

Comparison of Carcass and Meat Quality Traits among Three Rabbit Breeds

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Abstract

The objective of this study was to compare carcass composition and meat quality traits in the *longissimus dorsi* and *biceps femoris* muscles in the Hyla, Champagne and Tianfu Black rabbit breeds. Tianfu Black rabbits had the heaviest head, skin, thoracic viscera and commercial carcass percentage ($p < 0.05$). In addition, Tianfu Black had the highest pH_{0h} value, followed by the Champagne and Hyla breeds ($p < 0.01$) in the *longissimus dorsi* and *biceps femoris* muscles. Tianfu Black had a higher a^* (0 h and 24 h) than the other two breeds in both *longissimus dorsi* and *biceps femoris* muscles ($p < 0.05$). The Hyla, Champagne, and Tianfu Black breeds showed a similar pattern of differences for meat quality traits (pH, L^* , a^* and b^*) measured in fresh meat (0 h) and meat stored for 24 h. Hyla had the highest IMF values of the three breeds ($p < 0.01$). The lower intramuscular fat of Tianfu Black and Champagne rabbits gives them an advantage over Hyla rabbits among most consumers seeking lean rabbit meat.

Keywords: rabbit meat, breed, carcass composition, meat quality

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Introduction

In European countries and the Mediterranean area, people have consumed rabbit meat for a long time. Rabbit meat has lower cholesterol content and higher levels of protein with essential amino acids than meat from other animal species (Dalle Zotte and Szendro, 2011). In addition, rabbit meat can be regarded as a functional food because of its potential for improvement in state of health and reduction of disease risk (Dalle Zotte and Szendro, 2011). Rabbit meat provides consumers with rich nutritive and bioactive compounds such as PUFA, DHA, and selenium to improve physiological functions. In addition, the low n-6/n-3 ratio in rabbit meat helps control cardiovascular and other chronic diseases. In the past 50 years, rabbit meat production in the world has increased 2.5 fold; 1.6 million tons were produced in 2009. China, Italy, Spain and France are the main rabbit meat producers (FAOSTAT, 2010). In commercial rabbit breeding, acceptable meat quality standards are one of the most important limiting fac-

tors for the economic output of a farm unit (Rotolo *et al.*, 2013). Color, intramuscular fat (IMF) content, and pH value are all typical meat quality parameters (Dalle Zotte, 2002).

Hyla is a productive breed that is widely used in cross-breeding programs around the world (Hamouda *et al.*, 1990). Hyla is a breed that has fast growth and high feed conversion as well as large litter size and high survival rate. Champagne displayed a high growth rate in young rabbits and was the most productive among medium-sized breeds (Bolet *et al.*, 2004). Champagne is famous for its special fur and high meat production. Tianfu Black is a Chinese indigenous breed developed by the Sichuan Agricultural University in 2001. Currently, Tianfu Black rabbits are popular among Chinese breeders, but it is not well-known elsewhere the world. No research comparing carcass and meat quality traits among these three medium-size rabbit breeds currently exists in China. Thus, the objective of this research was to compare carcass and meat quality traits in *longissimus dorsi* and *biceps femoris* muscles in the Hyla, Champagne, and Tianfu Black rabbit breeds. Two muscles were considered in this research because pH levels and rates of metabolism have been found to be dissimilar in different rabbit muscles (Blasco *et al.*, 1990; Ouhayoun *et al.*, 1983, 1988; Vigneron *et al.*, 1976).

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Materials and methods

Animals

This study was carried out at the experimental rabbitry of the Institute of Animal Genetics and Breeding, Sichuan Agricultural University, China. A total of 340 rabbits (168 males and 172 females) were used in this study. The number of rabbits by breed was 130 Hyla, 130 Champagne and 80 Tianfu Black. Rabbits were reared in individual cages after weaning at 6 weeks of age and fed ad libitum with a commercial diet using standard feeding and management protocols (NRC, 1977).

Carcass traits

Rabbits were slaughtered at 10 wk of age. The slaughter and carcass dissection procedures followed the World Rabbit Science Association (WRSA) recommendations (Blasco and Ouhayoun, 1996). The slaughter weight, head, skin, thoracic viscera (heart, lungs, trachea, esophagus and thymus), liver, kidneys, commercial carcass (includes head, thoracic viscera, liver and kidneys), reference carcass (no head or viscera) was weighed. Percentages of head, thoracic viscera, liver, kidneys and dissectible fat were calculated relative to the commercial carcass weight. Percentage of skin relative to slaughter weight as well as percentages of commercial and reference carcass weights relative to slaughter weight (dressing percentage) were also computed (Peiretti *et al.*, 2013).

Meat quality traits

Measurements of pH ($\text{pH}_{0\text{h}}$) and color ($L^*_{0\text{h}}$, $a^*_{0\text{h}}$, $b^*_{0\text{h}}$) were taken within 15 min after slaughter. Subsequently, after carcasses had been chilled for 24 h at 4°C measurements were taken for pH ($\text{pH}_{24\text{h}}$), color ($L^*_{24\text{h}}$, $a^*_{24\text{h}}$, $b^*_{24\text{h}}$), and intramuscular fat (IMF). Measurements of pH, IMF and color were taken from the *biceps femoris* and *longissimus dorsi* muscles. The pH measurements were taken with a probe using a pH meter (Model PH-STAR CPU, Meister®, Germany). The probe was inserted directly into the muscle to a depth of 3 mm. The objective color was measured by using a Konica Minolta colorimeter modal (CR-400, Japan) and the CIELAB system. Color data were expressed in terms of Lightness (L^*), redness (a^*) and yellowness (b^*). Lightness (L^*) ranged from black (0) to white (100), redness (a^*) ranged from green (-60) to red (+60) and yellowness (b^*) ranged from blue (-60) to yellow (+60). The IMF was analyzed using the modified Soxhlet method (AOAC, 1980).

Statistical analysis

Carcass and meat quality traits were analyzed using the following linear model:

$$Y_{ijk} = \mu + B_i + S_j + e_{ijk}$$

Where Y_{ijk} was a meat quality trait, μ was the overall mean for each trait, B_i was the breed effect, S_j was the fixed sex effect, and e_{ijk} was the random error. Least squares means and their standard errors were computed for each breed. Breed least squares means were compared using Bonferroni t-tests. Computations were carried out using the general linear model (GLM) procedure of SPSS 21 (IBM, USA).

Results and Discussion

Carcass traits

Least squares means for carcass traits and dressing percentages in three rabbit breeds are presented in Table 1. No significant differences in slaughter weight was found among the three rabbit breeds ($p > 0.05$) which indicated that the two exotic breeds (Hyla and Champagne) or local breed (Tianfu Black) had similar growth rates under the feeding levels and handling techniques utilized in the present study.

Tianfu Black rabbits had the highest head percentage, followed by Champagne, whereas Hyla had the lightest heads. In addition, skin percentage in Tianfu Black was significantly higher than in the other two breeds ($p < 0.01$). Lighter skins in the Hyla and Champagne rabbits may have given them an advantage in heat dissipation (Zeferino *et al.*, 2013) relative to Tianfu Black rabbits. The substantially higher head and skin percentages of Tianfu Black would help farmers easily distinguish these rabbits from other medium-size breeds.

Significant differences between the three rabbit breeds existed for visceral organs (Table 1). Tianfu Black rabbits had heavier thoracic viscera than Hyla and Champagne rabbits ($p < 0.05$). Champagne and Tianfu Black had similar liver and kidney percentages which were higher than that of Hyla ($p < 0.05$). Thoracic viscera, liver and kidney are important organs to ensure that an animal has a healthy body and high productivity. Pascual and Pla (2007) suggested that higher head and thoracic viscera percentages may be due to lower degree of maturity of an animal. Commercial carcasses of Tianfu Black rabbits were significantly heavier than those of the Hyla and Champagne rabbits ($p < 0.05$; Table 1). However, there was no signifi-

Table 1. Least squares means for carcass traits and dressing percentages in three rabbit breeds

Trait	Hyla	Champagne	Tianfu Black	P-value
Slaughter weight (g)	2230±12	2244±11	2231±9	0.208
Head (%)	8.58±0.23Bb	9.24±0.17Ba	11.34±0.28A	0.004
Skin (%)	12.63±0.23Bb	13.36±0.18Ba	15.63±0.25A	0.006
Thoracic viscera (%)	1.28±0.04b	1.19±0.03b	1.40±0.05a	0.014
Liver (%)	3.31±0.08b	3.79±0.07a	3.78±0.08a	0.012
Kidney (%)	1.08±0.05b	1.30±0.06a	1.27±0.07a	0.036
Commercial carcass (%)	62.71±0.51b	63.15±0.39b	64.87±0.41a	0.032
Reference carcass (%)	54.71±0.41	55.14±0.30	55.98±0.35	0.057

The data are expressed as least square means±standard errors (Means±SE).

Values with different superscripts within the same row differ significantly at $p<0.05$ (a, b) and $p<0.01$ (A, B).

cant differences among these three rabbit breeds for reference carcass percentages.

Paci *et al.* (2012) reported different percentages of skin, head, liver, kidney and reference carcasses in a local rabbit breed and commercial hybrid rabbits in Italy. Similarly, differences in skin, thoracic viscera, liver, kidney, commercial and reference carcass percentages were found between Botucatu and New Zealand White × Botucatu breed groups under three stress temperatures (Zeferino *et al.*, 2013) and in a local rabbit population in Tuscany (Italy) in indoor and outdoor housing systems (D'Agata *et al.*, 2009). Slaughter trait differences were also found in various large, medium, and small rabbit breeds (Chiericato *et al.*, 1994; Pla *et al.*, 1996; Tümová *et al.*, 2010). However, Ortiz Hernández and Rubio Lozano (2001) reported that breed and sex had no influence on carcass muscle percentage in New Zealand, Californian, Chinchilla, and Rex breeds in Mexico.

Meat quality traits

Table 2 and 3 show least squares means for *longissimus dorsi* and *biceps femoris* meat quality traits. Tianfu Black rabbits had higher $\text{pH}_{0\text{h}}$ for *longissimus dorsi* ($p<0.009$; Table 2) and *biceps femoris* ($p<0.012$; Table 3) than Hyla and Champagne rabbits). Conversely, Tianfu Black had lower $\text{pH}_{24\text{h}}$ than Hyla and Champagne rabbits for *longissimus dorsi* ($p<0.006$; Table 2). In addition, the lower $\text{pH}_{24\text{h}}$ for *biceps femoris* in Tianfu Black than in Hyla and Champagne rabbits was nearly significant ($p<0.054$; Table 3). Hyla and Champagne rabbits had similar $\text{pH}_{0\text{h}}$ and $\text{pH}_{24\text{h}}$ values for both muscles. Values of $\text{pH}_{0\text{h}}$ were higher than values of $\text{pH}_{24\text{h}}$ in Tianfu Black, Hyla and Champagne. Lastly, values of $\text{pH}_{0\text{h}}$ and $\text{pH}_{24\text{h}}$ in *longissimus dorsi* were similar to corresponding values in *biceps femoris* in these three breeds. Our $\text{pH}_{24\text{h}}$ values were similar to those of Mazzone *et al.* (2010) who reported $\text{pH}_{24\text{h}}$ in male rabbits subjected to smooth ($\text{pH}_{24\text{h}}=5.79$) and rough

loading methods ($\text{pH}_{24\text{h}}=5.81$).

Muscles have been found to possess a variety of different chemical components. For example, slow red fibers are rich in oxidative enzymes, but rapid white fibers are rich in both glycogen and glycolytic enzymes. These enzymatic differences lead to differences in muscle fiber topology. This has been called muscular heterogeneity. Muscular heterogeneity would produce differences in acidification kinetics and the ultimate pH in different muscles (Blasco and Piles, 1990; Nath and Rao, 1985; Niedzwia-dek *et al.*, 1983; Osman, 1991; Renou *et al.*, 1986). In our case, differences in pH found in the *longissimus dorsi* and *biceps femoris* muscles here suggest that the acidification process in these two muscles differed in the three breeds. The pH also affects the appearance of raw meat and the tenderness of cooked meat. On the other hand, muscle ultimate pH has an important influence on meat quality (Watanabe *et al.*, 1996) and is related to the rate of glycogen breakdown and liberation of lactate post-slaughter. Thus, our goal was to achieve an ultimate pH a little lower than 6.0 by 24 h (Table 2, Table 3). This was considered to be essential for good product quality (Mach *et al.*, 2008; Terlouw, 2005). A pH substantially lower than 6.0 (e.g., 5.0) would make the meat too firm and dry because the myofibrillary network would shrink and water holding capacity (WHC) would decrease.

Least squares means for *longissimus dorsi* (Table 2) showed that there were no significant differences among the three rabbit breeds for $L^*_{0\text{h}}$ and $L^*_{24\text{h}}$. Values of $a^*_{0\text{h}}$ in Tianfu Black rabbits were significantly different from $a^*_{0\text{h}}$ values in Hyla and Champagne breeds ($p<0.01$), but there was no significant differences between Hyla and Champagne breeds ($p>0.05$). The value of $a^*_{24\text{h}}$ in Tianfu Black rabbits was significantly higher than that of Hyla rabbits ($p<0.05$), and Champagne rabbits had no significant differences with Tianfu Black and Hyla rabbits ($p>0.05$). Tianfu Black rabbits had a significantly higher $b^*_{0\text{h}}$

Table 2. Least squares means for *longissimus dorsi* meat quality traits in three rabbit breeds

Trait	Hyla	Champagne	Tianfu Black	P-value
pH _{0h}	6.56±0.05B	6.48±0.04B	6.67±0.05A	0.009
pH _{24h}	5.80±0.03A	5.76±0.01A	5.66±0.02B	0.006
L* _{0h}	50.29±0.53	49.05±0.59	48.76±0.74	0.244
L* _{24h}	59.96±0.74	59.31±0.63	58.54±0.45	0.286
a* _{0h}	4.25±0.43B	3.99±0.31B	5.86±0.48A	0.003
a* _{24h}	4.09±0.37b	4.63±0.35ab	5.46±0.40a	0.048
b* _{0h}	2.29±0.27b	2.52±0.21ab	3.06±0.28a	0.044
b* _{24h}	4.88±0.29B	6.66±0.32A	4.64±0.32B	0.008
IMF (%)	1.411±0.81A	0.017±0.001B	0.021±0.001B	0.001

The data are expressed as least square means±standard errors (Means±SE).

Values with different superscripts within the same row differ significantly at $p<0.05$ (a, b) and $p<0.01$ (A, B).

Table 3. Least squares means for *biceps femori* meat quality traits in three rabbit breeds

Trait	Hyla	Champagne	Tianfu Black	P-value
pH _{0h}	6.42±0.07B	6.44±0.04B	6.75±0.06A	0.012
pH _{24h}	5.82±0.02	5.81±0.01	5.70±0.02	0.054
L* _{0h}	51.71±0.73b	51.90±0.47b	54.07±0.53a	0.016
L* _{24h}	63.19±0.74	61.87±0.67	61.29±0.66	0.198
a* _{0h}	3.11±0.38b	3.31±0.25b	4.67±0.43a	0.011
a* _{24h}	3.99±0.38b	4.04±0.29b	5.10±0.43a	0.041
b* _{0h}	1.46±0.22C	2.18±0.18B	3.12±0.18A	0.001
b* _{24h}	6.20±0.35A	6.75±0.36A	5.20±0.32B	0.008
IMF (%)	2.245±0.073A	0.031±0.004B	0.030±0.003B	0.001

The data are expressed as least square means±standard errors (Means±SE).

Values with different superscripts within the same row differ significantly at $p<0.05$ (a, b) and $p<0.01$ (A, B, C).

than Hyla rabbits ($p<0.05$), and Champagne rabbits had no significant differences with Tianfu Black and Hyla rabbits ($p>0.05$). Champagne rabbits had significantly higher values of b*_{24h} than Hyla and Tianfu Black rabbits ($p<0.01$), but no significant differences were found between Hyla and Tianfu Black rabbits ($p>0.05$). Hyla rabbits had a significantly higher IMF than Champagne and Tianfu Black rabbits ($p<0.01$), and there was no significant differences between Champagne and Tianfu Black rabbits ($p>0.05$). Thus, a* (0 h and 24 h) and b* (0 h and 24 h) values in the *longissimus dorsi* muscle were significantly different among these three rabbit breeds ($p<0.05$).

Least squares means for *biceps femoris* (Table 3) showed that that no significant differences existed for L*_{24h} among the three rabbit breeds ($p>0.05$). The L*_{0h}, a*_{0h} and a*_{24h} values were significantly higher in Tianfu Black rabbits than in Hyla and Champagne rabbits ($p<0.05$). Tianfu Black rabbits had higher b*_{0h} values than Champagne rabbits ($p<0.01$), and b*_{0h} values in Champagne rabbits were higher than in Hyla rabbits ($p<0.01$).

Comparisons of meat color trait least squares means for *longissimus dorsi* muscle (Table 2) and *biceps femoris* muscle (Table 3) indicated that: 1) The value of L*_{24h} in the three rabbit breeds was higher than that of L*_{0h} in

both *longissimus dorsi* and *biceps femoris* muscles. However, the *biceps femoris* muscle had somewhat higher L*_{0h} and L*_{24h} values than the *longissimus dorsi* muscle; 2) Values of a*_{0h} and a*_{24h} were larger in *longissimus dorsi* than in *biceps femoris* in the three rabbit breeds; and 3) Values of b*_{24h} were higher than those of b*_{0h} in the three rabbit breeds in the *longissimus dorsi* and *biceps femoris* muscles, and values of b*_{0h} and b*_{24h} were similar in both *longissimus dorsi* and *biceps femoris* muscles.

The meat color depends on the level of myoglobin, oxydo-reduction, the degree of oxidation of iron atoms, and on a possible denaturation of globin (Guidera *et al.*, 1997; Monika *et al.*, 2010; Newcom *et al.*, 2004; Pla *et al.*, 1996). Tianfu Black had the highest values for a*_{0h} and a*_{24h} indicating that meat from Tianfu Black rabbits had a darker red color than meat from the other two breeds. Higher a* values in Tianfu Black were likely related to higher pigment content (Renner, 1990). Champagne rabbits had the highest b*_{24h} values in both *longissimus dorsi* and *biceps femoris* muscles. However, differences in b*_{24h} observed here among breeds were small, thus it is likely that consumers would be unable to distinguish differences in yellowness visually.

Pascual and Pla (2007) reported that selection for growth

rate in rabbits would increase the oxidative metabolism route and change the meat color. However, Hernández *et al.* (2006) reported that selection for growth rate did not affect the main sensory characteristics of meat, such as tenderness, juiciness, and fibrousness, but it had a negative effect on aniseed odor, aniseed flavor, and liver flavor. Intense artificial selection for growth rate of meat-type birds has resulted in a higher incidence of abnormal conditions (e.g., PSE-like meat), however this has not been found in rabbit meat (Cavani *et al.*, 2009). Several researchers reported that the pre-slaughter environment (e.g., housing temperature, rearing techniques, feeding regimens, transport conditions and time) influenced blood biochemical parameters and meat traits in rabbits (Combes *et al.*, 2010; Corino *et al.*, 2007; Sabuncuoglu *et al.*, 2011), thus producers should offer rabbits suitable pre-slaughter environmental conditions to obtain high-quality meat.

Least squares means for *longissimus dorsi* (Table 2) indicated that Hyla rabbits had significantly higher IMF values than Champagne and Tianfu Black rabbits ($p < 0.01$), and that there were no significant differences between Champagne and Tianfu Black rabbits ($p > 0.05$). Similarly, least squares means for *biceps femoris* (Table 3) showed that Hyla had a far higher IMF than the other two breeds ($p < 0.01$; Table 3). Thus, Hyla rabbits had substantially higher IMF values than other two breeds in both muscles. However, the *biceps femoris* IMF values were all larger than the corresponding *longissimus dorsi* IMF values for the three breeds. The IMF value here was far lower than the IMF value in lean meat (5.4 ± 0.9) found in hybrid rabbits produced by crossing two SIKA genotype lines in Slovenia (Polak *et al.*, 2013). These authors reported that lean meat IMF content differed by genotype line, sex and age at slaughter and that IMF increased with age. Ouhayoun (1988) found differences in hind leg fat content among seven breeds of large, medium and small size rabbits slaughtered at 11 wk of age; large size breeds had lower fat content than small size breeds. Compared to pig meat, rabbit meat has a lower intramuscular fat and this intramuscular fat has a high percentage of unsaturated fatty acids and a low cholesterol level (Cavani and Petracchi, 2008; Hernández *et al.*, 2006). These characteristics give rabbit meat an advantage over pork when attracting consumers intent on buying healthy meat.

Conclusions

This study found differences in carcass and meat quality traits among three rabbit breeds. Tianfu Black rabbits

had higher commercial carcass, head, skin, and thoracic viscera percentages than Hyla and Champagne rabbits. Tianfu Black had the lowest pH at 24 h, the highest redness color values at 0 and 24 h post-mortem, and lower intramuscular fat percent than Hyla and Champagne. Conversely, Hyla rabbits had the highest pH values, lightness, and yellowness at 24 h as well as the highest intramuscular fat percentages. Based on results here, we recommend the Tianfu Black breed for commercial rabbit production.

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