An Evaluation of the Protein Quality of Mormon Crickets (*Anabrus simplex* Haldeman) When Used as a High Protein Feedstuff for Poultry[1]

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ABSTRACT Two feeding trials were conducted to evaluate the protein quality of Mormon crickets (*Anabrus simplex* Haldeman) when fed to broiler chicks. The first trial was designed to identify the limiting amino acids in Mormon crickets using purified diets. The basal diet was supplemented with amino acids based on an amino acid analysis of Mormon crickets and preliminary feeding trials, and the results indicated that methionine and arginine were probably colimiting.

In the second experiment Mormon crickets were incorporated into practical diets replacing soybean meal as the major source of protein. In an 8-week feeding trial the corn-cricket diet compared favorably with a corn-soybean meal diet with no significant differences in weight gain or feed/gain ratios. There was no adverse effect on the taste of the meat from birds fed the corn-cricket diet as determined by a taste panel.

(*Key words*: crickets, protein feedstuffs, protein quality)

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INTRODUCTION

Despite the use of insects as a food source by a wide variety of animals, there have been relatively few studies incorporating insects in the diets of domestic animals. Calvert *et al.* (1969) and Teotia and Miller (1973) analyzed house fly (*Musca domestica* L.) pupae for amino acids, protein, fat, and minerals and found them to be a rich source of protein, energy, and trace minerals. In addition, the amino acid profile appeared to be quite good when compared with soybean meal. Teotia and Miller (1973) added house fly pupae to broiler chick diets in place of soybean meal and after 4 weeks found no significant differences in final body weights or feed/gain ratios between chicks fed the house fly pupae diets and the soybean meal controls. However, exact comparisons of protein quality are difficult due to the differences in the protein content of house fly pupae and soybean meal (61.4 and 44%, respectively). In a second article Teotia and Miller (1974) incorporated house fly pupae into broiler diets but this time adjusted the levels of corn, milo, and either soybean meal or house fly pupae so that protein levels were nearly equal. After 7 weeks there were no significant differences in either final body weights or feed/gain ratios. In addition, an informal taste panel could not detect any differences between birds fed the control and experimental diets.

In a similar type of experiment Calvert *et al.* (1969) found a slight improvement in the final body weights of broiler chicks fed a corn-house fly pupae diet compared to those fed a conventional corn-soybean meal diet. There were no differences in feed/gain ratios between the two treatments.

Despite these studies, in general, few definite statements can be made concerning the nutritional quality of the protein of insects. From a review of the literature (Calvert *et al.*, 1969; Teotia and Miller, 1973, 1974; Phelps *et al.*, 1975; Ramos de Conconi and Bourges, 1977; Ocio and Vinaras, 1979; DeFoliart *et al.*, 1982), it appears that in general, insect protein is low in the sulfur amino acids methionine and

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cysteine. However, in none of the feeding trials were any attempts made to identify the limiting amino acid(s).

We are currently involved in the study of the protein quality of the Mormon cricket, *Anabrus simplex* Haldeman. This species is endemic to the western US and it travels in large bands (Cowan, 1929; Wakeland, 1959), which makes it possible to harvest large quantities for nutritional studies. In a previous paper (DeFoliart *et al.*, 1982), we presented the amino acid, protein, fat, and mineral content of dried ground Mormon crickets. In this paper, we describe a series of experiments designed to evaluate the protein quality of Mormon crickets when fed to broiler chicks in both purified and conventional diets. In addition, we also tested whether incorporation of substantial amounts of Mormon crickets into the diets of broiler chicks had any adverse effect on the taste of the meat.

MATERIALS AND METHODS

All crickets used in these experiments were collected in northwestern Colorado near Dinosaur National Monument during July of 1980, 1981, and 1982. A variety of trapping methods were used to collect the crickets, and at the end of each collecting day the crickets were taken to a local meat processing plant and frozen. The crickets were transported back to Madison packed in dry ice and were kept frozen until needed for feeding trials, at which time they were dried in a radiant heating oven at 45 C for approximately 72 hr. The dried samples were then finely ground for incorporation into diets. The protein content of dried Mormon crickets varies considerably (unpublished results) and, as a result, Kjeldahl analyses were performed on each batch of crickets prior to each experiment.

In both experiments, day-old broiler chicks of both sexes were weighed, wing-banded, and placed in conventional electrically heated chick starting batteries. Groups of 8 chicks were assigned to each treatment so that the mean and standard error of each group was similar. Lighting was continuous and food and water were provided *ad libitum*. Chicks were weighed twice weekly and food consumption determined.

Experiment 1

Three groups of 8 birds each were assigned to each of the 4 treatments and fed the appropriate diet for 14 days. All diets contained 21.5% crude protein (CP) and were kept isocaloric and isonitrogenous by the addition of glutamic acid in place of the test amino acid. The basal diet contained (in %) corn starch 44.0, ground crickets 48.2, corn oil 2.0, mineral mix (Maruyama *et al.*, 1976) 5.1, vitamin mix (Maruyama *et al.*, 1976) .5, choline chloride (60%) .2, vitamin E (250 IU/g) .005, and a selenium premix (containing 1 mg Se/g) .01.

Experiment 2

Three groups of eight birds each were assigned to one of two treatments and fed either the corn-ground cricket or the corn-soybean meal diet (see Table 1) for 8 weeks. All diets were formulated to meet or exceed National Research Council (1977) recommendations. Initially the birds were given the 23% CP diet. After 3 weeks the unconsumed food was removed and replaced with the appropriate 20% CP diet. This procedure was repeated at the end of 6 weeks with the 18% CP diet. At 4 weeks the birds were removed from the batteries and placed in growing batteries with three birds per cage. After 8 weeks on the diets the birds were sacrificed and the carcasses used for evaluation by a taste panel.

Differences between the meat of birds fed the corn-ground cricket and the corn-soybean meal diets was evaluated with a taste panel using the triangle test (Amerine *et al.*, 1965). In this test each member of the panel receives three portions of meat, either two from the experimental group and one from the control or two from the control and one from the experimental group. The members are then asked to determine which of the two samples are the same. Based on the probability of the tasters randomly determining the correct sample, the results can be analyzed to determine if differences exist between the two samples.

The data from Experiments 1 and 2 were analyzed with Tukey's Studentized range test (Snedecor and Cochran, 1980), and for Experiment 1 the effect of interactions was tested by two-way analysis of variance.

RESULTS AND DISCUSSION

Amino acid analysis (DeFoliart *et al.*, 1982) indicated that methionine was the first limiting amino acid with arginine and tryptophan second and third limiting, respectively. When chicks were fed a purified diet containing ground crickets in preliminary feeding trials,

TABLE 1. *Composition of diets used in Experiment 3*[1]

	Corn-ground cricket diet			Corn-soybean meal diet		
Weeks	1–3	4–6	7–8	1–3	4–6	7–8
Corn	641.0	716.0	763.0	526.0	614.0	679.0
Soybean meal	...	...	...	379.0	302.0	248.0
Ground crickets	283.0	224.0	184.0	...	...	...
White grease	30.0	5.0	0	50.0	40.0	30.0
Dicalcium phosphate	24.0	24.0	24.0	22.0	22.0	22.0
Limestone	11.0	11.0	11.0	11.0	11.0	11.0
Vitamin mix	5.0	5.0	5.0	5.0	5.0	5.0
Salt	4.0	4.0	4.0	4.0	4.0	4.0
Choline chloride (50%)	2.6	2.6	2.6	1.0	1.0	1.0
Vitamin E, IU/kg	5.5	5.5	5.5	8.3	8.3	8.3
DL-Methionine	4.0	3.0	2.0	2.0	1.0	0
L-Arginine	4.0	3.0	2.0	0	0	0
DL-Tryptophan	1.0	.5	.5	0	0	0
L-Lysine	.5	.5	.5	0	0	0
Trace mineral mix[2]	.7	.7	.7	.7	.7	.7

[1] Except where noted, all values are gram per kilogram.

[2] Trace mineral mix contained the following (in g/kg unless indicated otherwise): ferric citrate .3, manganese sulfate .3, zinc carbonate .1, selenium .1 mg/kg.

arginine and methionine were found to be the limiting amino acids, but the order in which these two amino acids became limiting was unclear.

Because of the results of the preliminary experiments, the first experiment was designed to study supplementation of a purified diet with arginine and methionine in a 2 × 2 factorial design. Analysis of final body weights (Table 2) showed a significant increase ($P<.05$) only when both arginine and methionine were added to the basal diet. Addition of either amino acid separately appeared to increase final body weights, but the differences were not significant. A two-way analysis of variance showed no methionine-arginine interaction. Feed/gain ratios showed a significant decrease ($P<.05$) again only when both arginine and methionine were added to the basal diet. Methionine supplementation alone also appeared to lower feed/gain ratios, although the decrease was not significant, and arginine supplementation had no effect. In this case, however, two-way analysis of variance indicated a significant ($P<.05$) interactive effect of the two amino acids.

The second experiment compared chicks fed a conventional corn-soy diet against those fed a corn-ground cricket diet. When males and females were analyzed separately, no significant differences were obtained and so all the birds from each dietary treatment were pooled for the final analysis. There were no significant differences between the weights of the two groups

TABLE 2. *Final body weights and feed/gain ratios of chicks fed purified diets for 14 days*

	Final weight	Feed/gain
	(g)	
Basal	191.4 ± 2.9[a]	1.75 ± .07[a]
Basal + .55% DL-methionine	211.6 ± 4.1[a]	1.60 ± .05[a]
Basal + .55% L-arginine	211.6 ± 5.9[a]	1.76 ± .04[a]
Basal + .55% methionine, .55% arginine	262.9 ± 14.0[b]	1.34 ± .01[b]

[a,b] Means (± SE) within columns with different superscripts are significantly different.

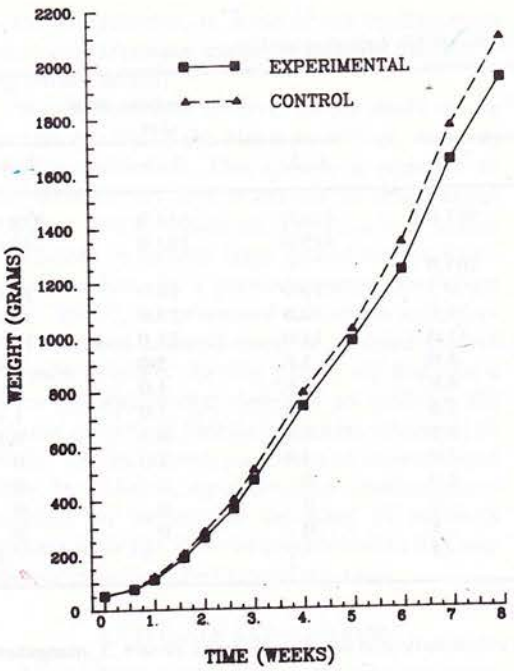

FIG. 1. Weight of broiler chicks fed control (corn-soybean meal) and experimental (corn-crickets) diets for 8 weeks.

(Fig. 1), although the control birds were somewhat heavier. Final body weights (corn-soy 2095 g; corn-crickets 1947 g) and feed/gain ratios (corn-soy 2.19; corn-cricket 2.25) were not significantly different.

To determine if feeding crickets to broiler chicks had any effect on the carcass quality, birds from this experiment were evaluated by a taste panel using the triangle test as explained in the methods section. The dark meat was used in these trials as it was reasoned that if there were differences between the two samples they would most likely be evident in this type of meat. Only 8 of the 26 panelists correctly identified the "odd" sample indicating no significant difference ($P<.05$) in the taste of the two samples.

These results indicate that the quality of Mormon cricket protein is comparable to soybean meal. Although amino acid analysis indicated that methionine was the first limiting amino acid, supplementation of both arginine and methionine was required to effect a significant increase in weight gain or decrease in feed/gain ratios. Part of the reason for this may be due to the high choline levels found in crickets (4900 mg/kg). Choline can act as a methyl group donor in transmethylation reactions thereby sparing the use of methionine for this purpose (Pesti *et al.*, 1979). This phenomenon has been shown to decrease the methionine requirement for both rats and poultry and may explain the results obtained in Experiment 1.

Our studies are in agreement with those of Calvert *et al.* (1969) and Teotia and Miller (1973, 1974) in showing that, in general, the nutritional quality of insect protein was good when fed to young chicks and that, even at fairly high levels, incorporation of insect protein into the diet had no effect on carcass quality. While presenting data on amino acid analysis of house fly pupae, the above investigators made no attempt to determine the limiting amino acid with a bioassay. Our data, however, indicate that determination of protein quality based solely on amino acid analysis may be misleading. In contrast to the amino acid analysis, which predicted methionine to be the first limiting amino acid, a chick bioassay indicated that arginine and methionine are probably co-limiting in Mormon cricket protein.

Although methionine supplementation may be practical, arginine supplementation is probably not economical. Mixing ground crickets with a complementary protein, perhaps sunflower, sesame, or peanut meal, however, might lead to economical mixtures adequate in both arginine and lysine and only require methionine supplementation. We are currently using a computer program to determine the optimal mixtures of these protein sources for broiler chicks.

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