Effects of Dietary Metabolizable Energy Level on Growth Performance and Serum Biochemical Indices in 1- to 3-Week-Old Sichuan White Geese (Postprint)

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Abstract

The present study was conducted to investigate the effects of dietary metabolizable energy (ME) level on growth performance and serum biochemical indices of 1- to 3-week-old Sichuan White geese. A total of 780 healthy 3-day-old Sichuan White geese with similar body weight were randomly allocated into 5 groups with 6 replicates per group and 26 geese per replicate. A single-factor experimental design was employed, with five dietary ME levels: 12.86, 12.13, 11.43, 10.73, and 10.00 MJ/kg, and dietary crude protein level was fixed at 20%. The experimental period lasted 18 days. The results showed: 1) The group with dietary ME level of 10.00 MJ/kg exhibited extremely significantly higher average daily feed intake and feed-to-gain ratio than other groups ($P<0.01$), and the groups with dietary ME levels of 12.13 and 10.00 MJ/kg displayed significantly higher final body weight and average daily gain than the group with dietary ME level of 10.73 MJ/kg ($P<0.05$). 2) The group with dietary ME level of 12.86 MJ/kg had the highest feed cost, whereas the group with dietary ME level of 10.73 MJ/kg had the lowest feed cost. 3) The group with dietary ME level of 12.86 MJ/kg showed significantly or extremely significantly lower serum total cholesterol content than other groups ($P<0.05$ or $P<0.01$), the groups with dietary ME levels of 10.73 and 10.00 MJ/kg demonstrated extremely significantly lower serum low-density lipoprotein content than other groups ($P<0.01$), and the group with dietary ME level of 12.86 MJ/kg exhibited extremely significantly higher serum aspartate aminotransferase and alkaline phosphatase activities than other groups ($P<0.01$). Therefore, regression analysis indicated that for 1- to 3-week-old Sichuan White geese, the recommended dietary ME level was 12.22 MJ/kg when using low feed-to-gain ratio and high average daily gain as evaluation criteria, and 10.75 MJ/kg when using high average daily gain and low feed cost as evaluation criteria.

Full Text

Effects of Dietary Metabolizable Energy Level on Growth Performance and Serum Biochemical Indices of Sichuan White Geese Aged from 1 to 3 Weeks

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Abstract: This experiment was conducted to investigate the effects of dietary metabolizable energy (ME) level on growth performance and serum biochemical indices of Sichuan white geese aged from 1 to 3 weeks. Seven hundred and eighty healthy 3-day-old Sichuan white geese with similar body weight were randomly allocated into 5 groups with 6 replicates per group and 26 geese per replicate. Using a single-factor experimental design, five dietary ME levels were established: 12.86, 12.13, 11.43, 10.73, and 10.00 MJ/kg, with dietary crude protein level maintained at 20% across all groups. The experiment lasted for 18 days. The results showed: 1) The average daily feed intake and feed-to-gain ratio of the 10.00 MJ/kg ME group were extremely significantly higher than those of other groups ($P<0.01$). The final weight and average daily gain of the 12.13 and 10.00 MJ/kg ME groups were significantly higher than those of the 10.73 MJ/kg ME group ($P<0.05$). 2) The feed cost of the 12.86 MJ/kg ME group was the highest, while that of the 10.73 MJ/kg ME group was the lowest. 3) The serum total cholesterol content of the 12.86 MJ/kg ME group was significantly or extremely significantly lower than that of other groups ($P<0.05$ or $P<0.01$). The serum low-density lipoprotein content of the 10.73 and 10.00 MJ/kg ME groups was extremely significantly lower than that of other groups ($P<0.01$). The activities of aspartate aminotransferase and alkaline phosphatase in serum of the 12.86 MJ/kg ME group were extremely significantly higher than those of other groups ($P<0.01$). In conclusion, regression analysis indicates that when selecting low feed-to-gain ratio and high average daily gain as indicators, the recommended dietary ME level for Sichuan white geese is 12.22 MJ/kg; when selecting high average daily gain and low feed cost as indicators, the recommended dietary ME level is 10.75 MJ/kg.

Keywords: brooding period; Sichuan white geese; metabolizable energy; growth performance; feed cost

Introduction

Geese are coarse-feed-tolerant poultry that can generally save 70% of concentrate feed while maintaining growth rate under conditions of sufficient forage and relative concentrate supplementation. Geese have a crude protein (CP) absorption rate from green forage as high as 76%, similar to that of sheep, making them truly grain-saving poultry [1]. The period from 1 to 3 weeks of age is a critical stage for early growth and development of meat geese and is crucial for later growth. Previous studies have shown that dietary ME level has no significant effect on the growth performance of meat geese, indicating that meat geese have a relatively wide adaptation range to dietary ME levels. For example, Li et al. [2] reported that dietary ME levels of 12.86, 12.13, and 11.43 MJ/kg had no significant effects on average daily gain, feed-to-gain ratio, or average daily feed intake of 1- to 3-week-old meat geese. Min [3], Wei et al. [4], and Wang et al. [5] found that dietary ME levels ranging from 9.61–12.96 MJ/kg, 10.11–13.45 MJ/kg, and 10.83–11.75 MJ/kg, respectively, had no significant effect on average daily gain of meat geese. Regarding the appropriate dietary ME level for meat geese during the brooding period, different researchers have obtained widely varying results, ranging from 9.95 to 12.13 MJ/kg. Yang [6] suggested that the appropriate dietary ME level for Sichuan white geese aged 1–4 weeks was 9.95 MJ/kg. Li et al. [2], Lin [7], Ma et al. [8], and Min [3] considered the appropriate dietary ME level for brooding meat geese to be between 11.40–11.87 MJ/kg. In contrast, the NRC (1994) [9] recommended a standard dietary ME level of 12.13 MJ/kg. Therefore, this experiment was designed to investigate the effects of different dietary ME levels on growth performance, feed cost, and serum biochemical indices of 1- to 3-week-old Sichuan white geese under actual production conditions in China, aiming to determine the appropriate dietary ME level and provide a scientific basis for establishing nutritional standards for meat geese.

Materials and Methods

2.1 Experimental Diets and Design

The experimental diets were formulated according to the NRC (1994) [9] recommendations for goose nutrient requirements and current practical production requirements in China. A single-factor experimental design was employed with five dietary ME levels: 12.86, 12.13, 11.43, 10.73, and 10.00 MJ/kg. The dietary crude protein level was maintained at 20% across all treatments. Corn and soybean meal served as the main ingredients, and five experimental diets were prepared and fed to the five experimental groups. The apparent metabolizable energy (AME) values for the main ingredients corn, soybean meal, wheat bran, and alfalfa meal were referenced from Wang [10] and Sheng [11] as 13.26, 9.00, 8.80, and 4.25 MJ/kg, respectively. The composition and nutrient levels of the experimental diets are presented in Table 1 . The diets were pelleted using a pellet mill. All experimental diets were randomly sampled, ground through a 1 mm sieve, stored at room temperature, and analyzed for dry matter (DM), CP, organic matter (OM), crude fiber (CF), ether extract (EE), calcium (Ca), phosphorus (P) content, and gross energy (GE).

2.2 Experimental Animals and Management

A total of 1,300 one-day-old Sichuan white geese from the same hatch were selected. After a 3-day adaptation period, 780 healthy individuals with similar body weight were chosen and randomly divided into 5 groups according to the principle of no significant difference between groups ($P>0.05$). Each group consisted of 6 replicates with 26 geese per replicate, with equal numbers of males and females. The experiment began at 4 days of age and ended at 21 days of age, lasting 18 days total. The first 1–3 days served as a pre-trial period during which the diet was gradually transitioned from commercial starter feed to the experimental diets, while days 4–21 constituted the formal experimental period. Geese were raised on net floors with ad libitum access to feed and water via nipple drinkers. The initial brooding temperature was 28°C, which was gradually reduced by 1.5–2.0°C daily until it reached ambient temperature. The disease prevention and control protocol included: subcutaneous injection of 1 mL goose plague yolk antibody at 1–3 days of age, subcutaneous injection of combined goose infectious serositis and colibacillosis vaccine at 7–10 days of age, and injection of avian influenza vaccine (H5+H9) at 14 days of age. Goslings were fed using small feed troughs with a feeding method of frequent small meals to ensure constant feed availability. Feed remaining weight was measured daily at 08:00, and mortality and culling numbers were recorded daily.

2.3 Growth Performance Measurement

On days 1 and 18 of the experiment, geese were weighed after 6 hours of fasting to determine initial and final body weight. Weight and number were recorded by replicate to calculate initial weight, final weight, average daily feed intake, average daily gain, and feed-to-gain ratio based on daily records of feed provision and remaining feed.

2.4 Serum Biochemical Indices Measurement

At the end of the brooding period, 12 geese with body weight close to the average (2 per replicate) were randomly selected from each group, totaling 60 geese. Before morning feeding, approximately 5 mL of blood was collected from the wing vein using a 5 mL disposable syringe. The blood was placed at 4°C for 1–2 hours, then centrifuged at 3,000 r/min at low temperature (4°C) for 20 minutes. The serum was collected and stored for determination of lipid metabolites (total cholesterol, triglycerides, low-density lipoprotein, and high-density lipoprotein) and protein metabolites (alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, total protein, albumin, globulin) content or activity.

2.5 Statistical Analysis

Data were initially processed using Excel 2003 software. Variance analysis and significance testing were performed using the GLM module in SPSS 11.5 software, with Duncan's method for the former and S-N-K (Student-Newman-Keuls) method for the latter. The regression linear model in SPSS 11.5 software was used to fit data from each energy group to determine the appropriate dietary ME level. The model was as follows:

$$y = a + bx$$

where y represents average daily feed intake or feed-to-gain ratio, x represents dietary ME level, a is a constant, and b represents the slope.

Results

3.1 Effects of Dietary ME Level on Growth Performance of 1- to 3-Week-Old Geese

As shown in Table 2 , with decreasing dietary ME level, final weight and average daily gain showed a trend of first increasing, then decreasing, and then increasing again, while average daily feed intake and feed-to-gain ratio showed a gradually increasing trend. The average daily feed intake and feed-to-gain ratio of the 10.00 MJ/kg ME group were extremely significantly higher than those of other groups (P<0.01). The final weight and average daily gain of the 12.13 and 10.00 MJ/kg ME groups were significantly higher than those of the 10.73 MJ/kg ME group (P<0.05). The 10.00 MJ/kg ME group had the highest average daily feed intake and feed-to-gain ratio.

Regression analysis indicated that both average daily feed intake (y_1) and feed-to-gain ratio (y_2) had extremely significant linear relationships with dietary ME level (x), with linear equations as follows:

$$y_1 = 132.994 - 4.644x \quad (P < 0.01, R^2 = 0.664)$$

$$y_2 = 2.997 - 0.102x \quad (P < 0.01, R^2 = 0.859)$$

Using these linear equations, when the feed-to-gain ratio was relatively low (1.75) and average daily gain was highest (44.61 g/d), the dietary ME level was 12.22 MJ/kg. When both feed-to-gain ratio (1.99) and average daily gain (44.61 g/d) were at their highest, the dietary ME level was 9.87 MJ/kg. These results demonstrate that experimental geese could regulate feed intake according to dietary ME level, and when dietary ME level was low, they could increase feed intake to promote growth.

3.2 Effects of Dietary ME Level on Feed Cost of 1- to 3-Week-Old Geese

As shown in Table 3 , the 12.86 MJ/kg ME group had the highest feed cost at 7.06 yuan/kg, while the 10.73 MJ/kg ME group had the lowest feed cost, which was 0.85 yuan/kg lower than the 12.86 MJ/kg ME group. Similarly, using the linear equation $y_2 = 2.997 - 0.102x$ (P<0.01, $R^2 = 0.859$) as a model, the dietary ME level was 10.75 MJ/kg when optimal economic benefits were achieved.

3.3 Effects of Dietary ME Level on Serum Biochemical Indices of 1- to 3-Week-Old Geese

As shown in Table 4 , with decreasing dietary ME level, serum total cholesterol and low-density lipoprotein contents were highest in the 10.73 MJ/kg ME group. The serum total cholesterol content of the 12.86 MJ/kg ME group was significantly or extremely significantly lower than that of other groups (P<0.05 or P<0.01). The serum low-density lipoprotein content of the 10.73 and 10.00 MJ/kg ME groups was extremely significantly lower than that of other groups (P<0.01). No significant differences were observed in serum triglyceride or high-density lipoprotein contents among groups (P>0.05).

As shown in Table 5 , the activities of serum aspartate aminotransferase and alkaline phosphatase in the 12.86 MJ/kg ME group were extremely significantly higher than those in other groups (P<0.01). The serum total protein and globulin contents of the 12.13 and 10.73 MJ/kg ME groups were significantly or extremely significantly higher than those of the 12.86 and 11.43 MJ/kg ME groups (P<0.05). The serum globulin content of the 10.00 MJ/kg ME group was the lowest, being significantly lower than that of the 12.86, 12.13, and 11.43 MJ/kg ME groups (P<0.05). No significant differences were observed in serum alanine aminotransferase activity, alanine aminotransferase/aspartate aminotransferase ratio, albumin content, or urea nitrogen content among groups (P>0.05).

Discussion

4.1 Effects of Dietary ME Level on Growth Performance of 1- to 3-Week-Old Geese

Dietary ME level is an important factor affecting animal feed intake. As dietary ME level increases, animal feed intake decreases. Poultry have a strong instinct to "eat for energy," and although feed intake decreases, total ME intake remains relatively stable to maintain feeding stability and growth performance [12]. Yang et al. [13], De Freitas et al. [14], and Cao [15] investigated the effects of dietary ME level on growth performance of meat ducks, quails, and meat geese, respectively, and found that as dietary ME level decreased, average daily gain of experimental animals showed a decreasing trend, while average daily feed intake and feed-to-gain ratio showed increasing trends. The present study showed that with decreasing dietary ME level, final weight and average daily gain first increased, then decreased, and then increased again, while average daily feed intake and feed-to-gain ratio gradually increased. These results indicate that reduced dietary ME level affects feed intake, thereby decreasing average daily gain. However, when dietary ME level decreases to a certain extent, meat geese significantly increase average daily feed intake to maintain a relatively high growth rate. Therefore, meat geese have the ability to regulate feed intake according to dietary ME level to maintain stable growth performance, which explains why geese can achieve relatively high growth rates and performance under extensive feeding systems such as grazing.

4.2 Effects of Dietary ME Level on Serum Biochemical Indices of 1- to 3-Week-Old Geese

Blood is an important component of the internal environment in animals, transporting metabolic substrates and waste products. Changes in blood components can reflect metabolic status and health condition. Dietary ME level can affect serum biochemical indices, thereby influencing animal health.

Total cholesterol is an important energy storage substance in animals, and low-density lipoprotein is a lipoprotein particle that transports cholesterol into peripheral tissue cells. Both serum total cholesterol and low-density lipoprotein contents can reflect lipid metabolism status, and excessively high levels can cause arteriosclerosis and sudden death in poultry. The present study showed that dietary ME level had certain effects on lipid metabolites total cholesterol and low-density lipoprotein contents, which showed a trend of first increasing, then decreasing, then increasing again, and finally decreasing with increasing dietary ME level. Chen et al. [16] and Jing [17] reported that dietary ME level had significant effects on serum total cholesterol and low-density lipoprotein contents, which decreased significantly with increasing dietary ME level. Jiang et al. [18] obtained similar results. This phenomenon may be because increased dietary fat reduces the activities of lipogenic enzymes, acetyl-CoA carboxylase, and fatty acid synthase, which leads to decreased serum low-density lipoprotein and total cholesterol contents [19]. Keren-zvi et al. [20] increased dietary ME level by adding palm oil and demonstrated that vegetable oil has adverse effects on fat synthesis.

Total protein is synthesized by the liver, and its content directly reflects feed conditions and animal growth, development, and physiological status. Within a certain range, increased serum total protein content indicates enhanced liver synthetic capacity. Serum globulin is a protein involved in immune function and is an important indicator for assessing liver function and nutritional status. Globulin content and albumin/globulin ratio in serum can accurately reflect protein metabolism, liver function normality, and protein absorption and metabolism status. Özek et al. [21] found that dietary ME level had extremely significant effects on serum total protein content in quails, which increased with decreasing dietary ME level, consistent with the present study results. This suggests that when dietary ME level decreases, liver protein synthesis capacity is enhanced to maintain a positive dynamic balance with tissue proteins [22]. Normal serum alkaline phosphatase activity is an indicator for understanding the degree of liver damage. Under normal conditions, it can be excreted through the bile duct, but when severe liver lesions occur, its excretion is blocked and synthesis decreases, causing serum alkaline phosphatase activity to decline rapidly.

The present study showed that when dietary ME level was 12.86 MJ/kg, serum alkaline phosphatase activity was extremely significantly higher than in other groups, indicating that excessively high dietary ME level may cause liver damage in geese. Aspartate aminotransferase is the most sensitive indicator for liver function measurement. It is an enzyme synthesized in hepatocytes and involved in metabolism within hepatocytes. When hepatocytes are damaged, cell membrane permeability increases, releasing the enzyme into the blood and increasing its activity in serum. Guan et al. [23] reported that serum aspartate aminotransferase activity in roosters increased with increasing dietary ME level initially, but began to decrease when dietary ME reached a certain level, consistent with the results of the present study.

4.3 Dietary ME Requirement for Brooding Meat Geese

Regression analysis showed that both average daily feed intake and feed-to-gain ratio had extremely significant linear relationships with dietary ME level. Using the linear equations, when feed-to-gain ratio was low and average daily gain was highest, dietary ME level was 12.22 MJ/kg; when both feed-to-gain ratio and average daily gain were highest, dietary ME level was 9.87 MJ/kg. Therefore, geese have a strong ability to regulate feed intake according to dietary ME level to maintain relatively high growth rates. In actual production, appropriate dietary ME levels can be adopted based on objective conditions such as production level and scale. Under conditions with abundant supply of green forage and roughage, lower dietary ME levels can be used to promote meat goose growth rate through increased feed intake. In this case, the recommended dietary ME level for meat geese is 9.87 MJ/kg, consistent with Yang [6] who reported a dietary ME requirement of 9.95 MJ/kg for Sichuan white geese aged 1–4 weeks, and Wang et al. [24] who recommended an appropriate dietary ME level of 10.0–10.5 MJ/kg for 1- to 4-week-old meat geese. When using low feed-to-gain ratio and high average daily gain as evaluation indicators, the recommended dietary ME level is 12.22 MJ/kg, which is consistent with recommendations by Fu et al. [25] (12.20 MJ/kg), Wang et al. [26] (12.12 MJ/kg), Zhang et al. [27] (12.12 MJ/kg), and NRC (1994) [9] (12.13 MJ/kg). Additionally, the present study results showed that lower dietary ME levels resulted in lower meat goose production costs, with optimal economic benefits achieved at a dietary ME level of 10.75 MJ/kg. Zhang et al. [28] reported that the dietary ME level for Taihu geese during the brooding period was 10.50 MJ/kg. Thus, the large variation in dietary ME levels reported in previous studies may be related to the specific conditions and evaluation criteria used, as different measurement indicators can lead to substantial differences in recommended dietary ME levels.

Through regression analysis, when dietary CP level is 20%, using low feed-to-gain ratio and high average daily gain as evaluation indicators, the recommended dietary ME level for 1- to 3-week-old Sichuan white geese is 12.22 MJ/kg; using high average daily gain and low feed cost as evaluation indicators, the recommended dietary ME level is 10.75 MJ/kg.

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