EFFECTS OF DRYING METHODS ON THE PROXIMATE COMPOSITION OF PERIWINKLE (*TYMPANOTONUS FUSCATUS*) PRESERVED IN NATURAL AGENTS

BY

Joy Osahenrumwen OKOGUN (Miss)
MAT. NO: AGR1800291

THE DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT
FACULTY OF AGRICULTURE
UNIVERSITY OF BENIN
BENIN CITY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN. IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF AGRICULURE, DEGREE IN AQUACULTURE AND FISHERIES MANAGEMENT OF THE UNIVERSITY OF BENIN, BENIN CITY, EDO STATE, NIGERIA.

MAY, 2024

CERTIFICATION

This is to certify that this project was carried out by Joy Osahenrumwen OKOGUN, Under my supervision in the Department of Aquaculture and Fisheries Management, Faculty of Agriculture, University of Benin, Benin city, Edo State, Nigeria**.**

____________________ ____________

Prof. O.J Abolagba Date
Supervisor

____________________ ____________

Dr. Wangboje Date
Head of Department
Department of aquaculture and fisheries management.

DEDICATION

This study is dedicated to Almighty God who made it possible for the success and completion of this Project and to my late father Snr. Apostle J. F. O Onaghise, who has been my source of inspiration and light.

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ABSTRACT

Periwinkles are small edible snails commonly available for sale in the southern part of Nigeria. The increasing awareness that periwinkle is highly proteinous, one of the cheapest sources of protein and help for body and mental development as increased the demand in different country. The study investigated the effect of oven – drying and smoke – drying methods on the proximate composition of periwinkle (*Tympanotonus fuscatus*) preserved in natural agents. 50g of periwinkle were measured for each drying method and preserved with salt, lime, lemon and alum within 24 hours. Each sample were dried at about $55^{o}c$ – $70^{o}c$. The samples were labelled T1 -T13 including the fresh sample. T5 retained the least moisture ($p<0.05$) and had the highest fat content, fibre content and ash content($p<0.05$). There was a substantial difference between ($p<0.05$) the crude protein and carbohydrate contents of the preserved samples using the different drying processes. T5 had more excellent qualities compared to the others and should be the recommended drying procedure for retaining excellent qualities

CHAPTER ONE

1.0. INTRODUCTION

Periwinkles are gastropods belonging to the phylum Mollusca, they are herbivorous invertebrates and usually found in the sea mostly in the brackish and littoral regions. Periwinkle is a shellfish that has a soft body and the predominant genera are; *Tympanotonus fuscatus,* and *Pachymelania aurita* (Ekpe Inyang 2018; Jimmy and Okonkwo, 2016; Adebayo-tayo, 2016). The *Pachymelania aurita* species is characterized by a sharp spine that is dependent on the age of the species and they have broader aperture than *T. fuscatus*, that has granular turreted and spiny shells with tapering ends (Aigberua and Izah, 2018; Abiabo and Asuquo, 2020). The *Tympanotonus fuscatus* species is the most common edible brackish water species found in the Niger Delta region of Nigeria. It is locally known as “ISAM” or “PIOM PIOM” to the people of Niger Delta and serves as good delicacy in soups.

Tympanotonus fuscatus species is about 4.5-5cm in length, usually dark brown or black in color, with a solid spiral shell (turbinate) and commonly abundant in the mangrove mud flat. *T. fuscatus* are of two known varieties namely; *Tympanotonus fuscatus var fuscatus*, that has spine on its shell and *Tympanotonus fuscatus var radullar* that has a smooth or granular shell. Although both species can exist in the same habitat in the ecosystem, one of the varieties usually dominate the other (Nwiyi and Okonkwo, 2013).

Periwinkles are desirable seafood and a cheap source of protein, vitamins and minerals. Periwinkle is well appreciated seafood because of its low cholesterol, fats and carbohydrate content (Archibong *et al.*, 2014; Nrior *et al.*, 2017; Ngozi *et al.*, 2020). In recent years, there has been an increased demand for periwinkle due to its culinary values especially among the people of Niger Delta region of Nigeria. Traditionally, periwinkle is harvested by hand picking either from a boat or rock/muddy surfaces, usually by the fishermen, especially the women and children (Oluyemi *et al*., 2019) and these seafoods are highly perishable possibly due to the chemical effects of atmospheric oxygen and activities of aerobic microorganisms (Adesanya *et al*., 2021). Approximately a day after periwinkles have been shucked, it becomes unsuitable to consume unless subjected to further processing and appropriate preservation methods (Obire *et al.*, 2017). Periwinkle can be subjected to food processing methods of either roasting, smoking and drying etc which reduces the microbial load of the food products and extend the product shelf life.

1.1. Justification

The increasing awareness that periwinkle is highly proteinous and one of the cheapest source of protein and helpful for body and mental development and also boost brain lipids with omega 6 fatty acids has increased the demand in different countries (Adebayo *et al*. 2006)

Preliminary investigation revealed that the processors steam the periwinkle in their shell for about 10 minutes, allow it cool and manually shuck the meat from its shell using a needle. Thereafter, the meat is preserved in a refrigerator if available, but the absence of adequate cold chain system, due to inconsistent power supply in Nigeria, prompt some of the processors to preserve the periwinkle meat in either salt, lemon, lime, alum etc., which are natural preservative agents. Ibeh *et al*. (2023) in a study on the preservation of periwinkle with potassium sorbate and natural agent (alum) at ambient temperature hypothesized that shucked periwinkle shelf-life can be extended by natural preservatives to prevent the growth of spoilage microorganisms. The technique of preserving periwinkle meat in natural preservative agents is adequate for a short period (about 24 hours), when the meat is intended for quick sales in the fresh form. To enhance the preservative, shelf-life stability and quality of fresh periwinkle, further processing methods such as smoking and drying is required.

Most of the studies on the processing methods of periwinkle were based on sun drying and smoking methods. Adebayo *et al*. (2008) on the comparative effects of oven drying and sun drying methods on the microbiological, proximate nutrient and mineral composition of *Tympanotonous spp*. and Paul *et al.* (2022) on the proximate composition and biological properties of smoke-dried *Tympanotonus fuscatus* reported that the preservation and processing methods applied on shellfishes have reasonable effects on their proximate composition.

This study is therefore designed to ascertain the effects of natural preservatives and drying methods on the proximate composition of periwinkle, in view to improve on the quality of the processed products and to establish standards that meets with the increasing consumer awareness on the consumption of seemingly better, healthier and safe naturally preserved processed periwinkle.

1.2. Aim and Objectives of the Study

The aim of this study is to ascertain the effects of drying methods on the proximate composition of periwinkle (*Tympanotonus fuscatus*) preserved in natural agents.

The objectives of the study are to

1. determine the proximate composition of the dried *Tympanotonus fuscatus* spp. preserved in natural agents (salt, lemon, lime, alum) and dried with different energy sources

2. compare the effects of smoke-drying and oven-drying techniques on the proximate composition of *Tympanotonus fuscatus* spp. preserved in natural agents (salt, lemon lime, alum).

CHAPTER TWO

2.0 LITERATURE REVIEW

Periwinkles are small edible snails commonly available for sale in markets, especially in the southern part of Nigeria, in sub - Sahara Africa; there is the drastic increase in consumption levels of periwinkle due to the recent awareness of avoiding red meat for health reasons (Peterson *et al.* 2009).

Tympanotonus fuscatus are shell fish dominantly found in brackish waters of the riverine areas of Nigeria, where they are highly prolific and a cheap source of protein in many homes compared to other conventional protein sources, they are also transported to many non-riverine towns and cities, where they are used to prepare various palatable dishes in hotels and restaurants, across the country Nigeria. (Adebayo *et. al.,* 2008) It is the most common periwinkle found in Nigeria. (*Tympanotonus fuscatus*) which are of two (2) varieties; *Tympanotonus fuscatus var fuscatus* which has spine on its shell and *Tympanotonus var radullar* which has a smooth or granular shell (Nior *et al*., 2006) They both can exist within the same ecosystem but one variety is usually dominant in the ecosystem. They are about 4.5-5cm in length usually dark brown or black and have a solid spiral (turbinate) shell. Periwinkles (*Tympanotonus fuscatus*) are commonly abundant in mangrove mud flat; it is edible and common to the Niger Delta region of Nigeria. It is locally known as "PIOM PIOM" to the people of Niger Delta, "Isawuru" by the Yoruba's, "Imekpe" by the urhobo's and "kawa" by the hausa's, "ISAM" to ibo's and calabar's. It serves as good delicacy in soups (Ngozi *et al*., 2011)

Periwinkle meat is a cheap source of animal protein to many poor families in Nigeria when compared with other sources such as meat, fish, egg, chicken and meat (Ogungbenle and Omowole, 2012; Johnnie *et al.,* 2020). According to Inyang *et al.* (2018), seafood which include periwinkle offers consumers superior quality protein than what is obtainable in meat and poultry.

A study carried out by Ogungbenle and Omowole (2012) revealed that periwinkle (*Tympanotonus fuscatus var. radula*) contains 74.74% protein, 1.32% fat, 0.18% carbohydrate, 9.56% ash, 0.74% crude fibre and 13.45% moisture. Periwinkle is also rich in minerals, essential amino acids and some vitamins (Ogungbenle and Omowole, 2012; Ekop *et al*., 2019).

Omega 6 fatty acids present in periwinkle in reasonable amount could offer some health benefits such as brain development, reduction in dementia linked to Alzheimer's disease, symptoms of osteoarthritis and rheumatoid arthritis. Low prevalence of heart diseases among people of the Niger Delta could be as a result of high intake of periwinkle (Nrior *et al.*, 2017). The consumption of periwinkle is known to boost reproduction and help in the treatment of endemic goiter. There is vitamin A in periwinkle which could be beneficial to the eyes and skin.

Also found in periwinkle is vitamin D important in the development of bones and teeth. Nutritional benefits of periwinkle is not limited to the meat. Ground shell of periwinkle provides calcium for animal feed (Jimmy and Okonkwo, 2016; Asemota *et al.,* 2019). The shell of periwinkles are also used for medicinal purposes, bait for catching small fish, gravel supplements, production of scouring powder, ornamentals and cosmetics, powder for pimples and fertilizers (Okpeku *et al*., 2013). Most of the soups prepared in the country Nigeria particularly some native soups in the Niger Delta region such as 'ekpang nkwukwo', 'edikang ikong' 'afia efere', 'afang' and 'asa' are incomplete without the addition of periwinkle which makes it more delicious and nutritious. Tympanotonus species is known as 'isam', 'mfi' and 'udekana' by the Igbos and the people of Akwa Ibom and Niger Delta, respectively. Irrespective of social status, many people relish eating soup prepared with periwinkle and other seafood (Inyang *et al.,* 2018; Chika and Mercy, 2019; Ekop *et al.,* 2019; Adesanya *et al.,* 2021).

In recent years, the demand for periwinkle is increasing due to its affordability, availability and rise in human population (Ogungbenle and Omowole, 2012). Various anthropogenic activities especially in the Niger Delta region where periwinkles are in abundant supply predisposes them to heavy contamination by toxic heavy metals (Chioma *et a*l., 2021). Although *T. fuscatus var. radula* could withstand polluted environment to some extent, a lot of concern have been raised concerning decline in size, population and availability of periwinkles (Bob-manuel, 2012; Okpeku *et al*., 2013). The use of mercury in medicine, electrical fittings, pesticides and other agrochemicals predisposes the environment to pollution. Some activities associated with pollution of the environment with lead include crude oil exploration, pipeline transportation and corrosion inhibition (Otitoju and Otitoju, 2013). According to Elekima *et al.* (2020), periwinkles have met several criteria for selection as an ideal bio indicator of metals. The accumulation of mercury and lead in periwinkle over time as a result of biomagnification, cross reactivity between the heavy metal and radioactive agent might lead to food poisoning in humans (Davies *et al*., 2006; Freeman and Ovie, 2017). High level exposure to mercury causes permanent damage to the brain, kidney and fetuses still undergoing development. There is high risk of miscarriages in pregnant women due to exposure to high amounts of lead. Severe damage to the brain and kidney which ultimately lead to death is caused by lead. Intake of food with high level of lead can elicit vomiting, abdominal pain, drowsiness and convulsion (Otitoju and Otitoju, 2013; Abiaobo *et al.*, 2020). Commonly practiced processing method of freshly harvested periwinkle (FHP) is by boiling this edible food with or without the shell (Omenwa *et al*., 2011). Despite numerous nutritional and health benefits derived from eating periwinkle, one of the major limitations is short shelf life (Inyang *et al*., 2018). Traditionally, periwinkle is preserved by drying or smoking (Ngozi et al., 2020) and according to Nrior *et al.* (2017), periwinkle is best preserved by sun-drying, oven-drying, smoke-drying storage at constant temperature or kept inside a refrigerator. Research findings have shown that different processing and preservation methods to some extent influences the level of nutrients and other properties of food including shellfish species (Devi, 2015; Venugopal and Gopakumar, 2017).

2.1. Processing and Preservation

Processing refers to the mechanical or chemical operations performed on fish in order to transform or preserve them. It also refers to the processes associated with fish and fish products between the time fish are caught or harvested, and the time the final product is delivered to the customer (Zohar *et al.*, 2001) Fish preservation is the method of increasing the shelf life of fish and other fish products by applying the principles of different branches of science in order to keep the fish, after it has landed, in a condition wholesome and fit for human consumption (Sun da wen, 2008)

The purpose of processing and preservation is to get the periwinkle to the ultimate consumer in good, usable condition. The steps necessary to accomplish this begin before the periwinkle is collected and do not end until the periwinkle is eaten or processed into edible form (Kilgen *et al*., 2002) Periwinkle begins to spoil as soon as it is caught. Therefore, the key to delivering a high-quality product is the use of natural preservatives such as lime, salt and potassium aluminium sulphate (alum). Periwinkle that is spoiled is obviously unusable. Periwinkle that is not cared for may not be so obviously bad, but it loses value because of off-flavors, mushy textures or bad colour that will discourage a potential purchaser from buying. If customers have bought bad periwinkles, they probably won’t buy another one. On the other hand, if you consistently deliver good quality at a fair price, people will become loyal customers. (sinha et al., 2000). There are different forms of processing which include;

- Primary processing and
- Secondary processing.

2.2 Primary Processing

Primary processing is the processes involves in preserving the periwinkle before it is being converted into an acceptable form to the consumer. Periwinkles are highly perishable, although they have the ability to stay outside water or dehydrated for weeks due to their nature of coiling inside their shell. Concern for quality should begin immediately after collection (obire et al., 2020) The first collection is to bring the periwinkle on board in good condition. Periwinkles should come in contact with clean surfaces. It is important that the bacterial contamination be kept low by keeping the collection bag or baskets and storage boxes free of dirt, or any pollutant with the use of clean sea water and scrubbing brush for this purpose. (Troller et al., 2000) for high quality periwinkle, brining, liming and use of alum (potassium aluminum sulfate) should be applied.

2.3 Secondary Processing

The purpose of secondary processing is to convert the raw fish into a form that is still acceptable to the consumer and that has a longer shelf life. Secondary processing includes;

2.3.1. Salting

Whether an end in itself, or as part of a smoking or drying process, salting has been used for thousands of years to preserve marine products, salting has not adverse effect on the value of periwinkle protein. Bacterial growth can be significantly retarded by the presence of sufficient quantities of common salt (sodium chloride). When periwinkle is placed in a brine solution, the salt penetrates the periwinkle, and the waters extracted from the tissues by osmosis. At a salt concentration of 6-10 percent in periwinkle, the activity of most bacteria that cause spoilage will be inhibited. The higher the salt concentration in the periwinkle, the longer its storage life. Several methods of salting are commonly used: dry salting, kench salting, brine salting and pickle salting. (Foster Smith *et a*l.,2018). Dry salting is the simplest method and used primarily for marine organisms with high water content. Granular salt is rubbed onto the outer and inner surface of the shelled

Tympanotonus fuscatus. Kench salting is a similar method that involves stacking split periwinkle with layers of salt. The pickle or liquid formed is allowed to drain. In Brazil and India, sardines are preserved by pressing and salting. Avoiding air exposure is almost impossible in these dry-salting processes. However, wrapping the product in a plastic bag reduces contact with air.

The wet-salting methods (brine and pickle) are recommended for tropical applications, especially with aquatic organisms containing high fatty acid content. In brine salting, the entire or periwinkle is immersed in an aqueous salt solution. An 80-100 percent saturated brine solution (270-360g of salt per liter of water) is preferred. For strongly cured periwinkle, about 30g of salt per 100g of periwinkle is needed. During processing the brine solution will become diluted as water is drawn from the periwinkle. Another wet cure is pickle salting. The periwinkle is covered with salt and placed in layers with salt between the layers, since a watertight container is used, the brine that is formed begins to cover the fish. If the periwinkle is not completely covered within 3-4 hours, saturated brine is added to cover them. A lid is placed over the fish to ensure that they are completely submerged in the liquid. At least 10-24 days are required for complete curing (Powers *et al*. 2013)

Halophilic or salt-tolerant bacteria or molds may grow on incompletely dried salted periwinkle or on dry salted periwinkle that have become moist. However, pickle-cured fish are free of growths of halophiles, because these organisms are aerobic, and the brine of pickle-cured fish does not contain sufficient oxygen to support their growth. These oxygen-poor environments also support their growth. This oxygen-poor environment also reduces rancidity in fatty periwinkle (Ezeama *et al.,* 2018).

2.3.2. Drying

This is the removal of moisture content from an aquatic organism in this case “periwinkle”. Drying involves the application of energy in order to vaporize and mobilize the moisture content within the porous products. During this process, the heat and mass transfer occurs simultaneously (Sinha *et al*., 2018.).

There are different forms of drying which include;

- Sun drying
- Smoke drying
- Oven drying

2.3.2.1. Sun drying

Most of the aquatic species in rural areas of the tropics are preserved by sun drying. While the cost of sun drying is low, there are significant losses due to spoilage, contamination by dust, and insect infestation, particularly when the fish are laid close to the ground. As a first step, raised structures would reduce contamination from some wastes and insects.

Solar dryers are simple and inexpensive and can eliminate much of the spoilage that occurs with traditional drying methods. These driers usually have a wood or bamboo frame table, covered with plastic or glass to produce an enclosed chamber, the surface of the table can be covered with black plastic or paint to absorb the sun’s heat, with openings at the top and bottom of the drier, air will be heated and flow around the fish.

Periwinkle exposed to this flow of heated air will rapidly lose moisture, reducing drying time by as much as half over open air drying. Similar driers have been constructed in Bangladesh, Indonesia, Rwanda, the Philippines, and Papua New Guinea. Solar driers have a number of advantages over traditional drying methods. They exclude rain, insects, animals, and dirt, and can produce temperatures high enough to reduce the possibility of mold or bacteria spoilage.

A wide variety of designs for solar driers has been developed. Most require only inexpensive, readily available materials. In addition to plastic film and bamboo, discarded oil drums, scrap wood, thin metal sheeting, and even mud may be used (Okoh, 2012).

2.3.2.2. Smoke-drying

Smoking is another traditional preservation technique that is used to prepare aquatic organisms such as: fish, periwinkle among others with long storage lives. Smoke contains substances that kill bacteria, thus helping to preserve the produce. The heat also dries the organism. Often times, periwinkle are salted before they are smoked. In tropical countries, aquatic organisms like periwinkle are heavily smoked at relatively high temperatures so that they are also cooked. In hot smoking, temperatures may remain between 60º-110ºC for 4-6 hours. This is usually long enough to eliminate the non-sporulating spoilage bacteria. However, the spores of *Bacillus subtilis* and *B. mesentericus* survives even with longer periods of smoking. The bactericidal action of the smoke is considerably increased by the presence of salt in the fish.

In simple Ghanaian smokers, the fish are laid on trays or hung in the column of smoky air above the fire. The traditional mud oven is often cylindrical with a thatched cover, with a stokehole is located in the base wall and the oven grill bars installed at about 1m off the ground. The fish are placed on the grill bars and must be regularly turned to encourage even drying and smoking. A variation from the mud stove involves the use of 250-gal steel drums instead of mud for the construction of the cylinder, the drums are cut along their length and rejoined to form a larger cylinder. Fish are smoked on grills within this cylinder. The Ivory Coast kiln is efficient and simple and has a degree of acceptance, even though it deviates from traditional designs, the base of the kiln is 2x2 m and is about 1m high. The sides are sheet metal or corrugated zinc, nailed to wooden support posts in the four corners, a steel drum, with a hole cut about one-third of the way down the side, is laid horizontally through one of the kiln walls. The fish trays are stacked on top of the oven,

The Chorkor smoker is gaining acceptance by West African women involved in traditional fish smoking. The design, based on traditional smokers, has a long life, low construction cost, and low firewood consumption. The capacity of this smoker is large and up to 18kg of fish can be smoked on each tray, with as many as 15 trays fitted on the oven. The oven is rectangular and about twice as long as they are wide and there is a dividing wall in the middle, with two stokeholes in the front, and a fire pit in each chamber. The walls are made of clay mud, cement, or clay blocks. The top of the walls must be level so that the wooden-framed trays can rest snugly against them. The oven should be low but the fire ought to be at least 60 cm below the lowest tray. The wooden frames of the drying trays rest on the edge of the oven walls and therefore do not catch fire, these trays effectively form a chimney above the fire in which heat and smoke constantly circulate. (Sinha *et al.,2018*).

2.3.2.2 Oven drying

This is a type of drying that involves the use of an Oven. A drying oven is a type of oven that is used to remove moisture from an object or material. The stove uses heat to evaporate the water, and the resulting vapor is vented outside. They are typically used for materials sensitive to water damage, such as electronic components or chemicals. Oven dry method is the most accurate and simplest method for water content determination. In this method complete drying of moisture content occurs and water content in sample is calculated accurately by a maintained temperature in the oven (105° C to 110° C) for 24 hours. It is the most expensive form of drying technique. It requires less man power compared to smoke drying. Drying ovens are used to speed up the drying process by creating optimal conditions for evaporation. By using a hot air oven, the material is dried by convection heating which circulates the air around the material. This type of drying is effective and efficient for large quantities (Patric *et al*., 2018).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study Area

Ogbe-ijaw market is one of the main fish market located at Warri South West Local Government Area of Delta state. It covers land area of 494 sq/mi (1,279 km^2) and ha a density of 325 sq/mi (125.5km^2) as recorded in the population census of 2022.

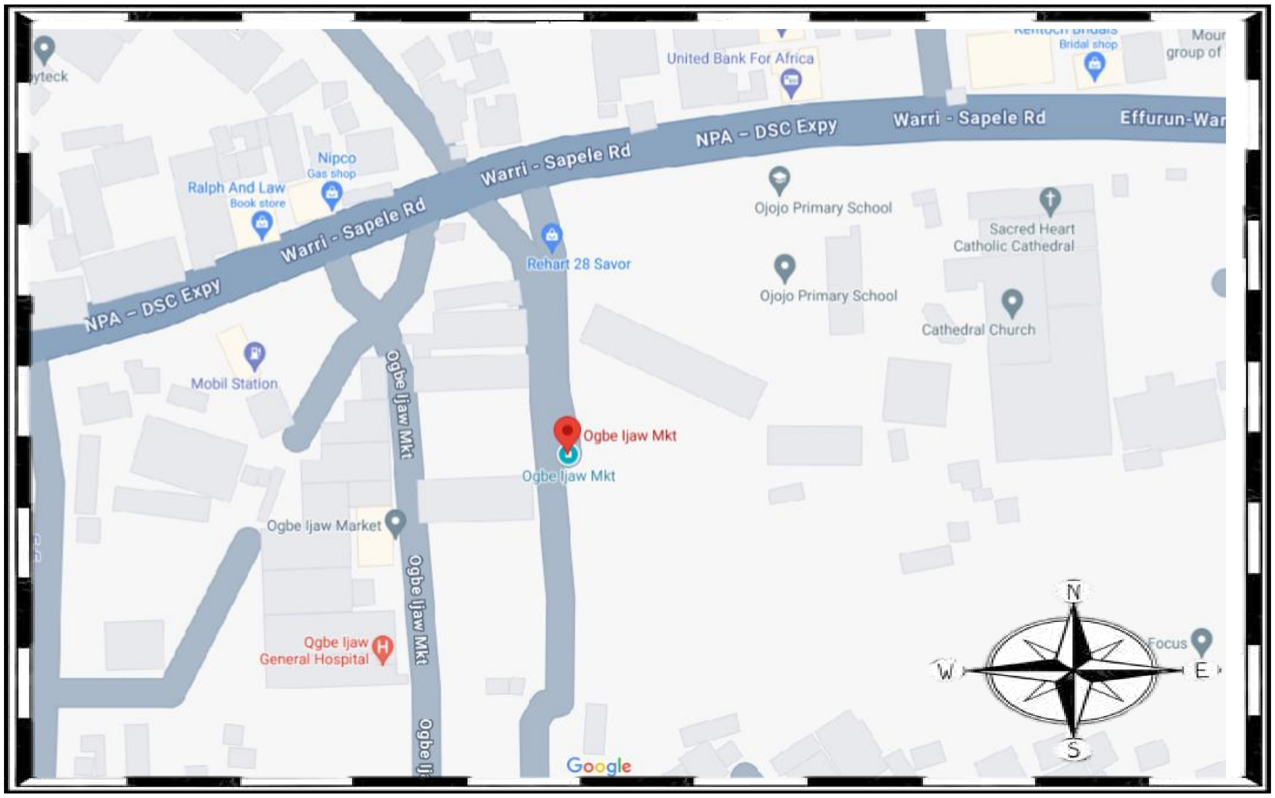


Figure 3.1: Map showing Ogbe Ijaw market in Warri

Source: Google map (2024)

3.2 Experimental Design

The experiment was designed as a 2 (energy sources) by 4 (treatments) factorial design and replicated three times under a completely randomized design.

3.3. Processing of Samples

The samples were thoroughly rinsed in running water to remove muddy particles and other debris matter. The periwinkle was then boiled at a temperature of 100^{o}C for 10 minutes to enable shucking and the meat was removed from its shell into a clean bowl using a sterile needle. The periwinkle meat was divided into four (4) portions of equal sizes and tagged A, B C, and D. Each of the portion was then preserved in a 20 Litre solution, containing either of the natural agents (salt, lemon, lime and alum) at inclusion levels of 5% concentration respectively and cover for a period of 24 hours. The samples were thereafter removed from the preservative solutions, rinsed in running water and placed on a covered rack to drain before drying will commence.

3.3.1. Smoke - drying procedure

'Smoke drying' method described by Abu and Eli (2019) with some modifications will be adopted in smoking the preserved samples. 50g of periwinkles was poured inside a sterilized removable wire mesh tray and kept on a rack. The smoking kiln (improved design) was loaded with charcoal and ignited to preheat the chamber for 15-17 min. and afterwards the periwinkles was placed at the central chamber for smoking at a controlled temperature range that was maintained between 50-70^{o}C. Smoking operation was done until a constant dried weight was obtained and the hot smoked periwinkles was allowed to cool at ambient temperature (28±2°C) and packed in sterile zip lock packs that was stored on shelf at room temperature (30±2°C).

3.3.2.Oven - drying procedure

An oven dryer, electrically powered, was set to operate at 65ºC and when the oven was heated up, the metal trays loaded with the preserved samples was introduced into the oven. To ensure uniformity in drying, the trays containing the periwinkle samples was swapped with top trays brought lower and lower ones sent up at 30 minutes interval. The optimal temperature of the oven was maintained between 50 - 70ºC. The drying operation was done until a constant dried weight was obtained and the hot dried periwinkle was allowed to cool at ambient temperature (28±2°C) and packed in sterile zip lock packs that was stored on shelf at room temperature (30±2°C).

3.4. Determination of Proximate Composition

The recommended methods of the Association of Official Analytical Chemist (AOAC 2006) was used for analyzing the proximate composition of the periwinkle samples subjected to the different natural preservation agents (salt, lemon, lime and alum) and processed using the drying techniques (smoke-dried and oven-dried).

3.4.1.Materials

Materials needed for the analysis includes;

- Dried Periwinkle (*Tympanotonus fuscatus*)
- Sterilized needles
- Hand gloves
- Bowls
- Analytical balance
- Drying oven
- Desiccator

- Muffle furnace
- Soxhlet extraction apparatus
- Kjeldahl digestion apparatus
- Fibertec system or manual filtration apparatus
- Crucibles
- Weighing dishes
- Beakers
- Pipettes
- Concentrated sulfuric acid
- Hydrogen peroxide
- Sodium hydroxide pellets
- Copper sulfate
- Concentrated ammonium hydroxide
- Petroleum ether
- Acetone
- Nitric acid
- Standard acid and base solutions
- Indicators
- Distilled water

3.4.2 Sterilization of Materials

All glass wares such as pipettes used in the study were thoroughly washed with detergent and rinsed in clean water to ensure that they were grease free. They were allowed to drip dry and arranged in cannisters. The glass wares were then properly sterilized in an autoclave at 121°C for 15 min. at Pa/pressure. Those that had screw caps were sterilized with their caps relatively loose around the glass mouth. The inoculating loops were sterilized by the red heat method with the aid of the Bunsen Burner flame before and after use. Commercial Petri dish which had been already sterilized were used.

3.4.3. Moisture content

1 gram of the dried periwinkle (smoke-dried and oven dried) was weighed into a dry pre-weighed crucible and dried in an oven (Astell Hearson, England) at 105°C for 18 h to a constant weight. The moisture content of the sample was then calculated using the formula below:

$$\text{Moisture content} = \frac{\text{Weight of fresh sample (g)} - \text{Weight of dry sample (g)}}{\text{Weight of fresh sample (g)}} \times 100$$

3.4.4.Carbohydrate content

0.1 g of periwinkle was weighed into a 25 ml volumetric flask. One milliliter (1 ml) of distilled water and 1.3 ml of 62% per chloric acid was added to the content of the flask. Thereafter, it was swirled for 20 min to achieve complete homogenization. Thereafter, the content of the flask was made up to 25 ml mark using distilled water and stoppered. The resulting solution was filtered through a glass filter paper. One milliliter (1 ml) of the filtrate was collected and transferred into a 10 ml test tube. The content of the test tube was diluted to volume using distilled water. One milliliter (1 ml) of the working solution was pipetted into a clean test tube and 5 ml Anthrone reagent was added. One millilitre (1 ml) of distilled water and 5 ml Anthrone reagent was mixed. The whole mixture read at 630 nm wavelength with the aid of UV visible spectrophotometer (Model 754 Ningbo Hinotek Tech. Co.) using 1 ml distilled water and 5 ml Anthrone reagent prepared as blank. Glucose solution (0.1 ml) was also prepared and was treated as the sample with Anthrone reagent. Absorbance of the standard glucose was read and the value of carbohydrate as glucose was calculated using the formula below:

$$\% \text{ CHO as glucose} = \frac{\text{Absorance of sample}}{\text{Absorbance of standard glucose}} \times 25$$

3.4.5. Crude protein

Exactly 0.5 g of periwinkle was transferred into Kjeldhal digestion flask. Then, one and half tablets of catalyst would be added into a flask containing 10 ml concentrated H_2SO_4. The flask with its content was gently heated in an inclined position in a fume cupboard until frothing ceases and boiled briskly until digestate is clear. The content was cooled and diluted to 100 ml with distilled water. Ten milliliter (10 ml) of the digestate was added to another flask with 45% NaOH solution (10 ml) and connected to a distillation apparatus. The ammonia was then subjected to steam distillation into boric acid (5 ml) indicator in a 100 ml conical flask and 50 ml distillate was then collected. The distillate was titrated against the standard acid (0.05 N) HCl.

$$\text{Crude protein (\%)} = \text{N} \times \text{Protein factor}$$

$$\text{Where: \% N} = \frac{\text{Sample titer - Blank titer x N of acid x 1.4 x 6.25}}{\text{Weight of Sample}}$$

3.4.6. Ash content

Porcelain crucible was weighed and 1.0 g of the periwinkle sample was placed in the porcelain crucible. The sample on the crucible was then ignited and thereafter dried on a mantle in a fume cupboard until the smoking ceased. The crucible containing 1.0 g of periwinkle sample was taken into a muffle furnace to ash for 3 h at 500°C. The ash left in the crucible was allowed to cool in a desiccator, weighed and the result obtained was expressed as the percentage ash.

Using this formula: $$\text{Ash (\%)} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.4.7. Crude fat (lipid) content

Two grams (2g) of the sample was carefully wrapped in a filter paper and placed in a soxhlet extractor. The dried distillation flask was weighed and the extractor was placed inside it. Slowly, solvent (acetone) was introduced into the distillation flask through the condenser attached to the Soxhlet extractor and a retort stand clamp was used to hold the set up. Cooled water jet was allowed to flow into the condenser. During the process of continuous refluxing, the lipid in the solvent chamber was extracted and when it was observed that fat in the sample had been completely extracted, the condenser and the extractor was disconnected. Then, the solvent was allowed to evaporate in order to concentrate the fat. The flask was then dried in the air or oven to constant weight and re-weighed to obtain the weight of fat in the sample.

$$\text{\% lipid} = \frac{\text{Weight of flask and extract} - \text{Weight of empty flask}}{\text{Weight of sample extracted}} \times 100$$

3.4. 8. Crude fiber content

The material without fat and sulphuric acid 1.25 % (w/v) was placed in a 200 ml beaker and 50 ml of NaOH (1.25% v/w) was covered with a watch glass. NaOH (1.25 % v/w) was used to mix the residue that was washed with 50 ml of water to the initial flask and then boiled for 30 min which gave an insoluble material. The insoluble material was placed on a filter paper, washed very well with hot water, and finally with 15 ml of 95%

ethanol. Thereafter, the filter paper was dried for 1 h at 100°C to a constant weight and incinerated to ash at 500°C for 1 h. After allowing the ash to cool, the weight was subtracted from the increase in weight of the filter paper because the insoluble material and the differences expresses the fiber.

$$\% \text{ Fiber} = \frac{\text{Weight of fiber}}{\text{Weight of sample}} \times 100$$

DETERMINATION OF ENERGY VALUE

The energy value of oven dried and smoked periwinkle subjected to different treatments was calculated using the water general factors for the energy density of fat (9kacl/g) and protein (4 kcal/g) (Kiczorowska *et al.,* 2019). The relationship between the crude values of protein, fat and carbohydrate was obtained from the proximate analysis as earlier described by Oginni (2019) was used to calculate the energy value of the samples.

$$\text{Energy value (kcal/100g)} = \text{P(protein)} \times 4 + \text{C(carbohydrate)} \times 4 + \text{F(fat)} \times 9$$

STATISTICAL ANALYSIS

All the analyses were carried out in duplicate. Statistical analysis was carried out with the aid of Statistical Package for Social Sciences (IBM, SPSS) version 23. Data generated from the analyses was subjected to Analysis of Variance (ANOVA) to determine significant difference as $P<0.05$. Duncan's multiple range tests was used in evaluating the differences between means.

CHAPTER FOUR

4.0 RESULT

4.1 Proximate Composition of Processed Periwinkle (*Tympanotonus fuscatus*)

Table 4.1. indicates the mean proximate composition of samples of fresh and dried (smoke-dried and oven - dried) *Tympanotonus fuscatus* species subjected to different treatment.

Table 4:1: Mean comparison of the proximate composition of dried (Smoke - dried and Oven - dried) periwinkle subjected to different treatments (alum, salt, lemon and lime).

Treatments	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate
T1	8.280 ± 0.838^{d}	61.31 ± 0.085^{f}	8.300 ± 0.566^{cde}	0.100 ± 0.283^{bc}	7.400 ± 0.169^{de}	14.61 ± 0.438^{c}
T2	7.330 ± 0.042^{c}	50.49 ± 0.056^{d}	8.600 ± 0.141^{cdef}	0.250 ± 0.042^{d}	7.920 ± 0.255^{ef}	25.41 ± 0.255^{e}
T3	8.670 ± 0.028^{de}	47.28 ± 0.14142^{c}	8.900 ± 0.283^{ef}	0.000 ± 0^{a}	$7.200 \pm 0{,}424^{d}$	27.95 ± 0.255^{f}
T4	6.550 ± 0.085^{b}	69.72 ± 0.523^{h}	9.000 ± 0.283^{ef}	0.280 ± 0.042^{d}	8.200 ± 0.212^{f}	6.25 ± 0.099^{b}
T5	3.330 ± 0.127^{a}	50.98 ± 0.113^{d}	9.200 ± 0.566^{f}	0.300 ± 0.071^{d}	9.340 ± 0.622^{g}	$27.20 \pm 0.\ 382^{f}$
T6	11.000 ± 0.567^{g}	62.80 ± 0.283^{g}	6.500 ± 0.141^{b}	$0.000 \pm 0\ ^{a}$	5.980 ± 0.0566^{b}	13.82 ± 0.226^{c}
T7	9.670 ± 0.042^{f}	69.86 ± 0.509^{h}	7.800 ± 0.283^{c}	0.000 ± 0^{a}	6.950 ± 0.184^{cd}	5.72 ± 0.368^{b}
T8	9.480 ± 0.283^{f}	57.72 ± 1.195^{e}	7.900 ± 0.707^{c}	0.100 ± 0^{bc}	6.490 ± 0.127^{bc}	18.32 ± 0.431^{d}
T9	10.000 ± 0.579^{f}	46.65 ± 0.071^{bc}	6.600 ± 0.424^{b}	0.000 ± 0^{a}	6.000 ± 0.099^{b}	$30.75 \pm 0.\ 976^{g}$
T10	9.670 ± 0.989^{f}	50.81 ± 1.44^{d}	7.900 ± 0.141^{c}	0.100 ± 0^{bc}	6.900 ± 0.424^{cd}	24.62 ± 1.216^{e}
T11	9.330 ± 0.042^{ef}	45.79 ± 0.296^{b}	8.000 ± 0.424^{cd}	0.000 ± 0^{a}	7.150 ± 0.099^{cd}	28.73 ± 1.400^{f}
T12	$8.670 \pm 0.\ 042^{de}$	50.31 ± 0.707^{d}	8.800 ± 0.141^{def}	0.150 ± 0.042^{c}	7.900 ± 0.325^{ef}	24.17 ± 0.537^{e}
T13	83.500 ± 0.707^{h}	11.71 ± 0.297^{a}	2.005 ± 0.078^{a}	$0.070 \pm 0.\ 014^{ab}$	$1.550 \pm 0.\ 071^{a}$	1.16 ± 0.573^{a}

Values are expressed as mean ± standard deviation of two duplicate. Different alphabet presented along the vertical axis indicates significant difference at $P< 0.05$ among different drying technique.

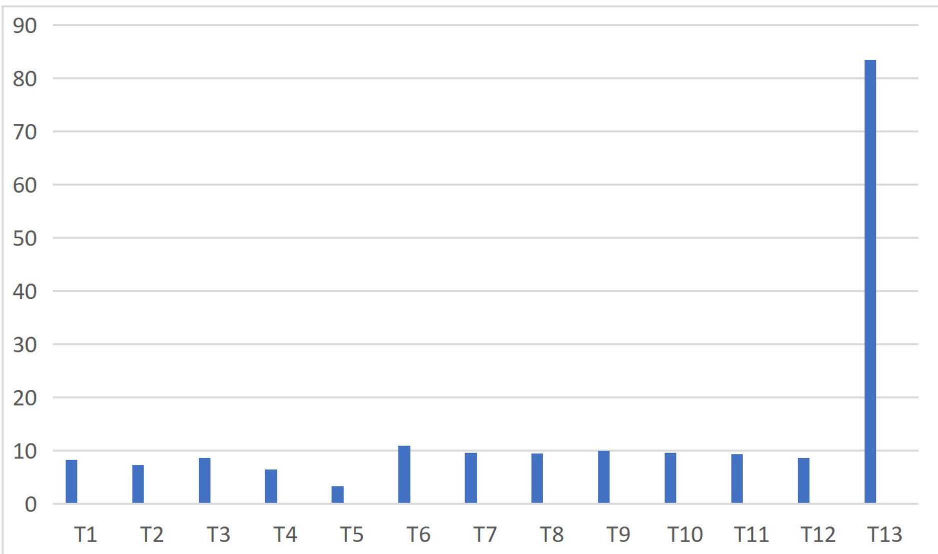
KEY: T1= Oven - dried market sample, T2 = oven - dried alum treated sample, T3 = oven - dried lime treated sample, T4 = oven - dried lemon treated sample, T5 = oven - dried salt treated sample, T6 = oven - dried untreated sample, T7 = Smoke - dried market sample, T8 = smoke - dried alum treated sample, T9 = smoke - dried lime treated sample, T10 = smoke - dried lemon treated sample, T11 = smoke - dried salt treated sample, T12 = untreated smoke - dried sample

4.1.1: Moisture content

The result showed that the samples T13 (83.500±0.707[h]) and T6 (11.00±0.567[g]) had higher moisture content and their mean values were significantly different when compared to the other samples (T1, T2, T3, T4, T5, T7, T8, T9, T10, T11, T12,). Sample T5 had the least moisture content concentration (3.330±0.127[a]).

Below is a graphical representation showing the samples with varying moisture content

Moisture content (%)



Samples

Fig 4:1 Moisture content of dried periwinkle treated with Alum, Salt, Lime and Lemon

4.1.2: Crude protein contents

The study revealed that samples T7 (69.86±0.509[h]) and T4 (69.86±0.509[h]) had the highest crude protein concentration that was significant different at P> 0.05 from the other samples (T1, T2, T3, T5, T6, T7, T9, T10, T11, T12). The sample T13 had the least crude protein concentration (11.71± 0.297[a]).

Below is a graphical representation showing the samples with varying Crude protein content.

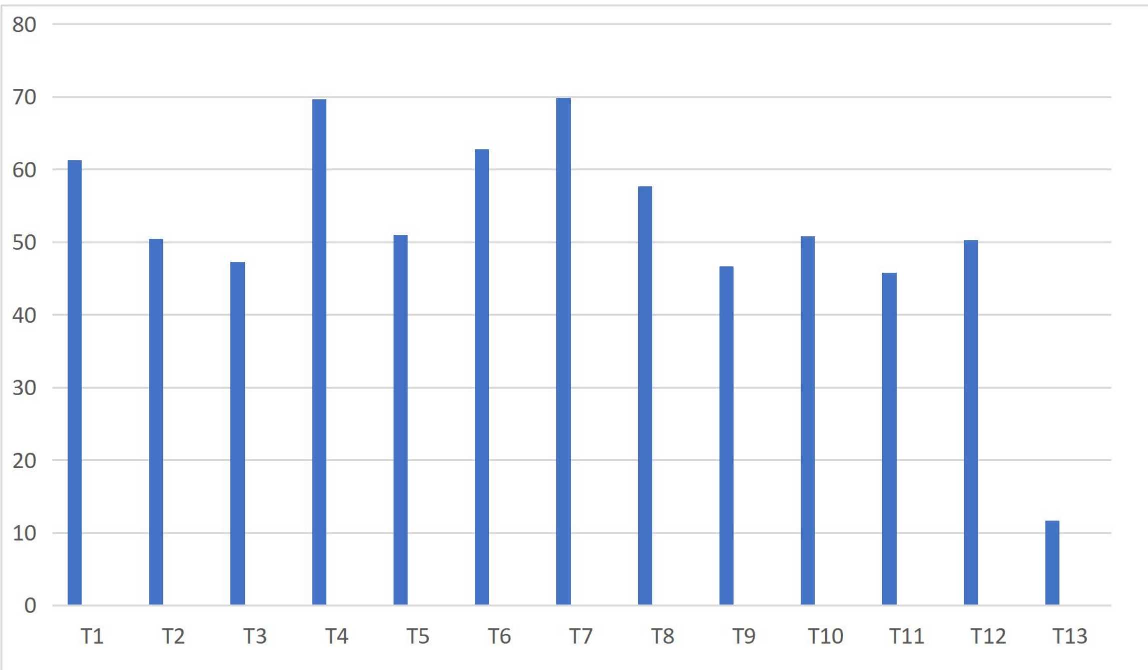


Fig 4.1:2; Crude Protein content of dried periwinkle treated with alum, salt, lime and lemon

4.1.3: Fat content

The result indicates that the sample T5 (9.200± 0.566[f]) had the highest fat concentration, followed by sample T4 (9.000 ± 0.283[ef]), and they are significantly different at p>0.05 from the other samples while sample T13 (2.005 ± 0.078[a]) had the lowest fat concentration.

Below is a graphical representation showing the samples with varying Fat content.

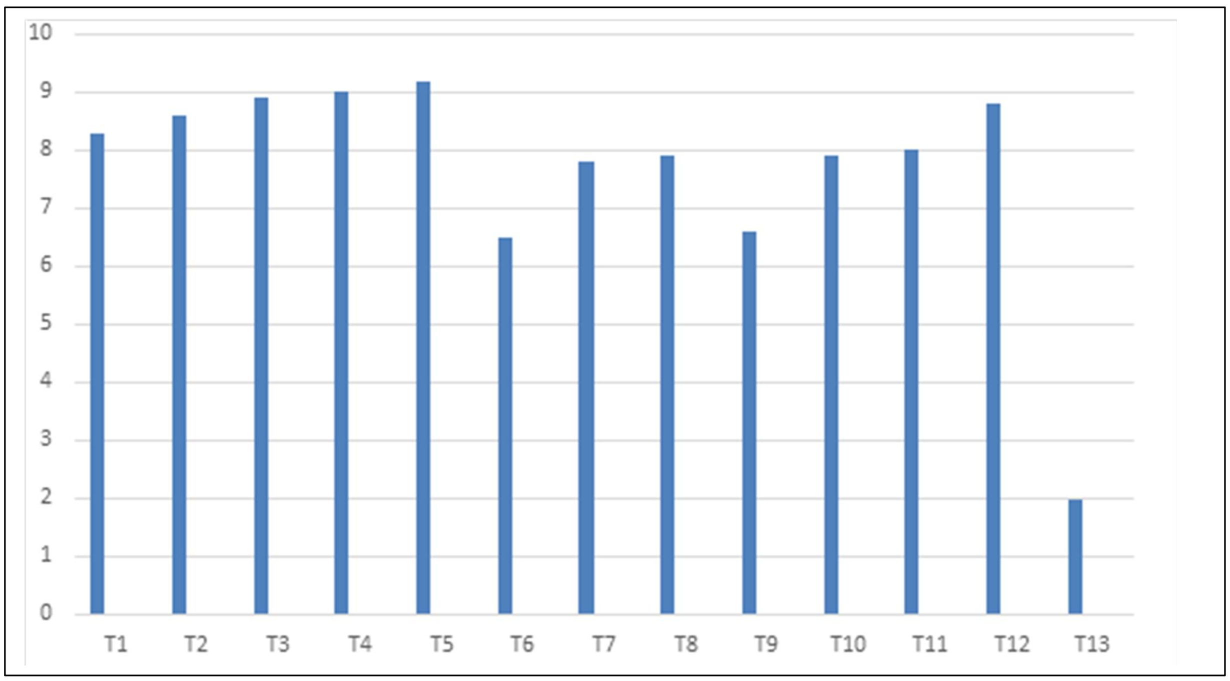
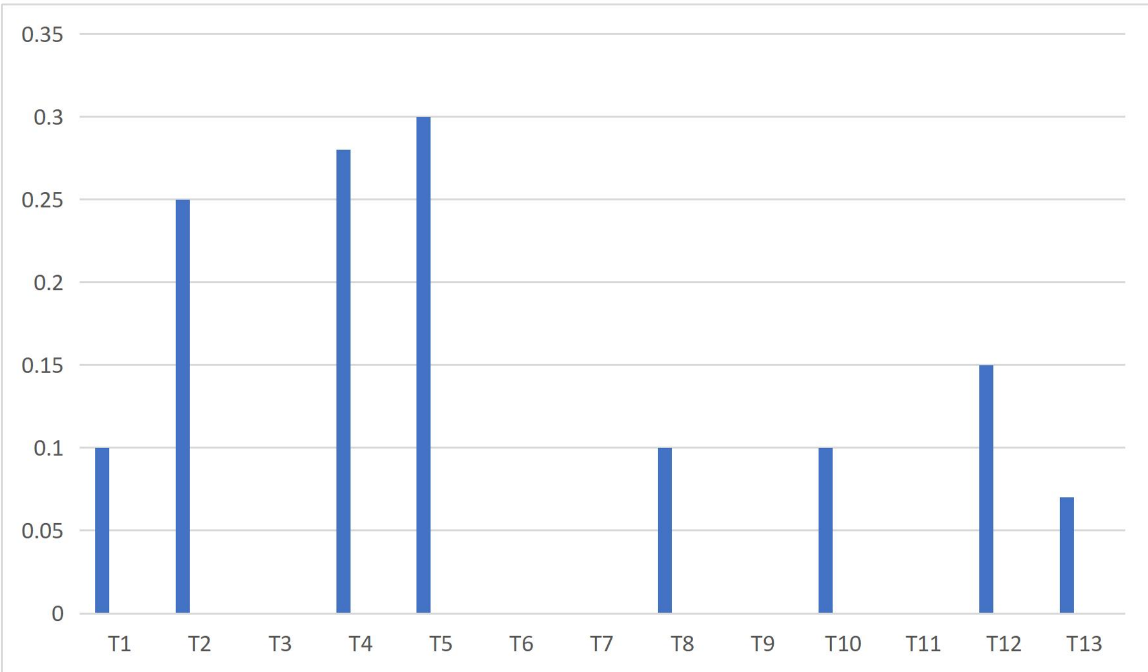


Fig 4.1.3: Fat content of dried periwinkle treated with alum, salt, lime and lemon

4.1.4: Fibre content

In this study, the sample with the highest Fibre content is T5 **(**0.300 ± 0.071^{d}**),** the second highest is T4 (0.280 ± 0.042^{d}) while the samples with the lowest Fibre content are T3(0.00±0.00[a]) T6**(**0.00±0.00[a]**),** T7**(**0.00±0.00[a]**),** T9**(**0.00±0.00[a]**)** and T11**(**0.00±0.00[a]**).**



Below is a graphical representation showing the samples with varying Fibre content.

Fig 4:4; Fibre contents of dried periwinkle treated with salt, alum, lime and lemon

4.1.5: Ash content

In this study, the sample with the highest Ash content is T5 **(**9.340 ± 0.622^{g}**)** the second highest is T4 (8.200±0.212[f]), and they are significantly different from the others. while the sample with the lowest ash content is T13 (1.550 ± 0.071^{a}).

Below is a graphical representation showing the samples with varying ash content;

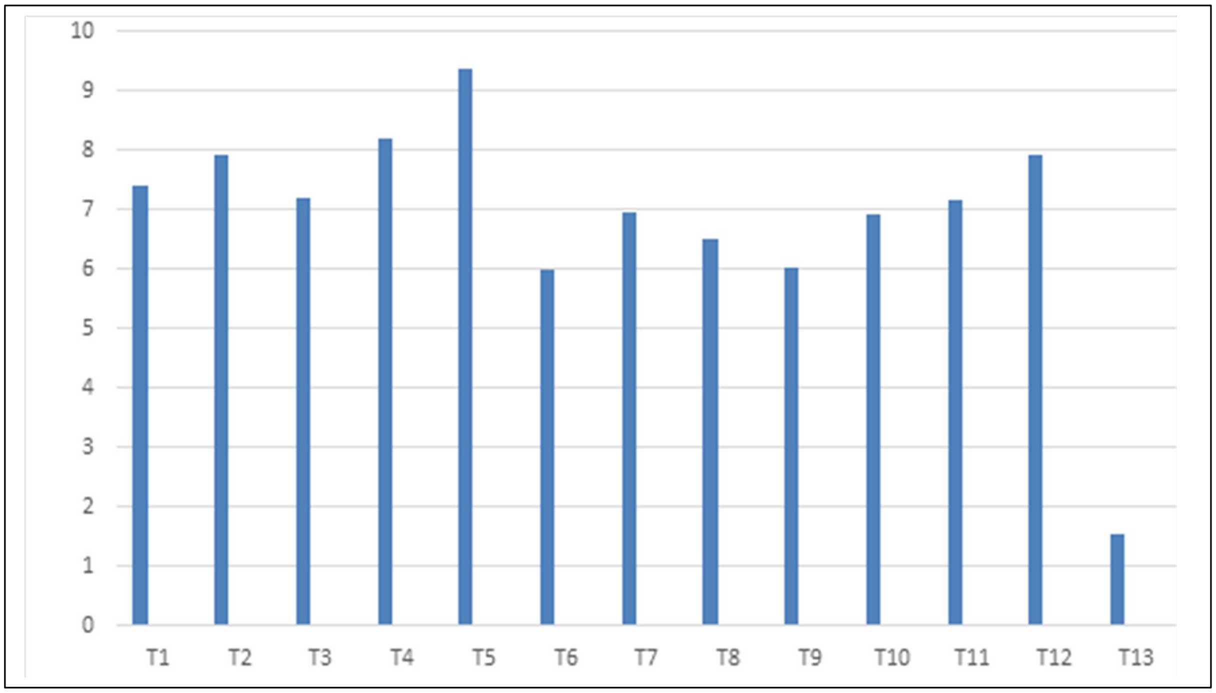


Fig 4.1. 5: ash content of dried periwinkle treated with alum, salt, lime and lemon

4.1.6: CARBOHYDRATE CONTENT

In this study, the sample with the highest carbohydrate content is T9 (30.75 ± 0.976^{g}), the second highest is T11 ($28.73 \pm 1{,}400^{f}$), while the sample with the lowest carbohydrate content is T13 (1.16 ± 0.573^{a}).

Below is a graphical representation showing the samples with varying Carbohydrate content:

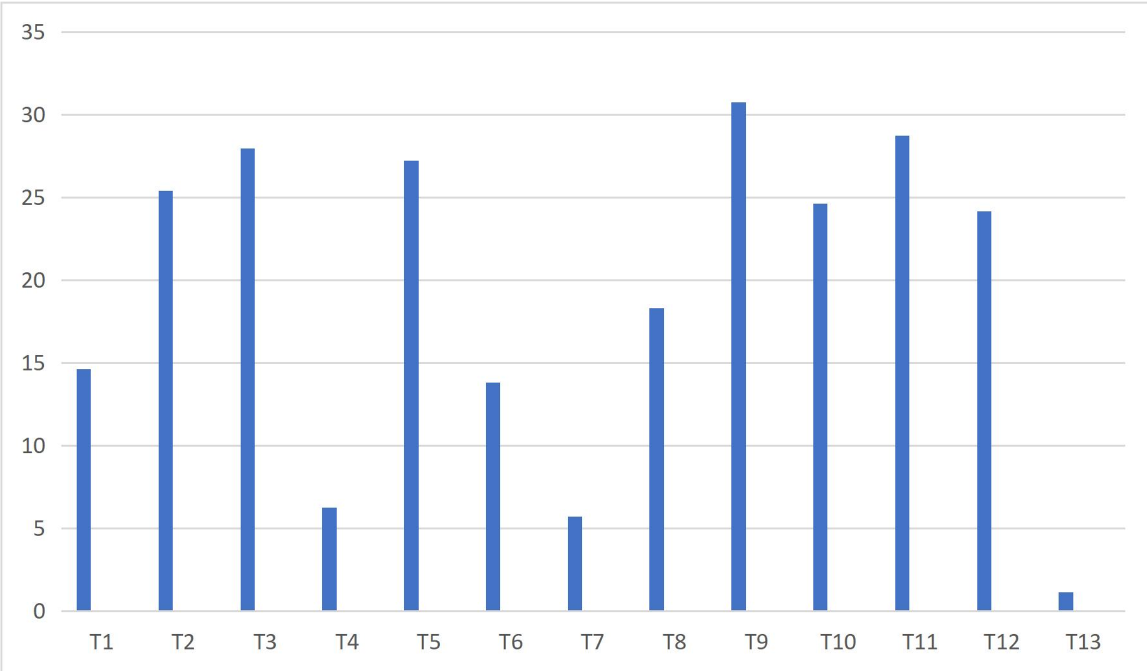


Fig 4.6: Carbohydrate content of dried periwinkle treated with alum, salt, lime and lemon.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Proximate Composition of Oven-Dried And Smoke-Dried Periwinkle Preserved In Alum, Lime, Lemon And Salt.

Table 1 shows the proximate composition of oven – dried and smoke – dried periwinkle (*tympanotonus fuscatus*) treated with alum, lime, lemon and salt.

5.1.1: Moisture content

According to the result in Table 1, the sample with the highest amount of moisture content was T13 (83.500±0.707^{h}), and the lowest was found in sample T5 (3.330 ± 0.127^{a}). The result disagrees with the result gotten from the research carried out by Ogungbenle and Omowole (2012) on the comparative effects of oven drying and sun drying methods on the proximate composition of periwinkle preserved in natural agents (alum) which had a value of (30.4^{g}) as the highest moisture content and (13.7^{a}) as the lowest moisture content.

In this study, T13 (83.500±0.707^{h}) had the highest moisture content because it was untreated and not dried. The fresh periwinkle sample served as a control sample for the study.

The result proved that salt is a better dehydrating agent compared to the lime, alum, and lemon. comparison of oven - dried and smoke -dried *tympanotonus fuscatus* with equal treatments showed that T5 (3.330 ± 0.127^{a}) had the lowest amount of moisture content compared to T11(9.330 ± 0.042^{ef}) because salt is a dehydrating agent as well as a preservative agent, it is used as a means of preserving perishable goods such as fish, periwinkle e. t. c. by reducing the moisture content of the goods thereby increasing the shelf life and reducing microbial load compared to the other treatment agent, this is also attributed to the fact that Salt attracts water due to a principle called osmosis. When salt dissolves in water (brine), it creates a region with a lower water concentration than the surrounding environment. Water naturally moves from areas of high concentration to low concentration, this draws water out of things like food placed in the brine, dehydrating them.

Lime: Quicklime (calcium oxide) can be dehydrating, but in a different way. It reacts with water to form calcium hydroxide (slaked lime), releasing heat. This can indirectly remove moisture through evaporation, but it's not the same as direct water absorption like salt.

Lemon and alum: These primarily contain citric acid and aluminum potassium sulfate respectively. While they might contribute slightly to drying due to their acidic nature or attracting some moisture, they aren't strong dehydrating agents compared to salt.

From the result of this study, I infer that oven –drying is a more efficient energy source for moisture content reduction compared to smoke- drying. In oven drying, T5 (salt treated periwinkle sample) had the lowest amount of moisture content with a mean value of 3.33, while in smoke- drying, T11 (salt treated periwinkle sample) had the lowest amount of moisture content with a mean value of 9.330 compared to the other dried treated samples.

Table 5.1.1: Comparative effect of oven – drying and smoke – drying of *tympanotonus fuscatus*

SAMPLES	OVEN – DRYING (T1 - T6)	SMOKE – DRYING (T7 – T12)
Market Periwinkle Sample	8.280 ± 0.838^{d}	9.670 ± 0.042^{f}
Alum treated periwinkle sample	7.330 ± 0.042^{c}	9.480 ± 0.283^{f}
Lime treated periwinkle sample	8.670 ± 0.028^{de}	10.000 ± 0.579^{f}
Lemon treated periwinkle sample	6.550 ± 0.085^{b}	9.670 ± 0.989^{f}
Salt treated periwinkle sample	3.330 ± 0.127^{a}	9.330 ± 0.042^{ef}
Untreated Periwinkle Sample	11.000 ± 0.567^{g}	$8.670 \pm 0.\ 042^{de}$

5.1.2. Crude protein content

In this study, the sample with the highest amount of crude protein content was T7 (Smoke – dried market periwinkle sample) with a value of 69.86 ± 0.509[h] and T4 (Oven – dried Lemon treated periwinkle sample) with a value of 69.72± 0.523[h]

while the sample with the lowest amount of crude protein content was T13 (Fresh market sample) with a value of 11.71± 0.297[a.]. The findings from this study was quite similar to that of previous study conducted by (Adebayo *et al.,* 2006) where oven – dried periwinkle was 60.5[g] while smoke – dried was 61.3[g] and the lowest amount of crude protein was found in the fresh periwinkle sample which had a value of 10.5[a.] The result of this differences was as a result of preservatives such as; lime, lemon, salt, and alum in this study of which none was applied in the previous studies. Another factor attributed to the differences was duration.

SAMPLES	OVEN – DRYING (T1 - T6)	SMOKE – DRYING (T7 – T12)
Market Periwinkle Sample	61.31± 0.085[f]	69.86± 0.509[h]
Alum treated periwinkle sample	50.49 ± 0.056[d]	57.72 ± 1.195[e]
Lime treated periwinkle sample	47.28± 0.14142[c]	46.65± 0.071[bc]
Lemon treated periwinkle sample	69.72± 0.523[h]	50.81± 1.44[d]
Salt treated periwinkle sample	50.98±0.113[d]	45.79±0.296[b]
Untreated Periwinkle Sample	6.500 ± 0.141[b]	50.31± 0.707[d]

Table 5.1.2; comparative effect of oven – drying and smoke – drying of *Tympanotonus fuscatus*

5.1.3. Fat content

The highest amount of Fat Content was found in sample T5 (Oven – dried salt treated periwinkle) which had a value of 9.200 ± 0.566^{f} while the lowest amount of fat content was found in sample T13 (Fresh Periwinkle Sample which had a value of 2.005 ± 0.078$^{a.}$ This result disagrees with previous findings by Tayo A.A et al., 2006, whose result had a value of 3.5^{g} as the highest and 0.05^{a} as the lowest. The difference between the research conducted by Tayo A.A et al., and this research is that treatments such as lime, lemon, salt and alum were applied in this research whereas previous research were only based on comparative differences between Oven – drying and smoke - drying techniques without the application of any preservatives.

Table 5.1.3: Comparative effect of oven – drying and smoke – drying of *Tympanotonus fuscatus*

SAMPLES	OVEN – DRYING (T1 - T6)	SMOKE – DRYING (T7 – T12)
Market Periwinkle Sample	8.300 ± 0.566^{cde}	7.800 ± 0.283^{c}
Alum treated periwinkle sample	8.600 ± 0.141^{cdef}	6.490 ± 0.127^{bc}
Lime treated periwinkle sample	8.900 ± 0.283^{ef}	6.600 ± 0.424^{b}
Lemon treated periwinkle sample	9.000 ± 0.283^{ef}	7.900 ± 0.141^{c}
Salt treated periwinkle sample	9.200± 0.566^{f}	8.000 ± 0.424^{cd}
Untreated Periwinkle Sample	6.500 ± 0.141^{b}	8.800 ± 0.141^{def}

5.1.4. Fibre content

From the result shown in Table 1, sample T5 (Oven – dried salt treated periwinkle sample), T4 (Oven – dried Lemon treated periwinkle sample) and T2 (Oven – dried alum treated periwinkle sample). With values $0.300 \pm 0.071^{d,}$ 0.280 ± 0.042^{d} and 0.250 ± 0.042^{d} respectively which are significantly similar at $P< 0.05$ have the highest amount of fibre content, T3(Oven – dried salt treated periwinkle sample), T6(Oven – dried untreated periwinkle sample), T7(Smoke – dried market periwinkle sample), T9(Smoke – dried lime treated periwinkle sample) and T11(Smoke – dried salt treated periwinkle sample) have no fibre content in their sample and are statistically similar at $P<0.05$. The result of this findings is very similar to that of Adebayo *et al.* (2006).

Table 5.1.4: Comparative effect of oven – drying and smoke – drying of the fibre content of *Tympanotonus fuscatus*

SAMPLES	OVEN – DRYING (T1 - T6)	SMOKE – DRYING (T7 – T12)
Market Periwinkle Sample	0.100 ± 0.283^{bc}	0.000 ± 0^{a}
Alum treated periwinkle sample	0.250 ± 0.042^{d}	0.100 ± 0^{bc}
Lime treated periwinkle sample	0.000 ± 0^{a}	0.000 ± 0^{a}
Lemon treated periwinkle sample	0.280 ± 0.042^{d}	0.100 ± 0^{bc}
Salt treated periwinkle sample	0.300 ± 0.071^{d}	0.000 ± 0^{a}
Untreated Periwinkle Sample	0.000 ± 0^{a}	0.150 ± 0.042^{c}

5.1.5. Ash content

The highest amount of ash content was found in T5 (Oven – dried salt treated periwinkle sample) with a value of 9.340 ± 0.622^{g} while the lowest amount of ash content was found in T13 (Fresh Periwinkle Sample) with a value of $1.550 \pm 0.071^{a.}$ the result from this study agrees with that of Adebayo et al., on the effect of drying methods on the biological and proximate composition of periwinkle (*Tympanotonus fuscatus*). Which had a value of 9.1^{f} and $1.45^{a.}$

5.1.6. Carbohydrate content

The highest amount of carbohydrate content was found in T9 (Oven – dried lime treated periwinkle sample) with a value of 30.75 ± 0.976^{g} while the lowest amount of carbohydrate content was found in T13 (Fresh Periwinkle Sample) with a value of $1.16 \pm 0.573^{a.}$ the result from this study agrees with that of Adebayo et al., on the effect of drying methods on the biological and proximate composition of periwinkle (*Tympanotonus fuscatus*). Which had a value of 9.1^{f} and 1.45^{a}.

In comparison to smoke - drying and oven - drying technique, periwinkle had more carbohydrate content in smoke -dried samples than in oven - dried samples.

Table 5.1.5: Comparative effect of oven – drying and smoke – drying on the carbohydrate content of *Tympanotonus fuscatus*

SAMPLES	OVEN – DRYING (T1 - T6)	SMOKE – DRYING (T7 – T12)
Market Periwinkle Sample	14.61 ± 0.438^{c}	5.72 ± 0.368^{b}
Alum treated periwinkle sample	25.41 ± 0.255^{e}	18.32 ± 0.431^{d}
Lime treated periwinkle sample	27.95 ± 0.255^{f}	30.75 ± 0. 976^{g}
Lemon treated periwinkle sample	6.25 ± 0.099^{b}	24.62 ± 1.216^{e}
Salt treated periwinkle sample	27.20 ± 0. 382^{f}	28.73 ± 1.400^{f}
Untreated Periwinkle Sample	13.82 ± 0.226^{c}	24.17 ± 0.537^{e}

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

Based on the result and findings, it can be inferred that Oven – drying is the best form of energy source for drying periwinkle because it reduces moisture content that could enhance spoilage compared to the smoke – drying.

The best treatment for moisture reduction is salt and this can also be attributed to the fact that Salt attracts water due to a principle called osmosis. When salt dissolves in water (brine), it creates a region with a lower water concentration than the surrounding environment. Water naturally moves from areas of high concentration to low concentration, this draws water out of things like food placed in the brine, dehydrating them. Salt is a more dehydrating agent compared to alum, lime, and lemon.

Oven – drying also increases the crude protein content of periwinkle compared to smoke – drying, it increases the fat content, fibre content and ash content.

Smoke- drying is best for increasing carbohydrate content, although, the values of Smoke-drying and Oven – drying from the result are very similar.

The best preservative agent is salt, closely followed by Lemon, lime and alum.

RECOMMENDATIONS

1. The use of Oven as an energy source for drying periwinkle should be encouraged since findings shows that the periwinkle dried with Oven had higher protein content than Smoke – drying source. It is therefore recommended that Oven – drying should be used as a source of drying periwinkle.

2. The use of salt for preservation and treatment should be encouraged since findings shows that salt reduces moisture content, increases crude protein, increases fibre content, ash and carbohydrate.
3. The use of Lemon for treatment should be encouraged among market women.
4. The periwinkle processors should observe strict hygiene measure during processing like shucking and washing using clean water, using of apron, hand gloves and hair net during processing so as to get good quality dried periwinkle
5. Education of fish processors and consumers by food surveillance agencies, including National Agency for food and Drug Administration and Control (NAFDAC), World Health Organization (WHO), United International Children Educational Fund (UNICEF) and United Nations on health implication of the consuming of not properly processed periwinkle
6. The Federal Government should provide adequate extension personnel to educate the processors/ marketers on effective use of Energy sources for drying.

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APPENDIX

Plate 1: Weighing of fresh periwinkle

Plate 2: Self shucked periwinkle sample

Plate 3: Treating of Periwinkle in preservation solutions (Alum, salt, lime and Lemon)

Plate 4: Spreading of periwinkle on the mesh wire for smoking

Plate 5: Weighing of smoked dried periwinkle

Plate 6: Weighing of oven dried periwinkle

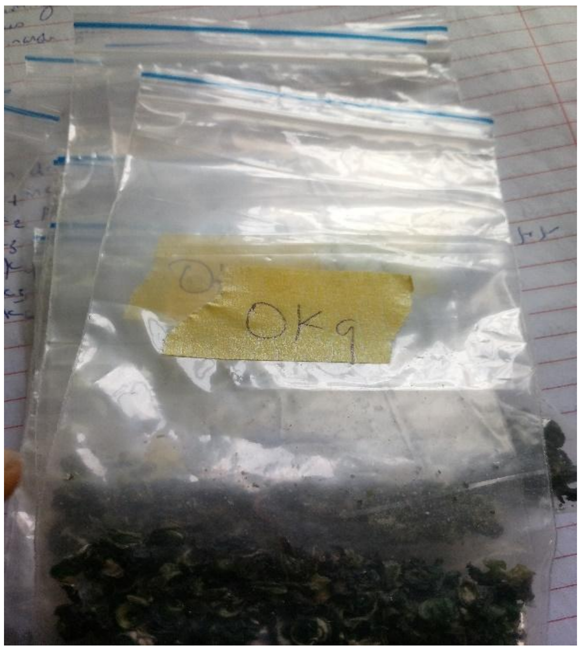

Plate 7: Packaged dried periwinkle for proximate analysis