Evaluation on Nutritional Value of Field Crickets as a Poultry Feedstuff

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ABSTRACT : The proximate analysis, amino acid content and true amino acid digestibility and TMEn for poultry of adult Field crickets *Gryllus testaceus* Walker, were investigated. The insect was also used as partial replacement of protein supplements in the broiler diet on an equal CP percentage and TMEn basis. The results indicated that the adult insect contained: crude protein 58.3%; fat 10.3%, chitin 8.7% and ash 2.96% on dry matter basis, respectively. The total amounts of methionine, cystine and lysine in the Field crickets were 1.93%, 1.01% and 4.79%, respectively, and their true digestibility coefficients, determined in cecectomized roosters, were 94.1%, 85% and 96%, respectively. The TMEn of this insect meal was 2,960 kcal/kg determined in cecectomized roosters. When corn-soybean meal diets were formulated on an equal CP percentage and TMEn basis, up to 15% Field cricket could replace control diet without any adverse affects on broiler weight gain, feed intake or gain:feed ratio from 8 to 20 d posthatching. ***(Asian-Aust. J. Anim. Sci. 2005. Vol 18, No. 5 : 667-670)***

Key Words : Field Cricket, Composition Analysis, Amino Acid Digestibility, Growth Performance, Poultry

INTRODUCTION

With the high rate at which the world population was growing, the world food supply should grow at the same rate if not faster. The most affected from these would be the people in the so-called third world countries. Therefore it was essential that cheaper sources of protein and other nutrients be found. This could be obtained from the plant materials in abundance (Rama Rao et al., 2004) or utilization of the wastes (Cho et al., 2004). However, insects, which were said to have a huge quantity in the nature, should be given priority in this quest. In fact, insects have played an important role in nutrition, especially in areas where human and domestic animal populations were subjected to chronic protein deficiency (DeFoliart et al., 1975; Conconi et al., 1984; DeFoliart et al., 1989). Though the chemical composition and nutritional value of some insects have been extensively investigated in various parts of the world (Phelps et al., 1975; Finke et al., 1985; DeFoliart et al., 1989;), more attention was paid to use insects as feedstuff (DeFoliart et al., 1982; Landry et al., 1986; Nakagaki et al., 1987). Compared to those insects, the Field cricket (*Gryllus testaceus* walker) occurs in dense in most areas of China and could be easily harvested in a considerable amount. Furthermore, it could be mass rearing under controlled condition according to our previous work. Therefore, we conducted the study on its nutritional profile and protein quality for poultry to demonstrate the nutritional value of Field cricket.

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Received September 20, 2004; Accepted December 22, 2004

MATERIALS AND METHODS

Materials

Insect samples were adults of Field cricket *G. testaceus* (50% male and female respectively), collected in Yangling district of Shannxi province in China. Shortly after collection, samples were stored at -20°C until required for analysis. Before analyses samples were washed with tap water, rinsed with distilled water, oven dried at 50°C for 72 h and ground to a 80 mesh size.

Other feedstuffs were purchased from Huaqing feed company of Shannxi province in China.

Chemical analysis

The ash, fat content and crude protein for field cricket and other feedstuffs were analyzed according to the procedures of AOAC (1990). Amino acids (AA) were determined with a Beckman Amino Acid Analyzer (121 MB, from America) after hydrolyzing with 6 N hydrochloric acid for 22 h at 110°C. Methionine and cystine were analyzed by using formic acid (9 parts of 88% formic acid plus 1 part 30% hydrogen peroxide) protection prior to acid hydrolysis (6 N hydrochloric acid for 22 h at 110°C). Chitin was prepared and determined by the methods of Wang et al. (2001).

True amino acid digestibility and TME_n

The precision-fed rooster experiments were conducted to determine the TMEn and true amino acid digestibility (TAAD) according to the methods of Douglas (1997). The Field cricket and fishmeal were respectively crop-intubated (30 g) to cecectomized roosters for the true digestibility of amino acid and TMEn. Adult Single Comb White Leghorn roosters were used for the experiments, and excreta were collected for 48 h after incubation. Gross energy was

Table 1. Composition of diets for insect meal substitution assay

Ingredients	Control diet	5% insect meal	10% insect meal	15% insect meal
Ground corn	57.29	57.66	58.43	59.59
Soybean meal	22.50	21.10	18.50	15.30
Fish meal	10.00	6.00	3.00	-
Insect meal	-	5.00	10.00	15.00
Soybean oil	7.10	6.70	6.20	5.80
Ground limestone	1.00	1.20	1.20	1.40
Dicalcium phosphate	1.00	1.30	1.70	2.00
Salt	0.40	0.40	0.40	0.40
Vitamin mix[1]	0.20	0.20	0.20	0.20
Trace mineral mix[2]	0.15	0.15	0.15	0.15
DL-methionine	0.28	0.24	0.20	0.16
L-lysine	0.08	0.05	0.02	-
Calculated composition				
CP	21.3	21.3	21.3	21.0
Ca	1.00	1.00	1.00	1.00
Nonphytate P	0.60	0.60	0.60	0.60
Digestible lysine	1.16	1.16	1.16	1.16
Digestible met+cys	0.91	0.91	0.91	0.91
TMEn (kcal/kg)	3,210	3,210	3,210	3,210

[1] Provided per kg of diet: vitamin A (from vitamin A acetate) 4,400 IU; cholecalciferol (as activated animal sterol) 1,000 IU; vitamin E (from dl-alpha tocopheryl acetate) 11 IU; vitamin B_{12} 0.01 mg; riboflavin 4.41 mg; niacin 22 mg; pantothenic acid 10 mg; menadione (from menadione dimethylpyrimidinol) 1.0 mg; folic acid 0.9 mg; thiamin (from thiamine mononitrate) 1.0 mg; pyridoxine (from pyridoxine hydrochloride) 2.0 mg.

[2] Provided per kg of diet: Mn (from manganese oxide) 75 mg; Zn (from zinc oxide) 75 mg; Fe (from iron sulfate) 50 mg; Cu (from from copper sulfate) 5 mg; I (from ethylene diamine dihydroiodide) 1 mg; Se (from sodium selenite) 0.2mg.

[3] The Ca and P values for fish meal, corn and soybean meal were derived from the NRC (1994). The TME_n of soybean oil, corn and soybean meal were analyzed to be 8,370 kcal/kg, 3,250 kcal/kg and 2,240 kcal/kg respectively. The CP of corn and soybean meal were determined to be 8.5% and 46.8% respectively. The other values were previously analyzed and listed in Table 2 to Table 4.

determined by using a bomb calorimeter. TAAD were calculated according to the method of Sibbald (1979), and TMEn was calculated by the method of Parsons et al. (1982). Endogenous energy and AA were determined from roosters that were deprived of feed for 48 h.

Insect meal substitution assay

The second experiment was conducted to determine the growth performance of broilers fed experimental diets. 200 one-week-old Arbor Acres broilers were used in this broiler experiments.

The room temperature ranged from 20°C to 23°C. Feed and water were supplied *ad libitum* and light was provided 24 h daily. The broilers were fed a 21.3% CP pretest diet (control diet) during the first 7 d posthatching. Following overnight fasting, the broilers were wing-banded, randomly selected, weighed in groups of five and transferred to wire cages for dietary treatments. The broilers of two adjacent cages were considered an experimental replicate and the four diets were fed to five replicates of 10 broilers from 8 to 20 d posthatching (50 broilers per treatment). The broiler feeding trials were designed for three levels of replacements of protein source by insect meal (5%, 10% and 15%) when substituted for corn and soybean meal (Table 1). Diets containing insect meal were formulated to be equal in TMEn and CP percentage to the control diet. The TMEn, CP and digestible amino acid values used for the insect meal and fish meal were those values determined in the precision-fed rooster assays, respectively, described above. TMEn, CP and digestible amino acid values for corn and soybean meal and the TMEn for soybean oil were analyzed prior to initiation of the experiment.

Statistical analysis

All data from the experiments were analyzed using the ANOVA procedure of SAS (SAS Institute, 1990) for completely randomized designs. Statistical significances of differences among treatments were assessed using the Duncan's multiple-range test.

RESULTS AND DISCUSSION

Proximate composition analysis of field cricket

The proximate composition of Field cricket was listed in Table 2. The crude protein percentage of Field cricket was 58.3% on a dry basis, comparable with those of conventional protein feed supplements, soybean meal, meat and bone meal and fishmeal. This cricket was higher than percentages of proteins reported for many insects, such as 58% protein content found in Mormon cricket *Anabrus simplex* Haldeman (DeFoliart et al., 1982) and a protein contents range of from 49.4% to 58.1% six larvaes of species belonged to Lepidoptera (Landry et al., 1986), but was somewhat lower than protein contents of some species.

Table 2. Chemical analysis of Field cricket compared with other feedstuffs (g/100 g, dry matter basis)[1]

Proximate analysis	Content %			
	Ash	Chitin	Fat	Crude protein
Field cricket	2.96	8.7	10.3	58.3
Fish meal	12.51	-	4.11	60.2
Meat and bone meal	31.65	-	8.47	48.5
Soybean meal	6.13	-	1.84	46.8

[1] All the values were the means of five determinations.

Table 3. Amino acid profile of Field cricket compared with fish meal (g/100 g, dry matter basis)[1]

Amino acid profile	%	
	Field cricket (CP: 58.3) AA percentage[2]	Fish meal (CP: 60.2) AA percentage
Arg	3.68	3.24
His	1.94	3.7
Ile	3.09	2.33
Leu	5.52	4.20
Lys	4.79	4.51
Met	1.93	1.59
Cys	1.01	0.49
Phe	2.86	2.35
Tyr	3.94	1.72
Thr	2.75	2.25
Val	4.42	2.62
Asp	6.29	4.77
Ser	3.72	2.06
Glu	9.07	6.02
Ala	5.55	3.33
Pro	4.50	2.71
Gly	3.62	3.11

[1] All the values were the means of five determinations.
[2] AA means amino acid.

for examples, 62% protein content in House cricket *Acheta domesticus* L. (Nakagaki et al., 1987) and 68% protein content in silkworm pupae (Wei and Liu, 2001). The results also indicated that the fat and, thus, energy content was higher in this insect powder than in the conventional protein supplements in all cases (Table 2). Chitin was used as a toxin binder and chitin supplementation significantly diminished the adverse effects of aflatoxin (Khajarern et al., 2003). The chitin content of this insect was 8.7%, and whether the insect chitin played a role of toxin binder or contributed any effects to broiler growth performance still needed further study.

Amino acid profile

Total amino acid profiles for Field cricket and fishmeal were shown in Table 3. The amino acids percentages of Field cricket were higher than those of fishmeal except for histidine. The percentage of lysine, methionine and cysteine were 4.79%, 1.93% and 1.01% respectively in Field cricket while they were 4.51%, 1.59% and 0.49% in fishmeal, indicated that the essential amino acids of this insect were adequate for poultry. Contrastively, the earlier studies showed that the essential amino acid of Mormon cricket and house cricket were deficient in methionine (DeFoliart et al., 1982; Finke et al., 1985; Nakagaki et al., 1987). For example, the percentage of lysine and methionine were 3.48% and 0.93% respectively (Cysteine was not reported, Nakagaki et al., 1987) in House cricket. In addition, the essential amino acids of larval of six species of Lepidoptera were deficient in methionine, cysteine and possibly lysine (Landry et al., 1986). Thus, Field cricket had an advantage on amino acid composition compared with other insects reported, that was, Field cricket contained high quantity of protein.

Table 4. True amino acid digestibility coefficients and TMEn for Field cricket and fish meal[1]

Components	TAAD[2]		Pooled SEM
	Field cricket	Fish meal	
Arg	93.6	90.8	2.3
His	96.2	93.3	2.7
Ile	89.1	90.1	1.7
Leu	93.6	93.5	4.4
Lys	96.0	92.0	2.2
Met	94.1	93.1	3.2
Cys	85.0	83.7	2.1
Phe	93.2	91.0	4.1
Tyr	92.7	93.2	3.2
Thr	95.3	91.7	2.4
Val	94.4	91.7	2.4
Asp	96.0	90.2	1.9
Ser	90.6	91.4	2.6
Glu	89.9	91.7	3.7
Ala	96.4	94.5	2.9
Pro	91.0	88.2	1.0
Mean	92.9	91.3	
TMEn	2,960	2,820	

[1] The true amino acid digestibility was the mean of five cecectomized roosters, expressed on an air-dry basis.
[2] TAAD means true amino acid digestibility.

True digestibility of field cricket

Our first rooster experiment was for true amino acid digestibility coefficients and TMEn values of the insect and the results were shown in Table 4. The true amino acid digestibility coefficients for essential amino acids ranged from 82% for cysteine to 99% for asparagine. The TMEn of the Field cricket was found to be 2,960 kcal/kg as measured in conventional birds. Most of the TAAD coefficients for Field cricket were higher than those for fishmeal except for isoleucine, tyrosine, serine and glutamic acid. The average of TAAD coefficients of Field cricket (92.9%) was higher than that of fish meal (91.3%). It revealed that the Field cricket contained not only high quantity of protein but also considerable amounts of digestible amino acid for poultry.

Growth performance of broilers fed experimental diets

In the second broiler experiment where insect meal

Table 5. Growth performance of broilers fed a diet containing different amounts of insect meal on an equal TMEn and digestible amino acid basis[1]

Diets	Weight gain (g)	Feed intake	Gain:feed (g/kg)
Control diet	351	568	0.618
5% insect meal	357	575	0.621
10% insect meal	352	558	0.631
15% insect meal	351	576	0.609
Pooled SEM	3	9	0.008

[1] Means of five groups of ten broilers, average initial weight=96 g.

replaced partial protein supplement on an equal of CP percentage and TMEn basis, broilers growth were not significantly affected among diets with up to 15% insect meals (Table 5). These results agree with previous research on broiler (Finke et al., 1985) that were no significant differences in weight gain or feed/gain ratios between broilers fed corn-cricket diets and those fed reference diets. Nakagaki et al. (1987) reported that gain/feed ratios improved significantly when diets were supplemented with methionine and arginine and based on an equal of TME_n and CP percentage. The difference of gain/feed ratios between our research and Nakagaki's (1987) was probably due to difference of the insect species and the supplemented amino acids, methionine and arginine. However, it was ascertained that the protein of Field cricket had no adverse effect as a feedstuff.

CONCLUSION

Our results indicated that the Field cricket contained not only certain quantity of protein but also considerable amounts of digestible amino acid. The Field cricket had an advantage on composition of amino acids for poultry, especially the percentage of lysine, methionine and cysteine, so it might be a new source of dietary nitrogen for poultry, at least would be extremely beneficial as a complement to a domestic animal diet and could be fitted in to meal patterns in a variety of ways. For this reason, the utilization of the insect resource as feed was practical and helpful for the protein deficiency for some area, especially the poverty region.

REFERENCES

AOAC. 1990. Official Methods of Analysis. 15th edn. Association of Official Analytical Chemists, Arlington, Virginia.

Cho, Y. M., G. W. Lee, J. S. Jang, I. S. Shin, K. H. Myung, K. S. Choi, I. H. Bae and C. J. Yang. 2004. Effects of Feeding Dried Leftover Food on Growth and Body Composition of Broiler Chicks. Asian-Aust. J. Anim. Sci. 17:386-393.

Conconi, J. R. E. de, J. M. Pino Moreno, C. M. Mayaudon, F. R. Valdez, M. A. Perez, E. E. Prado and H. B. Rodriguez. 1984. Protein content of some edible insect in Mexico. J. Ethnobiol. 4:61-72.

DeFoliart, G. R. 1975. Insects as source of protein. Bull. Ent. Soc. Am. 21(3):161-163.

DeFoliart, G. R. 1989. The human use of insects as food and as animal feed. Bull. Ent. Soc. Am. 35:22-35.

DeFoliart, G. R., M. D. Finke and M. L. Sunde. 1982. Potential value of the Mormon cricket (Orthoptera:Tettigoniidae) harvested as a high protein feed for poultry. J. Econ. Entomol. 75:848-852.

Douglas, M. W., M. L. Johnson and C. M. Parsons. 1997. Evaluation of protein ang energy quality of rendered spent hen meals. Poult. Sci. 76:1387-1391.

Finke, M. D., G. R. DeFoliart and M. L. Sundae. 1985. An evaluation of the protein quality of mormon cricket (*Anabrux simplex H.*) when used as a high protein feedstuff for poultry. Poult. Sci. 64:708-712.

Khajarern, J. M., S. Khajarern, T. H. Moon and J. H. Lee. 2003. Effects of Dietary Supplementation of Fermented Chitin-chitosan (FERMKIT) on Toxicity of Mycotoxin in Ducks. Asian-Aust. J. Anim. Sci. 16:706-713.

Landry, S. V., G. DeFoliart and M. L. Sundae. 1986. Larval protein quality of six species of Lepidoptera (Saturniidae, Sphingidae, Noctuidae). J. Econ. Ent. 79(3):600-604.

Nakagaki, B. J. and G. R. DeFoliart. 1987. Protein quality of the house cricket *Acheta domesticus* when fed to broiler roosters. Poult. Sci. 66:1367-1371.

Parsons, C. M., L. M. Potter and B. A. Bliss. 1982. True metabolizable energy corrected to nitrogen equilibrum. Poult. Sci. 6:2241-2246.

Phelps, R. J., J. K. Struthers and J. L. Moyo. 1975. Investigations into the nutritive value of *Macrotermes falciger* (Isoptera-Termitidae). Zool. Africana 10(2):123-132.

Rama Rao, S. V., M. V. L. N. Raju, M. R. Reddy and A. K. Panda. 2004. Replacement of Yellow Maize with Pearl Millet (*Pennisetum typhoides*), Foxtail Millet (*Setaria italica*) or Finger Millet (*Eleusine coracana*) in Broiler Chicken Diets Containing Supplemental Enzymes. Asian-Aust. J. Anim. Sci. 17:836-842.

SAS Institute Inc. 1990. SAS User Guide: Statistics. Version 6, 4th Edition. SAS Institute Inc., Cary, North Carolina.

Sibbald, I. R. 1979. A bioassay for available amino acids and true metabolizable energy in feedstuffs. Poult. Sci. 58:668-673.

Wang, D., J. J. Hu and M. T. Liu. 2001. Preliminary research of preparation chitin from Field cricket. J. Northwest Sci-Tech Univ. Agri. For. (Nat. Sci. Ed.). 29:63-65. (In Chinese, with English abstract).

Wei, M. C. and G. Q. Liu. 2001. The Research and Exploitation of Insect Protein. J. Central South Forestry Uni. 21:86-90 (In Chinese, with English abstract).