electrical stunning followed by cutting the jugular vein after 12 h feed withdrawal. The breast (pectoralis major) and thigh muscles (peroneus longus) were extracted from the right side of each carcass for meat quality detection.

Measurements of the physicochemical properties

The pH of muscles were determined at 45 min and 24 h postmortem at 2.5 cm depth using a pH meter (pH-STAR, SFK technology, Denmark). Meat color defined as lightness (L*), redness (a*), and yellowness (b*) was determined according to the method given by Jin *et al.* (2019) using a hand held color meter (CR 410, Minolta, Japan). The average values (pH and meat color) were defined from 3 measured values of the same area.

Table I. Ingredients and chemical composition of the experimental basal diets.

Item[1]	Age of Dong'an chicken	
	10-20 weeks	21-28 weeks
Ingredient (%)		
Corn	66.50	62.50
Wheat bran	4.00	3.00
Soybean meal	24.50	24.50
Limestone	1.00	6.00
Premix[2]	4.00	4.0
Total	100.00	100.00
Calculated composition (%)		
ME (MJ/kg)	11.66	11.07
CP	16.38	15.90
Ca	0.97	2.87
AP	0.47	0.46
Lys	0.78	0.75
Met	0.40	0.38
Met+Cys	0.68	0.65

[1]ME, metabolisable energy; CP, crude protein; Ca, calcium; AP, available phosphorus; Lys, lysine; Met, methionine; Met+Cys, methionine+cysteine. [2]Premix provided per kilogram of diet: vitamin A, 250 000 IU; vitamin D3,90 000 IU; vitamin E, 500 IU; vitamin B1, 52 mg; vitamin B2, 180 mg; vitamin B6, 113 mg; vitamin B12, 0.60 mg; vitamin K3, 105 mg; niacin, 738 mg; pantothenic acid, 226 mg; folic acidm, 24 mg; Zn, 3000 mg; Fe, 1500 mg; Mn, 1800 mg; Cu, 240 mg; I, 23 mg; Se, 4.80 mg; Ca, 10.00 g; P, 2.60 g; NaCl, 3.70 g.

The water loss rate (WLR), drip loss (DL), and cooking loss (CL) of muscles were measured 24 h postmortem. The WLR of muscles were determined as described by Weng *et al.* (2022). The WLR analysis was performed using a dilatometer (C-LM3B, Tenovo, Beijing, China). About 1 g samples were weighed 24 h postmortem (W_1). Thereafter, 20 filter papers were placed on the top and bottom of the sample. The sandwich was placed between the hard plastic plates on the platform of the dilatometer. The meat sample was pressurized (35 kg) for 5 min and weighed again (W_2). The WLR was calculated using the following equation: WLR (%) = $[(W_1-W_2)/W_1] \times 100\%$. The DL of muscles were determined as described previously (Zhang *et al*., 2015). This sample (3 × 2 × 1 cm) was weighed and recorded as W3, and then hung in a plastic bag in a refrigerator for 24 h at 4°C. After 24 h, the samples were weighed again and recorded as W4. DL was calculated using the following equation: DL (%) = [(W3-W4)/W3] × 100%. The CL of muscles were determined according to Baéza *et al*. (2021). About 10 g samples (W5) were placed on the steamer of an aluminum steame for

45 min and cooled at room temperature for 35 min, the samples were weighed again and recorded as W6. CL was calculated using the following equation: CL (%) = $W6/W5 \times 100\%$.

Measurements of the chemical components

The contents of moisture, crude protein, crude fat, and crude ash of the breast and thigh muscles were analyzed according to the procedures of the Association of Official Analytical Chemists (AOAC, 1995). Crude moisture contents were determined by oven drying at 105°C overnight. Crude protein (N×6.25) contents were measured by the Kjeldahl method with the Kjeltec System 8400 (FOSS NIRSystems Inc., Hillerød, Denmark). Crude fat contents were extracted in a Soxhlet apparatus using petroleum ether (2050, FOSS). Crude ash contents were measured by weight difference before and after converting 5 g of ground muscles to ashes in a muffle furnace (525 ℃).

Measurements of the muscle fiber density and diameter

The muscle fiber density and diameter was determined according to Zhao *et al*. (2024) and Cardiff *et al*. (2014). Briefly, muscle samples (1 × 1 × 1 cm) were fixed in 4% paraformaldehyde for more than 48 h, dehydrated in ethanol solutions of 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, and 95%, followed by embedding in paraffin. Histological sections were cut and then stained with hematoxylin-eosin. Three sections of muscle samples from each period were selected with 3 different fields of view for each slice. The cross-sectional area of each muscle fiber separately (μm^2) and average diameter (μm) were measured from at least 20 muscle fibers from each field.

Estimation of the mineral content of muscles

Concentrations of iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), selenium (Se), magnesium (Mg), and calcium (Ca) in the muscle samples were estimeted according to the method of Cheng *et al*. (2017) and Tang *et al*. (2015). Briefly, the fresh muscle samples were freeze-dried and then crushed. Approximately 2 g of the freeze-dried samples were weighted into the bottom of the digestion tube. Add 5 mL of concentrated nitric acid and 1 mL of hydrogen peroxide (H_2O_2) to the fume hood using a glass syringe, and then the sample was placed in a microwave digestion instrument. The digestion program was the following: 150 ℃ for 10 min, 180 ℃ for 5 min, and 200 ℃ for 25 min. After the digestion is complete, 0.4 mL of perchloric acid was added followed by ultrapure water in 50 mL volumetric flask to make up to volume. The mineral contents were analyzed by an inductively coupled plasma mass spectrometry (Optimal 2100DV, Perkin-Elmer-Sciex, Norwalk, NY, USA).

Determination of the muscle composition of hydrolyzed amino acid and fatty acid

The muscle samples were first completely dried in a freeze dryer. The method of the muscle composition of free amino acid and fatty acid was referred to the previous studies (Liu *et al*., 2021; Folch *et al*., 1957). About 0.5 g freeze-dried samples were weighed and mixed with 5 mL of 0.01 mol/L hydrochloric acid for preparation of homogenate, and then centrifuged at 5000 r/min^{-1} for 5 min. Then, 0.5 mL of the supernatant was mixed with 8% salicylic acid at 4 ℃ for 12 h. The mixture was centrifuged twice at 12000 r/min^{-1} for 10 min. The supernatants were used for estimation of amino acids in automatic amino acid analyzer (L-8900, Hitachi, Tokyo, Japan).

The muscle contents of fatty acids were determined using an Agilent 7890 N gas chromatography equipped with a flame ionisation detector (Agilent Technologies, Santa Clara, CA, USA) and a CP-Sil 88 fused silica open tube capillary column (100 m × 0.25 nm; Agilent Technologies, USA) based on the retention time and peak area of each fatty acid. About 0.2 g freeze-dried samples were weighed and placed in a hydrolysis tube, to which 4 mL of chloroacetyl methanol solution, 1 mL 1.0 mg/mL^{-1} C11:0 internal standard solution, and 1 mL of n-hexane in sequence were added. The bottle was capped and placed in an 80 ℃ water bath for 2 h. After cooling, 5 mL of 7% potassium carbonate solution were added and shake well. Centrifuged for 5 min at 1000 r/min^{-1}, filterd with a 0.2 μm membrane, and performed machine testing. The temperature of the syringe and detector were 260 ℃ and 270 ℃, respectively. The gas carrier is He (2.0 mL/min^{-1}), using a split flow syringe with a split ratio of 30:1. Saturated fatty acid (SFA) total proportion was the weighted percentage sum of myristic (C14:0), palmitic (C16:0), margaric (C17:0), stearic (C18:0), and eicosanoic (C20:0) acid. Total proportions of monounsaturated fatty acids (MUFA) included palmitoleic (C16:1), oleic (C18:1), eicosenoic (C20:1) acid. Additionally, the polyunsaturated fatty acid (PUFA) total percent summed linoleic (C18:2), linoleic (C18:3n6), α-linoleic (C18:3n3), dihomo-c-linolenic (C20:3n6), arachidonic(C20:4n6), and docosahexaenoic(C22:6n) acid.

Statistical analysis

Data were analyzed by t-test using SPSS Statistics software (version 21.0; IBM-SPSS Inc., Chicago, IL, USA) and expressed as means ± standard error of mean (SEM). Differences were considered significant at $P < 0.05$.

RESULTS

Effect of sex on physicochemical traits of DAC

The physicochemical traits in breast and thigh muscles of DACs are shown in Table II. The redness (a*) and pH_{45min} values of breast muscle and the CL of thigh muscle were significantly higher ($P < 0.05$) in males than in females. The yellowness values (b^*_{24h}) of thigh muscle and the WLR of breast muscle were markedly lower ($P < 0.05$) in males than in females. There were no significant differences ($P > 0.05$) in other traits between them.

Effect of sex on chemical composition and muscle fibers of DAC

The chemical composition and muscle fibers in breast and thigh muscles of DAC are reported in Table III and Figure 1. The crude fat content of breast and thigh muscle and the crude ash content of breast muscle were significantly lower ($P < 0.05$) in males than in females. The moisture content and muscle fiber density of thigh muscle were significantly higher ($P < 0.05$) in males than in females.

Effect of sex on mineral contents of DAC

Sex had no effect ($P > 0.05$) on the minerals contents in breast and thigh muscles of DAC (Table IV).

Effect of sex on hydrolyze amino acids profile of DAC

The hydrolyze amino acids composition in breast and thigh muscles of DAC are presented in Table V. The contents of Gly, Ala, and Pro of thigh muscle were significantly higher in males than in females ($P < 0.05$).

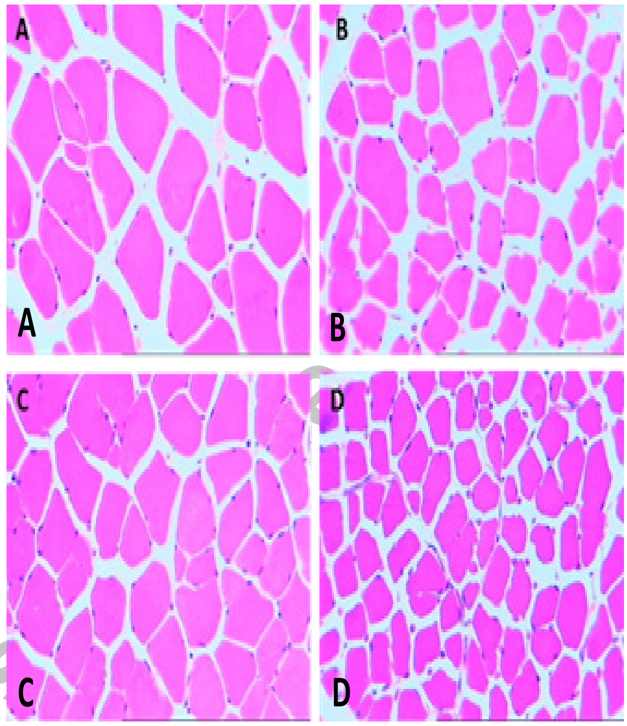

Fig. 1. Hematoxylin and eosin staining of Dong'an chicken meat (400 X). A, breast muscle of male; B, breast muscle of female; C, thigh muscle of male; D, thigh muscle of female.

Table II. Effects of sex on physicochemical traits in breast and thigh muscles of Dong'an chicken[1].

Items[3]		Breast muscle[2]				Thigh muscle[2]			
		Male	Female	SEM	p-Value	Male	Female	SEM	p-Value
pH_{45min}		6.20^{a}	6.01^{b}	0.11	0.032	6.00	6.02	0.08	0.332
pH_{24h}		5.77	5.69	0.10	0.315	5.73	5.81	0.11	0.378
$Color_{45min}$	L*	48.10	48.69	1.80	0.278	38.48	39.06	2.40	0.224
	a*	8.44^{a}	5.10^{b}	1.01	0.015	18.73	19.75	2.31	0.158
	b*	9.90	8.03	1.73	0.478	7.30b	8.85a	0.52	0.041
$Color_{24h}$	L*	50.70	52.42	2.29	0.398	43.59	43.89	2.68	0.247
	a*	8.96^{a}	6.51^{b}	1.25	0.029	15.86	16.07	3.09	0.355
	b*	13.90	14.00	1.76	0.193	9.54	10.88	2.71	0.295
WLR (%)		20.50^{b}	27.36^{a}	2.99	0.017	21.05	22.15	3.85	0.572
DL (%)		4.73	5.55	1.06	0.229	3.82	4.79	1.02	0.111
CL (%)		67.13	64.41	3.87	0.063	61.07^{a}	57.47^{b}	1.60	0.027

[1]Data are means of 16 chickens per group. [2]a,b Values with different superscripts in the same row differ significantly ($P < 0.05$). [3]WLR, water loss rate; DL, drip loss; CL, cooking loss.

Table III. Effects of sex on chemical composition and muscle fibers in breast and thigh muscles of Dong'an chicken[1].

Items	Breast muscle[2]				Thigh muscle[2]			
	Male	Female	SEM	p-Value	Male	Female	SEM	p-Value
Moisture (%)	71.66	70.73	0.49	0.107	73.47[a]	71.57[b]	0.60	0.012
Crude protein (%)	24.87	25.28	0.37	0.288	21.24	21.79	0.58	0.359
Crude fat (%)	0.61[b]	1.31[a]	0.26	0.021	2.22[b]	3.55[a]	0.61	0.047
Crude ash (%)	1.49[b]	2.37[a]	0.11	0.011	1.99	2.03	0.14	0.279
Muscle fiber diameter (μm)	22.49	23.45	1.23	0.521	20.10	21.58	1.01	0.225
Muscle fiber density (number/mm^2)	866.62	816.15	48.51	0.117	927.51[a]	875.11[b]	48.12	0.041

[1]Data are means of 16 chickens per group. [2]a,b Values with different superscripts in the same row differ significantly ($P < 0.05$).

Table IV. Effects of sex on selected minerals, inosinic acid and cholesterol contents in breast and thigh muscles of Dong'an chicken (wet tissue basis)[1].

Items[2]	Breast muscle				Thigh muscle			
	Male	Female	SEM	p Value	Male	Female	SEM	p-Value
Fe (mg/100g)	2.73	3.32	1.77	0.329	2.85	4.31	1.65	0.479
Mn (mg/100g)	0.08	0.06	0.02	0.158	0.10	0.07	0.03	0.372
Zn (mg/100g)	0.98	0.71	0.32	0.118	1.66	1.49	0.52	0.274
Cu (mg/100g)	0.06	0.08	0.05	0.318	0.05	0.07	0.02	0.372
Se (μg/100g)	31.53	31.94	8.13	0.527	32.92	32.90	8.52	0.163
Mg (mg/100g)	28.65	27.97	3.83	0.119	32.47	28.98	3.15	0.332
Ca (mg/100g)	8.64	8.73	0.49	0.158	7.26	6.95	0.53	0.521

[1]Data are means of 16 chickens per group. [2]Fe, Iron; Mn, Manganese; Zn, Zinc; Cu, Copper; Se, Selenium; Mg, Magnesium; Ca, calcium.

Table V. Effects of sex on hydrolyzed amino acids composition in breast and thigh muscles of Dong'an chicken (mg/g)[1].

Items[3]	Breast muscle[2]				Thigh muscle[2]			
	Male	Female	SEM	p Value	Male	Female	SEM	p Value
His	31.02	32.24	1.90	0.556	20.57	20.14	0.31	0.236
Ser	34.25	33.35	3.92	0.829	33.34	29.68	1.90	0.126
Arg	50.66	49.10	1.01	0.199	48.62	45.72	1.37	0.101
Gly	36.31	35.44	3.05	0.790	38.27[a]	33.39[b]	1.45	0.028
Asp	74.85	74.01	1.79	0.663	71.81	69.30	2.02	0.282
Glu	117.13	115.64	2.99	0.644	117.50	112.39	2.65	0.127
Thr	35.30	34.91	1.06	0.734	34.02	32.21	0.91	0.118
Ala	45.75	44.52	1.31	0.402	44.17[a]	40.57[b]	1.21	0.041
Pro	28.29	27.56	0.80	0.417	30.39[a]	27.84[b]	0.80	0.033
Cys	4.00	3.95	0.11	0.663	3.38	3.47	0.27	0.766
Lys	68.32	68.22	1.30	0.939	64.32	62.52	1.38	0.261
Tyr	25.13	25.54	2.06	0.854	23.37	22.90	0.95	0.648
Met	17.47	17.75	1.03	0.802	13.99	12.52	2.19	0.539
Val	40.67	40.27	1.17	0.750	36.98	35.25	0.78	0.091
Ile	37.49	37.26	1.05	0.836	34.78	33.31	0.81	0.144
Leu	62.61	62.22	1.43	0.795	59.40	57.02	1.27	0.135
Phe	30.87	31.06	1.10	0.869	29.81	28.44	0.62	0.092
EAA	292.74	291.69	7.47	0.895	273.31	261.27	6.52	0.139
TAA	740.13	733.03	21.85	0.762	704.73	666.68	17.53	0.096
EAA/ TAA(%)	39.56	39.80	0.45	0.617	38.79	39.19	0.22	0.142

[1]Data are means of 16 chickens per group. [2]a,b Values with different superscripts in the same row differ significantly ($P< 0.05$). [3]His, Histidine; Ser, Serine; Arg, Arginine; Gly, Glycine; Asp, Aspartic; Glu, Glutamic; Thr, Threonine; Ala, Alanine; Pro, Proline; Cys, Cystine; Lys, Lysine; Tyr, Tyrosine; Met, Methionine; Val, Valine; Ile, Isoleucine; Leu, Leucine; Phe, Phenylalanine; TAA, total amino acid; EAA, essential amino acid = Thr+Lys+Met+Phe+Ile+Leu+Val.

Table VI. Effects of sex on fatty acids content (% of total acids) in breast and thigh muscles of Dong'an chicken[1].

Items[3]	Breast muscle[2]				Thigh muscle[2]			
	Male	Female	SEM	p-Value	Male	Female	SEM	p-Value
C14:0	0.38^{b}	0.60^{a}	0.06	0.010	0.53^{b}	0.73^{a}	0.06	0.012
C16:0	25.88	26.11	0.89	0.806	21.42^{b}	24.40^{a}	1.04	0.028
C16:1	1.37	3.00	0.72	0.065	3.20	3.99	0.54	0.197
C17:0	0.28	0.25	0.04	0.400	0.27	0.28	0.02	0.620
C18:0	15.77^{a}	11.24^{b}	1.33	0.014	14.33^{a}	11.70^{b}	0.38	0.000
C18:1	22.11^{b}	33.50^{a}	2.26	0.002	26.90^{b}	31.82^{a}	1.30	0.019
C18:2	16.49	16.76	2.46	0.915	22.16	19.31	1.79	0.164
C20:0	0.11	0.10	0.04	0.687	0.14^{a}	0.11^{b}	0.01	0.022
C18:3n6	0.07	0.11	0.01	0.052	0.12	0.12	0.01	0.705
C20:1	0.23	0.30	0.08	0.453	0.39	0.31	0.04	0.115
C18:3n3	0.38	0.61	0.17	0.219	0.70	0.68	0.11	0.846
C20:3n6	0.76^{a}	0.35^{b}	0.09	0.004	0.45^{a}	0.32^{b}	0.03	0.023
C20:4n6	13.11	6.05	3.02	0.058	7.64^{a}	5.45^{b}	0.27	0.000
C22:6n	3.06^{a}	1.04^{b}	0.59	0.014	1.78^{a}	0.79^{b}	0.26	0.008
SFA[4]	42.42^{a}	38.29^{b}	1.21	0.028	36.67	37.22	1.60	0.213
MUFA[4]	23.71^{b}	36.79^{a}	1.09	0.015	30.49^{b}	36.13^{a}	2.34	0.009
PUFA[4]	33.87^{a}	24.92^{b}	2.96	0.004	32.84^{a}	26.66^{b}	1.96	0.020

[1]Data are means of 16 chickens per group. [2]a,b Values with different superscripts in the same row differ significantly ($P < 0.05$). [3]C14:0-myristic; C16:0-palmitic, C17:0-margaric; C18:0-stearic, C20:0-eicosanoic; C16:1-palmitoleic, C18:1-oleic, C20:1-eicosenoic; C18:2-linoleic, C18:3n6-linoleic, C18:3n3-α-linoleic, C20:3n6-dihomo-c-linolenic, C20:4n6-arachidonic, C22:6n-docosahexaenoic. [4]SFA, saturated fatty acid = C14:0+C16:0+C17:0+C18:0+C20:0; MUFA, monounsaturated fatty acids = C16:1+C18:1+C20:1; PUFA, polyunsaturated fatty acid = C18:2+C18:3n6+C18:3n3+C20:3n6+C20:4n6+C22:6n.

Effect of sex on fatty acids profile of DAC

The fatty acids composition in the breast and thigh muscles of DAC are shown in Table VI. The content of SFA in breast muscle and the content of PUFA in breast and thigh muscles were significantly higher in males than in females ($P < 0.05$). However, the content of MUFA in breast and thigh muscles was significantly lower in males than in females ($P < 0.05$). The C18:0, C20:3n6 and C22:6n contents in breast and thigh muscles, and the C20:0 and C20:4n6 contents in thigh muscle were significantly higher in males than in females ($P < 0.05$). The C14:0 and C18:1 contents in breast and thigh muscles were significantly lower in males than in females ($P < 0.05$).

DISCUSSION

The relatively high value of a* for male in breat muscle could be attributed to the physical activity of the males. A higher level of physical activity promotes an increase in the content of myoglobin, which is directly related to a greater value of redness (Gálvez *et al*., 2020). The value of b* was higher on female thigh muscle. The result was in agreement with the result of previous studies in chickens (Mosca *et al*., 2018). However, other researchers found that sex had no effect on meat color (Villegas-Cayllahua *et al*., 2025). Differences in meat color may be attributed to many factors such as heme pigments, moisture content, sex, strain, protein physical status, and stress (Dai *et al*., 2024).

In our study, pH was also affected by sex. After harvesting, postmortem glycolysis is activated and accumulation of lactic acid in the muscle is increased, which results in a decline in pH (López *et al*., 2011). The reduced pH indicated normal glycolysis in the muscle tissue after slaughter. In our study, the value of the $pH_{45\ min}$ for breast muscles was significantly higher in males than in females. Our results did not match those of Hussein *et al*. (2019), who reported that female breast muscles had higher pH than males. The differences in pH values in chicken muscles may be attributed to stress, slaughter weights, chicken genotype, slaughtering method, and glycogen reserves at slaughter (Glamoclija *et al*., 2015). However, sex did not influence the pH measured at 24 h postmortem. Similar findings were reported by Goo *et al*. (2019), and Uhlířová *et al*. (2018), who studied the non-significant effects of sex on carcass pH_{24h}.

Water loss rate is generally used to measure the water-holding capacity. A lower water-holding capacity in muscles can lead to the loss of nutrients and flavor, resulting in a decline in meat quality (Bai *et al*., 2022). In the present study, we found that the sex of DAC has a significant impact on the water loss rate of the breast muscles and was lower in males than in females, indicating a greater water-holding capacity and better meat quality in males. The current result was corroborated by Damaziak *et al*. (2014), who reported that muscles of male turkeys had higher water-holding capacity than those of females. We showed that higher CL for male in thigh muscle, and these results were comfirmed by Musundire *et al*. (2017), who found that males had a higher CL than females.

A comparative analysis of the chemical composition of meat from indigenous and commercial chickens, performed by Weng *et al*. (2022), confirmed the characteristics of high protein content and low fat content of indigenous chicken. The chemical composition of DAC meat confirms this result being characterized by high protein and low fat contents compared to the standard broiler meat. Sex has a significant effect on the chemical composition of breast and thigh meat. In the present study, females exhibited higher crude fat content of breast and thigh muscles than males, which is in accordance with Pornanek and Phoemchalard (2020). In addition, breast muscle from female had higher crude ash content. The current result was corroborated by Chodová *et al*. (2021), who reported that crude ash content was affected by sex, with higher values in females than in males. Sex affected myofibrillar fragmentation index and muscle tenderness values of broiler chickens (Hussein *et al*., 2019). Sex had a significant effect on the diameters of type IIA (red fibers) and type IIB (white fibers) muscle fibers of the wild-living mallards (Janiszewski *et al*., 2018). In the current study, sex effects were clear for muscle fiber density, where male muscles had higher values than those recorded for female. There is a close relationship between muscle fibers, lipid content, and physical properties. The type and quantity of muscle fibers directly affect the physical properties and functions of muscles, while lipid content indirectly affects their performance by affecting the composition of muscles. Regarding meat quality, an increase in muscle fiber density corresponded to meat with CL and a lower b* value in thigh muscle from male.

Amino acids are the key constituents of protein, and play an important role in optimizing animal production and human nutrition. It is beneficial to the scientific advancement to analyze the amino acid profiles of indigenous chicken. According to the ideal protein model recommended by FAO/WHO, the EAA/TAA proportion of high-quality protein is about 40% (Yuan *et al*., 2019). Our results showed that the EAA/TAA proportion of breast and thigh muscles are close to 40%, which indicated that DAC could provide good quality protein for human. Glutamic acid, aspartic acid, lysine acid, and leucine acid are the most abundant amino acid in other indigenous chicken (Zhao *et al*., 2011) and this corresponds to the results of this study. The composition and content of amino acids are important factors that affect the flavor of meat. In the present study, a minor effect of sex on amino acid content was reported for the muscle of DAC, and this result is consistent with no significant difference in inosinic acid content. Some studies also found that sex had no significant effect on the content of amino acid in other domestic species (Boz *et al*., 2019). In addition to fat content, more interest has been placed on fat quality, i.e., fatty acid composition. Saturated fatty acids are known to contribute to cardiovascular diseases and their intake should not exceed 10% (Kelava *et al*., 2020). Considering SFA, the highest concentration was found for C16:0, and it was significantly higher in the thigh muscle from female. Besides, the contents of C18:0 and C20:0 were higher on male breast and thigh muscle. With respect to MUFA, the highest concentration was measured for C18:1, and it was significantly higher in the breast and thigh muscle from female. The current result was corroborated by Onk *et al*. (2019), who reported that the breast meat of the female ducks contained higher proportions of C18:1 than male ducks. These results led to higher total SFA and lower total MUFA contents in male compared with females, which is in accordance with Yu *et al*. (2020). Considering PUFA, the highest concentration was found for C18:2. There were no statistically significant differences between the meat samples from male and female chickens in the content of this acid, which is in line with the studies Yu *et al*. (2020) reported that sex had no significant effect on the content of C18:2 in breast and thigh muscles of goslings and adult geese. However, the PUFA content was significantly higher in the breast and thigh muscle from male, which is mainly due to the significant increase of C20:3n6 and C22:6n contents. The current result was corroborated by Kowalska *et al*. (2020). Therefore, the current result was corroborated by Baeza *et al*. (2010), who reported that the MUFA percentage was higher and PUFA percentage was lower for the females than for males. These fatty acids are mainly stored in adipose tissue under triglyceride form, while the fatty acids of triacylglycerol are made up mainly of SFA and MUFA. The results indicated that females synthesising lipids earlier than males also deposited more MUFA than males. In additon, sex has a greater impact on fatty acids composition compared to amino acids composition in meat of DAC.

CONCLUSION

It was concluded that sex has an impact on meat quality of DAC. The male exhibited a higher CL, muscle fiber density, amino acids (Gly, Ala, Pro), and PUFA contents in the thigh muscle, and had a lower WLR, crude fat, and MUFA content in the breast muscle. Further research is required to explore the molecular mechanism of sex affecting meat quality.

DECLARATIONS

Acknowledgements

We thank all the members who participated in this study for their support and the experimental site keepers for their help.

Funding

This work was supported by the Scientific Research Foundation of Hunan Provincial Education Department, China (24B0649) and Natural Science Foundation of Hunan Province, China (2023JJ40097).

Ethical statement

The author declares that the sampling of the species under investigation was conducted in accordance with the international conventions on the use of animals in scientific research.

IRB approval

The study was approved by the Ethics Committee of Hengyang Normal University (Permit No. HNU-12).

Generative AI and AI-assisted technology statement

The authors declare that no genrative AI was used in the creation of this manuscript.

Statements of conflicts of interest

The authors have declared no conflict of interest.

REFERENCES

Anyona, D.N., Musyoka, M.M., Ogolla, K., Chemuliti, J.K., Nyamongo, I.K. and Bukachi, S.A., 2023. Characterization of indigenous chicken production and related constraints: Insights from smallholder households in rural Kenya. *Poult. Sci*., **102**: e01717. https://doi.org/10.1016/j.sciaf.2023.e01717

AOAC, 1995. *International Official Methods of Analysis.* 15th ed. AOAC Int., Washington, DC.

Baeza, E., Chartrin, P., Meteau, K., Bordeau, T., Juin, H., Le Bihan-Duval, E., Lessire, M. and Berri, C., 2010. Effect of sex and genotype on carcase composition and nutritional characteristics of chicken meat. *Br. Poult. Sci*., **51**: 344-353. https://doi.org/10.1080/00071668.2010.503472

Baéza, E., Guillier, L. and Petracci, M., 2021. Review: Production factors affecting poultry carcass and meat quality attributes. *Animal*, **11**: 100331. https://doi.org/10.1016/j.animal.2021.100331

Bai, H., Yang, B., Dong, Z., Li, X., Song, Q., Jiang, Y., Chang, G. and Chen, G., 2022. Research note: Effects of cage and floor rearing systems on growth performance, carcass traits, and meat quality in small-sized meat ducks. *Poult. Sci*., **101**: 101520. https://doi.org/10.1016/j.psj.2021.101520

Boz, M.A., Oz, F., Yamak, U.S., Sarica, M. and Cilavdaroglu, E., 2019. The carcass traits, carcass nutrient composition, amino acid, fatty acid, and cholesterol contents of local Turkish goose varieties reared in an extensive production system. *Poult. Sci*., **98**: 3067-3080. https://doi.org/10.3382/ps/pez125

Cardiff, R.D., Miller, C.H. and Munn, R.J., 2014. Manual hematoxylin and eosin staining of mouse tissue sections. *Cold Spring Harb. Protoc*., **6**: 655-658. https://doi.org/10.1101/pdb.prot073411

Chen, X., Cao, J., Geng, A.L., Zhang, X.Y., Wang, H.H., Chu, Q., Yan, Z.X., Zhang, Y., Liu, H.G. and Zhang, J., 2023. Integration of GC-MS and LC-MS for metabolite characteristics of thigh meat between fast- and slow-growing broilers at marketable age. *Fd. Chem*., **403**: 134362. https://doi.org/10.1016/j.foodchem.2022.134362

Cheng, Y., Chen, Y., Li, X., Yang, W., Wen, C., Kang, Y., Wang, A. and Zhou, Y., 2017. Effects of synbiotic supplementation on growth performance, carcass characteristics, meat quality and muscular antioxidant capacity and mineral contents in broilers. *J. Sci. Fd. Agric*., **97**: 3699-3705. https://doi.org/10.1002/jsfa.8230

Chodová, D., Tůmová, E., Ketta, M. and Skřivanová, V., 2021. Breast meat quality in males and females of fast-, medium- and slow-growing chickens fed diets of 2 protein levels. *Poult. Sci*., **100**: 100997. https://doi.org/10.1016/j.psj.2021.01.020

Cygan-Szczegielniak, D. and Bogucka, J., 2021. Growth performance, carcass characteristics and meat quality of organically reared broiler chickens depending on sex. *Animals* (Basel), 11:3274. https://doi.org/10.3390/ani11113274

Dai, Z., Feng, M., Feng, C., Zhu, H., Chen, Z., Guo, B. and Yan, L., 2024. Effects of sex on meat quality traits, amino acid and fatty acid compositions, and plasma metabolome profiles in White King squabs. *Poult. Sci*., **103**: 103524. https://doi.org/10.1016/j.psj.2024.103524

Damaziak, K., Michalczuk, M., Szara, T., Marzec, A. and Turek, B., 2014. Effect of genotype on selected quality attributes of Turkey bone. *Eur. Poult. Sci*., **78**: 1-17. https://doi.org/10.1399/eps.2014.12

Devatkal, S.K., Naveena, B.M. and Kotaiah, T., 2019. Quality, composition, and consumer evaluation of meat from slow-growing broilers relative to commercial broilers. *Poult. Sci.,* **98**: 6177-6186. https://doi.org/10.3382/ps/pez344

Folch, J., Lees, M. and Sloane, S.G.H., 1957. A simple method for the isolation and purification of total lipides from animal tissues. *J. biol. Chem*., **226**: 497-509. https://doi.org/10.1016/S0021-9258(18)64849-5

Gálvez, F., Domínguez, R., Maggiolino, A., Pateiro, M., Carballo, J., De Palo, P., Barba, F. and Lorenzo, J., 2020. Meat quality of commercial chickens reared in different production systems: Industrial, range and organic. *Annls Anim. Sci*., **20**: 263-285. https://doi.org/10.2478/aoas-2019-0067

Glamoclija, N., Starcevic, M., Janjic, J., Ivanovic, J., Boskovica, M., Djordjevic, J., Markovic, R. and Baltic, M.Z., 2015. The effect of breed line and age on measurements of pH-value as meat quality parameter in breast muscles (m. Pectoralis Major) of broiler chickens. *Proc. Fd. Sci*., **5**: 89-92. https://doi.org/10.1016/j.profoo.2015.09.023

Goo, D., Kim, J.H., Choi, H.S., Park, G.H., Han, G.P. and Kil, D.Y., 2019. Effect of stocking density and sex on growth performance, meat quality, and intestinal barrier function in broiler chickens. *Poult. Sci*., **98**: 1153-1160. https://doi.org/10.3382/ps/pey491

Huang, J., Rao, L., Zhang, W., Chen, X., Li, H., Zhang, F., Xie, J. and Wei, Q., 2023. Effect of crossbreeding and sex on slaughter performance and meat quality in Xingguo gray goose based on multiomics data analysis. *Poult. Sci*., **102**: 102753. https://doi.org/10.1016/j.psj.2023.102753

Hussein, E., Suliman, G.M., Al-Owaimer, A.N., Ahmed, S.H., Abudabos, A.M., Abd El-Hack, M.E., Taha, A.E., Saadeldin, I.M. and Swelum, A.A., 2019. Effects of stock, sex, and muscle type on carcass characteristics and meat quality attributes of parent broiler breeders and broiler chickens. *Poult. Sci*., **98**: 6586-6592. https://doi.org/10.3382/ps/pez464

Janiszewski, P., Murawska, D., Hanzal, V., Gesek, M., Michalik, D. and Zawacka, M., 2018. Carcass characteristics, meat quality, and fatty acid composition of wild-living mallards (*Anas platyrhynchos* L.). *Poult. Sci.,* **97**: 709-715. https://doi.org/10.3382/ps/pex335.

Jin, S., Yang, L., Zang, H., Xu, Y., Chen, X.Z., Chen, X.Y., Liu, P. and Geng, Z.Y., 2019. Influence of free-range days on growth performance, carcass traits, meat quality, lymphoid organ indices, and blood biochemistry of Wannan Yellow chickens. *Poult. Sci*., **98**: 6602-6610. https://doi.org/10.3382/ps/pez504

Kelava, U.N., Konjačić, M., Prpić, Z., Tomljanović, K. and Ugarković, D., 2020. Effect of sex and age on nutritional content in wild axis deer (*Axis axis* Erx.) meat. *Animals*, **10**: 1560. https://doi.org/10.3390/ani10091560

Kowalska, E., Kucharska-Gaca, J., Kuźniacka, J., Biesek, J., Banaszak, M. and Adamski, M., 2020. Effects of legume-diet and sex of ducks on the growth performance, physicochemical traits of meat and fatty acid composition in fat. *Sci. Rep*., **10**: 13465. https://doi.org/10.1038/s41598-020-70508-x

Kowalski, E., Aluwé, M., Ampe, B., Janssens, S., Buys, N., De Smet, S. and Millet, S., 2024. Effect of sire type and a by-product based diet on performance and meat quality in growing-finishing pigs. *Animal*, **18**: 101-106. https://doi.org/10.1016/j.animal.2024.101106

Liu, X., Liu, Y.W., Qu, X.Y., Chen, J.F., Xie, K.L., Wang, X.J., Qi, Y., Xiao, B. and He, C.Q., 2021. Effects of different levels of Hermetiaillucens larvae meal on performance, egg quality, yolk fatty acid composition and oxidative status of laying hens. *Ital. J. Anim. Sci*., **20**: 256-266. https://doi.org/10.1080/1828051X.2021.1878946

López, K.P., Schilling, M.W. and Corzo, A., 2011. Broiler genetic strain and sex effects on meat characteristics. *Poult. Sci.,* **90**: 1105-1111. https://doi.org/10.3382/ps.2010-01154

Mosca, F., Zaniboni, L., Stella, S., Kuster, C.A., Iaffaldano, N. and Cerolini, S., 2018. Slaughter performance and meat quality of Milanino chickens reared according to a specific free-range program. *Poult. Sci*., **97**: 1148-1154. https://doi.org/10.3382/ps/pex439

Musundire, M.T., Halimani, T.E. and Chimonyo, M., 2017. Physical and chemical properties of meat from scavenging chickens and helmeted guinea fowls in response to age and sex. *Br. Poult. Sci*., **58**: 390-396. https://doi.org/10.1080/00071668.2017.1313961

Onk, K., Yalcintan, H., Sari, M., Adiguzel, I.S., Yakan,

A. and Ekiz, B., 2019. Effects of genotype and sex on technological properties and fatty acid composition of duck meat. *Poult. Sci*., **98**: 491-499. https://doi.org/10.3382/ps/pey355

Panea, B. and Ripoll, G., 2023. Sex does not affect the colour, shear stress, and lipid oxidation of pork meat, but feed-added plant-derived extracts, storage time and packaging type do. *Foods*, **12**: 1720. https://doi.org/10.3390/foods12081720

Peng, S.M., Lin, Q., Jiang, G.T., Li, Y.H., Dai, Q.Z., He, X. and Yan, H.F., 2018. The complete mitochondrial genome of the Dongan black chicken and its phylogenetic analyses. *Mitochondrial DNA B Resour*., **3**: 1127-1128. https://doi.org/10.1080/23802359.2018.1521306

Petracci, M.E., 2011. BaézaHarmonization of methodologies for the assessment of poultry meat quality features. *World's Poult. Sci. J*., **67**: 137-153. https://doi.org/10.1017/S0043933911000122

Pornanek, P. and Phoemchalard, C., 2020. Feed added curcumin with increased solubility on plasma lipoprotein, meat quality, and fat content in broiler chicks. *Trop. Anim. Hlth. Prod*., **52**: 647-652. https://doi.org/10.1007/s11250-019-02052-4

Śmiecińska, K., Stępień, A. and Kubiak, D., 2022. Effect of variety and sex on the carcass and meat quality traits of guinea fowl (*Numida meleagris* L.). *Animals*, **12**: 2916. https://doi.org/10.3390/ani12212916

Tang, Z.G., Chen, G.Y., Li, L.F., Wen, C., Wang, T. and Zhou, Y.M., 2015. Effect of zinc-bearing zeolite clinoptilolite on growth performance, zinc accumulation, and gene expression of zinc transporters in broilers. *J. Anim. Sci*., **93**: 620-626. https://doi.org/10.2527/jas.2014-8165

Uhlířová, L., Tůmová, E., Chodová, D., Vlčková, J., Ketta, M., Volek, Z. and Skřivanová, V., 2018. The effect of age, genotype and sex on carcass traits, meat quality and sensory attributes of geese. *Asian-Australas J. Anim. Sci*., **31**: 421-428. https://doi.org/10.5713/ajas.17.0197

Villegas-Cayllahua, E.A., Dutra, D.R., Dias, A.V.L., Cavalcanti, É.N.F., Carneiro, N.M.G.M., Castilha, L.D. and Borba, H., 2025. Effect of sex and age on physicochemical and technological characteristics in the Longissimus thoracis et lumborum muscle in Botucatu rabbits. *Animals* (Basel). **15**: 2368. https://doi.org/10.3390/ani15162368.

Weng, K., Huo, W., Li, Y., Zhang, Y., Zhang, Y., Chen, G. and Xu, Q., 2022. Fiber characteristics and meat quality of different muscular tissues from slow- and fast-growing broilers. *Poult. Sci*., **101**: 101537. https://doi.org/10.1016/j.psj.2021.101537

Yamak, U.S., Sarica, M., Boz, M.A. and Ucar, A., 2016. The effect of production system (barn and free-range), slaughtering age and gender on carcass traits and meat quality of partridges (*Alectoris chukar*). *Br. Poult. Sci*., **57**: 185-192. https://doi.org/10.1080/00071668.2016.1144920

Yu, J., Yang, H.M., Lai, Y.Y., Wan, X.L. and Wang, Z.Y., 2020. The body fat distribution and fatty acid composition of muscles and adipose tissues in geese. *Poult. Sci*., **99**: 4634-4641. https://doi.org/10.1016/j.psj.2020.05.052

Yuan, J.L., Ni, M., Liu, M., Wang, H.Y., Zhang, C., Mi, G.Q. and Gu, Z.M., 2019. Analysis of the growth performances, muscle quality, blood biochemistry and antioxidant status of *Micropterus salmoides* farmed in in-pond raceway systems versus usual-pond systems. *Aquaculture*, **11**: 41-45. https://doi.org/10.1016/j.aquaculture.2019.734241

Zhang, J.F., Hu, Z.P., Lu, C.H., Bai, K.W., Zhang, L.L. and Wang, T., 2015. Effect of various levels of dietary curcumin on meat quality and antioxidant profile of breast muscle in broilers. *J. Agric. Fd. Chem*., **63**: 3880-3886. https://doi.org/10.1021/jf505889b

Zhao, G.P., Cui, H.X., Liu, R.R., Zheng, M.Q., Chen, J.L. and Wen, J., 2011. Comparison of breast muscle meat quality in 2 broiler breeds. *Poult. Sci*., **90**: 2355-2359. https://doi.org/10.3382/ps.2011-01432

Zhao, X.Y., Cao, Y., Li, H.Y., Wu, Y.P., Yao, Y.Y., Wang, L., Li, J.H. and Yao, Y., 2024. Development of myofibers and muscle transcriptomic analysis in growing Yili geese. *Poult. Sci*., **103**: 103328. https://doi.org/10.1016/j.psj.2023.103328