ISSN 1996-3351

Asian Journal of Biological Sciences

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OPEN ACCESS Asian Journal of Biological Sciences

ISSN 1996-3351
DOI: 10.3923/ajbs.2019.284.290

Research Article

Nutrient Composition of African Palm Grub (*Rhynchophorus phoenicis*) Larvae Harvested from Raphia Palm Trunk in the Niger-delta Swamps of Nigeria

[1]I.C. Okoli, [1]W.B. Olodi, [1]I.P. Ogbuewu, [1]N.O. Aladi and [2]C.G. Okoli

[1]Department of Animal Science and Technology, Federal University of Technology, P.M.B. 1526, Imo State, Nigeria
[2]Department of Environmental Health Sciences, National Open University of Nigeria, Abuja Nigeria

Abstract

Background and Objective: The world population is estimated to be more than 9 billion by the year 2050 and this will lead to increased demands for animal protein. Hence, there is need to explore other protein food resources such as insects. This study therefore was conducted to determine the nutrient value of the African palm grub (*Rhynchophorus phoenicis*) in Bayelsa state, Nigeria. **Materials and Methods:** Palm grubs were collected from Osika bush (OSB), Yenegue bush (YEB) and Obuolo bush (OBB) in the state and thereafter taken to the laboratory for analysis using standard methods. They were analyzed for linear body measurements and nutrient compositions using descriptive statistics. **Results:** Results of the proximate compositions indicate that palm grub is a rich source of nutrients. Mean magnesium, calcium, sodium and potassium content across locations differed significantly ($p<0.05$). Additionally, there was significant differences ($p<0.05$) in zinc and manganese concentrations across the three locations. The palm grub oil was found to be 100% unsaturated, which makes it to remain in its liquid phase at room temperature due to the presence of unsaturated fatty acids, oleic and linoleic acids. **Conclusion:** The high nutrient content of palm grub is a pointer that palm grub may be employed in ameliorating the problem of protein and micro nutrient deficiency in both humans and animals.

Key words: Palm grub, physical characteristics, nutrient compositions, Niger-Delta, Nigeria

Received: December 10, 2018 Accepted: January 30, 2019 Published: March 15, 2019

Citation: I.C. Okoli, W.B. Olodi, I.P. Ogbuewu, N.O. Aladi and C.G. Okoli, 2019. Nutrient composition of African palm grub (*Rhynchophorus phoenicis*) larvae harvested from raphia palm trunk in the Niger-Delta swamps of Nigeria. Asian J. Biol. Sci., 12: 284-290.

Corresponding Author: I.P. Ogbuewu, Department of Animal Science and Technology, Federal University of Technology, P.M.B. 1526, Imo State, Nigeria
Tel: +27631307576

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

As people all over the world continue to discriminate more on the type and sources of foods on the grounds of increasing health concerns and nutritional awareness, indigenous food sources such as the palm grub would become popular as alternative to red meat and chicken egg. Research into the advancement of production volume of the palm grub will therefore improve rural economies, if global and industrial demands for these products are created. Edible insects are traditional foods all over the world and are highly nutritious with high protein and mineral content depending on the specie. Notable examples of these species are the palm weevil, *Rhynchophorus phoenicis*, termites, *Macroterms nigeriense*, *Cerina forda* and variegated grasshopper, *Zonocerus verigatus*[1-3].

Rhynchophorus spp. are major pests of date palms, coconut palms, oil palms and sugarcane[4,5]. Though they are very destructive, their nutritional potentials have endeared them to man. The palm weevil, *Rhynchophorus phoenicis* is highly cherished in many tropical cultures including southern Nigeria. It inhabits oil palms, coconut and raphia palm and is found in wide geographical areas spanning many different climates such as Africa, southern Asia and southern America[6]. The weevil is attracted to dying or damaged parts of plants, cut or split palm trunks and can also attack undamaged palms as well as decaying sugarcane[7]. Palm grub is the larvae of the palm weevil (*Rhynchophorus pheonicis*). Currently, they available from the wild and also culturable under laboratory conditions[8,9]. Omoyinmi *et al*.[10] reported that the nutritive value of palm grub makes it suitable as replacement for fishmeal in fish feeds.

In commercial intensive poultry production, about 60-70% of the running cost is usually expended on feeding due to high cost of feed ingredients, the most important of these being fish meal. However, shortage and high cost of fish meal has affected the cost of poultry feeds and other intensive farming systems like cultured fish severely, making it expensive, hence the search for alternative and cheaper sources of animal protein in poultry and feeds[11,12]. Information on the actual feed values of the palm grub, needed for future experimentations especially in higher animals nutrition are however imperative.

The study therefore aim to determine the nutrient composition of African palm grub (*Rhynchophorus phoenicis*) larvae harvested from raphia palm trunk in the Niger-Delta swamps of Nigeria for possible use in livestock production.

MATERIALS AND METHODS

Study area: The palm grub was collected from three different locations, "Osika" bush of Oruma in Ogbia Local Government Area (LGA), "Ogbo" bush of Yenegwe-Epie and Edepie bush in Edepie in Yenagoa LGAs, all of Bayelsa state. Bayelsa state is situated in the south-south, the crude oil rich region of Nigeria. The state is located within latitude 4'15° and 5'23°N and longitude 5'22° and 6'45°E and shared common boundaries with Delta state on the north, Rivers state on the East and the Atlantic Ocean on the west and south. The vegetation is typically rainforest with two seasons, the rainy and dry seasons. The period of rainy season is from the months of April to October, while the dry season runs through November to March. People in the rural and semi urban areas are predominantly fishermen. They also cultivate crops like cassava, plantain and vegetables among others[9]. Bayelsa state is a typical rainforest zone and harbours many tropical rainforest plants including the raphia palm. Raphia palm is common in the tropical rainforest of Nigeria and is in high concentration in the marshy swamps, canals, creeks and tributaries of rivers such as the Orashi and Sombrio Rivers that flow through the study area to the ocean.

Sample collection: About 24 samples of palm grub were collected from two previously felled raffia palm trees at each of the three study locations (Osika" bush, "Ogbo" bush and Edepie bush). Eight live larvae (palm grub) were collected from each of the felled raffia palm trees in the three different locations during mid-day of January 12, 2018. The three different sample sets were put into three separate containers, filled with the starchy pulp of the raffia palm trunk, which is the natural environment of the palm grub and on which they feed[9]. Thereafter, the samples were transported to the laboratory for nutrient analysis. Physical measurements of the palm grub such as weight, length, width were also taken.

Proximate and nutrient analyses: The proximate biochemical composition was carried out at the Jaagee Laboratories Nig. Ltd., Ibadan, Nigeria, to determine the moisture content (MC), crude fibre (CF), crude protein (CP), ether extracts (EE), nitrogen free extract (NFE) and total ash (TA) according to the standard method[13]. The MC content was determined using an auto moisture analyser (model: ML-50). The EE was quantified using the Soxtec Extraction System, Soxtec, Model: 2050, while the CP level was determined using the modified Kjeldahl method as reported[14]. The iodine value (IV), peroxide value(PV), free fatty acid (FFA), acid value (AV), saponification value (SV) and refractive index (RI) on the extracted oil/fat were determined using standard methods. The NFE value was determined by difference. For gross energy analysis, the calorific measurements of palm grub was done with Cal 2K, C1.7 Bomb calorimeter. The mineral values in the palm grub was determined via an Atomic Absorption Spectrophotometer (AAS).

Statistical analysis: Data generated were subjected to analysis of variance (ANOVA). Differences between means where significant were separated using Duncan's multiple range test at 95% confidence intervals.

RESULTS

Physical characteristics of the palm grubs: Physical measurement of the palm grub, such as length, width and weight from the three different locations as shown in Table 1. Across the different study locations, weight values were highest for the grubs obtained from OSB followed by those obtained from OBB and YEB, although the differences were not significant ($p>0.05$).

Proximate biochemical compositions of the palm grubs: The proximate biochemical compositions of palm grubs from the three different locations of OSB, YEB and OBB are presented in Table 2. Dry matter content of samples from OBB was significantly ($p<0.05$) higher than that from OSB, but similar to that from YEB. Conversely, the moisture content in the OSB grub was significantly ($p<0.05$) higher than that of OBB. Results of crude protein content (Table 2) showed that there were no significant ($p>0.005$) difference among the samples from the three different locations. Ether extract (crude fat) content in OBB was significantly ($p<0.05$) higher than that of YEB but similar to OSB values ($p>0.05$). Crude fibre contents of the palm grubs were not significantly different across samples from the different location ($p>0.05$). Total ash content of the sample from YEB was significantly ($p<0.05$) higher than that from OSB, but similar to the value recorded for OBB ($p>0.05$). Nitrogen free extract (NFE) or carbohydrate content of palm grubs from YEB was significantly ($p<0.05$) higher than that from OSB.

Mineral composition of the palm grub: The macro-mineral composition of palm grub from the different locations of OSB, YEB and OBB are shown in Table 3. Results of sodium content showed that there were no significant ($p>0.005$) difference

Table 1: Physical measurement of the palm grub from the different locations

Parameters	OSB	YEB	OBB	Mean	SD	SEM
Weight (g)	10.26 ± 0.01^{a}	9.30 ± 0.0^{a}	9.47 ± 0.01^{ab}	9.68	0.51	0.29
Length (cm)	5.03 ± 0.01^{ab}	4.83 ± 0.00^{b}	5.27 ± 0.01^{a}	5.04	0.22	0.13
Width (cm)	2.33 ± 0.01^{ab}	2.23 ± 0.00^{a}	2.43 ± 0.13^{a}	2.33	0.10	0.06

^{ab}Means on the same row with different superscript are significantly different ($p<0.05$). OSB: Osika bush, YEB: Yenegwe bush, OBB: Obuolo bush

Table 2: Proximate composition of the palm grub from the different locations

Parameters	OSB	YEB	OBB	Mean	SD	SEM
Dry matter (%)	83.5^{b}	84.2^{ab}	86.00^{a}	84.57	1.29	0.75
Moisture content (%)	16.50^{a}	15.80^{ab}	14.00^{b}	15.43	1.29	0.75
Crude protein (%)	22.76	24.37	18.61	21.91	2.97	1.72
Ether extract (%)	51.42^{ab}	45.20^{b}	54.10^{a}	50.24	4.57	2.64
Crude fiber (%)	3.90	3.30	3.31	3.50	0.34	0.20
Total ash (%)	1.79^{b}	2.32^{a}	1.83^{ab}	1.98	0.30	0.17
NFE (%)	3.63^{b}	9.01^{a}	8.15^{b}	6.93	2.90	1.67
GE (kcal kg^{-1})	$6,569.8^{a}$	$6,199.14^{b}$	$6,679.59^{a}$	6,482.87	257.76	145.36

^{ab}Means on the same row with different superscripts are significantly different ($p<0.05$). OSB: Osika bush, YEB: Yenegue bush, OBB: Obuolo bush, NFE: Nitrogen free extract

Table 3: Macro minerals composition of palm grub from the different locations

Macro-mineral (mg/100 g)	OSB	YEB	OBB	Mean	SD	SEM
Sodium	2.22^{ab}	2.35^{a}	2.19^{ab}	2.25	0.08	0.05
Potassium	76.01^{b}	89.76^{a}	80.44^{ab}	82.07	7.02	4.05
Calcium	0.01^{b}	0.05^{a}	0.03^{ab}	0.03	0.02	0.01
Magnesium	5.91^{b}	7.22^{a}	5.99^{ab}	6.37	0.73	0.42
Phosphorus	1.22^{a}	1.19^{ab}	1.11^{b}	1.17	0.06	0.03

Table 4: Calcium/phosphorus and sodium/potassium ratios of palm grub from different locations

Parameters	OSB	YEB	OBB	Mean	SD	SEM
Ca/P ratio	0.01	0.01	0.03	0.03	0.01	0.01
Na/k ratio	0.29	0.03	0.03	0.12	0.15	0.09

Table 5: Micro-minerals composition (mg/100 g) of palm grub from the different locations

Micro-mineral	OSB	YEB	OBB	Mean	SD	SEM
Iron	1.00^{ab}	1.08^{a}	0.98^{b}	1.02	0.03	0.03
Zinc	0.06^{b}	0.08^{ab}	0.10^{a}	0.08	0.02	0.01
Manganese	0.05^{ab}	0.08^{a}	0.03^{b}	0.05	0.03	0.01
Chromium	0.03	0.03	0.04	0.03	0.01	0.01
Nickel	0.02	0.04	0.04	0.03	0.01	0.01
Lead	0.11	0.19	0.20	0.17	0.05	0.03
Copper	-	-	-	-	-	-

Table 6: Chemical composition of extracted oil derived from the palm gru

Parameters	OSB	YEB	OBB	Mean	SD	SEM
Moisture (%)	6.40^{a}	6.38^{ab}	6.43^{a}	6.40	0.03	0.01
Wij's IV (g/100 g)	182.00^{b}	189.00^{a}	189.00^{a}	186.67	3.56	2.06
RI (Brix %)	69.60^{ab}	67.00^{b}	73.10^{a}	69.90	3.06	1.77
PV (mg kg^{-1})	18.20^{b}	18.90^{a}	18.90^{a}	16.67	0.40	0.23
AV (mg KOH^{-1} g^{-1})	43.40^{ab}	41.56^{b}	43.58^{a}	42.85	1.12	0.64
SV (mg KOH^{-1} g^{-1})	398.50^{ab}	401.42^{a}	397.44^{b}	399.12	2.06	1.19

Table 7: Fat characteristics of oil extracted from the palm grub

Parameters	OSB	YEB	OBB	Mean	SD	SEM
Free fatty acid (%)	0.54^{ab}	0.64^{ab}	0.68^{a}	0.62	0.07	0.04
Unsaturation	100.00	100.00	100.00	100.00	0.00	0.00

among the samples from the three different locations. Potassium and calcium content in OSB were significantly ($p<0.05$) lower than that of YEB but similar to OSB values ($p>0.05$). Magnesium content in OSB were significantly ($p<0.05$) higher when to that of YEB but comparable to OBB value ($p>0.05$). Phosphorus contents of the palm grubs harvested in OBB was significantly ($p<0.05$) lower than in OSB but statistically same with the YEB location ($p>0.05$). The calcium to phosphorus and sodium to potassium ratios of palm grub from the different locations of OSB, YEB and OBB are shown in Table 4. The ratios were not significantly ($p>0.05$) affected by the locations.

Micro-minerals content of palm grub: The micro-mineral composition of palm grub from the different locations of OSB, YEB and OBB are shown in Table 5. It was observed that these micro mineral elements were also present in appreciable amounts in palm grub *(R. phoenicis)*. Across the different study locations, iron was found to be the highest micro-mineral in the palm grub with its content in samples from YEB being significantly higher than that of OBB. Iron and manganese content in YEB were significantly ($p<0.05$) higher when compared with values reported in OBB location but similar to OSB values ($p>0.05$). Zinc concentration in OSB was higher ($p<0.05$) when compared with value obtained in OSB location but similar ($p>0.05$) to that reported in YEB location. There were no significant ($p>0.05$) difference between chromium, nickel and lead values obtained across sample locations. Copper was not detected in any of the samples across the three locations.

Characteristics of oil extracted from palm grub: Table 6 showed that 62.00% of the palm grub oil was fatty acid with the sample obtained from OBB being significantly higher than that of OSB ($p<0.05$). This oil was 100% unsaturated showing why it remained liquid at room temperature.

The physical constants of oil extracted from the palm grubs collected from the different locations are shown in Table 7. Wij's iodine value (IV) content in samples YEB and OBB were significantly higher than that in OSB. Refractive index (RI) of oil palm from OBB was also significantly ($p<0.05$) higher than that from YEB. Peroxide values (PV) in samples of YEB and OBB were significantly ($p<0.05$) higher than that of OSB.

DISCUSSION

The lengths of grubs obtained from OBB location was higher than the group from YEB but comparable to the grubs harvested from OSB. In a similar study, Elemo *et al.*[15] reported that the palm weevil that produces the larvae measures 10.16 cm long and more than 5.08 cm wide. Omotosho and Adedire[7] reported a weight of 2.59-8.14 g, body length of 2.54-5.70 cm and body width of 0.77-2.05 cm of the grub, similar to the values obtained from the present study.

It was observed in the present study that the grubs had 84.57% dry matter, 15.43% moisture content, 21.91% crude protein, 50.24% ether extract, 3.50% crude fibre, 1.98% total ash, 6.93% nitrogen free extracts and mean gross energy value of 6482.87 kcal kg^{-1}. Mean moisture value of 14.00-16.50% obtained in this study was higher than the range of 8.80-11.30% reported by Opara *et al.*[9] and Onyeike *et al.*[16], but lower than the value of 43.46% reported by Elemo *et al.*[15]. The relatively high moisture content of the samples suggested that they stand the risk of microbial deterioration and spoilage during storage[16], hence samples should be utilized fresh or dried further to reduce the moisture content. Mean crude protein value of 21.91% obtained in the present study is less than the value of 23.44-66.30% reported byothers[9,15,16]. These differences arose probably as a result of the different moisture contents of the samples analysed by these different workers. However, the crude protein value reported in this study is higher than those of winged termite (20.0%), cow milk (3.8%), hen's egg (12.40%) and beef (18.0%), indicating that palm grub is a good protein sources[16]. The numerically high crude protein value of palm grub indicates that it can contribute significantly to the recommended human daily protein requirement of 23-56% stipulated by National Research Council[17]. Similarly, it could serve as a good source of cheap protein for monogastrics such as poultry and pigs. Elemo *et al.*[15] also reported that the amino acid pattern of the palm grub compared favorably to that of egg and the FAO reference pattern with exception of tryptophan and isoleucine, while all other essential amino acids were adequate[18]. The highest values of insect protein have however been reported for first instar stage (53.10%) and fourth instar stage (52.50%) of grasshoppers[3].

Mean ether extract value of 50.24% obtained in this study is less than the value of 54.20% reported by Opara *et al.*[9] and higher than the value of 28.90% reported by Ekpo *et al.*[19]. Elemo *et al.*[15] however reported an oil content of 37.12% while Omotoso and Adedire[7] reported a range of -61.45-62.13%. The high lipid content of *R. phoenicis* was a pointer that insects can provide supplementary dietary fat in feed formulation for animals[9]. The relatively high ether extract value in the palm grub also agreed with the report that many insects accumulate fat during larval development[20]. Fat is essential in diets because it increases the palatability by absorbing and retaining their flavours[21]. Mean crude fibre value of 3.50% obtained in this study is similar to the value of 3.35% reported by Opara *et al.*[9] but much lower than the range of 17.22-22.14% reported by Omotoso and Adedire[7]. Usually, this fibre is converted to energy-rich substances during eclosion[7]. The low fiber value is expected considering the high protein and fact contents of the grubs.

Mean total ash content of 1.98% obtained in this study is considerably less than the values of 4.20-5.20% reported by others[9,16] in similar analysis. However, the ash value was within the range reported for termites (1.90%) and African giant cricket (1.82%)[22]. These findings supported the earlier reports that insects contain moderate amount of mineral elements[23,24]. Mean total NFE content value of 6.93% reported in this study, is higher than the value of 3.56-5.53% (dry weight) earlier reported[25]. Gross energy content of the sample from OBB was significantly higher than that from YEB and the mean gross energy value of 6,569.87 kcal kg^{-1} in this study is much more than the value of 4786.00 kcal kg^{-1} reported by Elemo *et al.*[15] and 4250 kcal kg^{-1} reported by Opara *et al.*[9]. The energy value of 6,569.87 kcal kg^{-1} is also more than the range of daily energy need of 2500-3000 kcal reported for adult humans[16]. However the proximate results from this study indicated that most of this energy was derived more from the fat than the carbohydrate fraction of the palm grub. According to Elemo *et al.*[9] edible insects have been shown to have a higher protein content, on a mass basis, than other animal and foods such as beef, chicken, fish soybean and maize[26]. Ramos-Elorduy *et al.*[27] reported the nutritional value of 78 species of edible insects in Mexico, with protein values ranging from 15-81% and calorie content ranging from 2930-7620 kcal kg^{-1}.

Mineral composition: Mean sodium value of 2.25 mg/100 g, obtained in this study is far less than those of 52.0 mg/100 g, 2029 mg/100 g and 26.65 mg/100 g reported by Elemo *et al.*[15], Onyeike *et al.*[16] and Ekpo and Onigbinde[25], respectively. Mean potassium value of 82.07 mg/100 g obtained in this study is far much less than the value of 1025.0 mg/100 g reported by Elemo *et al.*[15] and higher than the value of 30.0 mg/100 g reported for *Orycetes rhinoceros* by Onyeike *et al.*[16]. Omotosho and Adedire[7] however reported a value of 455.02 mg kg^{-1} potassium in their study. Mean calcium value of 0.03 mg/100 g is lower than the value of 54.1 mg/100 g reported by Elemo *et al.*[15], which is same value reported by Alamu *et al.*[22]. Onyeike *et al.*[16] also reported calcium values of 2.0 and 1.0 mg/100 g for *O. rhinocerus* and *R. pheonicis* respectively. These reports showed that palm grub is very rich in potassium and poor in calcium. Magnesium content of samples from YEB was higher than that of OSB with mean magnesium value of 6.37 mg/100 g being lower than the value of 131.8 mg/100 g reported by Elemo *et al.*[15], which is same value reported by other researchers[16,22] however reported a value of 5.0 and 4.0 mg/100 g for *O. rhinoceros* and *R. pheonicis*, respectively which were similar to the value reported in the present study. The magnesium content will help in the biochemical reactions in the body of humans and livestock. It also helps to maintain normal muscle and nerve function, keep steady heart rhythm, supports healthy immune blood and regulates blood sugar levels. Mean phosphorus value of 1.17 mg/100 g is lower than the value of 685.0 mg/100 g reported by Elemo *et al.*[15]. The differences in the mineral content of the palm grub in the various locations could be due to variations in the dietary habits of the insects age (stage of development) or as a result of different ecotypes[9]. The levels of these minerals with the exception of calcium indicated that palm grub will be good source of minerals for young, pregnant and lactating mothers as well as monogastric animals like chicken and pigs. The ratio of calcium to phosphorus in palm grub is low and biologically poor because diets richer in phosphorus than calcium have been associated with bone calcium depletion[28].

This iron content values is far less than the value of 30.8 mg/100 g dry weight reported by Elemo *et al.*[15] and similar to the value reported by Alamu *et al.*[22] for short horned grasshopper (*Cytacnthacus naeruginosus*) and giant African cricket (*Brachytrupes membranaceus*). Zinc content in samples of OBB was significantly higher than that of OSB, with mean zinc content value of 0.08 mg/100 g being lower than values of 15.8 mg/100 g dry weight and 0.47 mg/100 g in early larval stage (ELS) reported by Elemo *et al.*[15] and Omotoso and Adedire[7], respectively. Again, manganese content in sample of YEB was higher than that of OBB, with mean manganese content values of 0.05 mg/100 g being lower than the values of 0.49-3.5 mg/100 g reported by others[7,15]. There was no significant difference between chromium values obtained across sample locations. However, mean chromium content of 0.03 mg/100 g is lower than the value of 0.49 mg/100 g[7]. Mean lead value of 0.17 mg/100 g is however lower than the value of 3.02 mg/100 g as earlier reported[7]. Copper was not detected in palm grub analyzed in this study and this agrees with the report of other authors[7].

The palm grub oil was found to remain in its liquid phase at room temperature, which is unusual for oils extracted from animals. This was attributed to the presence of unsaturated fatty acids in the oil, including oleic and linoleic acids[15]. This oil was 100% unsaturated showing why it remained liquid at room temperature. Insect's fatty acids are similar to those of poultry and fish in their degree of unsaturation[29]. In terms of the degree of saturation/unsaturation of the palm grub lipids, the Raphia palm larvae showed 100% content of unsaturation in this study as against the value of 38.90% reported by Ekpo *et al.*[19]. This explained that there is a high iodine number, low solidification values and liquid nature of the oils at room temperature Ekpo *et al.*[19]. The mean iodine value of 186.76 g/100 g obtained in this study is higher than the value of 123.6 g/100 g reported by Ekpo *et al.*[19] and less than the value[15] of 192.3 g/100 g. The higher peroxide value of the palm grub oil showed that it is quite susceptible to oxidative rancidity. This can however be prevented by storing it under dark cold conditions to protect it from light, oxygen and moisture[30]. The higher acid value however disqualifies the oil for use in paint and varnish industry.

CONCLUSION

The study shows that *Rhynchophorus phoenicis* is an essential source of different food components and nutrients. With the protein value higher than that of cow milk, hen's egg and beef makes it a good protein source. The numerically high crude protein value of palm grub indicates that it can contribute significantly to the recommended human daily protein requirement stipulated in 1991 by the National research Council. The protein solubility and the mineral content in palm grub as shown in this work makes it an important food item which needs industrial application and commercialization.

SIGNIFICANCE STATEMENT

This nutritional study showed that palm grub is a reservoir of essential micro and macro-minerals that could be employed in ameliorating the problem of mineral deficiency in both humans and animals. This study also demonstrated that insects can be incorporated in animal and human food as a source of protein and fats. The high oil content in palm grub as demonstrated in this study makes it an important raw material with the potential for industrial application and commercialization.

REFERENCES

1. Fasoranti, J.O. and D.O. Ajiboye, 1993. Some edible insects of Kwara state, Nigeria. Am. Entomol., 39: 113-116.
2. Mercer, C.W.L., 1994. Sago grub production in Labu swamp near Lae, Papua New Guinea. Klinkii, 5: 30-34.

3. Adedire, C.O. and A.F. Aiyesanmi, 1999. Proximate and mineral composition of the adult and immature forms of the variegated grasshopper, *Zonocerus variegatus* (L.) (Acridoidea: Pygomorphidae). Biosci. Res. Commun., 11: 121-126.
4. Vidyasagar, P.S.P.V., M. Hagi, R.A. Abozuhairah, O.E. Al-Mohanna and A. Al-Saihati, 2000. Impact of mass pheromone trapping on red palm weevil: adult population and infestation level in date palm gardens of Saudi Arabia. Planter (Malaysia), 76: 347-355.
5. Aldryhim, Y. and S. Al-Bukiri, 2003. Effect of irrigation on within-grove distribution of red palm weevil *Rhynchophorus ferrugineus*. Agric. Mar. Sci., 8: 47-49.
6. Kalshoven, L.G.E. and P.A.V. Lann, 1981. Pests of Crop in Indonesia. P.T. Ichtiar Van Hoeve, Jakarta, Indonesia, Pages: 701.
7. Omotoso, O.T. and C.O. Adedire, 2007. Nutrient composition, mineral content and the solubility of the proteins of palm weevil, *Rhynchophorus phoenicis* F. (Coleoptera: Curculionidae). J. Zhejiang Univ. Sci. B, 8: 318-322.
8. Omoyinmi, G.A.K., S.O. Fagade and A.A. Adebisi, 2005. Nutritive value of invertebrates cultured under laboratory conditions. Zoologist, 3: 33-39.
9. Opara, M.N., F.T. Sanyigha, I.P. Ogbuewu and I.C. Okoli, 2012. Studies on the production trend and quality characteristics of palm grubs in the tropical rainforest zone of Nigeria. J. Agric. Technol., 8: 851-860.
10. Omoyinmi, G.A.K., S.O. Fagade and A.A. Adebisi, 2005. Assessment of different organic substrates in the laboratory-culture of some live food organisms. Zoologist, 3: 105-111.
11. Okoli, I.C., C.N. Anyaegbunam, E.B. Etuk, M.N. Opara and A.B.I. Udedibie, 2005. Entrepreneurial characteristics and constraints of poultry enterprises in Imo state, Nigeria. J. Agric. Social Res., 5: 25-32.
12. Fakayode, O.S. and A.A.A. Ugwumba, 2013. Effects of replacement of fishmeal with palm grub (*Oryctes rhinoceros* (Linnaeus, 1758)) meal on the growth of *Clarias gariepinus* (Burchell, 1822) and *Heterobranchus longifilis* (Valenciennes, 1840) fingerlings. J. Fish. Aquat. Sci., 8: 101-107.
13. AOAC., 1997. Official Methods of Analysis of the Association of Official Analytical Chemistry. AOAC International, Washington, DC., USA.
14. William, P.C., 1964. Determination of crude (total) protein using thecolorimetric method. Analyst, 84: 281-283.
15. Elemo, B.O., G.N. Elemo, M.A. Makinde and O.L. Erukainure, 2011. Chemical evaluation of African palm weevil, *Rhychophorus phoenicis*, larvae as a food source. J. Insect Sci., Vol. 11. 10.1673/031.011.14601.
16. Onyeike, E.N., E.O. Ayalogu and C.C. Okaraonye, 2005. Nutritive value of the larvae of raphia palm beetle (*Oryctes rhinoceros*) and weevil (*Rhyncophorus pheonicis*). J. Sci. Food Agric., 85: 1822-1828.
17. National Research Council, 1974. Recommended daily dietary allowance RDA. Nutr. Rev., 31: 373-395.
18. FAO. and WHO., 1973. Energy and protein requirements: Report of a Joint FAO/WHO ad hoc expert committee. FAO Nutrition Meetings Report Series No. 52, FAO. and WHO., Geneva, Switzerland.
19. Ekpo, K.E., A.O. Onigbinde and I.O. Asia, 2009. Pharmaceutical potentials of the oils of some popular insects consumed in southern Nigeria. Afr. J. Pharm. Pharmacol., 3: 51-57.
20. Chapman, R.F., 1980. The Insects: Structure and Function. The English Language Book Society/Stoughton and Hodder, England.
21. Aiyesanmi, A.F. and M.O. Oguntokun, 1996. Nutrient composition of *Dioclea reflexa* seed: An underutilized edible legume. Riv. Ital. Delle Sotanze Grasse, 73: 521-523.
22. Alamu, O.T., A.O. Amao, C.I. Nwokedi, O.A. Oke and I.O. Lawa, 2013. Diversity and nutritional status of edible insects in Nigeria: A review. Int. J. Biodivers. Conserv., 5: 215-222.
23. Oduor, P.M., M.H. Struszczyk and M.G. Peter, 2008. Characterisation of chitosan from blowfly larvae and some crustacean species from Kenyan marine waters prepared under different conditions. Discov. Innov., 20: 129-136.
24. Ekop, E.A., A.I. Udoh and P.E. Akpan, 2010. Proximate and anti-nutrient composition of four edible insects in Akwa Ibom State, Nigeria. World J. Appllied Sci. Techonl., 2: 224-231.
25. Ekpo, K.E. and A.O. Onigbinde, 2005. Nutritional potentials of the larva of *Rhynchophorus phoenicis* (F.). Pak. J. Nutr., 4: 287-290.
26. Teffo, L.S., R.B. Toms and J.N. Eloff, 2007. Preliminary data on the nutritional composition of the edible stink-bug, *Encosternum delegorguei* Spinola, consumed in Limpopo province, South Africa. S. Afr. J. Sci., 103: 434-436.
27. Ramos-Elorduy, J., J.M.P. Moreno, E.E. Prado, M.A. Perez, J.L. Otero and O.L. de Guevara, 1997. Nutritional value of edible insects from the State of Oaxaca, Mexico. J. Food Comp. Anal., 10: 142-157.
28. Shils, M.E.G. and V.R. Young, 1988. Modern Nutrition in Health and Disease. Leg and Febiger Inc., Philadelphia, pp: 142-148.
29. De Foliart, G.R., 1991. Insect fatty acids: Similar to those of poultry and fish in their degree of unsaturation, but higher in the polyunsaturables. Food Insects Newslett., 4: 1-6.
30. Fernandez-Lopez, J., E. Sayas-Barbera, T. Munoz, E. Sendra, C. Navarro and J.A. Perez-Alvarez, 2008. Effect of packaging conditions on shelf-life of ostrich steaks. Meat Sci., 78: 143-152.