Thermal processing of palm weevil (*Rhynchophorus phoenicis*) larvae and effect on the minerals, vitamins and sensory attributes

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**Abstract**

Palm weevil (*Rhynchophorus phoenicis*) larvae serve as edible food sources in Nigeria. In this study, the effect of frying and roasting on the quality characteristics of the larvae was investigated. *Rhynchophorus phoenicis* larvae were processed by frying and roasting methods, and the products were analyzed for minerals, vitamins and sensory attributes. Frying was carried out for 2, 5 and 7 min, and roasting 5, 10 and 15 min. The physical properties of the processed larvae were also determined. The average weight (g) of the fresh larvae was 25.43 while a range of between 22.12 and 22.48 was obtained for the fried and roasted samples. Length ranged from 4.15 to 5.0, and width from 2.11 to 3.21. The fried samples had higher crude fibres and crude proteins than their roasted counterparts. A similar observation was noted for mineral contents, with the fried samples having higher values of calcium, sodium, potassium, magnesium, phosphorus, iron and zinc than the roasted samples. Values ranging from 133.66 and 162.15 µg/100g of vitamin A were obtained for the fried larvae samples, while vitamin C ranged from 7.62 and 9.61 mg/100g. The vitamins (A, C and E) were generally higher in the fried larvae samples than in roasted counterparts. Result of the sensory evaluation revealed that among the processed larvae samples, the sample fried for 2 min had highest scores of 6.55, 6.75, 6.80 and 6.70 in the attributes of appearance, aroma, texture, and overall acceptability; making it more acceptable to panelists than others. It was concluded that adoption of frying technique in the processing of *Rhynchophorus phoenicis* larvae had an advantage over roasting, as it enhanced the crude proteins and ash contents of the palm weevil larvae. Also, vitamins C and E was more abundant in the fried than roasted samples.

**Keywords:** *Rhynchophorus phoenicis* larvae, frying and roasting, physical properties, mineral contents, vitamins, sensory evaluation

**Introduction**

*Rhynchophorus phoenicis* is a common insect in many countries of Africa, especially Nigeria, which belongs to the family of Curculionidae. The larva of the insect is edible and can be consumed as food commonly served as in form of delicious meal after heat processing. As a result of the expensive cost of proteins of animal sources for human consumption, great efforts are being made on alternative sources especially from insects. Thus *R. phoénicis* could be of importance because its larvae have been identified as one of the good protein and lipid sources for human consumption. The larvae could be processed and eaten in countries where the insects are found, especially developing countries of Africa. This could also be of great importance in regions where consumption of animal proteins limited as a result of factors bordering on social-economic, cultural or religious reasons (Womeni *et al.*, 2012).

 Malnutrition has been a great concern in certain countries of low-income groups in many parts of the world. Hence other food sources, including edible insects, that has been under-utilised may be exploited in reducing such nutritional defects (Okunowo *et al.*, 2017). Such insects have been consumed by our for fathers in enhancing their nutritional intake as staple food or as a delicacy. The use of insects for human consumption or in the preparation of delicacies are common in Africa, Asia and Latin America (Van-Huis *et al*. 2013). There is however scarcity of data on the worldwide consumption of insects, while noting that more than 20000 species of insects have been identified which can serve as food or food ingredients. Rumpold and Schlüter (2013) reported the occurrence of different edible insects containing acceptable quantities of nutrients which may be of benefits to humans; such nutrients include protein, carbohydrate, fatty acids and minerals.

 Currently, there is discrimination among people in developing cou tries on types of edible in sects and their potential use as sources of foods, based on safety and nutritional concerns. However public awareness and campaigns on the nutritional potential of indigenous edible insects such as palm weevil (*Rhynchophorus phoenicis*) would be useful in convincing people as good protein alternatives to red meats and chicken eggs. Research intensifications and findings would afford progress in the production of *Rhynchophorus phoenicis* which ultimately may greatly enhance the economies of developing countries where these insects are found. Some types of edible insects include *Rhynchophorus phoenicis* and termites, which could be nutritious souces of proteins (Okoli *et al.*, 2019).

The present study was therefore carried out to determine the effect of processing, frying and roasting, on the minerals, vitamins and sensory attributes of palm weevil (*Rhynchophorus phoenicis*) larvae, with the aim of advising consumers of the best method of processing in order to optimize its inherent nutritional potential.

**Materials and methods**

Source of raw materials

The larvae of *R. phoenicis* were obtained from a Local Government Area (Idemiri North) of Anambra State, Nigeria (Figure 1). These were transported to the Food Microbiology laboratory, Department of Food Science and Technology, Michael Okpara University of Agriculture, Abia State, Nigeria. Processing of the larvae commenced immediately upon arrival. Other aspects of the processing took place in the central laboratory of National Root Crops Research Institute, Umudike, Abia State, Nigeria

Prior to processing, the *R. phoenicis* larvae were were sorted to remove the bad ones and extraneous materials, with the use of clean using water. The larvae were processed further inside boiling water for some minutes (1-2 min) to inactivate (kill) them. Draining of water was done and the larvae hung on bamboo barbecue skewers for heat treatment.

Thermal processing by Frying

The palm weevil larvae on skewers were subjected to frying using vegetable oil (Kings, Nigeria) in frying pans (90±2oC) for different time intervals (2, 5 and 7 min). Draining of the thermally processed palm weevil larvae was done and then allowed to cool. Samples were then taken for analyses.

Roasting of palm weevil (*Rhynchophorus phoenicis*) larvae

The palm weevil larvae on skewers were subjected to roasting over charcoal grill (95±2oC) at varying time intervals (5, 10 and 15 min). Intermittent turning of the larvae was observed to prevent burning or charring (Okaka, 2005). The roasted palm weevil larvae were then allowed cool (22oC) .

Physical properties of the palm weevil (*Rhynchophorus phoenicis*) larvae

Determination of the physical properties (weight, length and widths) of the fresh, fried and roasted palm weevil larvae was done. The weight was measured using analytical balance and calipers was used for measuring lengths and widths of the samples.

Determination of the proximate composition of the fresh, fried and roasted palm weevil (*Rhynchophorus phoenicis*) larvae

The proximate composition including moisture, ash, fat, and protein contents of the *ogiri* samples were determined using the methods of Association of Official Analytical Chemists (AOAC 2005). Carbohydrate was determined by difference.

Determination of the minerals

The methods of Saura-Calixto et al. (1983) and Bonire et al. (1990) were used for the determination of mineral contents in the gari samples. Digestion of the ash of the samples with perchloric acid and nitric acid of the samples was done for determination of potassium and sodium. The readings on Jenway digital flame photometer (spectronic20) was then taken. The vanado-molybdate colorimetric method was adopted in the determination of phosphorus. Calcium, magnesium, cupper, iron and zinc were determined spectrophotometrically by using Buck 200 atomic absorption spectrophotometer (Buck Scientific, Norwalk) and compared with absorption of standards of the minerals.

Determination of the vitamin contents

Vitamins A, C and E in the fresh, fried and roasted palm weevil larvae were determined according to the methods of AOAC (2005).

Sensory evaluation of the fried and roasted palm weevil (*Rhynchophorus phoenicis*) larvae

The fried and roasted palm weevil larvae samples were subjected to sensory evaluation for the attributes of appearance, aroma, taste, texture, crunchiness and overall acceptability. A semi trained twenty member panel was used and scores were allocated to the attributes based on a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The data collected were subjected to statistical analysis to determine possible differences among samples.

Statistical analysis

Data, which depended the different palm weevil larvae samples, were subjected to analysis using completely randomized design. Data were subjected to variance analyses and differences between means were evaluated by Duncan’s multiple range test using SPSS statistic programme, version 10.01 (SPSS 1999). The analysis was done in done in replicates. Significant differences were expressed at *p* < 0.05.

**Results and discussion**

In the present investigation, fresh palm weevil (*Rhynchophorus phoenicis*) larvae (Figure 1) were processed by frying and roasting (Figures 2 and 3). The physical characteristics of the fresh and processed larvae samples are presented in Table 1. The average weight (g) of the fresh larvae was 25.43 while a range of between 22.12 and 22.48 was obtained for the fried and roasted samples, with roasted samples having lower weights than their fried counterparts. Weights of both roasted and fried palm weevil larvae decreased with longer periods of roasting and frying. This was expected as heat treatments have would remove moisture from the larvae; the longer the treatment, the more moisture is removed. An average length of 5.13 cm was recorded for fresh larvae between 4.15 and 5.0; and 4.40 and 4.83 were observed for roasted and fried samples respectively. The fresh larvae of palm weevil also recorded the highest value of 3.50 cm. Lowest value of 2.11 and 3.03 were observed for larvae samples roasted for 15 minutes, and fried for 7 minutes respectively; while highest values of 2.74 and 3.03 were recorded for respective samples roasted for 5 minutes and fried for 2 minutes. The values lengths and widths obtained for the larvae samples are similar to those reported by Okoli *el al.* (2019), who obtained between 4.83 and 5.27 cm for lengths, and 2.11 and 3.5 cm for widths. The weights reported by the authors however differ from those obtained in the present study, possibly due to difference in varieties and species of the palm weevil (*Rhynchophorus phoenicis*) larvae used in the two studies. Frying and roasting for longer periods were observed to have proportional effect on the lengths and widths of the larvae samples.

Table 2 shows the results of the proximate composition (%) of the roasted and fried palm weevil larvae, along with that of fresh samples prior to processing. Moisture content was highest (34.04) in the fresh sample while lower values were recorded for roasted samples than their fried counterparts. Among the processed larvae samples, the lowest value, 24.02, was obtained for larvae sample roasted for 15 minutes, and the highest, 31.01, for sample fried for 2 minutes. Roasting as a method of processing was noted to have higher and significant effect (*p* < 0.05) on moisture in the larvae samples than frying processing technique, resulting in lower moisture contents in the roasted product than fried counterpart. Result of the crude proteins (%) showed that frying technique had a profound positive effect on the larvae samples, as higher values (25 and above) were recorded for fried samples than the roasted counterparts. The highest value of 25.11 was recorded for sample fried for 2 minutes while the lowest value of 23.01 was obtained for sample roasted for 15 minutes. Values of the crude proteins generally indicate that roasting and frying processes are of better advantage when carried out at minimal duration of time than longer periods, as losses were noticeable with longer periods of processing. Crude fat contents were higher in the fried larvae samples, and this could obviously be due to the use of vegetable oil during the frying process, which may have contributed to the increase in the fat contents. The range of values recorded in this study corresponds to the figure (25.01%) reported in a previous investigation by Womeni *et al.* (2012) on *Rhynchophorus phoenicis* larvae. In another similar report, Okunowo *et al.* (2017) recorded crude protein and crude fat contents of 24.43 and 33.25 respectively, and this further corroborates the values obtained in the present study.

 Ash contents of the *Rhynchophorus phoenicis* larvae were between 4.79 and 5.35, with the fresh sample recording the lowest value. The roasted larvae samples had a range of 5.09 and 5.23; the sample roasted for 5 minutes recorded the lowest value while the highest value was observed for sample roasted for 15 minutes. Furthermore, the fried samples had ash contents of between 5.10 and 5.35, with the sample fried for 2 minutes having the lowest value. The ash contents recorked in the present study compare favourably with those reported in previous investigations. Some of the other researchers who reported values similar to those obtained in this study include Okaraonye and Ikewuchi (2008), Elemo *et al.* (2011) and Ehounou *et al.* (2019). The carbohydrate contents of the larvae samples generally ranged between 10.45 and 17.39, the fresh sample having the highest value while the lowest was recorded for the sample fried for 7 minutes.

 Results of the mineral analysis (%) of the *Rhynchophorus phoenicis* larvae samples are presented in Table 3. Calcium content of 49.82 was recorded as the highest value for larvae sample fried for 7 minutes while 33.06 was the lowest value for that roasted for 15 minutes. Sodium ranged from the lowest value 50.73 (for the fresh sample) and 71.42 for sample fried for 15 minutes. A similar trend was observed for potassium, magnesium, iron and phosphorus, with the sample fried for 7 minutes having the highest values of 913.59, 44.21, 19.96 and 442.53 respectively. In a study reported by Ehounou *et al.* (2019), a value of 56.49 was obtained for sodium in processed *Rhynchophorus phoenicis* larvae, and this is similar to those recorded in the present study.

 Analysis of the vitamins in the *Rhynchophorus phoenicis* larvae samples (Table 4), revealed that vitamin A (µg/100g) ranged from 107.92 and 216.02, the highest value was recorded for the fresh sample and the lowest for the sample roasted for 15 minutes. Vitamin A was higher in samples fried for 2 and 5 minutes than others, with the exception of the fresh sample. The vitamin C (mg/100g) was highest in the fresh sample, having a value of 10.51. Higher values, which ranged between 7.62 and 9.61, were recorded for the fried samples than their roasted counterparts of 2.02 and 7.33. Value of 1.22 was obtained for the fresh sample as the highest vitamin E content (mg/100g) of the larvae samples, while the lowest value (0.74) was recorded for sample roasted for 15 minutes. Fried larvae samples recorded higher contents of vitamin E than other processed samples. In a similar study, Okunowo *et al.* (2017) also carried out vitamin analysis on *Rhynchophorus phoenicis* larvae, and comparison of the results with those obtained in the present study suggests slight variations, which may be due to possible difference in the species used in the studies.

 The mean scores obtained from the sensory evaluation of the roasted and fried palm weevil larvae are shown in Table 5. The sample fried for 2 minutes had the highest mean score of 6.55 in the sensory attribute of appearance, followed by sample roasted for 10 minutes with a mean score of 6.40 while sample roasted for 5 minutes recorded the lowest score. In the attribute of aroma, sample fried for 2 minutes also had the highest score, 6.75, while the lowest score was recorded for sample roasted for 10 minutes. However, sample roasted for 15 minutes recorded the highest value (6.65) in the attribute of taste, followed by the sample roasted for 5 minutes having a mean score of 6.60. Mean scores ranged from 5.30 and 6.80, with samples fried for 2 and 5 minutes having the highest and lowest scores respectively. The highest score of 5.95 was obtained in the attribute of crunchiness for sample fried for 5 minutes, while sample roasted for 5 minutes recorded the lowest score (5.25). The overall acceptability evaluation by the sensory panelists of the larvae samples indicates that fried samples had higher scores than their roasted counterparts, with sample fried for 2 minutes having the highest score, followed by that fried for 5 and 7 minutes respectively.

In conclusion, the result of this study suggests that adoption of frying technique in the processing of *Rhynchophorus phoenicis* larvae had an advantage over roasting, as it enhanced the crude proteins and ash contents of the palm weevil larvae. Also higher values were recorded for larvae sample fried for 5 minutes than the roasted counterparts. Furthermore, result indicates that vitamins C and E was more abundant in the fried than roasted samples, suggesting that frying technique may be preferable than roasting as a method of processing of *Rhynchophorus phoenicis* larvae, due to the enhanced quantities of the vitamins in the fried samples. The fried samples were also preferable than their roasted counterparts in most of the sensory attributes evaluated in this study.

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**Figure 1.** Fresh edible palm weevil larva

**B**

**A**

 **Figure 2.** Fried (A) and roasted (B) palm weevil (*Rhynchophorus phoenicis*) larvae

**Table 1.** Physical properties of roasted and fried edible palm weevil (*Rhynchophorus phoenicis*) larvae

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample**  |  **Weight (g)** | **Length (cm)** | **Width (cm)** |
| **Fresh**  |  25.43ab±0.24 | 5.13a±0.04 | 3.50a±0.14 |
| **Roasted** |  |  |  |
| ***5 min*** |  22.21bcd±0.01 | 5.00b±0.00 | 2.74d±0.02 |
| ***10 min*** |  22.12cd±0.03 | 4.63d±0.04 | 2.41e±0.01 |
| ***15 min*****Fried**  |  22.01d±0.01 | 4.15f±0.01 | 2.11f±0.01 |
|  ***2 min*** |  22.32abc±0.03 | 4.83c±0.04 | 3.21b±0.01 |
|  ***5 min*** |  22.41ab±0.01 | 4.63d±0.04 | 3.11bc±0.01 |
| ***7 min*** |  22.48a±0.01 | 4.40e±0.00 | 3.03c±0.01 |

Values are means of duplicate determinations; Means in the same column with different superscripts are significantly different (*p* < 0.05)

**Table 2.** Proximate composition of roasted and fried *Rhynchophorus phoenicis* larvae

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Samples**  | **Moisture Content****(%)** | **Crude Protein****(%)** | **Fat Content****(%)** | **Ash Content****(%)** | **Carbohydrate Content****(%)** |
| Fresh  | 34.04a±0.00 | 24.14d±0.01 | 19.63g±0.01 | 4.79g±0.00 | 17.39c±0.01 |
| Roasted  *5 min* | 29.23d±0.01 | 24.10e±0.00 | 22.03f±0.00 | 5.04f±0.00 | 19.60b±0.01 |
| *10 min* | 29.02e±0.01 | 23.50f±0.00 | 25.02e±0.01 | 5.20d±0.01 | 17.27d±0.01 |
| *15 min* | 24.02g±0.01 | 23.01g±0.01 | 27.52d±0.00 | 5.23c±0.00 | 20.02a±0.00 |
| Fried*2 min* | 31.01b±0.00 | 25.11a±0.01 | 28.35c±0.00 | 5.10e±0.01 | 10.45g±0.00 |
| *5 mi*n | 30.18c±0.00 | 25.02b±0.00 | 29.07b±0.00 | 5.25b±0.01 | 10.50f±0.00 |
| *7 min* | 28.44f±0.00 | 25.00c±0.00 | 30.01a±0.01 | 5.35a±0.01 | 11.23e±0.00 |

Values are means of duplicate determinations; Means in the same column with different superscripts are significantly different (*p* < 0.05)

**Table 3.** Mineral contents of roasted and fried *Rhynchophorus phoenicis* larvae

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample**  | **Calcium mg/100g**  | **Sodium mg/100g**  | **Potassium mg/100g** | **Magnesium mg/100g**  | **Iron** **mg/100g** | **Phosphorus mg/100g** | **Zinc mg/100g** | **Copper mg/100g** |
| **Fresh**  | 38.65b±6.35 | 50.73g±0.02 | 780.62g±0.01 | 29.72g±0.03 | 16.33f±0.01 | 390.14g±0.04 | 4.45f±0.04 | 0.09g±0.01 |
| **Roasted** |  |  |  |  |  |  |  |  |
| ***5 min*** | 36.28b±0.01 | 54.21f±0.01 | 823.33f±0.02 | 33.15f±0.02 | 18.32e±0.03 | 391.62f±0.03 | 5.81e±0.01 | 0.28c±0.01 |
| ***10 min*** | 34.61b±0.03 | 56.78e±0.02 | 840.05e±0.04 | 37.27d±0.03 | 19.43d±0.02 | 401.82e±0.03 | 5.93d±0.01 | 0.48b±0.01 |
| ***15 min*** | 33.06b±0.03 | 59.32d±0.02 | 883.45c±0.04 | 41.72b±0.02 | 19.92a±0.01 | 411.17d±0.04 | 6.12b±0.01 | 0.62a±0.01 |
| **Fried** |  |  |  |  |  |  |  |  |
| ***2 min*** | 46.22a±0.02 | 66.82c±0.01 | 860.65d±0.04 | 36.43e±0.01 | 19.63c±0.01 | 430.74c±0.03 | 5.91d±0.01 | 0.13f±0.01 |
| ***5 min*** | 48.15a±0.02 | 69.72b±0.03 | 891.44b±0.01 | 40.76c±0.03 | 19.83b±0.02 | 439.62b±0.02 | 6.08c±0.01 | 0.18e±0.01 |
|  ***7 min*** | 49.82a±0.02 | 71.42a±0.01 | 913.59a±0.01 | 44.21a±0.01 | 19.96a±0.01 | 442.53a±0.02 | 6.22a±0.01 | 0.25d±0.01 |

Values are means of duplicate determinations; Means in the same column with different superscripts are significantly different (*p* < 0.05)

**Table 4.** Vitamin contents of fresh, roasted and fried *Rhynchophorus phoenicis* larvae

|  |  |  |  |
| --- | --- | --- | --- |
| **Sample**  | **Vitamin A****(µg/100g)** | **Vitamin C** **(mg/100g)** | **Vitamin E (mg/100g)** |
| **Fresh** **Roasted** | 216.02a±0.02 | 10.51a±0.01 | 1.22a±0.01 |
|  ***5 min*** | 141.86d±0.02 | 7.33e±0.02 | 1.05c±0.01 |
| ***10 min*** | 126.02f±0.01 | 4.76f±0.04 | 0.91e±0.01 |
| ***15 min*****Fried** | 107.92g±0.01 | 2.02g±0.01 | 0.74f±0.01 |
| ***2 min*** | 162.15b±0.01 | 9.61b±0.01 | 1.18b±0.01 |
| ***5 min*** | 143.23c±0.01 | 9.04c±0.01 | 1.04c±0.01 |
| ***7 min*** | 133.66e±0.02 | 7.62d±0.01 | 0.96d±0.01 |

Values are means of duplicate determinations; Means in the same column with different superscripts are significantly different (*p* < 0.05)

**Table 5.** Mean scores of sensory evaluation of roasted and fried *Rhynchophorus phoenicis* larvae

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Sample** | **PT** **(min)** | **Appearance** | **Aroma** | **Taste** | **Texture** | **Crunchiness** |  **OA** |
| **Fried** | 2 | 6.55a±1.76 | 6.75a±2.36 | 5.45a±1.64 | 6.80a±1.36 | 5.40a±2.16 | 6.70a±2.08 |
| **Fried** | 5 | 5.80a±2.09 | 5.60ab±1.90 | 6.10a±2.49 | 5.30b±1.98 | 5.95a±1.82 | 6.50a±2.40 |
| **Fried** | 7 | 5.95a±2.09 | 5.70ab±1.90 | 5.65a±2.13 | 5.55ab±1.50 | 5.90a±2.05 | 6.40a±1.82 |
| **Roasted** | 5 | 5.25a±2.73 | 5.60ab±2.28 | 6.60a±2.48 | 5.85ab±2.28 | 5.25a±2.07 | 5.80a±2.46 |
| **Roasted** | 10 | 6.40a±2.09 | 5.20b±1.77 | 6.25a±2.40 | 5.45ab±2.35 | 5.65a±2.32 | 5.80a±2.02 |
| **Roasted** | 15 | 5.35a±2.32 | 5.90ab±2.15 | 6.65a±2.46 | 6.00ab±1.95 | 5.80a±2.17 | 6.05a±2.04 |

PT, processing time; OA, overall acceptability; Values are means of duplicate determinations; Means in the same column with different superscripts are significantly different (*p* < 0.05)