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Nutritional Evaluation, Functional Properties and Anti-Nutritional Factors of *Macrobrachium rosenbergii*, an Underutilized Animal

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Abstract. The proximate, nutritionally valuable minerals, functional and anti-nutritional factors of *Macrobrachium rosenbergii* were determined in the laboratory for human consumption. Results indicated a high protein content (68.88 ± 0.56%), ash (15.33 ± 0.14%), moisture (9.37 ± 0.03%), fat (5.36 ± 0.01%) and carbohydrate (1.06 ± 0.00%), while fibre was not detected. Protein solubility was pH dependent with minimum and maximum protein solubilities at pH 2, pH 6 and pH 11. Nutritionally valuable mineral analyses showed that *M. rosenbergii* contains phosphorus (126.18 ± 0.032 mg/100 g), magnesium (86.44 ± 0.10 mg/100 g), potassium (64.24 ± 0.20 mg/100 g), sodium (57.53 ± 0.15 mg/100 g), calcium (49.54 ± 0.11 mg/100 g), iron (7.20 ± 0.02 mg/100 g), manganese (0.89 ± 0.01 mg/100 g) and zinc (0.69 ± 0.01 mg/100 g). Copper, cobalt, lead, nickel and chromium were not detected. The sample had a minimum gelation concentration of (8.5 ± 0.10%), water absorption capacity (345.00 ± 0.30%), oil absorption capacity (521.36 ± 0.12%), foaming capacity (15.00 ± 0.05%), foaming stability (2.20 ± 0.01%, emulsion capacity (22.62 ± 0.03%) and emulsion stability (45.50 ± 0.15). Three anti-nutrients were determined: phytic acid was 4.00 ± 0.01 mg/100 g, oxalate 1.05 ± 0.00 mg/100 g while tannin was not detected.

Keywords: *M. rosenbergii,* protein solubility, functional properties, anti-nutrients, proximate composition

Introduction

One of the greatest challenges to man is facing, is the production and consumption of animal proteins in adequate proportions to aid the growth and development of the body. However, other nutrients, such as minerals, are also becoming a concern. In Nigeria, the use of prawn by nursing mothers and as additive in weaning food compositions is generally gaining acceptance. Some of the farmed crustaceans in Nigeria, include the prawn *(Macrobrachium rosenbergii, Penaeus* spp.*)* fresh water crab *(Cardisoma armatum),* marine crab *(Callinectes sapidus)* and crayfish *(Astacus)* (Yoloye, 1994). All these are consumed to supply animal proteins to the body.

In India, the white prawn *(Fenneropenaeus indicus*) and the tiger prawn *(Penaeus monodon*) are of great commercial importance, and they are extensively farmed along the eastern coast of India (Khan *et al.,* 2001). The meat of *M. rosenbergii* is good and it has longer shelf-life when preserved in a refrigerator. Leito and Rios (2000) reported that storing of *Macrobrachium rosenbergii* at 0 °C increases the shelf-life, pH, and the L-tryptophan levels of the prawn.

In Nigeria, most of the published papers are on shrimps of marine origin (particularly *Penaeus* spp.). Only a few studies are available on freshwater shrimps or prawns (genus *Macrobrachium* and others), which are assuming increasing economic importance since they are the cheapest sources of animal protein in the country. This work was conducted to determine the proximate composition, functional properties, mineral constituents and anti-nutritional composition of the freshwater prawn *(M. rosenbergii)* as a cheap source of animal nutrients.

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Materials and Methods

Macrobrachium rosenbergii samples were purchased from the Oba's Market in Ado-Ekiti, Ekiti State of Nigeria. The samples were sorted out of shaft and dried in a Gallenkamp oven at 60 °C to a constant weight according to the procedures described by Adedire and Aiyesanmi (1999). The dried sample was ground into powder with the laboratory pestle and mortar and kept until required. The moisture content, crude protein, fibre, ash and crude fat of the larvae and adults were determined by the methods described in AOAC (1990). Carbohydrate was calculated by difference. The variation of protein solubility with pH was determined using the method described by Adeyeye *et al.* (1994). The emulsion capacity and emulsion stability were determined by the method described by Sathe and Salunkhe (1981). The least gelation concentration, water absorption and oil absorption capacities and foaming properties were determined using the methods described by Adeyeye *et al.* (2002). Minerals were analyzed by dry-ashing 1g of the sample at 550 °C in a furnace by using the method reported by Oshodi (1992). The ash was dissolved in 10% HCl and filtered. Flame photometer model Corning 405

was used to determine sodium (Na) and potassium (K) contents. Calcium (Ca), iron (Fe), magnesium (Mg), zinc (Zn), copper (Cu), lead (Pb), nickel (Ni) and chromium (Cr) were determined by using atomic absorption spectrophotometer (model Alpha 4). Vanadomolybdate method was used to determine phosphorus content while CECIL colorimeter (mode CE-3041) was used to read absorbance at 725 nm. The estimation of phytin-phosphorus in the sample was determined by the modified methods of Enujiugha and Olagundoye (2001). Phytic acid was calculated by multiplying phytin-P by the factor of 3.55 (Enujiugha and Olagundoye, 2003). Oxalate content was estimated by the method of Day and Underwood (1986). Tannin content was determined by the qualitative method of Markkar and Goodchild (1996).

Results and Discussion

The proximate composition of *M. rosenbergii* is shown in Table 1. Protein and ash represent the major components of the sample. The high level of protein (68.88 ± 0.56%) makes *M. rosenbergii* a good source of protein than the soybean (48%) (FAO, 1981). The protein content values of *M. rosenbergii* agrees with the values reported by DeConconi *et al.* (1984) for some edible insect (45% to 81.7%). Both adults and children can get their daily minimum protein requirements by eating *M. rosenbergii*. The total ash content (15.33 ± 0.14%) is lower than that reported for adult *Zonocerus variegatus* (18.31 ± 3.43%) (Adedire and Aiyesanmi, 1999). The moisture content of 9.37 ± 0.03% is lower than that reported by Adedire and Aiyesanmi (1999) for the first instar stage of *Zonocerus variegatus* (35.071 ± 0.85%). Fibre was not detected in the sample but the value of carbohydrate and fat are 1.06 ± 0.00% and 5.36 ± 0.01%, respectively.

Table 2 shows the result of the mineral composition of *M. rosenbergii*. Phosphorus has the highest value of 126.18 ± 0.32 mg/100 g, magnesium 86.44 ± 0.10 mg/100 g, potassium 64.24 ± 0.20 mg/100 g, sodium 57.53 ± 0.15 mg/100 g, calcium 49.54 ± 0.11 mg/100 g, iron 7.20 ± 0.02 mg/100 g, manganese 0.89 ± 0.01 mg/100 g while zinc was least with a value of 0.69 ± 0.01 mg/100 g. These results show that *M. rosenbergii* is rich in minerals that are very essential for human growth and development. The values of sodium, potassium, phosphorus, calcium and magnesium would promote bone formation and development in adults and babies. These minerals are very essential for the babies that have just passed through the 3-4 months weaning period. The value of iron in the sample would also enhance the production of red blood cells which are very vital for life. The high content of iron and zinc in the sample are of particular interest since iron deficiency is a major problem in women diets in the developing countries, particularly among pregnant women and even children in Africa and Asia. Copper, cobalt, lead, nickel and chromium were not detected. Some of the physiological functions involving mineral elements include the regulation of body water, maintenance of acid-base balance, muscular contractions, normal response of nerves to stimulations and clotting of blood (Mudambi and Rajagopal, 1987). It is apparent from this study that *M. rosenbergii* is adequately equipped with food nutrients and mineral elements to cope with the physiological and metabolic demands of development.

The results of the pH effects on protein solubility are shown in Fig. 1. It shows high solubility in both acidic and alkaline media. The isoelectric point values are pH 2, 5 and 8. The isoelectric point of *M. rosenbergii* is close to the values reported by Ige *et al.* (1984) for some Nigerian oil seeds (IEP pH 6 and 8). The high solubilities of *M. rosenbergii* in both acidic and alkaline media indicate that it may be useful in the formulations of meat products and carbonated beverages (Olaofe *et al.*, 1998, 1993). The possession of 3 isoelectric points show that *M. rosenbergii* have more than one major protein constituents.

Table 1. Biochemical composition (% with mean ± Sd) of *M. rosenbergii*

Parameters	Percentage
Moisture	9.37 ± 0.03
Protein	68.88 ± 0.56
Ash	15.33 ± 0.14
Fat	5.36 ± 0.01
Fibre	Not detected
Carbohydrate	1.06 ± 0.00

Table 2. Mineral profile (mg/100 g with ± Sd) of *M. rosenbergii*

Minerals	Percentage
P	126.18 ± 0.32
Mg	86.44 ± 0.10
K	64.24 ± 0.20
Na	57.53 ± 0.15
Ca	49.54 ± 0.11
Fe	7.20 ± 0.02
Mn	0.89 ± 0.01
Zn	0.69 ± 0.01
Cu	ND
Co	ND
Pb	ND
Ni	ND
Cr	ND

ND = not detected

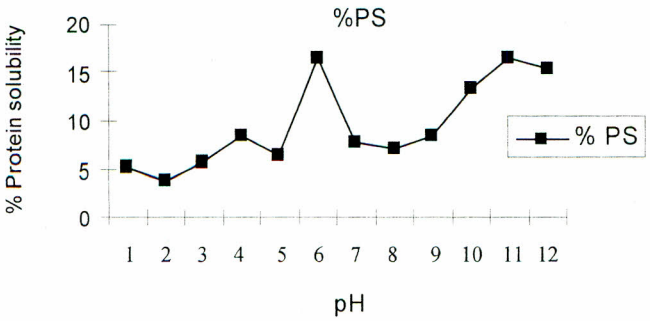

Fig. 1. pH effect on protein solubility in *M. rosenbergii* in Ado Ekiti, Nigeria.

The results of the functional properties are shown in Table 3. The water absorption capacity observed for *M. rosenbergii* (345.00 ± 0.30%) is higher than that of *Telfairia occidentalis* (85.0 ± 0.05%) and *Parkia biglobosa* (87.50 ± 0.00%) reported by Fagbemi and Oshodi (1991) and Adeyeye *et al.* (2002), respectively. The oil absorption capacity of *M. rosenbergii* (521.36 ± 0.12%) is higher than that reported by Oshodi and Ekperigin (1989) for *Cajanus cajan* (89.70%) and by Akubor and Chukwu (1999) for *Pentaclethra macrophylla* (89% - 115%). The foaming capacity (15.00 ± 0.05%) and foaming stability (2.20 ± 0.01%) are lower than that reported by Oshodi and Ekperigin (1989) for *Cajanus cajan* (160.00% and 14.60%, respectively). The low values favour their use as whipping toppings. The value of the lowest gelation concentration is 8.50 ± 0.10%. This value is lower than that reported for lupin (14%) by Sathe *et al.* (1982). *M. rosenbergii* would be very useful in the production of curd or as additives to other materials for forming gel in food products. The emulsion capacity and emulsion stability are 22.62 ± 0.03% and 45.50 ± 0.15%, respectively. The emulsion capacity and emulsion stability of 18.6% - 27.3% and 13.6% - 33.6%, respectively have been reported for bovine plasma protein concentrate in different salts (Oshodi and Ojokan, 1997). The high levels of emulsion capacity and emulsion stability of *M. rosenbergii* suggest that it would be desirable for the preparation of communited meats like sausages.

Table 3. Functional properties (%) of *M. rosenbergii*

Parameters	Mean ± Sd
Water absorption capacity	345.00 ± 0.30
Oil absorption capacity	521.36 ± 0.12
Foaming capacity	15.00 ± 0.05
Foaming stability	2.20 ± 0.01
Emulsion capacity	22.62 ± 0.03
Emulsion stability	45.50 ± 0.15
Least gelation	8.50 ± 0.10

Table 4 shows the levels of antinutrient substances in *M. rosenbergii.* Phytic acid has the highest value of 4.00 ± 0.01 mg/100 g, followed by oxalate 1.05 ± 0.00 mg/100 g while tannin was not detected in the sample. The level of phytic acid was lower than that reported for *Dioclea reflexa* 318.40 ± 0.30 mg/100 g (Aiyesanmi and Oguntokun, 1996) and for *Prosopis chilensis* 442 to 499 mg/100 g (Vijayakumari *et al.*, 1997). The lower level of phytic acid in *M. rosenbergii* would not cause any nutritive impairment in man. Phytate and polyphenols, which are widely distributed in legumes have been reported to inhibit iron absorption in man (Layrisse *et al.*, 1998). However, incorporation of vitamin A and phytase into foods have been reported to remove the inhibition (Layrisse *et al.*, 1998).

Table 4. Anti-nutrient composition (mg/100 g) of *M. rosenbergii*

Parameters	Mean ± Sd
Phytic acid	4.00 ± 0.01
Oxalate	1.05 ± 0.00
Tannin	ND

ND = not detected

The anti-nutritional nature of phytin lies in its ability to chelate proteases, amylases and mineral elements, especially calcium, magnesium, zinc and iron, thereby rendering them metabolically unavailable to man (Sharma and Sehgal, 1992). Continuous deprivation of these nutrients would subsequently lead to the development of oesteomalacia in animals (Forbes and Erdman, 1983). The oxalate level of *M. rosenbergii* (1.05 ± 0.00 mg/100 g) is lower than reported for *Ricinus communis* seeds (6.5 g/kg) by Enujiugha and Ayodele-Oni (2003).

Conclusion

This work has revealed the high potentials of *M. rosenbergii,* which have been hitherto underutilized. If consumed in adequate quantities, *M. rosenbergii* would alleviate the nutrient deficiencies prevalent in Nigeria and most of the developing countries in Africa and Asia. This view was also culminated from the recent increases in the prices of animal proteins. *M. rosenbergii* being very high in protein and mineral contents but low in anti-nutritional factors is recommended for adult consumption. Incorporation of *M. rosenbergii* into the weaning foods given to babies after the 4 to 6 months exclusive breast feeding would produce better results. This would supply the nutrient needs of the adults and the growing babies for months before they (i.e. children) are finally introduced to the family diets.

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