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Numerical Analysis of Meat Quality Traits of Ningdu Yellow Rooster

Yi Zhang[1*], Min Zhou[2], Wenbing Wu[1], Xuenong Zhu[2], Yuwen Tan[2]

[1]Department of Mathematics and Computer Science, Nanchang Normal University, Nanchang, China
[2]Biotech Research Institute of Nanchang Normal University, Jiangxi Province Key Lab of Genetic Improvement of Indigenous Chicken Breeds, Nanchang, China
Email: *605911246@QQ.com

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Abstract

In order to study the meat quality characteristics of Ningdu yellow rooster, the 7 indexes of 120 healthy Ningdu yellow roosters after slaughter at the age of 16 weeks were determined, and correlation analysis, regression analysis and principal component analysis were carried out among the indexes. The results showed that the variation coefficient of PH value was smaller than that of water drop rate and meat colorimetric, and the lactic acid produced by anaerobic glycolysis of glycogen in chicken meat was slower. Through correlation analysis, the 24-hour drip rate was strongly correlated with the 48-hour drip rate (coefficient ≥ 0.7, $p \leq 0.05$), and the other indicators were independent of each other. By means of regression analysis, the regression equation (fitting degree $R^2 = 0.984$) of 24- and 48-hour drip rate was established. Principal component analysis synthesized 7 indicators into 3 principal components, with a cumulative contribution rate of 70.13%, indicating that the meat quality of Ningdu Yellow chicken rooster is mainly selected by water drop rate, PH value and meat color test.

Keywords

Ningdu Yellow Rooster, Meat Quality, Numerical Analysis

1. Introduction

Ningdu yellow chicken are a small local breed with early maturing, excellent meat quality, stable production performance and population genetic performance [1]. It has a high economic value and social benefits, and has become the leading industry of Ningdu agriculture [2]. Ningdu yellow chicken meat is fresh and tender, high nutritional value, rich in most of the essential fatty acids needed by the human body, so favored by the majority of consumers. 2008 countries

have established animal meat quality measurement standard, the meat is one of the important indicators reflecting economic and livestock and poultry production performance, evaluation of livestock and poultry species value all have important significance, the domestic and foreign experts and scholars of different varieties of chicken meat have carried on the related research, such as Yuan Jin *et al.* [3], Yuan Dandan *et al.* [4], Pu Yonghua *et al.* [5], Hu Minqiang *et al.* [6], Li Hui *et al.* [7], Zhu Renjun *et al.* [8] respectively conducted relevant studies on the meat quality of Tibetan chicken, Wuhei black chicken, Taihe black bone chicken, Yunnan local native chicken, Qilin chicken, Imperial concubine chicken, and Wuding chicken. Yang Ye *et al.* studied the muscle fiber tissue characteristics and chicken tenderness of different local breeds of broiler chickens [9]. Pan Ke *et al.* conducted a comparative study on the quality of chicken meat in Jiangxi Province [10].

Most scholars choose hens as their subjects, few roosters, and a rooster to offspring meat properties has important genetic contribution, 16 weeks for the young rooster, rooster male characteristics gradually show, fleshy higher levels [9], this study selected Ningdu yellow chicken rooster as test material, measured meat quality traits of Ningdu yellow roosters for related research.

2. Materials and Methods

2.1. Materials

120 healthy 1-day-old Ningdu yellow rooster were randomly selected from the same batch and provided by Jiangsouthwest Division Technology Co., Ltd. in the chicken farm of Nanshi Science and Technology Co., LTD., Jinxian County, Jiangxi Province. 120 1-day-old Ningdu yellow rooster were raised to 16 weeks old under the same conditions. The diet composition and nutrition level were configured according to the NRC feeding standard of the United States and the Chicken Feeding Standard of China. The table of feed nutrient content and feed formula were shown in **Table 1** and **Table 2** respectively. Routine immunization and standard management were conducted, and the health status of chickens was regularly observed and daily records were made.

Table 1. Nutrient content table of feed.

Feed Name Metabolizable	Energy (MJ/kg)	Crude Protein (%)	Calcium (%)	Phosphorus (%)	Lysine (%)	Methionine (%)
Corn	14.06	8.9	0.02	0.27	0.27	0.14
Soybean meal	11.05	43	0.32	0.5	2.45	0.48
Wheat bran	6.57	14.4	0.18	0.78	0.47	0.15
Rice bran	2.68	14.5	0.07	1.43	0.365	0.183
Stone powder	-	-	36	-	-	-
Multi dimensional pre powder	-	-	15	2.6	-	2.8
Calcium phosphate	-	-	15	16	-	-

Table 2. Feed formula table.

Raw material	Composition ratio (%)	Metabolizable energy (MJ/kg)	Crude protein (%)
Corn	62	8.7172	5.518
Soybean meal	21	2.3205	9.03
Wheat bran	5	0.3285	0.72
Rice bran	2	0.0536	0.29
Calcium hydrogen phosphate	1.7	-	-
Stone powder	7	-	-
5% pre powder	1	-	-
Salt	0.3	-	-
Total	100	11.42	15.58

2.2. Method

After fasting for 12 hours at 16 weeks of Ningdu Yellow chicken, on-site slaughter determination was conducted in accordance with the provisions of THE DETERMINATION of PH of Meat and Meat Products GB/T9695.5-2008.

2.2.1. Determination of Meat Quality Index and Reasons for Index Selection

Determination of pH after 15 minutes value of pectoral muscle: the method of GB/T9695.5-2008 "determination of pH value of meat and meat products" was used. Take a piece of meat from the left pectoral muscle within 15 minutes of slaughter, and three different points were taken in the meat for determination. The final value was the average value of the three different points.

Pectoral muscle color difference measurement: cut the meat sample before the measurement, and measure it with a color difference meter after 15 minutes of exposure to the air. Record the L^*, a^*, b^* values, measure 3 points for each sample, and take the average. The chroma value DE = $(a^2 + b^2)^{1/2}$, the DE value is similar to the brightness or saturation of the color. The change of the value and DE value in the color difference value can better reflect the color stability of the meat. The L value (brightness), a value (redness), and b value (yellowness) indicate the measurement results. Among them, the L value is the most commonly used. The smaller the value, the redder the flesh is.

Pectoral muscle shearing force measurement: Refer to the People's Republic of China Agricultural Industry Standard NY/T 1180-2006 "Determination of Meat Tenderness-Shearing Force Determination Method", take a piece of meat from each pectoral muscle, and then divide each pectoral muscle into three strips (about 2 cm×) 2 cm × 3 cm) to measure the shear force. The final value is the average of the shear forces of the three strips.

Drip loss (hydraulic): sampling: weigh a cuboid (W_1) with length × width × thickness of 55 mm × 50 mm × 15 mm, then bind one end of the meat sample with a thin thread to make the muscle fiber downward, put it into an inflatable

plastic bag, seal it, tie the bag mouth, hang it in the refrigerator at 4˚C for 24 hours, weigh the meat sample (W_2), and calculate the dripping loss in 24 hours (%) = $(1 - W_2/W_1) \times 100\%$, stored for 48 hours, the meat sample was weighed (W_3), and the drip loss (%) = $(1 - W_3/W_1) \times 100\%$.

2.2.2. Analysis Method

The analysis tool uses SPSS19.0 for indicator description, correlation analysis, and regression analysis. Before performing the correlation analysis, to remove the unit limit of the data, reduce the interference of random factors, and transform it into a dimensionless pure value, the data is first centralized. After such a conversion, it does not affect the relationship between the indicators.

Correlation coefficient.

The centralization calculation is as follows:

$$y_{ij} = \frac{x_{ij} - \upsilon}{\sqrt{\delta}}$$

Among them: x_{ij} is the index value, υ is the index mean value, δ is the variance. The processed data conform to the standard normal distribution with a mean value of 0 and the standard deviation of 1.

3. Results and Analysis

3.1. Index Data Results and Analysis

The descriptive statistical parameters of the meat quality index are shown in Table 3. The variation of meat color a^* was the largest, the content of myoglobin in each sample varied greatly or the myoglobin oxidation rate of each sample was larger; the variation degree of pH after 15 minutes was the smallest (C.V = 4%), and the freshness of each sample became smaller within 15 minutes. The coefficients of variation of 24-hour and 48-hour drip loss rates were greater than 0.8, and the ability of each sample to maintain its water content was quite different.

As shown in Table 3, the range of indicators is compared. pH after 15 minutes < shear force < meat color a^* < meat color b^* < meat color L^* < Drip loss rate/% (24 hour) < Drip loss rate/% (48 hour).

Table 3. Meat Qulity characteristics statistics of Ning-du yellow roosters at 16 weeks of age.

Item	Mean (M)	minimum	maximum	Standard Deviation	Coefficient of variation among samples c.v/%	Range
Drip loss rate% (24 hour)	10.41**	0.53	31.86	9.13	88	31.33
Drip loss rate% (48 hour)	17.92**	1.54	46.67	14.65	82	45.13
Shear force	4.40**	1.83	8.58	1.23	27	6.75
pH value	6.23*	5.75	6.80	0.22	4	1.05
Meat color L^*	68.31**	53.05	77.57	5.47	8	24.52
Meat color a^*	1.04	−1.65	5.30	1.56	150	6.95
Meat color b^*	5.92**	−2.07	11.48	2.58	44	13.55

(independent sample t test, *means $P < 0.05$, **indicates $P < 0.01$.)

3.2. Correlation Analysis of Meat Quality Indexes

Meat color L^* and meat color a^* were significantly correlated with meat color B^* ($P < 0.01$), There was no significant correlation ($P > 0.05$) between 24-hour and 48-hour drip loss rate, shear stress, and pH after 15 minutes; there was no significant correlation between meat color a^* ($P > 0.05$), meat color L^*, meat color B^*, 24-hour and 48-hour drip loss rate, shear force and pH after 15 minutes; significant correlation ($P < 0.05$) was found in 24-hour and 48-hour drip loss rate, but not significantly correlated ($P > 0.05$) in shear force and pH after 15 minutes; the extremely significant correlation was found between meat color a^* and pH after 15 minutes The correlation ($P < 0.01$) was 48 hours drip loss rate, significant correlation ($P < 0.05$) was 24 hours drip loss rate, and no significant correlation ($P > 0.05$) was shear stress. The correlation of each trait was shown in Table 4. Conclusion: The 48-hour drop loss rate of this batch of Ningdu yellow rooster in meat quality can be assessed by the 24-hour drop loss rate character, other characters cannot be substituted for each other.

3.3. Regression Analysis of Meat Quality Indexes

According to the correlation analysis of the meat quality of 16-week-old Ningdu yellow rooster, the 48-hour drop loss rate can be evaluated by the 24-hour drop loss rate character, and the regression analysis of the 48-hour drop loss rate can be obtained by the 24-hour drop loss rate character.

The regression equation $Y = -0.677 + 0.619X_1$ (Y-24 h drip loss rate X_1-48 h drip loss rate) is adjusted to R^2 is 0.984.

F test results of the above model reached extremely significant level ($P < 0.05$), which was statistically significant.

3.4. Principal Component Analysis

KMO test Bartlett sphericity test and principal component analysis were carried out for the 7 meat traits of The Ningdu yellow rooster. The Bartlett test statistic P(Sig) = 0.00 < 0.01, indicating that there is a significant correlation between some variables, and the KMO value is 0.559, which is generally suitable for factor analysis. The results of principal component analysis are shown in Table 5.

It can be seen from Table 5 that the first three principal components were extracted for analysis according to the requirement of characteristic rooted ≥ 1. The characteristic root values of the chicken quality of Ningdu Yellow chicken were 2.126, 1.551 and 1.233, respectively. The contribution rate was 30.36%, 22.15% and 17.61%, respectively, and the cumulative contribution rate was 70.13%, which could reflect the overall situation of the meat quality of the chicken of Ningdu Yellow chicken at 16 weeks old. The expressions of eigenvector data substituted for the main component Y_1, Y_2 and Y_3 are, respectively:

$$Y_1 = 0.971X_1 + 0.976X_2 - 0.007X_3 - 0.385X_4 - 0.258X_5 - 0.023X_6 - 0.125X_7;$$

$$Y_2 = 0.109X_1 + 0.113X_2 + 0.379X_3 - 0.062X_4 + 0.450X_5 + 0.671X_6 + 0.852X_7;$$

$$Y_3 = 0.037X_1 + 0.020X_2 - 0.221X_3 + 0.573X_4 - 0.706X_5 + 0.595X_6 + 0.0037X_7.$$

Table 4. Correlation analysis table of meat quality indicators.

	Drip loss rate (24 hours)	Drip loss rate (48 hours)	Shear force	pH after 15 minutes	Meat colore L^*	Meat colore a^*	Meat colore b^*
Drip loss rate (24 hours)	1						
Drip loss rate (48 hours)	0.992**	1					
Shear force	−0.043	−0.043	1				
pH after 15 minutes	−0.232*	−0.259**	−0.089	1			
Meat colore L^*	−0.226*	−0.220*	0.150	−0.058	1		
Meat colore a^*	0.024	0.032	0.099	0.010	−0.086	1	
Meat colore b^*	−0.122	−0.111	0.111	0.090	0.357**	0.483**	1

Note: **indicates extremely significant correlation ($P < 0.01$) *indicates significant correlation ($P < 0.05$) Pearson two tailed test.

Table 5. Principal component analysis results of Ningdu yellow rooster.

Project		principal component I	principal component II	principal component III
Characteristics of the root		2.126	1.551	1.233
Contribution/%		30.36	22.15	17.62
Cumulative contribution rate/%		30.36	52.52	70.13
Feature Vector	Drip loss rate (24 hours) X_1	0.971	0.109	0.037
	Drip loss rate (48 hours) X_2	0.976	0.113	0.020
	Shear force X_3	−0.007	0.379	−0.221
	pH after 15 minutes X_4	−0.385	−0.062	0.573
	Meat colore L^* X_5	−0.258	0.450	−0.706
	Meat colore a^* X_6	−0.023	0.671	0.595
	Meat colore b^* X_7	−0.125	0.852	0.037

4. Discussion

1) Muscle tenderness is the main indicator for evaluating muscle quality. The measurement of the meat shearing force reflects the tenderness of the meat. The greater the shearing force, the worse the tenderness. Meat tenderness is mainly determined by the number of myofibrils and muscle connective tissue. And muscle fat. Age, gender, quality, weight gain speed, nutritional status, and exercise volume all directly affect the development of muscle fibers, which in turn affects muscle tenderness. the 16-week-old Fujian Hetian chicken breast muscle shear force is 3.36 G, TaiNing black-bone chicken 3.4 G, Beijing oil chicken 2.88 G, 90-day-old Kirin chicken is 4.92 G, 98-day-old Xingyi bantam chicken is 5.3 G, 120-day-old Wenchang chicken 5.64 G.

Conclution: 16-week-old Ningdu yellow rooster left pectoral muscle average shear force of 4.4G, better than 90-day-old Kirin chicken breast, 98-day-old Xingyi bantam chicken breast, 120-day-old Wenchang chicken breast [3]-[9]. Tenderness is good.

2) Drip loss rate refers to the ability of muscle protein to retain its moisture content when subjected to external forces, which directly affects the flavor, texture, nutritional content, juiciness, and other edible qualities of meat. The lower the drip loss, the better the meat quality. The 24-hour drip loss rate of 16-week-old Ningdu yellow roosters was 10.41%, and the 48-hour drip loss rate was 17.92%. The 24-hour and 48-hour drip loss rate is highly positively correlated R = 0.984 (P < 0.01), with a strong correlation. The regression equation $Y = -0.677 + 0.619X_1$ (Y-24 h drip loss rate X_1-48 h drip loss rate) is adjusted to R^2 is 0.984, it can be used as the best regression equation.

3) The pH after 15 minutes value is an important indicator that reflects the glycogenolysis rate of muscle 15 minutes after slaughter. After the animal dies, glycogen in the muscle undergoes anaerobic glycolysis to produce lactic acid, which leads to a decrease in pH [11]. The pH value is relatively neutral. Too high or too low is unfavorable. Too low or falling too fast is not conducive to the preservation of meat. Generally, the pH value of high-quality chicken is between 6.0 - 6.5 for 15 min, and the value of the Ningdu yellow rooster is 6.26. The pectoral muscle of Kirin chicken is 6.21, Wulong native chicken is 5.71, and Haidong chicken is 6.20. They are all high-quality chicken breeds [3]-[9].

4) The pigment of the muscle is mainly composed of myoglobin and hemoglobin, reflecting the freshness of the muscle, the flesh color a^* shows the greatest degree of variation (CV = 1.5), and the myoglobin is bright red when the muscle has just been cut open by O_2 Afterwards, the O_2 binding site in myoglobin is replaced by H_2O, and the muscles appear dark red. As time goes by, the nourished myoglobin is slowly oxidized to produce denatured myoglobin, which is brown. The flesh color b^* and the flesh color a^* have a Linear correlation.

5) using principal component analysis can provide theoretical reference for Ningdu yellow chicken meat rooster analysis, research has shown that the first principal component in 24 and 48 drip loss eigenvector coefficient was 0.971 and 0.976, respectively, can be regarded as whole drip loss factor, reflect Ningdu yellow chicken chicken rooster drip loss degree, explain the main component, the greater the drop of water, the greater the loss. In the second principal component, the characteristic vector coefficients of chroma L^*, a^* and b^* are 0.450, 0.671 and 0.852 respectively, which can be regarded as the overall chroma factor, reflecting the chroma of Ningdu Yellow chicken, indicating that the larger the principal component is, the greater the chroma will be. The ph15 value and chroma a^* of the third principal component can be regarded as the combined factor of pH and chroma. The results showed that the meat quality index of Ningdu yellow chicken should be based on water loss, chroma and PH15 min value.

5. Conclusion

Chicken quality is a complex concept, which is determined by a number of comprehensive factors, including nutritional value, flavor, tenderness, appear-

ance, storage performance and so on. This paper selects four indexes which are easy to measure the results, and discusses the meat quality of Ningdu yellow chicken, which can be used as the theoretical basis for further seed selection and breeding. It is easy to operate and screen in practical production.

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4) "Study on growth and development, tissue structure and whole genome expression profile of Ningdu yellow chicken" by NSFC (No. 31560630).

5) Analysis of lncrna differential expression profile in early testicular development of Ningdu yellow chicken (No. GJJ18079).

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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