EFFECTS OF CULTURE FACILITIES ON NUTRITIONAL VALUE AND ORGANOLEPTIC ASSESSMENT OF FARM RAISED *Clarias gariepinus* IN BENIN METROPOLIS.

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DEPARTMENT OF AQUACULTURE AND FISHERIES MANAGEMENT

FACULTY OF AGRICULTURE

UNIVERSITY OF BENIN

BENIN CITY, NIGERIA

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

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CERTIFICATION

This is to certify that this project was carried out by **Emmanuel Osaror, BRODRICK (AGR1800265)** in the Department of Aquaculture and Fisheries in the Faculty of Agriculture, University of Benin, Benin City, Nigeria.

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DEDICATION

This project work is first dedicated to the Almighty God, whose sustenance has been my anchor and to my irreplaceable family for their indelible support and belief in me all through my academic transit.

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ABSTRACT

This study determined the effects of culture facilities; (Earthen pond, Concrete tank, and Tarpaulin tank) on the nutritional value and organoleptic properties of *Clarias gariepinus* in Benin Metropolis. Thirty catfish samples (Ten samples from each culture facility) of average weight of 500g obtained from a reputable farm in Benin city were euthanized, eviscerated, degutted, and thoroughly washed under running water. The samples from the earthen pond, concrete tank, and tarpaulin were tagged sample A, B, and C respectively. The proximate analysis of the fresh and smoked-dried samples was done according to standard methods. Organoleptic assessment was done by trained panelists. The result reveals that *C. gariepinus* raised in the concrete tank had the best general acceptability in terms of appearance, texture, aroma and taste, although, there was no significant difference (P<0.05) across the samples. Proximate analyses of the fresh catfish showed that the sample raised in the tarpaulin had the highest moisture (75.13±0.66) followed by earthen pond (71.40±0.66) and concrete tank (68.56±0.66). Analyses on the smoked-dried catfish indicated that the crude protein was higher in sample A (62.04±62) immediately after smoke-drying while the least ((46.20±1.01) was from sample C after four weeks of storage under ambient temperature. There was significant difference (P<0.05) in the parameters across the samples. This study reveals that *C. gariepinus* raised in the tarpaulin tank has better nutritional value than those from the earthen pond and concrete tank respectivel

CHAPTER ONE

1.O INTRODUCTION

Aquaculture has been considered as one of the fastest growing food-producing sectors in aquatic field and is set to play a crucial role in meeting the increasing demand for fishery products due to rapid rise in human population and declining natural fisheries resources (Food and Agriculture Organisation FAO, 2018). Fish production through aquaculture is considered sustainable and the most efficient way to produce high quality proteins for human consumption (Ali *et al*., 2021; Khalli *et al*., 2021; Maulu *et al*., 2021). The demand for fish is significantly increasing with the increase in the world population because of their favourable taste, efficient feed conversion and high commercial value (Tevares *et al*., 2021).

Fish is an essential constituent of human diet and the benefit of this adequate matter is highly linked to the quality of their lipid content, a source of essential polyunsaturated fatty acids (PUFA), (Harris, *et al*., 2008; Baum, *et al*., 2012). In Nigeria, fish is highly accepted for it's availability, affordability, and sensory quality (Ighodaro and Abolagba 2010, Gulshan *et al*., 2014). Fish can be beneficial to eat whole because it has a high protein to fat ratio compared to goat, lamb, buffalo and chicken meat (Steffen, 2006). A portion of 140 grams of fish can provide about 50-60% of the daily diet of an adult (FAO, 2010).

Nutrients are substances which enrich the body, enhance growth, maintain and repair body parts (Srivastava & Srivastava, 2008). Nutrients can be categorised into micro and macro nutrients which are both crucial for good health. Macronutrients namely; proteins, lipids, ash and carbohydrates are present in the fishes (Lilly *et al.*, 2017). Proteins and fats are the most important nutrients in fish that determine the nutritional value of fish (Uttam, 2021). Micro-nutrients which includes vitamins and minerals are vital dietary elements that are essential in very small quantities that is, they must be supplied from outside sources to the body (Mohanty, 2011). Fish as a food has been contributing fundamentally in the provision of nutrient to many animals as well as humans. Fish is a great source of food and also have high nutritional value which promotes good health. Consumption of fish daily, has its role in the forestalling of heart disease (Chrysohoou *et al.,* 2007). Moisture, proteins, fats, minerals and vitamins make up crucial micro and macro nutrients that are responsible for implying nutritional value to the fish meat (Steffen, 2006). In comparison with other protein sources, macro and micro nutrients present in fish makes it preferable (Lilly *et al.,* 2017).

Cat fish (*Clarias gariepinus*) is basically fresh water fish that is well adapted to a confined environment and are resistant to manipulations and disease (Abdel-Mobdy *et al*., 2021). Catfish is very rich nutritionally, with a very high concentration of unsaturated fatty acids, vitamins, proteins and minerals (Nelson *et al.,* 2006). *C. gariepinus* in recent years has gained fast increase in consumption due to it's availability, consistency, and health benefits (Hoke *et al*., 2000). Catfish has become the preferred species due to their tolerance to high stocking density, ease of rearing and ability to resist disease infestation (Oyebola and Awodiran, 2015). *C. gariepinus* is listed as one of the most cultured fish species in Nigeria due to it's adaptability to captivity condition, rapid growth rate, flesh tastiness, hardiness, and disease resistance (Anoop *et al.,* 2009).

1.1 Justification of the Study

The high nutritional value of fish meat I s reflected in its favorable content of proteins, carbohydrates, minerals and vitamins (Ćirković *et al*., 2002). Nutritional value is used as an indicator of fish quality; it varies with diet, feed rate, genetic strain and age (Austreng and Refstie, 1979). The acceptability of fish and fish products by consumers is largely determined by several attributes of fish quality (Oluwalola and Adebayo, 2020). These attributes include; the nutrient content, microbial load with biochemical and physiochemical properties like flavour, texture, odour, and colour (Alam *et al*., 2012).

Generally, the nutrient profile of catfish reveals that it is highly rich in protein, low in fat and cholesterol, and a good source of certain vitamins and minerals (Robinson *et al*., 2001). The type of culture facility used for fish farming could also have an impact on the growth, health, and nutritional value of the fish being raised.

Related research works carried out includes; Estimation of Length-Weight Relationship and Proximate Composition of Catfish (*Clarias gariepinus* Burchell, 1822) from Two Different Culture Facilities (Olaniyi *et al*., 2015); Comparative Assessment of Nutrient Composition of Aquacultured and Wild Catfish (*Clarias gariepinus*) in Cross Rivers State Nigeria (Chibuzor *et al*., 2020) and Comparative Study of the Flesh Quality of *Clarias gariepinus* in Farm-raised and Wild Populations (Popoola and Fasakin, 2019). Majority of the previous work carried out chiefly compared the nutritional value of cultured *Clarias gariepinus* with that of the wild. Therefore, this study will investigate the effects of various culture facilities; (earthen ponds, concrete tanks, and tarpaulins) on the nutritional value and organoleptic assessment of raised *Clarias gariepinus.*

1.2 Aim and Objectives of Study

The aim of this study was to determine the effects of culture facilities on the nutritional value of farm-raised *Clarias gariepinus*.

The specific objectives were to determine the bi-weekly;

1. proximate composition of smoked dried *C. gariepinus* raised in various culture facilities

2. organoleptic assessment of smoke -dried *C. gariepinus* raised in various culture facilities.

CHAPTER TWO

2.0 LITERATURE REVIEW

Clarias gariepinus, also known as African sharp toothed catfish is a large, eel-like fish that is often dark gray or black in colour. It belongs to the kingdom: animalia, phylum: chordata, class: Actinopterygii, order: siluniformes, family: clariidae, genus: clarias and specie: gariepinus (Adebayo and Daramola, 2003). This fish specie has slender body, a flat bony head and broad terminal mouths with four pairs of barbells, have large accessory breathing organs made of modified gill arches (Adebayo and Daramola, 2003).

The African catfish, *C. gariepinus* is one of the most widely consumed freshwater fish in Nigeria due to its large acceptability (Eyo, 2001). Nutritional composition of cultivated fish is largely determined by the type of feed administered (Adebayo *et al.*, 2016). Other factors may include feeding habit, water quality, cultured medium and period (Fapohunda *et al.*, 2005).

2.1 Culture Facilities in Aquaculture

In Nigeria and other parts of the world, fish are cultured in different facilities depending on the choice or what is of most convenience to the farmer. The type of culture facility chosen depends on several factors, some of which include: type of species to be raised, climate of area, location of site, available funding for a structure, and size of the operation (Olaniyi *et al.*, 2015). These culture facilities are catagorised into raceways, ponds, cages, tanks, and recirculatory system (Ozigbo *et al.*, 2014). The type of culture medium used and their management have a significant influence on fish farm profitability (Ross and Waten, 1995) and the quality of fish products.

2.1.1 Earthen ponds:

Earthen ponds are the oldest and most common type of aquaculture (Henares *et al*., 2020). Pond is described as an earthen vessel for collecting and holding water with dikes and bottom soil to reduce seepage to the barest minimum (Igwe and Mgbaja, 2014). It entails the construction of ponds on land that have proximity to a water body. Typical fish ponds are earthen enclosures in which the fish live in a natural-like environment, feeding on the natural food growing in the pond itself from sunlight and nutrients available in the pond water (Olaniyi *et al*., 2015). They are comparatively inexpensive to construct and maintain with simple water in-flow/out-flow gates (i.e. monks) or pumps, and simple production strategies. Although many variations exist, they all consist of a large earthen pit (sometimes lined with plastic or concrete) surrounded by earthen levees or dikes, often in groups of interconnected ponds (Stefan *et al*., 2021).

Ponds are often in low-lying coastal areas vulnerable to unstable climate patterns such as sea-level rise and increased storms, or to increased flooding and drought cycles in inland systems (Partelow *et al*., 2018, Allison *et al.*, 2009, Ahmed and Diana, 2016). They can rely on fresh or brackish water inputs depending on the species and water sources (e.g. rivers, tidal), enabling a large diversity of plants (e.g. algae), fin-fish (e.g. catfish, tilapia, milk-fish) and invertebrates (e.g. shrimp, crabs, sea cucumber) in both mono and poly-cultures to be produced (Stefan *et al*., 2021). Production is also reliant on the provision of water quality, however, it can also cause pollution from excess fertiliser, antibiotics and excrement, requiring institutions for who can pollute and how much (Henares *et al*., 2020, Boyed, 2003). Depending on production goals, earthen pond aquaculture can be done with relatively minimal knowledge of species biology, growing conditions and technology, although economic risk, production, efficiency and pollution mitigation may be improved with increased knowledge (Stefan *et al*., 2021).

2.1.2 Culture Tanks

Fish culture tanks for the rearing of fish can be concrete, plastic, fibreglass and tarpaulin tanks. Fish farming can also be carried out in outdoor or indoor concrete or plastic tanks. Tanks can be in form of small aquaria (glass or plastic) or large fibre-glasses. Production tanks varies in size and shape, however, round tanks between 5,000 to 10,000 liters are most commonly used (Auatic Life Support System, 2013). Tanks need to be non corrosive, therefore, plastic or fiberglass is recommended. Smooth round tanks with a conical shaped bottom are considered advantageous as this will assist with waste solids disposal during draining (Ozigbo *et al*., 2014).

2.1.2.1 Concrete tanks:

Concrete tanks are usually constructed with concrete and reinforce with concrete to make them stronger construction of concrete ponds is often handled by high professionals in construction engineering (Idayat *et al.,* 2022). Lately, concrete tanks have gained a lot of prominence among fish pond operators; this is a way of raising fish closer to home because it requires less space and can be practiced within the home profitably (Olalekan *et al*., 2014).

2.1.2.2 Tarpaulins tanks

Tarpaulin tanks made of tarpaulins sewn together and attached to a metal or wooden frame for support (CatfishNigeria, 2013). They can be of different shapes with the rectangular and square shapes as the most common. This system of fish production is common in cities most especially where land is not readily available or suitable for earthen pond construction. Based on intensification, tarpaulin tanks can be managed through flow and occasional flushing. The source of water is majorly from borehole or Wells through pumps. Pond drainage is achieved by gravity (CatfishNigeria, 2013). The use tarpaulin is becoming rampant in Nigeria. The advantages associated with the use of tarpaulin tanks is that it can be dismantled and transferred to another place and also it's monitoring and management is easy. The risk of predation and poaching is minimised as the system is often installed in or close to the owner's residence. Tarpaulin tanks are not as durable as the aforementioned culture facilities, although it has lower installation cost when compared with the concrete tanks. Yield and returns are low as the number of fish stocked is low unless when operated under the intensive culture system. The offensive dour of fish water can become a problem to neighbours especially as it is install mostly close to residential areas, the cost of water management and electricity is also high (CatfishNigeria, 2013).

2.2 Nutritional Value of Fish

Fish is very vital to a nutritious meal in many areas across the world and it provides about 3.3 billion people with almost 20% of their average per capita intake of animal protein (Maulu *et al.*, 2021). Fish contains a high nutritional value due to having rich contents of protein, water, amino acid composition and fatty acids (Ahmed *et al*., 2022). Research and analyses has shown that fish provide protein of a superior quality with all the essential amino acids, as well as elemental sources of dietary vitamins and minerals, including zinc (marine fish), iron, calcium, phosphorus, iodine, selenium, vitamin A, D, E, several B vitamins (B3, B6, and B12), important amounts of PUFAs and various other micro-nutrients (Suleria *et al.*, 2015; Singh and Ranjan, 2015; Marques *et al.*, 2019).

The chemical composition of fish flesh is regarded as a reliable predictor of the fish's quality, nutritional value, physiological state and habitat (Ravichandran *et al*., 2011). Nowadays, fish and its products are considered as an essential component of the human diet due to their high nutritional content, particularly in terms of protein and omega-3 fatty acids, which are thought to aid in the maintenance of good health like prevention and treatment of cardiovascular, inflammatory and neurological diseases (Jan *et al*., 2021; Li *et al.*, 201 9).

The average proximate compositions of fish is shown in Figure 1.

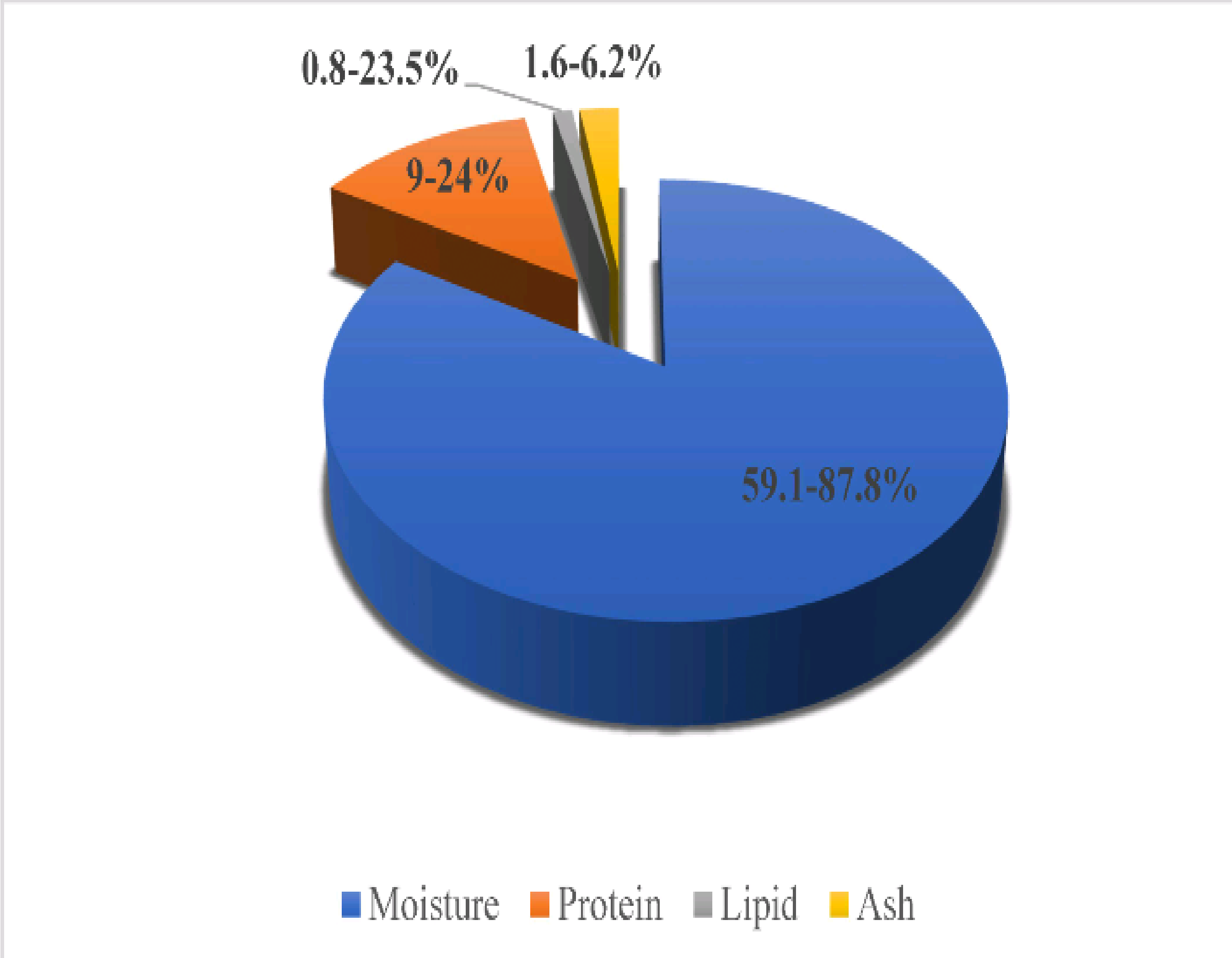

Figure 1: Average Mean Proximate Composition Data from sixty two species of fish

Source: Ahmed *et al*., (2011).

Table 1. Nutritional Composition of Fish Muscle and their Applications.

Nutrient	Percentage	Applications
Protein	15-24%	Potential source of animal protein, antioxidants and metabolic activities; improve muscle tissues and immunity; application in biotechnology and pharmaceutical (Mohanty *et al*., 2019).
Lipid	O.1-22%	Provide lipid-soluble vitamins (A and D) and essential omega-3s (PUFAs) absent in the body, lowering blood pressure and triglycerides in the blood; helps to reduce cardiovascular, childhood asthma, hypertension and Alzheimer's disease (Holma and Maalekuu, 2013).
Docosahexaenoic acid (DHA)	6.1-10.3%	Helps to improve brain and neuro development in children; involved in lipid metabolism and neural functioning and reduction in blood pressure and coronary heart disease (Mohanty *et al*., 2016).
Eicosapentaenoic acid (EPA)	3.7-4.5%	Protects against cardiovascular disease; involved in blood coagulation and aggregation of platelets; prevents dementia, atherosclerosis and rheumatoid arthritis (Jamshidi *et al*., 2020).
Vitamins	0.1%	Improves growth and development of children; aids in bone, teeth and cell repair; prevents eyesight loss and blood coagulation; accelerates chemical processes in the body (Mesias *et al*., 2015).
Minerals	1-2%	Have high bioavailability, easily absorbed by the body; helps in the synthesis of haemoglobin in RBCs and proper functioning of the thyroid gland (Suganthi *et al*., 2015).
- Calcium	0.5%	Mineralization and formation of bones; proper functioning of muscles and nervous system; involved in metabolic processes (Hantoush *et al*., 2015).
- Phosphorus	0.25%	Maintain teeth and bone structures; regulates acid–base equilibrium (Hantoush *et al*., 2015).

2.2.1 Protein and amino acid

Proteins are one of the essential macromolecules required by living organisms to carry out the functionality of the biological process (Arshad *et al*., 2022). Among the macro nutrient composition, protein in fish is an excellent source, because of the amino acid composition and degree of digestibility (Louka *et al*., 2004). The chemical composition of fish varies greatly from one to another depending on age, sex, environment and season with protein levels ranging from 16 - 21%, lipids 0.1 - 25%, ash 0.4 - 1.5% and moisture 60 - 81% (Lilly *et al.,* 2017). Aquatic protein is highly digestible and rich in several peptides and essential amino acids that are limited in terrestrial meat proteins, as for example methionine and lysine as suggested by Tacon and Metian (2013).

Recently, research has also been intensified on the beneficial health effects of fish protein in human nutrition (Rudkowska *et al*., 2010; Pilon *et al*., 2011). 60% of people from developing countries like Nigeria depend upon fish for over 30% of their animal protein supplies (Sujatha *et al*., 2013). Fish protein is mainly responsible for building and repairing muscle tissues, improving immunity and blood quality (Sujita *et al*., 2019). Fish proteins can also be used to prevent protein–calorie malnutrition (PCM) in animals (Lees and Carson, 2020). The protein immunoglobins act as an effective defence mechanism against viral and bacterial infections and also aids in the maintenance of water balance and electrolyte systems in humans (Balami *et al*., 2019).

Fish serve as a primary source of high biological protein, usually more than 70% to human food, by providing the EAA, including sulphur-containing amino acids (Pawar and Sonawane, 2013) and are thus considered a high-quality protein source containing all the EAA in balanced amounts with digestibility values of more than 90% (Pigott and Tucker, 2017).

2.2.3 Lipid

Lipids play an important role in the nutritional value of fish due to the presence of long-chain PUFAs which consist of omega-3 fatty acids, particularly EPA and DHA (Mesias *et al*., 2015). The composition of fatty acids in fish varies depending on factors such as species, diet and environmental factors like salinity, temperature, season, geographical location and whether the fish is wild or farmed (Tasbozan and Gokce, 2017). Fat is considered as the third principal constituent in fish muscle and generally reported within the range from 6% to 20%, primarily located in the subcutaneous tissue, liver, muscle tissue, mesenteric tissue, belly flap and head (Moradi *et al*., 2011).

Omega-3 fatty acids found in fatty fishes are known to be essential in the growth of children and prevent coronary heart disease (Abraha *et al*., 2018). Lipids and fatty acids also play an important role in membrane mediated process such as osmoregulation, nutrient assimilation and transport (Sujatha *et al*., 2013). PUFA in fishes is found in liquid form which flows in the blood vessels freely and this makes it different from other fats or oils (Morales *et al*., 2015). It was stated by David (2013) that the foetus and infants must be supplied with n-3 PUFA all through the pregnancy and lactation period which are considered to be significant for the central nervous system development.

Research have shown that an increased level of n-3 PUFA of about 1−1.5 g per day is mainly needed to bring a decline in the cardiovascular disease risk, including inflammatory response, blood pressure, plasma triacylglycerol levels, platelet aggregation (Balami *et al*., 2019). Many other benefits of n-3 PUFA include prevention against arrhythmia, therapeutics for asthma patients, protection against atherosclerosis and manic-depressive illness, reduced symptoms of cystic fibrosis and survival of cancer patients (Bowen *et al.,* 2016).

2.2.4 Vitamins

Fish is a vital source of vitamins (A and D) and a good source of B-group vitamins which are considered to be beneficial for the growth and development of children (Sangija *et al.,* 2021). The entire vitamins essential for human health is present in good amount in fish, but amount may vary according to the fish species (Pal *et al*., 2018). Many species of fishes store large amount of vitamin A & D in their liver (Balami *et al.,* 2019). Vitamin A helps for normal growth, formation of bones and teeth, building of cells and it also prevents the problem of poor eyesight and helps in the treatment of many eye diseases (Pal *et al.,* 2018).

Vitamin D present in fish was found in the form of vitamin D3 (cholecalciferol) which represents a three-fold higher potential efficiency ratio than that of vitamin D (ergocalciferol) and it was also found in the skin as 7-dehydrocholesterol after exposure to ultraviolet light (Hawk, 2020). Vitamin D deficiency leads to rickets, osteomalacia, a low bone mineral density (BMD) and increased cases of falling in people (Holick, 2008a). Beside bone connected issues deficiency of vitamin D has been connected with diabetes (Holick, 2008a), increased aggressiveness of certain cancers and increased occurrence of autoimmune diseases as well as cardiovascular diseases (Holick, 2008b; Norman, 2008). Vitamin B accelerates enzyme functioning which facilitates chemical processes in the human body whereas vitamin K is important for blood coagulation and helps to prevent internal bleeding in the body (Khalli and Sampel, 2018).

2.2.5 Minerals

Fish is an important source of micronutrients which are not widely available from other sources in the diets of poor people (FAO, 2002). Fish contain high-nutritional-value minerals in widely varying quantities including calcium, iron, zinc, selenium, iodine, phosphorus and potassium (Marque *et al*., 2019). In comparison with other minerals, the absorption of Ca in the body is inadequate (Sujitha *et al*., 2019). Calcium is significantly used for bone formation and mineralization, and the proper functioning of muscles and the nervous system (Sihotang *et al.*, 2019).

Iodine is crucial for the production of hormones, mostly thyroxin which aids in the to regulation of the body's metabolism. Selenium is an essential micro-nutrient for humans, acting as a cofactor in the reduction of antioxidant enzymes such as glutathione peroxidase in the form of selenoproteins, it is also responsible for thyroid function (Uttam, 2021). Low levels of selenium can increase the risk of myocardial infarction and increase mortality from cardiovascular disease, and have also been associated with an increased risk of cancer and kidney disease (Torgilson, 2010).

2.3 Factors Affecting the Nutritional Composition of Fish

Several factors can influence the nutritional composition of a fish flesh. Every step in the history of the fish, from the manner of production, the system of fish rearing and processing can have a great influence on the quality of the final product. Generally, factors which can have an effect on lipid content and composition in fish as a great component providing the valuable omega-3 FAs can be divided into the feeding, species, reproductive status, size or (age), water temperature, salinity and season (Henderson and Tocher, 1987; Ackman 1989; Saito *et al*., 1999; Alasalvar *et al*., 2002; Khalili Tilami and Sampels, 2018).

2.3.1 Feeding:

Under intensive culture, feeding regimen and feed composition have a major influence (Lie, 2001) especially on the lipid content and the FA composition (Henderson and Tocher, 1987; Morris, 2001; Shearer, 2001) which is well-addressed by Khalili Tilami and Sampels (2018). In contrary, as long as fish are fed adequate diets containing all their requirements in the sufficient amounts, the protein content and composition seem to be predetermined regardless of the diet content or the feeding regimen (Morris, 2001; Shearer, 2001). Besides the feeding, handling after the harvest, transport, possible storage or purging of the fish and the slaughter methods (Erikson, 2001; Robb, 2001) are important for the final product quality and can have an effect on lipid content and composition. Fish fed with a diet containing mainly plant protein sources, reduces the protein retention (Daniel, 2018). The reason could be due to the lack of essential amino acids in the plant proteins (Richard *et al*., 2011; Berge *et al*., 1998) or deficiency in liver metabolic adaptation to higher levels of plant proteins (Panserat *et al*., 2009). One other reason could be because plant proteins contain antinutritional factors such as protease inhibitors and saponins that reduces the digestion and absorption of nutrients. Utilization of plant proteins without amino acid supplementation (e.g. methionine or lysine) can increase the feed conversion ratio in fish (Berge *et al*., 1998). Currently, fish meal is still the primary source of protein for farmed fish (Tacon *et al*., 2011). As a result of fish meal replacement with plant proteins, decline in the protein biosynthesis in fish (e.g. rainbow trout) was observed (Panserat *et al*., 2008). By developing new feeding strategies, more than 50% of the fat of the feed can be substituted by vegetable oils during the main period of growth. For instance, replacement of rapeseed oil instead of fish oil (Bell *et al*., 2003) does not reduce the n-3 HUFA content in farmed fish as compared to the wild fish (Pike and Jackson, 2010). Variation in energy value of different fish species is related to the differences in fat content (Bogard *et al*., 2015). Carp diet supplemented with cereals which are rich in carbohydrate, has higher lipid content, lower amount of PUFA compared to wild one (Csengeri, 1996). It has been reported that moderate dietary carbohydrate level has positive effect on the growth of carnivorous fish (Hemre *et al*., 2002) whereas the excess amount of it has adverse effect, resulting in increased level of glycogen, lipid deposition in the liver and higher HIS (Tan *et al*., 2009, Ren *et al*., 2011).

2.3.2 Species:

Differences in muscle lipid content within fish species is noticeable which can cause differences in FA composition (Fontagné-Dicharry *et al*., 2010) which is well-addressed by Khalili Tilami and Sampels (2018). The amount or percentage of FAs for instance EPA and DHA are variable among and within a species which can indicate the great role of environment including the rearing condition of fish in the wild or farm (Kris-Etherton *et al*., 2002) or even between cage-reared and tank-reared fish fed with the same diet (Martelli *et al*., 2013), in this case differences in FAs might be due to the stocking density (Piccolo *et al*., 2008) or water and seasonal differences. In bottom dwelling species (as a typical lean fish), fat is stored in the liver. However, migratory species have a higher content of dark muscle rich in fat (Alam *et al*., 2012).

2.3.3 Reproductive status:

During the maturation, along with the accumulation of lipids in the gonads, changes in some FAs can happen (Pérez *et al*., 2007). In addition to the other functions of PUFA, their important role for the reproductive performance have been investigated. Based on Mazorra *et al*. (2003) and Jerez *et al*. (2016) findings, during the reproductive cycle, FAs are metabolized in different way either catabolized for energy or being stored in gonads in the purpose of formation of the membrane or eicosanoid synthesis. In many fish species, arachidonic acid (ARA, 20:4n-6) plays an important role for the successful reproduction (Tocher, 2010). This FA is the main precursor for the 2-series prostaglandins (PG-2), eicosanoids which influence the sexual behavior of female fish in many species in line with stimulating steroid synthesis in the ovary and trigger oocyte maturation (Mercure and Van der Kraak, 1995; Tocher, 2003). Ng and Wang (2011) suggest that high percentage of saturated fatty acid (SFA) in tilapia gonads is essential for the success in their reproduction. High levels of PUFA in the ovary of both marine and freshwater fish have been reported (Izquierdo *et al*., 2001). Fish ovaries have the ability to generate eicosanoids from arachidonic acid (ARA, C20:4n-6) (including prostaglandins PGE2 and PGF2α) or from EPA (prostaglandins PGE1 and PGE3), which are essential for the metabolism of that tissue in the final maturation phase (Sargent *et al*., 2002). Based on findings by Sorbera *et al*. (2001) and Bell and Sargent (2003) on the oocyte of European sea bass (*Dicentrarchus labrax*), eicosanoids generated from ARA (PGE2 and PGF2α) are responsible for regulating oocyte maturation, vitellogenesis and ovulation.

2.3.4 Water salinity temperature and season:

Influence of water salinity, temperature and seasonal changes on biochemical contents and FA profile of fish is known (Ackman, 1995; Leger *et al*., 1977; Bandarra *et al*., 1997; Farkas, 1984; Fonseca-Madrigal *et al*., 2012). According to Farkas (1984) and Haliloğlu *et al*. (2004), at low water temperatures, fish need PUFAs particularly DHA in order to tolerate the condition. Thus the main changes in the FA composition is an increase in DHA percentage at lower temperatures, therefore, higher amount of PUFA are to be expected in the fish living in the cold water. In many poikilotherms, with increase in the temperature, a decrease in the content of unsaturated FA was observed (Farkas, 1984). Also, Jobling and Bendiksen (2003), showed that lower water temperatures in general result in increased proportions of unsaturated FA and lower amount of SFA. More recently, Norambuena *et al*. (2016) indicated that water temperature obviously affected FA composition in salmon reared at 10 °C versus 20°C, where fish kept at lower temperature showed higher contents of n-6 FA in fillets. The same author also reported a decreased bio-conversion from ALA to EPA and DHA at the increased temperature. Seasonal changes on fish muscle FA composition from temperate water is accompanied by seasonal depletion in MUFA specifically in oleic acid (18:1n-9) somehow associated with mobilization through gonadal development stage (Sargent, 1995; Özyurt and Polat, 2006). During the critical period of winter season in temperate waters, fish may undergo depletion of lipid reserves, increase in the risk of disease due to the low temperature, less availability in food (Wedemeyer *et al*., 1976; Tort *et al*., 1998).

CHAPTER THREE

3.0 Materials and methods

3.1 Description of Study Area

The study was carried out in the Department of Aquaculture and Fisheries Management, Faculty of Agriculture, University of Benin. Benin city is the capital and largest city of Edo state, southern Nigeria. It lies within the coordinates; $6^0$20'21.0'N $5^0$37'2.0'E with a total area of 1204 kilometre square (465 sq mi). It is an important industrial and cultural centre, with the economy dominated by rubber and various oil producing companies. The population of the city is close to about 1.2 million people, with most of them taking their root from local Edo culture (LatLong net, 2024).

3.2 Experimental Design

The experiment was made up of two main factors, which were;

(1) One fish species *(Clarias gariepinus)*

(2) Culture facilities; (earthen pond, concrete tank and tarpaulin tank).

It was laid in a Completely Randomized Design involving 3 treatments by 3 weeks by 1 fish species. This will be replicated thrice.

3.3 Collection of Fish Samples

A total of thirty (30) live *Clarias gariepinus* of average weight of 500g were obtained from a reputable farm in Benin City. Ten (10) fish were obtained from each of the three culture facilities considered for the study; (that is; Earthen pond, concrete tank and tarpaulin tank). They were obtained from the same farm and transported to the fish processing unit of the Department of

Aquaculture and Fisheries Management, University of Benin in three containers with a polythene bag cover to avoid contamination.

3.4 Processing apparatus

The processing apparatus used were; electric blender, electric weighing balance, razor, knives, bowls and Magbon Alade smoking kiln.

3.5 Preparation of Fish Sample

The fish were killed, degutted, eviscerated and washed under running water to get rid of blood, gut content, smear and slime.

3.6 Preparation of Smoking Kiln

The smoking racks was thoroughly washed with iron sponge and water containing liquid soap to get rid of crumbs or debris from previous use. They were properly rinsed with clean water and allowed to dry in open air. The racks were properly oiled to prevent the fish sample from sticking to the racks during the smoked-drying process. The coal chamber of smoking kiln was cleaned and filled with charcoal as source of energy.

3.7 The Smoke Drying Process

The dressed fish species from the different culture facilities were dried in different compartments of the Magbon Alade smoking kiln in other to avoid cross contamination. The smoke drying was carried out with about 70^0C internal temperature until a constant weight was achieved (Adeyeye *et al*., 2015). The fish sample was checked at intervals during smoking and properly flipped to ensure uniform drying and to prevent charring. The properly smoke-dried fish were discharged from the smoking kiln and allowed to cool at room temperature. The weight of the sample was taken and recorded and after which, it was wrapped in a brown paper to prevent moisture absorption from the environment for a period of three weeks from which it was taken for weekly proximate analysis.

3.8 Proximate Analysis

The proximate analysis was carried out on the fresh fish species and on the smoke-dried fish species and weekly under ambient storage of three weeks. The proximate analysis was done to determine moisture content, crude protein, crude fibre, fat, ash and Nitrogen free extract (NFE) contents. Each analysis was carried out in triplicate.

3.8.1 Moisture content

Homogenized fish sample of 2g was placed into 50ml beaker of known weight. It was then dried in a drying oven at 105°C to 110°C for 3 hours to a constant weight. The moisture content obtained was calculated as follows in percentage

$$\% \text{ Moisture} = \frac{\text{Weight of wet sample - weight of dry sample}}{\text{weight of wet sample}} \times 100$$

3.8.2 Crude Protein Content

The sample was digested with a 15ml concentrated Sulphuric acid (H_2SO_4) in combination with a catalyst (a mixture of Potassium sulphate and Copper Sulphate) for about 90 minutes and left to cool for 15 minutes. The resulting digest was distilled in the presence of strong alkali Sodium hydroxide (NaOH). The ammonium that was released was collected in an aqueous solution of boric acid and was titrated against 0.01M HCL. The blank was ascertained by following the same procedure. Based on the determined ammonia, the equivalent nitrogen was calculated. To obtain the crude Protein in percentage, a factor of 6.25 was multiplied against the percentage Nitrogen of the sample (AOAC, 2005).

The protein content was calculated from

$$\text{Crude protein (\%)} = Na \times Va \times \frac{14}{1000} \times \frac{V_1}{V_2} \times \frac{100}{W} \times 6.25$$

Where;

N_a = concentration of HCL titration (0.1N)

V_a = volume of HCL used for titration

1000 = constant

3.8.3 Crude fibre

A sample of 2g weight was put in a conical flask. 1.25 % of the concentrated hydrogen sulphate (1000ml) was added and boiled for 30 minutes. A 1000ml volume was maintained constantly by adding warm water. It was then allowed to cool, after which it was filtered and washed to neutrality. The residue was washed back into the conical flask with 1.2% NaOH and made up to 100ml mark. It was boiled for 30 minutes maintaining the 100ml. Filtering was carried out after cooling, after which it was washed to neutrality. The residue was washed into a crucible of known weight with 1:1 ethanol/acetone and oven dried to a constant weight. It was then placed in a muffle furnace and ashed for 1 hour at 300^0C.

The crude fibre content was calculated as follows;

$$\% \text{ crude fibre} = \frac{\text{Ash weight}}{\text{weight of sample.}} \times 100$$

3.8.4 Ash content

2g of the sample was weighed into a crucible of known weight. The crucible was placed in a muffle furnace and the sample was ignited at 500°C to 600°C for 3 hours.

Ash percentage was calculated as;

$$\% \text{ Ash} = \frac{\text{Weight of Ash}}{\text{weight of sample}} \times 100$$

3.8.5 Fat content

Fat content is mostly measured by the extraction of fat by dissolving it in a suitable solvent. In the method below, the fat was obtained from the solution by evaporating the solvent and then weighed. The crude lipid content in the sample was extracted with the use of soxhlet extraction procedure. Finely blended sample of 2g was weighed (W_0) into a porous thimble and covered with a clean white cotton wool. Petroleum ether ($600cm^3$) was poured into a $100cm^3$ extracted flask, which was previously dried in an oven at 105°C and weighed (W_2), the porous thimble was placed in the soxhlet and the rest of the apparatus was assembled. Extraction was carried out for 5 hours. The thimble was meticulously removed and the extracted flask was placed in a water bath so to evaporate the petroleum ether and then dried in the oven at temperature of 105^0C to completely free the solvent and moisture. It was then cooled in a dessicator and reweighed (W_1). The percentage crude was calculated as seen below;

$$\% \text{ crude fat} = \frac{W_1 - W_2}{W_0} \times 100$$

Where;

W = Weight of sample (g)

W_1 = Weight of flask + oil (g)

W_E = Weight of flask (g)m

3.8.6 Total carbohydrate

The method of James (1995) was adopted. In this method the total proportion of carbohydrate in the sample was obtained by calculations using percentage weight method. The NFE was obtained by subtracting the amount of all four fraction above from 100%. The calculation was carried out as shown below;

% Nitrogen free extract = 100% - % Moisture content + % crude protein + % fat + % crude fibre.

3.9 Organoleptic Assessment

A fifteen (15) man panelist consisting of lecturers and students, randomly selected and briefly trained, was set up. The panel was saddled with the task of assessing the aroma, appearance, texture and taste of the smoke-dried fish sample from the various culture facilities in consideration. Questionnaires for the panelists score was prepared using ten (10) point hedonic scale described by Eyo (2001) as follows; (0-2 =Poor; 2-4 =Fair; 4-6 =Good; 6-8 =Very Good; 8-9 =Excellent). Each panelist was provided with water and cabin biscuits to clear their mouth before tasting the dried fish from each culture facility.

3.10 Statistical Analysis

Analysis of variance (ANOVA) was performed to obtain the difference between samples used for this experiment. Data analysis was carried out using GenStat software version 12.1. All analysis was carried out in triplicate using Duncan Multiple Range Test (DMRT) where $P < 0.05$ was applied to study the difference between means.

CHAPTER FOUR

4.0 RESULT

4.1 Nutritional Value of Fresh *Clarias gariepinus raised in various* culture facilities

Table 2 shows the mean nutritional value of fresh *Clarias gariepinus* raised in various culture facilities.

There was significance difference (P<0.05) in the moisture content of the fresh *C. gariepinus* raised in the various culture facilities. It can be seen that the highest moisture content (75.13±0.66) in fresh *Clarias gariepinus* raised in Tarpaulin tank while the least (68.56±0.66) was that from the concrete tank.

There was significance difference (P<0.05) in the crude protein of the fresh *C. gariepinus* raised in the various culture facilities. The highest crude protein (20.26±0.66) was seen in the fresh *C. gariepinus* raised in concrete tank while the least (16.26±0.66) was that from the tarpaulin tank.

There was significance difference (P<0.05) in the crude fat of the fresh *C. gariepinus* raised in the various culture facilities. The highest crude fat (8.42±0.32) was seen in fresh *C. gariepinus* raised in the concrete tank while the least (6.62±0.02) was that from the tarpaulin tank.

There was significance difference (P<0.05) in the crude fibre of the fresh *C. gariepinus* raised in the various culture facilities.

The highest crude fibre (0.05±0.02) was seen in fresh *C. gariepinus* raised in the concrete tank tank while the least (0.02±0.02) was that from the tarpaulin tank.

There was significance difference (P<0.05) in the ash content of the fresh *C. gariepinus* raised in the various culture facilities. The highest ash content (1.68±0.32) was seen in fresh *C. gariepinus* raised in both the earthen pond and the concrete tank while the least (1.32±0.32) was that from the tarpaulin tank.

There was significance difference (P<0.05) in the carbohydrate of the fresh *C. gariepinus* raised in the various culture facilities. The highest carbohydrate (0.87±0.32) was seen in fresh *C. gariepinus* raised in the concrete tank while the least was that from the tarpaulin tank.

Table 2. Nutritional Value of Fresh *C. gariepinus* raised in different culture facilities.

Parameters	Sample A (Earthen pond)	Sample B (Concrete tank)	Sample C (Tarpaulin tank)
Moisture	71.40 ± 0.66^{a}	68.56 ± 0.66^{a}	75.13 ± 0.66^{b}
Crude protein	18.94 ± 0.66^{a}	20.26 ± 0.66^{b}	16.26 ± 0.66^{c}
Crude fat	7.25 ± 0.32^{a}	8.42 ± 0.32^{b}	6.62 ± 0.02^{c}
Crude fibre	0.04 ± 0.02^{a}	0.05 ± 0.02^{a}	0.02 ± 0.02^{a}
Ash content	1.68 ± 0.32^{a}	1.68 ± 0.32^{a}	1.32 ± 0.32^{b}
Carbohydrate	0.69 ± 0.32^{a}	0.87 ± 0.32^{b}	0.65 ± 0.32^{c}

Means with different superscripts are statistically significant at $p<0.05$ across rows.

Note: Values are expressed as mean±Standard deviation.

4.1.2 Effects of smoke-drying and storage under ambient temperature on the nutritional value of *Clarias gariepinus* raised in different facilities

There was significant difference ($P<0.05$) in the moisture content of the smoked-dried *C. gariepinus* in the various culture facilities. The highest moisture (34.05±0.34) was recorded in the smoked-dried *C. gariepinus* raised in the earthen pond after four weeks of storage under ambient temperature while the least (10.80±0.12) was that from the tarpaulin tank immediately after smoke-drying.

There was significant difference ($P<0.05$) in the crude protein of the smoked-dried *C. gariepinus* raised in the various culture facilities. The highest crude protein (62.04±0.62) was recorded in the smoked-dried *C. gariepinus* raised in the tarpaulin tank immediately after smoke-drying while the least (46.20±1.01) was that from the earthen pond after four weeks of storage under ambient temperature.

There was significant difference ($P<0.05$) in the crude fat of the smoked-dried *C. gariepinus* raised in the various culture facilities. The highest crude fat (19.61±0.20) was recorded in the smoked-dried *C. gariepinus* raised in the tarpaulin tank immediately after smoke-drying while the least (12.80±0.12) was that from the earthen pond after four weeks of storage under ambient temperature.

There was no significant difference ($P>0.05$) in the crude fibre of the smoked-dried *C. gariepinus* raised in the various culture facilities. The highest crude fibre (0.15±0.00) was recorded in the smoked-dried *C. gariepinus* raised in the concrete tank immediately after smoke-drying while the least (0.10±0.00) was that from both the earthen pond and tarpaulin tank respectively after four weeks of storage under ambient temperature.

There was significant difference (P<0.05) in the ash content of the smoked-dried *C. gariepinus* raised in the various culture facilities. The highest ash content (4.26±0.04) was recorded in the smoked-dried *C. gariepinus* in the earthen pond immediately after smoke-drying while the least (2.98±0.03) was that from the concrete tank after four weeks of storage under ambient temperature. There was significant difference (P<0.05) in the carbohydrate of the smoked-dried *C. gariepinus* raised in the various culture facilities. The highest carbohydrate (3.40±0.04) was recorded in the smoked-dried *C. gariepinus* raised in the tarpaulin tank immediately after smoke-drying while the least (2.62±0.03) was that from the earthen pond after four weeks of storage under ambient temperature.

Table 4. Effects of smoke-drying and storage under ambient temperature on the nutritional value of *Clarias gariepinus* raised in different culture facilities

Parameter	Samples	Immediately after smoke-drying	2 weeks of storage	4 weeks of storage
Moisture	**A**	27.20±0.26[a]	28.12±0.28[a]	34.05±0.34[a]
	B	24.00±0.24[b]	26.12±0.24[b]	29.81±0.30[b]
	C	10.80±0.12[c]	11.09±0.11[c]	15.34±0.17[c]
Crude protein	**A**	51.35±0.52[a]	51.05±0.51[a]	46.20±1.01[a]
	B	54.55±0.55[b]	52.88±0.53[b]	49.93±0.50[b]
	C	62.04±0.62[c]	61.92±0.62[c]	59.32±0.59[c]
Crude fat	**A**	14.47±0.14[a]	13.89±0.14[a]	12.80±0.12[a]
	B	15.02±0.15[b]	14.83±0.72[b]	14.28±0.14[b]
	C	19.61±0.20[c]	18.98±0.19[c]	17.78±0.18[c]
Crude fibre	**A**	0.09±0.00[a]	0.11±0.00[a]	0.10±0.00[a]
	B	0.15±0.00[a]	0.14±0.00[a]	0.15±0.00[a]
	C	0.12±0.00[a]	0.12±0.00[a]	0.10±0.00[a]

Ash content	**A**	4.26±0.04^{a}	4.02±0.04^{a}	3.90±0.04^{a}
	B	3.19±0.03^{b}	3.19±0.03^{b}	2.98±0.03^{b}
	C	4.03±0.04^{c}	3.92±0.04^{c}	3.82±0.04^{c}
Carbohyddrate	**A**	2.63±0.03^{a}	2.81±0.03^{a}	2.62±0.03^{a}
	B	3.09±0.03^{b}	2.68±0.03^{b}	2.85±0.03^{b}
	C	3.40±0.04^{c}	3.97±0.04^{c}	3.64±0.04^{c}

Means on the same column with different superscripts are statistically significant ($P<0.05$).

Note: Values are expressed as mean±Standard deviation.

4.1.3 Organoleptic Assessment

The result from the organoleptic assessment conducted showed that there was no significant difference ($P<0.05$) in the organoleptic properties of the smoked dried *C. gariepinus* raised in the various culture facilities.

The highest appearance (8.73±1.28) was recorded in the smoked dried *C. gariepinus* raised in the earthen pond while the least (8.07±1.39) was that from the tarpaulin tank.

The highest texture (8.47±1.46) was recorded in the smoke-dried *C. gariepinus* raised in the tarpaulin tank while the least (8.00±1.25) was that from the earthen pond.

The highest aroma (8.00±1.20) was recorded in the smoked-dried *C. gariepinus* raised from concrete tank while the least (7.80±1.90) was that from the tarpaulin tank.

The highest taste (8.87±1.13) was recorded in the smoked- dried *C. gariepinus* raised from the earthen pond while the least (8.60±1.30) was that from the concrete tank.

Table 5. Organoleptic Assessment of *C. gariepinus* immediately after smoke-drying

Parameters	Sample A	Sample B	Sample C
Appearance	$8.73{\pm}1.28^a$	$8.73{\pm}1.10^a$	$8.07{\pm}1.39^a$
Texture	$8.00{\pm}1.25^a$	$8.33{\pm}1.18^a$	$8.47{\pm}1.46^a$
Aroma	$7.80{\pm}1.21^a$	$8.00{\pm}1.20^a$	$7.80{\pm}1.90^a$
Taste	$8.87{\pm}1.13^a$	$8.60{\pm}1.30^a$	$8.73{\pm}1.33^a$

Means with different superscripts are statistically significant ($P<0.05$).

Note: Values are expressed as mean±Standard deviation.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Moisture Content

The moisture content for the fresh samples ranged from 68.56±0.66 to 75.13±0.66. This range for moisture content agrees with the value obtained by Solomon and Oluchi (2018) who had moisture range of 69.32% to 74.08% for juvenile catfish fed Coppens and *Telfera occidentales* respectively. Immediately after smoke-drying the moisture content range obtained for the smoke-dried samples was 10.80±0.12 to 27.20±0.26. The reduction in the moisture content of the samples was as a result of the loss of water during smoke-drying which was observed by Ogbonnaya and Ibrahim (2009). The moisture range for the smoked-dried cat fish did not agree with the range reported by Ajibare *et al*. (2023) who had a moisture range of 38.35±0.39 to 40.46±1.98 in their study on the proximate composition and sensory evaluation of catfish (*Clarias gariepinus*) smoked with different materials. The difference in moisture range could be as a result of the materials they were smoked with. The range for moisture content obtained in this work for the smoke-dried catfish samples is higher than what was recorded by Yakubu and Ngueku (2015) who had 8.11% to 11.64%, this variation in values recorded may be attributed to the drying time the fish could have been subjected to. The smoke-drying process slowed down the spoilage activities of enzymes and bacteria. There was a general increase in the moisture content of the samples during storage under ambient temperature, this agrees with what was reported by Adeyemi *et al*. (2013). The increase in the moisture content can be attributed to the absorption of moisture from the environment, since there was no re-drying (Daramola *et al*., 2007). The highest crude fat was recorded in the sample from the tarpaulin tank which could be as the effect of the culture facility.

5.2 Crude Protein

The highest crude protein obtained for the fresh samples was 20.26±0.66. which is very close to the value obtained by Okereke *et al*. (2014) who reported 21.84±1.00 for fresh fish sample. Immediately after smoke-drying, the crude protein content of the samples increased and the range was from 51.35±0.52 to 62.04±0.62. The increase in the crude protein content may be due to product dehydration which concentrated the proteins during the heat treatment of the fish, thus increasing the nutritional value of the catfish according to Okereke *et al*. (2014). The crude protein content of the samples decreased with storage time under ambient temperature. This could be accrued to the gradual degradation of initial crude protein to more volatile products such as volatile bases, hydrogen sulphide and ammonia (Eyo, 2001). John *et al*., (2017) in their work on effect of storage methods on the nutritional qualities of African catfish also reported a decrease in the crude protein content of catfish stored under ambient temperature.

5.3 Crude fat

The result showed that the samples were significantly different ($P<0.05$) from one another. Also, there was an increase in the crude fat content of the samples immediately after smoke-drying. This could be as a result of the evaporation of moisture which agrees with the findings of Chukwu and Shaba (2009) and Ezembu and Onwuka (2015). From table 4, during the period of storage under ambient temperature, it was observed that the crude fat content of the samples decreased gradually. The reduction in crude fat content of the samples may be due to oxidative damage which is a major concern during fish storage as it contributes to quality degradation by altering the flavour, texture and colour, this is also in agreement with the works of Masniyom (2011) and Romotowska *et al*. (2016).

5.4 Crude fibre

Table 3 showed that there was increase in the crude fibre content of the samples immediately after smoke-drying which agrees with the report of Omoruyi *et al. (*2017). Table 3 also indicates that during the period of storage the crude fibre content of samples was decreased. The highest crude fibre was recorded in C. gariepinus from the concrete tank although the samples were not significantly different (P<0.05).

5.5 Ash content

Ash is a measure of the mineral content of any food including fish (Omotosho *et al*., 2011). Table 2 shows the result for the fresh samples which ranged from 1.32±0.32 to 1.68±0.32. There was no significant difference between sample A and B. Immediately after smoke-drying the result showed that ash content of all the samples increased and there was significant difference (P<0.05) among the samples. The increment in the ash content of the samples agrees with the study carried out by Oparaku and Mgbenka (2012). During the period of storage, there was gradual decrease in the ash content of the samples which agrees the work of Ayeloja *et al*. (2019).

5.6 Carbohydrate

The carbohydrate content of the fresh samples ranged from 0.65±0.32 to 0.87±0.32. Immediately after smoke-drying, the carbohydrate content of the samples increased. This result does not agree with the findings of Ndife *et al.* (2019). The carbohydrate content of the samples decreased gradually during the period of storage as shown on Table 4. This finding agrees with the work of Daramola *et al*. (2007). There was significance difference (P<0.05) of the during the period of storage.

5.7 Organoleptic Assessment

Food attributes are the important factor in predicting consumers' food choices decision (Jang *et al.,* 2009). Sensory evaluation is a critical part in food development because it determines consumers reaction to a product (Bouzgarrou and Sadok, 2017). It is generally assumed that consumers' primary consideration when selecting and consuming a new food commodity is the product's palatability and quality, with nutritional attributes taking a secondary role (olaniyi *et al*., 2016). The findings of the organoleptic assessment of this study revealed that there was no significant difference ($P<0.05$) across the samples. This is not in line with the result reported by Adibe *et al*. (2018) which may be due to the fact that their samples were treated with different spices. There was no significant difference ($P<0.05$) among the samples which may be due to the non-application of any special treatment to the samples. The result indicates that sample A had a better preference in taste followed by sample C and B respectively. C. gariepinus raised in the tarpaulin tank had the best general acceptability in terms of appearance, texture, aroma, and taste.

CHAPTER SIX

6.0 CONCLUSION

The result of this study reveals that the culture facility used in raising *C. gariepinus* has a significant influence on the nutritional composition of the fish species. The analysis of the fresh samples gave a result indicating that sample B from the concrete tank was better nutritionally than sample A from the earthen pond and sample C from the tarpaulin tank respectively. However, analysis on the smoked-dried sample adjudged sample C from the tarpaulin tank as being nutritionally valuable than sample B from the concrete tank and sample A from the earthen pond. This also proves that smoke-drying as a method of fish processing and preservation can also affect the nutritional value of *C. gariepinus.* The findings of this study also showed that storage time also affect the nutritional composition of a fish. The longer it is stored, the lesser the nutritional value becomes. The result from organoleptic assessment revealed that there was no significant difference amongst the samples from the earthen pond, concrete tank and tarpaulin tank respectively. The sensory evaluation of the samples gave a general rating of excellence for all samples. The findings suggest that the type of culture facility used in raising *C. gariepinus* can have an impact on the fish nutritional composition. Therefore, when considering the nutritional composition of *C. gariepinus*, it is worthwhile to take into account the culture facility in which the specie was raised.

6.1 RECOMMENDATIONS

This study has proven that the type of culture facility used in raising *C. gariepinus* has an effect on its nutritional composition. Thus, it is recommended that;

- The use of tarpaulin tank which showed a better result in the nutritional value of the fish raised in it, in comparison with other facilities like the earthen pond and concrete tank should be promoted in aquaculture. This will solve the problem of land and space as it is more convenient than the other facilities.

- Further studies can also be carried with the use of different fish species to re-validate this finding

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