# Protein Quality of the House Cricket, *Acheta domesticus*, When Fed to Broiler Chicks[1]

B. J. NAKAGAKI,[2] M. L. SUNDE,[3] and G. R. DEFOLIART[2]

*Departments of Entomology and Poultry Science, University of Wisconsin, Madison, Wisconsin 53706*

(Received for publication March 24, 1986)

*ABSTRACT* Two broiler chick feeding trials were conducted to determine the protein quality of dried house cricket meal. The first used semipurified diets to identify limiting amino acids. There were no significant differences in weight gain of chicks fed diets with amino acid additions, but feed:gain ratios indicated that arginine, methionine, and tryptophan were probably limiting.

In the second experiment, dried house cricket meal was incorporated into practical diets replacing soybean meal as the major source of protein. There were no significant differences in weight gain between chicks fed corn-soybean meal diet and those fed corn-cricket diets. Feed:gain ratios improved significantly when diets were supplemented with methionine and arginine.

(*Key words:* house crickets, insect protein feedstuffs, protein quality, broiler chickens)

1987 Poultry Science 66:1367–1371

## INTRODUCTION

DeFoliart *et al.* (1982) conducted proximate and amino acid analyses of field-collected Mormon crickets (*Anabrus simplex* Haldeman) and used crickets in diets for newly hatched broiler chicks. Although the dried, ground crickets contained 58% crude protein, amino acid analysis indicated that they were low in methionine and possibly low in arginine and tryptophan. In feeding trials, however, corn-cricket-based diets produced significantly better growth of chicks to 3 wk of age than was produced by a conventional corn-soybean-based diet. Supplementing the corn-cricket diet with additional amino acids resulted in no significant increase in growth.

Finke *et al.* (1985) fed purified diets to broiler chicks to identify the limiting amino acids in Mormon crickets, and found that methionine and arginine were probably colimiting. Again, however, when Mormon crickets were incorporated into practical diets replacing soybean meal as the major source of protein in an 8-wk feeding trial, the corn-cricket diet compared favorably with a corn-soybean meal diet, with no significant differences in chick weight gain or feed:gain ratios. In extensive feeding trials with rats, Finke *et al.* (1983) and Finke (1984) found that both the Mormon cricket and another cricket species, the house cricket (*Acheta domesticus* L.), were of high protein quality, with the Mormon cricket being equal and the house cricket slightly superior to soy protein at all levels of feeding.

The Mormon cricket occurs in dense, sometimes large bands or aggregations in certain areas of the western United States. Based on 1981 prices for corn and soybean meal, DeFoliart *et al.* (1982) estimated the wholesale value of crickets in a 1-$km^2$ band at up to $6,600 if harvested for use as a high protein feedstuff. Despite excellent nutritional results with feeding the Mormon cricket, however, methods of harvesting wild populations have not yet been developed, and the biology of the insect presently precludes any possibility that it can be mass reared economically.

Further interest in the house cricket was stimulated because this insect is amenable to mass rearing under controlled conditions and can produce six to seven generations per year. Further, the house cricket is an omnivore, and preliminary studies in our laboratory indicate that it may have the capability of recycling poultry manure into a protein-rich feedstuff for poultry on an economically competitive basis. The house cricket is easily adapted to domestic rearing and has not been studied as a source of nutrients. Therefore, feeding trials were conducted to evaluate the protein value of house crickets when incorporated into both conventional and semipurified broiler chick diets.

---

[1]Research supported by the College of Agricultural and Life Sciences, University of Wisconsin, Madison, Wisconsin 53706.

[2]Department of Entomology.

[3]Department of Poultry Science.

## MATERIALS AND METHODS

Crickets were reared at 35 ± 5 C on a standard broiler chick starter mash, killed by freezing, dried at 45 C for 72 h and ground to a 20-mesh size. Because of the cricket's high requirement for sodium (.4 to .7%) (Luckey and Stone, 1968), 1.28% NaCl was added to the cricket diet. Single proximate and amino acid analyses were carried out by Raltech Scientific Services (TM), and a mineral analysis by the Soil and Plant Analysis Laboratory, both of Madison, WI (Table 1). The high level of sodium observed in crickets, although higher than other insects, reflects their high requirement. Diets were formulated based on these analyses to arrive at protein and amino acid levels as close to National Research Council (1977) broiler chick requirements as possible.

Two experiments were conducted. The first was an attempt to identify limiting amino acids in semipurified diets. The second was a comparison of practical diets of corn and crickets supplemented with different levels of methionine and arginine.

In both experiments, 1-day-old, unsexed broiler chicks (Hubbard strain) were weighed, wingbanded and assigned to replicates by a stratified block design to minimize differences

TABLE 1. *Chemical analyses of the house cricket (Acheta domesticus L.)*

| | | |
|---|---|---|
| Proximate analysis[1] | (%) | |
| Crude protein | 62.0 | |
| Ether extract | 7.5 | |
| Ash | 4.6 | |
| Crude fiber | 7.0 | |
| Water | 5.2 | |
| Mineral analysis[2] | | |
| Phosphorus | .99 | |
| Potassium | 1.28 | |
| Calcium | .19 | |
| Magnesium | .11 | |
| Sulfur | .59 | |
| | (ppm) | |
| Zinc | 254 | |
| Manganese | 64 | |
| Iron | 155 | |
| Copper | 24 | |
| Aluminum | 34 | |
| Sodium | 9,210 | |
| Amino acid profile[1] | (% as is) | (mg/g protein) |
| Lysine | 3.48 | 56 |
| Histidine | 1.60 | 26 |
| Arginine | 3.73 | 60 |
| Aspartic acid | 5.46 | 88 |
| Threonine | 2.18 | 35 |
| Serine | 3.05 | 49 |
| Glutamic acid | 7.26 | 117 |
| Proline | 3.83 | 62 |
| Glycine | 3.65 | 59 |
| Alanine | 5.92 | 95 |
| Valine | 3.74 | 60 |
| Methionine | .93 | 15 |
| Isoleucine | 2.58 | 42 |
| Leucine | 4.50 | 73 |
| Tyrosine | 2.52 | 41 |
| Phenylalanine | 1.36 | 22 |
| Tryptophan | .38 | 6 |

[1] Raltech Scientific Services, Madison, WI.

[2] Soil and Plant Analysis Laboratory, Madison, WI.

in means and standard errors. Replicates were assigned randomly to 20-cage, electrically heated, chick starter batteries. Lighting was continuous and food and water were provided *ad libitum*. Chick weights and food consumption were determined twice weekly. The corn-soybean meal reference diet was the Animal Nutrition Research Council Reference Chick Diet (NRC, 1977) and contained 22.3% crude protein and 3,120 kcal/kg metabolizable energy (ME). All experimental diets were kept isonitrogenous and isocaloric within experiments by the addition of glutamic acid in place of the test amino acids.

*Experiment 1*. Two replicates of eight birds each were assigned to the corn-soybean meal reference diet and three replicates of eight birds to each of the six experimental diets for 21 days. The basal diet contained on a percentage basis: pearl starch grits, 54.3; ground crickets, 36.0; corn oil, 3.0; choline chloride (60%), .15; and minerals and vitamins to meet NRC requirements. The six experimental diets (Table 2) contained 23.3% crude protein and approximately 3,400 kcal/kg ME calculated from fat, protein, and carbohydrate levels of the meal.

*Experiment 2*. Three replicates of five birds were assigned to the reference diet and to each of the nine experimental diets for 14 days. The experimental design was a 3 × 3 factorial design with three levels of methionine and three levels of arginine as shown in Table 3. All nine experimental treatments contained 21.9% crude protein and approximately 3,360 kcal/kg ME. The basal diet contained on a percentage basis: ground corn, 66.7; ground crickets, 25.0; corn oil, 3.0; vitamin premix for semipurified diets (NRC, 1977), .5; choline chloride (50%), .2; calcium carbonate, 2.0; dicalcium phosphate, 2.0; manganese sulfate, .03; zinc carbonate, .01; and ferric ammonium citrate, .04. Differences between means were analyzed using Tukey's multiple range test for unequal sample sizes (United States Department of Agriculture, 1977).

## RESULTS AND DISCUSSION

Amino acid analysis indicated that methionine would be the first-limiting amino acid followed by arginine and tryptophan, with lysine and phenylalanine possibly deficient in the semipurified diet. There were, however, no significant differences among final weights of chicks fed the various experimental diets (Table 2). Chicks fed the reference (corn-soy) diets

TABLE 2. *Mean weights and feed:gain ratios for broiler chicks fed purified diets containing house crickets for 21 days (Experiment 1)*

| Diets[1] | Mean body weights ± SE[2] | Feed:gain |
|---|---|---|
| | (g) | (g/g) |
| Basal[3] | 412.1 ± 23.4[b] | 1.70[bc] |
| Basal + met (.45%)[3] | 399.2 ± 23.7[b] | 1.69[bc] |
| Basal + met (.45%) + arg (.10%)[3] | 379.4 ± 27.8[b] | 1.78[c] |
| Basal + met (.45%) + trp (.10%)[3] | 402.8 ± 23.4[b] | 1.66[bc] |
| Basal + met (.45%) + arg (.10%) + trp (.10%)[3] | 427.3 ± 20.3[b] | 1.51[a] |
| Basal + met (.45%) + arg (.10%) + trp (.10%) + lys (.10%) + phe (.10%) | 418.0 ± 21.4[b] | 1.57[ab] |
| Reference practical chick mash | 519.0 ± 22.3[a] | 1.76[c] |

[a–c]Means within the same column with different superscripts differ significantly ($P<.05$).

[1]Met = Methionine; arg = arginine; trp = tryptophan; lys = lysine; phe = phenylalanine.

[2]SE = Standard error.

[3]Glutamic acid added to provide .85% total supplemented amino acids.

TABLE 3. *Mean weights and feed:gain ratios for broiler chicks fed corn-cricket diets with methionine and arginine additions for 14 days (Experiment 2)*

| Diet additions | | | |
|---|---|---|---|
| Methionine | Arginine | Mean body weights ± SE[1] | Feed:gain |
| (%) | | (g) | (g/g) |
| 0 (Basal)[2] | 0 | 248.9 ± 14.7$^{a}$ | 1.44$^{bcd}$ |
| .15 | | 248.9 ± 9.04$^{a}$ | 1.42$^{bc}$ |
| .30 | | 244.5 ± 14.7$^{a}$ | 1.40$^{bc}$ |
| | .1 | 238.5 ± 21.7$^{a}$ | 1.48$^{cd}$ |
| | .2 | 250.0 ± 14.7$^{a}$ | 1.43$^{bcd}$ |
| .15 | .1 | 245.3 ± 13.4$^{a}$ | 1.31$^{a}$ |
| .30 | .1 | 242.1 ± 12.1$^{a}$ | 1.50$^{d}$ |
| .15 | .2 | 249.3 ± 17.4$^{a}$ | 1.37$^{ab}$ |
| .30 | .2 | 253.3 ± 15.6$^{a}$ | 1.30$^{a}$ |
| Reference practical chick mash | | 249.2 ± 14.8$^{a}$ | 1.58$^{e}$ |

[a–e]Means within the same column with different superscripts differ significantly (P<.05).

[1] SE = Standard error.

[2] Glutamic acid added to provide .5% total supplemented amino acids.

showed significantly better growth. The reason for this is not known.

Feed utilization was generally better for chickens fed the semipurified diets compared with those fed the practical reference diet because the energy content was somewhat higher (3,120 *vs.* 3,400 kcal/kg, calculated values). Feed:gain ratios of chicks fed diets supplemented with methionine plus arginine and tryptophan (Table 2) were higher than those of chicks fed the reference diet. There did not appear to be any additional response to lysine and phenylalanine.

Although the analysis indicated that methionine would be the first-limiting amino acid, the data do not support this. There is a suggestion based on the chick feed:gain ratios that tryptophan may be more limiting than methionine. These data may also indicate that the diets may contain a significant amount of cysteine. There may also be some choline-methionine interaction, with choline acting as a methyl donor (Pesti *et al.*, 1979). Mormon crickets have been shown to contain high levels of choline (Finke *et al.*, 1985).

Experiment 2 was conducted with practical corn-cricket formulations in an attempt to minimize differences in weights of chicks fed cricket diets *vs.* the reference diet. Although amino acid analysis indicated that methionine and arginine would be first and second most limiting, there were no significant differences in final weights of chicks fed any of the diets in experiment 2 (Table 3). Chick feed:gain ratios did decrease significantly with the addition of both methionine and arginine in two of four cases, but not with either alone. This is similar to the findings of Finke *et al.* (1985) with Mormon crickets. It is likely that methionine and arginine are colimiting.

All chicks fed experimental diets showed feed:gain ratios significantly better than those of birds fed the reference diet (Table 3). This may be due to the higher ME of the corn-cricket diets *vs.* the reference diet (3,360 kcal/kg *vs.* 3,120 kcal/kg, calculated values). There were no improvements in chick feed:gain ratios with the addition of higher levels of methionine and arginine, so supplementation at the lower levels was apparently sufficient. It is also apparent that the amino acid availability is quite high in cricket meal.

The data from this experiment show that the corn-cricket mixture contained enough of the essential amino acids to permit maximum gains, but addition of both arginine and methionine improved the feed utilization. These data demonstrate that dried house crickets are a good source of high quality protein for chickens, and in fact, may be better than amino acid analysis would indicate. Whether or not house crickets can become a useful ingredient in animal feeds will depend on how inexpensively they can be produced.

## REFERENCES

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.

Finke, M. D., 1984. The use of nonlinear models to evaluate the nutritional quality of insect protein. Ph.D. Diss. Univ. Wisconsin, Madison, WI.

Finke, M. D., G. R. DeFoliart, and N. J. Benevenga, 1983. A multi-dose assay of the protein quality of three insect species. FASEB Proc. 42:541. (Abstr.)

Finke, M. D., M. L. Sunde, and G. R. DeFoliart, 1985. An evaluation of the protein quality of Mormon crickets when used as a high protein feedstuff for poultry. Poultry Sci. 64:708–712.

Luckey, T. D., and P. C. Stone, 1968. Cricket Nutrition: Supplementation of grass by known nutrients. J. Insect Physiol. 14:1533–1538.

National Research Council, 1977. Nutrient requirements of domestic animals. No. 1: Nutrient requirements of poultry. Nat. Acad. Sci., Washington, DC.

Pesti, G. M., A. E. Harper, and M. L. Sunde, 1979. Sulfur amino acids and methyl donor status of corn soy diets fed to starting broiler chicks and turkey poults. Poultry Sci. 58:1541–1547.

United States Department of Agriculture, 1977. Comparisons among treatment means in an analysis of variance. Agric. Res. Serv., United States Dept. Agric., Sci. Educ. Admin., Hyattsville, MD.