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COMPARATIVE STUDIES OF THE NUTRITIONAL COMPOSITION OF SOME INSECT ORDERS

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ABSTRACT: *Insects are nutrient packed food resources for mankind and livestock. Food profile of Four (4) insects belonging to the Order; Lepidoptera (Cirina forda Westwood), Blattodea (Periplanata americana L), Coleoptera (Rhynchophorus phoenicis F) and Orthoptera (Zonocerus variegatus L) were analyzed according to standard measures and the results obtained showed that C. forda had the highest protein content (74.56%). The protein content of Z. variegatus was 69.52% while P. americana had 70.58% and the least value of 24.58% was obtained in R. phoenicis. Fat content was highest in R. phoenicis (46.56%) while in Z. variegatus, the value obtained was (16.24%). However, the values obtained in C. forda (8.77%) and P. americana (8.53%) compares favourably. Ash content was low in Z. variegatus (3.21%) and P. americana (3.24%) while the values obtained in R. phoenicis (6.21%) and C. forda (5.32%) compares favourably. The fibre content of R. phoenicis was the highest (7.55%) while the least value was obtained in Z. variegatus (2.42%). The values of carbohydrate in the insects are P. americana (9.44%), R. phoenicis (6.59%), Z. variegatus (3.84%) and C. forda (3.70%) respectively. Moisture content was highest in R. phoenicis (8.53%) while the values obtained in other study insects compared favourably. All the insects are good sources of mineral salts among which are Sodium, Potassium, Calcium, Magnesium, Zinc, Iron, Manganese and Phosphorus. Copper was not detected in any of the insects. The highest value of iron (9.25 mg/100g) was obtained in R. phoenicis while the least value was obtained in P. americana (5.68 mg/100g). Of all the insects sampled, R. phoenicis obtained the highest values in all the minerals. The result shows that all the minerals investigated are consistently higher in R. phoenicis than in all other insects. All the insects had anti-nutrients such as tannin, polyphenol, phytate, oxalate, saponin, alkaloids and flavonoids at tolerant quantities.*

KEYWORDS: Arthropods, Insects, Periplaneta Americana, Nutrient Composition, Minerals, Tannin

INTRODUCTION

The Class Insecta has more representatives in all habitats than any other organisms on earth and they are sustainable and secure sources of animal-based food in the diet (Dossey, 2013, van-Huis, 2013, Premalatha *et al.* 2011). Some insects are regarded as pests while some are beneficial to man. Among the beneficial ones are those that produce products that are valuable to man and his livestock (Omotoso, 2006) while the detrimental ones are those that cause destruction to man and his valuables. Among prominent Orders of insect are Coleopteran and Lepidopterans. These two orders contain insects that have more direct impacts on man and his activities. Some of the insects in these two Orders are pests of most crops. Orthopterans are generally regarded as a dominant group in most terrestrial habitats. These insects feed on all types of plants and they often cause serious economic

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damage. Blattodea are omnivores and are found in every part of the world with each continent having its own indigenous species. Cockroach is a prominent home pest which attacks/destroys man and his valuables including foods. All the insects are important pests of crops and household materials. The four orders of insects; Coleoptera, Orthoptera, Blattodea and Lepidoptera are common edible insects commonly eaten world-wide (Jongema, 2012).

Insects thrive better in the tropics because of the warm weather of this region which favour their development and growth. Thus, they are available in large quantities in this region. Considering the availability of these insects in large quantities in the tropics, however, efforts must be geared toward investigating and improving upon their use as alternative sources of nutrients. Though, some workers have established the importance of some insects as sources of good nutrients (Bednarova, *et al.* 2013, Belluco, *et al.* 2013). In view of this, more work needed to be done in prospecting for more edible insects considering the array of nutrients they possess. The traditional use of insects as food is widespread in tropical and subtropical countries and this provides significant nutritional, economic and ecological benefits for rural communities (DeFoliart, 1999). Edible insects are good sources of protein, fat and essential amino acids in the diet of both primates and human. Insects are capable of eliminating protein malnutrition in man (Kinyuru *et. al.*, 2010). Insects provide good sources of proteins, minerals, vitamins, and energy, and they cost less than other animal protein (Kinyuru, *et. al.* 2013, Bednarova, *et. al.* 2013).

MATERIALS AND METHODS

Collection of insects and assay preparations

The four insects used for this work are *Rhynchophorus phoenicis, Cirina forda, Zonocerus variegatus* and *Periplanata americana. R. phoenicis* were collected from fallen palm trees along River Ayanyan in Ado-Ekiti. Dried *C. forda* were purchased from Oja-Oba in Ado-Ekiti while *Z. variegatus* were collected from Ekiti State University campus in Ado-Ekiti. *P. americana* were collected from houses around student hostels in Ekiti State University Ado-Ekiti. All the insect samples except *C. forda* were killed by putting them in a deep freezer maintained at -10° C for 1 h. The insects were later removed and put in oven maintained at 65° C for 24 h. The wings of *Z. variegatus* and *P. americana* were carefully removed and each of the dried samples was pulverized separately with Binatone blender at the highest revolution. Each of the ground samples was stored in an air-tight plastic container and labeled.

Nutrient analysis

Nutrient analyses of the samples such as protein, fat, fibre, moisture, ash and carbohydrate contents were carried out using standard methods of AOAC (2005) and Joslyn (1970) explained by Omotoso (2015).

Mineral analysis

Mineral analyses of salts such as Sodium, Calcium, Phosphorus, Zinc, Iron, Magnessium, Copper, Potassium and Manganese were carried out on the insects using standard methods of AOAC (2005), Pearson (1976).

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Anti-nutrients analysis

Anti-nutritional contents such as tannin, polyphenol, oxalate, phytate, saponin, alkaloids and flavonoids were determined using standard methods of Harbone (1973), Day and Underwood (1986), Bohm and Kocipal-Abyazan (1994) Markkar and Goodchild (1996) explained by Omotoso (2015).

Statistical analysis

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

RESULTS

The results of the nutrient compositions of the insects is shown in Table 1 below. The results showed that *C. forda* had the highest protein content (74.56%). The protein content of *Z. variegatus* was 69.52% while *P. americana* had 70.58% and the least value of 24.58% was obtained in *R. phoenicis*. Fat content was highest in *R. phoenicis* (46.56%) while in *Z. variegatus*, the value obtained was (16.24%). However, the values obtained in *C. forda* (8.77%) and *P. americana* (8.53%) compares favourably. Ash content was low in *Z. variegatus* (3.21%) and *P. americana* (3.24%) while the values obtained in *R. phoenicis* (6.21%) and *C. forda* (5.32%) compares favourably. The fibre content of *R. phoenicis* was the highest (7.55%) while the least value was obtained in *Z. variegatus* (2.42%). The values of carbohydrate in the insects are *P. americana* (9.44%), *R. phoenicis* (6.59%), *Z. variegatus* (3.84%) and *C. forda* (3.70%) respectively. Moisture content was highest in *R. phoenicis* (8.53%) while the values obtained in other study insects compared favourably.

Table 1: Nutritional composition of four insect samples

Samples	%MC	%CP	%Fat	%Fibre	%Ash	%CHO
Rhynchophorus phoenicis	8.53±0.01	24.58±0.04	46.56±0.02	7.55±0.01	6.21±0.01	6.59±0.01
Cirina forda	5.03±0.00	74.56±0.01	8.77±0.03	2.63±0.03	5.32±0.01	3.70±0.02
Zonocerus variegatus	4.83±0.01	69.52±0.03	16.24±0.02	2.42±0.01	3.21±0.01	3.84±0.04
Periplanata americana	5.21±0.01	70.58±0.02	8.53±0.02	3.02±0.01	3.24±0.01	9.44±0.02

Each value is a mean of triplicate ± standard deviation.

Table 2 shows the result of the mineral salts in the insect samples in this study. All the insects are good sources of mineral salts among which are Sodium, Potassium, Calcium, Magnesium, Zinc, Iron, Manganese and Phosphorus. Copper was not detected in any of the insects. The highest value of iron (9.25 mg/100g) was obtained in *R. phoenicis* while the least value was obtained in *P. americana* (5.68 mg/100g). The result shows that all the minerals investigated are consistently higher in *R. phoenicis* than in all other insects. The values of minerals obtained in *C. forda* were closely related to the values obtained in *R. phoenicis*. The values of Sodium (38.54 mg/100g) and Phosphorus (91.36 mg/100g) obtained in *Z. variegatus* were the lowest among the study insects.

Table 2: Mineral composition of four insects

Minerals (mg/100)	*R. phoenicis*	*C. Forda*	*Z. variegatus*	*P. americana*
Sodium	60.35	51.35	38.54	40.26
Potassium	68.55	65.46	50.18	52.21
Calcium	65.20	44.65	37.87	40.22
Magnesium	71.43	68.95	56.95	57.30
Zinc	4.50	3.86	3.50	3.45
Iron	9.25	7.21	6.33	5.68
Copper	Nd	Nd	Nd	Nd
Manganese	2.33	1.28	1.20	1.16
Phosphorus	150.20	108.57	91.36	100.35

Table 3 shows the result of anti-nutrient composition of the insect samples in this study. The tannin content of *R. phoenicis* was 0.61±0.01mg/100g while that of *C. forda* was 0.54±0.01mg/100g. The values of tannin content in *Z. variegatus* and *P. americana* were 0.72±0.03mg/100g and 1.13±0.01mg/100g respectively. The polyphenol content of *R. phoenicis* was 0.56±0.01mg/100g while that of *C. forda* was 0.37±0.01mg/100g. The values of polyphenol in *Z. variegatus* and *P. americana* were 0.54±0.03mg/100g and 0.78±0.02mg/100g respectively.

Table 3: Anti-nutrients composition of insect samples

Minerals (mg/	*R. phoenicis*	*C. forda*	*Z. variegatus*	*P. americana*
Tannin	0.61±0.01	0.54±0.01	0.72±0.03	1.13±0.01
Polyphenol	0.56±0.01	0.37±0.01	0.54±0.01	0.78±0.02
Phytate	19.39±0.04	25.45±0.04	26.49±0.01	28.48±0.05
Oxalate	9.74±0.01	6.75±0.03	8.28±0.04	7.61±0.02
Saponin	20.38±0.04	8.65±0.01	6.74±0.01	5.46±0.01
Alkaloids	15.76±0.01	8.33±0.01	3.55±0.01	5.26±0.06
Flavonoids	5.39±0.02	3.44±0.02	2.52±0.02	4.32±0.01

Each value is a mean of triplicate ± standard deviation.

The phytate content of *R. phoenicis* was 19.39±0.04mg/100g while that of *C. forda* was 25.45±0.04mg/100g. The values of phytate content in *Z. variegatus* and *P. americana* were 26.49±0.01mg/100g and 28.48±0.05mg/100g respectively. The highest value of oxalate was obtained in *R. phoenicis* (9.74±0.01mg/100g) while the least value (6.75±0.03mg/100g) was obtained in *C. forda*. The Saponin content of *R. phoenicis* was 20.38±0.04mg/100g while that of *P. americana* was 5.46±0.01mg/100g respectively. Alkaloid was highest in *R. phoenicis* (15.76±0.01mg/100g) while least in *Z. variegatus* (3.55±0.01mg/100g). Flavonoids content of *R. phoenicis* was highest (5.39±0.02mg/100g) while least in *Z. variegatus* (2.52±0.02mg/100g).

DISCUSSION

Insects are important as food in nearly all cultures. The importance of insects as sources of good quality nutrients have been highlighted by many authors (Kourimska and Adamkova, 2016, Omotoso, 2015, Omotoso and Adedire, 2008). The results of the nutritional

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composition revealed that the moisture content of *Z. variegatus* was the least (4.83±0.01%) among all the insects in this study. Higher moisture values have been obtained by some workers in *Z. variegatus* (Geoffrey, *et al.* 2016, Sani, *et al.* 2014). The highest moisture content was obtained in *R. phoenicis* (8.53±0.01%). This value is higher than the values obtained in both the larval and pupal stages of *O. ferrugineus.* The results of this work showed that the moisture content of *C. forda* and *P. americana* compared favourably. The values obtained are higher that what was obtained in the pupal stage of *O. ferrugineus* but lower greatly from the values obtained in other insects (Abdel-Moniem, *et al.* 2017, Meetali, *et al.* 2014). The low moisture content of the insects in this study ranged from 4.83%-8.53% indicating that they contained 91.47%-95.17% dry matter. Thus, more nutrients with long shelf-life are present in the insects.

The protein contents of all the insects used in this study are higher thus, the insect species can be used to combat protein deficiencies in man and his livestock. It has been observed that the protein contents of insects vary from 20%-76% and they supplied more proteins and amino acids than other animals (Amza and Tamiru, 2017, Belluco, *et al.* 2013, Bednarova, 2013). The protein content of *R. phoenicis* in this study compares favourably with the value obtained by Okunowo *et al.* (2017) but lower than the value obtained by Abdel-Moniem *et al.* (2017). The protein content of *C. forda* which was the highest in this study was also higher than the values obtained by other authors (Adepoju and Daboh, 2013, Osasona and Olaofe, 2010). The protein contents of *Z. variegatus* and *P. americana* in this study are higher than the values obtained by other authors (Ghosh, *et al.* 2016, Geoffrey, *et al.* 2016, Sani, *et al.* 2014, Blasquez, *et al.* 2012) Insects are good sources of proteins and other nutrients hence, they are very important in future food security (Tiencheu and Womeni, 2017).

The fat content was highest in *R. phoenicis* indicating that the insect is a good source of energy. Higher fat content has been obtained by Okunowo *et al.* (2017). The high content of fat must have been derived from the diet of the organism. Diets of organisms have been observed to have effect on the growth, body weight and carcass quality of meat (Nualchuen, *et al.* 2017, Iqbal, *et al.* 2012). The fat content obtained in *C. forda* and *P. americana* in this study are lower than the values obtained in these same insects by some authors (Adepoju and Daboh, 2013, Blasquez, *et al.* 2012, Osasona and Olaofe, 2010). The fat content obtained in *P. americana* in this study is lower than the value obtained by Blasquez *et al.* (2012). The fat content of *Z. variegatus* in this study was lower than the values obtained by some authors (Geoffrey, *et al.* 2016, Ghosh, *et al* 2016, Sani *et al.* 2014) in the same insect. Insect fat are good sources of proteins and unsaturated oils (Abdalbasit, 2013).

The fibre content of *R. phoenicis* was highest among the four insect species in this study but lower than the values obtained by other authors (Okunowo, *et al.* 2017). The fibre contents of *C. forda*, *Z. variegatus* and *P. american* fall below the range obtained in some insect species (Amza and Tamiru, 2017) while that of *R. phoenicis* was within the range. Fibre is responsible for the peristaltic movement within the intestinal tract of animals (Oduor *et. al*, 2008). It has been observed that high fibre diets can be used to control weight increase. Moreover, a diet that has low fibre content can lead to constipation which is a serious physiological discomfort in animals (Groff *et. al.*, 1995).

The carbohydrate content of *R. phoenicis* was 6.59±0.01%. This value is lower than the value obtained by Abdul-Moniem *et al.* (2017) in the same insect. In this study, the carbohydrate content was highest in *P. americana* and lowest in *C. forda.* Very carbohydrate content has

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been reported by some authors (Meetali, *et al.* 2014, Blasques, *et al.* 2012). Carbohydrates are important sources of energy. The results of this study showed that the insects are not rich in carbohydrates hence, they may be used to form part of weight reducing diets for those wishing to loose weights. The carbohydrate content of *Z. variegatus* in this study was lower than the values obtained by some authors (Ghosh, *et al.* 2016, Sani, *et al.* 2014).

Ash content is an indication of the quantity of the minerals present in the insect. The larva stage of *R. phoenicis* contains the highest amount of ash than any other insect species investigated in this research. The insect has the highest value of each of the mineral investigated. This insect was closely followed by *C. forda* which ranked as the second best in mineral contents in this study. *P. americana* was the third best in mineral composition while *Z. variegatus* had the least quantity of minerals. *P. americana* came last in only two minerals (Iron and Manganese).

The mineral contents of *R. phoenicis* and *C. forda* are higher than those of *Z. variegatus* and *P. americana.* These are larval stages and it is at this stage that insects eat so much to derive all the nutrients they would require for their growth and development to the adult stage. The larval stage is usually the most destructive stage in the life of most insects because at this stage they eat so much in preparation for both the pupal and adult stages. While Copper was not detected in any of the insects used in this study, Iron was present at higher contents in all the insects. The iron contents of all the insects in this study are higher than the values obtained in some insects (Sani, *et al.* 2014, Adepoju and Daboh, 2013) but lower than the values in other insects (Omotoso, 2015, Ifie and Emeruwa, 2011). The content of Iron in each of the insects shows that each of them can be employed in correcting anemia in animals by incorporating them in the food/diets of animals. All the insects in this study are good sources of minerals such as phosphorus, calcium, potassium and sodium which are essential for the normal development and growth of organisms. Lactose intolerant people can rely on any of the insects in this study as a source of calcium for their normal development. It has been established that insects are alternative sources of calcium to man since enough milk which, is a good source of milk is not been consumed (Adamkova, *et al.* 2014).

The anti-nutrient contents of all the studied insects were negligible and they will not pose any threat to the health of animals. The oxalate and tannin contents of all the insects in this study were far lower than the values obtained by Sani *et al.* (2014) in grasshoppers but compared favourably with the values obtained by Ghosh *et al* (2016) in the same insect. Ant-nutrients form part of the defensive mechanisms of plants and thus are part of food of animals, especially those that feed on plants and plant products. Processing methods such as heating, soaking, sprouting and cookinh have been observed to impact on the anti-nutritional factors of plants (Soetan and Oyewole, 2009). Foods with lower anti-nutrient contents are good for the well-being of the people (Parul, 2014). Anti-nutrients have been observed to have positive effects on the health of animals through the contribution of dietary fibres (Palmer, 2011). Fibre is known to play important role in effecting movement of the bowels and in preventing cancer, cardiovascular diseases, diabetes and many other chronic human diseases (Yang, *et al.* 2017, Rao, *et al.* 2015).

CONCLUSION

Insects play major roles in food security, health, and environmental management. Edible insects are rich in protein, fat, fibre, ash, carbohydrates, vitamins and minerals. The insects

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used in this study are good sources of proteins, fats, fibre, minerals and they contained tolerant levels of anti-nutrients. Consumption of these insects are hereby recommended, to curb malnutrition in economically insolvent people.

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