INFLUENCE OF POST-HARVEST PROCESSING TECHNIQUES ON PROXIMATE AND ANTINUTRITIONAL COMPOSITION OF DUNG BEETLE LARVA FROM NIGER STATE, NIGERIA

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Abstract
Dung beetle larva is commonly consumed boiled, smoked or fried amongst the Gbagyi people of Niger State, Nigeria. This study was aimed at evaluating the effect of sundrying and frying on the proximate and antinutritional composition of dung beetle larva. The insect was divided into four groups: Fresh dung beetle (FDB), Sundried dung beetle (SDB), Fried dung beetle obtained from the market (FDBM) and Fried dung beetle processed in the laboratory (FDBL). The methods of Association of Analytical Chemistry (AOAC) were employed in the estimation of proximate composition and tannins content of the insect while the cyanide and oxalate contents were determined using alkaline picrate and radox titration with standard potassium permanganate. The results revealed the ash, crude protein and carbohydrates contents of SDB (12.84±0.04, 32.36±0.07 and 23.03±2.65) were increased when compared to FDB (5.87±0.86, 7.65±0.21 and 4.77±0.21). The lipid contents of FDBM (30.78±0.25) and FDBL (31.21±0.13) were higher when compared to FDB (4.40±0.28) and SDB (13.50±0.57). Crude fibre content was increased in SDB (7.95±1.34), FDBM (9.70±0.00) and FDBL (9.70±0.04) when compared to FDB (4.40±0.28). The highest moisture content was recorded for FDB (74.18±1.10) when compared with SDB (9.83±0.07), FDBM (8.15±0.07) and FDBL (8.05±0.07). The phytates content of SDB (790.79±5.81) was increased when compared to that of FDBM (257.92±0.00), FDBL (258.60±12.59) and FDB (40.12±1.94). Tannins content for FDBM (43.63±5.24) increased when compared to FDBL (34.13±1.38), SDB (26.88±5.56) and FDB (13.08±0.94). Cyanides composition of SDB (34.09±2.79) and FDBM (33.09±0.77) were higher when compared to FDB (24.53±2.55) and FDBL (18.75±0.28). Oxalates content in FDBL (475.43±20.68) and FDB (383.71±7.43) were higher when compared to FDBM (198.90±26.23) and SDB (180.00±0.00). These results obtained from this study provide insights into the nutritional qualities of dung beetle larva subjected to sundrying and frying techniques.

Keywords: *Dung beetle larva, proximate composition, sundrying, frying, antinutrients*

Introduction
In Nigeria, dung beetle larva (*Aphodius rufipes)* is called Gwazarma in Hausa, Okun in Yoruba, Eruru in Igbo and Gogolo in Gwari (Paiko *et al.,* 2012). It is one of the commonly consumed insects amongst the Gbagyi people in Niger state (Paiko *et al.,* 2012). FAO projected that the world population will exceed 9 billion around 2050 and there will be a food crisis due to a

reduction in production to secure food for the increased population (FAO, 2009). Concern for the food crisis demand new alternatives to the previous human food supply and one of the alternatives is to utilize edible insects (Van-Huis *et al.,* 2013).

Insects are regarded as future food source because they are rich in protein, minerals and vitamins (Nowat *et al.,* 2016). Thus the attention paid to them to combat the food crisis. Besides, there is low possibility of contamination with edible insects compared to current livestock food sources. Again, much less greenhouse gas per serving is emitted with edible insects (Conincx *et al.,* 2010). Also, less space is required to produce large quantity of insects than that required to raise conveniently same number of livestock. Furthermore, insects can be hygienically managed, raised under relatively clean environment and they are relatively safe from diseases such as mad cow disease, epidemic stomatitis and other common diseases-associated with livestock (Van Huis *et al.,* 2013).

Although, many edible insects including dung beetle larva have been reported to contain sufficient amounts of energy, protein, unsaturated fatty acids and trace elements (Hanboonsong, 2003; Rumfold & Schluter, 2013), studies on influence of post-harvest processing techniques on the nutritional contents of dung beetle larva are limited. Therefore, this study was undertaken to evaluate the effect of sundrying and frying on nutritional quality of dung beetle larva with a view of revealing its potential for use as human and animal food supplement.

Materials and Methods

Sample Collection and Identification

Samples of dung beetle larva (*Aphodius rufipes)* of average weight 450.9(g) were obtained from Kure and Bosso markets in Minna and Kotongora, Niger State, Nigeria. Fresh dung beetle larvae were handpicked and transferred to sterile perforated containers. The insects were identified and authenticated by an Entomologist in Department of Biological Sciences, Federal University of Technology, Minna, Nigeria. Insects were either used immediately or within 24 hours of storage at 4 .

Sample Preparation

The method of Sirithon and Pornpisanu (2008) was used for preparation of dung beetle larva. The abdomen of fresh samples of dung beetle larva were pierced to remove the faeces and washed in sterile hot water. The sample was subsequently divided into four groups namely: Fresh dung beetle (FDB), Sundried dung beetle (SDB), Fried dung beetle obtained from marketers (FDBM) and Fried dung beetle processed by frying in the laboratory (FDBL) at 60°C for 12 minutes. Each sample was pulverized and evaluated for their nutritional profiles.

Determination of Proximate Composition of Dung beetle larva

The methods of Association of Analytical Chemistry (AOAC) (1990) were employed in determining the proximate composition of the edible insects. The moisture content, crude protein and fibre, fat, total ash and carbohydrate compositions of each sample were determined.

Moisture Content

Four grams (4g) of each edible insect sample was transferred into a petri dish of known weight. The petri dish and its content were placed in the hot air oven at a temperature of 110℃ for two hours (2h) to dry. The weight of the dried sample was determined (AOAC, 1990). The percentage moisture content was calculated using Equation 1:

$$\% \text{ moisture content} = \frac{B}{B} \quad 100 \qquad (1)$$

Where A: weight of petri dish
B: weight of petri dish plus sample
C: weight of petri dish plus sample after drying

Crude Fibre

One gram (1g) of each insect sample was weighed and 30cm^3 of concentrated H_2SO_4 was added in a sterile conical flask and allowed to boil for thirty minutes. The mixture was filtered and passed over running water to wash off the acid and transferred to sterile conical flask. Twenty centimeter cube (20 cm^3) of dilute NaOH was added to the content of the flask and allowed to boil for twenty minutes. The mixture was again filtered, washed and transferred into a crucible. The weight of the sample was determined using a standard weighing balance and recorded. The sample was subsequently dried in the oven at a temperature of 90°C for a period of thirty minutes and transferred to the furnace at 540°C for 15 minutes to ash again. The resultant weight value was determined and recorded (AOAC, 1990). The percentage of crude fibre content was calculated using Equation 2:

$$\% \text{ crude fibre} = \frac{B}{} \quad 100 \qquad (2)$$

Where A: weight of sample
B: weight of sample plus crucible after drying
C: weight of crucible plus ash after hot spot furnace

Ash Content

Two grams (2g) of each insect sample was transferred into a clean crucible of known weight. The sample was ashed at 540°C for 15 minutes (AOAC, 1990). The weight of the ash was determined (AOAC, 1990). The percentage ash content of the sample was calculated using Equation 3:

$$\% \text{ Ash content} = \quad 100 \qquad (3)$$

Where W_1: weight of crucible
W_2: weight of crucible plus sample
W_3: weight of crucible plus ash

Lipid content

One gram (1g) of each insect sample was transferred to a filter paper of known weight and wrapped. The filter paper and its content was transferred to Soxhlet extractor and left there for 3 hours. The weight of the sample was subsequently determined after the extraction of the oil (AOAC, 1990). The percentage lipid content was calculated using Equation 4:

$$\% \text{ lipid content} = \frac{B}{B} \quad 100 \qquad (4)$$

Where A: weight of filter paper
B: weight of filter paper plus sample
C: weight of filter paper plus sample after extraction

Crude Protein

For each sample of edible insects, 0.5g was transferred into a digestion tube. Concentrated H_2SO_4 (15mL) and a catalyst (mercuric acid and potassium sulfate) were added to the content in the digestion tube and kept in the digestion box to digest until a clear solution was obtained. The content of the digestion tube was subsequently transferred to a round bottom flask and made up to 100 cm^3 with distilled water. Ten centimeter cube (10 cm^3) of the digested sample was transferred into a distiller with 10 cm^3 of NaOH. Ten centimeter cube (10 cm^3) of 2% boric acid was transferred to a conical flask and two to three drops of mixed indicator was added to the conical flask content. The resulting mixture was distilled to obtain 50 cm^3. The colour of the mixture changed from red to green. The sample was then titrated against $NH\ NO$ until the color changed from green to red (AOAC, 1990). The percentage protein was determined using Equation 5:

% protein = Tv 0.014 0.1 10 100 6.25 0.502 (5)

Where Tv = Titration value

Determination of Antinutritional Factors of Dung beetle larva

Tannins

The tannins content was determined following the methods of AOAC (1984). For each of sample, 0.2g was measured into a 50 cm^3 beaker. Then, 20 cm^3 of 50% methanol was added and covered with para film and placed in a water bath at 77-80^{O}C for 1hr. It was shaken thoroughly to ensure a uniform mixture. The extract was quantitatively filtered using a double layered Whatman's No. 1 filter paper into a 100 cm^3 volumetric flask, 20ml water was added; 2.5cm^3 Folin-Denis reagent and 10mL of Na_2CO_3 were added and mixed properly. The mixture was made up to mark with distilled water, and allowed to stand for 20 minutes for the development of a bluish-green colour. The absorbance of the tannic acid standard solutions as well as the samples was read after colour development, on a UV-spectrophotometer model 752 at 760nm.

Phytic Acid Content

The phytic acid content was determined using a modified indirect colorimetric method of Wheeler and Ferrel (1971). The method depends on an iron-phosphorus ratio of 4:6 and is based on the ability of standard ferric chloride to precipitate phytate in dilute HCl extract of the sample. Five grams (5g) of the sample was extracted with 20 cm^3 of 3% trichloroacetic acid and filtered. 5mL of the filtrate was used for the analysis; the phytate was precipitated as ferric phytate and converted to ferric hydroxide and soluble sodium phytate by adding 5 cm^3 of 1 M NaOH. The precipitate was dissolved with hot 3.2 M HNO_3 and the absorbance recorded immediately at 480 nm. Preparation of standard curve for phytic acid was done as follows: standard curve of different $Fe(NO_3)_3$ concentrations was plotted against the corresponding absorbance of spectrophotometer to calculate the ferric iron concentration. The phytate phosphorus was calculated from the concentration of ferric iron assuming 4:6 iron: phosphorus molar ratio.

Cyanide Content

Cyanide content was determined by alkaline picrate method according to Wang and Filled method as described by Onwuka (2005). Five grams (5.0g) of powdered sample was dissolved in 50 cm^3 of distilled water in a corked conical flask and the extraction was allowed to stand over-night, and filtered. 1 cm^3 of filtered sample was mixed with 4ml alkaline picrate in a corked

test tube and incubated in a water bath for 5mins. After development of reddish brown colour, the absorbance was read at 490 nm. The absorbance of the blank containing 1 cm^3 distilled water and 4mL alkaline picrate solution was also recorded. The cyanide content was extrapolated from cyanide standard curve prepared from different concentrations of KCN solution containing 5-50µg cyanide in a 500L conical flask followed by addition of 25 cm^3 of concentrated HCl.

Oxalate Content

Oxalate in the sample was determined by radox titration with standard potassium permanganate titrimetric method as described by Day and Underwood (1986). Two grams (2g) of the sample powder was suspended in 190mL of distilled water in 250 cm^3 volumetric flask, 10 cm^3 of 6 M HCI was added and the suspension digested at 100°C for 1hour, cooled, then made to the mark before filtration. Duplicate portion of 125 cm^3 of the filtrate were measured into beakers and 4 drops of methyl red indicator added. This is followed by the addition of concentrated NH_4OH solution drop wise until the test solution changed from salmon pink colour to a faint yellow colour (pH 4-4.5). Each portion was then heated to 90°C, cooled and filtered to remove precipitate containing ferrous ion. The filtrate is again heated to 90°C and 10 cm^3 of 5 % $CaC1_2$ solution added while being stirred constantly. After heating, it was cooled and left overnight at 5°C. The solution was then centrifuged at 2500 rpm for 5 mins, the supernatant decanted and the precipitate completely dissolved in 10 cm^3 of 20% (v/v) H_2SO_4 solution. The total filtrate resulting from the digestion was made up to 300 cm^3. Aliquots of 125 cm^3 of the filtrate was heated until near boiling and then titrated against 0.05 M standardized $KMnO_4$solution to a faint pink colour which persisted for 30secs. The calcium oxalate content was calculated using Equation 6:

$$T \times (Vme)\ (Df) \times \frac{10^5 \quad (mg/100g)}{(ME) \times Mf} \qquad (6)$$

Where, T is the titre of $KMnO_4$ (cm^3), Vme is the volume-mass equivalent (1cm^3 of 0.05 M $KMnO_4$ solution is equivalent to 0.00225g anhydrous oxalic acid), Df is the dilution factor V_T/A (2.5 where V_T is the total volume of titrate (300 cm^3) and A is the aliquot used (125 cm^3), ME is the molar equivalent of $KMnO_4$ in oxalate ($KMnO_4$ redox reaction) and Mf is the mass of flour used.

Statistical Analysis

Results were expressed as mean values ± standard deviation (S.D). Within groups, comparisons were performed by the analysis of variance using one-way ANOVA test. Significant difference between control and experimental groups were assessed by Duncan's Multiple Range Test (DMRT) (Yalta, 2008).

Results

The proximate components of dung beetle larva studied are represented in Table 1. The highest moisture content was recorded in FDB (74.18±1.10). Similar moisture contents were recorded for SDB, FDBM (8.15±0.07) and FDBL (8.05±0.07). The highest ash content was recorded for SDB (12.84±0.04) while the least was recorded for FDB (5.87±0.86). Fried samples obtained from the laboratory, FDBL (8.70±0.18) and fried sample obtained from market, FDBM (9.32±0.30) had similar ash contents.

Sundried sample, SDB (32.36±0.07) had highest crude protein value followed by FDBL (29.55±0.78) and FDBM (28.20±0.99). These values were however within the WHO standard value (23-56). Fresh sample, FDB (3.10±0.07) had the least crude protein content. Sundried sample, SDB (7.95±1.34) and fried samples obtained from the laboratory, FDBL (9.70±0.04) and market, FDBM (9.70±0.00) had similar crude fibre contents which were higher than the crude fibre content recorded for FDB (3.10±0.07). The values of crude fibre recorded for the samples were lower when compared with the WHO standard (12.50).

Fried samples obtained from the laboratory, FDBL (31.21±0.13) and market, FDBM (30.78±0.25) had the highest lipid content when compared to the sundried, SDB (13.50±0.57) and the fresh sample, FDB (4.40±0.28). This high lipid content of the fried samples compared favourably with the WHO standard (32.50).

The antinutritional components of dung beetle larva studied are represented in Table 2. Sundried sample, SDB (23.03±2.65) had the highest carbohydrate composition followed by the dried samples obtained from the laboratory, FDBL (13.10±1.17) and market, FDBM (13.85±0.35). The least carbohydrate content was recorded in fresh sample, FDB (4.77±0.21). The carbohydrate values from all the samples were very low when compared with WHO standard value (100.00).

The highest tannins content was recorded for FDBM (43.63±5.24) followed by FDBL (34.13±1.38) and SDB (26.88±5.86) respectively while FDB (13.08±0.94) had the least tannin value. These values were however lower than the WHO standard (70).

Sundried sample, SDB (790.79±5.81) had the highest phytates content followed by the fried samples, FDBM (257.92±0.00) and FDBL (258.60±12.59) while the least phytates content was recorded in fresh sample, FDB (40.12±1.94). These values were however above the WHO standard (100) except for fresh sample which had lower value of phytates when compared to WHO standard.

Table 1: Proximate composition of dung beetle larva

Values are means ± standard deviation for n=2. Means with the same superscript, in a same column, are not significantly different from each other ($P > 0.05$) using DMRT.

Dung beetle Larva	Proximate Composition (%)					
	Moisture	Ash	Crude protein	Crude fibre	Lipids	Carbohydrate
FDB	74.18±1.10[a]	5.87±0.86[c]	7.65±0.21[c]	3.10±0.07[b]	4.40±0.28[c]	4.77±0.21[c]
SDB	9.83±0.07[c]	12.84±0.04[a]	32.36±0.07[a]	7.95±1.34[a]	13.50±0.57[b]	23.03±2.65[a]
FDBM	8.15±0.07[c]	9.32±0.30[b]	28.20.99[b]	9.70±0.00[a]	30.78±0.25[a]	13.85±0.35[b]
FDBL	8.05±0.07[c]	8.7±0.18[b]	29.55±0.78[b]	9.70±0.04[a]	31.21±0.13[a]	13.10±1.17[b]
(WHO, 2004)			23-56	12.5	32.5	100

SDB-Sundried dung beetle larva FDB-Fresh dung beetle larva FDBL-Fried Dung beetle larva prepared in the laboratory
FDBM-Fried Dung beetle larva obtained from the market WHO-World Health Organization

The highest cyanides content was recorded in FDBM (33.09±0.77) and sundried samples, SDB (34.09±2.79). Least cyanide content was recorded for FDBL (78.75±0.28). The cyanides values were within the WHO standard (15-100).

Fried sample prepared from laboratory, FDBL (475.43±20.68) had the highest oxalates content followed by fresh sample, FDB (383.71±7.43). Sundried sample, SDB (180.00±0.00) and FDBM (198.90±26.23) had the least oxalates content. These values were higher than the WHO standard (80-120).

Table 2: Anti-nutritional composition of dung beetle larva

	Anti-nutritional components (mg/100g)			
Dung beetle Larva	Tannins	Phytates	Cyanides	Oxalates
FDB	13.08±0.94^{c}	40.12±1.94^{c}	24.53±2.55^{b}	383.71±7.43^{b}
SDB	26.88±5.56^{b}	790.79±5.81^{a}	34.09±2.79^{a}	180.00±0.00^{c}
FDBM	43.63±5.24^{a}	257.92±0.00^{b}	33.09±0.77^{a}	198.90±26.23^{c}
FDBL	34.13±1.38^{ab}	258.60±12.59^{b}	18.75±0.28^{c}	475.43±20.68^{a}
WHO (2004)	70	100	15-100	80-120

Values are means ± standard deviation for n=2. Mean values with the same superscript, in a same column, are not significantly different from each other ($P > 0.05$) using DMRT.
SDB - Sundried dung beetle larva
FDB - Fresh dung beetle larva
FDBL- Fried Dung beetle larva prepared in the laboratory
FDBM - Fried Dung beetle larva obtained from the market
WHO - World Health Organization

Discussion

In the present study, the moisture content of fresh dung beetle larva, FDB (74.18±1.10% was highest when compared to the other insects evaluated. This value was comparable to moisture content (70%) in frozen *Oedaleus abruptus* obtained by Arijit *et al*. (2013) and higher than the moisture value of (56.82%) for fresh *Rhynchophorus phoenicis (*Adult wine weevil) obtained by Amadi *et al.* (2014).

Similar moisture contents of 8.15±0.07% and 8.05±0.07% was recorded for fried dung beetle larva obtained from the market (FDBM) and fried dung beetle larva prepared in the laboratory (FDBL) respectively, from the present study. This moisture contents were lower than the values (12.14%) and (10.85 0.38%) reported for processed oven dried edible weevils by Braide and Nwaoguikpe (2011) and oven dried larva of *Cirina forda* by Omotoso (2006), respectively. Paiko *et al*. (2012) obtained moisture content of 4.52 0.21% for sundried dung beetle larva, a value slightly lower than the result (9.83±0.07%) obtained from the same insect in this research. Omotoso (2015) stated that low moisture content is an indication that the edible insect may be stored for a long period of time without spoilage.

In the present study, sundried dung beetle larva (SDB) had the highest ash contents (12.84±0.04%) as compared to other sample of insects analysed. This value was higher than the ash content of (2.74± 0.1 %) obtained by Paiko *et al*. (2012) for same insect.

Similar ash contents of 8.71±0.18% and 9.32±0.30% were obtained for fried dung beetle larva prepared in the laboratory (FDBL) and fried dung beetle larva obtained from the market (FDBM) respectively in the study. Omotoso (2015) obtained ash content of 11.83±0.14% from oven dried winged termite, a value higher than the present result.

Ifie and Emeruwa (2011) obtained ash contents of 4.0% from oven dried *Oryctes rhinoceros,* a value lower than the ash content of 5.87±0.87% obtained from fresh dung beetle larva (FDB) from the study. Ash contents could aid bowel movement and increase mineral contents in the human body (Braide & Nwaoguikpe, 2011).

Igbabul *et al.* (2014) obtained crude protein value of (54.36% to 56.78%) from sundried *Cirina forda* larvae, values lower than the result obtained from the current study. Similar high protein content of (about 60%) was recorded from selected acridid species which have a very high P/E ratio (more than 100 mg of protein/kcal) which proved this group of insects to be a good protein and energy supplement by Arijit *et al.* (2013).

In the present study, sundried dung beetle larva (SDB) has the highest crude protein (32.20±0.07%), value slightly lower than the crude protein of 35.44±0.62% from oven dried cricket obtained by Anhwange *et al.* (2016). Paiko *et al*. (2012) showed that sundried dung beetle larva contained crude protein content value (22.42%) lower than the result obtained in this study.

In the present study, fried dung beetle larva obtained from the market (FDBM) and fried dung beetle larva prepared in the laboratory (FDBL) had crude protein contents of 28.20±0.99% and 29.55±0.78%, respectively. Anhwange *et al.* (2016) obtained crude protein content of (49.55±0.15%) from oven dried termite, value higher than the result obtained in the present

study. Amadi *et al.* (2014) obtained crude protein value of 26.85% from dried palm weevil (*Rhychophorus phoenicus*) which was slightly lower than the result obtained in this study.

Fresh dung beetle larva (FDB) had the least crude protein content of 7.68±0.21% from this study, value significantly lower when compared with the recommended daily protein requirement (23-56%) stipulated by National Research Council (NRC, 1980). The protein contents was higher than the crude protein obtained from dried termite (2.400%) and dried winged termite (1.133%) recorded by Adeduntan (2005). The powder of the fresh dung beetle larva (FDB) under study may be incorporated into protein diets to improve its nutritive values.

Rumpold and Schlüter (2013) have observed nutrient compositions for 236 edible insects and have found that insects provide satisfactory amounts of energy and protein and meet amino acid requirements for human. Ramos-Elorduy *et al*. (2012), observed the protein contents in Orthopteran insects ranging from 43.9 to 77.1% of dry matter. The high level of protein in the edible insects mentioned above with the exception of fresh dung beetle larva (FDB) showed that they can contribute immensely to the daily protein requirement of 23-56% for humans as recommended by National Research Council when compared with the recommended daily protein requirement (23-56%) stipulated by National Research Council (NRC, 1980). Although, whole insects as a source of protein are of somehow lower quality than vertebrate animal products because of the indigestibility of chitin. The consumption of edible insects can supplement to a substantial degree some of the nutrients inadequate in cereals. Insect proteins have been recommended as a supplement for high cereal diets and weaning foods for infants (Food and Agricultural Organization/UN, 2004). Also, high protein is an indication that edible insect can be of great value to humans and animal ration which can replace animal protein usually absent in the diet of rural dwellers (Adeduntan, 2005).

From the present study, similar crude fibre contents were recorded for fried dung beetle larva obtained from the market, FDBM (9.7±0.00%) and fried dung beetle larva prepared in the laboratory, FDBL (9.7±0.04%). These values are comparable to the crude fibre content (9.81%) obtained from *Sphenarium borrei* (oven dried grasshopper) in Mexico by Ramos-Elorduy *et al.* (2012). Similar value of 10.50%was obtained from oven dried larva of *Oryctes monocereros* by Ifie and Emeruwa (2011). Omotoso (2015) also obtained fibre content of (17.94±0.20%) from oven dried winged termite, a value higher than that obtained in the present investigation.

High crude fibre contents were recorded for SDB (7.95±1.34), FDBM (9.70±0.00) and FDBL (9.70±0.04). High fibre contents have been used for weight control and fat reduction, as they give a sense of satiety even when small amount of food is consumed (Ekop, 2004). Sundried or fried dung beetle larva may be used for weight control and fat reduction in obese individual. The results indicate that solar drying and frying are capable of affecting the quantity of crude fibre to the similar degree. Therefore, the larva of dung beetle may be processed by either sundrying or frying.

Low crude fibre content of 3.10±0.07% was obtained for fresh dung beetle larva (FDB) in the present study. This value was comparable to crude fibre of 3.53% obtained from insects Isoptera by Alamu *et al.* (2013). Similar low dietary fibre of 1.68–3.40% was obtained from 14 edible insects in south-western Nigeria by Geoffrey *et al*. (2016) and 3.00% obtained from oven dried yam beetle by Adesina (2012). The appreciable level of crude fibre could be ascribed

to little amount of chitin normally found in edible insects. Oduor *et al*. (2008) reported that chitin is an insoluble fibre derived from exoskeleton 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). And fiber plays a role in the normal bowel function and may prevent chronic diseases such as cancer, coronary artery disease, and diabetes mellitus. Edible insects are good sources of dietary fiber and protein and have unique and excellent nutritional property compared to plant and animal nutrient sources (Geoffrey *et al*., 2016). A diet with very low fiber, could therefore lead to constipation which might bring discomfort to the body system with running stool (Groff *et al*., 1995).

Lipid content of 38.80±0.00% obtained from oven dried cricket by Anhwange *et al.* (2016), was slightly higher than the lipid contents of 30.78±0.25% and 31.21±0.13% recorded for fried dung beetle larva obtained from the market (FDBM) and fried dung beetle larva prepared in the laboratory (FDBL) in the present study. Similar high crude lipid content of 34.00% was obtained from oven dried larva of *Oryctes monocereros* by Ifie and Emeruwa (2011). The lipid contents of samples of dung beetle larva was higher than the lipid contents of meat, pork, and fish, all of which averaged less than 22% lipid (Geoffrey *et al*., 2016). Sundried dung beetle larva (SDB) had lipid content of 13.50±0.57% in the research, value significantly lower than the lipid content of 30.50 ± 1.20% obtained in sundried dung beetle larvae by Paiko *et al.* (2012). Fresh dung beetle larva (FDB) has low lipid content of 4.40±0.28%, value similar to the lipids content of 4.17% in *Rhynchophorus phoenicis* adult weevil (dry matter) by Amadi *et al.* (2014).

The result of lipid contents showed that the dung beetle larva like other edible insects can aid in building new cells, help in normal development of the brain, provide energy and nerves function. Furthermore, they could play an important role for human nutrition and help maintain body temperature (Anhwange *et al*., 2016).

The fat contents of insects depend on many factors such as species, reproductive stages, season, age (life stage), or sex, habitat and diet (Pennino *et al*., 1991; Raksakantong *et al*., 2016). For example, the fat content is higher in the larval and pupal stages, whereas at the adult stage, the fat content is rather low (Chen *et al*., 2009). Omotoso (2006) reported that lipids are vital in the structural and biological functioning of cells and that they help in the transport of nutritionally essential fat soluble vitamins.

The carbohydrate contents of 23.03±2.65% of sundried dung beetle larva from the present study, was appreciably higher than the carbohydrate value (13.07%) for same insects obtained by Paiko *et al*. (2012). Similar carbohydrate content of 22.16±1.09% was obtained in sundried *Bunaea alcinoe* reported by Dauda *et al*. (2014). According to Koumi *et al.* (2011), the carbohydrate contents of fish and soybean could be around 23 and 27%, respectively, which is slightly close to the carbohydrates content observed in the study.

Similar carbohydrate contents of 13.85±0.35% and 13.10±1.17% was obtained in fried dung beetle larva obtained from the market (FDBM) and fried dung beetle larva prepared in the laboratory (FDBL) respectively, in this study. The result indicates that frying and solar drying did not adversely affect the carbohydrate content of dung beetle larva. Igbabul *et al.* (2014) obtained carbohydrate content of 11.09-12.16% dry basis on *Cirina forda*, a value lower than the result obtained in the current study. Omotoso (2014) obtained high carbohydrate values of

40.93±3.20% and 38.47±4.24% from oven dried silk worm *Bombyx morilarvae* and *Bombyx moripupal* respectively.

Fresh dung beetle larva (FDB) had carbohydrates content of 4.77±0.21% in this study, a value slightly lower than the carbohydrate content of 2.06±0.01% and 1.97±0.01% obtained from oven dried *Macrotermes nigeriensis* and *Oryctes rhinoceros* respectively by Omotoso (2015).

The variances in carbohydrate contents of the edible insects could be due to differences in insect species, environment and the hard cover polysaccharide chitin of insects. Powdered dung beetle larvae could be incorporated into carbohydrate diets to increase their nutritive values.

Anti nutritional factors are usually present in plants but many phytophagous insects may retain these chemicals (Berenbaum, 1993). Hence, it is recommended to analyze these antinutrients if a phytophagous insect is being considered as food. Fried dung beetle larva obtained from the market (FDBM) and fried dung beetle larva prepared in the laboratory (FDBL) had higher tannins content of (43.68±5.24 mg/100g) and (34.13±1.83 mg/100g) respectively, from the study, values significantly lower than the tannins content of 250 mg/100g in oven dried winged termites by Adeduntan (2005).

Adeduntan (2005) obtained tannins content of 400 mg/100g in oven dried ant, value significantly higher than the result obtained. Tannins content obtained from the study was much higher than the plant food materials (Hassan *et al.,* 2011). Adesina (2012) obtained tannins content of 0.421 mg/100g and 0.481 mg/100g in oven dried yam beetle and oven dried palm weevil respectively, values significantly lower than the tannins content of (26.88±5.59 mg/100g) obtained from sundried dung beetle larva (SDB) in the research.

High levels of tannins in diets are ascribed to its ability to bind with proteins of saliva and muscular membrane. Tannins form insoluble complex with protein, which therefore interfere with the bioavailability of protein. This toxicity can be removed by heating, boiling and fermenting (Adeduntan, 2005). Therefore, sundried or fried dung beetle larva could be subjected to fermentation to further reduce the tannins level. Fresh dung beetle larva (FDB) had the least tannins content of 13.08±0.94 mg/100g than the other dung beetle larva samples evaluated, values similar to the tannins content (14.3 mg/100g) obtained from oven dried *Oryctes rhinoceros* by Ifie and Emeruwa (2011).

The phytates content obtained from sundried dung beetle larva, SDB (790.79±5.81 mg/100g) was significantly higher in the present study. Adeduntan (2005) obtained very high phytates content of 3159.017 mg/100g and 1100.46 mg/100g in oven dried cricket and oven dried grasshopper respectively, values significantly higher than the results obtained. Similar phytates content obtained for fried dung beetle larva prepared in the laboratory, FDBL (257.92±1.00 mg/100g) and fried dung beetle larva obtained from the market, FDBM (258.60±12.59 mg/100g) in the present research. The similarities in the phytates content may be due to similar processing techniques (frying) adopted in their preservation.

Ifie and Emeruwa (2011) obtained phytates content of 178 mg/100g in oven dried *Oryctes monoceros* larva, value significantly lower than the result obtained. Adeduntan (2005) also obtained phytates content of 2030.797 mg/100g and 2482.084 mg/100g in oven dried ant and oven dried termites respectively.

Fresh dung beetle larva (FDB) had the least phytates content (40.12±1.94 mg/100g) from the study, which was higher than the phytates content of (25.05±1.51 mg/100g) obtained from sundried soldier termites (*Comptotermes gestroi)* by Mathew *et al*. (2013). Adesina (2012) also obtained phytates content of 0.311 mg/100g and 0.276 mg/100g in oven dried yam beetle and oven dried palm weevil respectively. Phytic acid binds with other nutrients and makes them indigestible. Phytic acid combines with some essential elements such as iron, calcium, zinc and phosphorus to form insoluble salts called phytates, which are not absorbed by the body thereby reducing the bioavailability of these elements. Phytic acid is also able to make phytate protein complexes, decreasing protein solubility, thus reducing the availability of dietary protein (Francis *et al*., 2001).

Similar cyanides content was obtained for sundried dung beetle larva, SDB (34.09±2.79 mg/100g) and fried dung beetle larva obtained from the market, FBDM (33.09±0.77 mg/100g) in the present study. Adesina (2012) obtained cyanides content of 2.65 mg/100g and 2.53 mg/100g in oven dried *Heteroligus meles* and *Rhynchophorus phoenicis* respectively, values significantly lower than the result obtained.

In the study, the cyanides contents obtained from fresh dung beetle larva, FDB (24.53±2.55 mg/100g) was slightly comparable with raw edible Stinkbug, (*Encosternum delegorguei)* which had cyanides value of 23±3.1 mg/100g according to Robert *et al.* (2014). Cyanides content obtained from the study was lower than the toxic level of 50-200 mg/100g obtained by National Research Council, NRC (1974).

Fried dung beetle larva prepared in the laboratory (FDBL) had the least cyanides contents of 18.75±0.28 mg/100g in the study, value lower than the cyanides content of 67.0±3.4 µg/100g obtained from traditional processing of edible stinkbug by Robert *et al.* (2014) and below the toxic level by National Research Council, NRC (1974).

Robert *et al.* (2014) obtained oxalates contents of 1.26±0.07 mg/100g and 0.88±0.15 mg/100g from raw edible stinkbug and traditionally processed edible stinkbug, respectively, values which are significantly lower when compared with fried dung beetle larva prepared in the laboratory, FDBL (475.43±20.68 mg/100g) and fresh dung beetle larva, FDB (383.71±7.43 mg/100g) in the present study. Oxalates content of 6.90±0.91 mg/100g and 20.97±0.36 mg/100g obtained from dates and brebra seed flour by Umaru *et al.* (2007) were significantly lower than the results obtained.

Similar oxalates content was obtained for sundried dung beetle larva, SDB (180.00±0.00 mg/100g) and fried dung beetle larva obtained from the market, FDBM (198.90±26.23 mg/100g) in the present investigation, values were significantly higher than the oxalates content of 15.47±1.88 mg/100g obtained from sundried *Bunaea alcinoe* by Dauda *et al*. (2014). Mathew *et al*. (2013) obtained oxalates content of 8.46±1.51 mg/100g from sundried soldier termites, value significantly lower than the result obtained. Omotoso (2015) also obtained oxalates content of 1.03±0.01 mg/g and 1.09±0.01 mg/g from oven dried *Macrotermes nigeriensis* and oven dried *Oryctes rhinoceros* respectively. Oxalates are naturally occurring substances which are found in plants, humans and animals (Rahman *et al.,* 2013). Oxalates combine with calcium and magnesium to form insoluble Ca and Mg oxalates which lead to low serum Ca and Mg levels. Furthermore, people suffering from coronary heart disease are encouraged to consume moderately oxalate rich foods as it helps to reduce blood cholesterol

(Savage, 2000). Detoxification during processing reduces the oxalates content on the edible insects (Groff *et al.*, 1995).

Conclusion

The findings of this study revealed that edible dung beetle larva is a rich source of protein, fats, carbohydrates and crude fibre. It contained some amount of tannins, phytates, cyanides and oxalates which could be reduced by heating, boiling and fermentation. The edible insect may be recommended for human consumption and animal feed supplement. Solar drying should be adopted in the place of frying because solar drying retained more ash, crude protein and carbohydrate contents than frying. Furthermore, the technology is cost effective and simple to be implemented by farmers and individuals.

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