Nutritive value of the larvae of raphia palm beetle (Oryctes rhinoceros) and weevil (Rhyncophorus pheonicis)

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Abstract: The proximate nutrient composition, energy value, mineral concentrations, amino acid composition and chemical score of the larvae of raphia palm beetle (Oryctes rhinoceros) and weevil (Rhyncophorus pheonicis) were evaluated. Values of moisture, ash and crude protein were significantly (p < 0.05) higher in O rhinoceros than in R pheonicis while the reverse was the case for the values of crude fat, total carbohydrate and energy content. The crude protein content of both samples was high, with a value of 42.3 ± 0.84% for the palm beetle and 31.6 ± 0.59% for palm weevil, while crude fat was high (17.3 ± 1.2%) in palm weevil and very low (0.55 ± 0.10%) in palm beetle. The caloric value in kcal 100 g−1 sample was 425 in R pheonicis and was significantly higher (p < 0.05) than the value of 285 in O rhinoceros, due to a relatively higher crude fat and total carbohydrate in the former compared with the latter. The mineral concentrations were high and differed for all the elements, with O rhinoceros having the higher level of many of the mineral elements (calcium, magnesium, potassium, manganese, iron and phosphorus) compared with R pheonicis, consistent with a significantly higher (p < 0.05) ash content of 12.7 ± 0.81% in O rhinoceros against the value of 4.2 ± 0.45% ash in R pheonicis. The amino acid profile showed both samples to be good sources of essential and non-essential amino acids including cysteine and methionine, both of which contain sulfur. Valine, which had the lowest chemical score of 51.2%, was the most limiting amino acid for protein quality in both O rhinoceros and R pheonicis.

Keywords: Oryctes rhinoceros; Rhyncophorus pheonicis; larvae; nutritive value

INTRODUCTION

One of the most pressing nutritional problems facing the Nigerian populace and that of other developing nations of the world is how to augment the shortage of protein in diets of a large section of its population. On a global scale, there have been numerous suggestions on how to solve the problem of protein shortage.1–3 In a number of these suggestions, aimed directly at increasing the availability of protein foods, single-cell proteins and fish protein concentrates were stressed. Other approaches recommended the use of green leaves and leaf protein concentrates as supplements and vegetable and fish protein concentrates were stressed. Other approaches recommended the use of green leaves and leaf protein concentrates as supplements and vegetable proteins with complementary amino acid patterns.4

There is widespread protein-energy malnutrition (PEM) in Nigeria.5,6 Because of protein and energy deficiencies in foods such as Ogi, produced from cereal grains, attempts have been made to improve the nutritional quality of maize-based traditional weaning foods by supplementation with unfermented protein-rich legumes and oil seeds, and these attempts have met with limited success.7–9 Ossai and Malomo9 also reported protein-energy malnutrition as one of the most important nutritional deficiency problems in developing countries of the world. More recently, in Nigeria, PEM among children under four years occurs at a very low rate in males and females and was not sex-dependent.10 PEM in male and female children under four years of age also decreased haematological parameters (packed cell volume, haemoglobin concentration, white blood cell count) as well as biochemical parameters such as total blood protein and albumin, while the activities of serum glutamateoxalo acetate transaminase (SGOT), serum glutamate pyruvate transaminase (SGPT) and serum alkaline phosphatase (SALP) were elevated due, probably, to infections associated with PEM.11,12 The peasants in the northern states consume cereals and cereal products, fermented milk and milk products and some legumes as protein supplements. There are cases of true protein deficiency (kwashiokor) in many of the southern villages due to relatively high intakes of foods rich in carbohydrate, such as cassava, yam,
cocooyam and rice, without adequately supplementing their meals with fish, meat, small terrestrial game animals and other aquatic protein foods. In Nigeria, most peasants consume pap and akara in the morning, garri/cassava fufu in the afternoon and yam in the night, all of which are carbohydrate in nature. A large population of villagers also consume rice, which is carbohydrate in nature, at least once in three days in the understanding that by so-doing, they are changing diet (Onyeike EN, Morris PI, unpublished). In Nigeria, especially in the southeast, southwest and south-south geopolitical zones of Nigeria and especially in the reverine areas, the peasants supplement their meals of cassava, yam, cocooyam, rice and musa cultivars (plantain and banana) with small terrestrial game animals, fish and other aquatic protein foods. Other protein sources in their foods include snails, lizards, snakes and other reptiles, insect larvae, crickets, termites and similar insects as well as crayfish, crabs and slow-flying birds. These lesser known protein sources contain high levels of trace elements, mineral salts, protein with commendable essential amino acid patterns so that, if consumed in adequate quantity they could effectively combat this protein shortage.

*Oryctes rhinoceros* (palm beetle) and *Rhyncophorus pheonicis* (palm weevil) are common pests of raphia palm and *O rhinoceros* is so named because the adult beetle resembles the rhino. The palm beetle (Fig 1) and palm weevil (Fig 2) are predatory, feeding on the palm leaves, flowers and fruits. It is the adult that causes the most damage to the palm; the larvae feed only on decaying organic matter (palm logs, manure and rubbish dumps). Like other beetles and weevils, they undergo metamorphosis from egg to adult through larval and pupal stages. In Nigeria, especially in the southeast, southwest and south-south geopolitical zones where palms are cultivated on a commercial basis, the larvae of *O rhinoceros* and *R pheonicis* are a delicacy and are highly valued. These larvae are either eaten raw, boiled, fried or roasted and are sometimes used in the preparation of stews and soups. In Sapele in the south–south zone of Nigeria the larvae of both beetle and weevil are called ‘edible’. In Warri, also in the south–south zone, they are called ‘diet’.

Unfortunately, little is known of the nutritive value of many of these customary food items. The study reported here represents part of the general evaluatory tests on some of these customary items of food of the Nigerian peasants. Such information, it is believed, would lead to more judicious use of these food materials by Nigerians in particular and the international community in general.

**EXPERIMENTAL**

**Origin, preparation and storage of samples**

Live samples of the palm beetle (*O rhinoceros*) and weevil (*R pheonicis*) larvae were obtained from Obigbo town in Oyigbo Local Government Area of Rivers State in the south-south zone of Nigeria. They were purchased fresh from local palm wine tappers who harvested them from pest-infested and felled palm trees. The harvested larvae were sorted, cleaned, washed in deionised water and dried in an oven (Plus 11 Oven, Sanyo, Gallenkamp PLC, UK) at 105 °C for 20 h. The samples were then milled using a food grinder (Model MX 491 N, National, Sheffield, UK) to pass through a 30-mesh sieve, wrapped in dark polyethylene bags, sealed in a clean dry air-tight container and stored in a refrigerator at 4 °C for 4 days prior to analyses.

**Sample analyses**

The analyses of samples were done by pooling the larvae as composite samples. Proximate analysis was carried out to determine moisture, ash, crude fat and crude protein according to the methods of the Association of Official Analytical Chemists (AOAC). The AOAC method numbers were 14.004, 14.006, 7.062 and 2.057 for the determinations of moisture, ash, crude fat and crude protein. Moisture was determined by heating three 5.0-g samples of the wet substrate to constant weight in a hot air-circulating oven at 105 °C.
Ash was obtained by the incineration of three 1.0-g batches of the dried samples in a muffle furnace (LMF4 Carbolite, Bamford, Sheffield, UK) at 550°C for 6 h. Crude fat was determined by exhaustively extracting three replicates of 5.0-g samples in the Soxhlet apparatus using petroleum ether (bp 40–60°C) as the extractant.\textsuperscript{16,17} Crude protein was determined by the Kjeldahl method\textsuperscript{16} (AOAC Method number 2.057) in which nitrogen (N) was determined and % nitrogen in the meat sample, multiplied by a factor of 6.25 to obtain % protein, since proteins, on average, contain 16% nitrogen (100/16 = 6.25). The method involved the digestion of three 2.0-g samples with concentrated H\textsubscript{2}SO\textsubscript{4}, distillation of the digest to liberate ammonia which was trapped into 2.0% boric acid solution, followed by titration with 0.10 M HCl. Total carbohydrate was calculated by difference as reported.\textsuperscript{17} The energy content was calculated by multiplying the mean values of crude protein, crude fat and total carbohydrate by the Atwater factors of 4, 9 and 4, respectively, taking the sum of the products and expressing the result in kcal 100 g\textsuperscript{-1} sample as reported.\textsuperscript{18,19}

The minerals, calcium, magnesium, manganese, iron, copper and phosphorus, were determined by atomic absorption spectrophotometry.\textsuperscript{20} The samples were dry-ashed in a muffle furnace at 550°C for 6 h, the minerals extracted from ash with 20 ml of 2.50% HCl, heated in a steam bath to reduce the volume to 8.0 ml, which was transferred quantitatively to a 50-ml volumetric flask and diluted to volume using deionised water. The extracts were stored in dry clean plastic sample bottles and the mineral concentrations determined using an atomic absorption spectrophotometer (Perkin-Elmer, Model 2380, Sigma Chemical Company, St Louis, MO, USA). Sodium and potassium were determined by the flame photometric method of Chapman and Pratt\textsuperscript{21} using a low temperature direct reading digital single-channel emission flame photometer (Model PEP 7, Jenway Ltd, Dunmow, Essex, UK).

For amino acids analyses, 50 ml of 6.0 M HCl containing 25.0 µl of mercaptoethanol to protect half the cystine and methionine from oxidation\textsuperscript{22} were added to 1.0-g samples and refluxed under a stream of nitrogen at 110 ± 5°C for 24 h. The acid protein hydrolysate was cooled to room temperature (29 ± 1°C), filtered through Whatman Number 52 filter paper to remove any visible humin sediments, the humin precipitate washed with deionised water, the volume of the filtrate made up to 100 ml and 20 ml placed in a desiccator over potassium hydroxide and beside phosphorous(V) oxide.\textsuperscript{23} The desiccator was evacuated overnight to approximately 10 mm Hg to remove hydrochloric acid and dry the hydrolysate. The dried residues were dissolved in 25.0 ml of 0.20 M citrate buffer, pH 2.2, and the amino acids were estimated\textsuperscript{24} using the Technicon TSM-1 0209 Automated Amino Acid Analyzer (Model 1993, Essex, UK).

The concentration of each essential amino acid in a food protein is expressed as a percentage of the content of the same essential amino acid in a reference (whole hen’s egg) protein. That is, the ratio of essential amino acid in a food protein to that of the same amino acid in egg protein expressed as a percentage is known as the chemical score. The amino acid having the lowest chemical score is known as the limiting amino acid. Chemical score was in this study calculated by the method of Mitchell and Block.\textsuperscript{25}

Chemical score = \frac{\text{essential amino acid in food protein}}{\text{same essential amino acid in egg protein}} \times 100

Data analyses

The data in Table 1 were analysed statistically by use of Student’s t-test\textsuperscript{26} and significance was accepted at 5% level (\(p = 0.05\)). For mineral and amino acid compositions as well as chemical scores (Tables 2–5), means of duplicate determinations were calculated.

RESULTS AND DISCUSSION

The proximate composition and energy value of the samples investigated are shown in Table 1. The moisture contents were 16.7 ± 0.49% and 11.3 ± 0.77% for \(O\) rhinoceros and \(R\) pheonicis, respectively. These values were high compared with that of caterpillar (9.0%) but lower than those of hen’s egg (74.0%), termite (45.0%) and cow milk (85.0%).\textsuperscript{27} The relatively high moisture content of the samples suggests that they may be liable to bacterial spoilage during storage.\textsuperscript{28} The ash content of \(O\) rhinoceros (12.7 ± 0.81%) was significantly higher (\(p < 0.05\)) than that of \(R\) pheonicis (4.2 ± 0.45%). Both samples had high ash content indicating that they are good sources of mineral elements. \(O\) rhinoceros and \(R\) pheonicis had ash contents of more than 3.0% and are therefore of nutritional importance as a previous report has indicated that, when leaves are to be used as food for humans, they should contain about 3.0% ash.\textsuperscript{29}

Table 1. Proximate composition and energy content of Onyctes rhinoceros and Rhyncophorus pheonicis

<table>
<thead>
<tr>
<th>Constituents</th>
<th>(O) rhinoceros</th>
<th>(R) pheonicis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>16.7 ± 0.49a</td>
<td>11.3 ± 0.77b</td>
</tr>
<tr>
<td>Ash</td>
<td>12.7 ± 0.81a</td>
<td>4.2 ± 0.45b</td>
</tr>
<tr>
<td>Crude protein</td>
<td>42.3 ± 0.84c</td>
<td>31.6 ± 0.59d</td>
</tr>
<tr>
<td>Crude fat</td>
<td>0.55 ± 0.10f</td>
<td>17.3 ± 1.24e</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>27.7 ± 0.50h</td>
<td>35.6 ± 0.90g</td>
</tr>
<tr>
<td>Energy value (kcal)</td>
<td>285m</td>
<td>425m</td>
</tr>
<tr>
<td>(100 g\textsuperscript{-1} sample)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(a\) Values are means ± standard deviations of triplicate determinations. Values in the same row bearing different letters are significantly different at the 5% level (\(p = 0.05\)).
The protein levels of 42.3 ± 0.84% for *O rhinoceros* and 31.6 ± 0.59% for *R pheonicis* show that the samples are good protein sources. The values were higher than those of termite (20.0%), cow milk (3.8%), hen’s egg (12.4%) and dry locust; which was 53.0%, and beef (18.0%). They were, however, lower than those of caterpillar, which ranged from 49.0 to 68.0%. It is probable that the larvae may contain significant concentrations of non-protein nitrogenous polymers and that multiplying the total nitrogen by 6.25 may overestimate the true protein content. However, in most up-to-date nutritional studies, the Kjeldahl method has been employed in the measurement of total organic nitrogen irrespective of source (nucleic acids, glycoproteins, nitrosamine, glucosamine etc). The Kjeldahl method is suitable for the measurement of total organic nitrogen which may include nucleic acids and other nitrogen-containing compounds in addition to proteins. The protein content of *R pheonicis* was comparable to the 27.4% obtained by Morah. The high level of protein in the two samples may indicate that they can contribute significantly to the daily protein requirement of 23–56 g for humans as recommended by the National Research Council. Diets based on these samples are therefore recommended as good sources of protein for growing children, pregnant and nursing mothers, as well as individuals suffering from protein deficiency diseases, such as kwashiorkor, and all those at risk of protein deficiency diseases and disorders. Crude fat and total carbohydrate were significantly higher (*p* < 0.05) in *R pheonicis* than in *O rhinoceros*. The crude fat content of *R pheonicis* was comparably higher than those of caterpillar (15.0%), hen’s egg (10.0%) but lower than those of cow milk (48.0%) and termite (28.0%).

The energy content of 425 kcal 100 g⁻¹ sample for *R pheonicis* was significantly (*p* < 0.05) higher than that for *O rhinoceros*, which was 285 kcal 100 g⁻¹ sample. In order to provide the body with an energy intake of 2750 kcal, consumption of 964.8 g and 647.5 g of *O rhinoceros* and *R pheonicis* would be required, respectively. This energy value of 2750 kca ls, falls within the range of the daily energy need of 2500–3000 kcal reported for adults. In Nigeria today, the larvae of these beetles and weevils are in high demand as food materials that could combat protein and energy shortage. It also follows that if these larvae are consumed at only 290 g daily, *O rhinoceros* would provide an energy value of 827 kca ls while *R pheonicis* would give an energy value of 1232 kca ls. These energy values are within the range (800–1200 kcal) recommended by the Food and Agriculture Organization (FAO).

The mineral concentrations (mg 100 g⁻¹) of *O rhinoceros* and *R pheonicis* are presented in Table 2. Calcium, magnesium, potassium, manganese, iron and phosphorus were higher in *O rhinoceros* than in *R pheonicis*, though values for sodium and copper were significantly (*p* < 0.05) higher in the latter than in the former. Values of calcium and phosphorus were respectively significantly (*p* < 0.05) lower than those of cow milk (145 and 95 mg 100 g⁻¹), hen’s egg (45 and 200 mg 100 g⁻¹) and beef (13 and 120 mg 100 g⁻¹). It follows that diets formulated with these larvae may not be adequate for growing children whose calcium turnover is very rapid and who are prone to osteomalacia (softening of the bones), older women and individuals susceptible to osteoporosis (erosion of bone minerals) and colon cancer. Dietary calcium and phosphorus supplementation is therefore recommended for consumers of these larvae although care should be taken to avoid side-effects of calcium supplement overdose. For example, lead poisoning as a result of excessive intake of bone meals has been reported. The ratio of calcium to phosphorus in both samples is low and, indeed, biologically poor because phosphorus-rich diets with low calcium levels have been associated with increased loss of calcium in the bones. Diets based on the two samples should be fortified with calcium and phosphorus-rich foods such as leafy green vegetable, onions, fish and fruits. *R pheonicis* had a significantly (*p* < 0.05) higher sodium concentration but a lower concentration of potassium in comparison with *O rhinoceros*.

Both larvae are good sources of iron, especially *O rhinoceros*, and are therefore recommendable food materials for children, pregnant and nursing mothers, all female subjects, athletes and sportsmen and women who are at a greater risk of iron deficiency. Studies by O’Dell have shown that it is better to increase the iron content of food than to use iron supplement since an overdose of iron reduces the absorption of zinc in the small intestine. *R pheonicis*, having copper concentration of 261 mg 100 g⁻¹, can supply the recommended daily allowance of 2.50–5.00 mg 100 g⁻¹. The high concentrations of manganese in the two samples show that the consumption of these larvae can enhance the cofactor requirement of some metabolic enzymes.

The results of quantitative determination of the amino acids of the samples are presented in Tables 3 and 4. The amino acid profiles show that both samples contain appreciable quantities of non-essential and

Table 2. Mineral concentrations (mg 100 g⁻¹) of *Oryctes rhinoceros* and *Rhyncophorus pheonicis*

<table>
<thead>
<tr>
<th>Mineral</th>
<th><em>O rhinoceros</em></th>
<th><em>R pheonicis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Magnesium</td>
<td>5.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Potassium</td>
<td>30.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Sodium</td>
<td>40.0</td>
<td>2029</td>
</tr>
<tr>
<td>Manganese</td>
<td>380</td>
<td>231</td>
</tr>
<tr>
<td>Iron</td>
<td>1090</td>
<td>450</td>
</tr>
<tr>
<td>Copper</td>
<td>99.0</td>
<td>261</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>15.0</td>
<td>10.0</td>
</tr>
</tbody>
</table>

*Values are means of duplicate determinations on dry matter basis where the moisture contents of *Oryctes rhinoceros* and *Rhyncophorus pheonicis* were 16.7% and 11.3% respectively.*
The values of essential amino acids (Table 4) in threonine, lysine, histidine and arginine are good sources of the essential amino acids valine, isoleucine, methionine, leucine, phenylalanine, threonine, lysine, histidine and arginine (Table 4). The non-essential amino acid composition of Oryctes rhinoceros and Rhyncophorus pheonicis compared with those of some foods (Table 3) showed that the samples investigated contained appreciable quantities of aspartic acid, serine, glutamic acid, proline, glycine, alanine, cysteine and tyrosine. Concentrations of these amino acids in the two samples did not generally differ significantly (p > 0.05). In some cases, values of these amino acids were significantly higher than, in some cases significantly lower than and, in others, they did not differ significantly (Table 3) from those of beef, caterpillar, whole hen’s egg, casein and cow’s milk. Among the non-essential amino acids in the two samples investigated were high and did not differ significantly (p > 0.05). Among the essential amino acids of Oryctes rhinoceros and Rhyncophorus pheonicis, arginine, leucine and phenylalanine were found in higher concentration than other amino acids, whereas methionine, threonine and valine were present in relatively lower levels. The samples analysed are good sources of the sulfur-containing amino acids cysteine and methionine. Cystine, which is the oxidized form of cysteine consists of two molecules of the latter linked by disulfide bridges in which form it is isolated from the hydrolysate of proteins and, since the two halves of cystine are widely separated by other amino acid residues in polypeptides, cystine is not regarded as a separate amino acid. These larvae are therefore important food materials since they contain appreciable amount of the sulfur-containing amino acids (cysteine and methionine) which play a role in detoxification mechanisms. The growth-inhibiting effect of raw navy beans fed to rats has been attributed, in part, to a deficiency of methionine. The high contents of lysine and threonine in Oryctes rhinoceros and Rhyncophorus pheonicis are of nutritional significance since these amino acids are usually limiting in most cereals and legumes. Another limiting amino acid, tryptophan, could not be estimated due to limitations of the analytical method. This amino acid was partly destroyed during acid hydrolysis, and hence not determined. The presence of these amino acids in high concentrations would thus enhance the utilization of these amino acids.

### Table 3. Non-essential amino acid composition of Oryctes rhinoceros and Rhyncophorus pheonicis compared with those of some foods

<table>
<thead>
<tr>
<th>Food material</th>
<th>Asp</th>
<th>Ser</th>
<th>Glu</th>
<th>Pro</th>
<th>Gly</th>
<th>Ala</th>
<th>Cys</th>
<th>Tyr</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oryctes rhinoceros (mg·g⁻¹ N)</td>
<td>489</td>
<td>231</td>
<td>966</td>
<td>313</td>
<td>295</td>
<td>328</td>
<td>126</td>
<td>193</td>
<td>Present study</td>
</tr>
<tr>
<td>Rhyncophorus pheonicis (mg·g⁻¹ N)</td>
<td>511</td>
<td>244</td>
<td>975</td>
<td>313</td>
<td>295</td>
<td>328</td>
<td>126</td>
<td>181</td>
<td>Present study</td>
</tr>
<tr>
<td>Beef (mg·g⁻¹ N)</td>
<td>562</td>
<td>252</td>
<td>955</td>
<td>235</td>
<td>304</td>
<td>365</td>
<td>80</td>
<td>225</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Caterpillar (mg·g⁻¹ N)</td>
<td>631</td>
<td>291</td>
<td>801</td>
<td>346</td>
<td>326</td>
<td>407</td>
<td>187</td>
<td>509</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Whole hen’s egg (mg·g⁻¹ N)</td>
<td>601</td>
<td>478</td>
<td>796</td>
<td>260</td>
<td>207</td>
<td>370</td>
<td>152</td>
<td>260</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Casein (mg·g⁻¹ N)</td>
<td>455</td>
<td>385</td>
<td>1406</td>
<td>738</td>
<td>126</td>
<td>196</td>
<td>23</td>
<td>337</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Cow milk (mg·g⁻¹ N)</td>
<td>481</td>
<td>362</td>
<td>1390</td>
<td>571</td>
<td>123</td>
<td>217</td>
<td>51</td>
<td>297</td>
<td>FAO²⁷</td>
</tr>
</tbody>
</table>

*A Values are means of duplicate determinations.

### Table 4. Essential amino acid composition of Oryctes rhinoceros and Rhyncophorus pheonicis compared with those of some common foods

<table>
<thead>
<tr>
<th>Food material</th>
<th>Val</th>
<th>Ileu</th>
<th>Met</th>
<th>Leu</th>
<th>Try</th>
<th>Phe</th>
<th>Thr</th>
<th>Lys</th>
<th>His</th>
<th>Arg</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oryctes rhinoceros (mg·g⁻¹ N)</td>
<td>219</td>
<td>249</td>
<td>121</td>
<td>331</td>
<td>ND</td>
<td>288</td>
<td>209</td>
<td>276</td>
<td>239</td>
<td>510</td>
<td>Present study</td>
</tr>
<tr>
<td>Rhyncophorus pheonicis (mg·g⁻¹ N)</td>
<td>219</td>
<td>244</td>
<td>123</td>
<td>339</td>
<td>ND</td>
<td>297</td>
<td>191</td>
<td>281</td>
<td>243</td>
<td>495</td>
<td>Present study</td>
</tr>
<tr>
<td>Beef (mg·g⁻¹ N)</td>
<td>313</td>
<td>301</td>
<td>169</td>
<td>507</td>
<td>ND</td>
<td>275</td>
<td>287</td>
<td>556</td>
<td>213</td>
<td>395</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Caterpillar (mg·g⁻¹ N)</td>
<td>378</td>
<td>288</td>
<td>112</td>
<td>187</td>
<td>ND</td>
<td>378</td>
<td>268</td>
<td>402</td>
<td>194</td>
<td>261</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Whole hen’s egg (mg·g⁻¹ N)</td>
<td>428</td>
<td>395</td>
<td>210</td>
<td>551</td>
<td>ND</td>
<td>258</td>
<td>320</td>
<td>436</td>
<td>152</td>
<td>381</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Casein (mg·g⁻¹ N)</td>
<td>430</td>
<td>345</td>
<td>178</td>
<td>607</td>
<td>ND</td>
<td>334</td>
<td>297</td>
<td>518</td>
<td>186</td>
<td>239</td>
<td>FAO²⁷</td>
</tr>
<tr>
<td>Cow milk (mg·g⁻¹ N)</td>
<td>362</td>
<td>295</td>
<td>157</td>
<td>596</td>
<td>ND</td>
<td>336</td>
<td>278</td>
<td>487</td>
<td>167</td>
<td>205</td>
<td>FAO²⁷</td>
</tr>
</tbody>
</table>

*A Values are means of duplicate determinations. ND = not determined.
investigated in this study could be adjudged nutritious and highly nourishing samples of high availability for feeding individuals suffering from or at risk of protein-energy malnutrition (PEM). With increasing effort at solving the world’s protein need, especially for the low income earners and poor masses of the third world countries including Nigeria, O rhinoceros and R pheonicis are recommended as protein-rich foods that could contribute in combating the problems of protein shortage and its associated nutritional disorders.

**CONCLUSIONS**

This study has shown that the larvae of O rhinoceros and R pheonicis, hitherto classified as lesser-known food materials which can be harvested in large quantities and eaten by the local people, have the potential of providing large amounts of nutrients. The high nutritive value was evidenced by the high moisture content, ash, crude protein, crude fat as in R pheonicis and energy values. The meat was highly nutritional with good complement of the mineral elements calcium, magnesium, potassium, sodium, manganese, iron, copper and phosphorus.

The high concentrations of various essential and non-essential amino acids as well as the sulfur-containing amino acids are adjudged very beneficial in meeting human requirements for amino acids that are indispensable. In both samples investigated, valine had the lowest chemical score, which revealed it as the most limiting amino acid.

**REFERENCES**


