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The Red Palm Weevil, *Rhynchophorus ferrugineus* Olivier, As Edible Insects for Food and Feed a Case Study in Egypt.

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ABSTRACT

Edible insects, a traditional food all over the world, are highly nutritious with high fat, protein and mineral contents depending on the species and thus represent a noteworthy alternative food and feed source and a potential substitute e. g. for fishmeal in feed formulae. Research is required to develop and automatize cost effective, energy efficient and microbially safe rearing, harvest and post harvest processing technologies as well as sanitation procedures to ensure food and feed safety and produce safe insect products at a reasonable price on an industrial scale especially in comparison to meat products. In addition, consumer acceptance needs to be established. Insects are important as items of aesthetic values, pests and as food. *R. ferrugineus* is an economically important insect. It is an edible insect that is eaten in the tropics. Both the larval and the pupal stages of *R. ferrugineus* were analyzed for their nutrient composition, protein solubility, mineral, functional and anti-nutritional factors. The pupal stage had higher protein content (32.27%) than the larval stage which had 30.46%. The fat content of the larva was 22.24% while that of the pupa was 19.48%. The ash content was higher in the larva (7.64%) than that in the pupal stage (6.34%). The results of the mineral analyses showed that mineral salts are persistently higher in the larval stage. The functional analyses revealed that the larval stage is highly desirable for chopped meat or powdered food production than the pupal stage. The insect larvae could serve as an alternative source of protein and other nutrients supplement in human and animal diet.

Keywords: Entomophagy, *Rhynchophorus ferrugineus,* mineral and amino acids.

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INTRODUCTION

Insects form part of the human diet in many tropical countries [1, 2]. A number of review articles on entomophagy have subsequently appeared, either focusing on a particular part of the world, such as Africa [3], Australia [4], Latin America [5], and Southeast Asia [6] or discussing a certain topic, such as biodiversity [7] or nutrition [8]. Efforts are being made to list all species of arthropods eaten worldwide, and the number now stands at approximately1, 900 Sp. (http://www.ent.wur.nl/UK/Edible+insects/Worldwide+species+List/).

The increase in world prices for the most important agricultural crops will lead to an increase in prices for beef, pork, and poultry of more than 30% by 2050 compared with 2000 [9]. The same study indicates that the situation may be aggravated by climate change, causing prices to increase by an additional 18-21%. The increase in food and feed prices in the future will prompt the search for alternative protein sources, e.g., cultured meat [10], seaweed [11], vegetables and fungi [12], and mini-livestock [13].

Insects can be used as a replacement for fish meal and fish oil in animal diets. Global industrial feed production in 2011 was estimated at 870 million tons, worth approximately US$350 billion (http://www.ifif.org). Meal and oil from both fish and soybean are used for compound aquafeed and animal feed. Fish meal and fish oil were derived from 20.8 million tons (19%) of the global fish production of 145 million tons in 2008 [13]. With world prices of feed ingredients increasing, the industry is looking for alternative protein sources. There is much interest in possible replacements for these expensive ingredients [14]. The most promising insect species for industrial production are Black Solider Fly, the common house fly, the yellow mealworm, the lesser mealworm, silkworm (*Bombyx mori*) and several grasshopper species [15]. Black Solider Fly larvae convert manure to body mass containing 42% protein and 35% fat [16], which makes them a suitable source of feed for both livestock [17].

This is the first case study in Egypt used the red palm weevil *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae) as edible insect for food and feed. This study intends to give a descriptive analysis of the nutritional profile of red palm weevil larva and pupa, with the aim of reporting the chemical composition of the larva and pupa assessing its nutritional properties. These insects are collected from the trunks of palm date trees and prepared by frying in a pot or frying pan.

MATERIALS AND METHODS

Sample preparation

Larvae and pupae of Red Palm Weevil *R. ferrugineus* weighing a combined total of 340g were collected from Ismailia Governorate, 115 Km from Cairo, Egypt. They were washed and put in a vacuum desiccator for 12 hours. Fig. (1).

Figure (1): Larvae and pupae of Red Palm Weevil *R. ferrugineus* samples preparation to analysis.

Sample analysis

Lipid extraction was carried out with chloroform/methanol solvent (2:1 v/v), and the defatted sample was analyzed for total protein and ash content according to the method of AOAC [18].

The energy content of larvae were determined with a bomb calorimeter using benzoic acid as standard (AOAC).

Levels of sodium, potassium, magnesium, calcium, iron, manganese, and zinc were determined using a PerkinElmer Model 290 Atomic Absorption Spectrophotometer (PerkinElmer, www.perkinelmer.com) using standard methods (AOAC. Phosphorus content was determined by the molybdovanadate solution method (AOAC).

Qualitative analysis of larval amino acid content was carried out by hydrolyzing the sample with 6N HCl (AOAC). Amino acids were separated in the hydrolysate with a TechniCon analyzer (TechniCon, www.technicon.com). Tryptophan content was determined by hydrolysing 100mg of the sample with 10mL of 4.2N NaOH at 110°C for 20hours; analysis was done with the TechniCon analyzer (TechniCon). Physical constant determinations of the crude oil extract, iodine number, saponification value, and peroxide value were carried out using the methods described by Pearson [19]. Fatty acid analysis was carried out by acid catalysed trans-methylation of the lipid extract [20]. The fatty methyl esters were analysed on a Pye Unicam series 204 Gas Chromatograph (Philips, www.philips.com) with a flame ionization detector and a stainless steel column (152.4 cm and 3.17 mm id), packed with 20% diethylene glycol succinate on 80-100 mesh chromos orb for support. Column temperature was 180°C, injection port and FID were at 210°C, and nitrogen flow rate was set at 40 mL/min.

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 AND DISCUSSION

Over 1900 species of edible insects have been recorded in the diets of 300 ethnic groups from 113 countries. Many species of insects have served as traditional foods among indigenous peoples, and have played an important role in the history of human nutrition [21]. Insects have been reported to have more nutritional content than other conventional foods [22]. This paper reports the nutritional properties of red palm weevil *R. ferrugineus* larvae.

The result of the nutrient analysis revealed that the ash content in the larval stage was 7.64% while it was 6.34% in the pupal stage. Protein was 30.46% and 32.27% were obtained in the larval and pupal stages, respectively (Table 1). The moisture content ranged between 5.65% (in the larva) and 4.22% (in the pupa). Carbohydrate forms the main source of food found in the red palm weevil.

Table (1): The Results of analysis of the red palm weevil *R. ferrugineus* larvae and pupal g/100g of wet product.

Treatment	larvae	pupal
Moisture	5.65±0.7	4.22±0.3
Fat content	22.24±0.8	19.48±0.7
Crude fibre content	5.30±2.4	3.84±2.4
Crude protein content	30.46±1.0	32.27±1.3
Ash content	7.64±0.2	6.34±0.5
Carbohydrates	38.5±0.6	31.4±0.1
Energetic density (kcal/100 g of wet product)	261.6	237.6

Each value is a mean ± Standard deviation of three replicates (Tukey Test)

Ekpo and Onigbinde [23] reported a value of 66.61% for *R. phoenicis*. Insects vary widely in fat content. Isoptera (termites) and Lepidoptera (caterpillars) rank among the highest in fat. The fat content recorded implies that defatting would improve the concentration of other nutrients. The relatively high protein content (38.50%) dry weight observed is an indication that this insect can be of value in man and animal diet, particularly in developing countries where the cost of convectional protein sources are expensive. Furthermore, the protein content in the larva is able to significantly contribute to the daily protein requirements of humans, which is about 23-56g [24, 25].

The data in Table (2) show that the mineral analysis of the larvae of red palm weevil have minerals such as manganese, magnesium, calcium, phosphorus, iron, zinc, sodium, potassium. The high content of iron and zinc in many edible insects is of particular interest. Moreover, Morah [26] reported that *Rhynchophorus phoenicis* larva is a delicacy in southern Nigeria. The mineral composition was as follows; Ca (45.6), Zn (3.57), Fe (5.40), Mg (20.1), K (512), Na (346) and P (519) mg/100 g. In general, insect's protein tends to be low in the amino acid, methionine/cysteine but it is high in lysine and threonine, one or both of which may be deficient in the wheat, rice, cassava and maize based diets that are prevalent in the developing world [22].

Table (2): Minerals composition (mg/kg) of larvae stage of the red palm weevil *R. Ferrugineus*

Minerals	Mg/100kg
Sodium (Na)	460.0
Potassium (K)	45.0
Calcium (Ca)	22.0
Magnesium (Mg)	210.0
Iron (Fe)	99.0
Manganese (Ma)	4.0
Phosphor (P)	43.o
Zinc (Zn)	11.0
Cooper (Cu)	ND

Iron deficiency is a major problem in women's diets in the developing world, particularly among pregnant women, and especially in Africa [27]. Vegetarians everywhere are at risk of zinc deficiency. Magnesium is needed for more than 300 biochemical reactions in the body. It helps maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune blood and regulates blood sugar levels [28]. Though these food elements are in the larva, the insect could be consumed along with other food and animals rich in other essential minerals to further complement the diet of this larva. The levels of minerals present in the samples indicate that they will be good sources of minerals for young, pregnant and lactating mothers. Daily requirements of essential minerals can be derived from the consumption of these weevils. Minerals are very essential for the normal development and functioning of the body systems of organisms.

In (Table 3) the amino acid profile of the larva of red palm weevil *R. ferrugineus* is shown. The nutritional value of food largely depends on the quality of the protein it contains. This in turn, is determined to a great extent, by the amino acid composition. The results presented suggest that the larva is rich in essential amino acids, leucine, phenylalanine, and methionine and may well meet the minimum daily requirements[29]. This is particularly important as there is a need for novel protein sources owning to the increasing cost of convectional sources of protein in the third world. In addition, the cereal based diets common in developing countries could receive a boost with the inclusion of the larva in their diet.

Table (3): amino acids profiles of larvae of the red palm weevil *R. Ferrugineus*

Amino acids	g/100g protein
Alanine	2.50
Lysine	3.20
Arginine	4.22
Tryptophan	2.52
Tyrosine	2.63
Isoleucine	3.45
Valine	2.91
Histidine	3.16
Aspartic acid	8.81

Serine	4.22
Threonine	3.41
Proline	2.19
Glutamic acid	14.04
Cysteine	2.74
Phenyalanine	5.28
Glycine	2.76
Methoinine	2.84
Leucine	7.65

The results of the present study show that the red palm weevil, *R. ferrugineus* is an essential source of different food components and nutrients. The knowledge of the protein solubility and the mineral content of this organism make it an important food item which needs industrial application. The developmental stages of this weevil could be used in the preparation of animal feeds (e.g. poultry, goat and fish) and other feed formulations.

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