

Nutritional and Gut Microbial Analyses of Adult Male Cockroaches (*Periplaneta americana*) (Dictyoptera, Blattodea) from Three Locations in Abeokuta, Nigeria

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Summary: Cockroaches are cosmopolitan insects and are found in different parts of the house. There has been an increase call for their inclusion in the diet of both man and livestock. However, their nutritional value and gut microbial load based on different locations had received little attention in literature. This study aimed at investigating nutritive value and the microbial load in the gut of male cockroaches found in different locations (dumpsite, kitchen and toilet). Thirty (30) adult male cockroaches (*Periplaneta americana*), ten (10) from each location were used. The gut was taken out for microbial analysis and the other parts of the cockroaches were arranged for proximate composition, minerals and vitamins analysis using standard methods. Data analysis was done using one-way analysis of variance (ANOVA) and Student Newman Kuel was used for mean separation of significant means. The gut microbial analysis from the three locations revealed that bacterial and fungal counts (2.00×10^5 cfu/ml, 9.00×10^5 cfu/ml respectively) in cockroaches from the dumpsite were significantly higher ($p < 0.05$) than other sites. Cockroaches collected from the kitchen had highest Ca^{2+} and Mg^{2+} concentrations while cockroaches from the dumpsite had the least. Proximate composition showed that cockroaches from the kitchen had significantly higher ($p < 0.05$) protein, ash, fat and carbohydrate content than other locations. This study showed that location affects the nutritional and microbial content of cockroaches.

Key words: cockroaches, nutritional value, location, microorganisms

Introduction

Cockroaches are considered one of the most adaptable insect groups ever in human history (ETIM *et al.* 2013). Of the over 4,000 known species of cockroaches, only a dozen can be considered as pests. These include the American Cockroach; *Periplaneta americana* (about 30 millimeters long), the German cockroach, *Blattella germanica* (about 14 millimeters long), the Brown banded cockroach *Supella longipalpa* (about 14 millimeters long) and the oriental cockroach, *Blatta orientalis* (about 14 millimeters long). Reports have shown that the American cockroach, *P. americana* and the German cockroach, *B. germanica* are the most common cockroaches infesting buildings worldwide (UNEKE 2007, OMUDU and EYUMAH 2008).

Cockroaches live in groups and are attracted to humidity, warmth and darkness and are common in toilets, bathrooms, kitchens and dining and bedrooms. The American cockroach (*Periplaneta americana*) is the largest. They can survive up to two years, much longer than other cockroaches' types. Cockroaches have dirty habits with an ability to spoil food, transfer pathogens, cause allergic reactions and psychological distress (BRENNER 1995). Cockroaches breed and forage in sewer systems, garbage bins, and latrines (MPUCHANE *et al.* 2006). They are nocturnal in habit

and transmit pathogens rapidly at night (FISCHER *et al.* 2003). They frequently feed on human faeces, garbage and sewage; therefore they have copious opportunity to disseminate pathogenic agents (UCKAY *et al.* 2009). Their attraction to human and animal faeces, rotting food, secretions from corpses, sputum, pus, and the like gives them a well-earned "disgust factor" among the general public. These moist, organic habitats contain staggering amounts of bacteria, protozoa, amoebae, fungi, and other microbial material (WILLIAM *et al.* 2011).

It has been particularly difficult to determine specific nutritional values for cockroaches, partly because of the presence of microbial symbiotes (bacteroids) in specialized cells (mycetocytes) in the fat body. Elimination of symbiotes from *P. americana* by antibiotic treatment results in poor growth and diminished reproductive capacity (RICHARDS and BROOKS 1958).

YI *et al.* (2013) reported insect protein quality to be higher than soyabean and lower than casein proteins. BARROSO *et al.* (2014) stated that amino acid profile of some Diptera is superior to soyabean meal. Evaluation of the nutritive value of cockroaches become important as the insects could form a base for new feed product of considerable nutritive value. Similarly the nutritional value changes according to the preparation and processing before consumption

(drying, cooking, frying etc.) (HUIS-VAN *et al.* 2013). According to PAYNE *et al.* (2016) insect's nutritional composition showed high diversity between species. Due to the limited information, this study investigates the nutritional value of cockroaches based on their locations.

Materials and methods

Experimental Site

This study was carried out in the laboratory of the Department of Pure and Applied Zoology, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

Experimental Procedures

Adult cockroaches were captured (mostly at night time and early morning) from different locations in hostels at Camp Area of Abeokuta (kitchens, toilets and dumpsites) by hand picking method using sterile gloves and transferred to perforated containers for access to air. These containers were directly transferred to laboratory for further process. On the arrival of the cockroaches at the laboratory, ten male cockroaches were put into an envelope and kept in the freezer for 10 minutes to make them immobile. After 10 minutes, each cockroach was weighed using electric weighing scale and weight was calculated. Other cockroach samples (50) were arranged for chemical analysis.

(a) Morphometrics: The morphometric studies of each cockroach were also carried out with concise reading taken. The measurements of the following body parts were carried out using calibrated ruler: body length, head, thoracic, abdomen, wings length, prothoracic leg, mesothoracic leg and metathoracic leg. Each cockroach samples was dissected at a time to avoid mix up during microbial analysis of the gut content. The gut measurement (fore gut, mid gut and hind gut), each cockroach was dissected as the whole gut was removed carefully with the aid of forceps.

(b) Proximate Analysis: the moisture, ash, crude fat, crude fibre and crude protein, and carbohydrate content of the experimental cockroaches were determined by A.O.A.C. (1990) method.

(c) Mineral Analysis: Mineral (Na^+ , K^+ , Ca^{2+} , Fe , Mg^{2+} and Cl^-) composition of the cockroaches from the three locations were determined using Atomic Absorption Spectrophotometry (AAS).

(d) Vitamins Composition: Vitamin (Vitamins A, B_2 and C) composition of the cockroach samples were determined following methods of A.O.A.C. (1990).

All chemical analyses were done in triplicates.

(e) Microbial Analysis of the gut: Ten cockroaches (from each location) were dissected following protocols describe by ADEMOLU and IDOWU (2011). The whole gut was removed and the content emptied into sterile labeled petri dishes and kept in refrigerator for further microbial examination. The bacteria enumeration and identification were done by method of SNEATH *et al.* (1986). Identification

of fungi was done by BERNETT and HUNTER (1972) techniques.

Statistical Analysis

Data collected were analyzed using One-way Analysis of Variance (ANOVA). Separation of significant means was done using the Student-Newman-Keuls (SNK).

Results

The results of the morphometrics of cockroaches from three different locations are presented in Table 1. There was no significant difference ($p > 0.05$) in the measurement of head, thorax and abdomen of cockroaches from the three locations. The body length of the cockroaches from the three locations showed no significant difference ($p > 0.05$) as well. The metathoracic legs of cockroaches from the dumpsite ($3.96 \pm 0.45 \text{cm}$) had the lowest measurement compared to the toilet, which had the highest measurement of ($5.00 \pm 0.25 \text{cm}$). The body length and mesothoracic legs also followed the same trend. The body weight of cockroaches from the dumpsite was significantly higher ($p < 0.05$) than other locations.

Table 2 shows the proximate composition of cockroaches from different locations in Abeokuta. The moisture content of cockroaches in all three locations, and there was significant difference ($p < 0.05$) among cockroaches from the dumpsite to the cockroaches found in the toilet and kitchen. The cockroaches found in the dumpsite have the highest value of ($69.91 \pm 1.29 \text{acm}$) while kitchen has the lowest value of ($57.62 \pm 2.83 \text{bcm}$). Fat content, crude protein content and carbohydrate of cockroaches from the kitchen showed significant difference ($p < 0.05$) from the other two locations.

Mineral analysis of cockroaches from all three locations shows the presence of Na^+ , K^+ , Ca^{2+} ,

Fe , Mg^{2+} and Cl^- (Table 3). Cockroaches collected from the kitchen had the highest Ca^{2+} , g^{2+} concentrations, while cockroaches from the dumpsite had the least. It can also be seen that Fe^{2+} and Cl^- are the least minerals present in all three locations.

Results showed the presence of vitamins A, B_2 and C in the cockroaches from the three locations. There was significant difference ($p < 0.05$) in the composition of vitamin C.

Cockroaches in the kitchen have the highest vitamins while dumpsite has the least vitamins.

Vitamin A is least of vitamins amongst the cockroaches from all the three locations (Table 4).

Microbial analysis of the gut regions of *P. americana* is shown in Figure 1. It shows that fungi growth is significantly higher than bacterial growth in the gut of cockroaches picked from all the three locations. The result of microbial analysis conducted on the gut of cockroaches from the three locations revealed that bacterial and fungal counts ($2.00 \times 10^5 \text{cfu/ml}$, $9.00 \times 10^5 \text{cfu/ml}$ respectively) in

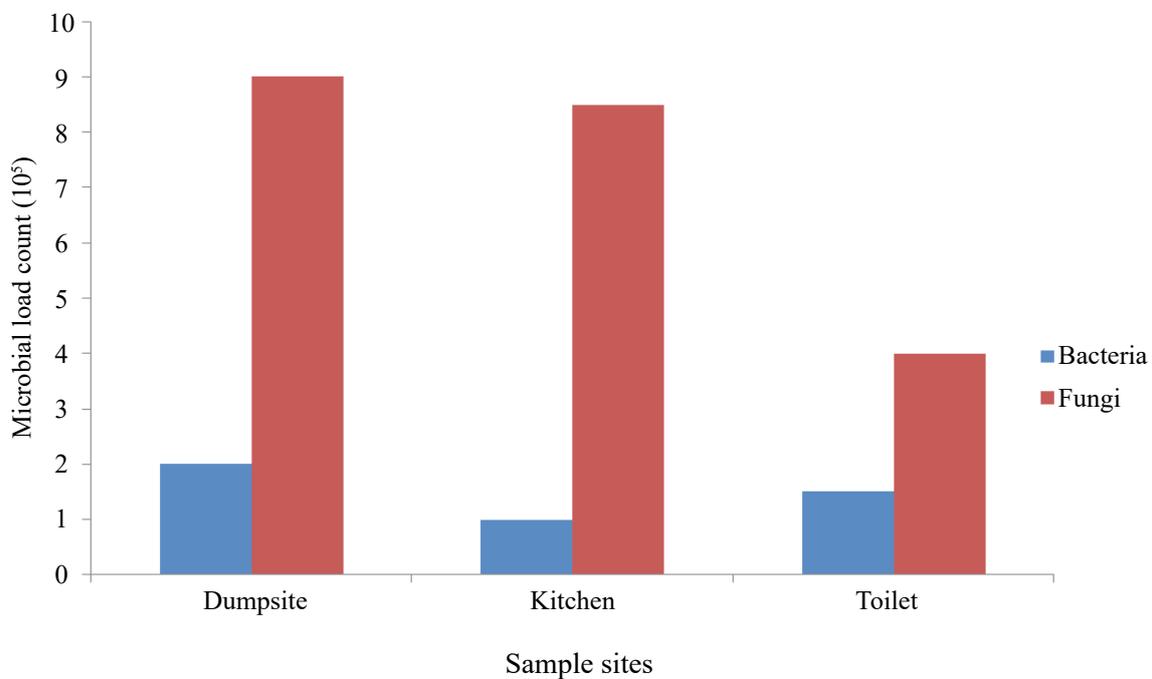


Fig. 1. Gut bacterial and fungi (cfu/ml) of adult male cockroaches (*Periplaneta americana*) from the three locations

cockroaches from the dumpsite were significantly higher ($p < 0.05$) than other sites.

Microflora isolated from the gut of the cockroaches from all the three location is presented in Table 5. The bacterial isolated from the gut of male cockroaches were *Staphylococcus aureus*, *Bacillus subtilis* and *Enterobacter* species. *Bacillus subtilis* appeared in all three locations.

Isolated fungi from the gut of male cockroaches were *Curvularia* species, *Geotricum* species, yeast, *Trichopton* species, and *Aspergillus candidus*. *Curvularia* species appeared in both dumpsite and kitchen while *Geotricum* species appeared in both dumpsite and toilet, and *Aspergillus candidus* appeared at both kitchen and toilet.

Discussion

In all of the examined cockroaches high concentrations of fat, ash, protein as well as carbohydrate were found in cockroaches from the kitchen, this is due to their diet and the richness in their food. This means that the adult *P. americana* cockroaches used in our study are a similar source of protein and lipids like other species of cockroaches (OONINCX and DIERENFELD 2012, BOSCH *et al.* 2014). This nutrient composition of these cockroaches makes them good sources of nutrient supply to humans and could make up animals feed.

It is reasonable to assume that sodium, potassium, magnesium, calcium, iron and chloride are essential minerals for the functions of insects. Which agrees with FINKE (2002) that stated that insects are also a relatively good source of minerals, such as phosphorus, magnesium, sodium or chloride, and trace elements. Mineral content of Ca²⁺ was high

which does not agree with (BARKER and DIERENFELD 1998, FINKE 2002, OONINCX and DIERENFELD 2012). Calcium concentration was highest in the kitchen and this could be due to their diet, they get to feed on food left over like fish, beans, cheese which are rich sources of calcium. Dumpsite appeared to have the lowest calcium concentration amongst the three locations and this could be due to their diet as well. Presence of calcium helps in wound healing. PEARSON and GILLET (1999) reported that calcium is the most abundant mineral element in the animal body and an important constituent of the skeleton and teeth, where around 99% of the total calcium in the body is body is found. Subsequently, *P. americana* extract has been widely used in China to heal severe ulcers and burns. It is administered intravenously and orally or directly applied on the wounds topically (BROWN *et al.* 2004, JEONG *et al.* 2004).

This study shows that fungal load is higher than bacteria, and there are high microbes in the gut of cockroaches, this means better utilization of food. The microbes were significantly higher in cockroaches from dumpsite compared to the other two locations. This is possibly due to moist environment which consists of decaying matter, household dirts and other particles unlike toilet which is usually dry and consist of debris and the kitchen which consists of food spills and left over. The feeding of cockroaches on dumpsites also enhance the growth of fungi due to the fact that they thrive in moist environment. They also aid in the digestion of food.

There was predominance of *Bacillus* sp. in the cockroaches from all the three locations. The distribution of bacterial organisms was not so different from the report of TATFENG *et al.* (2005) except that, in this work, *Bacillus* sp. was the most frequently seen

Table 1. Morphometric of adult male cockroaches (*Periplaneta americana*) from three locations in Abeokuta.*

Location	Average Body weight (g)	Body Length (cm)	Head (cm)	Thorax (cm)	Abdomen (cm)	Pro thoracic leg (cm)	Meso thoracic leg (cm)	Meta thoracic leg (cm)	Inner wing (cm)	Outer wing (cm)
Dumpsite	1.02	3.42±0.21 ^a	0.54±0.05 ^a	0.86±0.05 ^a	1.95±0.34 ^a	2.48±0.36 ^a	3.32±0.57 ^a	3.96±0.45 ^b	2.54±0.11 ^a	2.92±0.13 ^b
Kitchen	0.62	3.76±0.21 ^a	0.62±0.11 ^a	1.20±0.04 ^b	2.30±0.09 ^a	2.38±0.31 ^a	3.52±0.08 ^a	4.80±0.23 ^a	2.26±0.13 ^a	2.62±0.08 ^b
Toilet	0.98	3.83±0.26 ^a	0.78±0.13 ^a	0.88±0.04 ^a	1.98±0.29 ^a	2.62±0.08 ^a	3.80±0.34 ^a	5.00±0.25 ^a	2.80±0.10 ^a	3.22±0.06 ^a

Table 2. Proximate composition (g/100g) of adult male cockroaches (*Periplaneta americana*) from the three locations.*

Location	Moisture content	Fat content	Ash content	Crude fibre content	Crude protein content	Carbohydrate content
Dumpsite	69.91±1.29 ^a	6.92±1.30 ^b	4.16±0.23 ^b	2.56±0.08 ^b	3.12±0.17 ^b	13.33±0.47 ^b
Kitchen	57.62±2.83 ^b	9.96±1.41 ^a	6.84±1.19 ^a	3.81±1.13 ^a	4.58±0.71 ^a	17.19±2.83 ^a
Toilet	66.60±4.24 ^a	7.85±1.20 ^b	4.98±1.39 ^b	2.81±0.01 ^b	3.56±0.08 ^b	14.20±1.41 ^b

Table 3. Mineral composition (mg/100g) of adult male cockroaches (*Periplaneta americana*) from the three locations.*

Location	Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Fe ²⁺	Cl ⁻
Dumpsite	108.67±5.66 ^c	241.48±1.41 ^b	582.02±2.85 ^c	496.70±10.42 ^a	4.52±0.72 ^c	6.92±1.41 ^b
Kitchen	122.67±2.83 ^a	268.91±2.83 ^a	616.76±22.63 ^a	518.91±13.74 ^a	8.93±1.30 ^a	9.45±0.64 ^a
Toilet	116.78±4.24 ^b	261.33±5.66 ^a	601.45±2.05 ^b	512.08±16.97 ^a	6.93±0.04 ^b	7.08±0.11 ^b

Table 4. Vitamins composition (µ/100g) of adult male cockroaches (*Periplaneta americana*) from the three locations.*

Location	Vitamin A	Vitamin B	Vitamin C
Dumpsite	362.16±2.83 ^c	0.45±0.00 ^b	4.16±0.23 ^b
Kitchen	692.83±2.87 ^a	0.73±0.00 ^a	6.23±0.31 ^a
Toilet	451.75±7.07 ^b	0.54±0.01 ^b	4.79±0.99 ^b

* ^{abc} Mean (±Standard deviation) values in the same column having similar superscripts are not significantly different at p>0.05

Table 5. Distribution of microbiota from the gut of adult male cockroaches from the three locations.

Location	Bacteria	Fungi
Dumpsite	<i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i>	<i>Curvularia</i> species, <i>Geotricum</i> species, yeast
Kitchen	<i>Bacillus subtilis</i>	<i>Trichopton</i> species, <i>Curvularia</i> species, <i>Aspergillus candidus</i>
Toilet	<i>Enterobacter</i> species, <i>Bacillus subtilis</i>	<i>Geotricum</i> species, <i>Aspergillus candidus</i>

microorganism in cockroaches.

This study has revealed that cockroaches are in rich vitamins A, B and C. Insects contain a variety of water soluble or lipophilic vitamins (FINKE 2002, FINKE 2004, XIAOMING *et al.* 2010, OONINCX *et al.* 2012). Cockroaches from the kitchen are very rich in vitamin C this could be due to the types of food they get to feed on in the kitchen area which includes cereals, fruits these foods are found in the kitchen as remnants and food spills. Dumpsite had lowest concentration of vitamin A because sources of vitamin A include palm oil, fish, egg, green vegetables, tomato and these types of food are hardly present at the dumpsite.

Conclusion

This study showed that location had an effect on the nutritional value of cockroaches.

Cockroaches found in the dumpsite and toilets have higher microbial load and less nutritional values while cockroaches in the kitchen had more nutrients and vitamins and less microbes.

This indicates that cockroaches found in the kitchen can be added to animal feeds and can also be consumed by humans.

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