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The Nutritive Value of Guar Meal and its Effect on Growth Performance of Meat Ducks

Peng Peng[1,3], Xiaopeng Tang[2]*, Dun Deng[3] and Rejun Fang[1]*

[1]*Hunan Co-Innovation Center of Animal Production Safety, College of Animal Science and Technology, Hunan Agricultural University, Changsha, China*
[2]*State Key Laboratory Cultivation for Karst Mountain Ecology Environment of Guizhou Province, School of Karst Science, Guizhou Normal University, Guiyang, China*
[3]*Tangrenshen Group, Zhuzhou, China*

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PP designed and performed the experiments. PP and XT wrote the paper. DD and RF revised the paper.

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Chemical composition, DM digestibility, Growth performance, Guar meal, Metabolism energy

ABSTRACT

The aim of this study was to study the effects of different levels of guar meal (GM) on growth performance of meat ducks, to explore the possibility of GM as an alternative protein resource in meat duck diets. Firstly, the chemical composition, dry matter (DM) digestibility, metabolic energy (ME) were determined. Secondly, a total of four hundred eighty 15-day-old Shuanggui-tou meat ducks were divided into 4 treatments, 1) Control group (0% GM in the diet), 2) 3% GM group (3% GM in the diet), 3) 6% GM group (6% GM in the diet), and 4) 9% GM group (9% GM in the diet). All groups had 8 replicates and 15 birds were included in each replicate. The experiment lasted for 28 days. The average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR) were measured. Results showed that: (1) the DM, CP, EE, CF, Ash, Ca, Pi, GE content of GM is 89.96%, 47.80%, 4.92%, 6.43%, 4.49%, 0.3%, 0.63%, 4.66 Mcal/Kg, respectively, the composition of Met, Lys, Ile, Asp, Glu, Gly, His, Arg, Thr, Ala, Pro, Tyr, Val, Phe in GM is 0.499%, 2.023%, 1.485%, 2.795%, 4.834%, 11.543%, 2.626%, 1.315%, 6.128%, 1.491%, 1.905%, 1.750%, 1.498%, 1.680%, 2.184%, respectively. (2) The DMD and TDDM of GM is 47.13% and 58.31%, respectively. The AME, TME of GM is 2.71 Mcal/Kg and 3.03 Mcal/Kg, respectively. (3) Add GM to the duck diets significant affect the final weight (P<0.05), ADG (P<0.05), FCR (P<0.01), but had no effect on ADFI of ducks (P>0.05). Our results suggest that the GM would be a high quality protein resource in diets for meat ducks.

INTRODUCTION

Soybean meal (SBM) is widely used in poultry production. However, the SBM production in China is seriously deficient, and mainly relies on imports. It is of great significance for the development of Chinese poultry industry to seek soybean meal alternatives. The guar bean (*Cyamopsis tetragonoloba*) is an annual legume belonging to the Fabaceae family, which native to Africa, and now mainly produced in India and Pakistan (Pach and Nagel, 2018). Guar meal (GM) is a byproduct from guar gum industry, obtained after mechanical separation of endosperm from both germ and hull of guar seed (Janampet *et al*., 2016; Reddy *et al*., 2017). GM contains approximately 30-60 % protein on dry matter basis (Nidhina and Muthukumar, 2015; Janampet *et al*., 2016; Reddy *et al*., 2017; Pach and Nagel, 2018) and its amino acid (AA) composition quite similar to that of ground nut cake (Verma and McNab, 1984). It seems that GM is a desirable and viable protein source for animal feed formulators, especially when the rocketing prices of feed raw material.

In 1974, China had already introduced guar bean from Pakistan for trial promotion, and had been tried in Hunan, Guangdong, Sichuan, Hubei province and other places in China (Zhang, 1980). But, at present, due to the low production of guar bean, there are few researches and applications of GM in China. Due to its high protein content and relatively low price, GM presents itself as a viable alternative to SBM to be used as a protein supplement in poultry diets (Rao *et al*., 2015; Reddy *et al*., 2017). However, previous studies about GM used in poultry diets mainly focus on broilers and laying hens (Gutierrez *et al*., 2007; Ehsani and Torki, 2010; Rao *et al*., 2014; Tyagi *et al*., 2014; Salma *et al*., 2015; Rao *et al*., 2015; El-Masry *et al*., 2017), the researches about GM used in meat duck diets is rarely. So the aim of this study was to investigate the dry matter digestibility and metabolic energy of GM, and also to determine suitable level of GM in meat duck diets.

* Corresponding author: tangxiaopeng110@126.com; fangrj63@126.com
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MATERIALS AND METHODS

Chemical composition of GM

GM used in this study was imported from Pakistan. Dry matter (DM), crude protein (CP), crude fat (EE), crude fiber (CF), Ash, Calcium (Ca) and Phosphorus (Pi) content of GM were determined according to the AOCS (2009) method. Amino acids (AA) profile of GM was analyzed using an automatic AA analyzer (L-8800; Hitachi, Tokyo, Japan). Gross Energy (GE) was measured by oxygen bomb calorimeter parr 1281 (Parr Instrument Company, IL, USA) according to ISO 9831 (1998) method.

DM digestibility and metabolic energy determination

The experimental procedures were reviewed and approved by the Institutional Animal Care and Use Committee at the Hunan Agricultural University (Changsha, Hunan Province, China). DM digestibility and metabolic energy were measured by Emptying-force-feeding method (Sibbald, 1976). A total of 16 Shuanggui-tou meat ducks (Peking duck × hemp duck F1) with similar weight (2.20±0.15 kg) were divided into 2 treatments: (1) The starvation group and (2) GM group. Each treatment had 8 replicates. The starvation group was used to estimate metabolic and endogenous excretion (da Silva *et al*., 2012). The experiment procedure performed as previously described (Tang *et al*., 2018). Briefly, after a period of fast for 48 h, birds were fed 50 g GM. The birds in starvation group were kept under the same experimental conditions, at fasting, receiving only water for determination of the metabolic and endogenous losses (da Silva *et al*., 2012). The excreta were collected for 48 h. The excreta samples were dried at 65°C for 48 h, and milled for DM and energy analysis. DM was determined according to the AOCS (2009) method. Energy was measured by oxygen bomb calorimeter parr 1281 (Parr Instrument Company, IL, USA) according to ISO 9831 (1998). DM digestibility (DMD), true DM digestibility (TDMD), apparent metabolizable energy (AME), true metabolizable energy (TME) values were calculated according to the following formulae (Tang *et al*., 2018):

$$\text{DMD}\ (\%) = \frac{\text{DM input} - \text{DM output}}{\text{DM input}} \times 100$$

$$\text{TDMD}\ (\%) = \frac{\text{DM input} - (\text{DM output} - \text{endogenous DM loss})}{\text{DM input}} \times 100$$

$$\text{AME} = \frac{\text{ingested energy} - \text{fecal energy}}{\text{ingested energy}}$$

$$\text{TME} = \frac{\text{ingested energy} - (\text{fecal energy} - \text{endogenous energy loss})}{\text{ingested energy}}$$

Effect of GM levels on the performance of meat ducks

A total of four hundred eighty 15-day-old Shuanggui-tou meat ducks were divided into 4 groups, 1) Control group with 0% GM in the diet, (2) 3% GM group, (3) 6% GM group and (4) 9% GM group (9% GM in the diet). Each treatment had 8 replicates, and each replicate had 15 ducks. The composition and nutrition level of the diets is shown in Table I. All diets were formulated to meet nutrient requirements of meat-type duck (NY/T 2122-2012). The ducks were housed in an environmentally controlled room with a 24-h constant light schedule and *ad libitum* access to water and feed. Ducks were weighed and feed consumption was recorded weekly. Average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR) was calculated (FCR = ADFI / ADG). The experiment lasted for 28 days.

Table I. Diet composition and nutrient levels (on fed basis, %).

Ingredients	Control	3% GM	6% GM	9% GM
Wheat	77.00	76.50	75.60	75.40
Cottonseed meal	6.00	3.00	0.00	0.00
Guar meal	0.00	3.00	6.00	9.00
Oil bran	5.00	5.00	5.00	8.00
Corn protein	7.50	7.50	7.50	1.00
Zeolite powder	1.80	2.28	3.14	3.89
Limestone	0.60	0.57	0.53	0.50
$CaHPO_4$	0.50	0.55	0.62	0.68
Bone meal	0.50	0.50	0.50	0.50
Mildew preventive	0.05	0.05	0.05	0.05
Lysine	0.70	0.70	0.70	0.61
Methionine	0.00	0.00	0.01	0.02
NaCl	0.35	0.35	0.35	0.35
Premix[1]	1.00	1.00	1.00	1.00
Enzyme complex	0.03	0.03	0.03	0.03
Nutrient levels[2]				
ME (Mcal/Kg)	2.81	2.81	2.81	2.81
CP	16.10	16.12	16.09	16.19
Lys	0.79	0.79	0.79	0.79
Met	0.31	0.31	0.31	0.31
Met+Cys	0.58	0.56	0.55	0.54
Ca	0.92	0.92	0.92	0.92
Available Pi	0.26	0.26	0.26	0.26

[1]The premix provided following per kilogram of diet: Cu 20 mg, Fe 90 mg, Mn 70 mg, Zn 60 mg, I 0.38 mg, Se 0.20 mg, VA 3000 IU, VE 10 mg, VD3 500 IU, VK 0.5 mg, VB1 2 mg, VB2 5 mg, VB6 4 mg, nicotinic acid 20 mg, VB12 12 μg, D-pantothenic acid 15 mg, folic acid 550 μg. [2]nutrient levels were calculated values.

Statistical analysis

Results of chemical composition, DM digestibility, true DM digestibility, AME, TME of GM were expressed as mean. Results of growth performance were analyzed by one-way ANOVA using the SPSS 21.0 programs (SPSS, Inc., Chicago, IL, USA). Differences among treatment mean were determined using Duncan's multiple comparison test, $P < 0.05$ was considered significant, and $P < 0.01$ was considered extremely significant.

RESULTS AND DISCUSSION

Chemical composition of GM

The chemical composition of GM is shown in Table II. The nutritional profiles of GM vary widely according to different studies. Rao *et al*. (2014) reported that the CP content of GM was 48.6%, which is similar to the present study, but EE (6.39%), CF (11.97%), Ca (1.62%) and Pi (0.70%) was higher than the present study. The DM content in our study is similar to the results of Salma *et al*. (2015) (89.96% vs 89.49%), but CP (47.80% vs 50.09%), EE (4.92% vs 7.07%), CF (6.42% vs7.66%), Ash (4.49% vs7.88%) is lower and GE (4.66 Mcal/Kg vs 4.04 Mcal/Kg) is higher than that of Salma *et al*. (2015). Pach and Nagel (2018) reported that the DM, CP, EE, CF, Ash, Ca, Pi, GE content of GM is 93.8%, 59.5%, 9.06%, 5.33%, 6.08%, 0.2%, 0.74%, 21.1 Mcal/Kg, respectively. Compared to Pach and Nagel (2018), DM, CP, EE, Ash, Pi, GE content of GM in the present study is lower, and CF, Ca content is higher. The variations in proximate composition may be due to varieties, producing areas, and various processing techniques. It is important to analyze the proximate composition of GM before it is used in animal feed.

Table II. Chemical composition of guar meal (dry matter basis, %).

Item	Content
Dry matter, DM	89.94
Crude protein, CP	47.80
Ash	4.49
Crude fiber, CF	6.43
Crude fat, EE	4.92
Calcium, Ca	0.30
Phosphorus, Pi	0.63
Gross energy, GE (Mcal/Kg)	4.66

The composition of AA in GM is presented in Table III. GM is a good source of protein with an amino acid composition quite similar to that of ground nut cake (Verma and McNab, 1984). In this study, the Cys and Try were not detected. The composition of essential amino acids (EAA) Lys, Met, Thr, His, Leu, Ile, Phe, Val, Arg for poultry in SBM was 3.31%, 0.76%, 2.20%,1.48%, 4.25%, 2.55%, 2.77%, 2.63%, 3.92%, respectively (Pach and Nagel, 2018). It seemed that almost all EAA in GM is lower than SBM, except Arg, which is in accordance with Reddy *et al*. (2017) and Pach and Nagel (2018). However, Salma *et al*. (2015) reported that the Lys content in GM is higher than SBM, and Ile content in GM and SBM was equal. So, it is important to analyze the AA composition before using GM in poultry production, and additional AA may be added when necessary to make sure AA nutritional requirement for poultry.

Table III. The composition of amino acids in guar meal (%).

Item	Content	Item	Content
Lysine, Lys	2.023	Threonine, Thr	1.491
Methionine, Met	0.499	Alanine, Ala	1.905
Isoleucine, Ile	1.485	Proline, Pro	1.75
Leucine, Leu	2.795	Cystine, Cys	nd
Aspartic acid, Asp	4.834	Tyrosine, Tyr	1.498
Glutamate, Glu	11.543	Valine, Val	1.68
Glycine, Gly	2.626	Phenylalanine, Phe	2.184
Histidine, His	1.315	Tryptophane, Try	nd
Arginine, Arg	6.128	Total	43.76

nd: not detected.

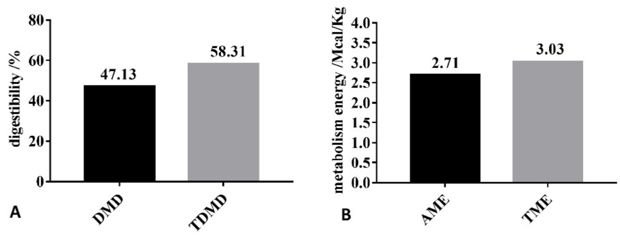

Fig. 1. Dry matter (DM) digestibility, true DM digestibility, apparent metabolizable energy and true metabolizable energy of GM for meat duck. A, Dry matter digestibility of GM; B, metabolic energy of GM. DMD, dry matter digestibility; TDMD, true dry matter digestibility digestibility; AME, apparent metabolizable energy; TME, true metabolizable energy.

Table IV. Effects of guar meal levels on the performance of meat ducks (g, g/d).

Item	Control	3% GM	6% GM	9% GM	P-value
Initial weight	493.4±3.9	493.6±3.7	493.9±3.1	494.1±2.7	0.984
Final weight	1644.5±21.8^{a}	1609.3±28.1^{b}	1662.2±44.4^{a}	1663.2±33.3^{a}	0.014
ADFI	131.4±3.4	129.8±4.0	132.0±3.9	132.7±4.4	0.513
ADG	41.1±0.8^{ab}	39.9±1.0^{b}	41.7±1.6^{a}	41.8±1.2^{a}	0.017
FCR	3.20±0.05^{B}	3.28±0.05^{A}	3.16±0.07^{B}	3.18±0.05^{AB}	0.003

ADFI, average daily feed intake; ADG, Average daily gain; FCR, feed conversion ratio; ^{a,b,c,} Means within rows with different letters differ significantly (P < 0.05); A,B means within rows with different letters differ extremely significantly (P < 0.01).

DM digestibility and metabolic energy of GM

The DMD, TDMD, AME, TME of GM are shown in Figure 1. In this study, the DMD and TDMD of GM is 47.13% and 58.31%, respectively. The AME, TME of GM is 2.71 Mcal/Kg and 3.03 Mcal/Kg, respectively. Nagpal *et al.* (1971) determined the ME value of GM for chicken as 2.01 Mcal/Kg, and Nadeem *et al.* (2005) reported that the ME value of GM for chicken was 2.311 Mcal/Kg. The above ME values are lower than the present study. Basically, the nutrition digestibility of chicken and duck is not the same. In general the digestibility of duck is higher than that of chicken (Tian *et al*., 2017). This is related to the digestive physiological characteristics of ducks. The pH value in the digestive tract of ducks is appropriate, which is advantageous to the digestive enzyme. At the same time, the capacity and weight of the digestive organs of duck is larger than that of chicken, which is conducive to the rapid digestion and absorption of the digested components (Fan *et al*., 2006).

Growth performance

Table IV shows the growth performance of ducks The duck diets supplemented with GM have significant affect on the final weight (P<0.05), ADG (P<0.05), FCR (P<0.01), but had no effect on ADFI of ducks. Compared to control group (0% GM), the final weight of 3% GM group decreased significantly (P<0.05) whereas the FCR of 3% GM group increased significantly (P<0.01). The growth performance of 6% and 9% GM group were similar to the control group. There have been many reports about the application of GM in broilers and laying hens, which reported that a certain level of GM would not affect the growth performance of broilers chickens and egg production performance of laying hens (Ehsani and Torki, 2010; Gheisari *et al*., 2011; Rao *et al*., 2014; Tyagi *et al*., 2014; Salma *et al*., 2015; Rao *et al*., 2015; El-Masry *et al*., 2017). There are a few studies on GM administered to duck diets. Because the digestive characteristics of duck are different from chicken, the results obtained from chicken experiment cannot be fully used for duck. For example, Hassan *et al*. (2013) and Salma *et al*. (2015) reported that when fed ≥5% GM in broilers the FI was reduced, which is not consistent with the result of this study. According to the present study, GM used upto 9% in ducks did not affect the ADG, ADFI and FCR. It would be a high quality protein source in duck feed.

CONCLUSION

In conclusion, GM is a good source of protein with the CP content as high as 47.80%. The AA in GM is reasonable, especially rich in Arg with 6.128% content. DMD and TDDM of GM is 47.13% and 58.31%, respectively. The AME, TME of GM is 2.71 Mcal/Kg and 3.03 Mcal/Kg, respectively. GM used up to 9% in ducks without affecting the ADG, ADFI and FCR. Our results suggest that the GM would be a high quality protein source in diets for meat ducks.

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Statement of conflict of interest

The authors have declared no conflict of interest.

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