Evaluation of Metabolizable Energy of Spray-dried Corn Bran for Meat-type Ducks: Postprint

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Abstract

This study aimed to evaluate the metabolizable energy of spray-dried corn gluten feed in Cherry Valley meat ducks and establish prediction equations for its metabolizable energy based on chemical composition. Sixty 56-day-old Cherry Valley meat drakes weighing (3.3±0.3) kg were randomly allocated into 6 groups with 10 replicates per group and one duck per replicate, with one group designated as the endogenous group. The true metabolizable energy (TME) assay method was employed: a single ingredient was force-fed at 2% of body weight following a 48-h fasting and emptying period, and excreta were collected using collection bags for 48 h post-feeding. The results demonstrated considerable variation in crude fat and crude fiber contents among the nutritional components of spray-dried corn gluten feed; according to the international feed classification system, some samples were categorized as energy feeds while others as protein feeds. The apparent metabolizable energy (AME), nitrogen-corrected apparent metabolizable energy (AMEn), TME, and nitrogen-corrected true metabolizable energy (TMEn) of spray-dried corn gluten feed were (6.36±1.61), (6.58±1.57), (7.84±1.54), and (7.29±1.50) MJ/kg, respectively, exhibiting large variation. The optimal prediction equation for TMEn was: TMEn=-0.219 NDF+16.940 (R2=0.881 4, P=0.0017). It can be concluded that significant differences existed in AME, TME, AMEn, and TMEn among different batches of spray-dried corn gluten feed in Cherry Valley meat ducks; the prediction equation for TMEn established using chemical composition exhibited a large coefficient of determination (R2), indicating strong reliability and reference value.

Full Text

Evaluation of Metabolizable Energy of Corn Gluten Feed with Solubles in Meat Ducks

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Abstract

This study was conducted to evaluate the metabolizable energy of corn gluten feed with solubles in Cherry Valley meat ducks and to establish prediction equations for its metabolizable energy based on chemical composition. Sixty 56-day-old Cherry Valley meat drakes with a body weight of (3.3±0.3) kg were randomly allocated to 6 groups, with 10 replicates per group and 1 duck per replicate; one group served as the endogenous group. The true metabolizable energy (TME) method was employed, wherein ducks were force-fed a single ingredient at 2% of body weight after a 48-hour fasting period, and excreta were collected for 48 hours post-feeding using collection bags. The results demonstrated substantial variation in the crude fat and crude fiber contents of corn gluten feed with solubles. According to the international feed classification system, some samples qualified as energy feeds while others were classified as protein feeds. The apparent metabolizable energy (AME), nitrogen-corrected apparent metabolizable energy (AMEn), TME, and nitrogen-corrected true metabolizable energy (TMEn) of corn gluten feed with solubles were (6.36±1.61), (6.58±1.57), (7.84±1.54), and (7.29±1.50) MJ/kg, respectively, showing considerable variation. The optimal prediction equation for TMEn was: TMEn = -0.219 NDF + 16.940 ($R^2 = 0.8814$, $P = 0.0017$). These findings indicate significant variation in AME, TME, AMEn, and TMEn values across different batches of corn gluten feed with solubles for Cherry Valley meat ducks. The high coefficient of determination (R^2) for the TMEn prediction equation suggests strong reliability and practical reference value.

Keywords: corn gluten feed with solubles; meat ducks; metabolizable energy; prediction equation

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Introduction

China is a major corn producer and consumer. With the development of the feed industry and expansion of corn processing, domestic demand for corn continues to grow. Corn deep processing generates approximately 30% by-products, such as corn gluten feed with solubles, corn germ meal, and dried distillers grains with solubles, depending on the processing technology. During corn wet milling, corn bran, germ, soluble protein, and starch are separated to produce corn starch. Corn gluten feed with solubles is obtained by spraying corn steep liquor onto corn bran and drying the mixture. Consequently, its quality and nutritional composition are largely influenced by the proportion of corn steep liquor added, as well as drying methods, temperature, and duration.

Currently, the *Chinese Feed Composition and Nutritional Value Table* (25th Edition, 2014) does not provide nutritional data for corn gluten feed with solubles. Previous analyses by Wang Wei, Dian Jiaojiao, and Lin Qian revealed large variations in the conventional chemical composition of different batches, with coefficients of variation (CV) for ether extract (EE), crude fiber (CF), and crude ash reaching 73.3%, 25.3%, and 28.2%, respectively. Metabolizable energy evaluations showed AME values of 7.54 and 8.26 MJ/kg in roosters and laying hens, respectively. However, no studies have evaluated the metabolizable energy of corn gluten feed with solubles in meat ducks. Therefore, this experiment selected 12 types of corn gluten feed with solubles from various regions of China to evaluate their metabolizable energy in meat ducks and establish chemical composition-based prediction equations, providing technical support for precise and efficient utilization of this ingredient in duck diets.

Materials and Methods

1.1 Experimental Materials

Twelve samples of corn gluten feed with solubles were collected from Shaanxi, Hebei, Shandong, Northeast China, and Sichuan. Using the quartering method, 1 kg of each sample was taken for conventional chemical component analysis, while the remainder was ground through a 1 mm sieve for force-feeding.

1.2 Experimental Methods

The TME evaluation method of Sibbald was adopted. Ducks were force-fed a single ingredient at 2% of body weight after a 48-hour fasting period, and excreta were collected for 48 hours post-feeding using collection bags.

1.3 Experimental Animals and Management

Sixty 56-day-old Cherry Valley meat drakes with an average body weight of (3.3±0.3) kg were randomly divided into 6 groups (10 replicates per group, 1 duck per replicate) based on similar body weight ($P > 0.05$). One group served as the endogenous group, while the remaining 5 groups were used for metabolizable energy evaluation of corn gluten feed with solubles across 3 batches of metabolic trials. The experiment was conducted in the metabolism chamber of the teaching and research base at the Institute of Animal Nutrition, Sichuan

Agricultural University. Ducks were housed individually in cages with ad libitum access to water and 24-hour lighting.

1.4 Measurements and Methods

Corn gluten feed with solubles were analyzed for gross energy (GE, using a PARR bomb calorimeter) and contents of dry matter (DM, GB/T 6435-2006), crude protein (CP, GB/T 6432-1994), CF (AOAC 962.09), EE (AOAC 920.39), ash (GB/T 6438-2007), neutral detergent fiber (NDF, GB/T 20806-2006), and acid detergent fiber (ADF, NY/T 1459-2007).

Excreta were analyzed for GE, DM, and CP using the same methods as for feed ingredients. Calculations of AME, AMEn, TME, and TMEn for corn gluten feed with solubles followed the methods described by Guo Yuming.

1.5 Statistical Methods

SAS 9.1.3 was used for correlation analysis between chemical composition and metabolizable energy. Stepwise regression was employed to establish prediction equations, with coefficient of determination (R^2) and P-value as evaluation parameters. $P < 0.05$ indicated significant difference, and $P < 0.01$ indicated highly significant difference.

Results

2.1 Chemical Composition of Corn Gluten Feed with Solubles

As shown in Table 1 , the nutritional composition of corn gluten feed with solubles was: DM 91.1% (range 89.8%-92.4%, CV 1.0%), CP 20.8% (range 17.0%-25.1%, CV 11.0%), ash 5.6% (range 4.0%-7.5%, CV 19.3%), CF 11.0% (range 6.1%-14.1%, CV 21.5%), EE 2.1% (range 1.2%-3.1%, CV 24.9%), ADF 12.4% (range 9.2%-15.7%, CV 14.5%), NDF 46.6% (range 33.5%-59.9%, CV 15.5%), and GE 17.02 MJ/kg (range 16.48-17.78 MJ/kg, CV 2.30%). EE showed the greatest variation (CV = 24.9%) with a low average content of 2.1%, while CF also exhibited substantial variation (CV = 21.5%) with a high average content of 11.0%. According to the international feed classification system, samples No. 4 and No. 10 were classified as energy feeds, while the remaining samples were protein feeds.

2.2 Metabolizable Energy of Corn Gluten Feed with Solubles

Due to vomiting or incomplete fecal collection during metabolic trials, the number of samples evaluated was less than the total collected. As shown in Table 2 , the evaluated 7 samples of corn gluten feed with solubles had mean AME, AMEn, TME, and TMEn values of 6.36 (range 3.82-8.48 MJ/kg), 6.58 (range 4.1-8.55 MJ/kg), 7.84 (range 5.38-9.89 MJ/kg), and 7.29 MJ/kg (range 4.91-9.19 MJ/kg), respectively. Metabolizable energy varied considerably among the 7 samples from different sources, with a CV of 25.4% for AME.

2.3 Correlation Analysis and Establishment of Prediction Equations

As shown in Table 3 , AME, AMEn, TME, and TMEn of corn gluten feed with solubles were significantly or highly significantly negatively correlated with NDF, CF, and ADF contents ($P < 0.05$ or $P < 0.01$). CF content was significantly or highly significantly positively correlated with ADF and NDF contents ($P < 0.05$ or $P < 0.01$), and ADF content was significantly positively correlated with NDF content ($P < 0.05$).

As shown in Table 4 , prediction equations for metabolizable energy were established with NDF as the primary factor. The reliability of equations improved to varying degrees when CP, EE, and ash were incorporated. The optimal ternary prediction equation for AME was: AME = -0.230 NDF + 0.191 CP + 0.980 EE + 8.835 ($R^2 = 0.9812$, $P = 0.0044$). For AMEn: AMEn = -0.214 NDF + 0.188 CP + 0.924 EE + 9.989 ($R^2 = 0.9778$, $P = 0.0056$). For TME: TME = -0.204 NDF + 0.203 CP + 1.000 EE + 10.327 ($R^2 = 0.9781$, $P = 0.0054$). The optimal unary prediction equation for TMEn was: TMEn = -0.219 NDF + 16.940 ($R^2 = 0.8814$, $P = 0.0017$).

Discussion

The average CP and CF contents of corn gluten feed with solubles in this study were 20.8% and 11.0%, respectively, classifying some samples as energy feeds and others as protein feeds according to the international feed classification system. The spraying process substantially improves the nutritional value of corn bran, with notable differences between sprayed and non-sprayed products. Wang Wei reported CP contents of 11.6% and 18.4% for non-sprayed and sprayed corn bran, respectively. Dian Jiaojiao measured CP content of 17%-18% and CF content of 7.1% in sprayed corn bran. Lin Qian reported CP contents of 19.90% and 17.71% and CF contents of 11.73% and 11.21% in two types of sprayed corn bran. These values are similar to our findings, though Anderson et al. reported a CP content of 15.7%. These results indicate that sprayed corn bran has higher CP content than non-sprayed corn bran, with substantial variation among different sources, likely due to differences in processing technology and the ratio of corn bran to corn steep liquor.

The evaluated AME, AMEn, TME, and TMEn values for meat ducks were 6.36, 6.58, 7.83, and 7.29 MJ/kg, respectively, which are lower than the AME of soybean meal in adult roosters (10.58 MJ/kg). Zhang Shiyuan et al. reported an AME value of 2.32 MJ/kg for corn bran in hens, substantially lower than that of sprayed corn bran, demonstrating that the spraying process increases both CP content and AME, as corn steep liquor is rich in protein. Wang Wei reported AME values of 8.26 and 7.55 MJ/kg for sprayed corn bran in roosters and laying hens, respectively. Wang Zhaoqun measured an AME of 8.12 MJ/kg, higher than our values, while Wang Hongyu reported AME and AMEn values of 5.40 and 5.04 MJ/kg in laying hens, lower than our findings. These substantial differences confirm that different poultry species exhibit varying digestive efficiency for the same feed ingredients due to physiological differences, and that a single feed ingredient database cannot be applied across species. They also confirm significant quality variation among different sources and batches of corn gluten feed with solubles, necessitating the establishment of prediction equations based on correlations between conventional chemical composition and metabolizable energy.

Our results demonstrate that metabolizable energy is highly significantly negatively correlated with NDF content, with the optimal TMEn prediction equation being: TMEn = -0.219 NDF + 16.940 (R^2 = 0.8814, P = 0.0017). Zhang Shuangjie et al. established a TME prediction equation for unconventional goose feeds: TME = 12.21 - 0.23 CF (R^2 = 0.82), indicating that CF affects energy utilization efficiency and utilization of other nutrients. Wan et al. developed a duck TME prediction equation for wheat milling by-products: TME = -0.17 NDF + 0.98 EE - 0.27 CP + 19.31 (R^2 = 0.99), where NDF was the optimal predictor and was significantly negatively correlated with TME, while EE inclusion as an important energy source improved equation accuracy. Song Daijun et al. established a TME prediction equation for fiber feeds in Tianfu meat ducks: TME = 10.37 + 0.22 NDF - 1.02 GE - 1.58 Ash (R^2 = 0.99), finding that fiber components were highly significantly negatively correlated with metabolizable energy, with NDF as the primary factor yielding the most accurate predictions. These studies support our selection of NDF as the predictor, and the R^2 and P-values of our regression equation demonstrate its reliability and practical reference value.

Conclusions

1. The ether extract content showed the greatest variation in the chemical composition of corn gluten feed with solubles, followed by crude fiber and crude protein. Some samples were classified as energy feeds, while others were protein feeds.

2. The average AME, AMEn, TME, and TMEn values of corn gluten feed with solubles in meat ducks were 6.36, 6.58, 7.84, and 7.29 MJ/kg, respectively.

3. The optimal prediction equation for TMEn was: TMEn = -0.219 NDF + 16.940 (R^2 = 0.8814, P = 0.0017).

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