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PHYSICOCHEMICAL CHARACTERIZATION AND FATTY ACID COMPOSITION OF *ORYCTES OWARIENSIS* LARVAE OIL

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Abstract: *Oryctes owariensis is one of the most widely prized edible insects consumed in Côte d'Ivoire. Oil extracted from this insect was analyzed for physicochemical properties and fatty acid constituents using standard methods. Results revealed that with oil content of 18.88 ± 1.3 %, Oryctes owariensis larvae are lipid-rich than most of edible insects. This oil shows a refractive index of 1.344 ± 0.002, specific gravity of 0.71 ± 0.10, acid value of 3.73 ± 0.02, iodine value of 105.27 ± 0.15, saponification value of 120.14 ± 1.5, unsaponifiables of 2.99 ± 0.31 %, peroxide value of 0.96 ± 0.02 and free fatty acid of 1.12 ± 0.03 (% oleic acid). As regards fatty acids profile, the unsaturated fatty acids in Oryctes owariensis oil were oleic (46.09 ± 0.07%), linoleic (3.25 ± 0.02 %) and Palmitoleic (1.06 ± 0.01 %), while the major saturated fatty acids were palmitic (39.55 ± 0.03 %) and stearic (10.05 ± 0.03 %). The unsaturated fatty acids accounted for 50.4 % of the total fatty acids whereas the saturated fatty acids constituted 49.6 % of the fatty acids. These values when compared with that observed in oils which have been considered to be of high quality, suggest that Oryctes owariensis oil has potentials that could be exploited by the industrial and pharmaceutical companies.*

Keywords: *Physicochemical Characterization, Fatty Acid Composition, Oryctes owariensis Larvae, oil, edible insect.*

1. Introduction

Insects are the most common multicellular organisms on planet Earth and are thought to account for >70% of all species. Insects are also among the most diverse groups of organisms in the history of life [1]. Although mainly recognised as pests or nuisances affecting human, plant and animal health, insects play an essential role in minimising of food safety in addition to providing ecosystem services (such as pollination, waste degradation and biological control). In a recent review, Van Huis [2] outlined the important role of insects in assuring food and feed security. Globally, it is believed that 1,900 species of insects are consumed by about 2 billion people, mainly in the developing world [2]. This has become especially important as the need for alternative protein sources increases due to rapid urbanisation in developing countries and the shifts in the composition of global food demand.

People in Africa, Asia and Latin America eat insects as regular parts of their diets. They may do so not only because conventional meats such as beef, fish and

chicken are unavailable and insects therefore are vital sources of protein, but also because insects are considered important food items, often delicacies [3]. Insects are a highly nutritious and healthy food source with high content of nutrients (fats, protein, vitamins, fibre and minerals) required by humans and animals. However, the nutritional composition of edible insects between and within species is highly variable, depending upon metamorphic stage, habitat and diet of the insect [4].

Edible insects are a considerable source of fat. Many authors investigated the content and composition of oils extracted from several insects [5, 6, 7, 8]. Their oils are rich in polyunsaturated fatty acids and frequently contain the essential linoleic and α-linolenic acids. The nutritional importance of these two essential fatty acids is well recognized, mainly for the healthy development of children and infants [9]. Greater attention has been paid to the potential deficient intake of these omega-3 and omega-6 fatty acids in recent times, and insects could play an important role, in particular in landlocked developing countries with lower access to fish food sources, by supplying these essential fatty acids to local diets [10].

In Cote d'Ivoire, *Oryctes owariensis* larva is one of the most widely prized and eaten insects. This larva is commonly hunted in dead trunks of palms by the villagers. Thus, it is either eaten raw, boiled, smoked or fried [11]. The present study was aimed at evaluating the physicochemical properties and fatty acid composition of dried *O. owariensis* larvae oil, with a view to revealing any possibility of its use as conventional oils for human and animal nutrition and industrial purposes.

2. Matherials and methods

Larvae collection and sample preparation

Fresh *O. owariensis* larvae were collected from dead trunks of raffia palms at Saïoua (6°29'31" N and 6°15'32" W) in Côte d'Ivoire. After collection, the larvae were placed in a cooler with ice to keep their freshness and then transported to the laboratory for flour preparation. Fresh larvae (1 kg) were cleaned to distilled water then, drained and dried at 65°C in an oven for 72 h. Dried larvae were ground using a porcelain motar to obtain the crude flour.

Oil extraction

Oil was extracted from 3 g of crude flour with 70 mL of n-hexane in a Soxhlet extractor [12]. Then, the solvent was gently evaporated with a rotary evaporatorty (Heidolph, Hei-Vap, Germany). The extracted lipid was weighted to determine the oil content of catepillar. Crude oil was stored at 4 °C in airtight brown sterile glass bottle until further use for physicochemical analysis.

Physicochemical analysis

Refractive index

Refractive index of *O. owariensis* oil was determined at 25 °C following the IUPAC [13] method by using a refractometer (Abbe, Optic Ivymen, Spain), respectively.

Acid, peroxide, iodine and saponification values

Acid index of *O. owariensis* oil was determined according to AOAC [12] official method with the morn ISO-9001. A volume of 100 mL ethanol was neutralised with a solution of NaOH (N/10). The titration was performed using a solution of KOH (1N) in the presence of phenolphthalein.

Iodine value of *O. owariensis* oil was determined according to AOAC [12] official method. A volume of 30 mL carbon tetrachloride was used to dilute 0.4 g oil in the presence of 25 mL of Wijs

reagent and 10 mL of acetate mercury. The titration was carried out using a solution of sodium thiosulfate (0.1 N).

The peroxide value was determined according to AOAC [12] method. A solution made out of potassium iodine added to a mixture of acetic acid – chloroform: 3/2 (v/v) has been used. The titration was carried out using a solution of sodium thiosulfate (N/100).

Saponification value was determined according to AOAC [12] official method. An amount of 2 g oil has been treated using alcoholic potash (0.5 N) and titrated hot with hydrochloric acid (0.5 N) in the presence of phenolphthalein.

Unsaponifiable matter

Unsaponifiable matter content of oil sample was determined following the IUPAC [13] method. For this, 100 mg of unsaponifiable fraction was dissolved in 2 mL of chloroform. To 1 mL of aliquot, 4 mL of a trifluoroacetic-chloroform (1:3, v/v) solution was added. The absorbance was measured at 620 nm using a spectrophotometer (T80+, PG instruments, England).

Fatty acid composition

The fatty acids were converted to their methyl esters (FAMEs) as described by the European Communities [14]. About 0.1 g of oil sample was mixed with 2 ml of n-heptane and 0.2 ml of a methanolic solution of potassium hydroxide (2N). The whole mixture was shaken up for 30 s and allowed to settle for 5 min. The top layer containing the FAMEs was used for gas chromatography (GC) analysis.

FAMEs solution (1 µl) containing the internal standard (erucic acid) was injected into a gas chromatograph (Shimadzu, GC 14 A, Japan) equipped with a flame ionization detector (FID) and a capillary column TRD1 (60 m X 0.25 mm i.d. X 0.25 µm film thickness). The carrier gas was nitrogen and the flow rate was adjusted to 23 ml/min. Temperature of detector was 325°C and that of injector was 275°C. The initial column temperature was fixed to 60°C and programmed to increase by 1°C per min intervals until 325°C and, kept for 10 min at this temperature. The fatty acid methyl esters peaks were identified by comparing their retention times with those of standards. After adjusting areas with the internal standard (erucic acid), the yield of each fatty acid was calculated as follow: area of the fatty acid/areas of total fatty acids in the oil sample × 100 (%).

Statistical analysis

Each sample was analyzed in triplicate and data are reported as mean ± standard deviation (SD). Analysis of variance (ANOVA) was performed using SPSS version 11.0 software. Statistical significance was set at $p \leq 0.05$.

3. Results and discussion

Physicochemical properties

Fat is the chief form in which energy is stored in insect larvae [15]. It is usually present in greatest amounts in the mature larvae before metamorphosis [16]. As regards *O. owariensis*, its oil content was amounted to 18.88 ± 1.3 % (dry matter) (Table 1). This value shows that *O. owariensis* larvae are lipid-rich than most of edible insects such as *Cirina forda* [17], *Zonocerus variegatus* [6], *Oryctes rhinoceros* and *Imbrasia belina* [18].

Physicochemical characteristics of *O. owariensis* oil are shown in Table 1. The oil from the studied larvae is a yellow brown and a colourless liquid (data not shown). Values of specific gravity and refractive index were found to be 0.71 ± 0.10 and 1.344 ± 0.002 respectively (Table 1). These values are lower than those of Arachis oil, linseed oil and olive oil [19]. This implies that the oil from this insect is

lighter than these seed oils that have been considered to be of high quality and as such would find much use in pharmaceutical industries. The oil of *O. owariensis* is more unsaturated than the seed oil which suggests that it might be more fluid at room temperature and less viscous at low temperatures. The low acid value (3.73 ± 0.02 mg KOH/g mg) is an indication of its lower susceptibility to rancidity which depicts a higher shelf life.

Table 1

Extraction yield and physicochemical properties of *O. owariensis* oil

Parameters	Values
Extraction yield (%)	18.88 ± 1.3
Refractive index	1.344 ± 0.002
Specific gravity	0.71 ± 0.10
Acid value (mg KOH/g mg)	3.73 ± 0.02
Free fatty acid (% oleic acid)	1.12 ± 0.03
Saponification value (mg KOH/g mg)	120.14 ± 1.5
Iodine value (g I_2/100 g)	105.27 ± 0.15
Unsaponifiables (%)	2.99 ± 0.31
Peroxyde value (meq O_2/kg)	0.96 ± 0.02

Values are mean ± standard deviation of three measurements (n = 3)

The acid value is low, acid value of 0.00 to 4.00 mg KOH/g oil is recommended for oil to find application in cooking [20]. Thus the oil from *O. owariensis* larvae could be suitable for cooking. The free fatty acid value of 1.12 ± 0.03 falls within the maximum limit of 5% for free fatty acids in high grade palm oil in Nigeria [21]. The data relevant to acid value and free fatty acid further indicate that *O. owariensis* oil is not much susceptible for fat degradation process during oil extraction too.

The peroxide value is used as an indicator of deterioration of oils, thus low peroxide value indicates resistance of the oil to peroxidation during storage. Fresh oils have peroxide values lower than 10 meq O2/kg and before oil becomes rancid, its peroxide value must be between 20 and 40 meq O2/kg [22]. The peroxide value of oil from *O. owariensis* larvae is very low (0.96 ± 0.02 mEq/Kg) compared to the maximum acceptable value of 10 meq KOH/g set by the Codex Alimentarius Commission for groundnut seed oils [23]. The oil is thus stable and would not easily go rancid. Peroxide formation is an indication that lipid oxidation is on-going, these compound react with low molecular weight metals to produce free radicals that are capable of further lipid oxidation [24].

The iodine value is a measure of the degree of unsaturation in oil and could be used to quantify the amount of double bonds present in the oil which reflects the susceptibility of oil to oxidation. The iodine value of *O. owariensis* oil was 105.27 ± 0.15 g I_2/100 g. This was close to the 108.00 ± 0.15 reported for *Macrotermes bellicosus* oil by Ekpo and Onigbinde [25]. This value was however, higher than the 92.62 ± 0.33 g I_2/100 g and 48.35±0.55 g I_2/100 g reported for *Coptotermes gestroi* and *Rhynchophorus palmarum L.* larva respectively [5, 8].

Saponification value is an index of average molecular mass of fatty acids in oil sample. The lower value of saponification value in *O. owariensis* oil (120.14 ± 1.5 mg KOH/g) suggest that the mean molecular weight of fatty acids is lower than that of *R. palmarum L.* larva oil (198.26±0.99 mg KOH/ g) or that the number of ester bonds is less when compared to that of *R. palmarum L.* larva oil [5]. Nevertheless, this saponification value is consistent to make the studied oil useful in soap industry.

Fatty acid profile

Figure 1 depicts the fatty acids profile of *O. owariensis*. The data given in the Table 2 showed that the unsaturated fatty acids in *O. owariensis* oil were oleic (46.09 ± 0.07%), linoleic (3.25 ± 0.02 %) and Palmitoleic (1.06 ± 0.01 %), while the major saturated fatty acids were palmitic (39.55 ± 0.03 %) and stearic (10.05 ± 0.03 %). This insect oil could be classified in oleic acid group.

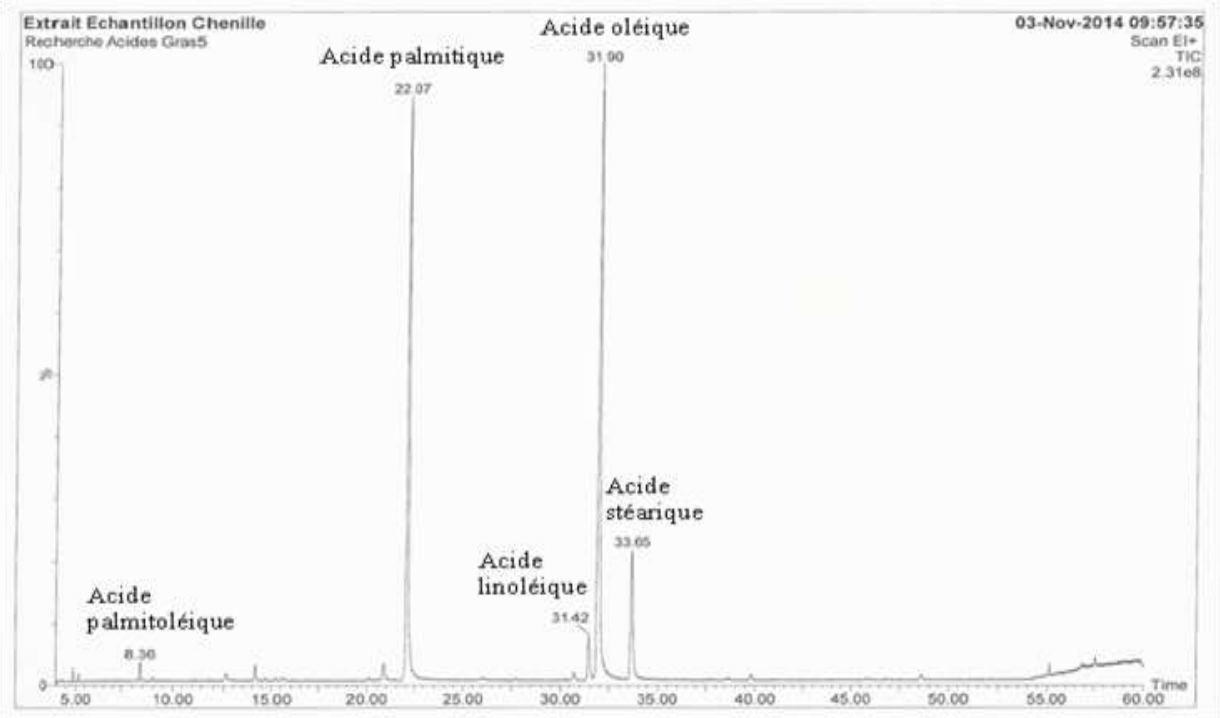

Fig. 1. Gas chromatograms of fatty acids methyl esters of *O. owariensis* oil analysed

Table 2

Fatty acids composition of *O. owariensis* oil

Fatty acid	Saturation	Values (%)
Essential		
Linoleic Acid	Omega 6 polyunsaturated	3.25 ± 0.02
Non-essential		
Palmitoleic Acid	Omega 7 monounsaturated	1.06 ± 0.01
Oleic Acid	Omega 9 monounsaturated	46.09 ± 0.07
Palmitic Acid	Saturated	39.55 ± 0.03
Stearic Acid	Saturated	10.05 ± 0.03
Ratios		
SFA		49.6
TUFA		50.4
MUFA		47.15
PUFA		3.25
PUFA / SFA		0.07

Values are mean ± standard deviation of three measurements (n = 3).
Abbreviations: SFA = saturated fatty acids TUFA =total unsaturated fatty acids; MUFA- monounsaturated fatty acids; PUFA: polyunsaturated fatty acid.

The unsaturated fatty acids accounted for 50.4 % while the saturated acids accounted for 49.6 % of total fatty acids (Table 2). The presence of both saturated and unsaturated fatty acids in this insect could be an advantage since they may complement the functions of one another. Oleic acid, a monounsaturated fatty acid, has been shown to be hypocholesterolemic [26]. Linoleic acid is important essential fatty acid required for growth, physiological functions and body maintenance [27]. Furthermore, Linoleic acid is one of the most important polyunsaturated fatty acids in human food because of its prevention of distinct heart and vascular diseases. Apart from preventing cardiovascular disorders such as coronary heart diseases and atherosclerosis; linoleic acid prevents high blood pressure. Also linoleic derivatives serve as structural components of the plasma membrane and as precursors of some metabolic regulatory compounds [28]. As far as concerned palmitic and stearic acids, which are the main saturated fatty acids of the studied oil, previous studies have shown that they are free from deleterious effect on plasma cholesterol [29]. In addition, they are often used in food industries to provide texture and softness to products [30].

4. Conclusion

Based on the present study, it appears that *O. owariensis* larva is a good source of oil, contains high amount of unsaturated fatty acids (50.4 %) mainly consist to oleic acid (46.09 %) which was found to be hypocholesterolemic and thus, desirable from the nutritional and health view points. So, this insect oil could be classified in oleic acid group. Also, the studied oil exhibited good physicochemical properties and could be useful for nutritional, pharmaceutical and industrial applications.

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