British Journal of Environmental Sciences

Vol.6, No.1, pp. 1-11, March 2018

Published by European Centre for Research Training and Development UK (www.eajournals.org)

THE NUTRIENT PROFILE OF THE DEVELOPMENTAL STAGES OF PALM BEETLE, ORYCTES RHINOCEROS L.

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ABSTRACT: *The palm beetles, Oryctes rhinoceros L are pests of palm trees in the tropics and are also very important as edible insects. This study was conducted to investigate the nutrient composition, mineral salt contents, functional properties and anti-nutrient factors of the developmental stages (i.e. larvae, pupae and adults) of Oryctes rhinoceros beetles. The samples were oven-dried and blended into fine particles before being used for nutrient composition analyses using standard procedures. Analysis of mineral salts, functional composition and phytochemical (anti-nutrient) composition were also carried out, using standard procedures. The results obtained showed that protein content was highest in the adult (74.18±0.15%) while larva and pupa had 70.76±0.12% and 65.34±0.11% respectively. The ash content of the larva was the highest with a value of 8.29±0.01% while the pupa and the adult had 3.17±0.01% and 5.29±0.01% respectively. The pupa was highest in fat content (20.21±0.03%) while the larva had 7.47±0.01% and the adult had 9.55±0.01%. The moisture contents of the larva, pupa and adult are 1.04±0.02%, 4.76±0.02% and 4.53±0.03% respectively. The larva stage had the highest soluble proteins while the lowest protein solubility was observed in the pupa stage. In the larva stage, the highest protein solubility occurred in acidic medium while in the pupa and adult, it occurred in basic and neutral media respectively. Phosphorus was consistently highest in all the developmental stages. While Cu was not detected in any of the developmental stages, Magnesium was the highest minerals in the beetle with the values of 71.54±0.20mg/100g, 56.55±0.13mg/100g and 58.73±0.11mg/100g in the larva, pupa and adults respectively. Other mineral salts that were detected include Na, K, Ca, Fe, Zn, Mn and Cr. All the developmental stages of O. rhinoceros have good functional properties and thus can be used in baking industries. They all have high water absorption capacity, oil absorption capacity, foaming capacity, emulsion capacity and good least gelation concentrations. The anti-nutrient values of all the developmental stages are of negligible quantity that will pose no threat to life since the values fall within the tolerance values. Oryctes rhinoceros is a good source of nutrients and minerals which can be put to better use to accelerate the proper growth and development of man and livestock.*

KEYWORDS: Phytochemicals, Anti-Nutrients, Water Absorption Capacity, Gelation.

INTRODUCTION

Oryctes rhinoceros L. is a major pest of palm trees such as the oil palms, coconut palms and raphia palms. Much of the pieces of information available on the palm beetle are centered on its tendencies as a major pest of agricultural products such as coconut palms, oil palms, ornamental palms, raphia palms, banana, sugar cane, pawpaw, sisal and pineapple (Bedford, 1980, Sharma and Gupta, 1988, Koo, *et al.*, 1991, DeFoliart, 2003, Rasmi, 2010, Al-deed *et al.*, 2012, Manjeri, *et al.*, 2014). The larval stage of the beetle is usually yellowish white in colour and may grow to about 60-100 mm long or more (Ooi, 1988). The pupa stage is yellowish brown in colour and may measure up to 50 mm in length (Bedford, 1974). The adults

ISSN 2054-6351 (print), ISSN 2054-636X (online)

are shiny dark brown or black in colour, stout looking and can be 35-50 mm in length (Bedford, 1974).

Oryctes rhinoceros is an important edible insect which is highly relished in the tropics. Scarabaeidae beetles are very important for religion, medicine, food, regalia and body ornamentation (Ratcliffe, 2006).In Africa, entomophagy is a traditionally and culturally acceptable way by which low income earners supplements the meager protein contents of their high carbohydrate diets (Ekpo*et al*., 2009). *Oryctes rhinoceros*are highly relished food items in Nigeria, especially among the rural populace.Oluwo*et al.*, (2012) reported that the larvae of *O. rhinoceros* are well relished as snacks or main meals in Southwest Nigeria.Grimaldi and Bikia (1985) reported that coconut larvae are favourite dish that are offered only to good and important friends in Cameroon.The beetles are currently available in most urban markets of the country.Insects are consumed in all tribes and cultures. In Northeastern India, the data on the consumption of insects showed that 61.21% are consumed at the larval stage while 16.67% and 11.11% are consumed at mature and adult hive stage respectively (Kato and Gopi, 2009). Animals and insects especially are eaten as medicinal resources for the treatment and relieve of a myriad of illnesses and diseases in practically every human culture (Costa-Neto, 2005). There are fewer literatures on the nutrients composition of the palm beetle, and this has facilitated the conduction of this work, to determine the nutrient composition, mineral salts composition, solubility, functional properties and the anti-nutrient composition of the developmental stages of the beetle.

MATERIALS AND METHODS

Collection and preparation of the developmental stages of *Oryctes rhinoceros*

The developmental stages (100 pieces of the larvae, pupae and adults) of *O. rhinoceros* used for this work were obtained from a farmer in Ifaki-Ekiti in Ekiti State of Nigeria. Ifaki-Ekiti is a town that is situated in the tropical humid region of Nigeria. The town lies on latitude7.79^0 N and Longitude 5.25^0 E and 457 meters elevation above the sea level. The developmental stages were handpicked into three plastic containers into which palm chippings have been added. The containers were used to convey the developmental stages of the beetle to the laboratory. They were allowed to stay for 3 h in the laboratory. Each of the developmental stages was washed with distilled water before being asphyxiated in a deep freezer at -10^o C for 3 h. The developmental stages were later oven-dried separately at 60^o C for 5 h. The dried samples were separately pulverized with a blender (Qasa model) into fine powder and kept in air-tight containers until needed for analysis.

Nutrient composition of the developmental stages of *O. rhinoceros*

The nutrient composition of each of the developmental stages was carried out by employing standard procedures. The moisture content, fat content, ash content and the mineral content were determined by the method of Association of Official Analytical Chemists AOAC (1990). Sodium and Potassium were determined by flame photometric method while Phosphorus was determined by the phosphovanado-molybdate reagent method reported by AOAC (2005) using Spectronic 20 Colorimeter. Mineralsalts such as Calcium, Magnesium, Iron, Zinc, Manganese, Lead, Nickel, Copper and Cr were determined with Alpha 4 Atomic absorption spectrophotometer. Protein content was determined by the method reported by Pearson (1976).

ISSN 2054-6351 (print), ISSN 2054-636X (online)

Protein solubility was determined by Biuret method, using Standard Bovine Serum (BSA). Joslyn (1970) method was employed in the determination of the crude fibre content. Carbohydrate was determined by difference.

Phytochemical (anti-nutrient) composition of the developmental stages of *O. rhinoceros*

The saponin content was determined by adopting the method reported by Obadoni and Ochuko (2001). Young and Greaves (1940) method was employed in phytin determination. Oxalate was determined by the method reported by Day and Underwood (1986). Tannin was determined by the method reported by Makkar and Goodchild (1996). Alkaloid was determined by the method reported by Harbone (1973) while Boham and Kocipal-Abyazan (1974) method was adopted in flavonoid determination.

Functional properties of the proteins of the developmental stages of *O. rhinoceros*

The methods reported by Coffman and Garcia (1977) were employed in the determination of the least gelation concentration (LG), foaming capacity (FC) and foaming stability (FS). Water absorption capacity (WAC) and oil absorption capacity (OAC) were determined by Beuchat (1977) methods while emulsion capacity (EC) and emulsion stability (ES) were determined by Yasumatsu*et.al.*,(1972) method.

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) and where significant differences existed, treatment means were compared at 0.05 significant level using Tukey Test.

RESULTS

The result of the nutrient composition of the developmental stages of the palm beetle, *O. rhinoceros* is shown in Table 1 below. The pupa stage has the highest moisture content of 4.76±0.02%. This value was closely followed by the 4.53±0.03% obtained in the adult while the larva recorded 1.04±0.02%. The protein content of the larva, pupa and adult were 70.76±0.12%, 65.34±0.11% and 74.18±0.10% respectively. All the stages had high content of protein. The highest value of ash (8.29±0.01%) was obtained in the larva stage while the pupa and the adult recorded 3.17±0.01% and 5.29±0.01% respectively. The fibre content of the larva, pupa and adult stages were 5.44±0.01%, 2.24±0.01% and3.69±0.01% respectively. The fat content of the pupa stage was 20.21±0.03% while the adult has 9.55±0.01% and the larva recorded 7.47±0.01%. Carbohydrate content was lowest in the adult (2.27±0.04%) while the pupa has 4.28±0.01% and the highest was obtained in the larva which has 7.01±0.10%. The gross energy derivable from the larva, pupa and adult stages are 1598.48Kj/100g, 1931.31Kj/100g and 1661.33Kj/100g respectively.

ISSN 2054-6351 (print), ISSN 2054-636X (online)

Table 1 Nutrient composition of the developmental stages of *O. rhinoceros*

Parameters (%)	Larva stage (100g)	Pupa stage (100g)	Adult stage (100g)
Moisture content	1.04±0.02	4.76±0.02	4.53±0.03
Protein content	70.76±0.12	65.34±0.11	74.18±0.10
Ash content	8.29±0.01	3.17±0.01	5.29±0.01
Fibre content	5.44±0.01	2.24±0.01	3.69±0.01
Fat content	7.47±0.01	20.21±0.03	9.55±0.01
Carbohydrate	7.01±0.10	4.28±0.01	2.76±0.04
Gross Energy (100g)Kj	1598.48	1931.31	1661.33

Each value is a mean ± Standard deviation of triplicate (Tukey test)

The result of the percentage protein solubility is shown in Fig. 1. The pupa stage persistently recorded the lowest protein solubilities among all the developmental stages. The highest protein solubility of 76.50% obtained in this stage was obtained in alkaline medium, pH 8. The proteins in the pupa tend to be more soluble in alkaline media than in acidic media. There was only one isoeletric point. In the adult stage, the highest protein solubility of 87.50% was obtained in the neutral pH of 7.0 while the least value of 84.20% was obtained in the pH 11. There are four isoelectric points and the proteins seemed to have affinity for acidic media. The proteins of the larva are highly soluble. The highest value 95.0% was obtained in both acidic medium (pH 1) and alkaline (pH 8) medium. Moreover, the least protein solubility value of 92.20% was obtained in alkaline medium of pH 11. There are two isoelectric points in the proteins.

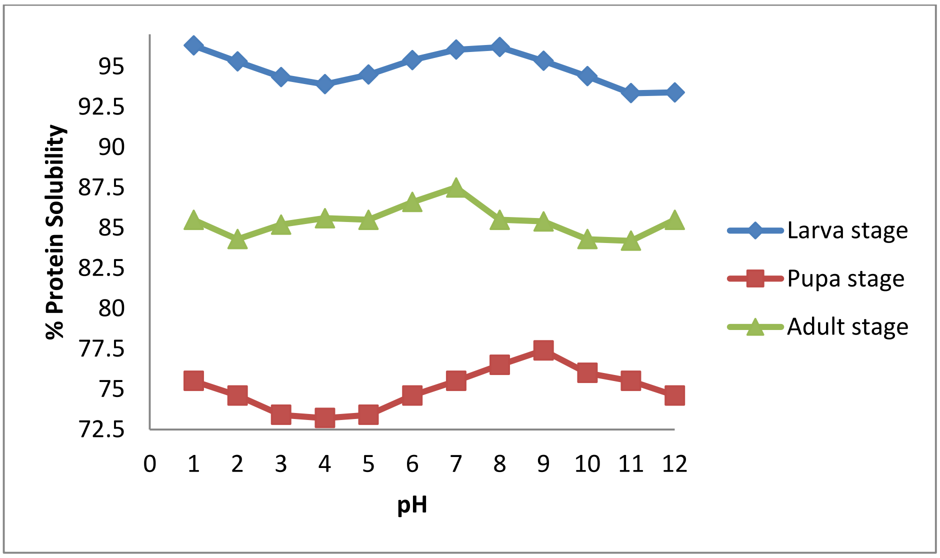

Fig. 1 Percentage (%) Solubility of the proteins of the developmental

Stages of the palm beetle, *O. rhinoceros*

Among the mineral salts obtained in the developmental stages of palm beetle, *O. rhinoceros* are sodium (Na^+), Calcium (Ca), Potassium, (K), Magnesium (Mg), Phosphorus (P), Iron (Fe), Zinc (Zn), Manganese (Mn) and Chromium (Cr) while Copper (Cu) was not detected in any of the developmental stages (Table 2.). The mineral salt with the highest value was Phosphorus and the highest value was obtained in the larva (113.015±0.61mg/100g) while the pupa and the adult had 76.70±0.15mg/100g and 84.85±0.30mg/100g respectively.Magnesium was the

ISSN 2054-6351 (print), ISSN 2054-636X (online)

second highest prominent mineral salts in all the developmental stages of the palm beetles. The values obtained in the larva, pupa and adult are 71.54±0.20mg/100g, 56.55±0.13mg/100g and 58.73±0.11mg/100g respectively. The third most common mineral salt in *O. rhinoceros* was Potassium. The highest value of Potassium was obtained in the larva, 67.54±0.14mg/100g, while pupa and adult stages obtained 45.77±0.21mg/100g and 49.62±0.10mg/100g respectively. The contents of Sodium in the larva, pupa and adult stages are 47.08±0.02mg/100g, 40.67±0.01mg/100g and 37.67±0.03mg/100g respectively. Calcium was highest in the larva (43.37±0.01mg/100g) while pupa and adult obtained 34.29±0.05mg/100g and 35.48±0.16mg/100g respectively. Iron content of the larva, pupa and adults are 6.35±0.01mg/100g, 5.54±0.01mg/100g and 5.87±0.01mg/100g respectively. The Zinc content was 4.55±0.01mg/100g for the larva, 4.55±0.01mg/100g for the pupa and 3.68±0.01mg/100g for the adult stage. Among the mineral salts that exist in negligible amount in the developmental stages are Chromium (larva 0.03±0.01mg/100g, pupa 0.02±0.01mg/100g and adult 0.01±0.01mg/100g respectively) and Manganese (larva 1.25±0.01mg/100g, pupa 1.02±0.01mg/100g and adult 1.08±0.01mg/100g respectively).

Table 2. Mineral salts composition of the developmental stages of *O. rhinoceros*

Mineral salts (mg)	Larva stage (100g)	Pupa stage (100g)	Adult stage (100g)
Na	47.08±0.02	40.67±0.01	37.67±0.03
K	67.54±0.14	45.77±0.21	49.62±0.10
Ca	43.37±0.01	34.29±0.05	35.48±0.16
Mg	71.54±0.20	56.55±0.13	58.73±0.11
P	113.15±0.61	76.70±0.15	84.85±0.30
Fe	6.35±0.01	5.54±0.01	5.87±0.01
Zn	4.55±0.01	4.55±0.01	3.68±0.01
Mn	1.25±0.01	1.02±0.01	1.08±0.01
Cu	ND	ND	ND
Cr	0.03±0.01	0.02±0.01	0.01±0.01

Each value is a mean ± Standard deviation of triplicate (Tukey test)

ND= Not Detected

The result of the functional properties of the proteins of the developmental stages of the palm beetles are presented in Table 3. The oil absorption capacity was highest in the larva, 360.22±0.10. This value was closely followed by the value obtained in the adult, 356.60±0.21% while the least was 350.47±011% obtained in the pupa stage. Water absorption capacity followed the same trend in all the developmental stages. The highest was obtained in the larva, 298.17±0.12% while adult has 281.35±0.20 and the pupa obtained 270.10±0.23%. The foaming capacity was lowest in the adult with a value of 5.50±0.10%. The pupa and the adult stages obtained 6.43±0.01% and 6.58±0.01% respectively. Foaming stability was 2.50±0.01% in the larva, 2.00±0.01% in the pupa and 5.50±0.02% in the adult stage. Emulsion capacity and emulsion stability in the larva are 40.25±0.02% and 48.59±0.03% respectively. In the pupa stage the values are 42.34±0.02% and 60.28±0.01% respectively. In adult stage the values are 46.35±0.03% and 50.44±0.09% respectively. The values of the least gelation concentrations were 2.00±0.01% in the larva, 4.00±0.01% in the pupa and 6.00±0.01% in the adult.

ISSN 2054-6351 (print), ISSN 2054-636X (online)

Table 3. Functional properties of the developmental stages of *O. rhinoceros*

Parameters (%)	Larva stage	Pupa stage	Adult stage
WAC	298.17±0.12	270.10±0.23	281.35±0.20
OAC	360.22±0.10	350.47±0.11	356.60±0.21
FC	6.58±0.01	6.43±0.01	5.50±0.10
FS	2.50±0.01	2.00±0.01	5.50±0.02
EC	40.25±0.02	42.34±0.02	46.35±0.03
ES	48.59±0.03	60.28±0.01	50.44±0.09
LG	2.00±0.01	4.00±0.01	6.00±0.01

Each value is a mean ± Standard deviation of triplicate (Tukey test)

The result of the anti-nutrients composition of the developmental stages of *O. rhinoceros* is presented in Table 4. Tannin, phenol, alkaloids, saponins, phytate and oxalate were detected in all the stages. Phytate was highest among all the anti-nutrients and the adult stage had the highest value of 41.07±0.18mg/100g. The larva and the pupa stages had 37.00±0.01mg/100g and 39.43±0.03mg/100g respectively. The values of Tannin in the larva, pupa and adult are 5.60±0.02mg/100g, 6.75±0.01mg/100g and 4.22±0.02mg/100g respectively. Oxalate was negligible in all the stages; the values for the larva, pupa and adult are 1.31±0.01mg/100g, 1.33±0.01mg/100g and 1.19±0.01mg/100g respectively.

Table 4. Anti-nutritional composition of the developmental stages of *O. rhinoceros*

Parameters (mg)	Larva stage (100g)	Pupa stage (100g)	Adult stage (100g)
Tannin	5.60±0.02	6.75±0.01	4.22±0.02
Total phenol	3.95±0.03	4.09±0.01	2.53±0.04
Alkaloids	2.44±0.01	4.99±0.01	3.35±0.02
Saponin	1.51±0.01	3.05±0.01	2.59±0.01
Phytate	37.00±0.01	39.43±0.03	41.07±0.18
Oxalate	1.31±0.01	1.33±0.01	1.19±0.01
Flavonoids	2.53±0.01	3.06±0.01	2.24±0.01
Phytic phosphorus	10.43±0.01	11.11±0.02	11.58±0.05

Each value is a mean ± Standard deviation of triplicate (Tukey test)

The alkaloids, saponin and flavonoids contents of the larva are 2.44±0.01mg/100g, 1.51±0.01mg/100g and 2.53±0.01mg/100g respectively. For the pupa stage, the alkaloids, saponin and flavonoids values are 4.99±0.01mg/100g, 3.05±0.01mg/100g and 3.06±0.01mg/100g respectively. However, in the adult stage, the alkaloids, saponin and flavonoids values are 2.53±0.01mg/100g, 3.06±0.01mg/100g and 2.24±0.01mg/100g respectively.

DISCUSSION

From this study, the results reveal that all the developmental stages of *O. rhinoceros* have high nutritional qualities. Table 1 shows that the moisture content of the 4.76±0.02% was highest in the pupa while the least value of 1.04±0.02% was obtained in the larva stage. In the adult, the moisture content was 4.53±0.03%. The value of the moisture content of each of the developmental stages are lower than the value (16.97%) reported by Olowu*et al.*, (2012) but higher than the values reported by Banjo *et al.,* (2006) for *Oryctes boas, Analeptestri fasciata, R. phoenicis* and *Anaphe venata.* Similarly, high moisture content like this has been reported in the black cutworm, *Agrotis ipsilon* by Ghaly (2009). All the developmental stages of palm beetles have lower moisture contents and this indicate that they can be stored for a very long time without spoilage since low moisture content connotes longer shelf life.

All the developmental stages of palm beetles are richer in protein, which form the bulk of their food components. The adult stage was the richest in protein with a value of 74.18±0.10% while the larva and pupa had 70.76±0.12% and 65.34±0.11% respectively. The protein contents (48%) reported by Olowu *et al.,* (2012) is lower than the values obtained in any of the stages. Moreover, Banjo *et al.,* (2006) also reported lower protein contents for *O. boas, A. trifasciata, R. phoenicis* and *A. venata.* The reason for this could have been from the methods applied and the temperature at which the specimen were oven-dried. Higher temperatures have been known to cause reduction in the values of proteins as a result of burning. Proteins are very important in animals for the building and the repair of worn-out tissues in the body.

The pupa and the adult stages are good sources of fat. The fat contents of all the stages are higher than the values reported by Banjo *et al.,* (2006) and Olowu *et al.,* (2012) for *O. boas* and *O. rhinoceros* respectively but lower than the value reported for *R. phoenicis* (42.70%-54.20%) by Opara *et al.,* (2012). Higher fat contents of 14.87%, 23.30%, 15.16% and 31.46% have been reported in *O. rhinoceros, R. phoenicis, Imbrasia belina* and *Macrotermes bellicosus* respectively by Ekpo *et al.,* (2009). The pupa stage had the highest fat content because the bulk of the food which the larva consumed were converted to fat and stored as energy source for the pupa stage. It is this stored energy that the pupa used for its development and growth since the pupa stage is a dormant stage. During this stage, reorganization and growth occurs despite the fact that the pupa do not feed. Insects are good sources of fat and oil. Ekpo *et al.,* (2009) reported that insect larva oils contained more unsaturated fatty acids because they have high iodine number, low saponification values and the oils are usually in liquid form at room temperature. The oil extracts of *O. rhinoceros* has been adjudged to have the highest levels of unsaturation of 65.61% while *M. bellicosus* has 50.02% levels of unsaturation (Ekpo, *et al.,* 2009). The oils of all the developmental stages of *O. rhinoceros* may have medicinal and pharmaceutical values.

The ash content of the larva was highest, followed by that of the adult while the pupa had the least. The ash contents of all the developmental stages are lower than the values reported by Onyeike *et al.,* (2005) and Olowu *et al.,* (2012) but compared with the values reported by Opara *et al.,* (2012) for *R. phoenicis.* Since the larva stage is the most destructive stage, during which they eat voraciously. The larva must have gathered all their nutrients from the food they ate. The reduction in the ash content of the pupa could have been as a result of the depletion of the mineral salts due to growth and development of the pupa. The ash content is an indication of the mineral salts present in the beetle. The larva stage is the richest in mineral salts, followed by the adult and the pupa respectively. Minerals are essential for the normal development and growth of organisms (Omotoso, 2009).

Crude fibre was highest in the larva stage and it could be due to the voracious consumption of food (palm tissues) by the larva. The fibre content reported in *O. boas* by Banjo *et al.,* (2006) is higher than the value obtained in the adult stage. Fibre is very important in bowel movement. The carbohydrate content of all the developmental stages are lower than the values reported by Banjo *et al.* (2006) in *O. boas, A. trifasciata, R. phoenicis* and *A. venata.* Olowu *et al.,* (2012) reported the carbohydrate contents of 20.35% in *O. rhinoceros.* The pupa stage persistently recorded the lowest protein solubilities among all the developmental stages. The highest protein solubility of 76.50% obtained in this stage was obtained in alkaline medium, pH 8. The proteins in the pupa tend to be more soluble in alkaline media than in acidic media. There was only one isoeletric point justifying that there are more than one amino acid in the pupa stage. In the adult stage, the highest protein solubility of 87.50% was obtained in the neutral pH of 7.0 while the least value of 84.20% was obtained in the pH 11. There are four isoelectric points and the proteins seemed to have affinity for acidic media. There are more amino acids in the adult stage than in other stages. The proteins of the larva are highly soluble. The highest value 95.0% was obtained in both acidic medium (pH 1) and alkaline (pH 8) medium. Moreover, the least protein solubility value of 92.20% was obtained in alkaline medium of pH 11. There are two isolectric points in the proteins. The larva stage is also very rich in so many amino acids. As food sources, 100 g of the pupa stage will yield the highest amount of energy (1931.31Kj). The larva will yield 1598.48Kj/100g while the adult will yield 1661.33Kj/100g. The energy yields of all the developmental stages of this insect are lower than the energy yield reported in all the developmental stages of *R. phoenicis* by Omotoso (2009) but higher than the value of 245.29Kcal/100g reported in *Macrotermes bellicosus* by Agomuo (2011).

Among the mineral salts obtained in the developmental stages of palm beetle, *O. rhinoceros* are sodium (Na^+), Calcium (Ca), Potassium, (K), Magnesium (Mg), Phosphorus (P), Iron (Fe), Zinc (Zn), Manganese (Mn) and Chromium (Cr) while Copper (Cu) was not detected in any of the developmental stages (Table 2).The highest mineral salt obtained in all the developmental stages was Phosphorus. Similar observation had earlier been reported by Banjo *et al.,* (2006), Omotoso (2006) and Omotoso (2009). Phosphorus is always the highest mineral salts obtained in plant eating insects because the insects always derive the mineral salt from the plants they eat. Phosphorus is a very prominent mineral that occur in plants. All the developmental stages of *O. rhinoceros* are rich sources of important mineral salts such as Sodium (Na), Potassium (K), Calcium (Ca), Iron (Fe), Magnesium (Mg) and Zinc (Zn). Sodium, potassium and Chlorine are important in the maintenance of osmotic balance between cells and the interstitial fluid (Soetan, *et.al.,*2010). The amount of minerals such as Lead (Pb), Manganese (Mn), Copper (Cu), Nickel (Ni) and Cobalt (Co) are negligible. The functions of mineral salts in the body of organisms are enormous. They help in promoting the normal functioning of the systems in the body. Magnesium, Copper, Zinc, Selenium, Iron, Manganese and Molybdenum are important co-factors found in the structure of certain enzymes and are indispensable innumerous biochemical pathways (Soetan, *et.al.,*2010). Iron is essential in the formation of the red blood cells. Red blood cells are important in oxygen carriage to respiring cells in the body (Soetan, *et al.,* 2010).

The results of the functional properties of palm beetle, *O. rhinoceros* show that the meat of all the developmental stages will be good and useful in food industries. The functional properties of proteins in food connote the physico-chemical properties which govern the behaviour of protein in foods. The insect can easily be incorporated into confectioneries and comminuted foods such as pie, cake and buns. The higher water absorption capacity shows that the meat of the insect will be very useful in confectionery industries that deal with baking processes such as bread bakeries. The higher oil absorption capacity also shows that the meat of the insect will be useful in cake and pie making industries since they will easily bind to greater quantities of oil. Higher water absorption capacity (93.33%) and higher oil absorption capacity (112.33%) had been reported in *R. Phoenicis* by Omotoso and Adedire (2008). The foaming capacity and stability are low. This show that the oil derived from beetle can be useful in food industries where foaming is essential to cause the rising of the food. The values of the emulsion capacity,

ISSN 2054-6351 (print), ISSN 2054-636X (online)

stability and least gelation concentrations are encouraging and they portray that palm beetle meats are good candidates for food industries.

The anti-nutrient contents of all the developmental stages of *O. rhinoceros* are very low. Similar observations of lower anti-nutrient values had been reported by Omotoso and Adedire (2008) in *R. phoenicis*. The low levels of oxalate, tannic acid, saponin, alkaloid and flavonoids obtained in the developmental stages of palm beetle are indications that all the stages are safe for human and livestock consumption. Oxalate are naturally occurring substances found in plants, animals and humans (Rahman, *et.al.,*2013). Saponins are also another naturally occurring compounds that are widely distributed in all cells of legumes (Shi, *et.al.*,2004). Saponin has some beneficial effects on human. They include; promoting the immune system so as to protect it against cancer , lowers cholesterol levels, lowers the risks of contacting cancer, lowers blood glucose response, inhibits dental caries and inhibits platelets aggregation in human (Shi, *et.al.*, 2004). Flavonoids are ubiquitous in plants and are recognized as the pigments responsible for the colours of leaves (Theoharis, 2000).

CONCLUSION

All the developmental stages of *O. rhinoceros* are rich in nutrients and minerals but the larva and the adult stages are consistently richer in nutrients than the pupal stage. The act of consuming any or all the developmental stages of the insect under study as alternative sources of animal proteins is highly recommended and encouraged. This is necessary in this period when the cost of meat and poultry products are costly in the market. The developmental stages of this insect can be incorporated into flour, condiments, seasonings and they can also be used as fillings of pies just to increase the quantity of proteins and other nutrients made available to animals.

REFERENCES

Agomuo, E. N. (2011). Proximate and fatty acid composition of Termites (*Macrotermesbellicose*).*International Science Research Journal*.3: 93-96.

Al-deed, M. A., Muzaffar, S. B. and Sharif, E. M. (2012). Interactions between phoretic mites and Arabian Rhinoceros beetle, *Oryctes Agamemnon arabicus. Journal of Insect Science.*12: 128.

AOAC (1990). Official methods of analysis, Association of Official Analytical Chemists. Washington DC, 15thedt.

AOAC, (2005). Official Methods of Analysis, Association of Official Analytical Chemists.Washington DC, USA, 18th ed, pp:1 – 45.

Banjo, A. D., Lawal, O. A.and Songonuga, E. A. (2006).The nutritional value of fourteen species of edible insects in southwestern Nigeria.*African Journal of Biotechnology*. 5 (3): 298-301.

Bedford, G. O. (1974). Descriptions of the larvae of some rhinoceros beetles (Coleoptera: Scarabaeidae, Dynastinae) associated with coconut palms in New Guinea. *Bulletin of Entomological Research.* 63(3): 445-472.

Bedford, G. O. (1980). Biology, ecology and control of palm rhinoceros beetles. *Annual Review of Entomology* 25: 309-339.

ISSN 2054-6351 (print), ISSN 2054-636X (online)

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour protein.*Journal agriculture and Food Chemistry*.25(2): 258-261.

Boham, B. A. and Kocipal-Abyazan, R. (1974).Flavonoids and condensed tannins from leaves of Hawaiian *Vaccinumvaticulatum*and *Vaccinumcalycinium. Pacific Sci.* pp 441-445.

Coffman, C. W. and Garcia, V. V. (1977). Functional properties and amino acid content of protein isolate from mung flour. *Journal of Food Science*.12: 473-484.

Costa-Neto, E. M. (2005). Animal-based medicines: biological prospection and the sustainable use of zootherapeutic resources. *Anais da Academia Brasileira de Ciencias*.77(1): 33-43.

Day, R. A. and Underwood, A. L. (1986).Qualitative analysis. 5thedt. Prentice-Hall Publication. 701pp.

DeFoliart, G. R. (2003). Food Insect as: Encyclopedia of Insects, Resh VH and Carde RT (edt) 1stedt. Academic Press, USA. pp 431-437.

Ekpo, K. E., Onigbinde, A. O. and Asia, I. O. (2009).Pharmaceutical potentials of the oils of some popular insects consumed in Southern Nigeria. *African journal of pharmacy and Pharmacology*.3(2): 51-57.

Ghaly, A. E. (2009). The Black Cutworm as a potential human food. *American Journal of Biochemistry and Biotechnology*.5(4): 210-220.

Grimaldi, J. and Bikia, A. (1985). *Le Grand livre de la cuisine Camerounaise.* P136.

Harbone, J. B. (1973). Phytochemical method, London Chapman and Hall Ltd. pp 49-188.

Joslyn, A. M. (1970). Methods in food analysis. Physical, Chemical and instrumental methods of analysis. 2nd Edit. Academic Press, New York, San Francisco, pp1-3.

Kato, D. and Gopi, G. V. (2009).Ethnozoology of Galo tribe with special reference to edible insects in Arunachal Pradesh. *Indian Journal of Traditional Knowledge.* 8(1): 81-83.

Koo, K. C., Ooi, P. A. C. and Ho, C. T. (1991). Crop pet an their management in Malaysia, Kuala Lumpur. Malaysia Tropical Press SdnBhd, ix+242p.

Manjeri, G., Muhamad, R. and Tan, S. G. (2014). *Oryctes rhinoceros* beetles, an oil palm pest in Malaysia. *Annual Research and Review in Biology.* 4 (22): 3429-3439.

Markkar, A. O. S. and Goodchild, A. V. (1996).Quantification of tannins. A laboratory manual International Centre for Agricultural Research in dry Areas (ICARDA). Aleppo, Syria. I-25pp.

Obadoni, O. Band Ochuko, P. O. (2001). Phytochemical studies and comparative efficacy of the crude extract of some homeostatic plants in Edo and Delta States of Nigeria. *Global Journal of Pure and Applied Sciences*.2: 203-208.

Olowu, R. A., Moronkola, B. A., Tovide, O. O., Denloye, A. A., Awokoya, K. N., Sunday, C. E. and Olujimi, O. O. (2012). Assessment of Proximate and Mineral Status of Rhinoceros Beetle Larva, Oryctes rhinoceros Linnaeus (1758) (Coleoptera: Scarabaeidae) from Itokin, Lagos State, Nigeria. *Research Journal of Environmental Sciences*. 6 (3): 118.

Omotoso, O. T. (2009). Nutritive value and aspects of digestive physiology of the palm weevil, *Rhynchophorusphoenicis*Fabricius (Coleoptera: Curculionidae). Ph.D Dissertation Federal University of Technology, Akure 182p.

Omotoso, O. T. and Adedire, C. O. (2008). Potential industrial uses and quality of oil of oilpal weevil, *Rhynchophorusphoenicis*F. (Coleoptera: Curculionidae). *Pakistan Journal of Science and Industrial Research*.51: 93-97.

Omotoso, O.T. (2006). Nutritional quality, functional properties and anti-nutrient composition of the larva of *Cirinaforda*(Westwood) (Lepidoptera: Saturniidae). *Journal of Zhejiang University Science B.* 7(1): 51-55.

ISSN 2054-6351 (print), ISSN 2054-636X (online)

Onyeike, E. N., Ayalogu, E. O. and Okaraonye, C. C. (2005).Nutritive value of the larvae of raphia palm beetle (*Oryctes rhinoceros*) and weevil, (*Rhynchophorusphoenicis*) *Journal of Science of Food and Agriculture*.85: 1822-1828.

Ooi, P. A. C. (1988). Insects in Malaysian Agriculture, Kuala Lumpur. Malaysian Tropical Press SdnBhd, viii+106p.

Opera, M. N., Sanyigha, F. T.,Ogbuewu, I. P. and Okoli, I. C. (2012). Studies on the production trend and quality characteristics of palm grubs in the tropical rainforest zone of Nigeria.*Journal of Agricultural Technology*. 8(3): 851-860.

Pearson, D. (1976). Chemical analysis of foods, 7thedt. London, Churchill Livingstone pp 7-11.

Rahman, M. M., Abdullah, R. B., and Wan Khadijah, W. E. (2013). A review of oxalate poisoning in domestic animals: tolerance and performance aspects. *Journal of Animal Physiology, Animal Nutrition.* 97(4): 605-614.

Rasmi, S. (2010). The Rhinoceros beetle, *Oryctes Agamemnon arabicus* in Tunisia: current challeng and future management perspectives. *Tunisian Journal of Plant Protection* 5(2): 179-194.

Ratcliffe, B. C. (2006). Scarab beetles in human culture. *Coleopterists Society Monograph.* 5: 85-101.

Sharma, S. and Gupta, S. G. (1988).Rhinoceros beetle, *Oryctes rhinoceros* (Coleoptera: Dynastidae) on banana from Nagaland. *Bulletin of Entomology* (New Delhi) 29(2): 228-230.

Shi, J., Arunasalam, K., Yeung, D., Kakuda, Y., Mittal, G., and Jiang, Y. (2004).Saponins from edible legumes: Chemistry, processing and health benefits. *Journal of Medicinal Food.* 7(1): 67-78.

Soetan, K. O., Olaiya, C. O. and Oyewole, O. E. (2010). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science.* 4(5): 200-222.

Theoharis, C. T. (2000). The effects of plant flavonoids on mammalian cells: Implications for inflammation , heart disease and cancer. *Parmacological Reviews*.52(4): 673-751.

Yasumatsu, K., Sawada, K., Moritaka, S., Misalei, M., Toda, J., Wada, T. and Ishii, K. (1972). Whipping and emulsifying properties of soy bean products. *Agriculture Biology and Chemistry*.36: 719-727.

Young, S. M. and Greaves, J. E. (1940). Influence of variety and treatment on phytin content of wheat. *Journal of Food Science*. 5: 103-108.

ISSN 2054-6351 (print), ISSN 2054-636X (online)