UNIVERSITY OF CAPE COAST

COMPARATIVE STUDY ON THE ORGANOLEPTIC PROPERTIES OF SALTED FERMENTED FISH

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BY

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DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature …………………… Date……………………………

Name:…………………………………………………………………….

Supervisor's Declaration

I hereby declare that the preparation and presentation of the thesis was supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Supervisor's Signature…………….……… Date……………………………

Name:…………………………………………………………………….

ABSTRACT

Salted fish is a Ghanaian delicacy used in meal preparation as a flavour and taste enhancer. This product is less expensive and afforded by all manner of persons across families and generations. The objective of the study was to compare two fermented fish (opaa and saflo) in their organoleptic properties and macro-nutrients composition. The mixed method design comprising sensory evaluation and laboratory work were employed for the study. Purposive and convenience sampling were used to select fishes from Mankessim market and panelists for the study. Questionnaires were used to collect data for sensory evaluation. The data was analysed using descriptive statistics and the means compared with two sample t-test. The study revealed that both fishes had good organoleptic properties and nutritional values. However, the palm nut soup used had statistical significant different in their organoleptic properties with a value of 0.002 which is less than the alpha value of 0.05. The fresh and fermented fishes had varied amount in their macro-nutrients composition. Hence, both fishes in their fresh and fermented had statistically significant difference with values of 0.018 and 0.021 for opaa and saflo respectively. The study recommended that, fermented fish should be used other protein sources to beef up their protein values due to the decrease in their nutrient values after fermentation. Additionally, spices like ginger, garlic, pepper can be used to boost their organoleptic properties during fermentation.

KEYWORDS

Fermented Fish

Macro-nutrients Composition

Palava Sauce

Palm-nut Soup

Panelists

Organoleptic properties

Opaa

Saflo

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DEDICATION

I dedicate this work to all those who helped in diverse ways to make it a success.

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LIST OF ACRONYMS

AOAC	Association of Official Analytical Chemists
FAO	Food and Agriculture Organisation
GSS	Ghana Statistical Service
MMDA	Mfantseman Municipal and District Assembly
NOAA	The National Oceanic and Atmospheric Administration
TVN	Total Volatile Nitrogen
USAID	United States Agency for International Development
W.H.O	World Health Organisation

CHAPTER ONE

INTRODUCTION

Background to the Study

Over the years, the population of the world has steadily been on the rise which has caused an increase in food consumption (Vareiro et al., 2009; Kearney, 2010). In this dispensation according to literature, people are conscious of the kind of prepared meals they consume in relation to with the correct amount of nutrients, and the actual food commodities used for a healthy body (Mahmud et al, 2018; Sanuade et al., 2018; Boccellino, & D'Angelo, 2020).

At the pinnacle of food budget, however, is a demand for first class protein foods because of their value in the development of human beings (Vareiro et al, 2009). Although, fish and other animal foods form a major component of people's diet, the former is preferred to meat due to its digestibility, less connective tissues and less cooking time (Faber et al., 2010, Schar et al. 2020). Globally fish has an estimated value between 17%-20% of total animal protein intake and about 19% of total animal intake in Africa (FAO, 2022, Obeiro et al., 2019). In support, USAID (2013) and FAO (2007), argue that singly, fish forms about 60% of animal protein consumed as part of Ghanaian diet, and contributes 22.4% of the food budget by households with 25.7% consumption in poor homes.

Fish is identified as having played a tremendous role in the diet of people (Khan et al., 2020). This essential role according to literature is based on its provision as a source of protein with a high biological value (Boler & Woemer, 2017). Examples of such valuable nutrients include, fats and oils but not limited to polyunsaturated fatty acids, vitamin A and D, vitamin B, and other micronutrients which are needed for proper growth, development and healthy body (Hammond, 1974; Boler & Woemer, 2017; Mahmud et al., 2018; Maulu et al., 2021, FAO, 2022). Additionally, consuming at least two servings of oily fish a week, reduces cardio-vascular diseases, depression, improves brain health, and eyesight, due to the omega-3 and vitamin A content (Maulu et al., 2021). Furthermore, this type of animal protein food contains all the essential amino acids required by the body for proper cell development, maintenance and or repair, hormone production and other important functions (Mendivil, 2021).

Despite these identified nutritional values in fish, literature argues that, there exist contaminants like mercury, dioxins, and pesticides which can harm the nervous system of a foetus or young child (Mozaffarian & Rimm, 2006). The authors continue that consumption of fish is linked to cancers and reproductive problems and other pollutants that can pose health challenges (Mozaffarian & Rimm, 2006).

Fish as an aquatic animal found in the sea, rivers, streams and other water bodies, can be grouped as seawater and fresh water fish. This is because each water body has specific species of fish in them. Fish by their nature gives room to spoilage (Singh et al., 2018).Generally, high moisture content, enzymatic actions, oxidation and high nutritional components (Amuna, 2014; Anon, 2021), make animal proteins susceptible to microbial attacks (Tettey, 1987; Sulleyman et al., 2018).

In order to offset some if not all of these harmful negative characteristics of fish, varying degrees of technology have been introduced to effect the treatment of protein foods and for that matter fish, without affecting the nutrient content, flavour and texture (Duah, et al, 2019). The application of different types of treatment to fish and other food commodities improves the taste of the commodity and this either render the microbes inactive or reduce their activities (Devrani & Pal, 2017). Moreover, such applications enable fish to stay for longer period of time, making it available during the lean season and to reach the vast population in good condition for consumption (Nwaigwe, 2017). These processes that are adopted to inhibit the growth of bacteria activities is termed preservation. This is a method or treatment normally used to improve on the quality standards, marketable value and shelf life of food items of which fish is no exception. This makes it more presentable and increase demand by buyers (Davies & Davies, 2009).

Preservation is a processing practice which prevents the growth of micro-organisms causing food spoilage (yeast, fungi and bacteria) and slows down the oxidation of fats that causes rancidity (Devram & Pal, 2017). The main principle of preservation is to slow down or prevent the action of food spoiling agents without damaging the food or adding harmful substances to it (Duah et al., 2019). Naturally, fish deteriorates quickly if not given the right care. Preservation is therefore, critically required to maintain the nutritional value, colour, texture and flavour and in addition enabling easy transportation of products (Encyclopaedia MDPI, 2021).

Preserving fish adds variety to meals, helps to avoid monotony, prevent waste and save money for other purposes (Coppola et al., 2021). The concept is important because of the many advantages, although, it may contain toxins when stored over a long period of time. Again, the chemicals added to fish during preservation could also pose certain challenges to the health of consumers (Iko Afé et al., 2021). In preservation of food commodities, literature states that, various methods are employed to keep food from spoilage after harvesting (Desrosier & Singh, 2018).

The preservation of fish can be grouped into two main methods: ancient and modern. The oldest and most frequently used methods of preservation in homes (ancient) includes; salting, drying, salting and drying, smoking, and curing while, other methods (modern) used commercially, follows as freezing, freeze drying, canning, pasteurization, irradiation, addition of chemicals like vinegar (pickling), benzoic, sulphites, ascorbic acid, and nitrates (Kumar, 2019). In the process of preserving fish, the consumer's desire for safety, nutritional quality, and required organoleptic attributes in food consumption should as much as possible be retained (Tsvetko & Stoyan, 2007). This need has supported the development of more current technological ways of preserving food to help consumers achieve their utmost satisfaction (Guzik et al., 2022). In this discussion, Essuman (1992) agree that, the techniques can be used singly or grouped to achieve the planned effects. Although all mentioned preservation methods are applicable to fish, this study is interested in the use of salt in fish preservation.

According to Thorarinsdottir et al., (2001), the salting method is applied to foods to destroy pathogens. The salting of fish as a method of preservation is cost effective and ancient (Carusi, 2019) as "Methuselah", which, has since been used over the years by generation upon generation to preserve the catch from the sea and other water bodies (Institute of Medicine (US) Committee on Strategies, 2010).

This ancient method has been used continuously, mainly to prevent post-harvest losses which could occur because of the handling and storage strategies applied after fish leaves its habitat (Kumar & Kalita, 2017). Though salted fish has benefits, WHO (2020) advises that, a high intake of salt leads to hypertension and other cardiovascular diseases. A person's daily recommended intake of salt should reasonably be one (1) teaspoon; equivalent to less than six (6) grams for an adult's consumption (British Heart Foundation, 2021). Literature argues that the quantity of salt applied to get fish fermented is highly above this recommended intake by the British Heart Foundation (2021). Authors therefore appropriately suggest that salted or fermented fish need to be soaked in water for some hours or overnight in order to get rid of some if not all the salt before adding to meals (WHO 2020).

In Ghana and elsewhere, one prominent food commodity, is the fermented salted fish, popularly called 'momoni', which, happens to be a favourite condiment added to local dishes like, okro stew and soup, palm nut soup, palava sauce, 'abomu" (grounded kontomire/garden eggs eaten with ampesi), garden eggs stew, "mpotompoto", (yam/ cocoyam porridge), as well as beans stew (Anihouvi et al., 2006: Kindossi et al., 2016). Mostly, salting of fish takes different dimensions to create varying kinds of 'momoni' which is similar to the old staple food (fermented fish) in Europeans cuisines and the 'garum' (fermented fish) in Greek and Roman cuisines (Giyatmi, 2017). The major interest is to make it a taste and flavour booster and this has given it names in different languages in Ghana. The Akans call it "momoni", Gas says "looshala", and for Ewes, it is "lafifi (Sawer, 2019). In Egypt and Sudan, it is called feseekh, which is served in Egypt as an appetizer as well as the main dish during certain feasts (El Sheikha et al., 2014). In Benin and Ivory Coast, the commodity is called, 'launhoin' (Anihouvi et al., 2006); Chinese call it 'cantonese' and is popularly nicknamed as the "poor man's food" due to the salt content, to bring variety and avoid monotony in their rice dishes (Anon, 2021). Again, the Greeks and Romans call fermented fish, 'garum' (Gityami, 2017).

Whilst China uses the commodity as a traditional weaning food, and as an accompaniment to rice and other staple meals (Yu et al., 1989, 1981; Topley, 1973), Iceland uses it particularly, fermented skate as their main meal before the celebration of Christmas Eve (Steingrimsdottir et al.,2018). In addition to making or creating asumptuous meal, the fermentation of fish also helps to reduce facilities needed to store fresh fish, as well as providing job opportunities for families living along the coast (FAO, 2022).

From literature, some countries ferment fish by drying with or without salt whilst others use the two processes. In Ghana both processes that is salting and drying are used and this study is interested in looking at the two. The salting process involves dry salting, where a measured quantity of rock salt is applied directly onto the fish and wet salting or brining, where an amount of salt is dissolved in water before the fishes are placed in (FAO, 2021). Fishes from both sea and river sources and type (white, oily, shell) can be salted, either whole (big/small), gutted or cut into pieces.

In Akan, Ga, and Ewe languages fermented fish means" stinking" that is something degradative or is an item that gives an offensive odour similarly to the 'garum' described by Gityami (2017). The degradative nature of the fish brings about the momoni flavour and taste where the fish after catch is left to stay overnight to get the flavour before salting to get the texture and taste (Peharubia, 2021).

Fish spoilage is hastened by factors like, oxidation, microbial action, enzymatic actions and moisture (Anon, 2021). Oxidation is a process whereby nutrients in food lose colour and break down when exposed to oxygen in the air. This causes some foods to brown losing their quality whereas others go rancid (fats and oils) hastening the destruction of oily fish as compared to white fish (Sampels, 2013); making the preservation of food vital to either slow down or prevent spoilage.

Microbial action from bacteria, moulds, yeast, and fungi, encourages deterioration and increase spoilage in foods faster since they are tiny and can only be seen under the microscope (Kuley et al., 2019). The authors continue that these microorganisms multiply faster when the right conditions like warmth, food such as sugar and moisture are available. Also, microbial action can cause food contamination during harvesting, storage, processing, distribution and handling or preparation (Desrosier& Singh, 2024) Moisture as another food spoilage factor, means the amount of water a substance contains. The higher the moisture content, the faster the spoilage and vice-versa. Thus, to make food stay for longer periods of time, the water in the food needs to be brought low or to the barest minimum. Thus, the reason above dictates that fresh catches are frozen, smoked, dried and salted to preserve them for a longer period and also prevent them from deteriorating faster.

Foods in their natural form are alive and subject to enzymatic actions through maturing and continuous ripening which further causes food to go bad. Though enzymes cause fruits, vegetables and other foods to ripen and look attractive, when the commodities are not used for some time, they decay. In fish and meat, this reaction causes it to decay, by becoming very soft and finally breaks apart.

During the process of salting fish, it is made to undergo autolysis where the fish is fermented for several hours before salting. This brings out the momoni flavour used for meal preparation as a taste and flavour enhancer. However, a pungent odour is left on the hand after handling salted fish which is profound than salted beef. The odour allows insect invasion which encourages maggot growth and infestation thus, affecting the shelf life of the fish. This odour can be perceived by the senses in a process called sensory analysis.

Quality is an attribute consumer's look out for when buying consumables. This helps them to have value for money. Likewise, in the use of food items for cooking, fresh and quality (Wasiu et al., 2016) is needed to prevent diseases and its associated complications. Thus, in assessing quality when selecting fish, organoleptic properties such as sight, smell, touch, taste can't be ignored (Essuman, 1992). The changes that occur in fish during preservation as a result of enzymatic action (Thorarninsdoltir et al., 2001), microbial growth (Elsevier, 2021) brings about the differences in sensory qualities. According to Addow et al (1990), the tongue has four (4) taste bud namely; bitter, salty, sweet and sour. These properties play a part in helping to differentiate between products.

The two fish species used in the study are; horse mackerel (Trachurus trachurus) popularly called "opaa" in Akan, "kpanla in Ga and "Fafa" in Ewe and Spanish mackerel (Scomberomorus tritor) which is also known as "Saflo and Safo by the Gas and Akans respectively. Spanish mackerel a fish from the family of Scombridae which is of Atlantic origin distributed around Canary Islands, Senegal, Gulf of Guinea and Angola. It is bluish-green on the back fading to silvery on the sides marked with three (3) rows of vertically elongated orange spots. It feeds on small pelagic mainly sardines and anchovies. It has five (5) years life span (North Carolina Environmental Quality, 2022, NOAA fisheries, 2022). On the other hand, the horse mackerel is found in the Gulf of Guinea extending to Ghana along the shores of the coastal regions because it prefers more temperate waters. It feeds on small fishes, shrimps and squids of varying age and growth. The common name horse mackerel is derived from Old Dutch word "Horsmakreel" meaning a mackerel which spawns over a shallow or bank, a hors, which is horse mackerel in English. It is also believed that the name came from the fish riding on the back of other fishes (NOAA, 2022).

Statement of the Problem

Preservation of fish is necessary to keep it in usable amounts and good shape until its usage is required, because the process makes the commodity available all year long, especially during the lean season (FAO, 2011). The several modes of preservation on one hand, are used to prevent losses and or waste of fish during bumper harvests, encourages the consumption of diversity of fish preparations which, on the other hand. This tends to prevent a monotonous provisions of fish diets. Aside the need to preserve, to avoid the monotonous way of consuming fish, several means are employed in processing fish to attain diverse alternatives. In line with this assertion, Boziaris (2014), opines that food processing is crucial because seafood, especially fish, is often treated to achieve two main goals: preservation and the acquisition of a wide range of goods. Although some traditional food preservation techniques may degrade or eliminate some vital nutrients or reduce their digestion (Holma et al., 2013), such techniques have been found to give fish their distinctive features. For example, Majumdar et al. (2009) suggested that fermentation, when used to preserve fish, enhances the sensory attributes of the fish. Although there are several ways to preserve fish and obtain them in a variety of methods, such as, smoking, salting, frying, and drying, fermentation, the latter is a popular approach since it is affordable (Isola et al., 2022). Authors argue that fermented fish has specific characteristics that offer consumers unique flavour and aroma (Giyatmi (2017). Invariably fermented fish or as locally called, 'momoni' has been used in Ghana to enhance food preparations as done elsewhere. This could be attributed to its distinctive qualities, especially in terms of the unique aroma that stands out whenever it is used as indicated by Giyatmi (2017). Additionally, fermented fish is cheaper than the fresh ones sold on the market and provides nutritional values when added to meals prepared at homes and or other commercial cooking outlets in the country. Wasiu et al. (2016), argued that the most important attribute of any product is its quality which is directly dependent on consumer satisfaction based on the sensory properties which include flavour, taste, palatability and aroma. The use of 'momoni' in meal preparations, has gained grounds in various Ghanaian homes and the study area is no exception. The fishes under study are predominately used in the study area in their fresh, smoked and fermented-salted states. However, their constituents and organoleptic properties are not known as there appear to be limited studies on comparing the organoleptic properties of different types of fermented fish. Authors have looked into areas pertaining to the methods used for fermented fish; Holma et al. (2013) investigated the proximate composition of redfish with three different traditional processing methods (smoking, frying and salting) and Amedekanya (2021) compared the nutritional composition and sensory properties of fermented cassava fish using different periods of fermentation. Based on this, the basic interest of this study is to conduct sensory analysis to find out if there are differences in the organoleptic properties (taste and flavour) of the two fishes. This study also finds it worthy to conduct a macro nutrients analysis for confirmation or otherwise of the proximate values of fermented fish made with the fishes under investigation.

Main objectives of the study

The study sought:

To compare the organoleptic properties and macro nutritional composition of the traditional fermented fish condiment "momoni" made from two different types of fish.

Specific objectives /Aims of the Study

The study seeks to investigate and compare the organoleptic properties of two fermented fish. Specifically, the study seeks to:

1. Compare the organoleptic properties of "momoni" made from Horse mackerel (Opaa) and Spanish mackerel (Saflo).
2. Compare the macro-nutrients composition of "momoni' made from Horse mackerel (Opaa) and Spanish mackerel (Saflo).

Research Questions and Hypotheses

Research questions

The questions for the research are;

1. What difference(s) exist in the organoleptic properties of the fermented fishes?
2. What are the macro-nutrients composition for fresh and fermented opaa and saflo?

Hypotheses

These hypotheses guided the study:

$H_{o:}$ There is no statistically significant difference in the organoleptic properties of fermented fish when used for/or:

a. stew
b. soup
c. steamed

$H_{1:}$ There is statistically significant difference in the organoleptic properties of fermented fish when used for/or:

a. stew
b. soup
c. Steamed

H_0: There is no statistically significant difference in the macro-nutrients composition of fermented opaa and saflo.

$H_{1:}$ There is statistically significant difference in the macro-nutrients composition of fermented opaa and saflo.

Significance of the Study

Fermented fish is a traditional food consumed in many cultures across the world and understanding its organoleptic properties from different species, contributes to preserving culinary traditions and cultural heritage.

The results of the study will be of benefit to households, caterers and the food industry to have a broader range of choices of fermented fish and the preferred type to use in their meal preparations to get the desired effects. This helps to promote diversity in food consumption.

Producers and other stakeholders will know the kind of fish to use for "momoni" to ensure consumer acceptability and satisfaction. This will enhance quality of the product.

The findings from the study will add to the body of knowledge for academic purposes and also serve as a basis for advanced research that may throw more light on the usage of "momoni".

Delimitations

The study focused on the use of two fish species from the mackerel family (horse mackerel and Spanish mackerel). The study was limited to investigating the organoleptic and proximate composition of fermented fish of horse mackerel and Spanish mackerel.

Limitations

The panelistts were asked to rinse their mouth with lemon juice before tasting a new dish. However, since the study was made up of six different dishes, the possibility of carry over effect of a tasted dish on the other may have occurred. Finally, the fermented fish samples were soaked in water for a period of time before using for soup, sauce and steaming them to decrease the salt quantity. The soaking of the fermented fish samples before using for the dishes might have affected the sensory properties of the fermented fish samples.

Operational Definition of Terms

Opaa: Opaa is a local name for horse mackerel in Ghana.

Saflo: Saflo is a local name attributed to Spanish mackerel in Ghana.

Organoleptic Property: Organoleptic property is the perception or satisfaction we derive from food through the use of our senses.

Fermented fish: Fermented fish is a fish which has gone through certain defined processes to create differences in taste, texture and flavour and is usually used as a condiment.

Palm-nut soup: Palm-nut soup is a soup prepared with palm fruits.

Palava sauce: Pa thelava sauce is a stew prepared with kontomire (cocoyam leaves).

Preservation: Preservation is a method applied to ensure that food is kept for future use without spoiling easily.

Organisation of the Rest of the Study

Chapter Two reviewed literature that is related to the study. The review consisted of the conceptual review and empirical review. The Third Chapter described the methodology that was used for the study (that is, research design, population, sample and sampling technique, data collection instrument, data collection procedures, ethical consideration, data processing and analysis). Results and discussion of data collected was done in Chapter Four. Finally, a summary, conclusion, recommendations, and areas for further research were presented in Chapter Five.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter presents the literature that was reviewed. The reviewing of literature in any research work is of utmost importance as it puts the research problem under investigation in its broader perspective. This chapter reviews literature under the following major sub-headings:

a) Conceptual Review

b) Empirical Review

Conceptual Review

Under the conceptual review, the study is interested in finding out about the following;

- Fish as a food commodity
- Nutritive Value of fish
- Classification of fish species
- Sources of fish
- Preservation of fish
- Mode of preserving fresh fish as "momoni"
- Concept of organoleptic properties of food commodities
- Proximate composition of fish

Fish as a Food Commodity

One of the most significant sources of animal protein in the tropics is fish, which is also widely acknowledged as an excellent source of other nutrients for the upkeep of a healthy body (Karrar, 2007). Fish contributes a significant amount of protein to the global diet, making up between 17% and

20% of all human meals (Obiero et al., 2019). The Ghanaian community is not an exception when it comes to the inclusion of diverse species of fish in daily meal provisions. Amedekanya (2021) argued that, diverse species of fish serves as a source of protein for individuals worldwide as it is incorporated in daily meals; since most households depend on the intake of fish to achieve their intake of balanced diet daily. Consequently, fish are consumed by both the poor and the rich, all age groups, invalids, convalescent and in both rural and urban areas; making fish an important source of animal protein.

Nutritive Value of Fish

Fish is among the greatest sources of animal protein. It meets more than 60% of Ghanaians' demand for animal protein and accounts for 15% of all animal protein sources in the nation (Asare-Donkor et al., 2018). Omega-3 polyunsaturated fatty acids and health-promoting oils can be found in fish (Mahmud et al., 2018). Amidst, it is regarded as an excellent supplier of calcium, phosphorus, and iron, which may be found in higher concentrations than in plants and meat from mammals (Lang, 2021). Additionally, fish supply the necessary amounts of animal protein and a number of other nutrients, such as vitamins A and B, which are particularly important for the liver, as well as vitamin E and K (Mohanty et al., 2015).

Nutritional studies have shown that fish protein is superior to beef protein, milk protein, and egg albumin and is in the same category as chicken protein (Lang, 2021). Fish, a type of seafood, has a chemical composition that is relatively similar to that of terrestrial animals; the main components are water (66–80%), proteins (15–20%), ash (0.5–2%), and lipids (5–10%) (Mohanty et al., 2015). Fish composition varies greatly depending on aspects such as size, age, sexual maturity, food, and others (Ashraf et al., 2011). Marine fish oils, are high in polyunsaturated fatty acids of the omega-3 series and are expedient in decreasing the threat of acquiring coronary heart disease and atherosclerosis as well as preventing some types of cancer. It has been shown to be beneficial in epidemiological, clinical, and nutritional studies on animals and humans (Turkmen et al., 2007). The seafood industry is increasing significantly as a result of consumers and business alike being more aware of the health benefits of dietary fish oil (Saito & Udagawa, 1992).

Classification of Fish Species

According to Oehlenschlager (2014), fish species can be classified into four distinct categories based on their habitat, anatomic shape, habitat use and nutritional constituents (Nonye, 2022).

Classification Based on Habitat

The habitat of fish species are used to group them into freshwater or marine species (Oehlenschlager 2009) and migrating fish. Oehlenschlager (2014) opined that certain fish species can be found in both freshwater and marine water as they can survive in both habitat. Freshwater fish species are fish species that can live and survive in water with low salinity (salt).

Freshwater fish species: These are fish species in water that has little or no salt which include spring, streams, ponds, lakes and others. Some common examples of freshwater fish species are cat fish (Clarias gariepinus), perch (Perca fluviatilis), carp (Cyprinus carpio), cod (Gadus morhua), pike (Esox lucius), mackerel (Scomber scombrus) redfish (Sebastes sp.) and others.

Marine fish species: Marine fish species are fish species found solely in waters with a high salinity, such as the sea as they thrive in such water.

Examples are herring (Clupea harengus), hawk fish (Oxycirrhites typus), cardinal fish (Pterapogon kaudern) and Mackerel (Scomber scombrus). These fish species are further grouped into three based on their feeding habit to include herbivorous fish (feed on vegetable origin such as algae and plant materials), carnivorous fish such as tuna and shark (feed on fish or other animals), omnivorous fish (feed on any food or diverse food including plant and animals), filtering fish (feed by filtering water from large amount of water that has been taken in to obtain food) and detritivore fish (feed on the waste of other fish products).

Migrating fish species: Migrating fish species are fish that spend their life span in both freshwater and marine water. Such fish live in either freshwater or marine water at a specific period of time. Basically, these fish species migrate due to diet and reproduction. Migrating fish species have been put into two categories according to their movement. They include anadromous fishes and catadromous fishes. Anadromous fishes are fishes which live in marine water bodies but were born in freshwater bodies and return to their place of origin during the stage they want to reproduce which include shad, trout salmon etc. whiles catadromous fishes live in freshwater but originated from marine water hence return to marine water when they want to reproduce (eg. sea lampreys and eels).

Classification of Fish Based on Morphology and Anatomic Shape

The anatomic classification focus on the structure or form of the fish. That is how the fish is shaped. The structure of fish is influenced by the medium where the fish lives, that is the physical attributes of the specific water where the fish lives. Fish is classified into three groups based on its anatomic shape to include cartilaginous fish species, bony fish species and jawless fish species (Nonye, 2022). Oehlenschlager (2014) also grouped them into round fish, snake-shaped fish and flat fish.

Bony fish species are also known as chondrichthyes (Nonye, 2022). The unique features of this fish species is that they possess jaws, a skeleton of bones, paired fins and scales. Examples are seahorse, salmon, trout and others. Cartilaginous fish are the species that possess cartilaginous skeletons with a ventrally-positioned mouth and a single set of oral jaws. An alternative name given to this type of fish species is osteichthyes (Nonye, 2022). They belong to the chondricthyes class and are located in marine water. Examples are skates, sharks and rays.

Jawless fish species are fish species that do not possess jaws, fins and have the ability to regulate their body temperature. They are widely known as agnatha fish species and are further classified into two to include mixinoideos and petromizontidos. Mixinoideos are those type of jawless fish species that have cylindrical and long body shape whiles petromizontidos possess the shape of a sucker with immobile mouth.

Classification Based on Habitat Use

Oehlenschlager (2014) simply define pelagic fish species as “fish that swim in the open sea in big swarms”. They are only connected to the top of the water column, and occasionally only to the open ocean instead of the coastal ocean environment (Cushing et al., 2019). According to Stephenson and Smeldbol (2014), because these fish species are widespread in a variety of marine waters, they often live in the middle and upper layers of the oceans and make up 20 to 25 percent of all yearly catches. Pelagic fish include sprat

(Sprattus sprattus), mackerel (Scomber scombrus), sardine (Sardina pilchardus), herring (Clupea harengus) and others. Ground fish species are classified into this type because they usually live on or are found near the bottom of the sea (Oehlenschlager, 2014) or seafloor. Some fish categories that are classified as ground fish are flatfish, rockfish, round fish and sharks (The National Oceanic and Atmospheric Administration [NOAA] Fisheries, 2022).

Classification of Fish Based on Nutritional Constituents

According to Oehlenschlager (2014), lean fish species have low fat content fish, medium fatty fish species, and fatty (oily) fish species are the four groups of fish that fall under the category of the edible part's fat content (fillet and muscle), which in some species can vary from 1% to 30% depending on their nutritional status and stage of development. Lean fat content fish species such as cod, Alaska Pollack etc. have fat content between one and five percent (examples are carp, redfish, sole etc.); fish species with fat content that range above five percent to ten percent are termed as medium fat fish species and they include catfish, tuna etc.; and high fish species have fat content greater than ten percent such as eel, mackerel and others.

Sources of Fish Species

Fish sources can be classified into two; their origin (where they are caught) and their fat content. According to the origin, there are two main sources which are: fresh water and sea water fish. Each source has its own peculiarity in the variety of fishes found in it. Generally, fish is grouped into three depending on their fat content which are:

1. White fish. These fishes have their fat stored in the liver with a white flesh
2. Oily fish. These fishes have their fat distributed in the flesh giving it a dark skin and flesh.
3. Shell fish. This type comes in two forms. Mollusks which has a soft body in a hard shell and crustaceans with jointed or segmented body.

Fish landings in West Africa account for more than 80% of all fish landings globally. The remaining portion originates from freshwater sources such the River Shari, Lake Volta, Lake Chad, and River Niger. The majority of the fish supply in Burundi, the Sudan, and Uganda comes from freshwater bodies. Despite having a coastline, the Sudan barely receives 3% of its annual fish catch from the ocean. The majority of the fish supply comes from the River Nile, which includes the Blue Nile and White Nile. Uganda's primary source of fish supplies is Lake Victoria. Significant amounts are additionally obtained from Lakes Albert, Edward and George. Fish is readily available in a variety of ways for ingestion, including fresh, smoked-salted, dried, salted and dried, tinned, fried, or grilled. Ghana's per capita fish intake was 20.3 kg in 1882 and 34.2 kg in 1997, the lowest and greatest levels ever (Subasingh, 2017). Currently, Ghana has a higher per capita fish consumption than all of Africa and the world combined, with 28 kg compared to 10.5 kg and 18.9 kg, respectively (Subasingh, 2017). Ghana needs to consume roughly 720 000 metric tons of fish yearly, but the country only produces 400,000 tonnes (Subasingh, 2017). Ghana's deficit amounts to 320,000 metric tonnes of fish and fisheries products each year.

Preservation of fish

Fish has lean and peak season like other foods. Post-harvest losses occur during bumper harvest because there are too many for local use. As a result, some are saved for later use. To extend the shelf life of food, preservation helps to give food special treatment or using specific techniques. These techniques, which can be carried out both at home and in a business setting, include drying, salting, smoking, and freezing. In underdeveloped nations like Nepal, canning, bottling, and the addition of additives like sugar, vinegar, and other less common modern ways are not feasible due to expensive procedures. The main goal of preservation is to postpone, lessen, or prevent rotting while still retaining as many qualities in the food as possible such as nutrients and flavour. Preservation allows food to be stored over a long period of time to prevent spoilage, save money, make food available during the lean season, to avoid contamination and food poisoning among others. Fish as a commodity is susceptible to spoilage and thus should be preserved to be able to withstand long storage and use over a period of time. It can be preserved by canning, salting and drying. The last method allows the fish to go through fermentation.

There are several methods of fish preservation which include drying, salting, freezing, smoking and fermentation. The methods of preservation can be grouped into two (2). These are modern and ancient methods. The oldest and most frequently used methods of preservation in homes (ancient) include; salting, drying, salting and drying, smoking, curing and the modern methods used commercially includes freezing, freeze drying, canning, pasteurization, irradiation, addition of chemicals like vinegar (pickling), benzoic, Sulphites, Sorbic acid, nitrates (Kumar, 2019). Some of the methods of fish preservation are discussed below: Salting is a method that is usually combined with other methods of preservation.

Freezing Method of Preserving Fish

The Chinese used chilling and even freezing in ice vaults outside of the winter, and the Romans and Greeks both keep compacted snow in insulated vaults as early as 1000 BC. According to Jessen et al. (2014). The first industrial patent for employing circulated brine at 17 °C wasn't obtained until 1913 Sabroe & Ottesen (1984). By developing the double belt freezer to great success in 1930, Clarence Birdseye and his American corporation made frozen foods readily available commodity. However, it took a long time for consumers to embrace frozen goods, and fresh fish is still seen as having higher quality. Promptly freezing the fish and then keeping it at a low, constant temperature, is feasible to produce frozen fish with a good eating quality.

Due to fish's great vulnerability to spoiling, freezing is a procedure that is frequently utilized before fish is either further preserved or consumed (Jessen et al., 2014). This is due to the fact that a bigger percentage of fish is always frozen. This approach essentially preserves fish for use as food, for processing, and for other purposes. If the procedures for handling and freezing fish are followed appropriately, the initial quality of fresh fish can be maintained within reasonable bounds. The primary quality of fresh fish are crucial to the final quality of frozen fish (Boknaes et al., 2001).

The value of frozen fish is influenced by a variety of factors. One prominent factor is how the fish was treated before being frozen. However, "it is evident that fish species will behave differently as to how their quality changes during frozen storage because differences exist between fish species on the extent and rate of the various post-mortem processes" (Jessen et al., 2014). The water content is quite high in both fish and animal muscles, and a water component of about 80% is not unusual. The fish's internal temperature rapidly drops to just below 0 degrees Celsius after freezing. Water turns from a liquid to a solid as ice crystals form at about -one degree Celsius. The heat generated by this exothermic process must be evacuated from the fish because the majority of the water in the muscle freezes to ice, which causes the temperature to drop slowly inside the fish during this freezing period. Freezing is a productive method used to preserve fish but has been identified to negatively influence fish.

According to Oehlenschlager (2014) Fish muscle may experience a number of alterations, including a reduction in its ability to hold water and undesirable modifications to its textural qualities, which produce a hard and dry product. Ante mortem variables, degree of comunition, pre-processing, or storage and duration temperature are some elements that have an impact on texture changes during frozen storage (Careche & Barroso, 2009).

Drying Method of Preservation

Fish is said to be dry when their surface moisture evaporates and when fluid from inside the fish rises to the surface due to air movement (temperature and humidity). The basic idea behind the food that is dried as a preservation technique is to reduce water content, which in turn reduces microbial activity because moisture or water is essential for microbial metabolism and growth (Mahmud et al., 2018). Preservation is crucial since fish and fishery products are recognized for having high moistness content while they are fresh, which creates environment that are ideal for microbial growth. Although the drying method is successful in ensuring that fishery products last long, it has drawbacks of its own when used improperly. Because lipid in food is linked to flavour and the production of off flavours, drying fish at a high temperature causes lipid oxidation and produces fish products with an off flavour (Shahidi & Hossain, 2022). Additionally, if the drying process is too quick, it may cause layer hardening (hard texture), which adversely affects the product's palatability; conversely, if the drying process is too slow, harmful bacteria may survive and grow (Mahmud et al., 2018). Horner (1997) grouped the drying method of fish preservation into three kinds to include air or contact drying, vacuum drying and freeze drying.

Smoking Method of Preserving Fish

To extend the shelf life of fish, a preservative technique called smoking uses heat to cure the fish. Adeyeye (2019) assert that fish is smoked using fire and that it is important to comprehend the mechanisms at play during the process in order to maximize the benefits of smoking. According to Kalita et al. (2020), smoking is a method of indoor food preservation in which fish are dried over a fire until the fish's bodily moisture evaporates as a result of the heat from the fire. For highly effective results, some researchers have advised combining smoking with one or more methods of preservation (Gómez-Estaca et al., 2007). In addition, Varlet et al. (2007) demonstrated that phenolic chemicals formed during the smoking process and the high-temperature condition work together to prevent oxidation and microbial growth. Additionally, the technique may contribute to the product's distinctive colour, texture, and fish odour, all of which are appealing to consumers (Baten et al., 2020). The surface drying that prevents microbial invasions, the reduction of water activities brought on by the pre-treatment process with salt, the deposition of phenolic compounds that help delay fish lipid autoxidation, and the deposition of antimicrobial substances are thus some of the preservation goals of smoking.

Depending on the temperature utilized, cold smoking and hot smoking are the two ways used to smoke fisheries goods. Fish is cold-smoked at a temperature of around 32 °C. This technique causes fish to coagulate proteins, inactivate food spoilage enzymes, and does not cook the fish (Alasalvar, 2011). At temperatures between 70 and 80 °C, hot smoking methods integrate the three basic processes of heating, drying, and smoking. Dry hot smoking which is done for 8-10 hours can last for six to nine months since it has a moisture content of 10-15% whiles wet hot smoking is carried out for about one to two hours and possess a moisture content of 40-55% (Adeyeye, 2019). Advantages of this method of preservation include its provision of high protein content with low saturated fat and enhancing colour and flavour of fish. Some negative effects of smoking include the direct exposure of foods to smoke when traditionally done with wood which might result in the build-up of dangerous chemicals such polycyclic aromatic hydrocarbons as a result of inadequate wood combustion. These substances may have harmful impacts on human health. According to Munasinghe et al. (2003), there is a considerable likelihood that the fish flesh treated by direct exposure to smoke will have an uneven distribution of volatile chemicals, which could negatively impact the final product's quality.

Fermentation Method of Preserving Fish

Fermented fish means allowing fish to go through certain defined processes to create differences in taste, texture and flavour. According to Clucas & Ward (1996), the process that fermented fish goes through differs based on the area of fermentation. Different nations manufacture fermented fish. Fish can be fermented by being treated with salt to speed up the fermentation process to prevent putrefaction. Marine finfish, freshwater fish, crustaceans, and shellfish can all be fermented (Wolfe & Dutton, 2015). In contrast, Southeast Asian nations, where fermented fish products are typically a paste or sauce, Africa typically ferments its fish whole or sliced into pieces (Anihuovi et al., 2006). Fermented fish products have specific local names attributed to them. Examples of names given to fermented fish are momoni, kako, koobi which are found in Ghana, shidal which is found in North-eastern region of India, (Majumdar et al., 2009), lanhouin in Togo and Benin, inasua from Maluku in Indonesia (Persulessy et al., 2020), Belacan Depik in Aceh Province, Indonesia (Murlida et al., 2022).

In the fermentation process of fish, the salting of the fish removes the water content and lowers the required moisture content for the support of microbial growth which causes food spoilage. Normally, the concentration of salt ranges between six to ten percent which, is expected to prevent the action of most food spoilage bacteria within the tissues of fish. Examples of fish species used for fermentation include cassava fish and king fish (Anihuovi et al., 2006), catfish (Ezeama & Udoh, 2012).

Advantages of fermentation include its ability to upsurge the shelf life of fish because fermented fish has less water content than fresh fish. Thus, the application of salt and drying during the process of fermentation reduces the amount of water of fish from 1 to 0.7-0.8 which makes fish not condusive to bacterial growth after fermentation (Isola et al., 2022). As such, a study conducted by Anihuovi et al. (2006) found that the water capacity of cassava fish after fermentation ranged from 0.65 to 0.77. Consistently, Ezeama and Udoh (2012) posit that fermented fish are enjoyable and have longer shelf life than fresh fish. Fermentation of fish, apart from being a preservation method, helps in developing suitable physicochemical characteristics responsible for favourable sensory properties (Majumdar et al., 2009). Fermentation also adds value to fish. Anihuovi et al. (2012) asserted that fish with poor quality or are regarded as unpopular species are usually fermented, therefore the process of fermentation helps to salvage fish that would otherwise have been thrown away.

Mode of Preserving Fresh Fish as Momoni

"Momoni" is a fermented fish product in Ghana which is widely used by numerous people due to its flavour-enhancing properties (Sanni et al., 2002). Its processing is similar to lanhouin, a fermented fish product of Benin. Some of the fish species which are usually processed into "momoni" include catfish, cassava fish, barracuda, scad mackerel, sea bream, and jack mackerel (Zang et al., 2020). The fish for "momoni" processing is washed and cut into small quantities or it could be left whole. It is further washed thoroughly and salted or left overnight before applying salt. After the application of salt which ranges from 15-25%, it takes three to eight days to ferment naturally after which it is either dried on the ground, grass, nets, stones or raised platforms for a period of 1 to 3 days (Tanasupawat & Visessanguan, 2014). After fermentation had continued for more than three days, the second salting is done, using 3/4 of the salt weight used in the first salting.

Concept of Organoleptic Properties of Food Commodities

Organoleptic properties of food denote the ability of food to cause stimulation to one's organ through sensory stimulus. These properties are the unique characteristics of food that affect the sense organs. They include taste, smell, texture, aroma colour and mouth feel. The analysis of every product to determine its organoleptic property is essential because the nutrition of a commodity becomes wasted if it is not consumed by consumers due to the products poor organoleptic property **(**Setyaningsih et al., 2019)**.**

Concept of Taste

The feelings triggered by food when it is put in the mouth are collectively referred to as taste sensations. According to Das (2005), it refers to the whole perception of the food that a consumer has after applying their senses. When the taste receptors are activated, the taste experience is felt. The cells responsible for taste, known as taste buds, are located on the tongue's upper surface (Iwaniak et al., 2016). At age 45, the total number of taste buds that are actively engaged starts to decline gradually; at around age 70, this process speeds up. The five fundamental tastes are sour, bitter, umami, salty, and sweet (Barragán et al., 2018). The tip of the tongue is most sensitive to sweetness and saltiness, the edges to sourness, and the back of the tongue to bitterness (Smith & Margolskee, 2001).

Giri et al. (2009) evaluated fermented fish paste to determine its salinity, sweetness, bitterness, umami, and sourness. The umami, bitterness, sourness, and saltiness of the various fermented fish pastes employed in the study were not significantly different from one another. Moreover, different fermented fish samples were found to possess a bitter off-taste, sweet off-taste and bitter taste (Schindler et al., 2011). As such, the taste of fermented fish could be described as either salty, sour, bitter or umami.

Concept of Texture

Food’s physical characteristics resulting from its structural components make up its texture, which is assessed through touching (Giese, 2003). Oluwamukomi & Lawal (2020); Dahl, (2022) described food texture as the characteristics of food that may be felt through hand or tongue contact. When food is put in the mouth or felt with the hand, the texture can be sensed. Thus, the precise texture of food can be detected by the touch, tongue, or teeth. Food might have a crunchy, soft, chewy, dry, or moist texture. Food’s texture is emphasized with regard to its acceptability and enjoyment. Food preference is influenced by its texture (Zhang, 2016). This is because food's quality can be determined through the texture of food put in the mouth as every type of food has its specific texture. For example, bubble gum is chewy and potato chips are crispy, hence if bubble gum is not chewy but soft or if potato chips become tender, they become undesirable to consumers.

Fish’s sensory quality is mostly influenced by its textural traits. From the time the fish is caught, harvested, or killed until it is consumed, many biochemical changes related to the start and resolution of rigor mortis take place, which affect the texture of the fish. The muscle is elastic and soft prior to the onset of rigor mortis. Due to the actomyosin complex's contraction, the muscle becomes hard in the rigor mortis stage, and once it resolves, the muscle returns to being soft but less elastic. The severity of these modifications and how they affect muscle texture rely on a variety of elements, including the species, capture techniques or pre-slaughter settings, post-mortem handling and care, and storage duration and temperature.

Concept of Smell

The aroma of food influences food preference and increases the urge to eat a certain food (Ferriday & Brunstorm, 2008). When the nose inhales the odor, the scent of food is noticed by the orthonasal route. It is also detected through the retronasal route while chewing food when the odor travels up the back of the throat. Food sweetness is said to be affected by the way it smells. Even though some foods may smell bad, people may nevertheless find them to be sweet.

Concept of Aroma

Aroma is regarded as an odour sensation. There are a huge number of different smells. Significant dietary components like sugar, carbohydrates, fat, and proteins, as well as vitamins and minerals, do not elicit an olfactory response. Aroma is a fundamental aspect of food that strongly persuades consumers to consume a particular dish, yet aroma has no direct nutritional impact. Foods only contain trace levels of the scent compounds. They are made up of organic substances from the fatty acid and alcohol groups. “The odour of fermented fishery products varies from mild to very pungent. Soft, semi-dry products usually have a strong smell but very dry fermented fishery products have a mild odour (El Sheikha, 2014)”. Due to their low odor thresholds, esters produce the fruity scent in fermented food (Liu et al., 2004; Pino & Queris, 2010). Yu et al. (2022) found that shrimp paste had cheese like and umami aroma.

Concept of Colour

According to Oehlenschlager (2014) "colour is the visual perception that results from the detection of light after it has interacted with an object. The perceived colour of an object is affected by three entities: the physical and chemical composition of the object, the spectral composition of the light source illuminating the object, and the spectral sensitivity of the eye". The perception of the colour of food indicates its state and composition (Javed, 2021). The type of fish utilized and the technique of processing both affect a product's colour. Poorly fermented fish typically has a grayish colour, while split and dried fermented fish typically has a light brown colour (El Sheikha, 2014). Long storage and more drying darken the product. Organoleptic traits linked to spoiling can include visual changes (such as discoloration), the emergence of unpleasant scents, and slime formation. (Hassoun & Karoui, 2017)

Concept of Mouthfeel

The rheological characteristics of foods during the initial phases of eating are essentially what connotes mouthfeel (Smith & Margolokee, 2001). It also includes kinaesthetic perception, which is derived from chewing, biting, and swallowing, which includes crunchy, hard, soft, brittle, tender, and chewy; temperature perceptions such as hot or cold; and chemical irritations such as burning, spicy hot, and tingling along with aroma and odor perception. Tactile perception is obtained from pressure and contact in the mouth on the size, form, and first textural impression such as juicy, fatty, creamy, dry (Tiefenbacher, 2019). Mouthfeel includes qualities like coating and astringency (Jack, 2022).

Proximate Composition of Fish

According to Mohanty et al., (2015) "proximate composition is generally the percentage composition of the four basic constituents viz water, protein, fat and ash (mainly minerals)". The term proximate composition refers to the biochemical components of fish, which include protein, moisture, and fat, which make up the majority of fish muscle. The degree of fish maturity, the sex of fish, the size of fish, and the season of the fish, all have an impact on the nutritional composition of fish (Sankar & Ramachandra, 2001). Gopakumar (2002) also made the case that biological factors, such as fish feeding patterns, life cycles, and environmental conditions, are to be blamed for variances in the proximate composition of fish. Oehlenschlager (2014,) also posited that "in the fish body itself, a certain degree of variability is found in basic components like water, fat and protein, which are not evenly distributed in the edible part but vary from head section to tail section or dorsal part to ventral part". Historically, the closest composition of fish has been used to represent the nutritional worth of fish (Suleiman & Abdullahi, 2009). The proximate value which includes moisture, protein, ash and lipids are discussed below:

Moisture

Moisture denotes the water content of fish. Pal et al. (2018) claim that the majority of a fish's meat is made up of water, which accounts for roughly 80% of fresh fish and an average of 70% of fatty fish. Therefore, water is what make fish susceptible to spoilage as fish contains higher water content of more than 65% (Mohanty et al., 2015). Confirming the assertion of Mohanty et al., (2015), water content of fermented catfish has been identified to be 73.25% by

(Ezeama & Udoh, 2012) whereas Amedakanya (2021) revealed that fermented cassava fish had a moisture content of 77.49%. The water content in fish muscle is tightly bound to the protein in the structure in such a way that it cannot readily be expelled even under high pressure. “After prolonged chilled or frozen storage, however, the proteins are less able to retain all the water, and some of it, containing dissolved substances, is lost as drip” (Pal et al., 2018).

Protein

For about 60% of people in developing nations, fish intake provides 30% of the animal protein they consume (Sujatha et al., 2013). Fish is the predominant source of animal protein in Ghana, where it accounts for 60% of total animal protein. As a result, an estimated 75% of fish production is consumed locally (Tall & Failler, 2012). Shabir et al. (2018) termed fish to be a potential medical food of the 21st century as the protein content of raw fish flesh ranges from 18-22%. According to (FAO 2020), the average amount of protein in fish muscle is estimated to range from 16% to 21%. Whereas some fish might rarely have a protein content of less than 16 or more than 21%. Saani et al. (2002) found that the protein content of fermented fish ranged from 16.8–21.9%. In another study, Alain et al (2013), identified protein contents in five marine fish species to range between 19%-21%.

Fish is produced at a lower cost per unit than other dietary protein sources like chicken, mutton, hog, beef, etc., and its value is comparable to that of meat protein but lower than that of milk and egg protein (Yeşilsu et al., 2021). Fish has a larger satiety impact than other forms of protein like beef, pork, chicken, or other animal protein because it also contains all the essential amino acids, including cysteine and methionine, which are sulfur-containing amino acids that are absent in plant protein (Mohanty et al., 2015). According to Yeşilsu et al. (2021), fish proteins among animal proteins have a well-balanced amino acid composition that are essentially advantageous for protein synthesis and utilization in the body. The protein composition of fish is noted to have a higher digestibility which ranges from 85-95% (Pal et al, 2018). Due to the low-fat content and high protein content of fish, its consumption is associated with for building and repairing muscle tissues, improving immunity and blood quality. The gelatine and collagen category of fish protein has high moisturizing properties with anti-wrinkle and anti-aging which are employed in the cosmetic industry (Guaadaoui et. al., 2014).

Lipids

Lipids are compounds that are soluble in organic solvents like chloroform, ether, or benzene but insoluble in water (Pal et al., 2018). Fatty acids and triacylglycerols are examples of lipids. Saturated fatty acids (no double bonds), highly unsaturated fatty acids (greater than four double bonds), and polyunsaturated fatty acids are three different categories of fatty acids (higher than 2 double bonds). "Marine fish are naturally high in omega-3 highly unsaturated fatty acids greater than 30 percent and are excellent sources of lipids for the manufacture of fish diets (Craig et al, 2017)".

Ash

The term "ash" refers to the inorganic residue that remains after the organic components in a meal sample have either completely oxidized or ignited. Ash content can be assessed as part of proximate analysis for nutritional evaluation and is a critical quality element for many food products.

Ashing is also the first step in getting a sample ready for a specific elemental analysis. Using the dry ashing method and a muffle furnace, the ash content of several food products is determined in this lab exercise. Ash content information can be expressed using both a wet weight basis and a dry weight basis thanks to the inclusion of moisture content determination (Ismail, 2017). Ash content, which is the inorganic residue leftover after water and inorganic matter have been removed by heating in the presence of oxidizing agents, is a measurement of the overall amount of minerals present in food. This idea underlies the three primary analytical techniques dry ashing, wet ashing, and low-temperature plasma dry ashing used to determine the ash content in foods. The technique selected for a specific analysis is determined by the goal of the analysis, the type of food being examined, and the equipment available.

Empirical Review

The review was done to cover the following areas;

- Proximate composition of fish,
- Variations in the proximate composition of fish,
- Organoleptic properties of fish and
- Mode of preserving fish.

Proximate Composition of Fish

Adeyemi et al. (2013) found that the proximate composition of fresh Horse mackerel constituted protein content of 58.15%, moisture of 73. 56%, ash of 8.6%, fibre of 15.73% and fat of 3.32%. He further revealed the proximate value of wood smoked horse mackerel was made up of 55.80% protein, 52.7% moisture, 19.40% ash and 7.45% fat. It is evident that although there was a reduction in the protein and moisture content of horse mackerel when smoked, it increased significantly in its ash and fat content. The nutritional composition of fresh fish after fermentation process was identified to change. Amedekanya (2021), revealed that nutritional constituents such as water, protein and ash decreased after fresh cat fish was fermented for five days. Thus, the moisture of fresh cassava fish decreased from 76.63% to 63.23% protein which was 72.66% became 36.49% and fat content also showed a decrease from 2.85% to 1.64%. On the other hand, the ash and fat content increased after the fermentation process with the following values 2.63% ash increased to 19.80%.

According to Amedekanya (2021), fermentation method of preserving fish is likely to reduce the protein and fat content of fish however, it does not deplete all the nutrients of fish. Consequently, fermented fish has its own nutritional value. A study conducted by (Majumdar et al. 2009) found that shidal, a salt-free fermented fish consisted of diverse nutrients which include protein (33.93%), ash (16.3%), moisture (18.84%) and lipid (16.73%). Ezeama & Udoh (2012) identified in a study that the proximate composition of fermented catfish with 15% salt fermented for two weeks was 73.25% moisture, 65.60% protein, 13.72% ash and 14.38% fat. A similar study on fermented fish conducted by Kindossi et al (2016) in Benin found that the nutritional constituent of cassava fish lanhouin from processing site and market had protein content of 53.8% and 49.3%, dry matter of 43.9% and 47.2%, lipid of 12.2% and 10.8% respectively. They also found that the nutritional constituent of Spanish mackerel lanhouin from processing site and market had protein content of 52.6% and 49.2%, dry matter of 43.4% and 45.4%, lipid of 42.8% and 47.4% respectively. Also, a study in Indonesia by

Mahulette et al. (2018) revealed that inasua which was fermented for a week with 20%- 30% salt constituted of 45.26% protein, 37.9% ash, 3.84% fat, 42.32% amino acid. Ormanci & Colakoglu (2014) found that lakerda a fermented fish constituted 14.64% protein, 52.22% moisture, 17.39% lipid and 15.14% ash.

Another study conducted by Murlida et al. (2022) revealed that Belacan Depik a fermented fish paste fermented for seven days with 5% salt and spices (2% torch ginger flowers and 2% lemongrass) had a protein content of 22.06%, moisture content of 45.56%, fat content of 4.33%, fibre of 1.58% and ash of 10.83%. Similarly, a study conducted by Amedekanya (2021) in Ghana found that cassava fish (momoni) fermented for five days had a protein content of 42.95%, ash of 3.87%, moisture content of 77.49% and fat content of 1.98%. The variations in the proximate composition of the aforementioned fermented fish might be due to the reason that different fermentation period and fermentation methods were used aside the use of different fish species. It is evident that fermentation does not eradicate the nutritional content of fish. Also, it can be argued that the fermentation method of persevering fish is employed by different countries and is not limited to only Ghana.

Variations in the Proximate Composition of Fish

Oetterer et al (2003) found in a study that salt has a significant influence on higher ash of sardine muscle. Consequently, Ezeama & Udoh (2012) revealed in a study that the fermentation of fish with salt resulted in an increase of ash (11.85% to 13.72%). Similarly, a study conducted by El-Bassir (2015) identified that the ash content of fresh fish increased from 9.99% to 17.85% after salt was applied to the fish. Also, Achinewhu & Oboh (2002) revealed in a study that the use of salt in fermenting fish was identified to lead to a significant reduction in the moisture content of fermented fish than unfermented fish. Accruing to the findings of Achinewhu & Oboh (2002) and El-Bassir (2015) found in a study found that the moisture content of fresh fish decreased from 70.754% to 23.138% after salt was applied to the fish. Similarly, Ezeama & Udoh (2012) revealed in a study that fermentation increased the fat content of fish whiles the moisture of fermented fish decreased with salt application. Similarly, Amedekanya (2021) identified a decrease in the moisture content of fish from 76.65% to 59.77% after salting. Additionally, salting of fish during the process of fermenting fish (momoni) was associated with the growth of bacteria. Thus, only salt-tolerant microorganisms can survive in high salt concentrations; lactic acid bacteria are inhibited by salt concentrations of up to 7%. (Horner, 1997).

In terms of the protein composition of fermented fish, Achinewhu & Oboh (2002) found that fermented sardinella had a higher protein content than unfermented sardinella thus, a protein percentage of 18 and 16 were achieved for fermented and unfermented fish respectively. Petrus et al (2012) identified that there was an increment in the protein content of fish fermented with more than 15% salt application. Relating to salting and the protein of fish, Ekunke et al. (2017) found that salted fish had higher protein content than frozen fish. That is, the protein content of fish with two different preservation methods were identified to be 12.41% and 10.04% when salted and frozen respectively. On the other hand, Ezeama & Udoh (2012) revealed in a study that fermentation was associated with a reduction in the protein composition of fish. This is because the crude protein of catfish of 69.56% was reduced to

65.60% after fermentation. Similarly, Anihuovi et al. (2012) identified that the fermentation of fish resulted in a reduction in the protein content of the fermented fish. That is the protein content of Adjuevan, a fermented fish decreased from 53.93% to 25.66 %. According to Anihuovi et al (2012), the decrease in the protein content of fermented fish is as a result of proteolysis effect that takes place during fermentation. This is because the protein of fermented fish is broken down into peptides and amino acids which could be lost in the exudates (extracted water) from the fish.

Consequently, the protein content of fish has been identified to reduce based on the period of fermentation. Thus, Mahulette et al. (2018) found a decrease in the protein content of inusua fermented for one week to 12 weeks decrease from 45.26% to 18.03%. Similarly, a study conducted in Ghana by Amedekanya (2021) revealed a reduction in the protein content of cassava fish fermented based on the duration of days for fermentation. That is, the protein content of fresh cassava fish fermented for a day was 7266% it then decreased to 42.75% after it was fermented for 3 days and further decreased to 36.49% when fermented for five days. There exist contradictory findings in terms of the protein content of fish and the use of salt in fermenting fish. However, it can be argued that the protein content of fish either high or low may be associated with the amount of salt applied during the process of fermentation or the period of fermentation.

Chemical compounds such as total volatile nitrogen (TVN) and biogenic amines (e.g histamine) which normally does not exist in the living tissues of fish are formed by autolysis and microbial actions during fermentation (Essuman, 1992). Anihuovi et al. (2006) found in a study that the histamine content of fermented fish was higher than the standard level of histamine recommended. That is, the histamine content was identified to be 21.4 -33.1 mg / 100 g which was higher than the recommended level of 20 mg / 100 g.

Also, the TVN contents of samples ranged from 264.7 to 389.8 mg N/ 100 g from one species to another with an average of 294.5 N/ 100 g for cassava fish (Anihuovi et al, 2006). Roy et al. (2015) revealed in a study conducted in India that the TVN of fermented fish was 210.92/100g. Gassem (2019) also identified in a study conducted in Saudi Arabia that the TVN for fermented fish ranged from 32.2 to 131.82 with an average of 78.86mg/100g. It is evident that the TVN level was higher for all the fermented fish and it exceeded the recommended level. As argued by Silva et al. (1998) TVN level ranging from 2-3.6mg/100g depicts the freshness of fish and makes it good for human consumption whereas TVN level above 50mg/100g is not good for human consumption. However other studies have found that the TVN fermented fish decrease when a higher amount of salt is used during the fermentation process. Thus, Desniar & Witajur (2009) identified the TVN level of fermented fish to be 18.42 mg/100g and 16.78 mg/100g when 30% salt and 50% salt were applied during the fermentation process respectively. Similarly, Petrus et al. (2012) revealed TVN level of 13.98 mg/100g with 10% salt application and 7.82 mg/100g for 50% salt application during the fermentation process. It can therefore be inferred from the findings of Desniar & Witajur (2009) and Petrus et al. (2012) that, the TVN level was higher in other studies because the salt application of fermented fish used may be low and below 10%.

The salt concentrations for fermented cassava fish ranged between 5.2% (Anihuovi et al, 2006). Petrus et al. (2012) found that the salt content of fermented fish in Indonesia ranged from 2.39% to 13.68%. Similarly, a study conducted by Gassem (2019) in Saudi Arabia found that the salt content of fermented fish (Hout-Kasf) ranged from 12.72% to 19.74% for twenty-four different fermented fish. Also, Kindossi et al. (2016) found that the salt content of spanish mackerel and cassava fish found in the market were18.7% and 19.3% respectively. In line with the above findings, Mahulette et al. (2018) also revealed that the salt content of inasua was 30.02%. From the assessed literature, it can be concluded that fermented fish varies based on the salt content with the least salt content of fermented fish identified to be 2.39% whiles the highest was found to be 30.02%.

A study by Kindossi et al. (2016) revealed that the dry matter content of lanhouin Spanish mackerel found in the market and processing sites were 45.4% and 43.4% respectively.

Organoleptic Properties of Fish

A study on fermented fish conducted in Benin by Dossou-Yovo et al. (2011) found that Spanish mackerel (Saflo) used to make lanhouin had a better organoleptic property than cassava croaker. Thus, the texture of Spanish mackerel (Saflo) lanhouin was determined to be 80% softer whiles cassava croaker lanhouin was 65% softer. Ezeama & Udoh (2012) found that stew that contained fermented catfish fermented with 10% salt and spices (1% red pepper powder and 1% garlic powder) was highly preferred by research panelists over fish that was fermented with only 10% salt, fish fermented with 15% salt and fish fermented with 15% salt and spices (1% garlic powder and

1% red pepper powder). Cadwallader & Kim (2010) found that fermented king fish had an acceptable high smell when compared with fermented cassava fish. Amedekanya (2021) found that cassava fish fermented for five days had a high flavour when used to prepare sauce than fish that was fermented for less than five. According to Petrus et al. (2012), the amount of salt used for processing fermented fish is associated with its organoleptic properties. Jittrepotch et al (2015) identified that fish fermented with 25% and 50% potassium chloride had the highest overall acceptance scores when compared with fish fermented with calcium chloride.

Petrus et al (2012) identified that fermented fish processed with 15% salt application had an appreciable texture than those fermented with below and above 15% salt application during processing. Amedekanya (2021) revealed that cassava fish that was fermented for three days had a soft texture than unfermented cassava fish.

Pertaining to the acceptability of food, appearance cannot be undermined (McClement, 2004). According to Amedekanya (2021) appearance adds to the appealing attributes of food. Thus, fish fermented with 15% salt application received high acceptability for appearance than other fermented fish samples and in comparing the appearance of fermented fish, it was found that the participants identified salted bottled fish to have a dry appearance than the other categories of fermented fish used for the study.

The overall acceptability of fish was linked with the days of fermentation and the salt application during the process. Petrus et al. (2012) revealed that fish fermented with 15% salt during fermentation had colour which was deemed acceptable by consumers. Amedekanya (2021) identified cassava fish that was fermented for three days to have high acceptability than other samples of fermented fish fermented with different duration of days. That is, 76.6% of participants deemed three days of fermented fish to be very good.

Mode of Preserving Fish

Kalita et al. (2020) found that smoking and sun drying were the most common methods of preserving fish in India whiles other methods were fermentation and pickling. That is, they found that all the sixteen communities involved in the study were found to smoke and sun -dry sixty species of fish out of a total of sixty-one species of fish. Similarly, Fokour et al. (2018) found that women in the Mfantseman municipality of the Central region, of Ghana were involved in the traditional smoking of fish as a method of preservation. Fish was found to be smoked by the use of chorkor smoker or clay oven. In line with the findings of Fokour et al. (2018), Asamoah (2019) also identified that smoking was a prominent method used in preserving fish in Ghana. Thus, smoking was usually done traditionally with chorkor smoker, however, the use of Abuesi gas smoker was revealed to be an effective way of preserving fish since it possessed a 60% processing rate than the chorkor smoker with a faster smoking time and lower fuel intake.

CHAPTER THREE

RESEARCH METHODS

Introduction

This chapter deals with the methodology used in conducting the study. It includes;

- Research design
- Study area
- Population of the study
- Sample and sampling procedures
- Data collection instrument
- Data collection procedures
- Ethical consideration
- Data processing and analysis

Research Design

The selection of a research design for a study centre on the purpose of the study. The main purpose of the study was to compare the organoleptic properties of two fermented fishes in terms of taste, flavour and other necessary attributes. The appropriate research design is very important in enabling one to aim at valid findings, comparisons and conclusions. Thus, the design chosen should be valid, workable and manageable (Kumar, 1999). The objective of the study allowed the researcher to use mixed method design involving a sensory evaluation and laboratory work.This was used to determine the organoleptic (sensory) properties (Meilgaard et al. 2007) in the fermented fishes. Also, laboratory experiment was used to determine the macro-nutrients composition of the two fishes in terms of their fresh and fermented states representing a quantitative data.

Study Area

The study was carried out in Mankessim, the largest urban center in the Mfantseman Municipality of the Central Region of Ghana on the main route to Sekondi-Takoradi. Mankessim is located roughly 75 kilometers (km) west of Accra at latitude 5.2728442 and longitude 1.0155385 west in the Greenwich Time zone. It has a population of roughly 38,313 and is situated at an elevation of 75 meters above sea level (Ghana Statistical Service [GSS], 2014). Despite being the historic home of the Fante ethnic group in Ghana (wikipedia.org/wiki/Mankessim), migration had brought in residents from other regions of the continent as well as the Ewes, Gas, Ashantis, Akwapems, and Ashantis. It has a large market that attracts traders from Ghana and beyond. These traders deal in general goods, food crops and all kinds of fish.

There is a ready market for fishes in the form of fresh, smoked and fermented fish coming from the surrounding villages along the coast in towns like Saltpond, Abandze, Kormantse, Otuam to mention but a few for sale. In the Municipality, fishing takes about 51% of total economic activities (Mfantseman Municipal and District Assembly [MMDA], 2021). Some indigenes work as subsistence farmers to support themselves and their families. Additionally, it's a depot for kako and momoni before they are transported to the various parts of the country and most of its inhabitants are also consumers of salted fish.

Study Population

Kumar (2005), defines population as gathering of elements that have similar attributes. Mankessim market is flooded with lots of fish of different varieties and species. The target population for the study were salted fish (horse mackerel- opaa and Spanish mackerel- saflo) and consumers of salted fish. Macro-nutrients analysis was fresh and fermented Opaa and Saflo. The accessible population for sensory evaluation were consumers of salted fermented fish that is individuals who regularly consume or use Opaa and Saflo "momoni" in their meal preparation. "Momoni" from both fishes including their fresh were also used for macro -nutrients determination. The researcher, randomly selected the fishes for the study because it is gotten all year round, can be fermented and consumers prefer to use them for their dishes in their homes. The fishes were from the mackerel family and are of the oily type of fish classification. The fishes are representatives of the salted fishes available in the study area. Panelists between the ages of 18 to 45 years were enrolled for the organoleptic (sensory) assessment. The age bracket is relevant because majority of these people do not have much health-related issue in terms of their salt intake regarding cardiovascular diseases and other diet related health challenges. According to Fryar et al, (2017), in the U.S.A in 2015-2016, hypertension among ages between18 to 39 was 7.5% as against 33.2% in the age bracket of 40 to 59 and 63.1% among 60 years and above. In Ghana the prevalence rate is 13.91% between the ages 55-64 and 2.82% for those within 25-34 years (Opoku et al., 2017). Also, between ages 40 and 50 one's sense of smell and taste begin to decrease (Lawless & Heymann, 2010).

Sample and Sampling Procedure

Sampling is a technique which has a range of methods that enables a researcher to reduce quantity of data needed to gather by taking cognizance of a subgroup rather than the total population. The quality of every research depends on not only the methodology and instrument used but also the suitability of the sample that is used. (Cohen et al., 2011).

Thus, purposive sampling technique is a deliberate choice of a participant due to the attributes the participant possess (Etikan, 2013), was adopted by the researcher in using her personal judgment to randomly select the fishes for the study. That is Opaa and Saflo. The selected fishes are available all year round and are used as “momoni” also they are common in the study area.

Six medium sized quality fresh fish were bought from Mankessim market representing three for each category of fish. The fermented fish for the study was self-made by the researcher. This was to make sure the ‘momoni’ was wholesome and of quality to prevent any adverse effects on the panelist after tasting the samples for sensory evaluation. The fresh fishes were carried in a clean ice chest filled with ice blocks from the market to the home for the preparation of the fermented fish. These fishes were wrapped in A4 sheets sealed, coded for identification and kept in a sterilised polythene wrapper bag to the Agric laboratory of University of Cape Coast for proximate analysis after the process of fermentation was done. The fresh fishes were sent to the unit a week and half earlier than the salted fish.

In making the fermented fish, they were washed with distill water to destroy pathogens, then further treated with diluted lime juice. All item such as knife, bowls, chopping board, tight-fitting containers were sterilized before use. These activities were done to prevent cross contamination.

The convenience sampling method was used to select panels for sensory evaluation. This gave the researcher the chance to enrol consumers who are familiar with the fishes and make use of them in their meal preparation. Saunders et al. (2007), describes convenience sampling as the easiest way to select cases. It is a non-probability sampling procedure which the researcher used to select her sample size based on proximity, accessibility and convenience. The subjects enrolled were fifteen (15) comprising six (6) males and nine (9) females representing 40% and 60% respectively. The hybrid form (researcher's own judgement) of sensory evaluation (Lawless & Heymann, 2010) was used where advantages of descriptive test in terms of the number of panelists was used that is between15-20, consumer acceptability and affective test (hedonic scale) were adopted by the researcher. The following rules served as guidelines for the selection of panelists for sensory evaluation:

- They should be non-smokers/alcoholics
- They should not be on medication, food allergies, diabetes, hypertension and other related cardiovascular diseases
- Must be a regular user of fermented fish (opaa and saflo 'momoni').

On the day of the evaluation, the participants should avoid:

- Sedatives food substances like coffee, toffee, tea, chewing gum and mouthwash.
- Heavy make-up and the use of lipstick/gloss.

- No food an hour before sensory testing (the best times is between 11:00am and 3:00pm).

NB: ***These rules are necessary to avoid interference in taste and flavours.***

Per these rules, the researcher and field assistants had an engagement with people around the community and had eighteen (18) participants but later three (3) withdrew from the study. The rest were given three days to prepare for the sensory activity.

Data Collection Instrument

Research is primarily about collecting relevant information to answer research questions to solve a problem. This information can be collected to solve a problem through the use of questionnaires, interviews, observations and already existing data for other purposes (Saunders et al., 2009)

An evaluation questionnaire was developed which included a 9-point hedonic scale ranging from dislike extremely (1) to like extremely (9) to collect primary data from panellists for sensory evaluation using sensory attributes. The attributes assessed were taste, texture, appearance, aroma and overall acceptability. The fermented fishes were used to prepare three dishes each that is palm-nut soup, palava sauce, and steamed fermented fish. These dishes were assessed using the sensory attributes (Meiligaard et al., 2007, Lawless & Heymann, 2004)

Data Collection Procedures

In the collection of data, a one-month period was used for both sensory evaluation and proximate analysis. A pilot testing was done for sensory evaluation to help in correcting errors and ambiquity in the structure of the questionnaire. Due to this no replication was done.

Preparation of momoni

Fresh fishes were bought from Mankessim market and taken home to prepare the “momoni”. Standardized method of processing salted fermented fish in terms of fermentation, salting and storage were employed. This was to maintain integrity of the samples and minimize variability. The fishes selected were;

- High quality fresh fish with firm flesh and mild flavour
- Weighted to determine the amount of salt to add (1/2 weight of salt to fish)
- Thoroughly washed under running water to remove dirt
- Further use distilled water to get rid of any impurities, foreign materials on the surface of the fishes.
- Gutted fishes from backbone and opened up
- Rinse them to remove entrails and blood
- washed again in water (with diluted lime juice to take away the fishy smell and destroy bacteria which could cause cross contamination)
- Each type was placed in different plastic bowls that have been sterilized with hot water (for them to sit in their own juices).
- Then left to stay overnight (between12- 24hrs) to /ferment

The salting and fermentation process;

- weighted rock salt was broken down due to its large crystals before using
- washed the ripen fishes and the bowls used
- spread salt in layers that is salt first in the bottom of bowl then place fish on salt.

- The action was repeated until all the fishes were covered with salt. This is to prevent microbial infestation.
- Then was left to stay for a week (7 days) and after dried in a fly-proof net to prevent housefly and other insect infestation for 3 days after the salting period was over.
- Stored in air tight containers to prevent exposure to air and moisture to ensure safety before use.

The preparation of the fishes for fermentation and salting has been shown in a flow chart below:

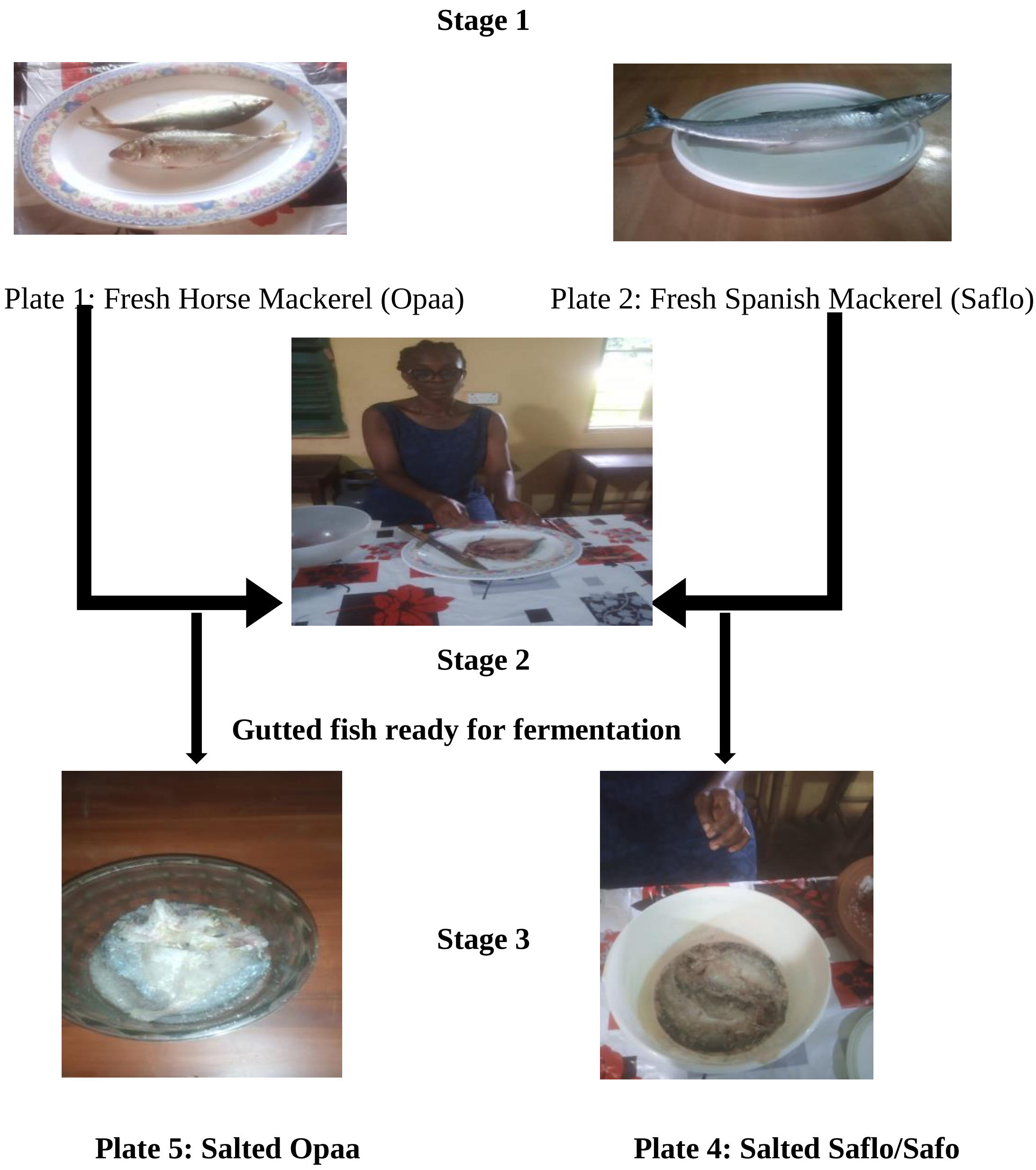

Figure 1: A flow chart showing the fermentation process of the fishes by the researcher

Sensory Evaluation

Palm nut soup, palava sauce and steamed fermented fish were prepared with either horse mackerel(opaa) or Spanish mackerel(safo/saflo) giving a total of six samples which were assessed by sensory panels using a 9-point hedonic scale.

Table 1: Number of Samples use for sensory evaluations

FISH	PALM-NUT SOUP	PALAVA SAUCE	STEAMED FERMENTED FISH
Horse mackerel (opaa)	1 sample	1 sample	1 sample
Spanish mackerel (safo/saflo)	1 sample	1 sample	1 sample

Source: fieldwork (2022)

These samples were analysed using a 9-point hedonic scale with it interpretation which is diagrammatically represented as;

Table 2: 9-point hedonic scale interpretation

Scale/ Interpretation
9. Like Extremely
8.Like Very Much
7.Like Moderately
6.Like Slightly
5.Neither Like nor Dislike
4.Dislike Slightly
3.Dislike Moderately
2.Dislike Very Much
1.Dislike Extremely

Source: Meilgaard et al 2007

The dishes (palm-nut soup and palava sauce) were evaluated using the following sensory attributes: taste, aroma/flavour, texture and overall acceptability. The panelist were also asked if they would buy the product if it was on the market using a Yes/ No response and gave reasons for their choice. The steamed fermented fish was also assessed using these attributes: colour/appearance, taste, aroma/flavour, texture and overall acceptability. Panelists were also asked to indicate whether they would buy the product if it's on the market, and gave reasons for their choice. In all, fifteen panelists were used for the sensory evaluation based on their regular use and likeness of fermented fish. The six samples were each identified with a three-digit code number. The panelists were trained prior to sensory evaluation on how to score using the 9-point hedonic scale, including overall acceptability and gave their comments. Each panelist was placed in a cubicle different from the other to ensure independence and prevent bias in assessing the dishes. The samples were randomly selected and served to panelists that is stew to one and soup to the other.

Samples Preparation

The "momoni" was used to prepare palava sauce and palm nut soup as they were popular dishes prepared in most homes. The "momoni" were weighed for each dish and soaked for thirty (30) minutes before using. Equal quantities of ingredients were also weighed and used in the sample preparation to ensure uniformity and prevent bias due to recipe formulation.

Finally the kontomire was added, stirred and remove after 5mins. Both stews were cooked for 27mins. Fermented fish was soaked in 400ml of water before use.

NOTE*: For the palm-nut soup and palava sauce, no meat/fish was added. This was to get the natural taste of the "momoni" from both fishes.*

Steamed fermented fish

Forty-five grams of either the horse mackerel momono or Spanish mackerel momoni was weighed and cut into 15 small chunks, soaked in 400ml of water and was steamed in a rice cooker for 10mins. This was done for both types of the fermented fish.

Proximate analysis

The Association of Official Analytical Chemist (AOAC, 2008) was used to determine the nutrient content as described by the proximate analysis. This was to determine the nutritional values of both fresh and fermented fishes under study. Data collected included percentage protein, carbohydrates, moisture, fats and oils, dry matter, ash and fibre. The following are the specific procedures for determination of the macro-nutrients composition of the fish samples. In the process, each macro- nutrient was weighed in triplicates to make the analysis valid and free from biasing. The analysis was conducted at the Agricultural Science unit of University of Cape Coast.

Moisture Determination by the Oven Dry method

Stainless steel crucibles were cleaned, dried, and weighed (X). Fresh samples weighing 10–12g were placed into pristine oven-dried crucibles and measured (Y). To achieve even heating, the base of the oven was covered with crucibles containing the sample. After that, they spent 48 hours in a thermostatically controlled oven at 105^0C. The samples were taken out at the conclusion of the time period, chilled in a desiccator, and weighed (Z). Every sample was run three times. The proportion of water lost by the sample was then used to calculate its moisture content.

$$\%\text{moisture content} = \frac{(Y-X)-Z}{Y-Z} * 100$$

Ash Determination

The dried samples were then heated gently in oven at 105^0C for about an hour and then transferred to furnace at a temperature of 550^0C overnight, the heating continued until all the carbon particles were burnt away. The residue left represented the total minerals of the fishes under study. The ash in the dish was removed from the furnace cooled in a dessicator and weighed. The ash content was then calculated as a percentage of the original sample.

$$\%\text{Ash content} = \frac{\text{weight of ash}}{\text{Original weight sample}} * 100$$

Oil/ Fat Determination by Soxhlet Extraction

Following continuous petroleum ether extraction, all of the lipid The Soxhlet apparatus method of extraction with ether, as described AOAC (2005), was employed to determine the crude fat content in the samples. In an ether solvent, the components in the sample were dissolved and eliminated by the organic ether. It was sufficient to determine the total fat content using diethyl ether or petroleum spirit extraction for the purposes of a proximate analysis (40-60^0 C). The ether was then evaporated, the residue was reweighed, and the result was determined arbitrarily because ether might not entirely extract all of the fats or oils but might also extract additional carotenoids. Since drying at 105°C could cause the loss of lipids and oils, drying was done at a temperature of roughly 60°C. Petroleum spirit with a boiling point of 40° to 60°C was the reagent utilized.

A 50 by 10mm soxhlet extraction thimble was filled with 10–12g of the milled samples and placed in a soxhlet extractor with a 50ml capacity. Weighed was a 250 ml clean, dry round-bottom-flask. The petroleum spirit was diluted to around 150 ml, attached to the soxhlet extractor, and the extraction process was carried out for six hours with the help of a heating mantle. The flask was removed after 6 hours and heated to 60°C for 2 hours. The flat-bottom flask was taken out, allowed to cool in a desiccator, and then weighed. As shown below, the percentage of fat and oil was computed.

Calculation

$$\text{Crude Fat (\%)} = \frac{\text{W (g)} \times 100}{\text{Sample (g)}},$$

Where W is Weight of Oil

Protein Determination

Based on the food's nitrogen content, protein content is determined. The kjeldahl was used to measure the protein. Digestion, neutralization or distillation, and titration are the three processes that make up the procedure.

Digestion

A 100 ml Kjeldahl flask was filled with 0.2g of the sample. The samples were mixed to 4.4mL of the digestion reagent and digested at 360^0C for two hours. In the same manner, digestion of the digestion mixture without a sample was performed to give the blank. Following digestion, the digests were quantitatively transferred into 50ml volumetric flasks and made up to the required volume.

Distillation

A steam distillation system was set up. For roughly twenty (20) minutes, distilled water was used to cleanse the distillation equipment. After cleaning the equipment, five milliliters of the boric acid indicator solution were added to a 100 milliliters conical flask, which was then positioned beneath the distillation apparatus's condenser with the condenser's tip fully submerged in the boric acid solution. Through the trap funnel, an aliquot of the sample digest was delivered to the reaction chamber. 50mL of the distillate was collected after 10mL of the alkali mixture was introduced to start the distillation process.

Titration

The distillate was titrated with 0.1NHCl solution until the indicator's original green colour changed to wine red. The titre value of the sample was adjusted to account for the digestion blank in the same manner. The nitrogen and consequently the protein content were calculated using the titre values that were obtained. 6.25 was the conversion factor.

$$\%\text{Total Nitrogen (TN)} = \frac{(\text{Sample titre value} - \text{Blank titre value})\ X\ 0.1\ x 0.01401\ x\ 100}{sample\ weight\ X\ 10}$$

% Protein = %N x 6.25

Crude Fibre Determination

One hundred millimetres of 1.25% sulphuric acid solution was added to a boiling flask containing about 1g of the sample, and the mixture boiled for 30 mins. The boiled sample was filtered into a designated sintered glass crucible of a known weight. The residue was removed by adding 100ml of the 1.25% NaoH solution and heating the mixture for 30 minutes. The residue then was rinsed with methanol and boiling water and filtered. The crucible which had previously been drying in an oven at 105^0C for the entire day, to know its original weight was heated containing the residue for about 500^0C in the furnace. It was cooled in a desiccator at room temperature and weighed.

Calculation

$$\% \text{ Crude fibre} = \frac{\text{weight loss thro ashing}}{\text{Sample weight}} \times 100$$

Carbohydrate Determination

Glucose solution, Anthrone Reagent, Procedure Extraction, and Colour Development were the used reagents. The following is a discussion of each reagent:

Stock solution: 0.250g of D-glucose (which was dried at 70°C in a vacuum oven using P2O5) was dissolved in water and diluted to 1 liter (1 ml is equal to 0.25 mg of glucose). Working standards: 50 ml flasks with a capacity of 0 to 20 ml each were pipette-filled with a stock solution ranging from 0 to 20 ml, so that 2 ml of each standard gave a range of 0- 0.20 mg glucose.

Anthrone Reagent

330ml of distilled water was added to 760ml of concentrated H_2SO_4 while maintaining coolness. 1g of anthrone and 1g of thiourea were added to the solution whilst stirring with a magnetic rod. The solution was transferred to a dark bottle and kept for two hours at +1°C.

Procedure Extraction

A glass bubble was inserted in the neck of a 50ml conical flask, which containing 50mg of the milled sample and 30ml of distilled water. The flask was then slowly simmered on a hot plate for two hours. Once it had cooled significantly, it was periodically topped up to 30ml, and filtered through No.

44 Whatman paper into a 50ml volumetric flask, and then diluted up to the volume. Preparation of the extract took place just before colour development. The same procedure was used to produce a blank.

Colour Development

A set of boiling tubes were filled with two milliliters (2 ml) of each standard, as well as 2 ml of the extract and a water blank. Both standards and samples received the same treatment. The tubes were quickly mixed with 10ml of the anthrone solution before being submerged in running water or an ice bath. The tubes were boiled for 10 mins in a beaker of boiling water in a dimly lit fume cupboard. The tubes were then submerged in cold water and allowed to cool, in complete darkness. Using water as a reference, the optical density was measured at 625 nm or with a red filter. From the standards, a calibration graph was produced and used to calculate the amount of glucose in the sample aliquot. The blank decision was handled similarly, with necessary subtraction performed.

$$\text{Soluble carbohydrates (\%)} = \frac{\text{C (mg)} \times \text{extract volume (ml)}}{10 \times \text{aliquot (ml)} \times \text{sample wt (g)}}$$

Where C = carbohydrate concentration from the calibration graph.

Recruitment and Training of Field Assistants

The researcher recruited and trained two field assistants to help in the sensory evaluation process. The field assistants were trained for a day on the rudiments of sensory evaluation and objectives of the study. The ethics provided during the training included:

a. Confidentiality and anonymity the hallmarks of research was explained to make them cautious of the researcher’s expectations.
b. Good rapport between the field assistants and panelists

c. They shouldn't force anyone to stay in the study
d. To be punctual
e. To be disciplined and committed to the task at hand
f. To be reliable in helping to meet the deadline for data collection
g. To exhibit good teamwork, honesty and be polite to panelists
h. Be neat, smart, respectful, focused and be ready to help where necessary.

The researcher went through the sensory activities and questionnaires with field assistants to prepare them for the task. They were taught to arrange the evaluation area in a way to avoid interference by panelists which could necessitate inaccuracy and kept panelists seated comfortably as they took their turns. The panelists were kept away from the preparation area.

Ethical Considerations

An introductory letter from the Department of Vocational and Technical Education of UCC was obtained for ethical clearance from the University of Cape Coast Institutional Review Board to conduct the study. The participants were recruited and taken through the consent form before they were enrolled in the study. The panelists were assured of anonymity and confidentiality. The panelists were identified with codes peculiar and different from each other during data collection. Also, the panelists were assured of confidentiality. Lastly, the panelists were assured of voluntary participation and so three of these participants withdrew from the study.

Data Processing and Analysis

The data collected on sensory evaluation was coded, edited and cleaned of errors. Data was quantitatively summarized in tables using frequencies, percentages, mean and standard deviations. The Statistical significance was determined at a probability value (p-value) of 0.05. P-values greater than 0.05 were considered statistically insignificant and values less than 0.05 was stated as statistically significant (95% confidence interval). The statistical analysis was carried out using Microsoft Excel Software 2013 and Statistical Package for Social Sciences Software Version 23.

The nutrients in test solutions were calculated using standard calculations. For each chemical test the readings were obtained in triplicate and the means calculated. In describing the different nutrients of the samples, percentages were used. Results of sensory evaluation were also analysed using frequency counts, means and standard deviations whiles some were presented in pictorial form (pie chart and bar chart).

Sources of Data

The study used both primary and secondary data. The primary data was from the results of the proximate analysis and the questionnaire administered during sensory evaluation. Secondary data was from literature.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter focuses on the results and the discussion of the study. The study sought to compare the organoleptic properties of salted fermented fish and the nutritional composition (macro) of the fishes in their fresh and fermented state. The study employed the quantitative approach with an experimental research design. The sample for the study was made up of two fishes (Opaa and Saflo) and 15 panelists were involved in appraising the organoleptic properties of the two fish samples. A questionnaire with both closed and open-ended items were used for the appraisal of the organoleptic properties of the two fish samples.

The study was guided by two research questions and two hypotheses while the background data panelists were also solicited for. The obtained data were analysed with the use of descriptive statistics (frequency counts and percentages, means, and standard deviation) and some were presented with pictorial representation (pie chart) whiles the hypotheses was tested with independent sample t-test.

Results

Demographic Data of Panelists

This section presents the demographic data of panelists who were engaged in the study. The demographic data of panelists focused on gender and age and the results are presented in Figure 4 and 5 respectively.

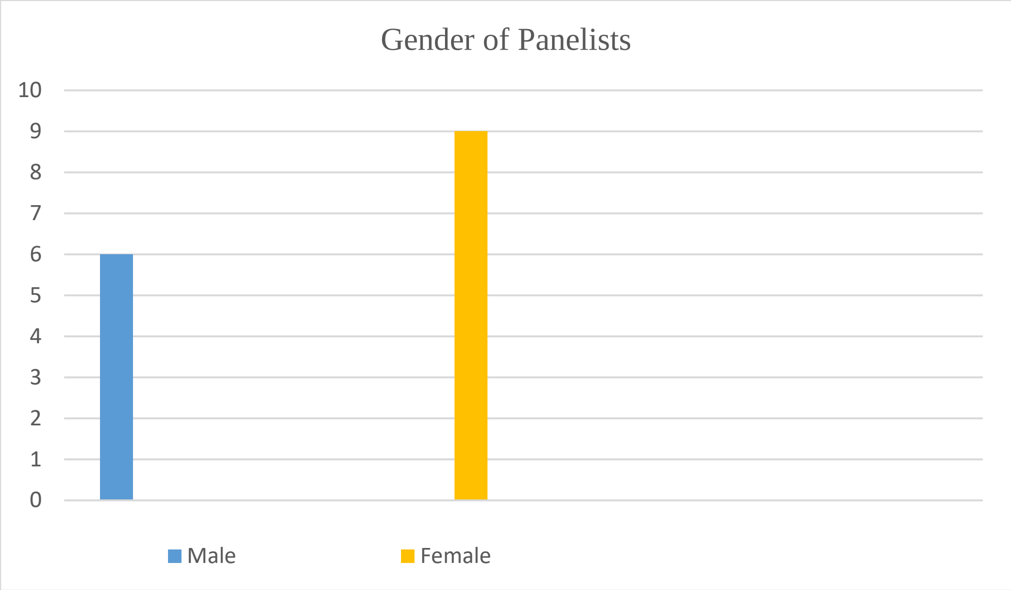

Figure 4: Gender of panelists

Source: Field Work, 2022

From Figure 4, out of 15 selected as sensory panelists for the study, males were 6 (40%) while females were 9 (60%) indicating that more females were on the panel than males. The panelists were selected based on the following criteria:

- They should be non-smokers/alcoholics
- They should not be on medication, food allergies, diabetes, hypertension and other related cardiovascular diseases
- Must be a regular user of fermented fish (opaa and saflo 'momoni').

On the day of the evaluation, the participants should avoid:

- Sedatives food substances like coffee, toffee, tea, chewing gum and mouthwash.
- Heavy make-up and the use of lipstick/gloss.
- No food an hour before sensory testing (the best times is between 11:00am and 3:00pm).

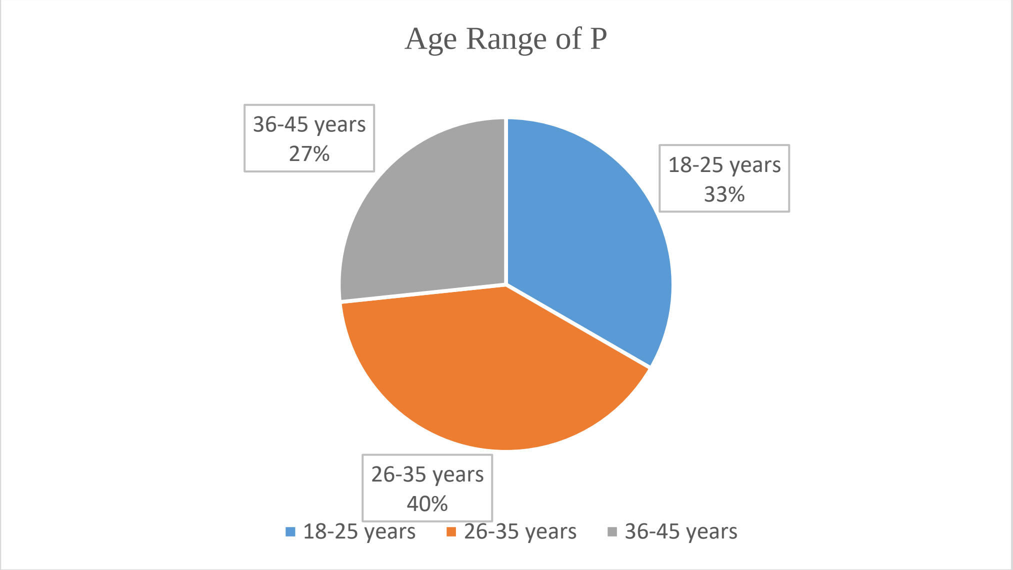

Figure 5: Age Range of Panelists

Source: Field Work, 20

From Figure 5, the age range of the sensory panelists ranged between 18 and 45 years. Five (33%) of them had ages between18-25, six (40%) panelists ranged from ages 26-35 years and 4 (27%) had ages falling within 36 and 45 years. Most panelists' age was between 26-35 years with the least number of panelists whose ages ranging from 36-45 years.

Analysis of the Questionnaire Data

Two research questions and two hypotheses were formulated for the study based on the specific objectives of the study. The two research questions were analysed with the use of descriptive statistics (frequency counts and percentages, Means and Standard deviation). Pertaining to reporting the data after analysis, some of the data were tabulated and some were also presented with pictorial representation (pie chart). In interpreting the mean scores, a standard mean which represent an average mean was established at 5.00. The standard mean was obtained from the spread of the 9- point hedonic scale for the variables. That is, dislike extremely (1), dislike very much (2), dislike moderately (3), dislike slightly (4), neither like nor dislike (5), like slightly (6), like moderately (7), like very much (8) and like extremely (9) represented the code for each scale; the values were added together and divided by the scale of 9; (1+2+3+4+5+6+7+8+9= 45), (45 ÷ 9 = 5.00). This resulted in a standard mean of 5.00. An interpretation was made that a score above 5.00 will depict a positive response while a mean score which is less than 5.00 will represent a negative response.

It can therefore be deduced from the standard mean score (5.00) that any recorded mean score above it will show that the organoleptic property of the fish samples is likeable whilst any mean score below the standard mean will indicate the unappealing nature of the organoleptic property of the fish sample. Further, standard deviation was presented to show the dispersion of responses provided by the panelists.

The standard deviation of the responses ranged from 0 to 1 where any scores within 0 depict the homogeneity of responses whereas scores within 1 indicate that the responses are heterogeneous. Also, standard deviation within 0 indicated that the responses were similar whiles the standard deviation within 1 will show that the panelists responses were widely spread.

The results of the two research questions are presented in Tables 3 to 12 and Figures 6 to 11.

Research Question One: What differences exist in the organoleptic properties of the fermented fishes?

To ascertain the differences that existed in the organoleptic properties of the two fermented fish samples (Opaa and Saflo), each of the fermented fish sample was used to prepare stew (palava sauce) and soup (palm-nut soup).

The raw fermented fish samples (Opaa and Saflo) were also steamed and presented for sensory evaluation. The results for the fermented fish samples used for stew (palava sauce), soup (palm-nut soup) and steamed are presented in Tables 3, 4 & 5 respectively.

In investigating the differences that existed in the fermented fish samples (Opaa and Saflo), each of the fermented fish sample was used to prepare palava sauce. The panelists appraised the palava sauce to assess the organoleptic properties of the fermented fish samples.

Table 3: Organoleptic Properties of Fermented Opaa and Saflo Palava Sauce.

		Responses				
		Like extremely	Like very much	Like Moderately	Like slightly	Means (M)
items	Sample	F (%)	F (%)	F (%)	F (%)	
Appearance	Opaa	5 (33.3)	7 (46.7)	3 (20.0)	-	8.13
	Saflo	5 (33.3)	8 (53.3)	1 (6.7)	1 (6.7)	8.13
Colour	Opaa	3 (20.0)	9 (60.0)	3 (20)	-	8.00
	Saflo	3 (20.0)	8 (53.3)	4 (26.7)		7.93
Aroma	Opaa	2 (13.3)	7 (46.7)	6 (40.0)	-	7.73
	Saflo	2 (13.3)	3 (20.0)	9 (60.0)	1 (6.7)	7.40
Texture	Opaa	1 (6.7)	9 (60.0)	5 (33.3)	-	7.73
	Saflo	1 (6.7)	9 (60.0)	4 (26.6)	1 (6.7)	7.67
Taste	Opaa	1 (6.7)	9 (60.0)	4 (26.6)	1 (6.7)	7.67
	Saflo	3 (20.0)	6 (40.0)	5 (33.3)	1 (6.7)	7.73
Mouth feel	Opaa	-	10 (61.8)	4 (26.6)	1 (6.6)	7.60
	Saflo	2 (13.3)	8 (53.3)	3 (20.0)	2 (13.3)	7.67
Overall	Opaa	4 (26.6)	7 (46.7)	4 (26.6)	-	8.00
acceptability	Saflo	5 (33.3)	5 (33.3)	4 (26.6)	1(6.7)	8.00
Mean of	Opaa					7.84
Means	Saflo					7.79

Standard Mean (5.00), Mean of Means Opaa (7.84), Mean of Means Saflo (7.79)
Source: Field Work (2022)

The results presented in Table 3 shows that the panelists found each of the stew prepared with fermented Opaa and Saflo to have good organoleptic properties. Thus, the mean of mean scores of (7.84 and 7.79) obtained for assessing the organoleptic properties of palava sauce prepared with fermented Opaa and Saflo respectively were higher than the standard mean of 5.00.

Although both fermented fish samples had good organoleptic properties/attributes the panelists agreed that some specific organoleptic properties/attributes of palava sauce prepared with fermented Opaa were better than palava sauce prepared with fermented Saflo. For instance, the colour, aroma and texture of fermented Opaa palava sauce were seen to be better than palava sauce prepared with fermented Saflo. The mean scores of (8.00> 7.93), (7.73>7.40) and (7.73>7.67) for the aforementioned organoleptic properties of Opaa and Saflo respectively.

On the other hand, palava sauce prepared with fermented Saflo had better organoleptic properties in terms of taste and mouthfeel than palava sauce prepared with fermented Opaa. However, the panel deemed stew (palava sauce) prepared with each of the fermented fish to have the same pleasing appearance and overall acceptability. Therefore, mean scores of 7.73 and 7.67 were obtained for taste and mouthfeel of palava sauce prepared with fermented Saflo, respectively whiles mean scores of 7.67 and 7.60 were obtained for taste and mouthfeel of palava sauce prepared with fermented Opaa respectively and means scores of 8.13 and 8.00 were recorded for both the appearance and overall acceptability of palava sauce prepared with either Opaa or Saflo respectively.

To ascertain the acceptability of fermented fish, the panelists were asked whether they were willing to buy any of the fermented products (Opaa and Saflo) on the market when used to prepare palava sauce. The results are presented in Figure 6.

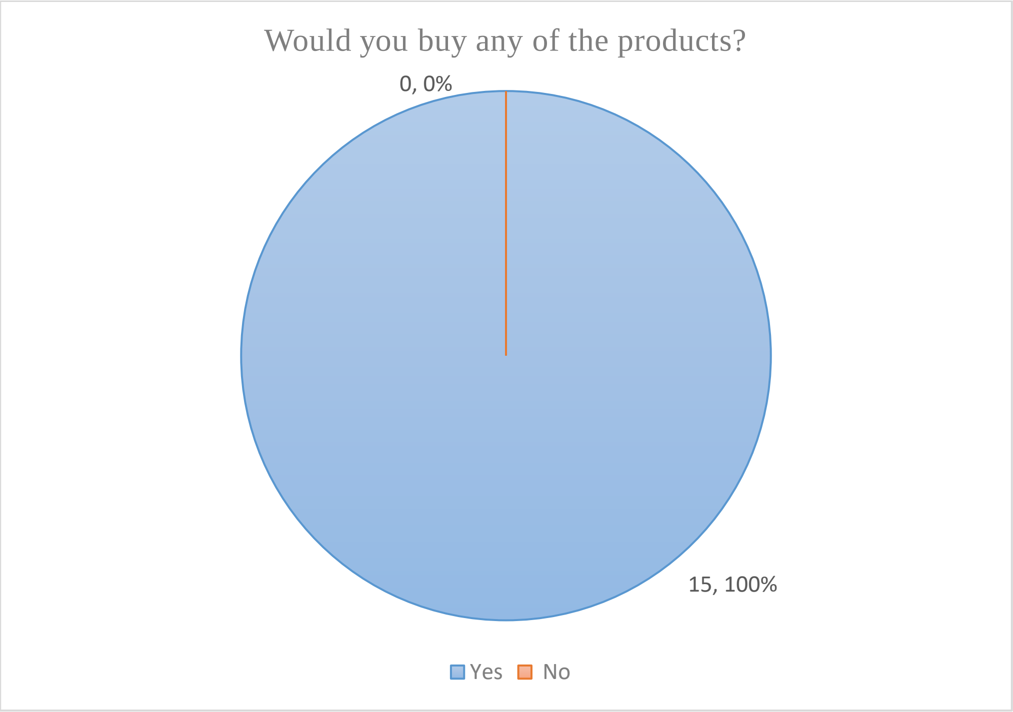

Figure 6: The willingness to buy fermented Opaa and Saflo palava sauce when it is on the market.
Source: Field Work, 2022

Figure 6 indicates that panelists had higher acceptability and likeness for fermented fish used for palava sauce. That is, all of them (100%) responded that they will buy the product if they find it on the market as none said otherwise.

The two fermented fish products (Opaa and Saflo) used for preparing palava sauce were compared by asking the panelists to choose the specific product they will buy if it is on the market. The results is presented in Figure 7.

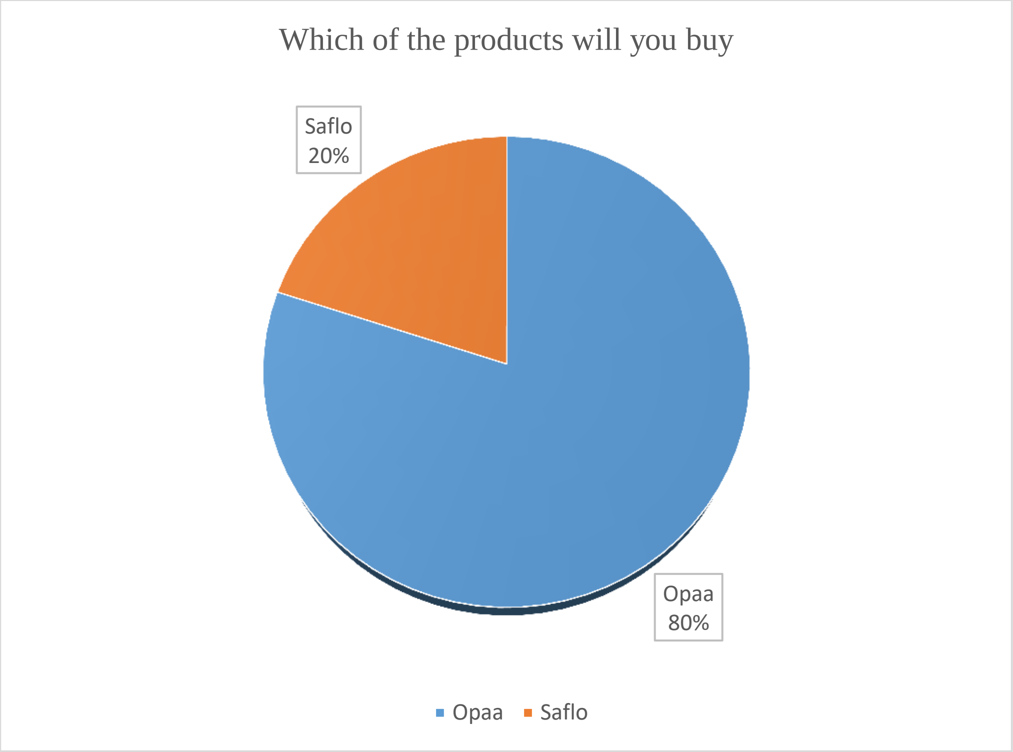

Figure 7: The preference of fermented fish product that panelists will buy when it is on the market.
Source: Field Data, 2022

Figure 7 shows that majority of the panelists preferred palava sauce prepared with fermented Opaa to palava sauce prepared with fermented Saflo. This is because 80% responded that they would buy fermented Opaa palava sauce when it is sold on the market whiles 20% liked to buy fermented Saflo palava sauce when it is on the market. Comparatively, the panelists chose palava sauce prepared with fermented Opaa over palava sauce prepared with fermented Saflo.

The panelists were to comment on why they would choose a product (fermented Opaa palava sauce/fermented Saflo palava sauce) over the other when it is found on the market. The results are presented in Table 4.

Table 4: Comments on why panelists would choose a Product over the other

Comments	Frequency (F)	Percentage (%)
The Opaa palava sauce taste better	2	13.3
The Opaa stew has a nice taste and aroma	4	26.7
Typical traditional palava sauce for Opaa	1	6.7
I would gladly buy saflo stew	1	6.7
The stew is very nice	2	13.3
Opaa stew is appealing	2	13.3
Everything about saflo stew is good	2	13.3
The Saflo has a chewy feel	1	6.7
Total	15	100

Source: Field Work (2022)

The result from Table 4 shows why the panelists would prefer a specific fermented fish over the other. Four (26.7%) of them said that Opaa stew has a nice taste and aroma, two (13.3%) each also preferred Opaa palava sauce over Saflo palava sauce due to its better taste, the stew is very nice. Opaa stew is appealing than Saflo stew, and everything about Saflo stew is good whiles three (6.7%) of the panelists each commented that Saflo found in the palava sauce has a chewy feel, he/she would gladly buy Saflo stew and Opaa stew was a typical traditional palava sauce.

To compare the differences that existed in the sensory properties of the fermented fish (Opaa and Saflo), each of the fish was also, used to prepare palm-nut soup to compare their sensory attributes by using nine (9) point hedonic scale to rate the attributes. The result is presented in Table 5.

Table 5: Organoleptic Properties of Fermented Opaa and Saflo Palm-Nut Soup

Organoleptic properties	Sample	Means	Standard Deviation
Appearance	Opaa	7.00	1.00
	Saflo	7.87	0.83
Colour	Opaa	7.00	0.85
	Saflo	7.87	0.83
Aroma	Opaa	6.80	1.32
	Saflo	7.60	0.63
Texture	Opaa	6.80	1.01
	Saflo	7.06	0.80
Taste	Opaa	6.00	1.07
	Saflo	7.33	0.98
Mouthfeel	Opaa	6.06	0.96
	Saflo	7.27	0.89
Overall acceptability	Opaa	6.60	0.91
	Saflo	7.73	0.70
Mean of Means	Opaa	5.64	1.02
	Saflo	7.53	0.81

Standard Mean (5.00), Mean of Means Opaa (5.64), Mean of Means Saflo (7.53)
Source: Field Work (2022)

It is evident from Table 5 that each of the palm nut soup prepared with fermented Opaa and Saflo had good organoleptic properties. Thus, the mean of all the mean scores of all the different attributes including overall acceptability were 5.64 and 7.53 obtained for soup prepared with fermented Opaa and soup prepared with fermented Saflo respectively were higher than the standard mean of 5.00. Table 5 indicates that the appearance of both fermented Opaa and Saflo found in the palm-nut soup prepared were good. That is, a mean score of 7.00 and 7.87 for fermented Opaa and fermented Saflo respectively were higher than the standard mean (5.00). However, the panelists were of the view that fermented Saflo had a better appearance than fermented Opaa when used to prepare palm-nut soup with a mean score of (7.87> 7.00).

Further, the colour of the fermented fish soups had mean scores of (7.00 and 7.87) for Opaa and Saflo respectively and were greater than the standard mean (5.00). The Table also indicates that the palm-nut soup prepared with fermented Saflo had a better aroma than palm-nut soup prepared with fermented Opaa based on the mean score of 7.60 > 6.80 respectively.

With regards to the texture, taste and mouthfeel of the fermented Opaa and Saflo when each was used to prepare palm-nut soup they were appreciable; because the mean scores of (6.80 and 7.60; 6.00 and 7.33; and 6.06 and 7.27) obtained respectively were higher than the standard mean (5.00). However, palm-nut soup prepared with fermented Saflo was deemed to be more appealing to the panelists than palm-nut soup prepared with fermented Opaa in comparing all the three organoleptic attributes aforementioned.

The overall acceptability of palm-nut soup prepared with each fermented fish (Opaa and Saflo) was good. That is mean scores of 6.60 and 7.73 obtained for fermented Opaa and Saflo respectively were higher than the standard mean of 5.00 whiles palm-nut soup prepared with fermented Saflo had a higher overall acceptability with a mean score of 7.73 than palm-nut soup prepared with fermented Opaa with a mean score of 6.60. The mean standard deviation (1.02) signifies that the responses of panelists on the organoleptic properties of fermented Opaa were heterogeneous whiles their responses on the organoleptic properties of fermented Saflo were homogenous/similar with a mean standard deviation of 0.81.

To determine the acceptability of fermented fish used for soup, the panelists were asked a question to find out if they were willing to buy any of the fermented products (Opaa and Saflo) on the market when used to prepare palm-soup. The results are presented in Figure 8.

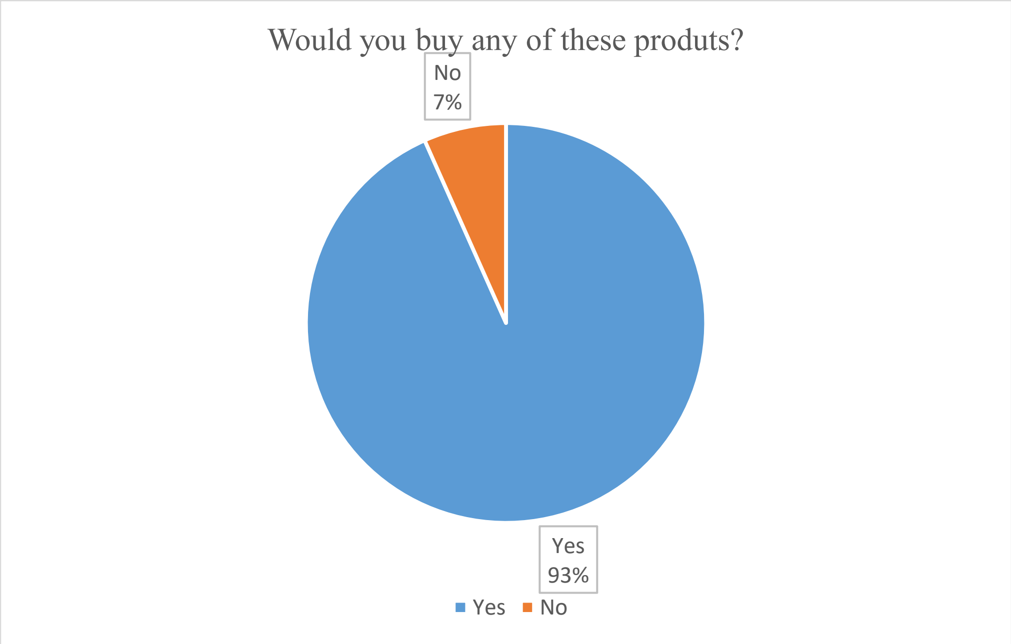

Figure 8: The willingness to buy any of the fermented fish products when used to prepare palm-nut soup on the market.
Source: Field Work, 2022

Figure 8 depicts that majority of the panelists were willing to buy the fermented fish products (Opaa and Saflo) on the market when they are used to prepare palm-nut soup. Thus, 93% of them responded they will buy whiles 7% said otherwise.

The two fermented fish products (opaa and saflo) used for palm nut soup were compared by asking the panelists to choose the specific product they will buy if it is on the market. The results is presented in Figure 9.

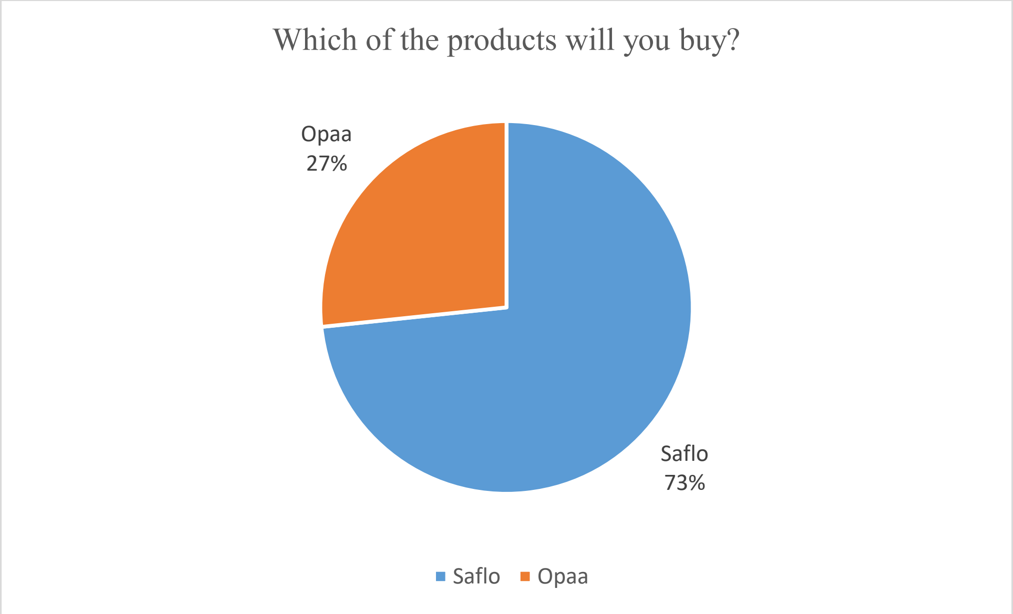

Figure 9: The fermented fish product that panelists will buy when it is on the market

Source: Field Work, 2022

Figure 9 shows that most of the panelists preferred fermented Saflo palm nut soup to fermented Opaa palm nut soup. This is because 73% responded that they would buy fermented Saflo palm-nut soup when it is sold on the market whiles 27% liked to buy fermented Opaa palm-nut soup when it is on the market.

The panelists were to comment on why they would choose a fermented fish product (Opaa or Saflo) used to prepare palm-nut soup over the other when it is found on the market. The results are presented in Table 6.

Table 6: Comments on why a Panelists would choose a Product over the other

Comments	Frequency (F)	Percentage (%)
The Opaa soup is tasty	1	6.7
The Saflo soup smells good and taste good	5	33.3
Saflo is quite okay for me	1	6.7
Very good saflo soup	3	20
Saflo soup is typical of conventional palm-nut soup	1	6.7
Opaa soup is nice	2	13.3
Everything about saflo soup is good	2	13.3
Total	15	100

Source: Field Work (2022)

It is evident from Table 6 that most of the panelists preferred to buy palm-nut soup prepared with fermented Saflo than palm-nut soup prepared with fermented Opaa when sold on the market. This is because 33.3% commented that the fermented Saflo soup smelled and tasted good, 13.3% each said that everything about Saflo soup was good and Opaa soup was nice whiles 6.7% each responded that the Saflo soup was a typical conventional palm-nut soup, Saflo soup was quite okay and Opaa soup was tasty.

To investigate the differences that could exist between the two fermented fish (Opaa and Saflo), they were steamed separately for the panelists to assess their organoleptic properties. The result is presented in Table 7.

Table 7: Organoleptic Properties of Fermented Steamed Opaa and Saflo.

Organoleptic properties	Sample	Means	Standard Deviation
Appearance	Opaa	7.67	1.05
	Saflo	7.60	0.83
Colour	Opaa	7.53	1.13
	Saflo	7.33	0.90
Aroma	Opaa	7.13	1.30
	Saflo	7.00	0.85
Texture	Opaa	7.53	0.92
	Saflo	7.06	0.80
Taste	Opaa	6.93	1.10
	Saflo	7.07	1.22
Mouthfeel	Opaa	6.93	1.16
	Saflo	6.60	1.55
Overall acceptability	Opaa	7.60	1.18
	Saflo	6.53	1.85
Mean of Means	Opaa	7.33	1.12
	Saflo	7.03	1.14

Standard Mean (5.00), Mean of Means Opaa (7.33), Mean of Means Saflo (7.03)
Source: Field Work (2022)

Information from Table 7 shows that both fermented steamed Opaa and Saflo had likeable organoleptic properties. This is because the mean of means scores (7.33 and 7.03) obtained for fermented steamed Opaa and Saflo respectively are greater than the standard mean score (5.00). In comparing these specific attributes (appearance, colour, aroma, texture and mouthfeel) for the two fermented steamed fish, Opaa was deemed to be more pleasing than Saflo. That is, the mean scores of 7.67 > 7.60, 7.53> 7.33, 7.13> 7.00, 7.53> 7.06 and 6.93> 6.60 were obtained for fermented steamed Opaa and Saflo in terms of appearance, colour, aroma, texture and mouthfeel respectively.

On the other hand, the panelists were of the view that fermented steamed Saflo had a better taste than fermented steamed Opaa as mean scores of 7.07 and 6.93 were recorded respectively. The overall acceptability of the two fermented steamed fish were good. However, fermented steamed Opaa yielded a higher overall acceptability than fermented steamed Saflo. Thus, mean scores of 7.60 and 6.53 obtained for Opaa and Saflo respectively were higher than the standard mean of 5.00 whiles the mean score for fermented steamed Opaa was evidently greater than fermented steamed Saflo. The mean standard deviations (1.12 and 1.14) signify that the responses of panelists on the organoleptic properties of fermented steamed Opaa and Saflo respectively were heterogeneous.

The panelists were questioned on their willingness to patronize fermented steamed Opaa and Saflo when it is on the market. The result is presented in Figure 10.

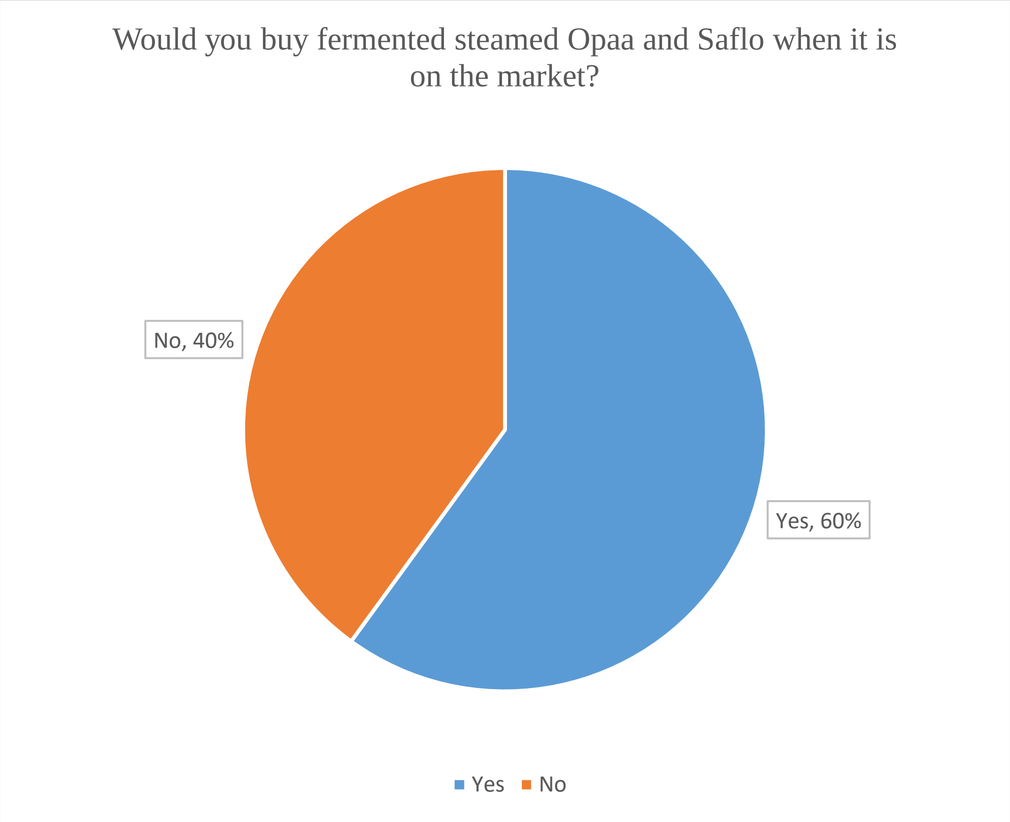

Figure 10: Panelists willingness to buy fermented steamed Opaa and Saflo when they are sold on the market.

Source: Field Work, 2022

Figure 10 gave an indication that 60% of the panelists were ready to purchase steamed fermented fishes (Opaa and Saflo) when it is sold on the market whiles the remaining 40% said otherwise. It is evident that most of the panelists were willing to buy the products whilst few were unwilling to buy them.

The study sought to compare fermented steamed Opaa and Saflo by asking the panelists to specifically select any of the product they like and would buy when found on the market. The result is presented in Figure 11.

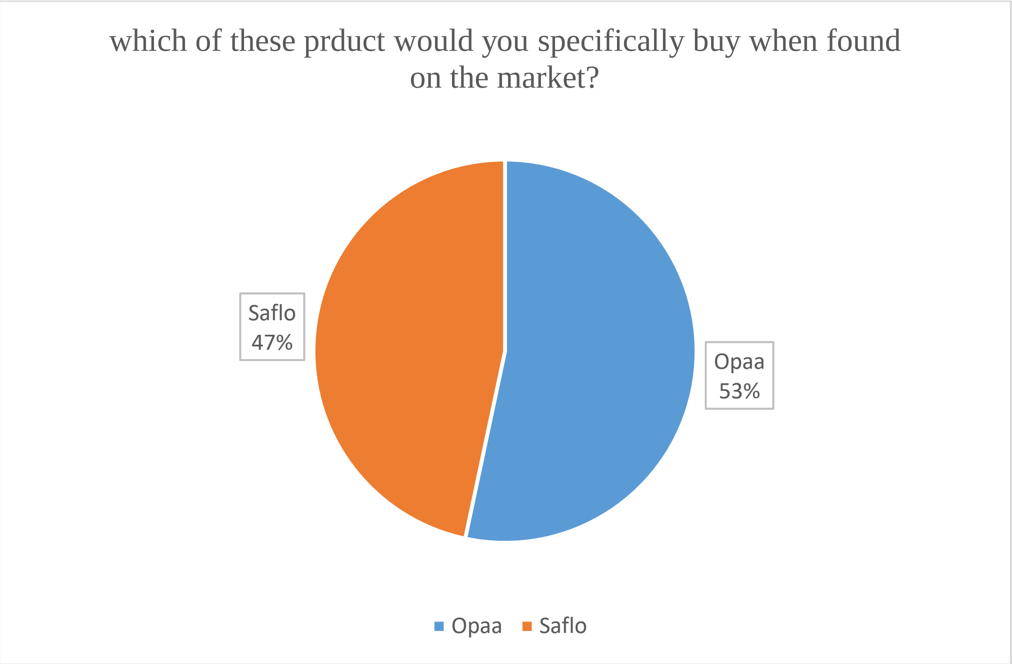

Figure 11: The specific fermented steamed product panelists would buy when sold on the market.

Source: Field Work, 2022

Figure 11 showed the willingness of the panelists to choose a specific steamed fermented product when found on the market. Thus, most of them representing 53% were willing to buy fermented steamed Opaa whiles 47% preferred to buy fermented steamed Saflo when found on the market.

The panelists were also asked to provide justification on why they would buy a specific fermented steamed product. The responses are tabulated in Table 8.

Table 8: Comments on why a Panelists would choose a Product over the other

Comments	Frequency (F)	Percentage (%)
They all taste good but I prefer Saflo	2	13.3
The opaa is good	3	20
Opaa taste good and nice	2	13.3
Saflo taste better	3	20
Opaa taste great	5	33.3
Total	15	100

Source: Field Work. 2022

It is shown from Table 8 that most of the panelists preferred to buy steamed fermented Opaa than steamed fermented Saflo when sold on the market. This is because 33.3% commented that the steamed fermented Opaa tasted great, 20% responded that steamed fermented Opaa was good whiles 13.3% each said that they all tasted good but preferred steamed fermented Saflo and steamed fermented Opaa tasted good and nice.

Research Question Two: What is the macro-nutrient composition for the fishes in their fresh and fermented states?

The macro-nutrients composition for the two fish samples (Opaa and Saflo), were analysed in their fresh and fermented states and the results presented in Table 9.

Table 9: The Macro-nutrient composition of fresh and fermented Opaa and Saflo Fish

Sample	Dry Matter (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
Fresh Opaa (control)	27.48 ±0.37	72.52 ±0.27	5.16 ±0.40	67.44 ±0.23	12.20 ±0.13	3.18 ±0.06	11.80 ±0.50
Fermented Opaa	40.37 ±0.17	59.63 ±0.17	18.56 ±0.24	41.76 ±0.30	4.24 ±0.09	5.36 ±0.08	3.97 ±0.22
Fresh Saflo (control)	26.08 ±0.43	73.92 ±0.43	6.25 ±0.41	71.85 ±0.68	7.70 ±0.14	2.52 ±0.13	11.60 ±0.70
Fermented Saflo	45.29 ±0.14	54.71 ±0.27	14.63 ±0.33	44.48 ±0.38	5.61 ±0.10	5.05 ±0.01	3.31 ±0.60

Source: Laboratory Work, 2022

- Results in wet weight
- All values are averages of triplicate determination of the nutrients
- Values are in percentages (%)
- Data is a representation of mean ±standard deviation
- Values are calculated per 100g

Table 9 indicates a variation in the macro- nutrient composition for both fresh fish samples and after the fermentation process. That is, there was a reduction in moisture (72.52% to 59.63%, 73.92% to 54.71 %) protein (67.44% to 41.76%, 71.85% to 44.48%), fat (12.20% to 4.24%, 7.70% to 5.61%), and carbohydrate (11.80% to 3.97%, 11.60% to 3.31%) for Opaa and Saflo respectively. On the other hand, there was an increment in Dry matter (27.46% to 40.37%, 26.08% to 45.29%), ash (5.16% to 18.56%, 6.25% to

14.60%) and fibre (3.18% to5.36%, 2.52% to 5.05%) for Opaa and Saflo respectively.

It can also be seen from Table 9 that differences existed between the macro-nutrients of the two fermented fishes. The mean scores for Opaa were higher than Saflo in terms of moisture (59.63%>54.71%), ash (18.56%>14.60%) fibre (5.36%>5.05%) and carbohydrate (3.97%>3.31%) whiles Dry matter (45.29%>40.37%), protein (44.48%>41.76%), fat (5.61%>4.24%) was higher in Saflo than Opaa. Both fresh fishes (opaa and saflo) were used as control to help observed any changes to the fishes after fermentation and salting which is evident from table 9. Thus, the value of protein for fresh opaa compared to salted opaa were 67.44% > 41.76, that of saflo was 71.45%>44.48%.

Likewise, moisture values for fresh opaa and salted opaa showed a decrease 72.51%> 59.63% and saflo 73.92%>54.71%. Fat content in these fishes were opaa 12.20%>4.24% and saflo 7.70%>5.61. Both fishes had a little variation of the carbohydrates in their fresh states but after fermentation there was a reduction: opaa 11.80%>3.97, saflo 11.60%>3.31%. However, some nutrient values appreciated after the fishes were fermented. Ash in fresh opaa as against fermented was 5.16 % <18.56, saflo was 6.25 %< 14.63. Crude fibre had these values opaa 3.16 %< 5.36, saflo 2.52 %< 5.05. Lastly, dry matter for opaa was 27.48% <40.37 and saflo 26.08 %< 45.29. The results above could imply that, fermentation and salting had a significant effect on both fishes (opaa and saflo).

Analysis of Research Hypotheses

Two hypotheses were formulated to guide the study. That is, there is no statistically significant difference in the organoleptic properties of fermented fish when used for preparing stew, soup or steamed and there is no statistically significant difference in the macro nutrient composition of opaa and saflo in the fresh and fermented states. The hypotheses were formulated in a null form. The null hypotheses indicated that there were no statistically significant differences which implies that there was no difference between the means. Both hypotheses were tested with the use of a two-sample t-test. An alpha level of significance of 0.05 was established to assess the Levene test.

As such, if an obtained significance value after testing the hypothesis is higher than the established significance level of 0.05, it will imply that equal variances were assumed so the variances for the two groups are the same. On the other hand, if the Levene's test sig value is less than the established alpha level of significance, it will signify that equal variances were not assumed hence the variances between the two groups were not the same.

After establishing the variance for the two groups based on the Levene's test sig value, an obtained Sig. value which is less than 0.05 will indicate that the result is statistically significant hence, there is a difference between the means and the obtained Sig. value is greater than 0.05, it will show that the result is statistically not significant hence, there is no difference between the means.

An inference can be made for the study's hypotheses that, an obtained Sig. value which is less than 0.05 will indicate that there is a difference between the organoleptic properties of fermented Opaa and Saflo which was used to prepare stew or soup, and a difference between the macro nutrients of the fishes in their fresh and fermented states, therefore the null hypothesis will be rejected. Whiles an obtained Sig. value greater than 0.05 will show that there is no difference between the organoleptic properties of fermented Opaa and Saflo which was used to prepare stew, soup, steamed and the macro nutrients of the fresh and fermented states, hence the null hypothesis failed to be rejected. The results of the hypotheses are presented in Tables 10, 11 and 12 respectively.

Research Hypothesis One: There is no statistically significant difference in the organoleptic properties of fermented fish when used for/or:

a. stew

b. soup

c. steamed

The hypothesis was set to assess if there will be a statistically significant difference in comparing the organoleptic properties of fermented Opaa and Saflo which were used for stew, soup or steamed.

Table 10: Difference between the Organoleptic Properties of Fermented Opaa and Saflo Palava Sauce

	Levene's test for equality of variance		Test for equality of means		
	F	Sig	T	Df	Sig(2-tailed)
Equal variances assumed	0.565	0.458	0.227	28	0.822
Equal variances not assumed			0.227	27.633	0.822

Source: Field Work (2022)

The results show that the sig value for Levene's test is 0.458 and it is greater than the alpha level of 0.05 which indicates that the variances for the two groups were assumed. Based on the establishment of homogeneity of variances with Levene's test, it was established that the variances for the two groups were the same. Therefore, using the levene's test to identify the sig value, an obtained sig value of (0.822) indicates that there is no statistically significant difference between the two groups.

This is because an inference can be drawn that there was no statistically significant difference between fermented Opaa palava sauce (M=54.87, SD= 3.78) and fermented Saflo palava sauce (M=54.53, SD=4.24); t (28) =.227, p=0.822 (two-tailed). A conclusion was drawn that there was no difference between the organoleptic properties of palava sauce stew prepared with fermented Opaa and Saflo. As such, the null hypothesis was failed to reject based on the results.

Table 11: Difference between the Organoleptic Properties of Fermented Opaa and Saflo Palm-Nut Soup.

	Levene's test for equality of variance		Test for equality of means		
	F	Sig	T	Df	Sig(2-tailed)
Equal variances assumed	1.028	0.319	-3.347	28	0.002
Equal variances not assumed			-3.347	27.380	0.002

Source: Field Work (2022)

The results from Table 11 depicts that the sig value for Levene's test is 0.319 and it is greater than the alpha level of 0.05 which indicates that the variances for the two groups were assumed. A conclusion can be drawn after establishing the homogeneity of variances with Levene's test that the variances for the two groups were the same.

Therefore, an obtained sig value of 0.002 indicates that there is a statistically significant difference between the two groups. This is because there was a difference between fermented Opaa palm-nut soup (M=46.27, SD= 5.68) and fermented Saflo palm-nut soup (M=52.73, SD=4.88); t (28) =-3.35, p=0.002 (two-tailed). It can be deduced that there was a difference between the organoleptic properties of palm-nut soup prepared with fermented Opaa and Saflo. Amidst, the null hypothesis was rejected based on the results.

Table 12: Difference between the Organoleptic Properties of Fermented Steamed Opaa and Saflo.

	Levene's test for equality of variance		Test for equality of means		
	F	Sig	T	Df	Sig(2-tailed)
Equal variances assumed	0.908	0.014	0.795	28	0.433
Equal variances not assumed			0.795	27.987	0.433

Source: Field Work (2022)

The results show that the sig value for Levene's test is 0.014 and it is less than the alpha level of 0.05 which indicates that the variances for the two groups were not assumed. Based on the establishment of homogeneity of variances with Levene's test, it was established that the variances for the two groups were not the same. As such, the sig value (0.433) obtained is higher than the sig value of 0.05 so it indicates that there is no statistically significant difference between the two groups.

This is because there was no difference between fermented steamed Opaa (M=51.33, SD= 5.80) and fermented steamed Saflo (M=49.67, SD=5.67); t (28) 0.795, p=0.433 (two-tailed). Therefore, there was no difference between the organoleptic properties of fermented steamed Opaa and Saflo. Hence, the null hypothesis failed to be rejected based on the results.

Research Hypothesis Two: There is no statistically significant difference in the macro-nutrient composition of fresh and fermented fish samples (opaa and saflo).

The hypothesis was set to assess if there will be a statistically significant difference in comparing the macro-nutrient content of both fish samples.

Following a T-test analysis, the subsequent values were obtained:

The p-value for fresh opaa and fermented opaa is 0.021, and the t-value is 2.513.

The p-value for fresh saflo and fermented saflo is 0.018, and the t-value is 2.724.

The t-value for comparing Fresh Opaa and Fermented Opaa is 2.513, with a corresponding p-value of 0.021. In the field of statistical analysis, a p-value less than 0.05 is often considered statistically significant. This threshold, often known as the alpha level, is a convention that serves to control the rate of false positives in statistical inference. In this situation, the p-value of 0.021 is less than the alpha threshold of 0.05, prompting us to reject the null hypothesis that there is no difference in the nutrient content between fresh and fermented Opaa. The positive t-value of 2.513 shows that the mean nutritional content is higher in the fermented Opaa compared to the fresh Opaa.

Fresh Saflo vs Fermented Saflo: The t-value for this comparison is 2.724 and the associated p-value is 0.018. Similar to the Opaa comparison, the p-value is less than the alpha level of 0.05, showing a statistically significant difference in the nutrient content between fresh and fermented Saflo. The positive t-value of 2.724 shows that the mean nutritional content is higher in the fermented Saflo compared to the fresh Saflo.

Discussion

This section presents the discussion of the findings of the study. The discussion is presented based on the research questions and research hypothesis that guided for the study.

Research Question One: What differences exist in the organoleptic properties of the fermented fishes?

The research question had the aim of comparing the differences that existed in the organoleptic properties of fermented Opaa and Saflo when used to prepare stew, soup or steamed. Two different local dishes were prepared with each of the fermented fish and were assessed by 15 panelists whiles each of the fermented fish was steamed and also assessed by the same panelists so as to know their organoleptic properties. The results of the study found that differences existed in the organoleptic properties of the fermented fish (Opaa and Saflo). That is, the panelists identified that fermented Opaa had better organoleptic properties than fermented Saflo when used to prepare palava sauce or steamed whereas palm-nut soup prepared with fermented Saflo had better organoleptic properties than fermented Opaa.

The findings of the study revealed that the panelists identified that fermented Opaa had better organoleptic properties than fermented Saflo when used to prepare palava sauce therefore the colour, aroma and texture of palava sauce prepared with fermented Opaa were better than palava sauce prepared with fermented Saflo. The differences found may be associated with the reason that fermented Opaa matches well with the ingredients used for preparing palava sauce than fermented Saflo which resulted in making its colour, aroma and texture more pleasing. Also, the ingredients for palava sauce balanced more with fermented Opaa. A similar study also found that the addition of spices improved the organoleptic properties of fermented fish. Thus, Ezeama and Udoh (2012) found that stew that contained fermented catfish which was fermented with 10% salt and spices (1% red pepper powder and 1% garlic powder) was highly preferred by research panel over fish that was fermented with only 10% salt.

Although palava sauce with fermented Opaa had better organoleptic properties when compared with fermented Saflo palava sauce, it was identified that palava sauce prepared with fermented saflo had a better taste and mouthfeel. Consequently, consumers are likely to prefer Saflo palava sauce, than palava sauce prepared with fermented Opaa. As the study has identified fermented Saflo to have a better taste and mouthfeel but its inferior to fermented Opaa in terms of colour, aroma and texture when used to prepare palava sauce. Consequently, consumers are likely to prefer Saflo palava sauce, to palava sauce prepared with fermented Opaa.

This is because taste sensations are the sum total of the sensations created by food when it is put in the mouth. As such, Elder & Krishna (2010) view it as the whole perception of the food that a consumer has after applying their senses.

In assessing the differences in the organoleptic properties of soup prepared with fermented Opaa and Saflo, it was revealed in the study that palm-nut soup prepared with fermented Saflo had better organoleptic properties than fermented Opaa. Fermented Saflo had a better appearance, aroma, texture, taste and mouthfeel than fermented Opaa when used to prepare palm-nut soup. It can be deduced from the panel view that fermented Saflo balances well when used to prepare palm-nut soup than fermented Opaa. In this vein, fermented Opaa was only inferior to Saflo comparatively when used for palm-nut soup, though fermented Opaa was found to also have good organoleptic properties. Consequently, fermented Saflo which was used to prepare palm-nut soup received a higher overall acceptability than palm-nut soup prepared with fermented Opaa.

Moreover, in comparing the differences in the organoleptic properties of fermented steamed Opaa and Saflo, the panelists identified that fermented Opaa had better organoleptic properties than fermented Saflo when steamed. Hence, the study specifically revealed that steamed fermented Opaa was deemed to be more pleasing than Saflo in terms of appearance, colour, aroma, texture and mouthfeel.

Whereas the panelists were of the view that fermented steamed Saflo had a better taste than fermented steamed Opaa. Accordingly, fermented steamed Opaa yielded a higher overall acceptability than fermented steamed Saflo. It could be realized that consumers would choose fermented steamed Opaa over fermented steamed Saflo since the former was deemed to have better organoleptic properties than the latter. The argument concurs with the stipulation of Tsvetko & Stoyan (2007) that consumer's desire for safety, nutritional quality, and organoleptic attributes in food consumption cannot be erased or undermined.

Research Question Two: What is the Macro-nutrient composition for the Fishes?

The research question was formulated to ascertain the macro-nutrients composition of the two fish samples used for the study. The macro- nutrients were looked at in term of its fresh state and fermented state for the two fish samples. The results of the study indicated that the two fish samples had good nutritional constituents although variations were identified between the two fish samples in their fresh state. Also, the macro- nutrients of the fishes varied after the fermentation process.

The results of the study revealed that the fish samples had acceptable nutritional constituent. Mohanty (2010) posited that the principal constituents of fish are: water 66-80 percent, proteins 15-20 percent, ash 0.5-2% and lipids 5-10 percent. The two fish sample used for the study had 72.51 and 73.92 water, 67.44 and 71.85 protein, 5.39 and 6.33, dry matter of 27.48 and 26.08 ash 12.20 and 7.70 lipids for fresh Opaa and Saflo respectively.

Adeyemi et al. (2013) found that the proximate composition of fresh Horse mackerel constituted protein content of 58.15%, moisture of 73. 56%, ash of 8.6% and fat of 3.32%. Similarly, El-bassir et al. (2015) identified that fresh cat fish has 70.75% water, 72. 35% protein 9.99 %ash, and 3.17% lipids. Therefore, the results of macro-nutrient composition of fresh Opaa and Saflo are not deficient to the nutritional constituents of the findings of (Adeyemi et al. 2013) and (El-Bassir et al., 2015). Amidst, Asare-Donkor et al., (2018) argued that it provides over 60 percent of Ghanaians' need for animal protein and 15% of the country's total animal protein sources.

According to Yeşilsu et al. (2021), fish proteins among animal proteins have a well-balanced amino acid composition that are essential for advantageous protein synthesis and utilization in the body. The protein composition of fish is noted to have a higher digestibility which ranges from 85-95% (Pal et al, 2018).

Furthermore, fish serves as a source of health-promoting oils and omega-3 polyunsaturated fatty acids (Mahmud et al., 2018). Aside from the nutritive value of fish, it has been found to be cheaper than other protein sources. Buttressing this assertion, Yeşilsu et al. (2021) stipulated that fish is cheap as it is produced at a lower cost per unit than other dietary protein sources like chicken, mutton, hog, beef, etc., and its value is comparable to that of meat protein.

The results of the study revealed that there were variation in the macro-nutrients of the two fish sample used for the study. That is they had 72.51% and 73.92 %water, 67.44% and 71.85 % protein, 27.48% and 26.08% dry matter, 5.39% and 6.33% ash 12.20% and 7.70% lipids for fresh Opaa and Saflo respectively. In line with the findings of the study, Kindossi et al. (2016) also identified variation in the nutritional constituents of two fish species (Spanish mackerel and cassava fish) used for lanhouin. Further, the dry matter content of the fermented Saflo (Spanish mackerel) was similar to the report of Kindossi et al. (2016) on Spanish mackerel lanhouin found in the market. Although there were variation in the nutritional constituent of the two fish samples for the study, Ashraf et al. (2011) asserts that fish composition shows a wide range of variation according to age, size, stage of sexual maturity, diet and other factors. It can therefore be concluded that the assertion of Asraf et al. (2011) explains the reason why nutritional value of the two fish samples used for the study varied although they both belong to the Mackerel family.

The results of the study found that there were changes in the nutritional constituent for both fish samples after the fermentation process. That is, there was a reduction in moisture (72.51% to 59.63%, 73.92% to 54.71%), protein (67.44% to 41.76%, 71.85% to 44.48%), fat (12.20% to 4.24%, 7.70% to 5.61%), and carbohydrate (11.80% to 3.97%, 11.60% to 3.31%) for Opaa and Saflo respectively. Accruing to the findings of the study, Amedekanya (2021), also revealed that the nutritional constituents such as water, protein and ash decreased after fresh cat fish was fermented for five days. Thus, the moisture of fresh cassava fish decreased from 76.63% to 63.23%, protein which was 72.66% became 36.49% and fat content also showed a decrease from 2.85% to 1.64%. The decrease in the aforementioned nutritional constituent was attributed to the application of salt as part of the fermentation process. In line with the assertion, Achinewhu & Oboh (2002) revealed in a study that the use of salt in fermenting fish was identified to lead to a significant reduction in the moisture content of fermented fish than unfermented fish. In line with the findings of Achinewhu and Oboh (2002) El-Bassir (2015) it was found that the moisture content of fresh fish decreased from 70.754% to 23.138% after salt was applied to the fish. In terms of protein reduction during the process of fermentation, Ezeama and Udoh (2012) revealed in a study that fermentation was associated with a reduction in the protein composition of fish. This is because the crude protein of catfish of 69.56% was reduced to 65.60% after fermentation. Similarly, Anihuovi et al. (2012) identified that the fermentation of fish resulted in a reduction in the protein content of the fermented fish. That is the protein content of Adjuevan, a fermented fish decreased from 53.93% to 25.66 %.

It is worthy to note that the protein content of Saflo was higher than that of Opaa in both their fresh and fermented state. Thus, the protein content of fresh and fermented Opaa and Saflo were (67.44% and 41.76%) and (71.85% and 44.48%) respectively. Whereas, Kindossi et al. (2016) found that the protein content (53.8%) of cassava fish lanhouin was higher than the protein content (49.2%) of lanhouin Spanish mackerel (Saflo). Also, the fat content for the fishes used for the study were (4.24% and 5.61%) for Opaa and Saflo after fermentation. In buttressing the higher fat content of fermented Spanish fish, Kindossi et al. (2016), reported a higher fat content of 42.8% and 47.4% for Spanish mackerel lanhouin found at the processing site and market respectively than fat content of 12.2% and 10.8% for processing site and market cassava fish lanhouin. It can be concluded that, the fat content of fermented Spanish mackerel was comparatively higher than other fish species (cassava fish and horse mackerel) in each of the studies.

According to Anihuovi et al (2012), the decrease in the protein content of fermented fish is as a result of proteolysis that takes place during fermentation. This is because the protein of fermented fish is broken down into peptides and amino acids which could be lost in the exudates (extracted water) from the fish. However, an early study by Achinewhu and Oboh (2002) had reported that fermented sardinella had a higher protein content than unfermented sardinella reporting a protein percentage of 18 and 16 were achieved for fermented and unfermented fish respectively. Consequently, Petrus et al (2012) attributed the increment of fish protein after fermentation to the quantity of salt applied as they identified that more than 15% salt application was linked with an increment in the protein content of fish fermented.

Protein which is a significant nutrient component of fish was found not only to have a linkage with salt but with the period of fermentation as well. Consequently, the protein content of fish has been identified to reduce based on the period of fermentation. Thus, Mahulette et al. (2018) found a decrease in the protein content of inusua which was fermented for one week to decrease from 45.26% to 18.03% after it was fermented for 12 weeks.

Similarly, a study conducted in Ghana by Amedekanya (2021) revealed a reduction in the protein content of cassava fish fermented based on the duration of days for fermentation. That is, the protein content of 72.66% fresh cassava fish which was fermented for a day decreased to 42.75% after it was fermented for 3 days and further decreased to 36.49% after it was fermented for five days.

Although there was a decrease in water, protein and fat, the findings of the present study showed a significant increase in ash (5.39% to 44.67%, 6.33% to 41.55%) and fibre (3.18% to 5.36%, 2.52% to 5.05%) for fermented Opaa and Saflo respectively. Consequently, Oetterer et al (2003) found in a study that salt has a significant influence on higher ash of sardine muscle.

The increase in ash concurs with the findings of Ezeama and Udoh (2012) who revealed in a study that the fermentation of fish with salt resulted in an increase of ash from 11.85% to 13.72%. Similarly, a study conducted by

El-Bassir (2015) identified that the ash content of fresh fish increased from 9.99% to 17.85% after salt was applied to the fish. It can be concluded that ash of fish increases regardless of being fermented or not due to salt application.

Fermentation of fish is done with the application of salt and it is a widely used method to preserve fish however, the findings of the study revealed that it influences most of the significant nutrients such as protein and fat. However, salt application is not only done during fermentation but is used with other methods of preservation due to the significant role it plays in preserving food items including fish.

This is because salt extracts water/moisture when applied to fish which lowers the rate of spoilage. However, to protect the nutrients of fish and to achieve optimal results during preservation, it is worthwhile to adopt other means of preservation to protect its safety and organoleptic qualities of fish. Several studies have identified that there was no negative effect of electrolyzed water technology when applied to fish products during preservation (Xu et al., 2014; Xuan et al., 2017).

Research Hypothesis One: There is no statistically significant difference in the organoleptic properties of fermented fish when used for/or:

a. **Stew (palava sauce)**
b. **Soup (palm-nut soup)**
c. **Steamed**

To test the research hypothesis, each of the fermented fish sample was used to prepare palava sauce, palm-nut soup and steamed for 15 panelists to appraise their organoleptic properties. The findings of the study showed that there was no statistically significant difference between the organoleptic properties of fermented Opaa and Saflo used to prepare palava sauce; a difference was found between the organoleptic properties of palm-nut soup prepared with fermented Opaa and Saflo; and no difference between the organoleptic properties of fermented steamed Opaa and Saflo

The findings of the study revealed that there was no statistically significant difference between the organoleptic properties of fermented Opaa and Saflo used to prepare palava sauce. Both accrued good organoleptic properties as they were found to have equal pleasing effect on the panelists. This is because fermented fish is generally used to improve the flavour and taste of dishes. As such, in comparing the sensory properties of catfish Ezeama & Udoh (2012) found that stew prepared with fermented catfish had higher sensory properties than stew prepared with unfermented catfish.

Also, the results of the study showed that there was a difference between the organoleptic properties of palm-nut soup prepared with fermented Opaa and Saflo. Therefore, the palm-nut soup with each of the fermented fish will vary in their organoleptic properties. The fermented Saflo palm-nut had a better appearance, aroma, texture, taste and mouthfeel than the fermented Opaa palm-nut soup. Thus, fermented Saflo palm-nut soup was preferred to fermented Opaa palm-nut soup.

However, the panelists found the aroma of Saflo to be better than opaa when used for palm-nut soup and is likely to contribute to the differences that was found in comparing the sensory properties of the two fish samples when used for preparing palm-nut soup.

Pertaining to the texture of Spanish mackerel which was deemed to be better than the texture of horse mackerel when used to prepare palm-nut soup, a similar study on fermented fish conducted in Benin by Dossou-Yovo et al. (2011) also found that the texture of Spanish mackerel (Saflo) lanhouin softer than cassava croaker lanhouin. Thus, the Spanish mackerel (Saflo) used to make lanhouin was considered to have a better organoleptic property than cassava croaker lanhouin.

Finally, the results of the study found no significant difference between the organoleptic properties of fermented steamed Opaa and Saflo. Hence, both had the same organoleptic properties and none was regarded superior to the other and both will gain high consumer satisfaction when sold on the market.

Research Hypothesis Two: There is no statistically significant difference between the macro-nutrients composition of fresh and fermented fish (opaa and saflo).

Hypothesis was ascertained whether there was statistically significant difference in the macro-nutrients composition of the fishes in their fresh and fermented states. A p-value of 0.05 was used as the threshold, and the values for opaa and saflo were 0.021 and 0.018 respectively less than the p-value. This showed that the macro-nutrient was statistically different in terms of protein, fats and oils, ash, moisture, dry matter, carbohydrates and fibre. As a result, the null hypothesis was rejected. In a study conducted by Amedakanya (2021), there were varied amounts of nutrients in the cassava fish used. This affirms the results of the study. Similarly, El-Bassir(2015) and Ezeama and Udoh (2012) in their various findings revealed differences in the nutrients content of the fishes they used.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter presents the summary, conclusions and recommendations of the study. It also suggested areas for further research.

Summary

The purpose of the study was to compare the organoleptic properties of two fermented fish (Opaa and Saflo). Two research questions and two hypotheses were set to achieve the purpose of the study. A quantitative approach with a mixed method design was adopted for the study. Purposive and convenience sampling techniques were used to select fishes and panelists for the study.

A total number of 15 panelists constituting 6 males and 9 females were involved in the study. The information acquired from the data collection were analysed with both descriptive and inferential statistics. The questionnaire which was used to collect data had both closed-ended and open-ended items.

The demographic data was analysed with the use of frequency counts and percentages, the two research questions were analysed with the use of descriptive statistics specifically, research question one was analysed with percentages. Research question two was analysed with frequency counts and percentages, means and standard deviations with pictorial representations (pie chart) and the hypotheses were tested with inferential statistics (Two sample T-test).

Key Findings

The following were the key findings based on the research questions and the hypotheses:

1. The two fish samples had good nutritional constituents although variations were identified between the two fish samples in their fresh state and after fermentation process. However, a significant decrease was identified in the protein content of Opaa and Saflo after fermentation.
2. Differences existed in the organoleptic properties of the fermented fish (Opaa and Saflo). That is, the panelists identified that fermented Opaa had better organoleptic properties than fermented Saflo when used to prepare palava sauce or steamed whereas palm-nut soup prepared with fermented Saflo had better organoleptic properties than fermented Opaa.
3. There was no statistically significant difference between the organoleptic properties of fermented Opaa and Saflo used to prepare palava sauce; a difference was found between the organoleptic properties of palm-nut soup prepared with fermented Opaa and Saflo; and no difference between the organoleptic properties of fermented steamed Opaa and Saflo.
4. There was statistically significant difference in the macro-nutrients composition of the fishes (opaa and saflo) in their fresh states and after they were fermented.

Conclusions

From the findings, the following conclusions were drawn:

1. The two fermented fish samples (Opaa and Saflo) had good organoleptic properties. However, differences existed as each has its own unique features that balances well when used to prepare a specific dish like palava sauce, palm-nut soup or steamed.
2. A statistically significant difference was not found between fermented Opaa and Saflo when steamed or used to prepare palava sauce because both fermented fish matched very well with ingredient uesd. Also, fermented Opaa and Saflo were pleasing and liked by panelists when steamed whilst the ingredients used for palm-nut soup balanced very well with fermented Saflo over fermented Opaa hence a statistically significant difference was achieved.
3. The fresh and fermented Opaa and Saflo were highly nutritious and could meet the nutritional needs of consumers although they had variations in their macro-nutrients constituents.
4. A statistically significant difference was detected in the macro-nutrient (opaa and saflo) in their fresh and fermented states.

Recommendations

Based on the findings and conclusions drawn from the study, the following recommendations were made:

1. Fermented fish should be used with fish, beef, beans and egg and other protein sources to meet the daily recommended value in meals since fermentation decreased the protein content of fish.

2. Spices like ginger, pepper and garlic can be used to further boost the organoleptic properties of fish during the fermentation process.
3. Fermented fish should be used sparingly as higher intake will accumulate salt in the body which will inadvertently cause cardio vascular diseases.
4. Both fishes can be used together for meal preparation in order to get the desired results.

Areas for Further Research

1. Future studies could identify and compare the proximate composition of fermented Opaa and Saflo by using fish samples sold in the market and not prepared by the researcher in order to either confirm or refute the findings of the current study.
2. Future studies could compare the organoleptic properties of fermented Opaa and Saflo by using fish samples sold in the market and not prepared by the researcher in order to either confirm or refute the findings of the current study.
3. Future studies could also replicate the study with different situations and different subjects to compare findings.

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