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Nutritional quality, functional properties and anti-nutrient compositions of the larva of *Cirina forda* (Westwood) (Lepidoptera: Saturniidae)

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Abstract: Determination of the proximate, nutritionally valuable minerals and anti-nutrient compositions in larvae of *Cirina forda* (W) showed that they contained high levels of protein, (55.50%±1.20%) with ash, moisture, fat, and carbohydrate levels being (10.26%±0.01%), (10.85%±0.38%), (4.68%±0.01%) and (18.70%±0.84%) respectively. Fibre was not detected. Protein solubility was higher in alkaline media than in acidic media while the isoelectric points were pH 4, 6 and 9 indicating that *C. forda* may be useful in food formulations involving foods like meat products. Phosphorus had the highest value of (215.54±0.21) mg/100 g while manganese had the lowest value of (1.14±0.10) mg/100 g. Copper, Co, Pb, Cr and Ni were not available. Water absorption capacity was (300%±0.15%), oil absorption capacity was (358.44%±0.21%) and foaming stability was (3%±0.00%). The results of anti-nutritional analysis revealed that oxalate and phytic acid contents were (4.11±0.05) mg/100 g and (1.02±0.00) mg/100 g respectively and that these values fell within nutritionally accepted values. Tannin was not detected in *C. forda. C. forda*, a rich source of animal nutrients, usable in human diets and animal feeds formulations.

Key words: *Cirina forda*, Anti-nutrients, Protein solubility, Mineral analysis, Proximate composition
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INTRODUCTION

Insects are the most successful group of animals constituting about 76% of known species of animals (Yoloye, 1988). Insects affect man either as destroyers of man's valuable materials and crops or as sources of his nutrients. Goodman (1989) reported that chitin, an important insect component, can significantly reduce serum cholesterol, and serve as a haemostatic agent for tissue repairs and for accelerating healing of burns and wound. The cultural practice of entomophagy is an old and well-established custom in non-industrialized regions of the world (Sutton, 1988). The high cost of animal protein, which is beyond the reach of the poor has greatly encouraged entomophagy. Insects are valuable sources of animal protein for Zambia's rural population since meat from domesticated and wild animals are scarce (Mwizenge, 1993). A 10% increase in the world supply of animal proteins through mass production of insects can largely eliminate the malnutrition problem and also decrease the pressure on other protein sources (Robert, 1989).

Studies in Nigeria have shown that entomophagy has contributed significantly to the reduction in protein deficiencies in the country (Ashiru, 1988, Fasoranti and Ajiboye, 1993).

Cirina forda is one of the most widely eaten insects in the Southern Nigeria (Fasoranti and Ajiboye, 1993). The larva of this insect is a delicacy served as snacks or taken with carbohydrate food in Nigeria (Anthonio and Isoun, 1982). The present work focuses on the proximate composition, protein solubility, mineral analysis, the functional properties and the anti-nutrient composition of *C. forda.* This work brings into focus the classes of food present in *C.*

forda, shows its mineral constituents, reveals its functional properties and the anti-nutrient compositions for possible domestic and industrial uses.

MATERIALS AND METHODS

C. forda larvae were collected from sheabutter tree. *Crossopteryx febrifuga* was starved for 24 h to eliminate their gut contents and then boiled for two hours before oven-drying at 40 °C for 24 h in laboratory (Fasoranti and Ajiboye, 1993). The dried samples were ground into powder with the laboratory pestle and mortar and kept until required.

Proximate analysis

Proximate analysis of the sample's moisture content, ash, ether extract and fibre content were done using the method reported by AOAC (1990). Nitrogen was determined by the micro-Kjeldahl method reported by Pearson (1976) and crude protein content was subsequently calculated by multiplying the nitrogen content by a factor of 6.25. Carbohydrate content was estimated by subtracting the sum of the weights of protein, fibre, ether extract and ash from the total dry matter and reported as nitrogen-free extractives (NFE by difference). The protein solubility was examined from pH 1~12 by the method of Adeyeye *et al*.(1994). All determinations were in triplicates.

Functional properties

The modified method of Adeyeye *et al*.(2002) was used to determine the foaming capacity, emulsion stability and least gelation capacity of the sample. The method reported by Beuchat (1977) was used to determine the oil absorption, water absorption and emulsion capacities, and the emulsion stability of the sample. All determinations were in triplicates.

Mineral analysis

Minerals were analyzed by the method reported by Oshodi (1992). Minerals were analyzed by dry-ashing 1 g of the sample at 550 °C in a furnace. The ash obtained was dissolved in 10% HCl, filtered with filter paper and made up to standard volume with dionised water. Flame photometry method reported by AOAC (1990) was used to determine sodium and potassium contents of the sample. Corning 405 flame photometer was used (AOAC, 1990). Calcium, Fe, Mg, Zn, Cu, Pb, Ni and Cr were determined using Alpha 4 atomic absorption spectrophotometer (AAS). Phosphorus content was determined by employing the method reported by Vanado Molybate and read on CECIL CE 3041 colorimeter (AOAC, 1990). All determinations were in triplicates.

Anti-nutrient analysis

The estimation of phytin-phosphorus (phytin-P) was by the colorimetric procedure of Wheeler and Ferrel (1971) as modified by Reddy *et al*.(1978). Phytic acid was calculated by multiplying phytin-P by a factor of 3.55 (Enujiugha and Olagundoye, 2001). Oxalate content was determined according to the procedure of Day and Underwood (1986). Tannin content was determined by the qualitative method of Markkar and Goodchild (1996) as modified by Enujiugha and Ayodele-Oni (2003). All determinations were in triplicates.

RESULTS AND DISCUSSION

The result of the proximate composition of *C. forda* is shown in Table 1. The moisture content was quite low (10.85%±0.38%) which may be advantageous in view of the sample's shelf-life. The result showed that *C. forda* is quite rich in protein (55.50%±1.20%). This value is higher than the values reported in the larval and adult stages of *Zonocerus variegatus* (50.39%±2.01%)~(53.10%±0.56%) by Adedire and Aiyesanmi (1999). However, the protein value compares favourably with the values obtained for periwinkle, *Pachymelania bryonensis*, (55.00%) and dogwhelk, *Thais cattifera*, (56.44%) (Mba, 1980; Udoh *et al*., 1985). Thus, *C. forda* could contribute

Table 1 Proximate composition of *C. forda* larva

Parameters	Percentage (%)
Moisture content	10.85±0.38
Protein content	55.50±1.20
Crude fat content	4.68±0.01
Ash content	10.26±0.01
Fibre content	Not available
Carbohydrate content (by difference)	18.70±0.84

Mean±*SD* of triplicate determinations

significantly to the recommended human daily protein requirement of 23%~56% stipulated by NRC (1980).

The ash content of *C. forda* averaged (10.26%±0.01%) which is higher than the values obtained for termites, *Trinervitermes germinatus*, (5.39%~13.90%) by Ajakaiye and Bawo (1990) but lower than the value obtained for *Chrysichthys* species, (17.9%) by Mba (1980). Since the ash content of a sample is a reflection of the minerals it contains, *C. forda* is therefore very rich in minerals as shown in Table 2 and could be particularly useful for children and pregnant and lactating women.

Table 2 Mineral composition of *C. forda* larva

Minerals	Amount (mg/100 g)
Sodium	45.26±0.01
Potassium	64.02±0.02
Calcium	33.16±0.10
Magnesium	62.31±0.01
Phosphorus	215.54±0.21
Zinc	3.81±0.01
Iron	5.34±0.11
Manganese	1.14±0.10
Copper	Not available
Cobalt	Not available
Lead	Not available
Chromium	Not available
Nickel	Not available

Mean±*SD* of triplicate determinations

The crude fat content was low, 4.68%±0.01%, lower than the values obtained for *Z. variegatus* (17.65%±3.24%)~(22.93%±3.37%) by Adedire and Aiyesanmi (1999). Fats are essential in diets as they increase the palatability of foods by absorbing and retaining their flavours (Aiyesanmi and Oguntokun, 1996), are also vital in the structural and biological functioning of the cells and help in the transport of nutritionally essential fat-soluble vitamins.

Crude fibre was not detected but the amount of carbohydrate obtained, (18.70%±0.84%) was higher than the values reported for *Z. variegatus* (9.68%±1.35%)~(12.07%±0.76%) by Adedire and Aiyesanmi (1999). The high carbohydrate content of *C. forda* makes it a good quality food.

The mineral element composition of *C. forda* is shown in Table 2. The result showed that phosphorus has the highest concentration, (215.54±0.21) mg/100 g while manganese recorded the lowest value of (1.14±0.10) mg/100 g. The next abundant mineral element was potassium which recorded (64.02±0.02) mg/100 g. Calcium averaged (33.16±0.10) mg/100 g. This value is lower than the value reported for the red ant, *Atta cephalotes* (47.8 mg/100 g) by Dunkei (1996). Zinc and iron content were (3.81±0.01) mg/100 g and (5.34±0.11) mg/100 g respectively. Dunkei (1996) reported that the giant cricket, *Brachytrupes membranaceus* has 9.5 mg/100 g of zinc while silkworm, *Bombyx mori* has 1.8 mg/100 g of iron respectively. Since *C. forda* is rich in iron, the blood building element, it would be desirable for human and animal consumption. Copper, cobalt, lead, chromium and nickel were not available in *C. forda* larva.

The result on the pH effect on protein solubility is shown in Fig.1. It shows lower solubility in acid media. Higher solubility values were obtained in alkaline media and the isoelectric points (IEP) values are 4, 6 and 9.

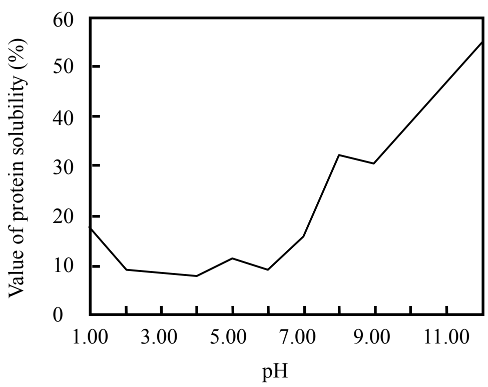

Fig.1 Protein solubility as a function of pH effects on *C. forda* larva

The high pH solubility of *C. forda* protein in alkaline media indicated that it might be useful in the formulation of food like meat products. The solubility of protein depends on hydration and the degree of hydrophobicity of the protein molecules (Sathe and Salunkhe, 1981). Denaturation processes may cause reduction in the hydration of protein thus, exposing more hydrophobic groups and thereby reducing the solubility of the protein in the lower pH regions (Aladesanmi *et al*., 1997). Perutz (1978) reported that the electrostatic interactions (ionization of interior non-polar groups) are more important than the surface change in the hydration of protein and might have contributed immensely to the improved protein solubility obtained for *C. forda* in the alkalinic pH regions. The possession of 3 isoelectric points (IEP 4, 6 and 9) suggests that *C. forda* has more than one major protein constituent.

The result on the functional properties of *C. forda* is shown in Table 3 indicating that the least gelation concentrate of *C. forda* is 6%. This value is similar to the value reported for bovine plasma protein concentrate, (BPPC, 6%) by Aladesanmi *et al.*(1997). This result will enhance the uses of *C. forda* in various food applications such as in comminuted sausage products and in new product developments where gelation may be needed to provide increased gel strength. The water absorption capacity was (300.00%±0.15%). This shows that *C. forda* is highly hydrophilic. Oil absorption capacity averaged (358.44%±0.21%). Oil absorption capacity is important since oil acts as flavour retainer and increases the palatability of foods (Kinsella, 1976). The emulsion capacity averaged 36.67%±0.11% while emulsion stability was 45.36%±0.21%. These relatively high levels of emulsion capacity and emulsion stability suggest that *C. forda* would be highly desirable for preparing comminuted meats.

Table 3 Functional properties of *C. forda* larva

Parameters	Percentage (%)
Water absorption capacity	300.00±0.15
Oil absorption capacity	358.44±0.21
Emulsion capacity	36.67±0.11
Emulsion stability	45.36±0.21
Foaming capacity	7.10±0.20
Foaming stability	3.00±0.00
Least gelation	6.00±0.00

Mean±*SD* of triplicate determinations

Foam formation and foam stability are functions of the type of protein, pH, processing methods, viscosity and surface tension (Yasumatsu *et al.*, 1972). The foaming capacity and foaming stability of *C. forda* were (7.10%±0.20%) and (3.00%±0.00%) respectively. Akubor and Chukwu (1999) reported that foams are used to improve the texture, consistency and appearance of foods.

The result of the anti-nutrient composition of *C. forda* is shown in Table 4. Phytic acid averaged (1.02±0.00) mg/100 g while oxalate recorded (4.11±0.05) mg/100 g. These values are lower than those reported in some proteinous foods. Vijayakumari *et al.*(1997) reported that 513 mg of phytic acid is present in 100 g of *P. chilensis*. *P. chilensis* is a legume that is very rich in methionine and cystine (de Lumen *et al.*, 1986). Enujiugha and Ayodele-Oni (2003) reported that tannin was not detected in *C. forda*.

Table 4 Anti-nutrient composition of *C. forda* larva

Anti-nutrient	Amount (mg/100 g)
Phytic acid	1.02±0.00
Oxalate	4.11±0.05
Tannin	Not detected

Mean±*SD* of triplicate determinations

The results of this work showed that *C. forda* is a rich source of nutrients and so may be recommended for consumption by economically weaker sections of populations throughout the developing countries, most especially in Africa and Asia, to alleviate the problem of nutrient/protein malnutrition. Further work is geared towards ascertaining the amino acid composition of *C. forda*.

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