Nutritional and Antinutritional Characteristics of Some Insects
Foraging in Akure Forest Reserve Ondo State, Nigeria

Adeduntan, S.A.
Department of Forestry and Wood Technology,
Federal University of Technology, P.M.B. 704, Akure, Nigeria

Abstract: The levels of some nutrients, minerals and anti-nutrients of eight dominant insects herbivore distributed among six families from Akure forest reserve (Aponmu) located in Ondo State, Nigeria were determined in order to ascertain their suitability as a food and feed source. The insects contained g per kg dry matter crude protein 72.93 - 1.13 g kg⁻¹, crude fiber 29.58 – 2.04 g kg⁻¹, ether extract 53.06 - 1.21 g kg⁻¹, Ash 7.72 - 0.69 g kg⁻¹ and Carbohydrate 86.67 - 23.00 g kg⁻¹, (as nitrogen free extracts). Generally, there are significantly (p < 0.05) higher Nitrogen free extract and crude fiber in treehopper, ash in termite, crude protein in Ant and moisture in Anaphae venata. The protein and oil contents revealed that the entire insect analyzed as a good source of edible protein, which compare to what is obtainable in chickens and beef suggest them as a potential protein supplement. The insects contained g kg⁻¹ Dm calcium which ranges between 0.0126 and 0.0015 (g kg⁻¹ Dm), magnesium between 0.0074 and 0.0025 g kg⁻¹ Dm, phosphorus between 1.224.67 and 425.00 ppm and iron ranges between 166.127 and 82.89 ppm. The calcium, magnesium and phosphorus in grasshopper were significantly (p < 0.05) higher, as well as iron in treehopper than any insect examined. The mineral composition was generally comparable with what is obtained in other insects. The insects contained tannin between 1050.00 and 250.00 mg kg⁻¹ and phytate between 3159.0169 and 1100.15 mg kg⁻¹ as the major anti-nutrient. The phytate and tannin recorded in this study are generally lower than the latter level of 1% and 20-40 kg-Dm, respectively. The presence of lower tannin and phytate content are of nutritional significance as tannin form insoluble complexes with proteins. More work is needed to ascertain the impacts of processing on the levels of these anti-nutritional factors.

Key words: Nutrition, insect, dominant, antinutrient, herbivores

INTRODUCTION

Insects constitute more than half of the known species of animal[1]. About one million species have been named and classified and several thousand more are discovered each year Vines and Rees[2] and that about 70% of all known species of animal are insects. Although there is many land animals and are widely spread, they adapt to all types of environment. Their ubiquity, small size, amazing range of adaptation and their fecundity, all make them man’s most serious rivals for the possession of the earth. Among the invertebrates, insects are the only group that can fly and feed on plant material, while some feed on animals’ tissue and waste[3].

It is hardly possible to over emphasize the importance of insects. Some insect like butterflies, bees and some sap sucking once bring direct benefit to man as pollinator of flower; some are predators on pest and as objects of beauty. Others are destructive to cloths, furniture, book and buildings for example Ant and Termites.

The notable destructive group species to forestry are the larvae of Lepidoptera (caterpillars), grasshoppers, locusts and termites. They defoliate the leaves of wilding poles, seedling, herb and shrubs that are suppose to regenerate the logged over forest.

Although, man suffers and benefits from the insects legions Vines and Rees[3], noted that on the whole the suffering outweighs the benefits. It was further observed that pollination is by far the most useful activity that insects carryout from his contribution. The most important crop pollinators are bees, although visitors to flowers also include small beetles and a variety of flies. Indirectly, insects also help man in other ways, predator insects, such as a wasps and ladybugs, attack harmful pest although those pest are often insects themselves.

Insects have played an important role in the history of human nutrition. In Africa, Asia and Latin America[4], Aletor[5], noted that Anaphae venata is a good source of protein in human diet since it averagely contains about 22.1 100 g of protein and Ashiri[6] reported a calorific value of 611k cal (2266 kJ)100g for the caterpillar of Anaphae venata. Other beneficial insects live on organic remains, helping to recycle nutrients that plants can then use. These recycles include minute insects, such as
springtails and a variety of heavily built beetles. Some of these beetles bury the carcasses of small birds and mammals, slowly scraping away the ground until the corpse sinks - below the surface. It is, however, not strange that people travel 200-300 km to pick caterpillars and tender leaves from trees. He further noted that in several area of Zimbabwe, Some families make a fairly good living from selling caterpillars. Insect are not only sold widely in the village market of developing world but many make their way to urban markets and restaurants.

Some of the selected dominant insect species are pests of some of economic timber tree species such as Anaphy venata which browses on the leaves of Triplochiton scleroxylon. Termites consume most of all available tree species as well as Tree hopper Meal bug is the pest of Cola gigantia fruit. Ant chew through most tree species for their shelter. Grasshopper and Cricket eat most of tree species mostly when they are in seedling state.

This study therefore, examined the nutrients, mineral and anti-nutrients of some selected insect species. The findings would further stress the understanding of populace for the consumption of these insect herbivores. The consumptions of these insects therefore will augment the diet of the rural dwellers thereby preventing malnutrition, and kwashiorkor in children. In addition, it will serve as biological control by reducing destructive activities of these herbivores in our forest ecosystem as well serve as wealth generation through the commercial rearing of these edible insects.

MATERIALS AND METHODS

The insect sampling was carried out in Permanent Sample Plot (PSP) 29 in Akure Forest Reserve. The 23.52 ha PSP is located at the southern end of the forest reserve. Akure forest reserve covers an area of 69.93 km². The reserve is under the management of Department of Forestry of Ondo State Government of Nigeria. The PSP 29 lies within the forest reserve along Ondo-Akure road at about 20 km south of Akure Latitude 7° 18'N and Longitude 5° 02'E.

Laying of plot: One hectare of forest plot was mapped out (100 x 100 m). This plot was divided into sub-plots of 25 x 20m totaling 20 plots. Using fifty percent sampling intensity ten plots were randomly selected. Thirty minutes were spent on each plot selected during which different species of insects were caught. All insects caught were mounted on a mounting board and were oven dried at temperature of 45°C for 4 days. Insects were identified in to order and species by consulting literatures and visiting Forestry Research Institute of Nigeria Ibadan (FRIN) museum. The frequencies of each species of insects from each plot were recorded and at the end of the exercise, the total frequencies of the insect were known. The insects with highest occurrence were selected as the dominant insect in the forest. Massive hunting for the most eight dominant insects were carried out by hand picking, sweep netting, and brushing and they were subjected to proximate, mineral and anti-nutrition analysis.

Proximate analysis: The samples were analyzed for proximate composition (crude protein, crude fiber, crude fat and crude ash) by the standard procedures of Association of Analytical Chemists[7]. However, crude protein values were subsequently obtained by using a factor of 6.25. Carbohydrate content (i.e. Nitrogen Free Extracts) of the insects were determined by subtracting the sum of the weights of crude protein, crude fiber, fat and crude ash from the total dry matter.

Mineral analysis: The concentrations of minerals (Ca, Fe, Mg and P) were determined after wet digestion with a mixture of perchloric and nitric acids using the Atomic Absorption spectrophotometer (AAS, model SP9, PyeUnicum, UK). Quantitative estimation of metal cat ions was done in determining the calcium and magnesium content of the samples.

Anti-nutrient determination: Phytate was determined according to the method of Wheeler and Ferrel[8]. Four gram of each of the sample was soaked in 100 mL 2% HCL for 6h and filtered. Then, 25 mL of the filtrate was placed in conical flask and 5 mL of 0.3% Ammonium thiocyanate solution was added. This was titrated with a standard FeCl₃ solution until a brownish-yellow color persists for 5min.

Tannin: Tannin was obtained by adopting the quantitative method of Markar and Goodchild[9]. 0.2 g of each of the sample was soaked in 10 mL of 70% acetone and placed in ice water bag and soaked for 12 min to extract the tannin. This was filtered and 0.5 mL of the distilled water was added to the filtrate. 0.5 mL of lowery reagent and 2.5 mL at 20% Na₂CO₃ were also added. The tube was vortexed and incubated for 40 minutes of room temperature and the result was read at wavelength 700 nm on corning colorimeter 253 against the blank. The value obtained was extrapolated from the standard tannin acid curve and then converted to mg TA/100g sample.

Method of data analysis: Data obtained for proximate, minerals and anti-nutrition properties were subjected to
Table 1: ANOVA table for proximate composition gkg⁻¹ Dm of dominant insects herbivore foraging in Akure Forest reserve Aponmu.

<table>
<thead>
<tr>
<th>Proximate content</th>
<th>Source of variation</th>
<th>Sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture content</td>
<td>Insect</td>
<td>673.4098765</td>
<td>7</td>
<td>96.2014108</td>
<td>13194.5</td>
<td>7.184E7E-37</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.011656524</td>
<td>16</td>
<td>0.000729101</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>673.4215562</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein</td>
<td>Insect</td>
<td>5143.089481</td>
<td>7</td>
<td>734.719788</td>
<td>47293.8</td>
<td>2.636E33</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.248536592</td>
<td>16</td>
<td>0.01553224</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>5143.260745</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ether extract</td>
<td>Insect</td>
<td>3342.744795</td>
<td>7</td>
<td>477.534970</td>
<td>89839.2</td>
<td>1.555E43</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.068504699</td>
<td>16</td>
<td>0.000531544</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>3342.755393</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>Insect</td>
<td>15.72587297</td>
<td>7</td>
<td>2.246553279</td>
<td>36370.8</td>
<td>2.154E7E-32</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.000988289</td>
<td>16</td>
<td>0.0058478</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>15.72686124</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude fibre</td>
<td>Insect</td>
<td>1447.855</td>
<td>7</td>
<td>206.8564</td>
<td>3556.998</td>
<td>2.677E-24</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.935647</td>
<td>16</td>
<td>0.058478</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1448.791</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen free extract</td>
<td>Insect</td>
<td>2352.646</td>
<td>7</td>
<td>336.0923</td>
<td>4506.11</td>
<td>3.838E6E-25</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>1.193375</td>
<td>16</td>
<td>0.074586</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>2353.81</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Result of Duncan Multiple Range test of proximate composition of dominant insect herbivore foraging in Akure Forest reserve Aponmu.

<table>
<thead>
<tr>
<th>Insect</th>
<th>Moisture content</th>
<th>Crude Protein</th>
<th>Ether Extract</th>
<th>Ash</th>
<th>Crude Fiber</th>
<th>Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ant</td>
<td>16.35±0.01*</td>
<td>72.93±0.34*</td>
<td>1.53±0.69*</td>
<td>0.69±0.03*</td>
<td>2.64±0.01*</td>
<td>23.06±0.54*</td>
</tr>
<tr>
<td>Termite</td>
<td>15.53±0.02*</td>
<td>2.40±0.02*</td>
<td>1.58±0.01*</td>
<td>0.89±0.09*</td>
<td>2.89±0.07*</td>
<td>24.67±0.10*</td>
</tr>
<tr>
<td>Cricket</td>
<td>19.47±0.00*</td>
<td>7.41±0.01*</td>
<td>2.13±0.03*</td>
<td>0.91±0.06*</td>
<td>5.16±0.02*</td>
<td>33.11±0.02*</td>
</tr>
<tr>
<td>Meal bug</td>
<td>7.33±0.03*</td>
<td>2.54±0.02*</td>
<td>15.86±0.09*</td>
<td>1.00±0.03*</td>
<td>9.45±0.13*</td>
<td>52.62±0.09*</td>
</tr>
<tr>
<td>Grasshopper</td>
<td>17.73±0.01*</td>
<td>22.12±0.06*</td>
<td>1.21±0.03*</td>
<td>4.30±0.07*</td>
<td>12.78±0.15*</td>
<td>56.55±0.13*</td>
</tr>
<tr>
<td>Anapha venata</td>
<td>36.33±0.01*</td>
<td>2.84±0.02*</td>
<td>14.13±0.09*</td>
<td>2.03±0.02*</td>
<td>17.54±0.06*</td>
<td>59.59±0.03*</td>
</tr>
<tr>
<td>Tree hopper</td>
<td>20.25±0.00*</td>
<td>34.00±0.05*</td>
<td>11.94±0.10*</td>
<td>7.71±0.12*</td>
<td>21.67±0.48*</td>
<td>63.45±0.46*</td>
</tr>
<tr>
<td>Winged termite</td>
<td>27.24±0.00*</td>
<td>1.33±0.03*</td>
<td>5.05±0.04*</td>
<td>3.22±0.01*</td>
<td>29.59±0.10*</td>
<td>86.67±0.18*</td>
</tr>
</tbody>
</table>

All values are Mean ± SE Means followed with the same alphabet in the same column is not significantly different (P< 0.05).

Table 3: ANOVA for mineral composition in gkg⁻¹ Dm and antinutrient in mg/100g of dominant insects herbivore foraging in Akure Forest Reserve

<table>
<thead>
<tr>
<th>Minerals</th>
<th>Source of variation</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean square</th>
<th>F-value</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>Insect</td>
<td>0.600398776</td>
<td>7</td>
<td>4.14000E-05</td>
<td>3024.061</td>
<td>9.366E18E-24</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>2.33333E-07</td>
<td>16</td>
<td>1.45533E-08</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>0.600010884</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium</td>
<td>Insect</td>
<td>5.82099E-05</td>
<td>7</td>
<td>8.31565E-06</td>
<td>739.693</td>
<td>7.177E19</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.0000001</td>
<td>16</td>
<td>1.125E-08</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>5.83889E-05</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td>Insect</td>
<td>1437365.980</td>
<td>7</td>
<td>20537.994</td>
<td>1627.514</td>
<td>1.321E21</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>22016.666667</td>
<td>16</td>
<td>1.326E6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>143948.625</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Insect</td>
<td>15968.70867</td>
<td>7</td>
<td>2281.254009</td>
<td>3220545</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>6.011333333</td>
<td>16</td>
<td>7.08333E-05</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>15968.782</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antinutrient</td>
<td>Phyrate</td>
<td>9654274.398</td>
<td>6</td>
<td>166904.733</td>
<td>1.15E+11</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>0.001953333</td>
<td>14</td>
<td>1.39524E-05</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>9654274.395</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tannin</td>
<td>Insect</td>
<td>216404.625</td>
<td>7</td>
<td>309148.667</td>
<td>59535.6</td>
<td>4.282E18E-34</td>
</tr>
<tr>
<td></td>
<td>Error</td>
<td>8.333333333</td>
<td>16</td>
<td>5.208833333</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>2164123.958</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

one-way analysis of variance where significant differences were discovered, means separation was done by Duncan Multiple Range Test[6].

RESULT

Five thousand eight hundred and eighty four (5,884) insect herbivores were encountered per hectare distributed among fifty insect species. These species belong to eleven Orders. It was observed that Anapha venata have the highest relative frequency 51.37%, followed by cricket with relative frequency of 5.44%. Other insect species used for nutritional analysis have their relative frequency above 1.00%.

The result from the Table shows that there were significant differences among the proximate composition of the insects (P<0.05).

The proximate chemical composition in gkg⁻¹ Dm of the eight dominant insects herbivore foraging in Akure forest reserve (Aponmu) is as presented in Table 2. The moisture content of the insects ranges between 36.34 and 7.33 gkg⁻¹ with the Anapha venata recording the
Table 4: Result of Duncan Multiple Range Test of mineral composition of dominant insect herbivore foraging in Akure forest reserve (Acoma)

<table>
<thead>
<tr>
<th>Insect</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Phosphorus</th>
<th>Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mg/100g)</td>
<td>(mg/100g)</td>
<td>(ppm)</td>
<td>(ppm)</td>
</tr>
<tr>
<td>Tree hopper</td>
<td>0.001±0.0004</td>
<td>0.007±0.0006</td>
<td>1224.6±0.3333</td>
<td>96.08±0.0034</td>
</tr>
<tr>
<td>Anaphes venata</td>
<td>0.001±0.0004</td>
<td>0.006±0.0001</td>
<td>500.00±0.0008</td>
<td>130.71±0.0008</td>
</tr>
<tr>
<td>Cricket</td>
<td>0.001±0.0001</td>
<td>0.004±0.0001</td>
<td>850.34±0.3333</td>
<td>112.37±0.0007</td>
</tr>
<tr>
<td>Winged termite</td>
<td>0.001±0.0001</td>
<td>0.006±0.0001</td>
<td>425.00±0.0004</td>
<td>82.89±0.0006</td>
</tr>
<tr>
<td>Meal bug</td>
<td>0.002±0.0001</td>
<td>0.008±0.0001</td>
<td>650.00±0.0008</td>
<td>123.50±0.0034</td>
</tr>
<tr>
<td>Termite</td>
<td>0.002±0.0001</td>
<td>0.004±0.0001</td>
<td>631.67±0.3333</td>
<td>150.74±0.0039</td>
</tr>
<tr>
<td>Ant</td>
<td>0.003±0.0001</td>
<td>0.005±0.0001</td>
<td>450.00±0.0004</td>
<td>137.88±0.0006</td>
</tr>
<tr>
<td>Grasshopper</td>
<td>0.012±0.0001</td>
<td>0.006±0.0001</td>
<td>675.33±0.3333</td>
<td>166.12±0.0006</td>
</tr>
</tbody>
</table>

All values are Mean ± SE Means followed with the same alphabet in the same column is not significantly different (P ≤ 0.05)

Table 5: Duncan result of Antinutrient composition in mg/100g of Dominant Insect Herbivore foraging in Akure forest reserve (Acoma)

<table>
<thead>
<tr>
<th>Insect</th>
<th>Phytate</th>
<th>Tannin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mg/100g)</td>
<td>(mg/100g)</td>
</tr>
<tr>
<td>Ant</td>
<td>203.70±0.0001</td>
<td>400.00±0.0006</td>
</tr>
<tr>
<td>Termite</td>
<td>2482.08±0.0002</td>
<td>948.33±1.6657</td>
</tr>
<tr>
<td>Cricket</td>
<td>3159.07±0.0001</td>
<td>500.00±0.0006</td>
</tr>
<tr>
<td>Meal bug</td>
<td>2256.67±0.0002</td>
<td>1159.00±0.0006</td>
</tr>
<tr>
<td>Grasshopper</td>
<td>1190.14±0.0001</td>
<td>1059.00±0.0008</td>
</tr>
<tr>
<td>Anaphes venata</td>
<td>1917.91±0.0003</td>
<td>753.33±3.3333</td>
</tr>
<tr>
<td>Winged termite</td>
<td>1128.22±0.0003</td>
<td>250.00±0.0006</td>
</tr>
<tr>
<td>Tree hopper</td>
<td>ND</td>
<td>100.00±0.0006</td>
</tr>
</tbody>
</table>

ND= Not Determined All values are Mean ± SE Means followed with the same alphabet in the same column is not significantly different (P ≤ 0.05)

The high crude protein content of Ant (72.93 g kg⁻¹) which is much greater than the value contained in water bottle (21.0 g kg⁻¹) as reported by Florence[10] and the crude protein content of meal bug, Grasshopper and Tree hopper. It is however, is comparable to the value obtained in beef (27.4 g kg⁻¹ Dm) and fish 28.5 g kg⁻¹ Dm[11]. The high crude protein content is an indication that the insects can be of value in man and animal ration and can equally replace higher animal protein usually absent in the diet of rural dwellers in developing countries. The ether extract (oil) of Winged termite of 53.06 g kg⁻¹ Dm is quite high which is a characteristics of good source of oil and can provide high calories of energy to both animal and animal feed with it. The ash content, which ranged from 9.88 to 0.70 g kg⁻¹ Dm is lower than the 20.8 g kg⁻¹ Dm present in oil bean (Pentaclethra macrophylla Berth)[11]. The insects cannot be adjudged a good source of mineral food as evident in Table 3. Among the element determined, Grasshoppers has the highest calcium value and Tree hopper has high Phosphorus values and as a result of this they could be used to feed or compound the feed of young once that are still developing in bone and teeth. Though these food elements are in the insects, the insects could be consumed along with other food and animals rich in these minerals to enhance healthy and strong bone.

**DISCUSSION**

The high protein content of Ant (72.93 g kg⁻¹) which is much greater than the value contained in water bottle (21.0 g kg⁻¹) as reported by Florence[10] and the crude protein content of meal bug, Grasshopper and Tree hopper. It is however, is comparable to the value obtained in beef (27.4 g kg⁻¹ Dm) and fish 28.5 g kg⁻¹ Dm[11]. The high crude protein content is an indication that the insects can be of value in man and animal ration and can equally replace higher animal protein usually absent in the diet of rural dwellers in developing countries. The ether extract (oil) of Winged termite of 53.06 g kg⁻¹ Dm is quite high which is a characteristics of good source of oil and can provide high calories of energy to both animal and animal feed with it. The ash content, which ranged from 9.88 to 0.70 g kg⁻¹ Dm is lower than the 20.8 g kg⁻¹ Dm present in oil bean (Pentaclethra macrophylla Berth)[11]. The insects cannot be adjudged a good source of mineral food as evident in Table 3. Among the element determined, Grasshoppers has the highest calcium value and Tree hopper has high Phosphorus values and as a result of this they could be used to feed or compound the feed of young once that are still developing in bone and teeth. Though these food elements are in the insects, the insects could be consumed along with other food and animals rich in these minerals to enhance healthy and strong bone.
formation in man and animals.

Barry, reported that phytate could interfere with mineral bioavailability when it is 1% or more in the diet but the one recorded in the entire insect in this study is much lower.

Barry, reported that condensed tannin (20-40 kg Dm⁻¹) has some beneficial effect in protein metabolism and the good palatability generally associated with low-tannin diets. However, Aletor, reported that high levels of tannins (76-90 g kg Dm⁻¹) could be detrimental if consumed. It was noted that tannins usually form insoluble complexes with protein, thereby interfering with their bioavailability and high tannin in diets is ascribed to its astringent property, which is a consequence of its ability to bind with proteins of saliva and mucosal membranes. The tannin content of the insects examine ranges between 1150.00 mg/100g and 250.00 mg/100g which is much lower than the 3.36 gkg⁻¹ Dm as contained in oil bean as reported by Enuguha and Agbede.

REFERENCES