EFFECT OF POST-HARVEST PROCESSING TECHNIQUES ON THE MINERAL COMPOSITION OF DUNG BEETLE LARVA IN PARTS OF NIGER STATE, NIGERIA

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Abstract

This study was designed to investigate the effect of frying and sundrying on the mineral composition of dung beetle larva consumed as a delicacy in Niger State, Nigeria. Analysis was carried out on fresh, sundried and fried dung beetle larval samples using standard methods. Results revealed that sundried dung beetle larva, SDB had the highest contents of manganese (8.85 ±0.21), copper (5.65±0.21), iron (224.0±5.66) and potassium (416.50 ±2.12) while fresh dung beetle larva, FDB had the least manganese (0.35 ±0.03), copper (1.07 ±0.03), iron (0.81 ±0.03) and potassium (18.50±1.27). Fried dung beetle larva prepared in the laboratory (FDBL) had the highest content of zinc (1.22±0.01), sodium (247.5±30.41), magnesium (315.00 ±2.83) and phosphorus (140.36 ±1.87) while FDB had the least zinc (0.24 ±0.02), sodium (27.55±1.63) and phosphorus (83.45 ±0.35). Fried dung beetle larva obtained from the market (FDBM) had the highest calcium content (1327.50±10.61) while SDB had the least calcium (84.50 ±0.28) and magnesium (22.40±6.42) contents. Similar manganese and iron contents were obtained in FDBL and FDBM. The results of this study showed that dung beetle larva processed by sundrying and frying retained many mineral elements. Therefore, sundried and fried dung beetle larva may serve as alternative source of minerals that could compliment the nutritional needs of individuals.

Keywords: *Dung beetle larva, mineral contents, frying, sun drying, Scarabaeidae.*

Introduction

Dung beetle (*Aphodius rufipes*) belongs to Coleoptera, family, Scarabaeidae (Foley, 2017). In Nigeria, dung beetle is called 'Okun' in Yoruba', 'Gwazarma' in Hausa, 'Gogolo' in Gwari, 'Kontoro' in Nupe' and 'Eruru' in Igbo (Paiko *et al.,* 2012). In Paikoro Local Government Area of Niger State, Northern Nigeria, dung beetle larva is widely consumed and seen as a delicacy. It is commonly consumed boiled, grilled, smoked or fried and served as snacks or taken with carbohydrate foods (Hanboonsong, 2003). The deficiency of food resources is an important issue for modern civilization and most of the developing countries are facing difficulties in providing sufficient food for their population. Thus, there is insufficient intake of protein leading to protein-energy malnutrition (Sani *et al.,* 2014).

Rumpold and Schluter (2013) reported that insects are high in energy with a high proportion of mono and polyunsaturated fatty acids. They provide satisfactory protein (20-80%) which meets the human amino acid requirements and are high in minerals such as calcium, copper, iron, phosphorus, magnesium, manganese and potassium. Paiko *et al.* (2012)

reported the presence of sodium, potassium, calcium, magnesium and phosphorus in dung beetle larva. Dung beetle larva is rich in proteins, minerals and is therefore future food source, thus, the growing interest in domesticating them for food and feed.

Given that many insects including dung beetle larva are seasonally available, there is the need to develop post-harvest processes to establish high quality, nutritious and safe – insect based foods beyond their harvesting season as alternative to established protein sources. Drying methods (sun or oven drying, drying over ashes, roasting) are more frequently used in developing nations for preserving insects (Van Huis, 2003; Chukwu, 2009).

Investigations into the effect of different drying processes on nutritional properties of insects are limited. Thus, this research was carried out in order to ascertain the influence of locally utilized processing methods of sun dying and frying have on the mineral compositions of dung beetle larva with a view of revealing the nutritional potential of the processed insect.

Materials and Methods

Sample Collection and Identification of Dung Beetle Larva Samples

Fresh and healthy whole samples of dung beetle larva (*Aphodius rufipes)* with average weight of 450.9g were purchased from markets in Minna and Kotongora, Niger State, Nigeria from December, 2016 to July, 2017. The sample of the edible insect was transferred to sterile perforated containers. The insect was identified and authenticated by an Entomologist in the Department of Biological Sciences, Federal University of Technology, Minna, Nigeria. The insect samples were either used immediately or within 24 hours after storage at 4℃ .

Sample Preparation

Fresh and healthy samples of dung beetle larva were divided into three groups; fresh dung beetle larva, FDB, sun-dried dung beetle larva, SDB and fresh samples processed by frying at 60℃ for 10 minutes (Sirithon & Pornpisanu, 2008) in the laboratory, FDBL. The fourth sample was fried dung beetle larva obtained from the marketers, FDBM. The abdomen of the fresh samples of dung beetle larva was pierced to remove the faeces and they were subsequently washed in sterile hot water before being processed. Each sample group was crushed into powdered form using sterile mortar and pestle. Samples were analyzed for mineral contents.

Determination of Mineral Composition of Dung Beetle Larva Samples

The methods of Association of Official Analytical Chemists, AOAC (1990) were employed in determining the mineral composition of the dung beetle larva samples. One gram (1g) of each insect sample was weighed into a 100 cm^3 beaker, 20 cm^3 of acid mixture 3:1 (Nitric acid/ perchloric acid) was added to the beaker containing the sample. The beaker containing the sample was transferred to a hot plate under a pressure cupboard and digested at 150℃ until a clear solution was obtained. Sample was allowed to cool and made up to 100 cm^3 mark with distilled water. This was then transferred to a plastic sample bottle and was taken for analysis. Flame photometry method was used to determine sodium and potassium contents of the sample. Iron, magnesium, calcium, zinc, manganese, and copper were determined using Alpha 4 atomic absorption spectrophotometer (AAS) and Phosphorus content was determined using a UV spectrophotometer.

Statistical Analysis

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

Results

The mineral components of processed samples of dung beetle larva studied are represented in Table 1. Amongst the various processed forms of the insect, sundried dung beetle larva, SDB had the highest manganese, copper, iron and potassium contents while fresh dung beetle larva had the least of these minerals. Fried dung beetle larva obtained from the market had the highest Ca content while SDB had the least. Similar Mn and Fe contents were obtained in FDBL and FDBM.

The content of Mn, Cu, Fe, Zn, Na, K, Ca, Mg and P for fresh dung beetle larvae (FDB), sundried beetle larvae (SDB), fresh samples processed by frying in the laboratory (FDBL) and fried dung beetle larva obtained directly from the marketers (FDBM) ranged from 0.35±0.03-8.85±0.21, 1.07±0.03-5.65±0.21, 0.81±0.03-224.00±5.66, 0.24±0.02-1.22±0.01, 27.25±1.63-247.5±30.41, 18.50±1.27-416.50±2.12, 84.50±0.28-1327.50±10.61, 22.40±6.42-315.00±2.83 and 83.45±0.35-140.36±1.87 respectively.

Table 1: Mineral composition of dung beetle larvae

	Mineral composition (mg/100g)								
Dung beetle larva	Mn	Cu	Fe	Zn	Na	K	Ca	Mg	P
FDB	0.35±0.03[c]	1.07±0.03[d]	0.81±0.03[c]	0.24±0.02[d]	27.25±1.63[c]	18.50±1.27[d]	127.50±2.12[c]	112.00±8.49[c]	83.45±0.35[c]
SDB	8.85±0.21[a]	5.65±0.21[a]	224.0±5.66[a]	0.47±0.01[c]	151.50±2.12[b]	416.50±2.12[a]	84.50±0.28[d]	22.40±6.42[d]	96.15±3.89[b]
FDBL	3.62±0.02[b]	5.13±0.11[b]	6.67±0.18[b]	1.22±0.01[a]	247.5±30.41[a]	186.90±2.26[b]	1172.00±8.49[b]	315.00±2.83[a]	140.36±1.87[a]
FDBM	3.91±0.04[b]	3.24±0.06[c]	6.52±0.27[b]	0.86±0.03[b]	122.5±2.12[b]	107.50±2.12[c]	1327.50±10.61[a]	280.00±11.31[b]	83.45±0.35[c]
(WHO, 2004)		2	15	15	2400	3500	1000	350	1000

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

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

Discussion

The manganese contents (8.85±0.21 mg/100g) obtained from sundried dung beetle larva, SDB as shown in Table 1 was higher than the values (3.70 ± 0.10 mg/100g) obtained from dung beetle and dried emperor moth caterpillar, *Cirina forda* (7.53±1.15 mg/100g) by Paiko *et al*. (2012, 2014). Igbabul *et al.* (2014) obtained a manganese content of 0.28 to 0.39 mg/g dry weight on *C. forda*, a value significantly (*P<0.05*) lower than the result obtained. This variation may be attributed to ecological factors and variation in species (Ajai *et al.,* 2013).

Similar manganese contents were recorded for fried dung beetle larva prepared in the laboratory, FDBL (3.62±0.02 mg/100g) and fried dung beetle larva obtained from the market, FDBM (3.91±0.04 mg/100g) in the present investigation. Akinnawo and Ketiku (2000) obtained manganese content of 7.0 mg/100g from oven dried larva of *C. forda*, value higher than the result obtained. Fresh dung beetle larva, FDB had the least manganese contents of 0.35±0.03 mg/100g, which was comparable to the manganese value (0.27 mg/kg) recorded in oven dried *Oedaleus abruptus* by Arijit *et al*. (2013) and 0.39±0.10 mg/100g of oven dried *Oryctes rhinoceros* obtained by Omotoso (2015).

Sundried dung beetle larva (SDB) and fried dung beetle larva prepared in the laboratory (FDBL) had copper contents of 5.65 ±0.21 mg/100g and 5.13±0.11 mg/100g respectively, in this study. These values were higher than the copper content of 4.36±0.17 mg/100g dry matter obtained from oven dried short horned grasshopper by Subhasish *et al.* (2016). Teffo *et al.* (2007) obtained copper content of 4.4 mg/100g from edible dried stinkbug (*Encosternum delegorguei),* a value lower than the result obtained in the present investigation.

The copper contents of 3.24±0.06 mg/100g obtained from fried dung beetle larva obtained from the market (FDBM) in this research, were moderately higher than the copper content of 1.74 mg/kg from oven dried *Oedaleus abruptus* by Arijit *et al*. (2013). Kinyuru *et al*. (2011) obtained copper content of 0.50 mg/100g from dried *Ruspolia differens* (brown grasshopper), value lower than the result obtained in this study.

Fresh dung beetle larva (FDB) had the least copper content of 1.07±0.03 mg/100g in the present study. Similar copper contents of 1.00 mg/100g were recorded for oven dried larvae of *Oryctes monoceros* by Ifie and Emeruwa (2011) and 1.13±0.50 mg/100g for sundried *Bunaea alcinoe by* Dauda *et al*. (2014).

Sundried dung beetle larva (SDB) had the highest iron content of (224±5.66 mg/100g) than other insects evaluated in the present study, a value significantly (*P<0.05*) higher than the iron content of 30.85 ± 0.31 mg/100g from same insects by Paiko *et al*. (2012). Similar high value was reported by Anhwange *et al.* (2016) for oven dried cricket (128.52±2.75 mg/100g) and oven dried termite (131.44± 1.38 mg/100g).

Similar iron contents of 6.67±0.18 mg/100g and 6.52±0.27 mg/100gwere obtained for fried dung beetle larva prepared in the laboratory (FDBL) and fried dung beetle larva obtained from the market (FDBM). These values are slightly lower than the iron content of 10.59±0.04 mg/100g and 8.57±0.03 mg/100g of oven dried *Macrotermes nigeriensis* and *Oryctes rhinoceros* respectively, by Omotoso (2015) and 29 mg/100g of oven dried termite by Alamu *et al.* (2013). Fresh dung beetle larva (FDB) had the least iron content of 0.81±0.31 mg/100g than other samples evaluated (SDB, FDBL and FDBM). This value is similar to 1.03 mg/100g of oven dried *Oedaleus abruptus* by Arijit *et al*. (2013) and 0.68 mg/100g of oven dried cricket by Alamu *et al.* (2013). Variation in iron content could be as a result of the insects feeding habits. The recommended dietary requirement (RDR) for iron is 2-5 mg/day.

In the present study, the zinc contents of 1.22±0.0 mg/100g obtained for fried dung beetle larva prepared in the laboratory (FDBL) was higher than the other insects evaluated. These results were significantly lower than the zinc concentration from oven dried silk worm *Bombyx morilarvae* (35.63±4.98 mg/100g), *Bombyx moripupal* (37.50±4.64 mg/100g) by Omotoso (2014), but similar to the result of (1.63±0.01 mg/100g) obtained from dried edible *Zonocerous variegatus by* Sani *et al*. (2014).

The zinc contents of (0.86±0.03 mg/100g) for fried dung beetle larva obtained from the market (FDBM) recorded in this study, were significantly low when compared to the zinc con tents of (17.34±0.40 mg/100g) obtained for oven dried short horned grasshopper by Subhasish *et al.* (2016). Dauda *et al*. (2014) obtained high concentration of zinc (24.73±0.90 mg/100g) in sundried *B. alcinoe* while Omotoso (2015) obtained *(*15.50±0.14 mg/100g) and (10.10±0.11 mg/100g) in oven dried *M. nigeriensis* and *O. rhinoceros* respectively.

From this study, low zinc contents of (0.24±0.02 mg/100g) were recorded for fresh dung beetle larva (FDB) respectively. This result is comparable to the zinc contents of (0.13 to 0.56 mg/g) from dried larva of *C. forda* obtained by Igbabul *et al.* (2014). Similarly zinc content of (0.70±0.00 mg/100g) was obtained from sundried dung beetle larva by Paiko *et al*. (2012).

The low zinc content observed in this study showed that the edible insects analyzed could not be used to compliment the daily dietary Zinc requirement of 15 mg/day of an adult of 60 kg body weight and boys and girls of 9-13 years (6 mg/day) (WHO, 2005; Omotoso, 2014). Fried dung beetle larva prepared in the laboratory (FDBL) had the highest sodium content of (247.5±30.41 mg/100g) when compared with other insects evaluated. This value is low when compared to the sodium content of (440.0 mg/100g) obtained from oven dried larva of *Oryctes monocereros* by Ifie and Emeruwa (2011).

The sodium contents of (151.56±2.12 mg/100g) for sundried dung beetle larva (SDB) and (122.5±2.12 mg/100g) for fried dung beetle larva obtained from the market (FDBM) respectively was comparable to the result (129.0 mg/100g) obtained by Paiko *et al*. (2012) for sundried dung beetle larva and (125.90±1.25 mg/100g) obtained by Dauda *et al*. (2014) for sundried *B. alcinoe*. Sodium content of (27.25±1.63 mg/100g) was obtained from fresh dung beetle larva (FDB) in this research. These results obtained in this study corroborate with values of 15.69±0.31 mg/100g and 21.37±0.22 mg/100g documented by Omotoso (2015) for oven dried *M. nigeriensis* and *O. rhinoceros* respectively. Furthermore, low sodium values of (10.52±1.31 mg/100g) and (11.66±1.22 mg/100g) was recorded for oven dried silk worm *B. morilarvae* and *B. moripupal* by Omotoso (2014) respectively. This variation in sodium contents can be ascribed to differences in geographical locations as well as inter-elemental interactions (Quin, 2005). Considering the importance of sodium in human metabolism, the amount of sodium recorded in the edible insects analyzed in the present study was significantly lower than the recommended value, 2400 mg. Incorporating the edible insects in the diets of both adults and children will greatly promote the normal functioning of the systems in the body.

The potassium content of (416.50±2.12 mg/100g) obtained from sundried dung beetle larva (SDB) was highest when compared with other insect evaluated in the study. Similar high potassium value of (422.00 mg/100g) dry matter was reported by Ramos-Elorduy *et al*. (2012) for dried edible *Spernarium histrio* (grasshopper). Paiko *et al*. (2012) reported potassium value of (92.50 ± 1.20 mg/100) for sundried dung beetle larva, a value which was significantly (*P<0.05*) lower when compared with the result obtained from this investigation. Fried dung beetle larva prepared in the laboratory (FDBL) and fried dung beetle larva obtained from the market (FDBM) had potassium content of (186.90±2.26 mg/100g) and (107.50±2.12 mg/100g) respectively in this study. These values were significantly higher than the potassium contents of (91.25±2.18 mg/100g) for sundried *B. alcinoe* by Dauda *et al*. (2014) and similar to the potassium value of (177.00 mg/100g) dry matter by Ramos-Elorduy *et al*. (2012) for dried edible *Spernarium histrio* (adult grasshopper).

Fresh dung beetle larva (FDB) had the least potassium content of (18.50±1.27 mg/100g) when compared with other insect samples evaluated in this research, a value similar to the result (18.65±1.42 mg/100g) obtained by Omotoso (2014) for oven dried silk worm *B. morilarvae*. Ifie and Emeruwa (2011) obtained value of (38.40 mg/100g) for oven dried larva of *Oryctes monocereros* and Omotoso (2014) obtained value of (22.45±1.72 mg/100g) from oven dried silk worm *B. moripupal*. Variation in potassium content could be attributed to the sampling location and the feeding habits of these insects. The high potassium content observed in this research showed that the edible insects studied could be sources of essential mineral nutrients and play important role in the synthesis of amino acids and protein. They may also help compliment the nutritional deficiencies of individuals (Ajai *et al*., 2013).

In the present study, calcium content was higher in fried dung beetle larva obtained from market (FDBL) (1327.50±10.61 mg/100g) than other insect samples evaluated. Ademolu *et al*. (2010) obtained calcium value of (552.00 mg/100g) for oven dried grasshopper (*Zonocerus variegatus*) (1st instar larvae) which was significantly (P<0.05) lower when compared to the result obtained. The high values obtained from the above mentioned insects meet the recommended daily intake of calcium (1300.00 mg per day) for adults (WHO, 2004).

Anhwange *et al.* (2016) obtained calcium value of (131.44 mg/100g) from oven dried cricket which was significantly (*P<0.05*) lower than the value (1172.00±8.49 mg/100g) obtained from fried dung beetle larva prepared in the laboratory (FDBL) in the study. Omotoso (2015) obtained very low calcium values of (23.67±0.03 mg/100g) and (12.54±0.34 mg/100g) in oven dried *M. nigeriensis* and *O. rhinoceros* respectively when compared with present result obtained. Dauda *et al*. (2014) obtained calcium value of (27.00±0.12 mg/100g) for sundried *B. alcinoe* which was low when compared to (127.50±2.12 mg/100g) recorded for fresh dung beetle larva (FDB) in this investigation. Paiko *et al*. (2012) obtained calcium value of (42.16 ± 0.10 mg/100g) from sundried dung beetle larva which was low when compared to the calcium contents of (84.50±0.28 mg/100g) recorded for sundried dung beetle larva (SDB) in this research. Therefore, incorporating the edible insects in the diets of both adults and children will greatly promote the vital functioning of the systems in the body.

In the present study, magnesium content of (315.00±2.83 mg/100) for fried dung beetle larva prepared in the laboratory (FDBL) was similar to the result obtained by Ramos-Elorduy *et al.* (2012) (352.00 mg/100g) of magnesium for oven dried *Sphenarium magnum* (adults grasshopper).

Fried dung beetle larva obtained from the market (FDBM) evaluated in this study contained (280.00±11.31 mg/100g) of magnesium, values which were significantly (*P<0.05*) lower than the value (498.00 mg/100g) obtained by Ramos-Elorduy *et al.* (2012) for oven dried grasshopper *(Encoptolophus herbaceous).* Alamu *et al*. (2013) obtained magnesium content (131.8 mg/100g) for fresh *Rhynchophorus phoenicis* which was higher than the value (112.00±8.49 mg/100g) obtained for fresh dung beetle larva in this study.

In this study, sundried dung beetle larva had the least magnesium value of (22.40±6.42 mg/100g) when compared with other insects evaluated, a value higher than (11.72 ±0.02 mg/100g) obtained from same insect by Paiko *et al*. (2012). Similar value of magnesium (27.53±3.76 mg/100g) had been reported by Omotoso (2014) for oven dried silk worm (*B. moripupal).* Magnesium is an important co-factor found in the structure of certain enzymes and is essential in several biochemical pathways (Soetan *et al.,* 2010). Incorporating the edible insects in the diets of both adults and children will greatly promote the vital functioning of the systems in the body.

In the present study, fried dung beetle larva prepared in the laboratory (FDBL) had the highest phosphorus content of (140.36±1.07 mg/100g) than other insect evaluated, a value comparable to (140.90 mg/100g) obtained for oven dried *Sphenarium histrio* obtained by Ramos-Elorduy *et al.* (2007). Paiko *et al.* (2012) obtained a value of (131.2 ± 0.01 mg/100g) for sundried dung beetle larva, a value which was higher than the phosphorus content of (96.15±3.89 mg/100g) for same insect in this research. Similar phosphorus contents of (83.45±0.35 mg/100g) and (83.45±0.35 mg/100g) were recorded for fresh dung beetle larva (FDB) and fried dung beetle larva obtained from the market (FDBM) in this study. These values are lower than the phosphorus content of (103.47±1.52 mg/100g) and slightly higher than (75.57±0.53 mg/100g) of oven dried *M. nigeriensis* and *O. rhinoceros* respectively obtained by Omotoso (2015).

The fairly high values of phosphorus content observed for the edible insects suggest that they are good sources of phosphorus which plays a vital role in calcification of bones and teeth, proper kidney function, cell growth and helps in maintaining the body's acid-alkaline balance (Fallon and Enig, 2001).

Conclusion
The results of this study suggest that sun drying improved the Mn, Cu, Fe and K contents of dung beetle larva. Frying also retained mineral elements such as Zn, Mg, Na and P.

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