Comparative Analysis of Meat Quality and Flavor of Broiler Chickens of Different Breeds and Feeding Periods

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Abstract

This study aimed to compare differences in body weight, conventional meat quality, and contents of intramuscular fat, amino acids, and fatty acids among different broiler breeds, in order to provide references for establishing meat quality evaluation indicators for broiler chickens. Fast-growing broilers (recessive white-feathered broilers and Anka chickens) and local breed broilers (Wenchang chickens, Beijing oil chickens, and Qingyuan partridge chickens) of the same age and under the same rearing conditions were selected as experimental materials. Sixty 9-week-old fast-growing broilers and sixty 17-week-old local breed broilers, each approaching average body weight, were weighed and slaughtered for determination of conventional breast muscle quality and contents of intramuscular fat, amino acids, and fatty acids in different breeds. Additionally, sixty 9-week-old and sixty 17-week-old recessive white-feathered broilers were weighed and slaughtered for determination of conventional breast muscle quality and contents of intramuscular fat, amino acids, and fatty acids at different rearing periods. The results showed that: 1) In comparisons among different breeds at slaughter age, Anka chickens had significantly higher body weight than other breeds ($P<0.05$); Beijing oil chickens had significantly lower breast muscle drip loss than other breeds ($P<0.05$); Wenchang chickens and Qingyuan partridge chickens had significantly lower breast muscle shear force than Anka and Beijing oil chickens ($P<0.05$); Anka chickens had significantly higher breast muscle meat color than other breeds ($P<0.05$); Beijing oil chickens had significantly higher breast muscle pH than other breeds ($P<0.05$); Wenchang chickens had significantly higher breast muscle intramuscular fat content than other breeds ($P<0.05$). Qingyuan partridge chickens had significantly higher contents of essential amino acids, non-essential amino acids, umami amino acids, sweet amino acids, and total amino acids in breast muscle than other breeds ($P<0.05$). Recessive white-feathered broilers and Anka chickens had significantly higher breast muscle saturated fatty acid content than other breeds (P<0.05). Recessive white-feathered broilers and Beijing oil chickens had significantly higher breast muscle essential fatty acid content than other breeds (P<0.05). Recessive white-feathered broilers had the highest breast muscle unsaturated fatty acid content. 2) In comparisons of different rearing periods, 9-week-old recessive white-feathered broilers had significantly higher breast muscle drip loss and contents of non-essential amino acids, umami amino acids, saturated fatty acids, and essential fatty acids than 17-week-old birds (P<0.05), while body weight, breast muscle pH, and breast muscle intramuscular fat content were significantly lower than those at 17 weeks (P<0.05). These results indicate that meat quality and flavor substance contents vary considerably among different broiler breeds and cannot be measured by a single indicator. From a nutritional perspective on meat quality, 9-week-old fast-growing broilers are superior to 17-week-old broilers.

Full Text

Comparison Analysis of Meat Quality and Flavor in Different Breeds and Feeding Periods of Broilers

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Abstract

This study aimed to compare differences in body weight, conventional meat quality, and contents of intramuscular fat, amino acids, and fatty acids among different broiler breeds, thereby providing a reference for establishing evaluation standards for broiler meat quality. Fast-growing broilers (recessive white-feathered broilers and Anka chickens) and local breed chickens (Wenchang chickens, Beijing fatty chickens, and Qingyuan partridge chickens) of the same age and under identical feeding conditions were selected as experimental materials. Sixty birds close to the average weight were chosen from 9-week-old fast-growing broilers and 17-week-old local breeds, then weighed and slaughtered to determine conventional breast meat quality and contents of intramuscular fat, amino acids, and fatty acids across breeds. Additionally, sixty recessive white-feathered broilers each at 9 and 17 weeks of age were weighed and slaughtered to evaluate how these same meat quality parameters varied with feeding period.

The results demonstrated: (1) Significant inter-breed differences at slaughter age. Anka chickens exhibited the highest body weight (P<0.05), while Beijing fatty chickens showed the lowest breast muscle moisture loss rate (P<0.05). Wenchang and Qingyuan partridge chickens had significantly lower breast muscle shear force compared to Anka and Beijing fatty chickens (P<0.05). Anka chickens displayed the highest breast meat color values (P<0.05), whereas Beijing fatty chickens had the highest breast muscle pH (P<0.05). Wenchang chickens contained the most intramuscular fat in breast muscle (P<0.05). Qingyuan partridge chickens surpassed all other breeds in essential amino acids, non-essential amino acids, umami amino acids, sweet amino acids, and total amino acids (P<0.05). Recessive white-feathered broilers and Anka chickens had higher saturated fatty acid contents (P<0.05), while recessive white-feathered broilers and Beijing fatty chickens excelled in essential fatty acids (P<0.05). Unsaturated fatty acid content was highest in recessive white-feathered broilers. (2) Regarding feeding period effects, 9-week-old recessive white-feathered broilers showed higher moisture loss rates and greater contents of non-essential amino acids, umami amino acids, saturated fatty acids, and essential fatty acids compared to 17-week-old birds (P<0.05), but lower body weight, breast muscle pH, and intramuscular fat content (P<0.05).

These findings indicate that meat quality and flavor substance contents vary considerably among broiler breeds and cannot be assessed using single indicators. From a nutritional quality perspective, fast-growing broilers slaughtered at 9 weeks of age are superior to those at 17 weeks.

Keywords: broilers; meat quality; intramuscular fat; amino acid; fatty acid

Introduction

As living standards improve, consumer demands for meat quality and flavor have intensified, with local chicken breeds gradually dominating global poultry markets and becoming mainstream in poultry production. However, chicken meat quality is influenced by multiple factors, including genetics, nutrition, and environment, with genetic background being particularly crucial. Substantial genetic differences exist among broiler breeds, resulting in distinct flavor profiles. Local yellow-feathered chickens are widely perceived as having superior taste, aroma, and tenderness compared to imported fast-growing breeds, attributes closely linked to their unique meat quality traits.

Previous research has primarily focused on comparisons within single types, such as different quality chickens or yellow-feathered broilers, or between one specific breed and others, such as Beijing fatty chickens versus white- or yellow-feathered broilers. This experiment selected representative breeds from two categories: recessive white-feathered broilers and Anka chickens as excellent imported fast-growing breeds, and Wenchang chickens, Beijing fatty chickens, and Qingyuan partridge chickens as superior Chinese local breeds. All five breeds were sourced from the National Local Chicken Genetic Resources Gene Bank (Jiangsu) with clear pedigrees and large sample sizes, ensuring high data reliability.

Currently, chicken flavor evaluation relies mainly on subjective assessment without standardized criteria. The reasons for local breeds' popularity remain unclear, as comprehensive scientific investigations with large datasets comparing conventional meat quality, intramuscular fat, amino acids, and fatty acids across breeds are lacking. Recessive white-feathered broilers typically reach market weight by 9 weeks and are usually slaughtered then to minimize feed costs and maximize economic returns. However, whether extending the feeding period improves meat quality has not been thoroughly investigated. This study compared body weight, conventional meat quality, and contents of intramuscular fat, amino acids, and fatty acids at slaughter age across five breeds, while also examining how meat quality changes with feeding period in recessive white-feathered broilers. The objective was to provide scientific evidence for breed selection, development, utilization, and establishment of meat quality evaluation standards, while offering theoretical guidance for consumers seeking high-quality poultry meat.

1.1 Experimental Animals and Management

All experimental chickens were selected from the National Local Chicken Genetic Resources Gene Bank (Jiangsu). Two hundred eggs each from fast-growing breeds (recessive white-feathered broilers and Anka chickens) and local breeds (Wenchang chickens, Beijing fatty chickens, and Qingyuan partridge chickens) were incubated in the same batch for inter-breed comparisons at slaughter age. An additional 200 recessive white-feathered broiler eggs were incubated for within-breed comparisons across feeding periods.

Throughout the experimental period, all breeds were fed commercial complete diets (purchased from COFCO Corporation) formulated according to Chinese Feeding Standards (NY/T 33-2004) for broiler nutritional requirements. Fast-growing broilers received starter feed from days 1-20, grower feed from days 21-48, and finisher feed from days 49-56. Local breeds received starter feed from days 1-42 and grower feed from days 43-119. All birds had ad libitum access to feed.

1.2 Experimental Methods

Sixty birds close to average weight were selected from 9-week-old fast-growing broilers and 17-week-old local breeds, then weighed and slaughtered. Additionally, sixty recessive white-feathered broilers each at 9 and 17 weeks of age were weighed and slaughtered. Post-slaughter breast muscles were collected for determination of conventional meat quality and contents of intramuscular fat, amino acids, and fatty acids across breeds and feeding periods.

1.3.1 Meat Quality Determination

pH, meat color, and moisture loss rate (water-holding capacity) were measured according to NY/T 1333-2007 "Determination of Livestock and Poultry Meat Quality." Shear force (tenderness) was determined following NY/T 1180-2006 "Determination of Meat Tenderness–Shear Force Method." Intramuscular fat content was analyzed according to GB/T 5009.6-2016 "Determination of Fat in Foods."

1.3.2 Amino Acid and Fatty Acid Content Determination

Amino acid contents were determined by high-performance liquid chromatography, while fatty acid contents were analyzed by high-performance gas chromatography. All samples were sent to the Institute of Food Quality, Safety and Testing, Jiangsu Academy of Agricultural Sciences for analysis.

1.4 Statistical Analysis

Data were initially processed using Excel 2016, then subjected to one-way ANOVA using SPSS 20.0 software. Independent samples t-tests were used to compare meat quality between the two feeding periods. Results are expressed as mean ± standard deviation, with $P<0.05$ considered statistically significant.

Results

2.1.1 Comparison of Body Weight, Conventional Meat Quality, and Intramuscular Fat Content Across Breeds at Slaughter Age

As shown in Table 1 , breed significantly affected body weight, conventional meat quality, and intramuscular fat content. Body weight differed significantly among Anka, Beijing fatty, Wenchang, and Qingyuan partridge chickens, with Anka being heaviest and Qingyuan partridge lightest. Breast muscle moisture loss rate was significantly higher in recessive white-feathered broilers, Anka chickens, and Wenchang chickens compared to Beijing fatty and Qingyuan partridge chickens ($P<0.05$), with Qingyuan partridge chickens showing higher values than Beijing fatty chickens ($P<0.05$).

Shear force was significantly greater in Anka and Beijing fatty chickens than in Wenchang and Qingyuan partridge chickens ($P<0.05$). Anka chickens exhibited the highest meat color values, significantly exceeding those of recessive white-feathered broilers, Wenchang chickens, and Beijing fatty chickens ($P<0.05$), while Beijing fatty chickens showed higher values than recessive white-feathered broilers and Wenchang chickens ($P<0.05$). Beijing fatty chickens had the highest breast muscle pH, significantly surpassing all other breeds (P<0.05), followed by Wenchang chickens, which exceeded recessive white-feathered broilers and Anka chickens (P<0.05). Wenchang chickens contained the most intramuscular fat, significantly more than all other breeds (P<0.05), while recessive white-feathered broilers, Anka chickens, and Beijing fatty chickens all had higher values than Qingyuan partridge chickens (P<0.05).

2.1.2 Comparison of Amino Acid Contents Across Breeds at Slaughter Age

Table 2 reveals significant breed effects on amino acid contents. Except for lysine, which did not differ significantly among breeds (P>0.05), and phenylalanine and tyrosine, which were similar between Qingyuan partridge chickens and recessive white-feathered broilers (P>0.05), Qingyuan partridge chickens showed significantly higher contents of all other amino acids, essential amino acids, non-essential amino acids, umami amino acids, sweet amino acids, and total amino acids compared to other breeds (P<0.05).

Anka chickens exhibited the lowest methionine, valine, and glutamic acid contents (P<0.05), while their leucine content was significantly lower than in recessive white-feathered broilers and Qingyuan partridge chickens (P<0.05). Phenylalanine, arginine, aspartic acid, serine, and tyrosine contents in Anka chickens were significantly lower than in recessive white-feathered broilers, Beijing fatty chickens, and Qingyuan partridge chickens (P<0.05), and histidine content was lower than in Beijing fatty and Qingyuan partridge chickens (P<0.05). Non-essential amino acids, umami amino acids, sweet amino acids, and total amino acids were significantly lower in Anka and Wenchang chickens compared to recessive white-feathered broilers, Beijing fatty chickens, and Qingyuan partridge chickens (P<0.05).

Glutamic acid and aspartic acid are the primary umami substances in meat. Based on glutamic acid content, the ranking was: Qingyuan partridge > Beijing fatty > Wenchang > recessive white-feathered > Anka. According to aspartic acid content, the order was: Qingyuan partridge > recessive white-feathered > Beijing fatty > Anka = Wenchang.

2.1.3 Comparison of Fatty Acid Contents Across Breeds at Slaughter Age

Table 3 shows that breed influenced fatty acid composition. Qingyuan partridge chickens had significantly lower contents of all fatty acids, saturated fatty acids, essential fatty acids, and unsaturated fatty acids compared to other breeds (P<0.05). Recessive white-feathered broilers generally had relatively high fatty acid contents, with significantly higher linolenic acid than all other breeds (P<0.05), higher myristic and palmitoleic acids than Wenchang, Beijing fatty, and Qingyuan partridge chickens (P<0.05), higher palmitic and docosatetraenoic acids than Beijing fatty and Qingyuan partridge chickens (P<0.05), higher oleic acid than Wenchang and Qingyuan partridge chickens (P<0.05), and higher linoleic acid than Anka, Wenchang, and Qingyuan partridge chickens (P<0.05).

Saturated fatty acid content was significantly higher in recessive white-feathered broilers and Anka chickens than in other breeds (P<0.05), with Wenchang chickens exceeding Beijing fatty and Qingyuan partridge chickens (P<0.05), and Beijing fatty chickens surpassing Qingyuan partridge chickens (P<0.05). Essential fatty acid content was significantly higher in recessive white-feathered broilers and Beijing fatty chickens than in Anka, Wenchang, and Qingyuan partridge chickens (P<0.05), with Anka and Wenchang chickens exceeding Qingyuan partridge chickens (P<0.05). Unsaturated fatty acid content was highest in recessive white-feathered broilers, significantly greater than in Wenchang, Beijing fatty, and Qingyuan partridge chickens (P<0.05), with Anka chickens also exceeding Wenchang and Qingyuan partridge chickens (P<0.05), Beijing fatty chickens surpassing Qingyuan partridge chickens (P<0.05), and Wenchang chickens exceeding Qingyuan partridge chickens (P<0.05).

2.2.1 Comparison of Body Weight, Conventional Meat Quality, and Intramuscular Fat Content in Recessive White-Feathered Broilers Across Feeding Periods

Table 4 demonstrates that 9-week-old recessive white-feathered broilers had significantly higher breast muscle moisture loss rates than 17-week-old birds (P<0.05), but significantly lower body weight, pH, and intramuscular fat content (P<0.05).

2.2.2 Comparison of Amino Acid Contents in Recessive White-Feathered Broilers Across Feeding Periods

As shown in Table 5 , 9-week-old recessive white-feathered broilers exhibited significantly higher contents of threonine, leucine, isoleucine, arginine, aspartic acid, serine, glycine, alanine, non-essential amino acids, and umami amino acids compared to 17-week-old birds (P<0.05), but lower lysine and valine contents (P<0.05).

2.2.3 Changes in Fatty Acid Contents in Recessive White-Feathered Broilers Across Feeding Periods

Table 6 reveals that 9-week-old recessive white-feathered broilers had significantly higher contents of myristic acid, stearic acid, linoleic acid, linolenic acid, docosatetraenoic acid, saturated fatty acids, and essential fatty acids than 17-week-old birds ($P<0.05$), but lower oleic acid and docosahexaenoic acid contents ($P<0.05$).

Discussion

3.1 Comparison of Body Weight, Conventional Meat Quality, and Intramuscular Fat Content Across Breeds at Slaughter Age

Fast-growing broilers reach market weight rapidly by 9 weeks of age, whereas local breeds grow slowly and require 17 weeks to achieve market weight. These developmental differences lead to substantial variations in meat quality and flavor substance contents. Physical indicators such as water-holding capacity, shear force, meat color, and pH reflect meat eating quality and economic value. Water-holding capacity, indicated by moisture loss rate, significantly influences meat juiciness, processing characteristics, and yield, and is associated with post-slaughter protein solubility. When protein content decreases, water-binding capacity diminishes, resulting in elevated moisture loss rates. Breeds with low water-holding capacity tend to lose nutrients more easily. In this study, Beijing fatty chickens demonstrated superior water-holding capacity, while recessive white-feathered broilers, Anka chickens, and Wenchang chickens showed relatively poor performance.

Tenderness is a primary determinant of meat quality and a critical factor in consumer satisfaction. Shear force values inversely correlate with tenderness—lower values indicate more tender, higher-quality meat. Breed differences in tenderness were evident, with Beijing fatty chickens showing relatively high tenderness. Since regional preferences for meat tenderness vary, breed selection and standard development should be adapted to local customs.

Muscle pH reflects processing quality, post-slaughter glycogenolysis rate and intensity, and meat shelf life. However, pH is a neutral indicator; excessively high values impede normal meat maturation, while overly low values lead to abnormal meat. Beijing fatty chickens exhibited the highest pH (6.00) and recessive white-feathered broilers the lowest (5.56), with moderate pH values across all five breeds. These inter-breed pH differences contribute to distinct processing flavors.

The balance between fat and lean meat determines basic and special flavor characteristics. Fat serves as a solvent for volatile flavor compounds, inhibiting their volatilization and preserving meat flavor. Different fat contents create sensory flavor differences, with higher fat levels potentially yielding richer taste and greater nutritional value. Intramuscular fat content differences inevitably affect muscle quality, with higher levels within an appropriate range associated with better meat quality and flavor. This study found breed differences in intramuscular fat content followed the order: Wenchang > Anka > Beijing fatty > recessive white-feathered > Qingyuan partridge. Wenchang chickens' high intramuscular fat content contributes to their rich yet non-greasy meat quality, while Qingyuan partridge chickens had relatively low levels, indicating substantial inter-breed variation.

3.2 Comparison of Amino Acid Contents Across Breeds at Slaughter Age

Muscle amino acid content is a crucial indicator for evaluating protein nutritional value and a primary chemical index affecting chicken flavor quality. Various amino acids correspond to different human taste sensations and significantly influence meat quality. Research has shown that amino acids can directly activate taste pathway ion channels on human type II receptor cells controlling umami and sweet tastes, with the brain' s umami control center located in the orbitofrontal cortex. Multiple G protein-coupled receptors on posterior tongue taste bud cells play important roles in glutamate umami taste transduction, demonstrating that amino acids directly affect chicken flavor.

Amino acids themselves possess distinct tastes: threonine, alanine, glycine, serine, lysine, proline, and hydroxyproline are primary sweet-tasting compounds, while aspartic acid, serine, glutamic acid, glycine, and alanine are major umami contributors. These amino acids collectively shape overall chicken flavor. Qingyuan partridge chickens showed the highest umami and sweet amino acid contents in this study, consistent with previous findings that breed significantly affects free amino acid contents. This inter-breed variation likely represents a primary cause of flavor differences. Qingyuan partridge chickens demonstrated relatively high contents of most amino acids, essential amino acids, non-essential amino acids, total amino acids, umami amino acids, and sweet amino acids, whereas Anka chickens had relatively low amino acid contents, suggesting superior flavor in Qingyuan partridge chickens. However, some amino acids and non-essential/total amino acid contents in Wenchang chickens were significantly lower than in recessive white-feathered broilers, indicating that free amino acids may not be the main reason for Wenchang chickens' superior flavor over recessive white-feathered broilers, similar to previous research findings.

Since 1908, research has identified monosodium glutamate as a key umami component. Free amino acids, particularly glutamic acid, are major contributors to umami taste. Monosodium glutamate has long been used to enhance meat flavor and impart umami to dishes. Both glutamic acid and aspartic acid possess monosodium glutamate-like flavors and are acidic amino acids. This study found the highest glutamic acid and aspartic acid contents in Qingyuan partridge chickens, followed by Beijing fatty, Wenchang, recessive white-feathered, and Anka chickens, indicating more delicious meat in Qingyuan partridge and Beijing fatty chickens. Serine and threonine participate in Maillard reactions with reducing sugars upon heating to generate important volatile flavor compounds. This reaction occurs at cooking temperatures and is crucial for meat flavor development, with Qingyuan partridge chickens showing the highest serine and threonine contents. Methionine, a sulfur-containing amino acid, is an important precursor for muscle flavor, and Qingyuan partridge chickens also had the highest methionine content. Collectively, these findings indicate that Qingyuan partridge chickens possess the best flavor profile at the amino acid level, suggesting that differences in flavor amino acid contents may contribute to distinct chicken flavors across breeds.

3.3 Comparison of Fatty Acid Contents Across Breeds at Slaughter Age

Fatty acid types and composition are important indicators for evaluating muscle nutritional value and correlate strongly with meat quality. Numerous reports confirm that breed significantly affects meat quality, which this study supports. Qingyuan partridge chickens had lower fatty acid contents than recessive white-feathered broilers, Anka chickens, Wenchang chickens, and Beijing fatty chickens. Recessive white-feathered broilers and Anka chickens had high saturated fatty acid contents, while Beijing fatty chickens excelled in essential fatty acids.

Fatty acids, particularly unsaturated fatty acids, are important precursors for aroma reactions (unsaturated fatty acid oxidation) and play vital roles in forming characteristic meat flavors. This study found that recessive white-feathered broilers had significantly higher unsaturated fatty acid contents than Wenchang, Beijing fatty, and Qingyuan partridge chickens, with Qingyuan partridge chickens having the lowest levels. From the perspective of flavor compounds provided by unsaturated fatty acids, recessive white-feathered broilers performed best, Qingyuan partridge chickens poorest, and fast-growing broilers outperformed local breeds. Essential fatty acid content is an important nutritional quality indicator, with recessive white-feathered broilers and Beijing fatty chickens significantly superior to other breeds. Docosahexaenoic acid, an indispensable nutrient for humans, was significantly higher in Wenchang and Beijing fatty chickens than in other breeds.

3.4 Comparison of Conventional Meat Quality and Intramuscular Fat, Amino Acid, and Fatty Acid Contents Across Feeding Periods in Recessive White-Feathered Broilers

Recessive white-feathered broilers are typically marketed at 9 weeks of age. When maintained to the market age of local breeds (17 weeks), their body weight doubled, and water-holding capacity, pH, and intramuscular fat content increased. However, most amino acid and fatty acid contents were lower at 9 weeks than at 17 weeks, suggesting that from a nutritional quality perspective, 9-week slaughter is optimal for white-feathered broilers. Previous research found that intramuscular fat in broiler breast and thigh muscles gradually decreased with age between 8-16 weeks, contrasting with other studies showing significant increases with age. Our results align with the latter, possibly because continued feeding of high-energy broiler diets after reaching market weight promoted fat deposition, or due to differences in selected time periods.

Flavor substance types and contents vary within the same breed. Meat quality is a complex concept that cannot be measured by single indicators. Moreover, due to regional differences and varying lifestyle habits, consumer preferences for meat quality differ, necessitating broader and deeper research to establish comprehensive quality standards.

Conclusion

1. Recessive white-feathered broilers had high unsaturated fatty acid content, Anka chickens had high saturated fatty acid content, Beijing fatty chickens exhibited high water-holding capacity and essential fatty acid content, Qingyuan partridge chickens showed high shear force and amino acid content, and Wenchang chickens demonstrated high shear force and intramuscular fat content.
2. Significant differences exist in meat quality and flavor substance contents among different broiler breeds, with varying types and levels that cannot be assessed using single indicators.
3. From a nutritional quality perspective, slaughtering fast-growing broilers at 9 weeks of age represents the optimal choice.

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