Comparison of true metabolisable energy and true amino acid availability between normal maize and quality protein maize (Shandan 17)

Shao Wei Zhai¹, Mei Li Zhang²

¹ Fisheries College of Jimei University. Xiamen, Fujian Province, China
² College of Animal Science. Yangtze University, Hubei Province, China

ABSTRACT

A precision-fed assay was conducted to determine true metabolisable energy and true amino acid digestibility in Chinese quality protein maize (QPM) compared with normal maize (NM). Thirty adult roosters, kept in individual cages, were made to fast for 48h and then tub-fed 50g QPM or NM per bird and their excreta was collected for the subsequent 48h. Additional fifteen roosters were made to fast in order to estimate endogenous losses of energy and amino acids (AA) in excreta. Gross energy of the two types of maize were similar; the lysine content in NM and QPM were 0.27% and 0.41% (DM basis), respectively. True metabolisable energy (TME) and true metabolisable energy nitrogen corrected (TMEn) values of QPM and NM were not significantly different (P>0.05). Digestibility of some AA, including lysine and methionine, in QPM were higher than those in NM (P<0.05). The results of this study indicated that the nutritive value of QPM might be higher than that of NM.

Key words: Amino acid digestibility, Normal maize, Quality protein maize, Roosters, True metabolisable energy.

RIASSUNTO

CONFRONTO TRA ENERGIA METABOLIZZABILE VERA E DISPONIBILITÀ AMINOACIDICA VERA IN MAIS NORMALE E IN MAIS DI ELEVATA QUALITÀ PROTEICA (SHANDAN 17)

La presente prova di alimentazione è stata condotta al fine di determinare l’energia metabolizzabile vera e la disponibilità aminoacidica vera in mais cinese ad elevata qualità proteica (QPM) confrontato al mais normale (NM).

Tranta galli adulti, allevati in gabbia individuale, dopo 48 ore di digiuno sono stati alimentati con 50g/capo di QPM o NM, sono state poi raccolte le escreta per le 48 ore successive. Ulteriori quindici galli sono stati tenuti a digiuno per stimare le perdite endogene di energia e di aminoacidi nelle deiezioni. L’energia lorda dei due mais era simile, il contenuto di lisina in NM e in QPM era di 0,27% e 0,41% (SS) rispettivamente.

In QPM e NM i valori di energia metabolizzabile vera (TME) e di energia metabolizzabile vera corretta per l’azoto (TMEn) non erano significativamente diversi (P>0,05).

Corresponding author: Dr. ShaoWei Zhai. Department of Animal Nutrition and Feed Science. Fisheries College of Jimei University. Yindou Road 43, Xiamen, Fujian Province, 361021, P.R. China - Tel. +86 592 6183667 – Fax: +86 592 6181476 - Email: zhaisw@jmu.edu.cn

Paper received November 10, 2006; accepted April 12, 2007
Introduction

Lysine is the primary essential amino acid in normal maize (NM), while lysine content in NM is very low. Breeding of maize for high lysine content was initiated by Mertz et al. (1964). Due to disadvantages in agronomic characteristics, the application of the previous maize containing high lysine content was restricted. Quality protein maize (QPM) is developed by conventional breeding methods that have improved those agronomic shortcomings and amino acid (AA) content in recent years. Compared with NM, the nutritive advantage of high lysine content maize has been shown in broilers (Drews et al., 1969; Cambel and Magsalin, 1990; Shbusuban et al., 1990) and layers (Osei et al., 1999). While those studies mainly focused on the production responses of poultry fed rations containing high lysine maize, little information about the energy and essential amino acid (EAA) availability in QPM was available, which limits the further application of QPM in poultry rations. The objective of the present study was to determine the true metabolisable energy (TME) and true AA availability of QPM and compare the differences between NM and QPM.

Material and methods

Materials and chemical analyses
QPM (Shandan 17) and NM were obtained from Northwest Sci-Tech University of Agriculture and Forestry Northwest. They were all planted in the Yangling district of China. Samples of NM and QPM were analysed for dry matter, crude protein, ether extract, ash, calcium, phosphorus using Association of Official Analytical Chemists’ approved methods 934.01, 984.13, 973.18, 924.05, 927.02 and 965.17, respectively (AOAC, 1990). According to the procedures of Song et al. (2004), concentrations of AA (except for tryptophan) were determined using ion-exchange chromatography following hydrolysis in 6N HCl for 24h at 110°C. Analysis of methionine and cysteine were conducted using formic acid (9 parts of 88% formic acid plus 1 part 30% hydrogen peroxide) protection prior to acid hydrolysis (6N HCl) for 24h at 110°C. Tryptophan was determined by the alkaline hydrolysis method (Andersen, 1991) with reverse-phase-HPLC (LC 10, Shimadzu, Kyoto, Japan). The gross energy of maize and excreta samples was determined in an automatic adiabatic oxygen bomb calorimeter (PARR 1281, Automatic Energy Analyzer, Moline, IL).

Experimental procedures
All procedures for housing and maintaining the poultry during the experimental period were approved by the Chinese Association of Animal Science and Veterinary Medicine and National Animal Welfare Committee.

The assay was conducted according to the method of Sibbald (1976) with several modifications. Forty-five adult Single Comb White Leghorn roosters (2.15±0.16kg, BW) were used in this study. They were kept in individual cages in a temperature control room (18 to 20°C under a daily light period of 16h and with free access to water).
Treatments (2 types of maize and a fasting treatment) were allocated at random to 45 roosters; there were 15 birds per treatment. Before the start of a collection period, all the birds were made to fast for 48h. For each bird two treatments of 50g of NM or QPM were given via crop intubation. During the subsequent 48h, excreta from three roosters from the same treatment were pooled for later analysis. The extent of replication was, therefore, five replicates per treatment.

The excreta were collected according to the study of Douglas et al. (1997). The collected excreta were stored frozen at -20°C until analysed. The frozen excreta from each bird was dried to a constant weight at 65°C, allowed to reach equilibrium with the atmospheric moisture for a 24h, weighed, and ground to pass through an 80-mesh sieve.

Amino acids and energy content of endogenous faeces were determined from roosters of fasting treatment that were deprived of feed for 48 h following the initial 48h fasting period.

True digestibility of amino acids was calculated according to the method of Sibbald (1976), TME and true metabolisable energy nitrogen corrected (TME$_n$) were calculated by the method of Parsons et al. (1982).

Statistical analyses
All data from the experiment were analysed using a one-way ANOVA (SAS Users Guide, 1999), and the significant effect was assumed at P<0.05.

Results and discussion

Chemical composition of quality protein maize and normal maize

The analysed chemical composition of the maize samples is shown in Table 1. Compared with NM, QPM contained higher concentrations of crude protein, aspartate, lysine, histidine, arginine, proline, cysteine and tryptophan and lower concentrations of tyrosine, leucine, and phenylalanine. The concentrations of other AA were similar.

As was expected, lysine level in QPM was greater than that in NM, in agreement with previous reports (Ladely et al., 1995; Osei et al., 1999). Ninety-six percent of the total kernel protein is located in the germ and endosperm with the endosperm containing 78% of the total kernel protein. Endosperm protein is made up of about 25% glutelin proteins and 60% relatively poor quality zein proteins with a low lysine content compared to glutelins (Wilson, 1987). Contents of glutelin proteins and zein proteins in total kernel of QPM are different from those in NM, with the endosperm containing 50% glutelin proteins and 23% zein proteins (Mertz et al., 1964). Therefore, the QPM might have higher lysine content than NM.

This study showed that concentration of tryptophan in QPM was higher than that in NM, while Drews et al. (1969) reported that the tryptophan level did not increase. Additionally, the arginine level in QPM increased with the increased lysine level, while the leucine level and ratio of leucine:isoleucine in QPM were lower than those in NM, which is similar to results of other studies (Zarkadas et al., 1995; Osei et al., 1999).

Energy and amino acids availability

As illustrated in Table 2, the values of TME and TME$_n$ in QPM were higher than those in NM, but the difference was not significant (P>0.05). Osei et al. (1999), Sullivan et al. (1989), and Zhai (2002) observed that QPM and NM had similar gross energy. Zhai (2002) also found that there were no differences in energy avail-
The study of Sullivan et al. (1989) has shown that digestible energy and energy availability in QPM were similar to those in NM when fed to pigs.

The true AA digestibility in QPM was higher than those in NM for five amino acids, but not significantly different for the other amino acids (Table 2). Of particular commercial importance, two of the five AA that had increased digestibility were lysine and methionine. These results indicated that the digestibility of amino acids in QPM could be at least equal to or greater than those in NM. At present, it seems that there would be no other reports about AA digestibility in QPM. Douglas et al. (2000) have shown that the low phytate and high protein corns had higher amino acids digestibility than that of normal corn when the amino acids balance was improved. Thus, it is possible that the change of some AA concentrations and zein/gluteline ratio in QPM may contribute to higher AA digestibility because of a better AA balance in QPM.

The higher concentrations of some amino acids combined with equal or higher digestibility indicated that QPM might contain more digestible AA than did NM. The latter effect was particularly evident for lysine in QPM, for which both the lysine concentration and digestibility of lysine were higher than those for NM.

### Table 1. Nutrient composition of Normal Maize and Quality Protein Maize.

| Item                  | NM       | QPM      |
|-----------------------|----------|----------|
| Moisture %            | 12.03    | 12.11    |
| Crude Protein % DM    | 9.22     | 10.01    |
| Gross Energy MJ/kg DM | 18.61    | 19.04    |
| Ether Extract % DM    | 3.94     | 4.41     |
| Ash                   | 1.46     | 1.41     |
| Calcium               | 0.07     | 0.07     |
| Phosphorus            | 0.21     | 0.22     |
| Amino acids (% DM):   |          |          |
| Aspartate             | 0.53     | 0.69     |
| Threonine             | 0.28     | 0.30     |
| Serine                | 0.33     | 0.36     |
| Glutamate             | 1.61     | 1.60     |
| Alanine               | 0.62     | 0.61     |
| Valine                | 0.35     | 0.38     |
| Ileucine              | 0.30     | 0.29     |
| Leucine               | 1.00     | 0.87     |
| Tyrosine              | 0.43     | 0.40     |
| Phenylalanine         | 0.41     | 0.35     |
| Lysine                | 0.27     | 0.41     |
| Histidine             | 0.31     | 0.43     |
| Arginine              | 0.36     | 0.46     |
| Cystine               | 0.24     | 0.28     |
| Methionine            | 0.18     | 0.19     |
| Tryptophan            | 0.08     | 0.12     |
| Proline               | 0.66     | 0.86     |
Conclusions

True metabolisable energy and true AA digestibility of QPM are equal or superior to those of NM, which indicated that the nutritive value in QPM might be higher than in NM.

The authors wish to express their appreciation to M. E. He, who provided the quality protein maize samples; to X. N. Zhao for help with amino acids analysis, to M. Xie for his helpful editing comments during the preparation of this manuscript.

This research was supported by Science Foundation of Jimei University, China (No.2Q2006027).

REFERENCES

AOAC, 1990. Official Methods of Analysis. 15th ed. Association of Official Analytical Chemists, Washington, DC, USA.
Andersen, S.B., 1991. Determination of tryptophan with HPLC after alkaline hydrolysis in autoclave using α-methyl-tryptophan as internal standard. Acta Agric. Scand. 41:305–309.
Cambel, I.H., Magsalin, M.P., 1990. Evaluation of yellow corn and quality protein maize in feed rations for broilers. USM College of Agriculture Research Journal (Philippines). 1:40-46.
Drews J.E., Moody, N.W., Hays, V.W., Speer, V.C., Ewan, R.C., 1969. Nutritional value of opaque-2 corn for young chicks and pigs. J. Nutr. 97:537-541.
Douglas, M.W., Johnson, M.J., Parsons, C.M., 1997.
Evaluation of protein of energy quality of rendered spent hen meals. Poult. Sci. 76:1387-1391.

Douglas, M.W., Peter, C.M., Boling, S.D., Parsons, C.M., Baker, D.H., 2000. Nutritional evaluation of low phytate and high protein corns. Poult. Sci. 79:1586–1591.

Ladely, R.A., Klopfenstein, T.J.S., Sindt, M.H., 1995. High-lysine corn as a source of protein and energy for finishing calves. J. Anim. Sci. 73:228-235.

Mertz, E.T., Bates, L.S., Nelson, O.E., 1964. Mutant gene that changes protein composition and increases lysine content of maize endosperm. Science 145:279-280.

Osei S.A., Dei, H.K., Tuah, A.K., 1999. Evaluation of quality protein maize as a feed ingredient for layer pullet. J. Anim. Feed Sci. 8:181-189.

Parsons, C.M., Potter, L.M., Bliss, B.A., 1982. True metabolizable energy corrected to nitrogen equilibrium. Poult. Sci. 61:2241-2246.

SAS, 1999. SAS User's Guide: Statistics, version 8. Institute Inc., Cary, NC, USA.

Sbusuban, C.P., Olanday, P.O., Cambel, I.H., 1990. Advantages of quality protein maize (QPM) in broiler ration. USM Research and Development Journal 1:5-17.

Sibbald, I.R, 1976. A bioassay for available amino acid and true metabolisable energy in feedstuffs. Poult. Sci. 55:303-308.

Song, G.L., Li, D.F., Piao, X.S., Chi, F., Chen, Y., Moughans P.J., 2004. True Amino Acid Availability in Chinese High-oil Corn Varieties determined in two types of chickens. Poult. Sci.83:63-688.

Sullivan, J.S., Knabe, D.A., Bockholt, A.J., Gregg, E.I., 1989. Nutritive value of quality protein maize and food corn for starter and grower pigs. J. Anim. Sci. 67:1285-1292.

Wilson, C.M., 1987. Preteins in kernel. In: S.A.Watson and P.E. Ramsread (eds.) Corn Chemistry and Technology. American Association of cereal Chemists, St.Paul, MN, USA, pp 273-277.

Zarkadas, C.G., YU Z.,Hamilton, R.I., Pattison, P.L., Rose, N.G.W., 1995. Comparison between the protein of northern adapted cultivators of common maize and quality protein maize. J. Agric. Food Chem. 43:84-93.

Zhai, S.W., 2002. Nutritional evaluation and application of quality protein maize in layer ration. M. S. Thesis, Northwest Science and Technology University of Agriculture and Forestry, Yangling, Shaanxi, China.