

Factors Affecting the Inosine Monophosphate Content of Muscles in Taihe Silkies Chickens

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ABSTRACT : In this paper, changes in the concentration of inosine monophosphate (IMP) of muscles in Taihe Silkies chickens from 2 to 28 weeks of age were studied. The results showed that: (1) with increasing age, IMP content of muscles decreased continuously. (2) the relationship between body weight and IMP content of musculus pectoralis major was significantly negative ($p < 0.01$), so was body weight and IMP content of musculus peroneus, and their coefficients of correlation were -0.45, -0.38 respectively; the relationship between IMP contents of musculus pectoralis major and that of musculus peroneus was more significantly positive ($p < 0.01$), and its coefficient of correlation was 0.59. (3) by multiple regression analysis, changes of IMP content of muscles depended on the weeks of age and body weight. (4) from 2 to 28 weeks of age, the heritabilities of IMP content of musculus pectoralis major were calculated between 0.33-0.48, and those of musculus peroneus were calculated between 0.51-0.69. (*Asian-Aust. J. Anim. Sci. 2002, Vol 15, No. 9: 1358-1363*)

Key Words : Taihe Silkies Chickens, Inosine Monophosphate, Relationship, Multiple Regression, Heritability

INTRODUCTION

For many years, the flavor of meat and meat products has been extensively studied. Among major substances contributing to flavor are amino acids and inosine monophosphate (IMP) (Zhu and Lu, 1996). Because IMP is a major component of meat flavor, it is considered as a key index of meat flavor (Suzuki et al., 1994; Fuyimura, 1998). Taihe Silkies chicken is a special rare chicken in the poultry gene pool of China, which is of special nourishing and medical value (Liu and Zhu, 1998). Chen et al. (1997) systematically studied the IMP contents of musculus pectoralis major in Xiaoshan chicken, Baier chicken, Langshan chicken, Silkies chicken, Beijing fatty chicken and Baier chicken by Xiaoshan chicken crosses, he pointed out that IMP content of musculus pectoralis major (2.62 mg/g) was the highest in Silkies chicken muscles. Those in Xiaoshan chickens, Baier chickens, Langshan chickens and Beijing fatty chickens were 1.95 mg/g, 2.48 mg/g, 1.85 mg/g and 2.47 mg/g respectively. This paper reports the effects of age and genetic factors on IMP contents of musculus pectoralis major and musculus peroneus from Taihe Silkies chickens.

MATERIALS AND METHODS

Materials and sampling methods

Taihe Silkies chickens were from the population conserved in Institute of Poultry Science of Jiangsu

Province, and they were fed on the same diet and circumstances.

24-32 chickens were randomly taken from 4 families at 2, 4, 6, 8, 10, 12, 16, 20, 24 and 28 weeks of age, and their fasting weights were collected before slaughter, and their fresh musculus pectoralis major and musculus peroneus were taken, and frozen at -20°C .

Determination method

1.25 g muscle sample was homogenated with 6% perchloric acid buffer by homogenator at 5 to 10°C . Every homogenating sample was centrifuged and filtrated with 0.45 μm film to obtain inosine monophosphate mixture solution (pH 6.5), which was analyzed by using Waters high performance liquid chromatograph equipped with a Symmetry C18 column (3.9 mm \times 150 mm, 5 μm). The mobile phase was 0.05 M phosphoric acid and triethylamine buffer (pH 3.2)/acetonitrile (95/5, v/v) at a constant flow of 0.8 ml/min. The column temperature was 25°C and the wavelength 254 nm. The washing time of each sample was 15 min. Identification was made by comparison with retention times of the corresponding contrast standard. At the same time, the content of carnine (HR) in the sample was assayed (Sun and Lou, 1993; Li and Huang, 1995).

Statistical analysis

SAS software (V. 6.12) was used for statistics analysis. The main effects of IMP contents of muscles among weeks of age were analyzed by Duncan Test of the GLM procedure. The difference of IMP contents of muscles between gender at the same week of age was compared by T-test (Hui and Jiang, 1996). The method of half sibs intra-class correlation was employed to estimate the heritability

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of IMP contents of muscles (Sheng and Chen, 1999). The formula used was:

$$h^2 = 4\sigma_s^2 / (\sigma_s^2 + \sigma_e^2)$$

where h^2 is heritability of IMP contents of muscles; σ_s^2 is the variance component of sire; σ_e^2 is the component of random error.

RESULTS

IMP content of muscles in Taihe Silkies chickens at different ages and sexes (Table 1, 2; Figures 1, 2 and 3)

Study of IMP contents of musculus pectoralis major and musculus peronaeus in Taihe Silkies chickens from 2 to 28 weeks of age showed that IMP contents of muscles decreased with the increasing week of age and body weight. Average IMP content of musculus pectoralis major (4.56 ± 0.84) was higher than that of musculus peronaeus (2.98 ± 0.50) ($p < 0.01$). IMP contents of musculus pectoralis major at 2 and 4 weeks of age were significantly higher than those from 8 to 28 weeks of age ($p < 0.05$), and there were no differences of IMP contents of musculus pectoralis major from 8 to 28 weeks of age. There were no differences in IMP contents of musculus peronaeus from 2 to 12 weeks of age ($p > 0.05$), so were those from 16 to 24 weeks of age. There were no differences in IMP contents of musculus pectoralis major and musculus peronaeus between females and males ($p > 0.05$), except that in musculus peronaeus at 28 week of age. As IMP contents of musculus pectoralis major decreased, there were some variation of that in males and females, and the variation of musculus peronaeus at different sexes was similar to that of musculus pectoralis major.

Correlation of body weight and IMP contents of muscles from 2 to 28 weeks of age in Taihe Silkies chickens (Table 3)

The negative relationships between body weight and IMP contents of muscles in males and females were very significant ($p < 0.01$). The positive relationships between IMP contents of musculus pectoralis major and that of musculus peronaeus in males and females were significant ($p < 0.01$). Those correlations were similar to the combined sexes.

Regression of IMP contents of muscles in Taihe Silkies chickens on weeks of age and body weights

Because the difference of IMP contents of muscles between males and females was almost insignificant at the each week of age, bivariate regression was used to analyze the regression of IMP contents of muscles on weeks of age and body weights. Bivariate regression equation of IMP contents of musculus pectoralis major (Y_1) on weeks of age (X_1) and body weights (X_2) was as followed: $Y_1 = 5.8318 + 0.0458X_1 - 0.0039X_2$, and it significantly existed ($F = 15.1460$, $p = 0.0029$), so stepwise method was used to get the best linear regression equation, it was $Y_1 = 5.7888 - 0.0026X_2$, and the coefficient of determination was 0.8020. This showed that body weight had significant effect on IMP contents of musculus pectoralis major, and weeks of age had no significant effect on it.

Bivariate regressive equation of IMP contents of musculus peronaeus (Y_2) on weeks of age (X_1) and body weights (X_2) was $Y_2 = 3.7812 - 0.0106X_1 - 0.0014X_2$, which significantly existed ($F = 108.2340$, $p = 0.0001$), so stepwise method was used to get the best linear regression equation, it was $Y_2 = 3.7912 - 0.0017X_2$, and coefficient of determination of this equation was 0.9671. Body weight

Table 1. IMP contents of muscles in Taihe Silkies chickens at different ages

| Weeks of age | Sex | Number of sample | Body weight(g) (mean±SD) | IMP contents of musculus pectoralis major (mg/g sample) (mean±SD) | IMP contents of musculus peronaeus (mg/g sample) (mean±SD) |
|--------------|-----|------------------|-----------------------------|--|---|
| 2 | M+F | 24 | 81.91±9.76 ^f | 6.43±1.53 ^a | 3.73±0.93 ^b |
| 4 | M+F | 24 | 145.08±27.93 ^{ef} | 5.27±1.02 ^b | 3.42±0.80 ^b |
| 6 | M+F | 24 | 193.75±46.58 ^e | 5.13±1.22 ^d | 3.35±1.20 ^b |
| 8 | M+F | 24 | 372.75±49.97 ^d | 4.59±1.28 ^{cd} | 3.19±1.09 ^d |
| 10 | M+F | 24 | 378.29±81.60 ^d | 4.36±1.46 ^{cd} | 3.15±1.23 ^{ab} |
| 12 | M+F | 24 | 465.38±76.22 ^d | 4.33±1.22 ^{cd} | 3.16±1.05 ^{ab} |
| 16 | M+F | 32 | 703.66±105.32 ^b | 3.94±1.06 ^{cd} | 2.59±0.82 ^{bc} |
| 20 | M+F | 24 | 683.78±135.17 ^c | 3.91±0.91 ^{cd} | 2.57±0.81 ^{bc} |
| 24 | M+F | 24 | 758.72±185.76 ^b | 3.89±0.70 ^{cd} | 2.57±0.74 ^{bc} |
| 28 | M+F | 24 | 948.12±223.21 ^a | 3.73±0.91 ^d | 2.09±0.70 ^c |
| Mean | | 248 | | 4.56±0.84 ^A | 2.98±0.50 ^B |

Note: Having the same letter in superscript means insignificant difference ($p > 0.05$), such as a and a, or a and ab. Having no same letter in superscript means significant difference ($p < 0.05$), such as a and b.

Table 2. IMP contents of muscles in Taihe Silkies chickens at different ages and sexes

| Weeks of age | Sex | Number of sample | Body weight(g) (mean±SD) | IMP contents of musculus | IMP contents of musculus |
|--------------|-----|------------------|-----------------------------|--|---|
| | | | | pectoralis major (mg/g sample) (mean±SD) | peronaeus (mg/g sample) (mean±SD) |
| 4 | M | 12 | 157.33±23.18 ^f | 5.18±3.39 ^d | 3.39±0.74 ^d |
| | F | 12 | 121.75±20.58 ^e | 5.44±3.48 ^a | 3.48±0.96 ^d |
| 6 | M | 12 | 212.50±37.84 ^f | 5.24±0.98 ^a | 3.55±1.12 ^{at} |
| | F | 12 | 167.50±46.52 ^e | 4.98±1.52 ^{ab} | 3.06±1.32 ^a |
| 8 | M | 12 | 375.78±51.90 ^e | 4.45±1.44 ^a | 3.34±1.18 ^a |
| | F | 12 | 368.50±46.56 ^{cd} | 4.82±1.00 ^a | 2.95±0.94 ^a |
| 10 | M | 12 | 435.44±77.71 ^{de} | 4.48±1.25 ^{ab} | 3.11±1.16 ^{ab} |
| | F | 12 | 344.00±64.26 ^d | 4.28±1.63 ^b | 3.18±1.32 ^a |
| 12 | M | 12 | 485.21±79.21 ^d | 4.07±0.97 ^b | 3.07±0.94 ^{ab} |
| | F | 12 | 442.25±68.59 ^c | 4.63±1.25 ^{ab} | 3.28±1.20 ^a |
| 16 | M | 16 | 724.68±111.36 ^c | 3.90±0.97 ^a | 2.57±0.86 ^b |
| | F | 16 | 645.87±59.59 ^b | 4.06±1.32 ^a | 2.64±0.75 ^{ab} |
| 20 | M | 12 | 775.00±159.36 ^c | 4.18±0.97 ^a | 2.58±0.69 ^b |
| | F | 12 | 643.75±105.19 ^b | 3.80±0.88 ^a | 2.57±0.88 ^{at} |
| 24 | M | 12 | 878.33±140.44 ^b | 3.98±0.53 ^a | 2.54±0.72 ^b |
| | F | 12 | 648.66±145.58 ^b | 3.81±0.83 ^a | 2.59±0.79 ^{ab} |
| 28 | M | 12 | 1072.09±218.32 ^a | 3.58±0.80 ^d | 2.16±0.64 ^d |
| | F | 12 | 843.23±172.53 ^a | 3.86±1.02 ^a | 2.04±0.78 ^a |

Note: Having the same letter in superscript means insignificant difference ($p>0.05$), such as a and a. or a and ab; Having no same letter in superscript means significant difference ($p<0.05$), such as a and b.

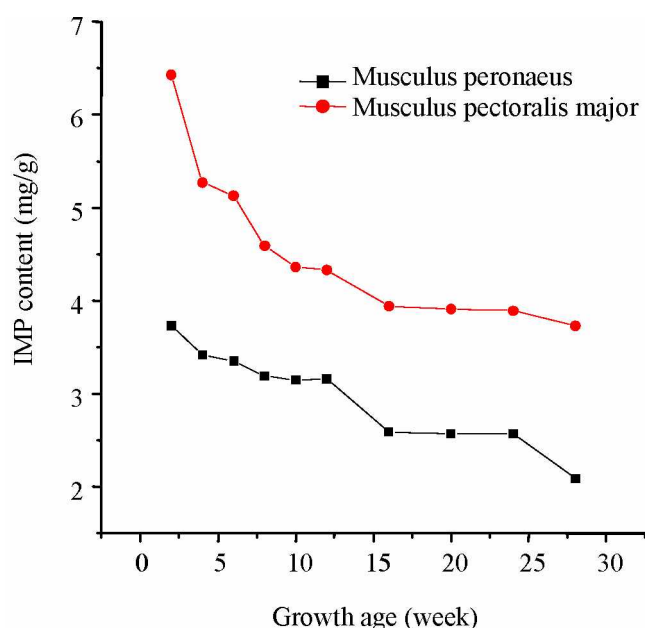


Figure 1. The change of IMP content with age.

had significant effect on IMP of musculus peronaeus, and week of age had no significant effect on it.

Heritability of IMP contents of muscles in Taihe Silkies chickens at different ages (Table 4)

Heritabilities of IMP contents of musculus pectoralis major and musculus peronaeus were moderate. The

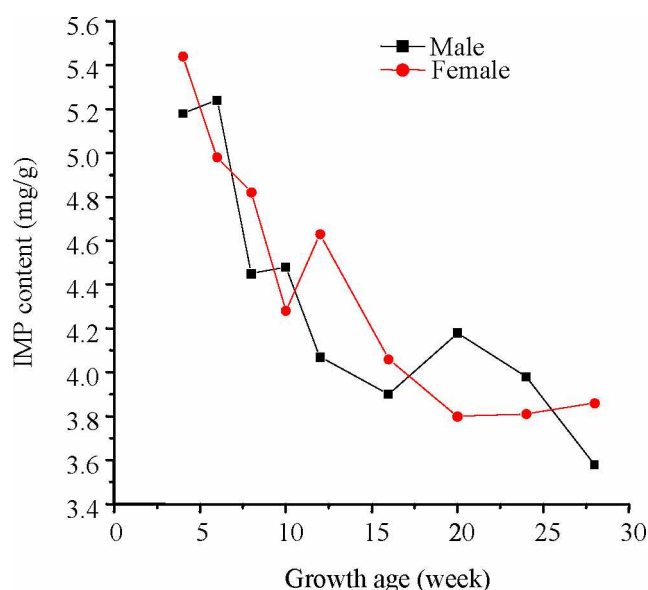


Figure 2. The change of IMP content of musculus pectoralis major with age at different sexes.

heritability range of IMP contents of musculus pectoralis major was 0.51-0.69, and it was the highest at 16 weeks of age (0.69). The heritability range of IMP contents of musculus peronaeus was 0.33-0.48, and the highest was 0.48 at 10 weeks of age.

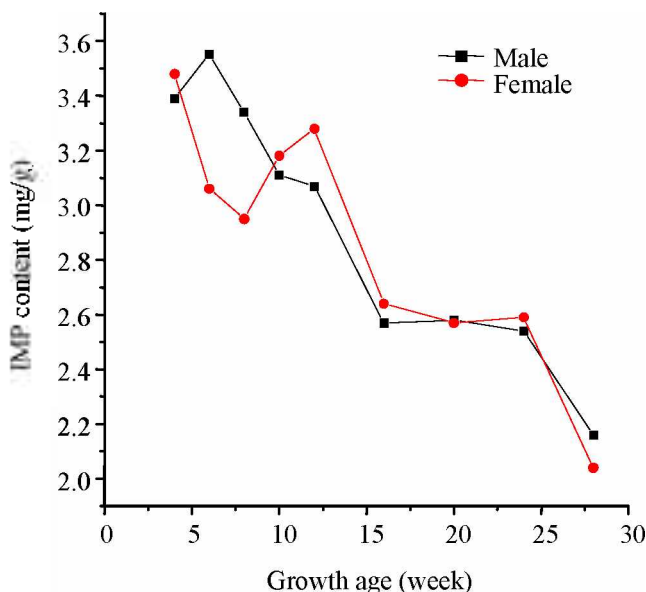


Figure 3. The change of IMP content of musculus peronaeus with age at different sexes.

Table 3. Relationships of body weight and IMP contents of muscles in Taihe Silkies chickens

| Sex | Relationship of body weight and IMP contents of musculus pectoralis major | Relationship of body weight and IMP contents of musculus peronaeus | Relationship of IMP contents of musculus pectoralis major and musculus peronaeus |
|-----|---|--|--|
| M | -0.35** | -0.37** | 0.52** |
| F | -0.33** | -0.29** | 0.65** |
| M+F | -0.45** | -0.38** | 0.59** |

Note: “***” means very significant relationship ($p < 0.01$).

Table 4. Heritability of IMP contents of muscles at different ages in Taihe Silkies chickens

| Weeks of age | Heritability of IMP contents of musculus pectoralis major | Heritability of IMP contents of musculus peronaeus |
|--------------|---|--|
| 2 | 0.66 | 0.45 |
| 4 | 0.61 | 0.46 |
| 6 | 0.66 | 0.42 |
| 8 | 0.61 | 0.43 |
| 10 | 0.65 | 0.48 |
| 12 | 0.51 | 0.34 |
| 16 | 0.69 | 0.42 |
| 20 | 0.55 | 0.33 |
| 24 | 0.67 | 0.39 |
| 28 | 0.62 | 0.42 |
| Mean | 0.62 | 0.41 |

DISCUSSION

Mechanism of IMP metabolism

IMP is rich in the meat of chicken, fish, and et al., and represents meat flavor (Sun and Lou, 1993; Huang and

Jiang, 1994). The flavor forms on the basis of muscle change after animal died. When an animal has just died, glycogen in the muscles is broken down by anaerobic glycolysis, and at this time tissues harden, water-holding capacity decreases and no flavor is produced. After several hours have passed, corpses rigidities disappear and tissues soften (Yamamoto et al., 1991; Kuchiba et al., 1991). During this process, meat produces amino acid and sugar et al., at the same time, meat produces IMP by degrading ATP under the catalysis of enzyme. Production of IMP and its metabolism product undergo the following paths (see Figure 4) (Fuke et al., 1991).

Poultry degrades ATP and produces IMP by path A; shrimp and crab degrade ATP by path A and B; ink fish and octopus degrade ATP by path B, this process is called “maturation”. The quantity of IMP produced in this process has close relation to the flavor of meat (Huang and Jiang, 1994). The difference of IMP of different species is very large, and main reasons are genetic origin (Liu, 1980; Li and Huang, 1995; Chen et al., 1997).

Comparison of IMP contents of muscles in Taihe Silkies chickens from 2 to 28 weeks of age

The results of IMP contents of muscles in Taihe Silkies chickens at different ages and sexes showed that IMP contents of muscles decreased with growing age and body weight. This conclusion was in agreement with the reports of Li and Wang (1995) and Chen et al. (1997) and the differences were insignificant. IMP contents of musculus pectoralis major were higher than those of musculus peronaeus, and this point was unanimous with report of Liu (1980). The study of Xu (1997) pointed out that the relationship between IMP contents of musculus pectoralis major and testosterone in plasma in Arbor Acres broiler chicken was significantly positive, and that between IMP contents of musculus pectoralis major and adrenocortical steroids in plasma was significantly negative; at the same time, the relationship between IMP contents of musculus peronaeus and testosterone in plasma was significantly negative, and that between IMP contents of

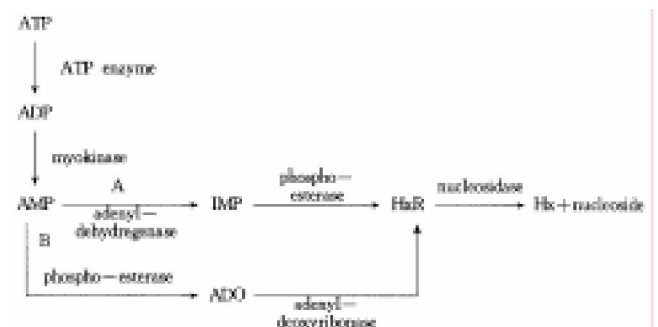


Figure 4. The processes of ATP degradation.

musculus peroneus and adrenocortical steroids in plasma was significantly positive. He suggested it may be the direct reason that IMP contents of musculus pectoralis major were higher than those of musculus peroneus, and testifies plasma testosterone strongly affected the flavor of meat. The report of Fu and Chen (1998) indicated that plasma testosterone of Silkies chickens was gradually increasing before 28 weeks of age. Liu (1980) and Chen (1997) reports indicated that IMP contents of muscle decreased with increasing age. Those results indicated that both plasma hormone and some direct factors had close relation with IMP contents of muscles. In this study, IMP contents of muscles were not agreement with related reports and IMP contents of muscles varied at different sexes during the decreasing period; those were maybe related with material, sampling, circumstance, diet, temperature and method of determination. In this study, IMP contents had some differences with their studies. Main reasons may be different experimental breeds, different ages of samples, different diet components and etc.

Correlations of body weight and IMP contents of muscles in Taihe Silkies chickens

The coefficients of correlation between IMP content of muscles and body weight in Taihe Silkies chickens were moderately negative, which were more significant ($p < 0.01$). It seemed to be the reason that the flavor of miniature chicken was intensive. Coefficients of correlation between body weight and IMP contents of musculus pectoralis major or musculus peroneus in males were bigger than those in females. This result provided the reason for explaining IMP contents of muscles in females was higher than that in males. This result indicated that IMP contents of muscles could be improved by selecting body weight.

Regression of IMP contents of muscles in Taihe Silkies chickens on weeks of age and body weights

The linear regression equations of IMP contents of muscles on weeks of age and body weights showed that IMP contents of musculus pectoralis major and musculus peroneus only had significant linear relation with body weight, and had no significant linear relation with weeks of age. This conclusion told us that we should not only pursue the improvement of body weight. Otherwise, this would affect Silkies chickens special quality to some degrees.

Moderate heritability of IMP content of muscles in Taihe Silkies chickens

IMP contents of muscles in Taihe Silkies chickens were moderate heritability. The heritability range of IMP contents of musculus pectoralis major was 0.51-0.69, and that of musculus peroneus was 0.33-0.48. The reason that IMP content heritability of musculus pectoralis major was

higher than that of musculus peroneus was that circumstance strongly affected IMP contents of musculus peroneus, such as musculus peroneus movement.

The heterosis of the trait which had high heritability was always insignificant (Wang, 1994). This report was consistent with the study of Chen (1997). However, during the breeding period, by selecting for IMP contents of muscles in Taihe Silkies chickens, the high heritability should lead to high IMP contents by a big margin in a short time.

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