

NUTRITIONAL EVALUATION OF THE GIANT GRASSHOPPER (*ZONOCERUS VARIEGATUS*) PROTEIN AND THE POSSIBLE EFFECTS OF ITS HIGH DIETARY FIBRE ON AMINO ACIDS AND MINERAL BIOAVAILABILITY

Solomon M¹* Ladeji O¹ and H Umoru²



Mariam Solomon

*Corresponding author Email: danladis2003@yahoo.com

¹Mariam Solomon and Olusola Ladeji - Department of Biochemistry, Faculty of Medical of Sciences, University of Jos, P.M.B. 2084, Plateau State, Nigeria

²Hauwa Umoru - Federal Universities of Technology, Yola, Adamawa State, Nigeria

ABSTRACT

The biological value of giant grasshopper protein (*Zonocerus variegatus*) was evaluated by comparing the weight gained, food efficiency ratio (FER), protein efficiency ratio (PER) of rats fed standard laboratory chow with that of rats fed giant grasshopper, Soyabean(*Glycine max*) and crayfish. The effect of high fibre content on utilization of nutrients has also been assessed in rats fed the supplements. Each diet produced a progressive gain in body weight ranging from 32.1 ± 2.0 g in rats feeding on control diet to 56.0 ± 2.0 g for rats feeding on giant grass-hopper. FER ranges between 0.22 in rats fed on laboratory chow to 0.44 in giant grass-hopper fed rats while PER ranges between 1.12 in laboratory chow fed rats to 1.90 in rats fed giant grass-hopper. Despite the fact that food and protein intake of rats on control and experimental diets were identical, at the end of the 28 day feeding period, the growth rate, FER and PER of giant grass-hopper fed rats were significantly higher ($P < 0.05$) compared with rats fed on Soyabean(*Glycine max*), laboratory chow and crayfish supplemented diets, thus suggesting that the giant grass-hopper protein was superior in terms of quality and was better utilized. The fiber content in giant grass-hopper was 15%, which was thrice the amount present in laboratory chow and one and half times the amount present in crayfish. Plasma levels of total protein, essential amino acids and minerals in rats on different diets were almost identical. This seems to suggest that the high fiber content in giant grass-hopper did not seem to affect the bioavailability and levels of these parameters determined in the plasma especially the total protein and minerals. The significant increase in body weight, the high values of FER and PER together with ease of collection(possibility of cultivation) and economic aspect would make giant grasshopper a suitable alternative, digestible and highly nutritive protein and its inclusion in food supplementation would provide good quality protein especially in developing countries. Additionally, giant grasshopper protein may also be included in animal feed formulation.

Key words: Giant Grasshopper, Protein Efficiency Ratio

INTRODUCTION

Protein energy malnutrition (PEM) contributes to more than 50% of the deaths of children under five years all over the developing countries [1]. As long as protein-energy malnutrition prevails in developing countries, the search for low cost, nutritious and easy to prepare locally available complementary foods will continue.

Efforts to improve the health and nutritional status of growing children have been directed towards diet supplementation. Supplements are prepared from locally available sources and the ones that have been used include soyabean, crayfish [2] and various leafy vegetables [3]. Vegetables such as legumes are suitable with cereals as this increases the protein quality of the cereal-based complementary food and can even supplement the deficient amino acids. However, problems of availability of suitable vegetable supplements vary from place to place. Moreover the use of legumes may be limited due to the presence of anti nutritional factors such as amylase inhibitor, protease inhibitor, phytates and condensed tannins which prevent nutrient bioavailability unless they are processed [4].

All these factors have increased the search for newer supplements among edible insects. Hundreds of species of insects have been used as human food. Some important groups include grasshopper, caterpillar, beet grubs and winged termites. These insects have played an important part in the history of human nutrition in Africa, Asia and Latin America. Most insects are cheap, tasty and a good natural source of protein and minerals. Many species of insects are lower in fat and higher in protein [5].

In Borno State of Nigeria, giant grasshopper (*Zonocerus variegatus*) is widely eaten as a delicacy. These grasshoppers weighing between 10 and 15g are caught at night during the cold weather (November- February), boiled briefly and then roasted. The roasted grasshoppers are readily displayed in markets and sold like meat. Previous work on the chemical analysis of this insect had shown it to contain 58.0g/100g crude protein, 12.4/100g crude fibre, 15.5g/100g crude lipid, an array of essential amino acids in the right proportion, and high amount of sodium, potassium, calcium and phosphorus [6]. The aim of this study was to evaluate the biological value of the giant grasshopper protein (as compared to soybeans or crayfish) as determined by measurement of growth rate, food efficiency ratio and serum amino acid level and also to assess the physiological effect of the high fibre content using serum cation levels as indices.

MATERIALS AND METHODS

Preparation of supplemented diets

- (a) *Zonocerus variegatus* (58.0g protein per 100g DM) supplement was prepared by mixing 22.7g of *Zonocerus* with 60g maize flour.(10g protein per 100g DM).
- (b) Crayfish (54.0g protein per100g DM). Supplement was prepared by mixing 24g crayfish with 60g white maize grit.
- (c) Soyabeans (42.0g protein per100g DM) supplement was prepared by mixing 30g of Soyabeans with 60g white maize grit.
- (d) Laboratory chow (20% protein), a product of Pfizer Feeds, Kaduna, Nigeria.

In the preparation of supplemented diets a, b and c above, water was added to give a semi-solid paste which was rolled and cut into pellets. These were dried in an oven at 56°C. Laboratory chow was used as control diet.

Feeding Experiment

Weanling male albino rats bred in University of Jos animal house from stock obtained at the National Institute of Pharmaceutical Research, Abuja, Nigeria were used. Twenty four rats weighing 40.0±2.5g were distributed evenly into 4 groups (6 rats/group). Rats were maintained at the animal house temperature (21±2°C) and fed with laboratory chow for 48h. At the end of 48h, group 2 received soyabean supplement (20g/rat/day), group 3 crayfish supplement (20g/rat/day) while group 4 received giant grasshopper (20g/rat/day) supplemented diet. Group 1 served as the control and was fed laboratory chow 20g/rat/day. The rats were housed individually in polypropylene cages. Water was given *ad libitum*, weighed diet was given so that each rat received 4g protein/day, and diet not consumed was collected, dried and weighed. Rats were fed for 28 days. The rats were weighed initially and at the end of each week. Weight gained, food efficiency ratio (FER) and protein efficiency ratio (PER) were determined as follows:

$$\text{Weight gained} = \frac{\text{weight after x days (g)} - \text{Initial weight (g)}}{\text{Initial weight (g)}}$$

Initial weight (g)

$$\text{FER} = \frac{\text{Gain in body weight (g)}}{\text{Food intake (g)}}$$

Food intake (g)

$$\text{PER} = \frac{\text{Gain in body weight (g)}}{\text{Protein intake (g)}}$$

Protein intake (g)

Serum levels of essential amino acids before the start of feeding and after 4 weeks of feeding on supplements was also assayed.

Collection of blood

Rats were sacrificed at zero and 28 days after ether anesthesia and blood collected by cardiac puncture. The blood was allowed to clot and serum group-pooled and stored at -20°C pending analysis.

Free amino acids in serum were determined with ion-exchange amino acid analyzer on a protein-free filtrate using the chromatographic methods of Spackman and Moore [7]. Total protein was determined by the Biuret micro method as modified by Kingsley [8]. Sodium,

potassium, calcium, zinc and iron were determined in diluted serum using polarized atomic absorption spectrophotometry according to the procedure of Harris[9].

Statistical Analysis

Values are expressed as mean \pm SD. Randomized Complete Block Design Analysis of Variance was used. P values less than 0.05 were considered significant.

RESULTS

The food intake and gain in body weight of rats, food efficiency ratio (FER) and protein efficiency ratio (PER) of supplements are presented in Table 1. Food and protein intake of rats on all the supplemented diet was identical. All supplements produced an increase in body weight, FER and PER. The weight gain ranges between 32.1g for rats fed on control diet and 56.0g for rats fed diet 4. Food efficiency ratio ranges between 0.22 and 0.44 and PER from 1.12 to 1.90 for rats on control diet and those fed diet 4 respectively. Weight gain, FER and PER of rats fed grasshopper supplements were statistically significantly higher ($p < 0.05$) compared to other supplements. Rats fed on control diet had the lowest FER and PER.

Total protein levels and amino acid profile are presented in Tables 2 and 3. Total protein levels in serum were almost identical for rats on different diets. There were no significant differences in serum essential amino acid levels of supplemented diets. The effect of giant grasshopper supplemented diet on serum level of cations is shown in Table 4. Sodium and calcium levels were significantly higher ($p < 0.05$) in serum of rats fed supplement 4. Levels of other cations were almost identical for both control and experimental rats.

DISCUSSION

The effect of maintaining weanling rats on different protein sources on body weight, FER, PER, amino acid profile and serum levels of cations have been assessed. The increase in weight observed when supplemented diets were fed to rats as the sole protein source would suggest that all the diets adequately supported growth. The significant difference in body weight of rats fed grasshopper supplemented diet (Diet 4) at the end of the 4th week would suggest that the protein in diet 4 is of good quality and was better utilized. Studies have shown that a protein that produces a weight gain of 25g in 4 week when fed to rats as the sole source of dietary protein is generally considered a good quality protein [8].

PER is the ability of a protein to support growth in young rapidly growing rats as shown by Sarwar and McDonough [9]. Though the food and protein intake of rats on diets 3 and 4 were the same, rats on diet 4 gained more weight. This would suggest that the grasshopper protein was superior and slightly better utilized than that of either soyabean or crayfish which are commonly used as supplements in developing countries. Similar results have been obtained with several species of lipidoptera larvae when used as a sole source of protein [10]. The FER and PER values obtained for supplement 4 agreed with reported values for casein supplement [11]. The observation that there was no significant difference in the levels of essential amino acids of supplemented diets seems to suggest that the giant grasshopper protein is of good biological value and these amino acids released and absorbed were well utilized. This is

further supported by the observation that total protein values in serum were almost identical. The almost identical PER value obtained with supplement 4 and compared to PER values of casein appears to suggest the giant grasshopper protein is highly digestible. This would make the amino acids available for absorption thus augmenting growth. Nakagagi and Finke [12] have reported the superiority of house cricket *Acheta domestica* protein to soyaprotein in promoting growth at all levels of intake.

Serum levels of sodium and calcium were significantly higher in supplement 4. The 15% fibre level in giant grasshopper was about thrice the amount of the fibre in laboratory chow and 1½ times the amount in crayfish. Definitely rats on supplement 4 consumed more fibre. Sodium, potassium calcium and phosphorus play a crucial role in fluid balance, enzyme activity and bone growth. Serum level of these cations may be affected by presence of high level of fibre in the diet. The finding that levels of virtually all cations were identical would appear to suggest that the high fibre in diet 4 did not negatively affect mineral bioavailability especially zinc, iron and calcium which are known to be affected by dietary fibre [13, 14, 15].

CONCLUSION

The good quality protein present in giant grasshopper with high biological value as shown by high FER and PER values, together with ease of collection and breeding, and the economic aspects would make it a good quality protein source. Breeding of grasshopper should be encouraged for use in dietary supplementation especially in developing countries such as Nigeria. Additionally, giant grasshopper protein may be included in animal feed formulation.

Table 1: Food intake and gain in body weight of rats and food efficiency ratio (FER) and protein efficiency ratio (PER) of supplements (mean ± S.D of 6 rats)

Dietary group	Food intake(g)	Protein intake (g)	Gain in body weight (g)	FER	PER
1 (Lab.chow)	140.0±1.5	28.6	32.1±2.0	0.22	1.12
2 (Soyabean)	140.0±1.6	28.5	38.0±2.5	0.27	1.33
3 (Crayfish)	139.3±1.8	28.8	48.0±3.1 ^b	0.34 ^b	1.66 ^b
4 (Grasshopper)	140.0±1.5	29.0	56.0±2.0 ^a	0.44 ^a	1.90 ^a

a= significantly higher compared to other supplements (p<0.05)

b= significantly higher compared to soybeans and laboratory chow.

Table 2: Plasma level of essential amino acids and total protein in rats before the start of feeding on supplements

Dietary group	Essential amino acid levels in serum uM/L								Total Protein (g/100ml)
	Ileu	Leu	Lys	Met	Thr	Phe	Val	Trp	
1	0.05	0.066	0.012	0.01	0.15	0.03	0.04	0.004	4.6±0.2
2	0.07	0.06	0.13	0.01	0.18	0.03	0.05	0.003	4.8±0.6
3	0.09	0.075	0.16	0.02	0.16	0.04	0.06	0.01	4.7±0.5
4	0.11	0.08	0.11	0.02	0.18	0.05	0.08	0.02	5.0±0.6

Table 3: Plasma level of essential amino acids and total protein in rats after 4 weeks of feeding on supplements

Dietary group	Essential amino acid levels in serum uM/L								Total Protein (g/100ml)
	Ileu	Leu	Lys	Met	Thr	Phe	Val	Trp	
1	0.06	0.06	0.09	0.016	0.18	0.03	0.040	0.005	4.6±0.1
2	0.07	0.07	0.11	0.012	0.17	0.04	0.040	0.006	4.7±0.0
3	0.08	0.08	0.12	0.013	0.16	0.04	0.045	0.01	5.1±0.2
4	0.09	0.08	0.14	0.015	0.20	0.04	0.050	0.02	4.8±0.2

Values are mean ± SD for three determinations.

Table 4: Effect of giant supplements diet on serum level of Cations (mM litre⁻¹)

Period of dietary feeding	Dietary group	Na	K	Ca	Mg	Zn	Fe
Week 0	1	120.0±6.0	5.4±0.50	1.5±0.02	0.6±0.1	0.02	0.05
	2	121.0±5.0	5.0±0.5	1.4±0.02	0.6±0.1	0.02	0.03
	3	125.0±4.0	5.0±0.45	1.6±0.02	0.5±0.2	0.02	0.03
	4	128.2±3.0 ^a	6.0±0.80	3.5±0.40	0.8±0.1	0.04	0.05
Week 4	1	121.0±3.0	5.5±0.40	2.5±0.10	1.0±0.03	0.02	0.03
	2	120.0±2.0	5.2±0.60	2.2±0.20	1.0±0.05	0.02	0.02
	3	124.2±3.0	5.4±0.70	3.8±0.25	1.0±0.04	0.04	0.03
	4	126.2±2.5 ^a	5.8±0.30	5.0±0.80 ^a	1.5±0.04	0.05	0.06

Values are mean ± S.D for 3 determinations.

a= significantly higher (p<0.05) compared to supplement 1

REFERENCES

1. **Pelletier DL, Frongillo EA and JP Habicht** The effect of malnutrition on child mortality in developing countries. *WHO Bull.*1995;**75(4)**:443- 448.
2. **Temple VJ, Ladeji O, Solomon M and HG Gowok** Proximate Chemical composition of three locally formulated complementary foods. *West Afr.J.Biol.Sci.* 1996; **5(2)**: 134-143.
3. **Ladeji O, Okoye ZSC and Z Waidu** Effect of supplementation of laboratory chow with sorrel leaf on body weight and serum levels of amino acids and minerals in rat. *Food Chemistry* 1997; **59 (1)**: 15-17.
4. **Ejigui J, Savoie L and J Martin** Influence of traditional processing methods on the nutritional composition and antinutritional factors of red peanuts and red kidney beans.*J.Biol.Sci.*2015;**5**:597-605.
5. **Dunkel V and M Berenbaum** Edible insects. *The food insects Newsletter.* 2000; **9 (2)**: 3-6.
6. **Olusola L, Solomon M and H Maduka** Proximate Chemical Analysis of *Zonocerus veriegatus* (Giant Grasshopper) *Nig J. of Biotech* 2003; **14**: 42-45.
7. **Spackman DH and S Moore** Automatic recording apparatus for the chromatography of amino acids. *Anal.Chem* 1998; **30**: 1190-1191.
8. **Kingsley GY** The direct biuret method dor the spectrophotometric determination of serum proteins. *J.Lab. Clin. Med.* 1942; **27**: 840.
9. **Harris LE** Nutrition research.*Techniques for domestic and wild animals* 1970;**1**:84321.
10. **Sabba Rau BH, Ramana KV and N Singh** Studies on the nutritive value of leave proteins. *J.Sci. Food Afric.* 1972; **23**: 233-244.
11. **Sarwar G and FE McDonough** Evaluation of protein digestibility, corrected amino acid score method for assessing protein quality of foods. *J.Ass.of.Anal.Chem.* 1990 ;**73**: 347-56.
12. **Finke A and H Nakagaki** Food insects a source of high quality protein. *J.Econ. Entomol.* 1987 ;**79**: 600-604.
13. **Dahiya S and CA Kapoor** Protein quality of home-processed supplementary foods. *Food Chemistry* 1993; **48 (2)**: 183-188.

14. **Nakagaki B and A Finke** Comparison of diets for mass-rearing *Acheta domesticus* as a novelty food. *J.Econ.Entomol.* 1991; **84**:891-896.
15. **Erdman G** Phytic acid and zinc bioavailability in human nutrition. *J. Agric. Food Chem.* 1979 ; **27 (3)**: 11-14.
16. **Reinhold JG, Faraji B and F Ismail-Beigi** Decreased absorption of calcium, magnesium, zinc and phosphorus by humans due to increased fibre consumption. *J.Nutr.* 1976; **106**: 493-503.
17. **Guthrie B and MF Robinson** Zinc balance studies during wheat bran supplementation. *Fed. Proc.* 1978; **37**: 254-258.

Department of Biochemistry
Faculty of Medical Sciences
University of Jos, Jos, Nigeria

25th March, 2008

The Editor
AJFAND

Dear Sir/Madam

LETTER OF CONSENT TO PUBLISH IN AJFAND

I write to give my consent that the manuscript titled “**Nutritional Evaluation of the Giant Grasshopper Protein And Mineral Bioavailability**”, should be published in your journal.

Thank you

Signed
Dr O.Ladeji

Department of Biochemistry
Federal University of Technology Yola
Adamawa State, Nigeria

12th March, 2008

The Editor –in- Chief
AJFAND

Dear Sir,

MY CONSENT TO PUBLISH IN AJFAND

This is to indicate my consent that our article titled **Nutritional Evaluation of the Giant Grasshopper Protein and the possible effect of its high fibre on amino acid and mineral Bioavailability**, should be published in your esteemed Journal.

Thank you in anticipation of your kind acceptance.

Signed
Hauwa Umoru

