Nutritional and Functional Characterization of Edible Insects in Nigeria: A Sustainable Protein Source

ABSTRACT

Introduction: Food insecurity in Africa persists due to extreme poverty, water scarcity, land degradation, and climate change. Many African countries continue to experience chronic hunger and malnutrition. To meet people's nutritional needs, it's important to use economical natural food sources, including edible insects. In Nigeria, edible insects play a vital role in human nutrition.

Aim: This study investigated the nutritional value and functional properties of four commonly consumed insects: *Rhynchophorus phoenicis* larva, *Oryctesrhinoceros* larva, *Acheta domesticus*, and *Macrotermesbellicosus*.

Method: Proximate composition, vitamin content, and functional properties were determined using standard analytical methods.

Results: Statistical analysis revealed significant differences in lipid (8.3% - 28.7%), crude protein (31.9% - 38.2%), carbohydrate (3.1% - 31.9%), moisture (9.2% - 58.9%), and ash content(2.9% - 14.1%) among the insects. Vitamin A values ranged from 2.2 to 4.2μM, while vitamin C values were between 11.5 and 56.8 μM. Functional properties showed variability in water and oil absorption capacity, emulsion activity, foaming capacity, and stability.

Conclusion: These results indicate that these insects have potential as nutrient-rich food sources and could form the basis for new food products with considerable nutritional value.

Keywords: *Rhynchophorus phoenicis* larva, *Oryctesrhinoceros*larva, *Acheta domesticus*, *Macrotermesbellicosus,* proximate analysis, functional properties.

1. INTRODUCTION

One of the prominent issues facing world development is that of undernutrition and poverty. A recent report by the Food and Agriculture Organization (FAO and WHO, 2020) estimated the number of people globally experiencing food insecurity at 750 million, a number which rises to two billion when moderate food insecurity is considered, with over 20% of children under five showing stunted growth.As reported by Obada et. al., (2021), Nigeria remains one of the 20 African countries responsible for 80% of global malnutrition. Increasing population growth increases demand for protein but available farmland is limited. A lack of protein in the diet can greatly affect growth, immune function, and metabolism and sometimes lead to protein-energy malnutrition (Sani et. al., 2014).

Many species of insects have been used as human food in Nigeria some of which include grasshoppers, winged termites caterpillars, beetles as well as crickets.They are conceived as an alternative food source, oil, and protein, providing essential nutrients. Yet, unlike a meal-based approach, they are not considered complete foods. In recent times, there has been a renewed research interest in the potential of insects for food and animal feed (Van Huis, 2020; Babarinde et. al., 2021). This may be probably due to their high protein, vitamin, and mineral benefits (Parker et. al., 2020; Naseem et. al., 2021) and the potentials of insects to replace expensive protein sources such as fish that are becoming unaffordable to poor people and low-income farmers who rely on these expensive protein sources as an important component of animal feed.

The larva of the beetle *Rhynchophorus phoenicis* (F) popularly known as snout beetlehas high nutritive value and therefore,is a delicacy in various regions in Nigeria. Some tribes (the Urhobo and Isoko in Delta state) strongly recommend it for their pregnant women, probably as a source of essential nutrients (Ekpo, 2003, Ekpo and Onigbinde 2005, 2008). The larva of *Oryctes rhinoceros* (coconut rhinoceros beetle)and adult *Macrotermesbellicosus*(winged termite) are delicacies served as snacks or taken with carbohydrate foods. *Acheta domesticus*popularly known as house cricket is roasted for eating.

Edible insects present a lot of benefits in combating nutritional deficiency. Although, variable between insect species (Van, 2013), the high protein and fat contents of edible insects compare favorably to meat and fish (Barroso et. al., 2014). Furthermore, the amino acid profiles of several species have been demonstrated to contain a high proportion of essential amino acids. Edible insects also present a promising source of micronutrients. Knowledge dissemination is important in achieving the global use of insects as food (Govorushko, 2019) and increasing willingness to pay for insect-based food (Lombardi et. al., 2019). However, there

is still concern about the safety of edible insects since there are no legislation guiding their production, consumption and commercialization especially in Nigeria (Usman and Yusuf, 2021).

Several research in Africa have examined the nutritional composition of a certain species, group, or genus (Adepoju and Ajayi, 2016). There is less research on the functional characterization, nutritional value, and diversity of insects consumed in Africa especially in Nigeria. Therefore, this research provides a comparative analysis across multiple species, contributing new insights for combating nutrient deficiency, industrial food processes, and animal feed formulations.

2. Materials

2.1.Sample collection

Live larvae of *R. phoenicis* and *O. rhinoceros*weighing 400 g and 300 g were collected from rot palm trees and raphia palms respectively at Illushi, Edo State, Nigeria.500 g and 300 g of live house crickets (*A. domesticus)* and live termites (*M. bellicosus*) were collected by hand with collection of *M. bellicosus*during their nuptial flight. Samples were collected in June and washed to remove dirt. Viable samples were selected and identified by a zoologist.

2.2.Instruments

Some of the instruments used for the analyses in the study are: Spectrophometer (GENESYS 180 model, BioTek, Winooski, U.S.A.), micropipette (EXII MULTI model, Nichipet, Chiyoda-ku, Japan), desiccator (Model DWA205, DWK Life Sciences Limited, Staffordshire, England), muffle furnace (Model M-525 SII, Hamilton Instrument, Cinnaminson, U.S.A.), micro-Kjeldahl digestion flask (Model K1100F, Xian Yima Optoelec Xian, China),Markham's steam distillation apparatus (L485/3 model, Jindal Medical & Scientific Instruments, Delhi India), Beaker (Model 3451305, CORNING INC, Corning, U.S.A), Porcelain crucible (Eisco, Haryana, India), Weighing balance (Model CNA403, CGOLDENWALL, U.S.A), Refrigerator (Model WHD-113FSS1, Haier thermocool, Qingdao, China), Measuring Cylinder (Eisco, Haryana, India), Hot air oven (Model FML801, MOOSOO, Kent, U.S.A), Steam bath (Model 402, LABOTEC, South Africa).

3. Methodology

3.1. Preparation of sample

Within 24 hours of collection, the samples were dried in an oven regulated at 40 ^{O}Cfor 1 hour (aside from those for moisture content) and blended using an electric blender. The blend samples were stored separately in air-tight containers for further analytical use.

3.2. Determination of proximate composition

Proximate composition of the insects was examined using the method of (AOAC) 2012. Protein determination was carried out using the MicroKjedhal's method as published by Pearson (1976).

3.3. Moisture content

To determine the moisture content, a known quantity of each sample (2.0 g) was weighed and dried in an oven at 40°C to a constant weight. The dishes and samples were then cooled and re-weighed, and the moisture content was estimated using the equation below.

$$\text{Moisture (\%)} = \frac{\text{Loss in weight}}{\text{Weight of sample (g)}} \times 100$$

3.4. Ash content

5 g of the sample was weighed into a previously burned and cooled porcelain plate. The dish and contents were gently charred over a low flame before been placed in a muffle furnace at 550-600 ^{0}C. After cooling in a desiccator, they were re-weighed. The total ash content was determined using equation below.

$$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.5. Fat content

A washed, dried, and cooled quick-fit flask was weighed. The samples (2 g) were weighed into an extraction thimble and placed in the quick-fit soxhlet apparatus with a solvent flask holding 250 ml of diethyl ether and a condenser. The setup was heated for 16 hours for full extraction. The extract was evaporated at 70°C to eliminate any residual solvent. The apparatus was re-weighed, and the percentage fat was computed using the formula below.

$$\text{Fat (\%)} = \frac{\text{Weight of fat (g)}}{\text{Weight of sample (g)}} \times 100$$

3.6. Crude protein

Two grams of each of the samples was mixed with 10 ml of concentrated H_2SO4 in a heating tube. One tablet of selenium catalyst was introduced into the tube and the mixture was heated inside a fume cupboard. The digest was transferred into distilled water. A known volume, 10 ml portion of the digest mixed with equal volume of 50% NaOH solution was poured into a kjeldahldistillation apparatus. The mixture was distilled and the distillate collected into 2% boric acid solution containing 3 drops of methyl red indicator. A total of 50 ml distillate was collected and titrated as well. At the end point, the colour turned to wine colour, indicating that all the nitrogen had been trapped as ammonium chloride. The sample was duplicated and the average value taken. The crude protein was determined by multiplying nitrogen by a constant factor of 6.25.

3.7. Carbohydrate

The procedure of carbohydrate determination is also known as Nitrogen Free Extract (NFE). NFE was determined using the equation below.

$$\%NFE = 100 - (\%\ ash + \%\ fat + \%\ crude\ protein + \%\ moisture)$$

3.8. Determination of vitamins

Vitamins were determined using the methods outlined by AOAC (2012).

3.9. Vitamin A concentration

1 g of samples were carefully weighed into a 100 ml flask with a reflux condenser. Then, 10 ml pure alcohol and 20 ml alcoholic sulphuric acid were added. The condenser and flask were wrapped in aluminium foil. They were refluxed for 45 minutes and chilled. Next, 5 ml of water was placed into each flask and transferred to a separating funnel. Diethyl ether (30 ml) was used to remove non-saponified materials. The ether extract was washed to remove acid and dried over anhydrous sodium sulphate.The extractwas evaporated at a low temperature and protected from sunlight.The solvent was removed with a stream of nitrogen, and the residues were promptly dissolved in 10 ml isopropanol. The extinction of the freshly produced extract in isopropanol was measured at 325 nm versus a solvent blank (T1). After removing the cuvettes and exposing them to UV radiation until extinction stopped, the absorbance (T2) was measured. The standard vitamin A solution (ST1 - ST2) received the same treatment as described in the equation below.

$$\text{Vitamin A}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{T1 - T2}{ST1 - ST2} \times 1 \times \text{Dilution factor}$$

3.10. Vitamin C concentration

Ascorbic acid was determined by titration with diphenol indo 2, 6 – dichlorophenol (DPIP). The powdered sample (0.2 g) was mixed with 4 ml of a buffer solution made up of 1 g/l oxalic acid

and 4 g/l sodium acetate anhydrous. This was titrated against a solution containing 295 mg/l DPIP and 100 mg/l sodium bicarbonate. Vitamin C content of the samples was calculated using the equation below.

$$\text{Vitamin C}\left(\frac{\text{mg}}{100\text{g}}\right) = \frac{\text{MV} \times 100 \times 100}{10\text{B}}$$

M = mass of ascorbic acid tritrimetric equivalent to 0.001 M DPIP solution (mg)

100 is the dilution ratio of the sample taken, the second 100 is the scaling factor for conversion to per 100 g of raw material, 10 is the titrate volume

V = titrant volume (0.00 1 M DPIP solution) ml

B = weight of the sample extract used

3.11. Vitamin E concentration

One gram of the ground sample was measured into 100 ml flask and 10 ml of absolute alcohol (ethanol) was added. Twenty millilitres of 1 M alcoholic sulphuric acid and 18 ml of concentrated H_2SO4 in 1 L of ethanol were added and refluxed for 45 min and cooled in a reflux condenser. A volume of 10 ml of the clear solution was pipette into a test tube and heated in a water bath at 90 ^{O}C for 30 min and allowed to cool. A standard and a blank were prepared and the absorbance read at 470 nm. Vitamin E was calculated using the equation below.

Vitamin E (mg/100g) = Absorbance x Dilution factor

3.12. Determination of functional properties

Water and oil absorption capacitywere determined using the methods outlined by AOAC (2010).

3.13. Water Absorption Capacity

Two grams of the sample powder was weighed into centrifuge tube and 20ml of distilled water was added, the tube was shaken and allowed to stand at room temperature (25 ^{0}C) for 30mins and then centrifuged for 30mins at 200rpm. The excess water was decanted by inverting the tubes and the weight of the water bound was determined by difference.

$$\text{Water absorption capacity} = \frac{\text{W2} - \text{W1}}{\text{W0}}$$

Where;

W_0= weight of sample

W_1= weight of tube

W_2= weight of tube and sample.

3.14. Oil Absorption Capacity

Two grams of the sample powder was weighed into a centrifuge tube and 20ml of oil was added and the tube was shaken and allowed to stand at room temperature (25^{o}C) for 30mins. It was then centrifuge for 30min at 200rpm and the excess oil was decanted by inverting the tubes and the weight of the oil bound was determined by difference.

$$\text{Oil absorption capacity} = \frac{W2 - W1}{W0}$$

Where;

W_0= weight of sample

W_1= weight of tube

W_2= weight of tube and sample.

Emulsion capacity, activity and stability were determined by the method described by Okezie and Bello (1988). Foam capacity and stability were estimated by the method of Narayana andNarsinga, (1982).

3.15. Statistical analysis

Statistical package for service solutions (SPSS) version 23 was used to analyse the data and presented as mean ± Standard Error of Mean (SEM). One-way ANOVA was used to compare the proximate value, vitamin content and functional properties of the insects. Differences were considered significant at $P < 0.05$.

4. Results

The order, local name and consumption stage of the studied insects are presented in Table 1.

Table 1: **Order, local name, and consumption stage of four edible insects consumed in Nigeria**

Order	Scientific name	Common name	Local name	Consumption stage
Coleoptera	*Ryhnchophorus Phoenicis*	Palm weevil	Isoko: Odidi	Larva
Coleoptera	*Oryctes rhinoceros*	Rhinoceros beetle	Isoko: Akpakara	Larva
Orthoptera	*Acheta*	House	Isoko:	Adult

domesticus cricket		Ozeze		
Isoptera	*Macrotermes*	Winged	Isoko:	Adult
Bellicosus termite		Ofuru-Ukpe		

Results of the proximate analysis of *R. phoenicis* larva, *O. rhinoceros*larva, *A. domesticus*,and *M. bellicosus*are shown in Table 2.

Table 2: Proximate analysis (%) of four edible insects in Nigeria

Insects	Moisture	Lipid	Protein	Carbohydrate	Ash
Ryhnchophorus phoenicis	58.5± 0.78[a]	23.8 ± 0.29[b]	23.8 ± 0.29[b]	3.1 ± 0.14[c]	2.9 ± 0.15[b]
Oryctes rhinoceros	58.2 ± 0.23[a]	13.7 ± 0.29[c]	13.9 ± 0.91[c]	9.3 ± 0.27[b]	4.9 ± 0.07[b]
Acheta domesticus	9.2 ± 0.29[c]	8.3 ± 0.51[d]	38.2 ± 0.21[a]	31.9 ± 0.37[a]	12 ± 0.35[a]
Macrotermes bellicosus	12.1 ± 0.59[b]	28.7 ± 0.29[a]	35.0 ± 0.91[a]	10.1 ± 0.33[b]	14.1 ± 0.24[a]

Results represent the Mean ± SEM of three estimations; Values are the % wet weight of the larvae.Different letters within the same column indicate significant differences ($P < 0.05$).

Proximate analysis of the studied edible insects showed that moisture was highest in *R. phoenicis* larva with a content of 58 ± 0.78% and the least value of 9.2 ± 0.29% was found in *A. domesticus*. The difference in moisture content among the insects was statistically significant with $P < 0.05$. The highest crude protein content was found in *A. domesticus*with a value of 38.3 ± 0.21%. The high protein content in *A. domesticus*may be attributed to its adult stage, as insect maturity can influence nutrient accumulation. The difference in protein content among the insects was also statistically significant with $P < 0.05$. The insect with the richest carbohydrate

content of 31.9 ± 0.37% was *A. domesticus*while *R. phoenicis* larva had the lowest content of 3.1 ± 0.14%. The highest lipid value of 28.7 ± 0.29% was recorded in *M. bellicosus*. Ash value of the four insects ranged from 2.9 ± 0.15% to 14.1 ± 0.24%.

Results of vitamins A, C, and E of the studied insects are shown in Table 3 below.

Table 3: Vitamin Content (μM) of four edible insects in Nigeria

Insects	Vitamin A	Vitamin C	Vitamin E
Rhynchophorus phoenicis	3.2 ± 0.01[b]	56.8 ± 0.96[a]	21.8 ± 0.33[c]
Oryctes rhinoceros	2.6 ± 0.06[c]	27.5 ± 0.38[b]	25.3 ± 0.39[b]
Acheta domesticus	4.2 ± 0.01[a]	11.5 ± 0.66[d]	24.1 ± 0.31[b]
Macrotermesbellicosus	2.2 ± 0.08[c]	14.7 ± 0.22[c]	32.6 ± 0.24[a]

Results represent the Mean ± SEM of three estimations; Different letters within the same column indicate significant differences ($P < 0.05$)

Vitamin A value of the studied insects/insect larva ranged from 4.2 ± 0.01 to 2.2 ± 0.08 inμM. *A. domesticus*was richest in vitamin C when compared to the other insects investigated while *M. bellicosus*was observed to contain the highest vitamin E value.

Result of the functional properties (%) of the studied insects are presented in Table 4.

Table 4: Functional properties(%) of four edible insects in Nigeria

Parameters	*RyhnchophorusPhoenicis*	*OryctesAchetarhinoceros*	*Acheta domesticus*	*Macrotermesbellicosus*
Water absorption	140.0± 0.21[a]	136.7± 0. 19[a]	166.7± 0.06[a]	170.0± 0.06[a]

capacity (WAC)
Oil absorption 113.3± 0. 10^{b}103.3± 0.06^{b}146.7± 0.13^{b}143.0± 0. 10^{b}
capacity (OAC)
Emulsion activity (EA)39.7± 1.42^{c}79.3 ± 0.87^{c}84.3± 1.14^{c}81.6± 1.2^{c}
Emulsion capacity (EC)37.0± 0.58^{c}82.0± 1. 16^{c} 87.7± 0.34^{c}82.5± 1.46^{c}
Emulsion stability (ES)33.3 ± 0.34^{c}75.7 ± 2. 19^{c}79.0 ± 1.53^{c}76.3 ± 0.88^{c}
Foam capacity (FC) 7.7 ± 0.34^{d}5.3 ± 0.34^{d}6.7 ± 0.34^{d}7.7 ± 0.34^{d}
Foam stability(FS) 3.0 ± 0.58^{d}1.3 ± 0.34^{e}1.7 ± 0.34^{e}2.7 ± 0.67^{e}

Results represent the Mean ± SEM of three estimations; Different letters within the same column indicate significant differences ($P < 0.05$)

The results revealed that *Macrotermesbellicosus*had the highest water absorption capacity(WAC) of 170.0 ± 0.06% with *Ryhnchophorus Phoenicis* and *Oryctes rhinoceros* having comparable values of 140.0 ± 0.21% and 136.7 ± 0. 19%. The difference in the water absorption capacity (WAC) among the insects was statistically significant with $P < 0.05$. Oil absorption capacity (OAC) was highest in *Acheta domesticus*with a value of 146.7 ± 0.13% and lowest in *Oryctes rhinoceros* with a value of 103.3 ± 0.06%. Emulsion activity (EA), Emulsion capacity (EC), and Emulsion stability (ES) were highest in *Acheta domesticus*. Foam capacity (FC) and foam stability (FS) were in the range of 7.7 ± 0.34% to 5.3 ± 0.34% and 3.0 ± 0.58% to 1.3 ± 0.34%.

5. Discussion

The consumption of edible insects (entomophagy) in Africa, is a traditional and culturally acceptable way by which the low-income group in the society supplements the meager protein content of their high carbohydrate diets (Ekpo et. al., 2009).Numerous species of insects have been consumed as food by humans in Africa, including various aquatic insects, cicadas, winged ants, larvae and pupae of ant brood, wasps, bees, winged termites, adults and grubs of beetle, caterpillars, and grasshoppers (Thomas et. al., 2019).

In Nigeria, insects such as termites, crickets, and beetle larvae form an important portion of the diets of many cultures and communities, where they are included as a planned portion of the diet or snacks, as this helps rural households to meet their dietary and nutritional needs (Gahukar, 2020). Insect consumption just like onions, carrot, and garlichelp to lower blood total cholesterol levels (Eromosele et. al., 2024).Although, they are not available all through the year, processing them can help in extending the period of availability for consumption and income generation.

The results of this research agree with the broader cultural practice of entomophagy in Africa, revealing that edible insects can serve as sources of essential nutrients for the poor in society. Specifically, *Acheta domesticus*and *Macrotermesbellicosus*were discovered to be rich in protein and other nutrients.

Some studies earlier conducted reported morphometric parameters and/or proximate values of insects/insect larvae which closely agrees with observationsof this study. The insect

larvae had higher moisture values than their adult counterparts making most of their nutrients available to the body upon consumption. The major setback of high moisture content is that it reduces the period of preservation due to the risk of spoilage by micro-organisms.

The protein content of the studied insects ranged from 13.9 ± 0.91% to 38.2 ± 0.21%. These results were quantitatively comparable to protein contents of 43.8% and 71.0% in termites and crickets, respectively (Oibiokpa et. al., 2017). When compared to the value of protein contained in conventional meat, dairy products, fish, and plants, Jacob et. al., (2013) highlighted that the protein content in crickets and termite were considerably higher. These are crucial to preventing health deficiencies linked to the lack of proteins in infants and children such as "kwashiorkor"and an alternative to hidden hunger prevalent in developing countries like Nigeria (Gibson, 2015).

Protein plays a vital role in the maintenance of body tissue including development and growth. In the absence of energy, it can be broken down to release energy, it is involved in the production of hormones, which help to control body functions and help regulate cell growth. It also plays a major role in the formation of enzymes which increases the rate of chemical reactions in the body.

Edible insects contain fat content ranging from 1-67%. The fat content are higher in the larval stage. The fat content in *Macrotermesbellicosus*and *Ryhnchophorus Phoenicis*was higher than in other insects, which could be the reason why their gross energy is high, as fat contributes more calories than twice the contribution of carbohydrates and proteins. These results are consistent with Bukkens (1997), who reported that Lepidopteran caterpillars and palm weevils larvae contain higher fat than any other insect species. Edible insects can be used to provide essential fatty acids required by the human body (Kewuyemi et. al., 2020). Fat functions as an important depot for energy storage, insulates and protects the body, regulates temperature, and helps the body to absorb vitamins A, D, and E.

The carbohydrate content of the studied insects is lower when compared to values of 24.7% for winged termites and 48.2% dry weight for grasshoppers as reported by Ahmad et. al., (2013). Carbohydrates are important nutritive elements in the human body. They are most valuable among other food components (Offiah et. al., 2019).

Ash is a reflection of the mineral content contained in a sample. Ash content analysis showed that *M. bellicosus*and *A. domesticus*had higher values than the other insects whose results closely agree with other values of 4.3% reported by Solomon et. al., 2012, 2.8% and 2.6% for green and brown *Ruspoliadifferens* reported by Kinyuru et. al., 2006.

Vitamins are a group of organic substances needed for normal cell function, growth, and development. Except for vitamin D, vitamins cannot be synthesized in the human body, they must be supplied in the diet. The vitamin content of these insects/insect larva is suggestive of their potential in alleviatingvitamin deficiency.

Winged termites (*M. bellicosus*) contain a high content of vitamins A and C. Vitamin A plays a vital role in vision, immune function, reproduction, growth, and development. It also forms and maintains healthy teeth, skeletal tissue, mucus membranes and skin.

R. Phoenicis had the highest vitamin C value when compared to the other insects studied. Vitamin C forms an important protein called collagen used to make skin, tendons, ligaments, and blood vessels. It aids in the absorption of iron, wound healing, and repair of cartilage, bones, and teeth.

M. bellicosus was observed to contain the highest amount of vitamin E which is a fat-soluble nutrient found in many foods. It acts as an antioxidant in protecting the body tissues from damages caused by free radicals, helps keep the immune system strong against viruses and bacteria, and helps the body in making use of vitamin K.

The water absorption capacity (WAC) ranged from 136 ± 0. 19% to 170.0 ± 0.06%. This shows that the insect/insect larva can be incorporated into aqueous food formulations. Oil absorption capacity (OAC) ranged between 103.3 ± 0.06% to 146.7 ± 0. 13%. Oil absorption capacity (OAC) is important since oil acts as a flavor retainer and increases the palatability of foods. The emulsion capacity, activity, and stability were high and can be compared to what other researchers earlier reported. The results suggest that these insects would be highly desirable for preparing comminuted meats. Foam formulation and stability are functions of the type of protein PH, processing methods, and surface tension. Foam capacity and stability ranged between 5.3 ± 0.34% to 7.7 ± 0.34% and 1.3 ± 0.34%to 3.0 ± 0.58% respectively. Akubor and Chukwu (1999) reported that foams are used to improve the texture, consistency, and appearance of foods.

Alimitation of this researchis that the nutritive value of these insects can vary with seasons and environmental factors, which were unaccounted for here. Future research should find out how these factors affect nutritive levels to provide a broad knowledge of their potential in combating nutrient deficiency.

6. Conclusion

Thehealth and well-being of an individual depend on the interaction between his/her genetic potential and exogenous factors like adequacy of nutrition, safety of the environment and social interaction. Protein, lipids, carbohydrates, and vitamins are vital food nutrients required in the body for growth, repair of tissues, energyproduction, reproduction, and health maintenance. Deficiency of these nutrients results in different disease conditions such as marasmus, night blindness, soft bones, stunted growth, poor immunity, kwashiorkor, and sterility among others. Milk and eggs are great sources of these nutrients but due to their high cost, they are unavailable to the low-income group in the society.

This research affirms the fact that edible insects provide higher amounts of proteins, fats, carbohydrates, and vitamins than beef and chicken. Their consumption could play a crucial role in alleviating protein-energy malnutrition and vitamin deficiencies.Moreover, this knowledge justifies the fact that these insect/insect larva are important food items requiring industrial application and commercialization to providesustainable solutions in meeting nutritional needs.

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8. Conflict of interest

None

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