Postprint of Research on Muscle Quality of Bian Chicken

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Abstract

This study aimed to investigate the meat quality of Bian chickens. Sixty 1-day-old Bian chickens were selected and randomly allocated to 6 replicates, with 10 birds per replicate (half male and half female). They were raised under conventional conditions and slaughtered at 112 days of age to determine carcass characteristics, conventional meat quality traits, muscle chemical composition, and flavor substance profiles. The results showed that both Bian roosters and hens had dressing percentages exceeding 88% and eviscerated yields over 65%. The shear force of breast muscle was extremely significantly higher in roosters than in hens ($P<0.01$). The crude protein contents of breast muscle in roosters and hens were 84.67% and 87.63%, respectively, which were extremely significantly higher than those of thigh muscle ($P<0.01$). The crude fat contents of thigh muscle in roosters and hens were 11.08% and 13.02%, respectively, which were extremely significantly higher than those of breast muscle ($P<0.01$). The total fatty acid contents of breast and thigh muscle in roosters were 31.74 mg/g and 99.44 mg/g, respectively, while those in hens were 29.57 mg/g and 114.29 mg/g, respectively. The total amino acid contents of breast and thigh muscle in roosters were 80.47% and 96.06%, respectively, while those in hens were 80.20% and 93.75%, respectively. Differences in total fatty acid and total amino acid contents among muscle parts were extremely significant ($P<0.01$), whereas differences between sexes were not significant ($P>0.05$). In conclusion, Bian chickens exhibit excellent slaughter performance, tender meat, rich nutritional value, superior meat quality, and high flavor substance content, establishing them as an outstanding local chicken breed.

Full Text

Research on Meat Quality of Bian Chickens

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Abstract: This experiment aimed to investigate the meat quality characteristics of Bian chickens. Sixty 1-day-old Bian chickens were selected and randomly divided into 6 replicates with 10 birds per replicate (half male and half female), raised under conventional conditions. At 112 days of age, the birds were slaughtered to determine slaughter performance, conventional meat quality traits, muscle chemical composition, and flavor compounds. The results showed that both cocks and hens achieved dressing percentages above 88% and eviscerated yields above 65%. The shear force of breast muscle in cocks was significantly higher than in hens ($P<0.01$). Crude protein contents in breast muscle of cocks and hens were 84.67% and 87.63%, respectively, significantly higher than those in leg muscle ($P<0.01$). Crude fat contents in leg muscle of cocks and hens were 11.08% and 13.02%, respectively, significantly higher than those in breast muscle ($P<0.01$). Total fatty acid contents in breast and leg muscle of cocks were 31.74 mg/g and 99.44 mg/g, respectively, while those of hens were 29.57 mg/g and 114.29 mg/g, respectively. Total amino acid contents in breast and leg muscle of cocks were 80.47% and 96.06%, respectively, while those of hens were 80.20% and 93.75%, respectively. Significant differences in total fatty acids and total amino acids were observed between muscle locations ($P<0.01$), but not between sexes ($P>0.05$). These findings indicate that Bian chickens exhibit excellent slaughter performance, tender meat, rich nutritional value, good meat quality, and high flavor compound content, representing a superior local chicken breed.

Keywords: Bian chicken; slaughter performance; meat quality; fatty acids; amino acids

Bian chicken is the only excellent local chicken breed in Shanxi Province and is listed in the National Conservation Directory of Livestock and Poultry Genetic Resources. The breed originates from the hilly regions of Youyu County in Shanxi Province and the Ulanqab League in Inner Mongolia, on both sides of the Great Wall. Local people refer to the Great Wall as "Bian Qiang" (border wall), hence the name Bian chicken. The breed is characterized by large body size, large eggs, and cold tolerance. Currently, no studies on the meat quality of Bian chickens have been reported domestically. To facilitate the development and utilization of this excellent local breed, this study measured the slaughter performance and meat quality of 112-day-old Bian chickens to provide a theoretical basis for conservation and breeding programs.

1.1 Experimental Materials

Bian chickens were obtained from the National Bian Chicken Conservation Farm at the Institute of Animal Husbandry and Veterinary Medicine, Shanxi Academy of Agricultural Sciences. Sixty 1-day-old chicks were randomly divided into 6 replicates with 10 birds per replicate (half male and half female) and raised in cages under identical conditions with free access to water and feed.

1.2 Diet Composition and Nutrient Levels

The dietary nutrient levels for Bian chickens were formulated according to the requirements of common laying hens. Birds received pellet feed from 1 to 42 days of age and powdered feed from 43 to 112 days of age. The basal diet composition and nutrient levels are presented in Table 1 .

Table 1 Composition and nutrient levels of basal diets (air-dry basis)

Item	1-42 days of age	43-112 days of age
Ingredients		
Corn		
Soybean meal		
Limestone		
$CaHPO_4$		
Total		
Nutrient levels		
Crude protein (CP)		
Crude fat (EE)		
Total phosphorus (TP)		
Calcium (Ca)		

1.3 Sample Collection and Measurements

1.3.1 Sample Collection At 112 days of age, 12 Bian chickens were randomly selected (half male and half female), slaughtered by neck bleeding, and used for carcass measurements. Breast muscle samples were sent to China Agricultural University for conventional meat quality analysis, while both breast and leg muscles were analyzed for chemical composition and flavor compounds.

1.3.2 Slaughter Performance Measurements Slaughter performance was evaluated according to the Chinese agricultural industry standard NY/T 823-2004.

1.3.3 Conventional Meat Quality Measurements **Shear force:** Fresh breast muscle samples were cut into strips (1.0 cm wide × 0.5 cm thick) with tendons, fat, and fascia removed. Shear force values were measured using a

C-LM2 muscle tenderness meter, with each sample measured three times and the average recorded.

Water loss rate: Approximately 1.5 g of breast muscle (with tendons, fat, and fascia removed) was trimmed into thin slices, placed between 18 layers of filter paper on each side, sandwiched between two rigid plastic plates, and pressed with a 35 kg weight for 5 minutes. The sample weight was measured immediately after pressure removal.

pH: Three different locations on the breast muscle were cut open with surgical scissors, and a pH meter electrode was inserted approximately 1 cm deep into the muscle. Three readings were taken for both breast and leg muscle pH at 3-4 hours post-slaughter, and the average was calculated. Due to experimental constraints, pH measurements were conducted 4-5 hours after slaughter.

Meat color: Lightness (L*), redness (a*), and yellowness (b*) values were measured according to the Chinese agricultural industry standard NY/T 1180-2006.

1.3.4 Muscle Chemical Composition Analysis Crude protein content was determined using the Dumas combustion method. Approximately 100 mg of meat sample was placed in the sample inlet of a Rapid N III nitrogen analyzer (Elementary, Germany) for automatic measurement. Crude fat content was determined using the filter bag technique with an ANKOM-XT10 fat analyzer. Moisture content was measured according to GB 5009.3-2010.

1.3.5 Flavor Compound Analysis Fatty acid content was determined by high-performance gas chromatography using a 6890N gas chromatograph. Amino acid content was determined by high-performance liquid chromatography using a Hitachi L-8900 amino acid analyzer.

1.4 Data Processing and Statistical Analysis

Data were expressed as mean ± standard deviation. A database was established and analyzed using SPSS 18.0 statistical software. Differences between groups were evaluated using LSD tests.

2 Results

2.1 Slaughter Performance of Bian Chickens

As shown in Table 2 , no significant differences ($P>0.05$) were observed between 16-week-old cocks and hens in dressing percentage, half-eviscerated yield, eviscerated yield, or breast muscle percentage. The leg muscle percentage in cocks (24.25%) was significantly higher than in hens ($P<0.01$), while the abdominal fat percentage in hens (5.41%) was significantly higher than in cocks ($P<0.01$).

Table 2 Slaughter performance of Bian chickens

Item	Cocks	Hens
Dressing percentage (%)	88.78$\pm$2.89\|88.12$\pm$0.88\|\|$Half-eviscerated yield$($\pm$1.89\|79.50$\pm$1.03\|\|$Eviscerated yield$($\pm$1.55\|65.19$\pm$1.20\|\|$Breast mu$	

In the same row, values with different capital letter superscripts indicate extremely significant differences (P<0.01), while the same or no letter superscripts indicate no significant difference (P>0.05).

2.2 Conventional Meat Quality of Bian Chickens

As shown in Table 3 , the shear force of breast muscle in cocks (2.82 kg) was significantly higher than in hens (P<0.01). No significant differences (P>0.05) were observed between cocks and hens in water loss rate, pH, or meat color of breast muscle.

Table 3 Conventional meat quality of Bian chickens

Item	Cocks	Hens
Shear force (kgf)	2.82$\pm$0.22^{A}\|2.03$\pm$0.08^{B}\|\|$Water loss$($\pm$2.16\|31.44$\pm$2.51\|\|pH\|5.76$\pm$0.03\|5.74$\pm$0.06\|\|$*$ $*Meat color*$ $*$||||$Lightness(L*)$|54.42$\pm$0.97\|52.88$\pm$0.33\|\|$Redness(a*)$\|1.46$\pm$1.01\|2.56$\pm$0.85\|\|$Yello$	

In the same column, values with different capital letter superscripts indicate extremely significant differences (P<0.01), while the same or no letter superscripts indicate no significant difference (P>0.05).

2.3 Muscle Chemical Composition of Bian Chickens

As shown in Table 4 , when comparing sexes, hens showed significantly higher crude protein content in breast muscle (87.63%) than cocks (P<0.05), with no significant differences in other indices (P>0.05). When comparing muscle locations, dry matter and crude protein contents in breast muscle were significantly higher than in leg muscle for both sexes (P<0.01), while crude fat content in leg muscle was significantly higher than in breast muscle (P<0.01).

Table 4 Muscle chemical indices of Bian chickens (%)

Item	Cocks		Hens	
	Breast muscle	Leg muscle	Breast muscle	Leg muscle
Dry matter	26.77$\pm$0.40^{Aa}\|22.82$\pm$0.27^{Bb}\|26.85$\pm$0.24^{Aa}\|23.88$\pm$0.67^{Bb}\|\|$Crude protein$\|84.67$\pm$0.71^{Ab}|8			

In the same row, values with different lowercase letter superscripts indicate significant differences (P<0.05), different capital letter superscripts indicate extremely significant differences (P<0.01), and the same or no letter superscripts indicate no significant difference (P>0.05). The same notation applies to subsequent tables.

2.4 Flavor Compounds in Bian Chicken Meat

As shown in Table 5 , Bian chicken meat contained 20 fatty acids, including 8 saturated fatty acids (SFA) and 12 unsaturated fatty acids. In cocks, SFA content in breast muscle was 12.79 mg/g (40.39% of total fatty acids) and unsaturated fatty acid content was 18.95 mg/g (59.61%); in leg muscle, SFA was 37.09 mg/g (37.30%) and unsaturated fatty acids were 62.35 mg/g (62.70%). In hens, SFA content in breast muscle was 11.81 mg/g (39.94%) and unsaturated fatty acids were 17.76 mg/g (60.06%); in leg muscle, SFA was 42.45 mg/g (37.14%) and unsaturated fatty acids were 71.84 mg/g (62.86%).

When comparing sexes, no significant differences (P>0.05) were observed between cocks and hens in saturated fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, unsaturated fatty acids, or total fatty acids in either muscle location. When comparing muscle locations, all fatty acid indices in leg muscle were significantly higher than in breast muscle for both sexes (P<0.01).

Table 5 Fatty acid content in Bian chicken muscle (mg/g)

Item	Cocks		Hens	
	Breast muscle	Leg muscle	Breast muscle	Leg muscle

Item	Cocks		Hens	
C10:0	0.13$±0.05\|0.03±0.00\|0.16±0.06\|0.04±0.01\|\|$C12:0$\|0.21±0.04\|0.02±0.01\|0.28±0.05\|0.02±0.01\|\|$C14:0$\|0.14±0.02\|0.03±0.01\|0.20±0.04\|0.04±0.01\|\|$C14:1$\|0.21±0.04\|0.71±0.15\|0.19±0.05\|0.87±0.25\|\|$C15:0$\|0.04±0.02\|0.20±0.05\|0.04±0.02\|0.24±0.05\|\|$C16:0$\|8.92±1.95\|26.91±5.56\|8.06±2.16\|31.61±7.95\|\|$C16:1$\|1.47±0.49\|6.33±1.41\|1.21±0.43\|7.42±1.45\|\|$C17:0$\|0.04±0.00\|0.13±0.00\|0.05±0.02\|0.16±0.05\|\|$C17:1$\|0.05±0.00\|0.05±0.00\|0.05±0.00\|0.13±0.11\|\|$C18:0$\|3.27±0.39\|9.12±0.92\|3.10±0.67\|9.58±1.97\|\|$C18:1c$\|9.75±2.16\|33.63±5.62\|8.49±2.71\|38.63±8.62\|\|$C18:2c$\|4.38±0.52\|16.19±0.60\|4.55±1.34\|19.84±4.25\|\|$C18:3n6$\|0.02±0.00\|0.08±0.00\|0.02±0.01\|0.09±0.03\|\|$C20:0$\|0.04±0.01\|0.16±0.05\|0.04±0.02\|0.19±0.06\|\|$C18:3n3$\|0.20±0.03\|0.88±0.09\|0.21±0.08\|1.10±0.06\|\|$C20:2$\|0.08±0.00\|0.18±0.02\|0.09±0.03\|0.19±0.03\|\|$C22:0$\|0.08±0.02\|0.13±0.02\|0.06±0.01\|0.12±0.01\|\|$C20:3n6$\|0.27±0.06\|0.41±0.03\|0.25±0.04\|0.40±0.05\|\|$C20:3n3$\|0.01±0.00\|0.05±0.02\|0.01±0.00\|0.04±0.01\|\|$C20:4n6$\|2.34±0.25\|3.93±0.54\|2.42±0.41\|3.39±0.37\|\|$C20:5n3$\|0.02±0.01\|0.03±0.02\|0.02±0.00\|0.02±0.02\|\|$C22:6n3$|0.32±0.03|0.39±0.07|0.31±0.02|0.35±$0.03			
SFA	12.79	37.09	11.81	42.45
MUFA	11.31	40.21	9.79	46.42
PUFA	7.64	22.14	7.97	25.42
UFA	18.95	62.35	17.76	71.84
TFA	31.74	99.44	29.57	114.29

As shown in Table 6 , no significant differences (P>0.05) were observed between sexes in amino acid content of either muscle location. When comparing muscle locations, leg muscle showed significantly higher contents of glutamic acid, phenylalanine, leucine, and total amino acids than breast muscle in both sexes (P<0.01), with no significant differences in other amino acids (P>0.05).

Table 6 Amino acid content in Bian chicken muscle (%)

Item	Cocks		Hens	
	Breast muscle	Leg muscle	Breast muscle	Leg muscle
Asp	8.05$±0.18\|7.89±0.21\|8.20±0.09\|8.31±0.07\|\|$*Ser*|7.98±0.25|7.91±0.26|8.17±0.16|8.10±0.			
TAA	*|80.47±2.60^{Bb}|96.06±3.27^{Aa}|80.20±2.60^{Bb}|93.75±$3.96			

3 Discussion

3.1 Slaughter Performance of Bian Chickens

Dressing percentage and eviscerated yield are important indicators for evaluating slaughter performance in livestock and poultry. Generally, dressing percentages above 80% and eviscerated yields above 60% are considered indicators of good slaughter performance. In this study, Bian chickens achieved dressing percentages of 88.78% in cocks and 88.12% in hens, with eviscerated yields of 66.76% and 65.19%, respectively, demonstrating good slaughter performance as a dual-purpose breed. No significant differences were observed between sexes in dressing percentage, half-eviscerated yield, eviscerated yield, or breast muscle percentage. However, cocks showed significantly higher leg muscle percentage than hens, consistent with previous measurements and representing a characteristic feature of this breed' s carcass composition. Hens exhibited significantly higher abdominal fat percentage than cocks, likely related to sex differences.

3.2 Conventional Meat Quality of Bian Chickens

Tenderness is a dominant factor determining meat quality and a key indicator of consumer satisfaction with meat texture. Research by Ren et al. indicates that lower shear force values correspond to better tenderness and meat quality. Li et al. reported shear forces of 3.05 kgf and 2.33 kgf for breast muscle in male and female Taihang chickens, respectively, while Xie et al. reported values of 3.07 kgf and 2.65 kgf for Jinghai yellow chickens. In this study, Bian chickens showed shear forces of 2.82 kgf and 2.03 kgf for cocks and hens, respectively, indicating superior tenderness compared to Taihang and Jinghai yellow chickens. The significantly lower shear force in hens demonstrates that female Bian chickens produce more tender meat than males.

Water loss rate is an important indicator of chicken meat quality that directly affects palatability attributes including flavor, juiciness, tenderness, color, and aroma. Li et al. reported water loss rates of 23.75% and 30.30% for male and female Taihang chickens, respectively, while Xie et al. reported 32.35% and 33.43% for Jinghai yellow chickens. This study found water loss rates of 26.80% and 31.44% for Bian chicken cocks and hens, respectively—higher than Taihang chickens but lower than Jinghai yellow chickens. Although hens showed higher water loss than cocks, the difference was not significant, indicating similar meat quality between sexes.

pH is one of the most widely used indicators in meat quality assessment, directly affecting meat preservation and cooking loss. Xi et al. define pH_1 as the value measured 45 minutes post-slaughter and pH (ultimate pH) as the value measured after 24 hours of storage at 4°C. The pH values of 5.76 and 5.74 measured in this study for cocks and hens, respectively, are slightly lower than the range of 5.8-6.3 reported by Xi et al., likely due to measurement timing constraints (4-5 hours post-slaughter in this study).

Meat color is an important visual assessment parameter that creates the first impression for consumers and significantly influences purchasing decisions. In this study, cocks exhibited higher L* values while hens showed higher a* and b* values, but none of these differences were significant, indicating similar meat quality between sexes.

3.3 Muscle Chemical Composition of Bian Chickens

Meat quality is primarily determined by moisture, crude protein, and crude fat content. Higher dry matter content generally indicates greater nutrient density in muscle. Chicken muscle typically contains 70-75% moisture, and within this range, higher moisture content correlates with better palatability. In this study, breast muscle moisture content was 73.23% in cocks and 73.52% in hens, while leg muscle moisture was 77.12% and 76.12%, respectively. The similar moisture contents between sexes indicate comparable meat quality, though leg muscle moisture was significantly higher than breast muscle in both sexes.

Recent research has increasingly focused on protein and fat as important indicators of meat quality. Protein is the main component of muscle dry matter and, while not directly affecting flavor, influences aroma formation during meat maturation. Fat affects not only meat tenderness but also juiciness and flavor. The results demonstrate that breast muscle contains significantly higher crude protein than leg muscle in both sexes, indicating superior nutritional value. Conversely, leg muscle shows significantly higher crude fat content than breast muscle, suggesting poorer fat deposition capacity and flavor in breast meat—one reason why consumers prefer leg meat.

3.4 Meat Flavor of Bian Chickens

Extensive research on meat flavor has established that the types and composition of fatty acids are important indicators for evaluating muscle nutritional value. Unsaturated fatty acids play a crucial role in forming characteristic meat flavor compounds. This study found no significant differences in saturated, monounsaturated, polyunsaturated, unsaturated, or total fatty acids between sexes. However, highly significant differences were observed between muscle locations, with all indices being significantly higher in leg muscle than breast muscle. These results indicate that Bian chickens contain high proportions of unsaturated fatty acids, offering good nutritional value, and that leg muscle provides not only higher nutritional value but also more flavor precursors than breast muscle.

The content, types, and proportions of amino acids are primary indicators for evaluating protein nutritional quality, with higher amino acid content generally indicating better nutritional value. This study identified 17 amino acids in Bian chicken meat, with contents exceeding 80% in breast muscle and 93% in leg muscle. No significant differences were observed between sexes. However, total amino acid content was significantly higher in leg muscle than breast muscle

for both sexes. Additionally, leg muscle contained significantly higher levels of umami amino acids (glutamic acid), bitter amino acids (phenylalanine), and leucine compared to breast muscle, while other amino acids showed no significant differences.

In conclusion, Bian chickens demonstrate excellent slaughter performance, tender meat with high protein and low fat content, and abundant flavor compounds, establishing them as a superior local chicken breed.

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Note: Figure translations are in progress. See original paper for figures.