Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 49 (2012) 9782-9786

ISSN: 2229-712X

Proximate and anti-nutritional composition of two common edible insects: yam beetle (*Heteroligus meles*) and palm weevil (*Rhynchophorus phoenicis*)

Adesina Adeolu Jonathan

Department of Chemistry, Ekiti State University, PMB 5363, Ado Ekiti. Nigeria.

ARTICLE INFO

Article history:

Received: 12 June 2012;

Received in revised form: 23 July 2012;

Accepted: 30 July 2012;

Keywords

Heteroligus meles,
Rhynchophorus phoenicis,
Proximate and anti-nutrients Compositions.

ABSTRACT

Determination of the proximate and anti-nutritional composition of two common edible insects: yam beetle (*Heteroligus meles*) and palm weevil (*Rhynchophorus phoenicis*) was carried out and the results showed that they both contained an appreciable levels of protein (38.10 and 50.01% respectvely), with moisture, ash, fibre, lipid, carbohydrate and gross energy levels being:(1.01, 5.78, 3.00, 32.01, 20.10% and 521.41Kcal/kg) and (1.16, 4.92, 2.56, 21.12, 20.23% and 480.02Kcal/kg) respectively. The results of the anti-nutritional analysis revealed that oxalate (total and soluble) were (29.00 and 19.32mg/100g) and (21.72 and 14.01mg/100g) for yam beetles and palm weevils respectively. These results were fairly high compared to other anti-nutritional components of the studied insects but generally fall within nutritionally accepted values. The lower values of phytic acid, HCN and tannins (0.311, 2.651 and 0.42mg/100g) and (0.276, 2.531 and 0.481 mg/100g) respectively for yam beetle and palm weevils. These results were generally far below toxic levels in men. Statistically, there exists positively high significant difference between the compositions of the two insects at $r_{0.05}$ and n-2 degree of freedom while the index of forecasting efficiency (IFE) was very high at 99.5% which indicates that the error of prediction was very minimal. The moisture, ash and crude fibre of the insects were very low compared to fish meat and beef. These insects therefore could serve as additional promising sources of protein and fat for the teaming population and animal feeds formulations.

Introduction

Insects are the most successful group of animals constituting about 76% of known species of animals (Yoloye, 1988). Insects affect man either as destroyers of man's valuable materials and crops or as sources of his nutrients. Goodman (1989) reported that chitin, an important insect component, can significantly reduce serum cholesterol, and serve as a haemostatic agent for tissue repairs and for accelerating healing of burns and wound. The cultural practice of entomophagy is an old and well-established custom in non-industrialized regions of the world (Omotoso, 2006). The high cost of animal protein, which is beyond the reach of the poor has greatly encouraged entomophagy (Adesina *et al., 2010*). Insects are valuable sources of animal protein for Zambia's rural population since meat from domesticated and wild animals are scarce (Mwizenge, 1993). Robert (1989) reported that a 10% increase in the world supply of animal proteins through mass production of insects can largely eliminate the malnutrition problem and also decrease the pressure on other protein sources. Studies in Nigeria have shown that entomophagy has contributed significantly to the reduction in protein deficiencies in the country (Omotoso, 2006).

Though some insects are pests, as they affect man and destroy valuable materials and crops, edible insects are important dietary components in many developing countries (Ekop *et al.,2010*). Ene (1963) has listed locust, termites, ants, grasshopper, weevils, beetles, crickets, and caterpillars among commonly consumed insects in Nigeria. Most insects are known to contain phytic acid as the only prominent anti-nutrient, but Ekop (2004) has shown that this toxic component are easily detoxified during processing like – frying, boiling and roasting. Studies in Nigeria show that most Nigerians have directly or indirectly consumed edible insects, although this is more prevalent in rural than urban areas (Ekop *et al.,*2010). According to Adeyeye (2011), termites are also useful to man, mainly as food for man and animals. Beyond West Africa, much importance has been attached to termites as food. Hickin (1971) reported that they are on sale in the United States, together with other insects, enveloped in candy. In places where meat and other protein containing foods are scarce termites constitute a useful source of protein. Some insects such as oysters, beetles grubs and termites are collected mainly by women and children; and according to Akingbohungbe (1988) grasshoppers and crickets are eaten mainly by children, as food. Ekop *et al.(*2010), Children and pregnant women, especially *primigravida*, naturally relish the savour of roasted cricket and winged termites. Caterpillars are regular in the rural village menu but animal meat is rather a stranger (Muyay, 1981). The aversion to insects as human food among Europeans is nothing more than custom and prejudices as rightly asserted by Owen (1973). Generally, grubs of the palm weevil are fried and eaten in several parts of Western and Niger Delta regions of Nigeria, where active marketing and roadside- hawking are seen along busy roads. *Cirina forda* is one of the most widely eaten insects in the Southern Nigeria (Fasoranti and Ajiboye, 1993). The larva of this insect is a delicacy served as snacks or taken with carbohydrate food in Nigeria (Omotoso, 2006).

In Uganda, the larvae of many species of the larger beetles are sought and eaten but are not as popular and important, as termites and grasshoppers in their diet (Adeyeye, 2011; Ekop *et al* 2010). Different ethnic groups in Africa may consume insects

Tele:
E-mail addresses: jonaoluade@yahoo.com

based on prevalence and seasonal ubiquity of particular insects species. This helps to ameliorate the chronic or seasonal shortage of vertebrate protein in sub- Sahara Africa. Kent (2002), observed that Food supply and nutritional status in many African countries are inadequate in quantity and quality. This contributes to the widespread of malnutrition in the continent. In almost every legume, especially beans and rice, we ingest some significant numbers of rice weevils *(Sitophilus oryzae*) larvae, and this has been suggested by Taylor (1975) to be an important source of vitamin. Ekop *et al*.(2010), reported that the consumption and usage of various insects for rituals and medicinal purposes are among the traditions and customs of the medieval African that has persisted till date and that the paucity of literature data and information has not allowed fast wide spread of insects consumption as viable alternative source of food.

The present work focuses on the proximate and anti-nutrient composition of Yam beetle (*Heteroligus meles*), Palm weevil (*Rhynchophorus phoenicis*). This work brings into focus the classes of food present in them and the awareness will encourage continued consumption and exploitation of these alternative cheap sources of lesser-known food item and for possible domestic and industrial uses.

Materials and methods

Fifteen identified samples of each edible insects- Yam beetle(*Heteroligus meles*) and Palm weevil (*Rhynchophorus phoenicis*) were randomly collected using entomological nets, and some handpicked from different local farms in Ifaki Ekiti, Ekiti State. The i were insects were killed as recommended by Banjo *et al*. (2006). The frozen samples were then allowed to de-froze at room temperature in the laboratory and finally oven-dried to constant weight at about 65ºC for 24 hours with the exception of the samples for moisture determination. Dry samples were sub-grouped according to their species.The wings and hairs were removed before being ground into powder with an electric grinder. Each ground sample was stored in labeled air-tight plastic containers and preserved in air-dried-oven for laboratory analysis. Samples digestion and dissolution was done according to the method described by Whiteside (1979), using dry- ashing/ digestion for solutions meant for titration experiments.

Proximate analysis

Proximate analysis of the sample's moisture content, ash, ether extract and fibre content were done using the method reported by AOAC (2005). Nitrogen was determined by the micro-Kjeldahl method reported by Pearson (1976) and crude protein content was subsequently calculated by multiplying the nitrogen content by a factor of 6.25. Carbohydrate content was estimated by subtracting the sum of the weights of protein, fibre, ether extract and ash from the total dry matter and reported as nitrogen-free extractives (NFE by difference). All determinations were in triplicates.

Anti-nutrient analysis

The estimation of phytin-phosphorus (phytin-P) was by the colorimetric procedure of Wheeler and Ferrel (1971) as modified by Reddy et al.(1978). Phytic acid was calculated by multiplying phytin-P by a factor of 3.55 (Enujiugha and Olagundoye, 2001). Oxalate content was determined according to the procedure of Day and Underwood (1986). Tannin content was determined by the qualitative method of Markkar and Goodchild (1996) as modified by Enujiugha and Ayodele-Oni (2003). All determinations were in triplicates. For HCN determination, alkaline sample solution was titrated with standard 0.02N $AgNO_3$ to a permanent turbid KI indicator end point.

Note: 1 ml of 0.02N $AgNO_3$ = 1.08 mg HCN. (AOAC, 2005)

Results

Table 1a gives the percentage composition of the following parameters; Moisture, Ash, Fiber, Lipid, Crude protein, Caloric value in Kcal/kg, and CV% for the insects studied

Parameters	Yam beetle (*H. meles*)	Palm weevil (*R. phoenicis*)	Mean	SD	CV%
Moisture	1.01	1.16	1.09	0.106	9.270
Ash	5.78	4.92	5.35	0.608	11.36
Fibre	3.00	2.56	2.78	0.311	11.19
Lipid	32.01	21.12	26.57	7.700	28.98
Protein	38.10	50.01	44.06	8.421	19.11
Carbohydrate	20.10	20.23	20.17	0.092	0.010
Caloric value	521.41	480.02	500.72	49.27	9.840

Table 1b gives the statistical data from table 1a

r_{xy}	$(r_{xy})^2$	CA	IFE %
0.999	0.998	0.045	99.5

Table 2a Results of Anti-Nutrient (mg/100g)

Parameters	Yam beetle (*H. meles*)	Palm weevil (*R. phoenicis*)	Mean	SD	CV%
HCN	2.651	2.531	2.591	0.085	3.28
Total Oxalate	29.00	19.32	24.15	6.845	28.3
Sol. Oxalate	21.72	14.01	17.87	5.451	30.5
Phytate	0.311	0.276	0.293	0.025	8.53
Tannin	0.421	0.481	0.451	0.042	9.31

Table 2b gives the statistical data from table 2a

r_{xy}	$(r_{xy})^2$	CA	IFE %
0.999	0.998	0.045	99.5

Discussion

The result of the proximate composition of both Yam beetle (*Heteroligus meles*) and Palm weevil (*Rhynchophorus phoenicis*) are shown in Table1a. The moisture content was quite low (1.01 and 1.16% respectively) which may be advantageous in view of the sample's shelf-life. A careful study of the data in Table 1a shows that Palm weevil (*Rhynchophorus phoenicis*) was higher (1.16) percentage moisture when compared with the values for yam beetles which has a value of 1.01% . The moisture content of the entire insects are generally low. This indicates that they can all be preserved for a reasonable period of time without the risk of microbial deterioration and spoilage. The long shelf-life promised here is an added advantage over other sources of protein like beef, egg, fish, which are easily prone to spoilage on careless keeping. The values (1.01&1.16%) obtained here are slightly lower than the value (3.41%) reported by Banjo *et al*. (2006) for cricket. This disparity might be due to the size, maturity (age) and location (habitat) of the samples collected for analysis.

The Ash contents of both Yam beetle (*Heteroligus meles*) and Palm weevil (*Rhynchophorus phoenicis*) (5.78 & 4.92% respectively), although the value obtained for Yam beetles was slightly higher than that of palm weevil but fairly close to the values obtained for termites, *Trinervitermes germinatus*, (5.39%~13.90%) by Ajakaiye and Bawo (1990) but lower than the value obtained for *Chrysichthys* species, (17.9%) by Mba

(1980) and equally close the values reported for grasshopper (4.30 -6.40%) by Ekop *et al.*(2010). Since the ash content of a sample is a reflection of the minerals it contains. There is a consensus among researchers that ash content of a given sample correlates the mineral contents of the sample. It stands to suggest that the four insects studied here can give a fair source of mineral elements as earlier reported by Ene (1963) and could be particularly useful for children and pregnant and lactating women.

The lipid content of the two insects studied were 32.01& 21.12% for Yam beetle (*Heteroligus meles*) and Palm weevil (*Rhynchophorus phoenicis*) respectively, the average value being 26.57% as contained in Table 1a. These values are in greater agreement with the values obtained for *Z. variegatus* (17.65%±3.24%) ~ (22.93%±3.37%) by Adedire and Aiyesanmi (1999). Fats are essential in diets as they increase the palatability of foods by absorbing and retaining their flavours (Aiyesanmi and Oguntokun, 1996), are also vital in the structural and biological functioning of the cells and help in the transport of nutritionally essential fat-soluble vitamins. Both insects can provide supplementary dietary fat in feed formulation for animal husbandry. The quality of this fat needs to be ascertained in future research, since high density lipoprotein (HDL) is preferred to low density lipoprotein (LDL) in the prevention of heart arrest. Usually, unsaturated fats have HDL while saturated fats are associated with LDL.

The results showed that the two insects were fairly rich in protein (38.10&50.01%) respectively for Yam beetle (*Heteroligus meles*) and Palm weevil (*Rhynchophorus phoenicis*). These values were lower than the values reported in the larval and adult stages of *Zonocerus variegatus* (50.39%±2.01%)~(53.10%±0.56%) by Adedire and Aiyesanmi (1999). However, the protein value obtained for palm weevil compares favourably with the values obtained for periwinkle, *Pachymelania bryonensis*, (55.00%) and dogwhelk, *Thais cattifera*, (56.44%) (Mba, 1980; Udoh et al., 1985). Thus, *C. forda* could contribute significantly to the recommended human daily protein requirement of 23%~56% stipulated by NRC (1980).

The amount of carbohydrate obtained for the insects were 20.10 & 20.23% yam beetle and palm weevil respectively. These values are slightly higher than some literature (Dunkel, 1996) values for similar insects; e.g cricket, large grasshopper, red ant and giant water beetle: 5.1, 2.2, 2.9, and 2.1% respectively). Insects are therefore not a good source of carbohydrate as revealed in this work. Human adult need about 400 – 500g carbohydrate intake as starch.

Crude fiber content in the edible insects under study is 3.00 and 2.50% for yam beetle and palm weevil respectively. These are appreciably high and could be attributed to little amount of chitin found normally in insects, Oduor *et al*.(2008), have reported that chitin and chitosan yield differ with species. The physiological role of crude fiber in the body is to maintain an internal distention for proper peristaltic movement of the intestinal tract (Oduor *et al*., 2008). A diet very low in fiber, could therefore lead to constipation which might bring discomfort to the body system with running stool (Groff at al., 1999). Diets with high fiber content have been used for weight control and fat reduction, as they give a sense of satiety even when small food is eaten (Ekop, 2004). The results of crude fiber content (3.00 and 2.50%) of the two insects corroborate and compared favorably with those of Banjo *et al*.(2006) for similar species. From the above, these insects are good sources of crude fiber.

The calculated gross energy values for the insects are appreciably high. They are varying but generally higher than some literature for similar insects. The variation might stem from variation in the fat control which seems to be influenced by the age, sex and habitat of the species (Ekop *et al.*, 2010). The mean energy values with the standard deviation are as follows: Yam beetle 521.41 > Palm weevil 480.02 Kcal/kg. None of the insects when taken in isolation as diet can meet the recommended daily allowance of 2500 – 3500 kCal. These insects need to be taken along side with other food items or taken as snacks, tip-bits and delicacy. However, insects can contribute greatly to the caloric content of food.

The results of anti-nutritional components of the studied insects were presented in Table 2a. Phytic acid averaged (0.311 and 0.276) mg/100 g in *H. meles* and *R. phoenicis* respectively while oxalate recorded (29 and 19.32) mg/100 g. These values are lower than those reported in some proteinous foods. Vijayakumari et al.(1997) reported that 513 mg of phytic acid is present in 100 g of *P. chilensis*. *P. chilensis* is a legume that is very rich in methionine and cystine (de Lumen et al., 1986). Phytate, like oxalates, limit the availability of some notable minerals like magnesium, iron, and even calcium (Groff *et al*., 1995). Considering the trace values in the edible insects, means that they could be consumed without any fear of harm to the human body in respect to phytic acid toxicity. Phytic acid has also been implicated in the removal of phosphorus and causing indigestion and flatulence in human system (Ndubuakaku *et al*., 1998). The values of oxalate were exceptionally higher than other anti- nutrient values. The lethal dose of oxalate is between 200mg/100g and 500mg/100g (Pearson, 1973). With detoxification through processing, these edible insects are safe for consumption with respect to oxalate toxicity. Oxalates are known to sequester and precipitate some useful metallic elements, thus making them unavailable for adsorption in human system (Groff *et al*., 1995).

The HCN content of *H. meles*, and *R. ph*oenicis were 2.187/100g, 2.651mg/100g and 2.531mg/100g, respectively. HCN are highly toxic to animals. The lethal dose of HCN to human is considered to be 35mg(Oke 1969). While NRC (1974) gave the toxic level to be between the range 50-200mg/100g. The HCN values obtained for all the samples showed that they are negligible; hence they are not toxic to humans when consumed as per HCN toxicity. High level of HCN has been implicated for cerebral damage and lethargy in man and animals (Akyildiz *et al*., 2010; Ekop *et al*.,2010).

Tannin contents obtained from studied insects were 0.421 and 0.481 mg/100g for *H. meles* and *R. phoenicis* respectively. Tannins possess both toxic and therapeutic functions. They are toxic in that they coagulate protein (Groff *et al*., 1995). This toxicity can be removed by heating. Okon and Ekop (2009) had shown that boiling and fermenting can drastically reduce tannin in cowpea. The trace level of tannin contents in these edible insects is therefore considered to be below toxic level in humans. Recent studies have demonstrated that products containing chestnut tannins at low dosages (0.15-0.2%) in the diet can improve broiler chicken performance and wellbeing (Schiavone *et al*., 2007). The trace values of anti-nutrient content recorded for *H. meles*, and *R. phoenicis* showed that they can be consumed without fear of toxicity. This result will encourage the incorporation of these insect into food feeds formulations. Tannins are capable of lowering available protein by antagonistic competition and can therefore elicit protein deficiency syndrome (Ekop, 2009).

Table 1b and 2b shows the statistical summary of the results in tables 1a and 2a. The tables showed a linear correlation coefficient (r_{xy}) was positively and significantly higher at $r_{0.05}$ and n-2 degrees of freedom (df) for both the proximate composition presented in table 1a and anti-nutritional contents presented in table 2a. The coefficient of determination was also high in both set of parameters considered. The coefficient of alienation (C_A) (4.5%) was very low, which showed that a reasonable relationship exist between the nutrient compositions of the two insects which indicates that they can be eaten in complimentary of one another. The index of forecasting efficiency (IFE) was high at 99.5% for both set of data. The IFE if actually the reduction in the error of prediction of relationship, meaning that relationship would very easy to predict between the yam beetle (*H. meles)* and palm weevil (*R. phoenicis).*

Conclusion

The results of this work showed that yam beetle (*H. meles)* and palm weevil (*R. phoenicis)* are rich source of nutrients and so may be recommended for consumption by economically weaker sections of populations throughout the developing countries, most especially in Africa and Asia, to alleviate the problem of nutrient/protein malnutrition. The anti-nutrient contents of the four edible insects studied, were observed to be generally low and within safe consumption levels. On the whole, result of this study has confirmed that these edible insects could contribute significantly to the recommended daily protein of 123 – 56% stipulated by NRC(1989). Based on the results of this work, it may be concluded that identified crickets, grasshoppers, yam beetles and palm weevils are non-toxic edible insects, rich in protein and caloric values. Their continued consumption is, therefore, advocated and encouraged in solving the problem of malnutrition among the less-privileged in this part of Nigeria in particular, and the world at large where need arises.

Reference

Adedire CO, Aiyesanmi AF. (1999) Proximate and mineral composition of the adult and immature forms of the variegated grasshopper, *Zonocerus variegatus* (L.) (Acridoidea: Pygomorphidae) *Bioscience Research Communications*. 11:121–126.

Adesina, A.J, Olagboye, S.A, Agbaogun. B (2010). Proximate analysis of maggots meal as supplement for fish meal. *Int. Jour. Bioscience*, Vol.5 No 3: 59-63.

Adeyeye, E. I. (2011).Fatty acid composition of *zonocerus variegatus, macrotermes bellicosus* and *anacardium occidentale* kernel. *International Journal of Pharma and Bio Sciences*. Vol. 2 issue 1: B135- B144.

Akingbohungbe, J.O.(1988). Insects Structure. McGraw Hill Book Company Inc. New York. Pp 97-98.

Akyildiz, B.N., Kurtoglu, S., Kondolot, M., Tunc, A. (2010). Cyanide Poisoning caused by Ingestion of Apricot seeds. *Ann. Trop. Paediatr*. 30(1): 39- 43.

Aiyesanmi AF, Oguntokun MO. (1996) Nutrient composition of *Dioclea reflexa* seed–an underutilized edible legume. *Rivista Italiana delle Sostanze Grasse*.73:521–523.

Ajakaiye CO, Bawo A. (1990) Comparison of the chemical composition of *Trinervitermes germinatus* (Wasmann) with that of its feed. *Nigerian Journal of Entomology*.2:90–99.

A.O.A.C.(Association of Official Analytical Chemists), (2005). Official Methods of Analysis, 15th edn. (Gaithersburg, S. edn). AOAC Press, Washington DC., USA. Pp. 78- 90.

Banjo, A.D., Lawa, O.A. and Songonuga, E. A. (2006). The Nutritional Value of Fifteen Species of Edible Insects in Southwestern Nigeria. *African Journal of Biotechnology*, 5: 298-301.

Day RA, Underwood AL. (1986).Qualitative Analysis. 5th Ed. New Delhi, India: Prentice-Hall Publications. p. 701. de Lumen BO, Becker R, Reyes PS. (1986) Legumes and a cereal with high methionine/cystine contents. *Journal of Agric Food Chem.* 34:361–364.

Ekop, A.S.(2004). Effects of Processing on the Chemical Composition of Maize. *24th Annual Conference of Nigerian Society of Biochemistry and Molecular Biology.* University of Calabar. Nov 24th -27th.

Ekop, A.S. (2009). Changes in Amino acid composition in African yam beans and African locust beans on cooking. *Pakistan J. of Nutr*. 5(3): 254 – 256.

Ekop, E. A, Udoh, A. I. and Akpan, P. E. (2010) Proximate and anti-nutrient composition of four edible insects in Akwa Ibom state, Nigeria. *World Journal of Applied Science and Technology.* Vol.2. No. 2. 224 – 231

Ene, J.C.(1963). *Insects and Man in West Africa*. Ibadan University Press, Ibadan. Pp. 11-13.

Enujiugha V.N, Olagundoye, T.V.(2001) Comparative nutritional characteristics of raw fermented and roasted African oil bean (*Pentaclethra macrophylla* Benth) seeds. *Rivista Italiana delle Sostanze Grasse*. 78:247–250.

Enujiugha VN, Ayodele-Oni O. (2003) Evaluation of nutrients and some anti-nutrients in lesser-known, underutilized oilseeds. *International Journal of Food Science and Technology.* 38:1–4.

Fasoranti JO, Ajiboye, D.O. (1993) Some edible insects of Kwara State, Nigeria. *American Entomologist*. 39:113–116.

Goodman, W.G. (1989). Chitin: A Magic Bullet? *A Food Insect Newsletter*. 3: 6-9

Groff, J., Gropper, S. and Hunt, S.(1995). Advanced Nutritional and Human Metabolism. 2nd edn., New York. Pp. 221- 362.

Hickin, N.E. (1971).Termites: a world problem. Hutchinson University Library, London

Kent, G. (2002). Africa's Food Security under Globalization. *AJFNS*. 2: 22-29.

Markkar AOS, Goodchild AV. (1996) Quantification of Tannins. A Laboratory Manual. Aleppo, Syria: International Centre for Agricultural Research in Dry Areas (ICARDA) Press; pp. 4–25.

Mba AU. (1980). Chemical composition of some local sources of protein foods for man. *Nigerian Journal of Nutritional Science*. 1:142–147.

Muyay, F.A.(1981). Les Insectes Comme Aliments de I' Homme CEEBA Publications Series 11 vol.69. Bandundu, Zaire. Pp 177. (English Language Review by Dan Turk in Food *Insects Newsletter.* 4(2): 5-6, 8).

Mwizenge ST. (1993). Delicious insects: seasonal delicacies in the diet of rural Zambians. World and I. 8:234.

National Research Council, NRC (1989). *Recommended Dietary Allowances.* 8th edn. Food and Nutrition Board: National Academy of Science, Nigeria. Pp. 20- 40.

Ndubuakaku, V.O., Uwangbute, A.C. and Nnanyelugo, D.O. (1988). Flatulence and other Abdominal Discomforts associated with Cowpea. *Appitite*. 13: 171- 181.

NRC (National Research Council) Recommended Dietary Allowances. 9th Ed. Washington DC: Nat. Acad. Sci; 1980.

Pearson D.(1976). Chemical Analysis of Foods. 7th Ed. Livingstone, London: Churchill. pp. 7–11.

Oduor, P.M., Struszczyk, M.H. and Peter, M.G. (2008). Characterization of Chitosan from Blowfly Larvae and Some Crustacean Species from Kenyan Marine Waters Prepared under different Conditions. *Discovery and Innovation.* 20(2): 129- 142.

Oke, O.L. (1999). Nutritive value of some Nigerian melon. *Nuture*. 207(49). Pp. 178- 180

Omotoso, O.T. (2006). Nutritional quality, functional properties and anti-nutrient compositions of the larva of *Cirina forda* (Westwood) (Lepidoptera: Saturniidae). J *Zhejiang Univ Sci B*. 7(1): 51–55.

Person, D. (1973). *Laboratory Techniques in Food Analysis*. Butterworths, London. Pp. 33- 52.

Reddy NR, Balakrishnan CN, Salunkhe DK. (1978). Phytate, phosphorus and mineral changes during germination and cooking of black grain (*Phaseolus mungo* L.) seeds. *Journal of Food Science.* 43:540.

Robert K. (1989) .The application of industrial technology for production of insects as food. *The food Insect Newsletter.* 3:3.

Schiavone, A., Guo, K., Tassone, S., Gasco, L., Hermandez, E., Denti, R., and Zoccarate, I., (2007). Effects of a natural extract of chestnut wood on digestibility, performance traits, and nitrogen balance of broiler chicks. *Poultry Science*. 87: 521-527.

Udoh, A.P, Effiong, R.I, Edem D.O. (1985). Nutrient composition of dogwhelk (*Thais cattifera*), a protein source for humans. *Tropical Science.* 35:64–67.

Vijayakumari K, Siddhuraju P, Janardhanan K.(1997). Effect of domestic processing on the levels of certain antinutrients in *Prosopis chilensis* seeds (Molina) Stunz. *Food Chemistry*. 59:367–371.

Wheeler E.L, Ferrel R.E.(1971). A method for phytic acid determination in wheat and wheat fractions. *Cereal Chem.* 48:312–320.

Yoloye, V.L. (1988). *Basic Invertebrate Zoology*. 1st edn. University of Illorin Press, Illorin. P.192.