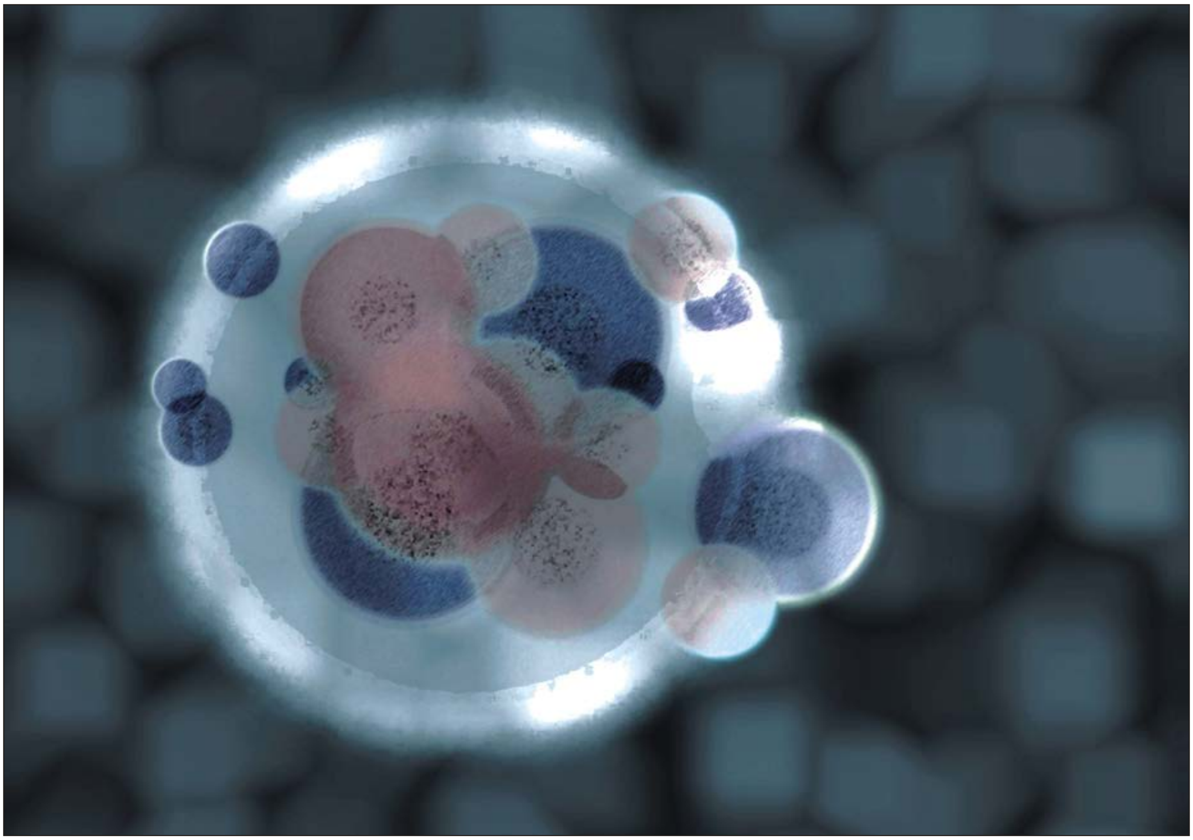

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Rhynchophorus phoenicis (F) Larva Meal: Nutritional Value and Health Implications

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Abstract: Proximate and chemical analysis was carried out on the larva, larval protein and oil, of *Rhynchophorus phoenicis* (F.). The chemical score of the protein was evaluated. A high total carbohydrate (35.58% wet weight) and protein (31.61% wet weight) content was observed. The protein was rich in the essential amino acids (with histidine, methionine and phenylalanine being very high) and has a protein score of 72.97% with valine as the limiting amino acid. The oil had a high proportion (60.91%) of unsaturated fatty acids, part of which were the essential fatty acids, linoleic acid and linolenic acid. The mineral analysis revealed a very high sodium (20.29 mg/100 g) content with moderate levels of iron, copper and manganese (4.50 mg/100 g, 2.61 mg/100 g and 2.31 mg/100 g, respectively), very low potassium (0.15 mg/100 g) and low calcium/potassium ratio (0.10).

Key words: *Rhynchophorus phoenicis* (F) larva, nutritional value, larval oil

INTRODUCTION

The larva of the beetle *Rhynchophorus phoenicis* (F.) is cherished as food among the many communities in Nigeria and around the world, especially in those places where palms (oil, raphia and coconut) are cultivated on commercial basis (DeFoliart, 1992; Allotey and Mpuchane, 2003; Choon-Fah *et al*., 2008). In the Niger Delta area and Eastern States of Nigeria, this larva is often a cherished delicacy. In fact, it can be seen hawked along major roads and markets in Edo and Delta States of Nigeria (Ekrakene and Igeleke, 2007). From Sapele where it is called edible worm or maggot to Warri where they call it diet, down to Bayelsa, Rivers, Cross Rivers, Akwa Ibom and all the Eastern states of Nigeria, it is widely consumed either raw, boiled, fried, smoked and sometimes used in the preparation of stews and soups, as part of a meal or as a complete meal. Among the various ethnic nationalities in Nigeria, the Binis (Edo) call it orhu, the Esans (Edo), okhin, the Ibibios (Akwa Ibom), nten, the Ibos (South Eastern Nigeria), eruru or akwangwo or nza, the Idomas (Benue), eko-ali, the Isoko (Delta), odo, the Itsekiris (Delta), ikolo, the Urhobos (Delta), edon, the Yorubas (South Western Nigeria), awon or ekuku. In Ogoni land, it is used to treat cough in children.

Due to the high level of consumption of this larva in these aforementioned areas, it has become pertinent to evaluate the nutritional component of the larva as well as proffer advice on the health implications of their consumption.

MATERIALS AND METHODS

Live larvae of *Rhynchophorus phoenicis* (F.) were collected with the help of local palm wine tapers, from raphia palms in Oyigbo town in Rivers State, Nigeria. They were transported to the laboratory together with their wet/moist feed of raphia palm pit in a well ventilated container and were used within 24 h of collection.

Proximate analysis of the samples was carried out in triplicate, according to standard methods (AOAC, 1984) in order to determine the moisture, crude protein, ash, crude fat and total carbohydrate, respectively. The energy value was calculated using the Atwater factors 4, 9 and 4 for protein, fat and carbohydrate, respectively (FAO/WHO/UNU, 1991; Chaney, 2006a). The mineral composition was determined as described by AOAC (1984). The method described by Aremu *et al*. (2007) was modified for the preparation of protein concentrate. Sample powder was defatted by the Soxhlet method using petroleum ether (60-80±°C). Six hundred grams of the defatted flour was suspended in distilled water at room temperature (29±1°C) and at a powder-solvent ratio of 1:10. The slurry was stirred for 1 h. After adjusting the pH of the slurry, the extraction was then allowed to continue with occasional shaking for 12 h while maintaining the pH. The slurry was then centrifuged at 8000 rpm for 30 min. The extraction was repeated on the residue and supernatant was precipitated by drop-wise addition of 0.1 M HCl. The precipitate formed in each case was centrifuged at 8000 rpm for

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30 min. The curd obtained was reslurried in distilled water and spray dried. The spray dried sample was used as protein concentrate. Samples were hydrolyzed in consistent boiling hydrochloric acid for 22 h under nitrogen flush. The amino acid profile of the protein concentrate was determined using a Technicon Sequential Mutlisample Amino Acid Analyzer. Then the chemical score of the protein was determined by comparison with WHO reference protein pattern (FAO/WHO/UNU, 1991). Oil was extracted from the larva, according to the method described by Aremu *et al.* (2007). Oven dried sample was extracted in Soxhlet apparatus with chloroform-methanol mixture (2:1) for 20 h under nitrogen atmosphere. Solvent was removed under reduced pressure in a rotary evaporator. Toluene was added to ensure removal of any water through azeotropic distillation with toluene. The fatty acid profile of the oil was determined by gas liquid chromatography, using a Pye Unicam Series 104GCD equipped with flame ionization detector and connected to a Hitachi model 056 recorder (Hitachi Ltd., Tokyo, Japan), at PZ Nigeria limited, Aba, Nigeria.

Statistical analysis: Data obtained were presented as Mean±SD (where possible) and analyzed by simple percentages.

RESULTS AND DISCUSSION

Table 1 shows the proximate profile of *Rhynchophorus phoenicis* larva. The moisture content observed in this study is less than the reported values for termite, cow milk, egg, beef, chicken, pork and fish but higher than that of caterpillar (Matthews and Garrison, 1975; FAO, 1981; Singh, 2004). The moisture content of food is an index of water activity (Olutiola *et al.*, 1991) and is used as a measure of stability and susceptibility to microbial contamination (Uraih and Izuagbe, 1990). So, the shelf-life of *Rhynchophorus phoenicis* larval meal can be improved by processes such as sun-drying, frying or roasting, which brings about dehydration and have earlier been reported to extend the keeping quality of pork meals. The observed crude fat content is higher than the reported values for caterpillar, egg, but is less than that of termite and cow milk (FAO, 1981; Singh, 2004). One implication of this high fat content is that the undefatted larva will be prone to deterioration via lipid peroxidation (http://www.cyberlipid.org/preox/oxid0002.htm), which may be accompanied by increased browning reactions leading to reduced lysine availability. No wonder, Osabor *et al.* (2008) wrote: the knowledge of the fat content of any food item helps to ascertain the shelf-life of the food. The high fat content also implies that the

Table 1: Proximate composition of *Rhynchophorus phoenicis* larva

	Composition		
Parameters	Wet weight	Dry weight	Lean weight
Moisture (%)	11.30±0.77	-	-
Crude fat (%)	17.33±1.24	19.54±1.40	-
Ash (%)	4.18±0.45	4.71±0.51	5.86±0.71
Crude protein (%)	31.61±0.59	35.64±0.67	44.29±0.83
Total carbohydrate (%)	35.58±0.90	40.11±1.01	49.85±1.26
Total metabolizable energy (kcal/100 g)	424.73	478.84	376.56

Values are Means±SD of triplicate determinations

Table 2: Mineral profile of *Rhynchophorus phoenicis* larva

Mineral	Composition (mg/100 g)
Calcium	0.01
Magnesium	0.04
Potassium	0.15
Sodium	20.29
Manganese	2.31
Iron	4.50
Copper	2.61
Phosphorus	0.10

Values are Means±SD of duplicate determinations

relative proportion of the other nutrients can be improved by defatting and dehydrating the larva (Table 1). The ash content of the larva is relatively higher than the reported values for egg, meat, chicken (Matthews and Garrison, 1975; Singh, 2004). The crude protein content observed here, for the larva, is higher than those reported for cow milk, egg, termite and beef but lower than those of caterpillar and locust (FAO, 1981; Singh, 2004). This high protein content implies that *Rhynchophorus phoenicis* larva meal can contribute significantly to the daily human protein requirements, usually about 23-56 g (FAO/WHO/UNU, 1991; Chaney, 2006a). The total carbohydrate content obtained here is higher than the reported values for caterpillar, termite, cow milk and egg (FAO, 1981; Singh, 2004).

This result indicates that the larva is a poor source of calcium, magnesium, potassium and phosphorus, but rich in sodium, manganese, iron and copper. Thus, diets based on it must be fortified with foods rich in these deficient minerals (Table 2). The low calcium to phosphorus ratio (0.100) portend danger to consumers of the meal, since diets rich in phosphorus but low in calcium, are associated with osteoporosis (Crook, 2006). The copper content of the larva can supply the recommended minimum daily allowance, which is 0.9-1.91 mg (McGilvery and Goldstein, 1983). Copper is a cofactor for ceruloplasmin, cytochrome c oxidase, dopamine β-hydroxylase, lysyl oxidase, superoxide dismutase and C_{18}, Δ^9-desaturase, while manganese is a component of arginase and pyruvate carboxylase (Chaney, 2006b). The larva can also supplement the daily iron requirement. Iron is a component of hemoglobin, myoglobin, cytochromes, myeloperoxidases etc. (Chaney, 2006b). The sodium content of the larva is very high. The implication of this is that diets containing it may not be safe for people genetically predisposed to, or having essential hypertension. High dietary intake of sodium significantly raises blood pressure and in addition, aggravates the pathological effects of raised blood pressure (Komiya *et al*., 1997; De Wardener and MacGregor, 2002; O'Shaughnessy and Karet, 2004; Blaustein *et al*., 2006; Bulent and Mustafa, 2006). Apart from these, dietary salt has also been implicated in the induction of many other harmful effects that are not blood pressure dependent (De Wardener and MacGregor, 2002). High salt intake:

- Increases left ventricular mass, thickens and narrows resistance arteries, including the coronary and renal arteries (De Wardener and MacGregor, 2002)
- Increases the prevalence of strokes, the severity of cardiac failure and the tendency of platelet aggregation (De Wardener and MacGregor, 2002)
- In renal disease, accelerates the rate of renal functional deterioration (Bakris and Smith, 1996; Komiya *et al*., 1997; De Wardener and MacGregor, 2002)
- Increases the severity of asthma and bronchial reactivity in male asthmatic patients (Carey *et al*., 1993; De Wardener and MacGregor, 2002)
- In both humans and experimental animals is known to cause gastritis and when co-administered with known gastric carcinogens promote their carcinogenic effect (De Wardener and MacGregor, 2002)
- Leads to a raised urinary calcium which in the long term may lead to bone resorption. This increased calcium loss, in post-menopausal women, is responsible for the reduction in femoral and pelvic bone densities (De Wardener and MacGregor, 2002)

In this study, very low potassium content was observed. This implies that without potassium supplementation, individuals consuming this meal run the risk of low dietary potassium intake. Low dietary potassium has been associated with the pathogenesis of essential hypertension (Morris *et al*., 1999; Coruzzi *et al*., 2001; Adrogué and Madias, 2007):

- Increases systolic blood pressure both in subjects with essential hypertension (Morris *et al*., 1999; Coruzzi *et al*., 2001) and in normotensive subjects (Morris *et al*., 1999; Adrogué and Madias, 2007)

Table 3: Amino acid profile of *Rhynchophorus phoenicis* larva's protein

Amino acid	Composition (g/100 g) protein
Lysine*	4.49
Histidine*	3.88
Arginine	7.92
Aspartate	8.17
Threonine*	3.05
Serine	3.90
Glutamate	15.45
Praline	5.00
Glycine	4.72
Alanine	5.25
Cysteine	2.02
Valine*	3.51
Methionine*	1.97
Isoleucine*	3.91
Leucine*	5.42
Tyrosine	2.89
Phenylalanine	4.75

*Essential amino acids

Table 4: Comparison of *Rhynchophorus phoenicis* larva protein with WHO reference protein pattern (WHO, 1981; McGilvery and Goldstein, 1983)

Amino acid	Reference pattern (g/100 g) protein	Chemical score (%)
Lysine	5.17	86.85
Histidine	1.77	219.21
Threonine	3.47	87.90
Valine	4.81	72.97
Methionine	1.53	128.76
Isoleucine	4.19	93.32
Leucine	7.03	77.10
Phenylalanine	3.01	157.81

- Provokes sodium retention-by lowering renal sodium excretion - in both normal and hypertensive subjects (Adrogué and Madias, 2007). This way, it modulates the pressor effects of dietary sodium (Coruzzi *et al*., 2001). Herein, lays the danger of consuming *Rhynchophorus phoenicis* larva meal, without appropriate potassium supplementation, or processing to reduce sodium content

The amino acid profile and chemical scores of *Rhynchophorus phoenicis* larva are shown in Table 3, 4, respectively. It is rich in the essential amino acids (especially histidine, methionine and phenylalanine) and can meet the minimum daily requirements (McGilvery and Goldstein, 1983; FAO/WHO/UNU, 1991) for the essential amino acids, except valine. Relative to WHO reference protein pattern (McGilvery and Goldstein, 1983; FAO/WHO/UNU, 1991), its limiting amino acid is valine and its protein score is 72.97%. This score is higher than the reported value for caterpillar, comparable to that of soy bean and lower than those of human milk, egg, cow milk and beef (FAO, 1981; McGilvery and Goldstein, 1983). The fatty acid profile of *Rhynchophorus phoenicis* larval oil is given in Table 5. The proportion of unsaturated fatty acids in the oil (Table 6) is higher than the reported values for lard, cocoa butter, palm oil and coconut oil, but less

Table 5: Fatty acid profile of *Rhynchophorus phoenicis* larval oil

Fatty acid	Composition (%)
Palmitic acid	38.16
Stearic acid	0.93
Myristoleic acid	2.93
Palmitoleic acid	8.40
Oleic acid	43.69
Linoleic acid*	4.58
Linolenic acid*	1.31

Values are Means±SD of duplicate determinations. *Essential fatty acids

Table 6: Degree of saturation of *Rhynchophorus phoenicis* larva oil

Component	Composition (%)
Total saturated fatty acid	39.09
Total unsaturated fatty acid	60.91
Monounsaturated fatty acid	55.02

than those of castor oil, almond oil, olive oil, groundnut oil (Evans, 2005; Martirosyan *et al*., 2007). The high content of unsaturated fatty acids implies that:

- The oil is safe for consumption by individuals prone to dyslipidemia, diabetes mellitus and cardiovascular diseases. Decreased intake of saturated and increased intake of unsaturated fatty acids reduces the risk and severity of cardiovascular diseases and other diseases associated with dyslipidemia (Martirosyan *et al*., 2007). This is so because the intake of unsaturated fatty acids lowers serum cholesterol and triglyceride levels (Chaney, 2006a). And in this case, about 10% of the unsaturated fatty acids is made up of the essential fatty acids, linoleic and linolenic acids, which further enhances the advantage (Martirosyan *et al*., 2007)
- The oil has a high tendency to undergo spoilage. The possibility of becoming rancid, on keeping due to peroxidation, increases with increase in degree of unsaturation

In conclusion, the results of the present study show that *Rhynchophorus phoenicis* larva is a rich source of good quality protein, iron, manganese, copper and relatively rich and safe oil-since insect oils have low cholesterol contents (DeFoliart, 1992). However, we recommend that diets containing them be fortified with valine and mineral nutrients (especially potassium) such that the sodium and potassium is synchronized. We also recommend that the oils be protected from light and oxygen and stored at very low temperatures to avoid peroxidative changes.

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