American Journal of Innovative Research and Applied Sciences. ISSN 2429-5396 I www.american-jiras.com

ORIGINAL ARTICLE

BIOCHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF LARVAE OF *RHYNCHOPHORUS PHOENICIS* COLLECTED FROM ROT PALM TREES (*ELAEIS GUINEENSIS*) IN PALM GROVES IN TOGO

| Agbémébia Y. Akakpo [1*] | Larounga Tchaniley [2] | Elolo G. Osseyi [1] | and | Tchadjobo Tchacondo [1] |

[1.] Laboratoire des Sciences Biomédicales, Alimentaires et de Santé Environnementale [LaSBASE] | Ecole Supérieure des Techniques Biologiques et Alimentaires (ESTBA) | Université de Lomé | Togo, BP : 1515, Lomé-Togo |
[2.] Laboratoire de Recherche sur les Agroressources et la Santé Environnementale (LARASE) | Ecole Supérieure d'Agronomie (ESA) | Université de Lomé | Togo, BP : 1515, Lomé-Togo |

| Received August 31, 2020 | | Accepted August 12, 2020 | | Published September 20, 2020 | | ID Article | Agbémébia-Ref.1-ajira310820 |

ABSTRACT

Background: The larvae of *Rhynchophorus phoenicis* from palm trees (*Elaeis guineensis*) can be good food sources but remain little used because of lack of knowledge. **Objective**: This work involves nutritional assessment of the larvae of the palm trees and its consumption knowledge. **Methods**: Sectional study was conducted among people in Lomé. Data were collected using questionnaires. The proximate composition moisture, protein levels, fat content, carbohydrates content, ash and essential minerals contents were determined. **Results**: The analysis carried out focused on the dried and roasted larvae. Though the larvae of palm trees were known by 71.43% of people, they're less consumed due to the lack of nutritional knowledge. More than 80% of people consume larvae dried or roasted. The proximate composition of the larvae of the palm tree showed that they are rich in protein and fat. The effect of the cooking method was examined and the results obtained showed that, with the exception of proteins value 29.57 ± 0.49% for roasted larvae, the dried larvae contain more lipids (60.16 ± 1.73%), proteins (30.69 ± 0.70%), mineral matter such as calcium (13.94 ± 4.63%), magnesium (237.33 ± 6.61%) and iron (15.38 ± 1.00%). Statistical difference ($p > 0.05$) was noted between dried and roasted larvae samples for each parameter expects proteins content. **Conclusion**: The larvae of the palm trees contain not only proteins and fat, but also major minerals. The larvae could be transformed into different value-added products for human nutrition due to its nutritional properties. This larva may constitute a cheaper source of essential nutrients that is easily available and affordable to the natives within the localities where the larvae are found.
Keywords: *Palm trees, Rhynchophorus phoenicis, nutritional value, consumption, Togo.*

INTRODUCTION

In Africa, in spite of substantial efforts to increase foodstuffs, malnutrition persists and food insecurity remain a major problem of more housekeeping [1]. Although the causes of malnutrition are many and diverse, inadequate intake of foods and essential nutrients has been reported to be a major contributory factor to under-five malnutrition [2]. About 10.7% (815 million) of the world's population suffer from chronic undernourishment [3]. More than thousand millions of young people and children suffer from malnutrition in the world including 20 million of children of less than 5 years old that suffer chronic malnutrition [4, 5]. In Togo, a study reported 14.3% of malnutrition rates for children of less than 5 years old [5]. This prompts the need for more balanced and environmentally friendly methods for producing nutritious foods. The use of insects as food is among the many approaches that have been thought to provide a long-lasting solution to this foreseen future deficit in animal protein supply. The adequacy of a diet is determined by the amount of nutrients it contains and provides to meet the needs dictated by an individual's physiological state and genetic make-up.

Insects are traditional foods in most cultures in Africa, Asia and Latin America, playing an important role in the history of human nutrition [6]. They are an important resource for the native population who, like other indigenous groups, deploy much effort in their collection and utilisation as food. It is demonstrated that 100 g of insects contains proteins 3 to 4 time higher than the one of chicken and pig that could cover nutritional need in minerals and vitamins [4]. In tropical Africa, insects represent an appreciated food source, d for some population [7]. So, from the workshop at Douala (Cameroun) in 1992 on promotion of non-conventional food resources, it was recognised that the valorisation of insects and larvae represents the principal way to face proteins malnutrition [8]. Insects constitute quality food and feed, have high feed conversion ratios, and emit low level of greenhouse gases [9]. Some studies were performed to evaluate the nutritional value of insects and larvae [10, 11]. Most of the studies reported that the nutritional health can be improved by the consumption of novel source of food among which insects, mushroom, snails, and larvae [8, 12].

Rhynchophorus phoenicis Fabricius (*R. phoenicis*) is an edible worm known as « Snout beetles ». It has various names from different ethnic groups: Nsombé (Congo), Nten (Akwa Ibom) and Orhu (Edo) in Nigeria [13]. The species *phoenicis*, insect Coleoptera (*Curculionidae*), is one of the ten species of *Rhynchophorinae* [14]. The larvae of *R. phoenicis* are mainly found in palm trees (*Elaeis guineensis*). The female of this *Curculionidae* lays her egg in hole caused by human activities especially during the collection of palm sap. The larvae are harvested (are the insects farmed, if not rather use collected) from dead raffia palm and oil palm trees. From edible insects consumed, larvae of *R. phoenicis* are mainly sold in markets and restaurants [15]. A research work reported that the larvae of *R. phoenicis* are rich sources of essential nutrients [16]. The larvae of palm trees are mainly recommended for pregnant women due to its nutritional value [17]. In some regions, the larvae are roasted and eaten with cassava or macabo [18]. The use of the larvae in the formulation of bread, biscuits has been reported [19, 20].

Edible insects have played a nutritional role in the diet of people in many parts of the world [21]. They are currently being promoted as an inexpensive alternative source of protein in underdeveloped countries due to the rising cost of conventional animal protein and the foreseen future deficit in its supply. In some areas of Togo, the larvae of palm trees are available all year round in palm-growing communities and the consumption has grown into a traditional habit. The larvae have been well appreciated by people. So, for the question, "what is your interest in consuming larvae of palm trees?" the answers are not objective. However, it is necessary to investigate the nutritional value of the larvae of palm trees in order to make a scientific recommendation resource to encourage their consumption [10, 11]. Evaluation of the nutritive value of this larva becomes important as the insect larva could form a base for new food products of considerable nutritive value. This work was performed to investigate the nutritional value of larvae of *R. phoenicis* from the rot palm trees consumed in Togo.

1. MATERIALS AND METHODS

1.1. Area of study and site of samples collection

The biochemical composition was carried out in the laboratory of Food control and normalisation of Institut Togolais de Recherche Agronomique (ITRA) and in the laboratory of Food Sciences and Technology of Ecole Supérieure des Techniques Biologiques et Alimentaires (ESTBA), University of Lomé (Togo).

Live larvae were collected in two different palm groves in Notsè a site located in the Plateaux region of Togo. Palm groves were far from each other of 4 km. Notsè is located in region of Plateaux at 100 km from Lomé. The region of Plateaux precisely is at 6° 30′ and 8° 20′ latitude and 0° 52′ and 1° 38′ East longitude.

1.2. Data and samples collection

First of all, an investigation was performed to collect information concerning the importance of larvae of palm trees. Base on questionnaires, local names, cooking methods and consumption of larvae of palm trees were collected from the people in Lomé, capital of Togo. The information was collected from a total of 70 people in different sectors of Agoè, Agbalépédo, Djagblé, Gbossimé, Totsi and at University of Lomé.

Live larvae of *R. phoenicis* were collected from rot palm trees (*Elaeis guineensis*) which were used for the extraction of palm sap. The live larvae collected from the rot palm tree were assembled to one sample and dry in the oven at 65°C for 48 hours. The samples were divided in two parts. The first part was kept dry and the second part was roasted 15 minutes using hotplate at a temperature of 105°C. Each dry and roasted sample was ground and the flour was packaged in aluminium paper and stored at ambient temperature of the laboratory. The photography of larvae of *R. phoenicis* from palm trees is presented in Figure 1.

Figure 1: Photography of fresh larvae of *Rhynchophorus phoenicis* of palm trees

1.3. Determination of proximate composition

The moisture content was estimated by gravity method using 5 g of larvae sample which has been placed in the oven BINDER at 105°C for 4 hours according to NF T60-201 (1984). The ash content was determined by complete incineration of 5 g of samples in the oven mark VULCAN^{TM} 3-550 at 550°C during 6 hours as described by NF ISO 6884 (1986). The total protein content was carried out by Kjeldahl method using TECATOR KJELTEC System 1002 Tecator apparatus according to NF V18-100 (1977). The crude protein content was calculated by multiplying the percentage of total nitrogen by the conversion factor 6.25. The lipid content was determined based on the Soxhlet method according to NF V 03-904 (1973). Briefly, 5 g of each larva samples were putted into a Soxhlet extraction cartridge. The assembly was placed in the extractor (RAFATEC II, 1050 Extractor). The n-hexane was used as the solvent for the extraction for 6 hours. At the end of the extraction, the glasses containing the fat were removed and placed in an oven 105°C for 15 minutes. The carbohydrate content has been determined by the differential method according to [22]. According to the principle of this method, the sample is essentially made of water, minerals, proteins, fats and carbohydrates. The content of carbohydrates was determined by deduction according to the following expression:

$$\% \text{ Carbohydrates} = 100\% - (\% \text{ Water} + \% \text{ Ash} + \% \text{ Proteins} + \% \text{ Lipids}) \quad \textbf{(1)}$$

The theoretical energetic value was calculated using the Merrill and Watt coefficients as described by FAO [23], where 1 g of lipids correspond to 9 kcal, 1 g of proteins and carbohydrate each other correspond to 4 kcal. The calorific value per 100 g of the dried sample was obtained as follows:

$$\text{Calorific value (kcal/ 100g)} = (\% \text{ Lipids x } 9) + (\% \text{ Proteins x } 4) + (\% \text{ Carbohydrates x } 4) \quad \textbf{(2)}$$

1.4. Determination of mineral content

The determination of the content of magnesium (Mg), iron (Fe), calcium (Ca), zinc (Zn) and copper (Cu) were carried out by flame atomic absorption spectrometry (ASA), while cadmium (Cd) and lead (Pb) content were determined using electrothermic absorption spectrometry (ASA) mark VARIAN according to the method described in standard NF EN 14082 [24]. Phosphorus (P) content was determined using molecular absorption spectrometry according to NFT90-023 (1982). Each mineral in samples was quantified by using the standard solution of each mineral from which standard curve was plotted out. Briefly, 2 mL of oxygen water, 2 mL of concentrate nitric acid and 1.5 mL of concentrate sulphuric acid were added to the sample and kept at 80°C for 3 hours in bain-marie for mineralisation. Then, the solution obtained was filtered in glass phial of 50 mL and completed with distilled water. All determinations were carried out in duplicate.

2. Statistical analysis

Results were expressed as the mean ± Standard error. Means and standard deviations were calculated using Microsoft Excel 2013. Sphinx Plus²-V5 was used for investigation data collection and calculation of percentages. Significance threshold was set at $p < 5\%$.

3. RESULTS

3.1. Local names of larvae of palm tree in Togo

The results from the investigation on local name of larvae of palm trees according to ethnic group were presented in Table 1. It appears that the local names of larvae of palm trees are related to each ethnic group.

Table 1: Local names of larvae of palm trees used in Togo.

Ethnic groups	Local names
Ewé and Watchi	Asra, Asran, Dékpoményon, Gbamido, Tatran, Gbomi, Konokounou
Guin and Mina	Atran
Kabyé	Abilé, Kpatouluon, Alasa, Kpakpatona

3.2. Knowledge and frequency of consumption of the larvae of palm trees

The results on the knowledge and the frequency of consumption of larvae of palm trees were summarized in table 2. The results showed that 71.43% of the respondents know the larvae of *R. phoenicis* against 21.43% don't know it. Among 71.43% of people who know the larvae of palm trees, 41.43% have consumed it and 30% of people don't consume it. However, with 41.43% of consumers only 6.90% of people consume usually larvae against 37.93% of people who consume rarely the larvae of palm trees. Furthermore, larvae are mainly consumed roasted (58.62%), dried (20.69%), boiled (13.79%) and fresh without treatment (6.90%). Thus, nearly 80% of people used drying and roasting to cook larvae of palm trees.

Table 2: Knowledge and frequency consumption of larvae of palm trees.

	Responses		Number of people	Percentage (%)	Total
Knowledge	Yes	Once consume	29	41.43	50 (71.43%)
		Never consume	21	30	
	No answer		5	7.14	5 (7.17%)
	No	Once heard	5	7.14	15 (21.43%)
		Know people who consume	10	14.29	
Consumption	Usually consume		2	6.90	29 (100%)
	No answer		16	55.17	
	Consume rarely		11	37.93	
Cooking methods	Drying		6	20.69	29 (100%)
	Roasting		17	58.6	
	No treatment		2	6.90	
	Boiling		4	13.79	

3.3. Biochemical contents of larvae of *R. phoenicis*

Results obtained showed that the dried and roasted larvae of *R. phoenicis* contained low level of moisture .The lipid content were 6.29 ± 0.42% (roasted larvae) and 60.16 ± 1.73% for dry larvae. The proteins contents were respectively 30.69 ± 0.70% for dry larvae and 29.57 ± 0.49% for roasted larvae. No statistical difference was observed.

Table 3: Proximate composition (% of dry matter) of dried and roasted larvae of palm trees.

Parameters	Dried larvae	Roasted larvae
Moisture (%)	6.32 ± 2.15	7.33 ± 0.75
Dried matter (%)	93.67 ± 2.15	92.66 ± 0.75
Ash (%)	4.90 ± 0.80	1.24 ± 0.62
Proteins (%)	30.69 ± 0.70	29.57 ± 0.49
Lipids (%)	60.16 ± 1.73	6.29 ± 0.42
Carbohydrates (%)	6.01 ± 2.29	55.57 ± 0.15
Calorific value (kcal/ 100 g)	688.36 ± 21.93	397.17 ± 14.27

The values represent the mean ± standard error of two determinations

3.4. Minerals contents of larvae of *R. phoenicis*

The *Rhynchophorus phoenicis* larvae contained significant amount of important minerals (Table 4). The results showed that the magnesium levels was 237.33 mg/100g for dry larvae and 128.16 mg/100g for roasted larvae. The iron (15.38 ± 1.00 mg/100g) and calcium (13.94 ± 4.63 mg/100g) are well represented in dried larvae. The cadmium and lead content in dried and roasted larvae are 0.006 mg/100g of cadmium and 0.002 mg/100g of lead. There was no significant difference between samples ($p > 0.05$).

Table 4: Minerals contents of dried and roasted larvae of palm trees.

Parameters	Dried larvae	Roasted larvae
Magnesium (mg/100 g)	237.33 ± 6.61	128.16 ± 6.48
Iron (mg/100 g)	15.38 ± 1.00	9.21 ± 0.03
Calcium (mg/100 g)	13.94 ± 4.63	6.91 ± 0.74
Zinc (mg/100 g)	6.26 ± 0.06	3.98 ± 0.03
Copper (mg/100 g)	3.43 ± 0.07	3.24 ± 0.04
Phosphorus (mg/100 g)	1.03 ± 0.29	0.99 ± 0.29
Cadmium (mg/100 g)	0.006 ± 0.001	0.005 ± 0.001
Lead (mg/100 g)	0.002 ± 0.001	0.002 ± 0.001

The values represent the mean ± standard error of two determinations.

4. Discussion

In Togo, though the larvae of palm trees were known by 71.43% of people, they're less consumed due to the lack of nutritional knowledge and food practices. Among the consumers, more than 80% of the respondents consume larvae dried or roasted. Thus, the dry and roasted larvae were used for nutritional evaluation. The results of the proximate composition and mineral contents of larvae of palm trees showed that the moisture was 6.32% for dried larvae and 7.33% for roasted larvae. The ash content of *R. phoenicis* was 4.90% and 1.24% respectively for dry larvae and roasted larvae. The ash content is similar to the one previously reported by Ekpo and Onigbinde [13] and less than the 7.70% reported for roasted larvae [15] and 1.00 ± 0.19% reported for dried larvae [25]. This may thus suggest that the larva is rich in mineral content. The proteins contents of insects is between 45.6 to 79.6% of dry matter according to [7]. In this study, the content of proteins in dried larvae is 30.69 % and 29.57 % for roasted larvae. The high protein content of the larva highlight the potential of the larva as food to combating protein deficiency. Nevertheless, these values were higher than 22.06 % for dry larvae [13], 27.57 % for roasted larvae [15] and 24.43 ± 1.30% for the dried [25] previously reported. The larvae of *R. phoenicis* are a good source of digestive proteins which can cover food imbalances [26]. Malnutrition in developing countries is more a problem of caloric and protein deficiency [27]. They could be used to respond to proteins' needs which is between 23 to 56 g/kg [28]. Malaisse [7] reported a fat content of insects between 8.1 to 35.0% of dry matter. The fat content of the larvae of palm trees obtained is respectively 60.16 % for dry larvae and 6.29 % for roasted larvae. This result is higher than 15.36 ± 0.82% reported by Okunowo *et al.* [25]. These values were lower than the 66.61 % of dry matter reported by Ekpo and Onigbinde [13] and 62.15 % of dry matter for fresh larvae reported by Edijala *et al.* [15]. On the other hand, the fat content in this study was above 25.30% of fresh matter previously reported in the literature [10]. The larvae of *R. phoenicis* contained high proteins and fat and so are extremely energetic [27]. The carbohydrates contents obtained is 6.01% for dry larvae with 688.36

Kcal /100g of dry matter. This value is higher than 1.2% of dry matter reported by Nzikou *et al.* [26]. The variations in the nutritional composition of the larvae reported here and those previously reported for *R. phoenicis* may be due to the variations in the source, diet and age of the larvae analysed [21]. Because of their high protein content, consumption of the *R. phoenicis* larvae can be used as a human food supplement to balance diet [25]. The larvae is currently being promoted as an alternative source of protein and micro nutrient deficiency for preventing severe acute malnutrition (SAM) and possibly anemia [29, 30] and can be incorporated into biscuits for a nutritious snack for pregnant women [20].

Insects are known to be rich sources of various macro and trace elements. These elements are probably accumulated for future use in adult exoskeletal and connective tissue synthesis. Results of the mineral composition of *R. phoenicis* show that 100g sample of the insect will meet the RDA values for iron, zinc, copper, manganese and magnesium in most third world countries. Iron deficiency is a major problem in women diets, particularly among pregnant women, in the developing world [31]. So, the concentrations (dry weight bases) of the larvae of palm trees contained more minerals such as magnesium 237.33 mg/100g dry larvae and 128.16 mg/100g roasted larvae and iron 15.38 mg/100g for dry larvae and 9.21 mg/100g roasted larvae. These values are higher than 7.54 mg/100 g of magnesium and 12.24 mg/100 g of iron reported by Banjo *et al.* [10] and 6.25 ± 0.06 mg/kg of iron reported by Markmanuel *et al.* [32]. The calcium content is 13.94 mg/100g for dry larvae and 6.91 mg/100g for roasted larvae, and phosphorus content is 1.03 mg/100gfor dry larvae and 0.99 mg/100g for roasted larvae are less than 39.58 mg/100 g (calcium) and 126.4 mg/100 g (phosphorus) reported by Banjo *et al.* [10]. Copper content is 3.43 mg/100g dry larvae, 3.24 mg/100g roasted larvae and 3.98 mg/100g roasted larvae for zinc. This results are respectively higher than Cu (3.31 ± 0.04 mg/kg) Zn (5.36 ± 0.11 mg/kg) reported by Markmanuel *et al.* [32]. These results showed that the consumption of the larvae of palm trees could cover the minerals need for humans [17] which is for a man of 70 kg, 1 to 3 mg of copper, 0.5 to 1.2 for calcium, 0.35 for magnesium and 0.010 to 0.020 for iron per day [33]. The lead and cadmium contents are respectively 0.006 mg/100g and 0.002 mg/100g. These values are less than 0.039 mg/100g of cadmium and 0.08 mg/100g of lead reported by Ekpo and Onigbinde [13]. The presence of these minerals could be explained the contaminations accumulated in the palm trees due to the area [34]. However, the cadmium and lead contents obtained are less than 0.1 to 0.5 mg/kg of lead in poultry meat and 2 mg/kg of cadmium in molluscs and cephalopods set by Codex standard 193 [34]. This larva may constitute a cheaper source of essential nutrients that is easily available and affordable to the natives within the localities where the larvae are found. The observed properties show that the larvae of palm trees are good food stuffs and can be used for human food [16].

5. CONCLUSION

This work has been undertaken to evaluate knowledge on the cooking methods, the frequency of consumption and the nutritional value of the larvae of *R. phoenicis* through a survey and the determination of the proximate biochemical composition. Although, the larvae of the palm tree are known, they are less consumed due to the lack of nutritional knowledge. The most wide spread cooking methods for consumption remains drying and roasting. It arises from the physicochemical analyses that the contents of proteins, lipids and minerals of the larvae of the palm tree are rather interesting. The high percentages of proteins, lipids and major minerals such as iron, calcium and magnesium show that the larvae can be used to compensate food imbalances in some essential nutrients.

Acknowledgment: This work was carried out with the collaboration of all authors. Authors read and approved the final manuscript and would like to thank this collaboration.

Conflict of interest: Authors declare that no competing interests exist.

6. REFERENCES

1. Ekoué S. et Kuevi-Akue K. Enquête sur la consommation, la répartition et l'élevage des escargots géants au Togo. *Tropicultura*. 2002; 20(1):17-22. *www.tropicultura.org*
2. Sarika C., Joanna R. and Bhushan P. Addressing child under nutrition: can traditional practices offer a solution?, *Global Health Action*. 2017; 10(1): 1327255. https://doi.org/10.1080/16549716.2017.1327255
3. FAO/IFAD/UNICEF/WFP/WHO. The state of food insecurity and nutrition in the world 2017. Building resilience for peace and food security. 2017, Rome: FAO.
4. Mignon J. (2002). L'entomophagie : une question de culture ? *Notes techniques*, *Tropicultura*. 2002; 20(3) : 151-155.
5. UNICEF, United Nations Children's Fund, the (Unicef). La situation des enfants dans le monde 2005 : l'enfant en peril. 2004, 160p. www.cosmovisions.com/biblio.htm
6. Adedire C.O. and Aiyesanmi A.F. Proximate and mineral composition of the adult and immature forms of the variegated grasshopper, *Zonocerus variegatus* (L) (*Acridoidea*: *Pygomorphidae*). *Bioscience Research Communications*/ 1999; 11(2): 121-126. https://link.springer.com/article/10.1631/jzus.2007.B0318
7. Malaisse F. Se nourrir en forêt claire africaine .Approche écologique et nutritionnelle. CTA - *Presses Agronomiques de Gembloux 2000*, 383p.
8. Mbétid-Bessane E. Commercialisation des chenilles comestibles en République Centrafricaine. *Tropicultura*. 2005; 23(1): 3-5.
9. Huis A., Van Itterbeeck J., Klunder H., Mertens E., Halloran A., Muir G. and Vantomme P. Edible insects: Future prospects for food and feed security. In: *Food and Agriculture Organization of the United Nations (FAO)*. *Forestry Paper. 2013;* 171: 67-79.
10. Banjo A.D., Lawal O.A. and Songonuga E.A. The nutritional value of fourteen species of edible insects in southwestern Nigeria. *African Journal of Biotechnolog*. 2006; 5(3): 298-301. http://www.academicjournals.org/AJB
11. Okaraonye C.C. and Ikewuchi J.C. *Rhynchophorus phoenicis* (F) Larva meal: nutritional value and health implications. *Journal of Biological Science*. 2008; 8(7): 1221-1225. http://dx.doi.org/10.3923/jbs.2008.1221.1225
12. Womeni H.M., Linder M., Tiencheu B., Mbiapo F.T., Villeneuve P., Fanni J. and Parmentier M. Oils of insects and larvae consumed in Africa: potential sources of polyunsaturated fatty acids. *OCL*. 2009*;* 16(4): 230-235. https://doi.org/10.1051/ocl.2009.0279

13. Ekpo K.E. and Onigbinde A.O. Nutritional Potentials of the larva of *Rhynchophorus phoenicis* (F). *Pakistan Journal of Nutrition.* 2005; 4(5): 287-290. http://dx.doi.org/10.3923/pjn.2005.287.290
14. Avand-Faghih A. (2004). Identification et Application Agronomique de Synergistes Végétaux de la Phéromone du Charançon *Rhynchophorus ferrugineus* (Olivier) 1790. Life Sciences [q-bio]. INAPG (AgroParisTech). Thèse de Docteur de l'INA-PG Mention : Biologie et Agronomie : protection des cultures, 182p. https://pastel.archives-ouvertes.fr/pastel-00000692
15. Edijala J.K., Egbogbo O. and Anigboro A.A. Proximate composition and cholesterol content of *Rhynchophorus phoenicis* and Oryctes larvae. *African Journal of Biotechnoly*. 2009; 8(10), 2346-2348. http://www.academicjournals.org/AJB
16. Omotoso O.T. and Adedire C.O. Nutrient composition, mineral content and the solubility of the proteins of palm weevil, *Rhynchophorus phoenicis* f. (Coleoptera: Curculionidae), *Journal of Zhejiang University SCIENCE B.* 2007; 8: 3-18. https://doi.org/10.1631/jzus.2007.B0318
17. Ekpo K.E. Biochemical investigation of the nutritional value and toxicological safety of entomophagy in Southern Nigeria. PhD Thesis, Ambrose Alli University, Ekpoma, Edo State, 2003.
18. Hardouin J. et Mahoux G. Zootechnie d'insectes-Elevage et utilisation au bénéfice de l'homme et de certains animaux. Bureau pour l'Echange et la Distribution de l'Information sur le Mini-élevage (BEDIM), 2003 ; 164p. http://www.bedim.org/insectes/start.htm
19. Ifie I. Nutritiona and Quality Attributes of Wheat Buns Enriched with the larvae of *Rhynchophorus phoenicis* F. *Pakistan Journal of Nutrition. 2010;* 9(11): 1043-1046. http://dx.doi.org/10.3923/pjn.2010.1043.1046
20. Ayensu J., Lutterodt H., Annan R.A., Edusei A. and Loh S.P. Nutritional composition and acceptability of biscuits fortified with palm weevil larvae (*Rhynchophorus phoenicis* Fabricius) and orange-fleshed sweet potato among pregnant women. *Food Sci Nutr*. 2019: 7: 1807-1815. https://doi.org/10.1002/fsn3.1024
21. Zielińska E., Baraniak B., Karaś M., Rybczyńska K. and Jakubczyk A. Selected species of edible insects as a source of nutrient composition. *Food Research Internationa*. 2015; 77: 460-466.
22. AOAC, (2000). Official Methods of Analysis. Horwitz (Ed.), AOAC Washinton D.C. Bragagnolo N. Comparative aspects of meats according to fatty acid profile and cholesterol level. Second International Virtual Conference on port Quality-via Internet, 2000.
23. FAO (1970). Food composition table for use in Africa. Italy, Rome, FAO, Doc. Nutr. 3: 218p.
24. AFNOR (2003). Food products - Determination of trace elements - Determination of lead, cadmium, zinc, copper, iron and chromium by atomic absorption spectrometry (ASA) after dry calcination. Afnor Saint Denis (FRA).
25. Okunowo W.O., Olagboye A.M., Afolabi L.O. and Oyedeji A.O. Nutritional value of *Rhynchophorus phoenicis* (F.) larvae, an edible insect in Nigeria. *African Entomology*. 2017; 25(1): 156-163. http://dx.doi.org/10.4001/003.025.0156
26. Nzikou J.M., Mbemba F., Mvoula-Tsiéri M., Diabangouaya-Batéla B., Malela K.E., Kimbonguila A., Ndangui C.B., Pambou-Tobi N. P., Silou Th. and Desobry S. Characterisation and Nutritional Potentials of *Rhynchophorus phoenicis* Larva Consumed in Congo-Brazzaville. *Current Research Journal of Biological Sciences.* 2010*;* 2(3): 189-194. https://maxwellsci.com/jp/abstract.php?jid=CRJBS&no=47&abs=08
27. DeFoliart G.R. Insects as human food. Some nutritional and economic aspects. *Crop Protection.* 1992; 11(5): 395-399. https://doi.org/10.1016/0261-2194(92)90020-6
28. FAO/OMS/ONU. Energy and Protein requirements: Report of a Joint FAO/WHO/UNU Expert consultation. WHO Technical Report Series 724, 1991. Http://www.fao.org/docrep/003/aa040e/AA040E01.htm
29. Parker M., Zobrist S., Mansen K., Soor S., Laar A., Asiedu C. and Lutterodt H. Nutrient analysis of farmed palm weevil larvae for the advancement of edible insects in Ghana. *The FASEB Journal*. 2017; 31(1 Supp): 639.636-639.636.
30. Okoli I.C., Olodi W.B., Ogbuewu I.P., Aladi N.O. and Okoli C.G. Nutrient Composition of African Palm Grub (*Rhynchophorus phoenicis*) Larvae Harvested from Raphia Palm Trunk in the Niger-delta Swamps of Nigeria. *Asian Journal of Biological Sciences.* 2019; 12: 284-290. DOI: 10.3923/ajbs.2019.284.290
31. UNACC-SN. United Nation Administrative Committee on Co-ordination - Subcommittee on Nutrition: Micronutrient Deficiency. The Global situation. SCN News. 1993; 9: 11-16.
32. Markmanuel D.P., Young E. and Godwin J. The effects of processing on heavy metals concentrations and health risk assessment in African palm weevil (*Rhynchophorus phoenicis*) larvae. *Toxicology and Applied Pharmacology Insights*. 2020; 3(1): 5.
33. Alais C., Linden G. et Miclo L. Biochimie alimentaire. 5e éd. Collection Sciences sup Dunod, Paris, 2003; 264p. https://www.eyrolles.com/Sciences/Livre/biochimie-alimentaire-9782100038275/
34. Codex standard 193. Norme générale codex pour les contaminants et les toxines présents dans les produits de consommation humaine et animale. 1995, 1-55.

Cite this article: Agbémébia Y. Akakpo, Larounga Tchaniley, Elolo G. Osseyi, and Tchadjobo Tchacondo. BIOCHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF LARVAE OF RHYNCHOPHORUS PHOENICIS COLLECTED FROM ROT PALM TREES (ELAEIS GUINEENSIS) IN PALM GROVES IN TOGO. *American Journal of Innovative Research and Applied Sciences. 2020; 11(3): 193-198.*