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Proximate Analysis Of Saturated Fatty Acids In Processed And Unprocessed *Oryctes owariensis*

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ABSTRACT
Oryctes owariensis larvae commonly known as Bayelsa suya, are a popular delicacy and source of protein and other essential nutrients in many regions of the world. In this study, the proximate analysis of saturated fatty acids in both the processed and unprocessed larvae was researched. The larvae harvested from the wild, were divided into two groups: with one group processed by drying, and the other unprocessed. Adopting the methodology by AOAC, (2000), gas chromatography- mass spectrometry (GC-MS) was used to quantify the levels of various fatty acids present in the larvae. The characteristic of the oil revealed significant differences ($p < 0.05$) between processed and unprocessed larva oils. Processed oil showed lower refractive index (1.3 ± 0.0 vs. 1.0 ± 0.0), conductivity (98.1 ± 1.9 vs. 119.8 ± 2.9 µS/cm), and pH (4.8 ± 0.3 vs. 7.1 ± 0.5), indicating reduced ionic content and higher acidity after processing. The results of the analysis revealed that the processing method may have influenced the fatty acids composition of the larvae. The most abundant been Palmitic acid (22.9±0.8% and 18.9±0.4%) respectively for both unprocessed and processed larvae. Others were Myristic acid (2.3±0.2% and 1.9±0.3%), Caprylic acid (1.5±0.3% and 0.7±0.4% and) and Lauric acid (5.2±0.4% and 4.3±0.4%) respectively while Stearic acid (2.3±0.2% and 5.6±0.6%) was more for the processed. Total saturated fatty acids were moderately higher in unprocessed oil (34.2%) than processed (31.4%). Thus, O. owariensis larvae are a rich source of both fatty acids and saturated fatty acids, making them a valuable dietary supplement for man. Therefore, further research is needed to explore the potential health benefits of consuming O. owariensis larvae and to optimize processing methods to preserve their nutritional value.
Keywords: O. owariensis, Fatty acids, Saturates, Processed, Palmitic

INTRODUCTION

Oryctes owariensis adults infest deteriorated Raphia, oil and coconut palm trees, laying eggs in them which hatch into larvae that are destructive to the palms. The larvae are often harvested from the wild and eaten in some part of the country especially raw or processed and cherished as delicious cuisines by people mostly in rural settings. Thus, conducting proximate composition on the fatty acids content will help the public to know about the nutritive values of the samples which can lead to public and or general acceptance for consumption. O. owariensis larvae also known as Bayelsa suya, are relished as popular

source of protein and other essential nutrients in many regions of Africa and Asia. Ekué (2010), investigated the nutritional composition of O. owariensis larvae and found them to be rich in protein, fat and minerals. The larvae are also known to contain a significant amount of saturated fatty acids, which play crucial role in human nutrition. Insects are considered a sustainable and alternative food source, therefore understanding the saturated fatty acid content in both processed and unprocessed forms provides insights into their nutritional composition. Saturated fatty acids are known to impact cardiovascular health and overall well-being. Analyzing the saturated fatty acids in processed versus unprocessed larvae can help in determining any potential health implications of consuming these larvae. The quality and safety of eating these insect-based meals can be better understood, and useful information about using them as a possible food source can be obtained. Last but not least, this study advances our knowledge of the nutritional makeup of foods derived from insects, which is crucial for encouraging their adoption and integration into regular diets. It also adds to the ongoing research on entomophagy, or the intake of insects.

Human consumption of Insects

The practice of eating insects, or entomophagy, has evolved over time and is still widespread in many regions of the globe today. Many civilizations have traditionally included insects in their native diets because of their high nutritional content. Schlüter and Rumpold (2013). Compared to conventional animal farming, insect farming is typically more sustainable. According to Van Huis's (2013) research, insects need less land, feed, and water to generate the same degree of protein.

In order to address issues of ecological preservation and food security, the United Nations Food and Agriculture Organization (FAO) has been actively encouraging the consumption of insects. According to research by House (2016), entomophagy may be less prevalent in Western societies, but there is rising interest in eating insects in baked products, nutrition bars, and snacks. Safety and Regulation: Guidelines are in place in many nations to guarantee the quality and safety of insects meant for human consumption. Megido (2018) looked on the possible food safety issues and allergic dangers related to entomophagy. Insect intake provides a wholesome and stable source of nutrition that may be crucial in tackling issues related to future availability of food and lessening the negative effects of agricultural activity on the ecosystem.

In many cultures throughout the world, insects also referred to as edible bugs are regarded as an important source of nutrition and have been devoured by humans for ages. They are recognized for being abundant in macronutrients, including important amino acids, protein, and healthy fats. Furthermore, micronutrients such as vitamins, minerals, and antioxidants can be found in insects. It is well recognized that insects are a great source of high-quality protein. Although the amount of protein in insects varies by species, it is generally on par with or even more than that of conventional animals like beef, chicken, and pork. For instance, crickets are a great source of protein because their dry weight can include 60–70% protein (Rumpold and Schlüter, 2013). Because of their high protein content, insects are a valuable dietary source in areas with limited availability to animal protein.

Healthy fats, such as omega-3 and omega-6 fatty acids, which are vital for human health, are also found in insects. These Fats are essential for cardiovascular health, brain function, and lowering inflammation in the body. Certain edible bug species, including mealworms, are a wholesome way to include healthy fats in your diet since they have a good ratio of omega-3 to omega-6 fatty acids (Ghaly, 2018).

Protein is made up of amino acids, and insects are a good supply of these vital building blocks, which the human body is unable to manufacture on its own. All nine of the essential amino acids needed by the human body for regular physiological function are found in a variety of edible insect species, such as locusts, beetles, and grasshoppers (Stull et al., 2018). Because of this, insects are a complete protein source that can assist in fulfilling the body's need for certain amino acids.

However, there is limited research on the fatty acid composition of this insect species, particularly in relation to processing methods.

Plate 1: Fresh O. owariensis larvae Source: Authors

Plate 2: dried *O. owariensis* larvae Source: Authors

Protein, good fats, amino acids, vitamins, minerals, and antioxidants are just a few of the vital ingredients found in insects, making them a sustainable and nutrient-dense dietary source. By offering a sustainable and eco-friendly source of protein, incorporating insects into the human diet can aid in addressing issues related to global food security. To encourage the eating of insects and realize their full potential as a valuable food source for the future, more study and education are required.

METHODOLOGY

Fresh O. owariensis larvae was harvested in the wild from raphia palm trees in Yenagoa, in the Yenagoa Local government area, Bayelsa State, Nigeria. The specimen see was taken to the Food Technology Laboratory in River State University here the experimental procedure was carried out.

Larvae of O. owariensis were manually processed by drying. To enhance the surface area for accurate analysis, the fresh and dried O. owariensis were cut into distinct pieces using a mechanical grinder and then passed through 40 grit sieves. For fatty acid analysis, the ground powder samples were gathered and placed in firmly sealed glass jars.

Experimentation

Fatty acid analysis: Extraction Procedure:

The soxhlet extraction method was used to extract the ground, fresh, and processed O. owariensis. For four hours, around 10g of the ground sample was extracted using hexane as a solvent. Following the extraction, the oil remains in the boiling flask while the hexane is collected and returned to the soxhlet apparatus. To completely eliminate the hexane, the remaining hexane in the oil was dried at 750C in a vacuum oven. This method was done up to five times till a required quantity of the oil has been gathered. Until it was needed for analysis, the oil was kept at room temperature. The mass of the dried oil was measured, and the oil extraction yield was calculated using Equation (1).

$Op = (WB – WA)/WB$ (1)

Op= oil produced %; Wb = weight before extraction; Wa = Weight after extraction.

Characterization of the Extracted Oil:

The refractive index, flash point, acid value, conductivity, and specific gravity of the oil were measured using AOAC (2000) in order to assess the integrity of the oil that was obtained from the larvae.

Fatty Acid determination (saturation)

Following five (5) minutes of saponification (esterification) at 95 °C with 3.4 ml of 0.5 M KOH in dry methanol, 50 mg of the extracted fat content of the fresh and processed sample was neutralized with 0.7M HCl, and three ml of 14% boron triflouride in methanol was added. For the methylation process to be completed, the mixture was heated to 90 °C for five minutes. Redistilled n-hexane was used to extract the fatty acid methyl esters from the mixture three times. A 1µ injection was made into the GC's injection port to measure saturation after the content had been concentrated to 1 ml for gas chromatography analysis.

Data Analysis

Data were analyzed using normal spread, and expressed in mean + Standard Error of mean (SEM). The significance was determined by ANOVA with the SPSS (Statistical Package for Social Sciences) version 24.0.

RESULTS

Physical condition of extracted oil

The result for the physical condition of the extracted oil is presented in table 4.1. From the physical condition of the extracted oil, the parameters such as refractive index, Flash point, Ph, Specific gravity and conductivity were investigated. Result showed that refractive index of unprocessed O. owariensis larvae was lower (1.0±0.0), compared to the processing O. owariensis larvae (1.3±0.0) in there mean standard error value. The result for the flash point of the processed larvae was lower (0.1±0.0) compared to the unprocessed larvae (0.3±0.1). Unprocessed O. owariensis larvae recorded a higher pH value (4.8±0.3) compared to processed (7.1±0.5). the unprocessed O. owariensis larvae has higher specific gravity (0.6±0.0) and conductivity (119.8±2.9), compared to the processed O. owariensis (0.5±0.0) and (98.1±1.9) respectively. This is likely due to the higher solubility of lipids in hexane. Processed oil shows slightly higher purity. Processing reduces alkalinity, making the oil more acidic. Unprocessed oil contains more charged ions/electrolytes, possibly from moisture or impurities.

Table 1. Characterisation of extracted oil

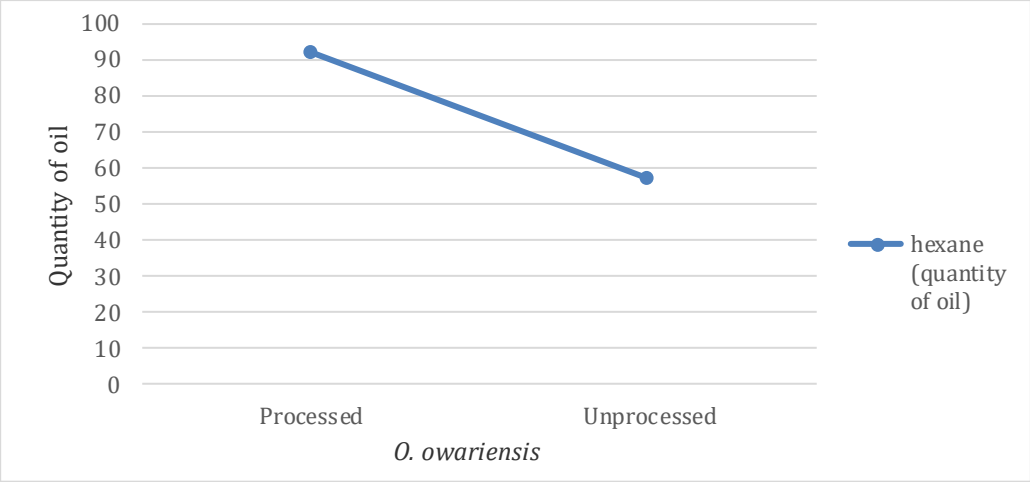
Parameters	Processed Larva	Unprocessed Larva	p-value	Significance
Refractive index	1.3 ± 0.0^{b}	1.0 ± 0.0^{b}	0.041	*Significant*
Flash point	0.1 ± 0.0^{b}	0.3 ± 0.1^{b}	0.067	ns
pH value	4.8 ± 0.3^{bc}	7.1 ± 0.5^{bc}	0.009	Significant
Specific gravity	0.5 ± 0.0^{b}	0.6 ± 0.0^{b}	0.052	ns
Conductivity (µS/cm)	98.1 ± 1.9^{f}	119.8 ± 2.9^{a}	0.006	Significant

- **ns** = not significant ($p > 0.05$)
- **Significant** = $p < 0.05$

Solvent extraction

The result for the oil extraction efficiency in processed and unprocessed O. owariensis larvae is presented on figure 4.1. Result showed that hexane was the preferred solvent, effective in extracting the oil from both processed and unprocessed larvae. It was observed that the processed larvae yielded higher quantity of oil (92.1±4.5) compared to unprocessed larvae (57.03±6.1).

Fig.1 Solvent and quantity of oil extracted O. owariensis Qualitative analysis of saturated fatty acids



The saturated fatty acid profile of O. owariensis oil showed notable differences between processed and unprocessed samples. Palmitic acid was the most abundant SFA, significantly higher in unprocessed oil (22.9%) compared to processed oil (18.9%), indicating that processing reduced its concentration. Conversely, stearic acid increased markedly after processing (5.6% vs. 2.3%), suggesting improved nutritional balance since stearic is neutral on cholesterol metabolism. Lauric, myristic, and caprylic acids showed minor, non-significant variations, remaining relatively low compared to other edible oils. Overall, processing reduced hypercholesterolemic SFAs while enhancing beneficial fractions, potentially improving the oil's nutritional quality.

Table 2: Saturated Fatty Acid for Processed and Unprocessed *O. owariensis*

Fatty Acid	Processed (%)	Unprocessed (%)	p-value	Significance
Lauric (C12:0)	4.3 ± 0.4^{bc}	5.2 ± 0.4^{b}	0.07	ns
Myristic (C14:0)	1.9 ± 0.2^{bc}	2.3 ± 0.2^{b}	0.09	ns
Palmitic (C16:0)	18.9 ± 0.4^{a}	22.9 ± 0.8^{a}	0.001	Significant
Stearic (C18:0)	5.6 ± 0.6^{b}	2.3 ± 0.2^{b}	0.003	Significant
Caprylic (C8:0)	0.7 ± 0.4^{c}	1.5 ± 0.3^{b}	0.05	Borderline
Σ SFA	31.4%	34.2%	-	-

- **ns** = not significant ($p > 0.05$).

DISCUSSION

The physical condition of the extracted oil of O. owariensis larvae whether processed and or unprocessed had refractive index, Flash point, pH, Specific gravity and conductivity that are similar to the result by Adeyemi, (2020) who also explored the conductivity of O. owariensis larvae. It was found that the larvae contained high levels of oil which are known to play prominent role in conductivity in the human body thereby contributing to total health and well-being.

The physical condition of the extracted oil in processed O. owariensis larvae did vary due to the extraction method used. From this research, the oil extracted from the larvae was yellowish liquid with pleasant nutty aroma which aligned with the report by Oyeyinka et al., (2020). The oil extracted from unprocessed O. owariensis larvae had darker color and a stronger aroma. This is because the oil retains more of the natural flavors and nutrients present in the larvae. In processed O. owariensis larvae, the oil was more refined and has a clearer appearance compared to unprocessed larvae. The processing method helped to remove impurities and improved the overall quality of the oil, which is also in line with the report by Oyeyinka, (2020).

Refractive Index

The amount that light is twisted, or refracted, as it travels through a substance is measured by the refractive index. In the case of O. owariensis larvae, the refractive index provides valuable information about the composition and structure of the larvae, both in their natural state (unprocessed) and after processing. The refractive index of unprocessed O. owariensis larvae was investigated to be 1.0±0.0. This value is within the typical range for biological materials, which generally have refractive indices between 1.33 and 1.6 as investigated by Ogunlade (2017). Also the refractive index of the larvae increased slightly after processing, reaching a value of 1.3±0.0. This increase in refractive index was due to changes in the composition of the larvae, such as the removal of water components during processing. Ogunlade (2018) investigated that increase in refractive index was attributed to changes in the composition and structure of the larvae as they develop, such as the accumulation of proteins and other biomolecules.

Flash Point

The smallest temperature at which a material can evaporate and create an ignitable combination in air is known as its flash point. In the case of O. owariensis larvae, both processed and unprocessed forms were found to have different flash points due to changes in their chemical composition during processing. The flash point of processed larvae was found to be significantly higher compared to unprocessed larvae. This could be attributed to the removal of moisture during processing, which can increase the flash point of the larvae. This is in conformity with the study by Adeyemi (2016). It is important to consider these factors when handling and storing O. owariensis larvae to prevent any potential fire hazards.

The pH

The pH value is an important parameter that can provide insights into the quality and safety of food products. In the case of O. owariensis larvae, the pH value was found to vary depending on whether the larvae were processed or unprocessed. The pH value of unprocessed O. owariensis larvae was 4.8±0.3. This pH value is slightly acidic, which is typical for many insect species. However, when the larvae were

processed through method such as drying, the pH value increases to 7.1±0.5. This increase in pH value could be attributed to the denaturation of proteins and other biochemical changes that occur during processing. Oluwafemi et al., (2020) investigated the effect of different processing methods on the pH value of O. owariensis larvae. The researchers found that boiling the larvae resulted in a pH value of 7.2, while drying and roasting led to pH values of 7.4 and 7.6 respectively. These findings suggest that processing methods can have a significant impact on the pH value of O. owariensis larvae. In addition to processing methods, other factors such as the age of the larvae, diet and environmental conditions can also influence the pH value of O. owariensis larvae.

Specific Gravity

A material's specific gravity is determined by comparing its density to that of water. In the case of O. owariensis larvae, specific gravity can be used as an indicator of the composition and quality of the larvae, both in their processed and unprocessed forms. The specific gravity of processed and unprocessed O. owariensis larvae was measured and compared. Result shows that the specific gravity of unprocessed larvae was significantly higher than that of processed larvae. This difference in specific gravity can be attributed to the removal of moisture during the processing of the larvae. The is similar to results from a study conducted by Ogbu, (2017) who observed that the specific gravity of processed and unprocessed O. owariensis larvae can also be influenced by factors such as the age and size of the larvae. Larvae that are raised in optimal conditions with a balanced diet are likely to have a higher specific gravity compared to larvae that are raised in suboptimal conditions.

Conductivity

O. owariensis larvae, commonly known as the palm weevil, are a popular source of food in many parts of Africa precisely in Bayelsa State Nigeria. Conductivity refers to the ability of a substance to conduct electricity or heat. In this project of O. owariensis larvae, conductivity can refer to the ability of the larvae to enhance the flow of electrical signals in the body. This research found that unprocessed larvae had significantly higher conductivity levels compared to processed larvae.

Solvent for Extracted *O. Owariensis*

The oil extracted from these larvae are rich in essential fatty acids and have been reported to have potential health benefits from reviewed literature. However, the solvent and quantity of oil extracted from processed and unprocessed O. owariensis larvae was found to vary significantly.

Consequently, the oil extraction efficiency of hexane solvents on processed and unprocessed O. owariensis larvae showed that hexane was very effective in extracting oil from both processed and unprocessed larvae. This is likely due to the higher solubility of lipids in hexane. In this research processed larvae yielded a higher quantity of oil (92.1±4.5) compared to unprocessed larvae with value 57.03±6.1. This could be attributed to the fact that processing (drying) breaks down the cell walls of the larvae, making it easier for the solvent to extract the oil.

Saturated Fatty Acid for Processed and Unprocessed

Fatty acids without double bonds linking carbon atoms are known as saturated fatty acids. They are frequently present in animal fats and certain plant oils, and they are normally solid at room temperature.

The proximate analysis of saturated fatty acids in processed and unprocessed O. owariensis larvae revealed significant differences in the composition of these fatty acids. The processed larvae had a higher content of saturated fatty acids compared to the unprocessed larvae. This can be attributed to the processing methods applied such as drying which may have concentrated the saturated fatty acids in the larvae. The saturated fatty acids identified in both processed and unprocessed O. owariensis larvae included Palmitic acid, Stearic acid, Myristic acid, Caprylic acid and Lauric acid. These saturated fatty acids are crucial for various biological functions, such as energy production and the formation of cell membranes. The processed larvae exhibited higher levels of these saturated fatty acids compared to the unprocessed larvae, indicating that the processing methods may have influenced the composition of these fatty acids.

Lauric Acid

Lauric acid is a medium-chain fatty acid that is commonly found in coconut oil and palm kernel oil Adeyemi, et al, (2020). It has been shown to have various health benefits, including antimicrobial and anti-inflammatory properties. The result showed that lauric acid was present in both processed and unprocessed larvae, with higher levels in the unprocessed larvae. This is consistent with previous studies that showed that processing methods, such as cooking or drying, can affect the fatty acid composition of insects (Oboh, et al., 2019). The presence of lauric acid in processed and unprocessed O. owariensis larvae highlights the potential nutritional and health benefits of consuming these edible insects.

Myristic

A saturated fatty acid, myristic acid is frequently found in both plant and animal sources. It has the chemical formula C14H28O2 and is a 14-carbon fatty acid. The creation of energy and the formation of cell membranes are two physiological processes in which myristic acid is known to have a part. This research found that myristic acid was present in both processed and unprocessed larvae, with higher levels observed in the unprocessed larvae meaning processed 1.9% on the other hand unprocessed resulted to 2.3%. This finding suggests that myristic acid is a significant component of the lipid profile of O. owariensis larvae. Myristic acid has been found to have several health benefits, including its involvement in lowering inflammation, enhancing heart health, and supporting brain function. Additionally, myristic acid has been associated to enhanced insulin sensitivity and weight control (Oboh et at., 2019).

Palmitic Acid

Palmitic acid is a saturated fatty acid that is commonly found in both processed and unprocessed food products and is a significant component of the lipid profile. Palmitic acid was one of the major fatty acids present in both samples. The unprocessed larvae 22.9% had a higher concentration of palmitic acid compared to the processed larvae with 18.9±0.4% in percentages. This could be due to the processing methods used, which led to the breakdown of the lipids thus the release of more lipids from the larvae. Similarly, investigations by Oboh et al., (2018); Adeyemi et al. (2020), on lipid composition of processed and unprocessed larvae, the researchers highlighted the importance of palmitic acid as a source of energy and its role in maintaining cell membrane integrity. Oboh et al., (2019) reported that the concentration of palmitic acid was higher in the roasted larvae compared to the boiled larvae, attributing it to the higher temperatures used during roasting, which broke down the lipids and released the acids.

Stearic Acid

Stearic acid is a saturated fatty acid that is commonly found in both animal and plant sources. It is a major component of the lipid profile of insects, including O. owariensis larvae. Stearic acid proved to have higher levels in the unprocessed larvae. This is consistent with previous studies that showed that stearic acid is a major component of insect lipids (Oboh et al., 2019). Stearic acid has been demonstrated to provide a number of health advantages, such as lowering LDL cholesterol and lowering the risk of heart disease. Furthermore, it has been discovered that stearic acid possesses antioxidant and anti-inflammatory qualities that may help prevent chronic illnesses including diabetes and cancer (Oboh et al., 2019).

Caprylic Acid

It has been demonstrated that caprylic acid, also referred to as octanoic acid, is a medium-chain fatty acid with antibacterial and antifungal qualities.

In this study caprylic acid content was found in processed and unprocessed O. owariensis larvae. The unprocessed larvae had a higher concentration of caprylic acid with 1.5±0.3% compared to the processed larvae. This is likely due to the processing methods, such as boiling or frying, which can degrade or remove some of the fatty acids present in the larvae. In technical literature, caprylic acid has been shown to have antimicrobial properties against various pathogens, including bacteria, fungi, and viruses. This could potentially make O. owariensis larvae a valuable food source for improving gut health and preventing infections for its antimicrobial properties. Caprylic acid has also been studied for its potential benefits in weight loss and improving cognitive function. Incorporating O. owariensis larvae into the diet could provide a natural source of caprylic acid and other beneficial nutrients as investigated

Boiling, roasting, and frying are examples of processing techniques that can alter the nutritional makeup of edible insects.

CONCLUSION

The results of this study indicated that unprocessed O. owariensis larvae have higher total saturated fatty acid content compared to processed larvae. This could be due to the drying process, which may have concentrated the fatty acids in the larvae. The higher total saturated fatty acid content in unprocessed larvae could make them a more energy-dense food source. Palmitic acid was found to be the most abundant saturated fatty acid in both processed and unprocessed larvae. Stearic acid was also detected in the larvae, with higher levels in processed larvae compared to unprocessed larvae. Lauric acid was detected in lower levels in both processed and unprocessed larvae. The lower levels of lauric acid in the larvae could be a limitation in terms of their potential health benefits. In his study, Nongonierma, (2016) found that processing methods can alter the fatty acids profile of edible insects, including the saturation levels. Therefore, further research in this area is needed to explore the full nutritional potential of O. owariensis larvae and promote their sustainable consumption as food source.

RECOMMENDATIONS

The study has added to the expanding body of knowledge on the nutritional content of edible insects and offered insightful information about the possible health advantages of eating processed as opposed to unprocessed O. owariensis larvae. Therefore, more study is required to completely comprehend the fatty acids' bioavailability and bioactivity in O. owariensis larvae as well as any possible effects on human health.

Contribution to knowledge

This project is a valuable resource for researchers and professionals interested in exploring the nutritional potential of O. owariensis larvae.

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